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JORDAN

FEASIBILITY STUDY ON THE USE OF SUSTAINABLE AVIATION FUELS

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FOREWORD

In June 2022, on the 50-year anniversary of the Stockholm Convention, the International Civil Aviation Organization (ICAO) launched the Assistance, Capacity-building, and Training for Sustainable Aviation Fuels (ACT-SAF) programme to aid developing states in their transition to cleaner energy for aviation.

Later in 2022, the 41st ICAO Assembly adopted a long-term global aspirational goal (LTAG) for international civil aviation: collectively targeting net-zero carbon emissions by 2050, as a contribution to global climate action in line with the objectives of the UNFCCC Paris Agreement. The ICAO Assembly, through Resolution A41-21, emphasized the need for targeted support to developing states, including enhanced access to financial resources, technology transfer, and capacity-building initiatives.

With the adoption at the 3rd ICAO Conference on Aviation Alternative Fuels (CAAF/3) in November 2023 of the ICAO Global Framework for Sustainable Aviation Fuels (SAF), Lower Carbon Aviation Fuels (LCAF) and other Aviation Cleaner Energies, ICAO and its Member States have agreed to strive to achieve a collective global aspirational Vision to reduce CO_2 emissions in international aviation by 5 per cent by 2030 through the use of SAF, LCAF and other aviation cleaner energies (compared to zero cleaner energy use).

The Vision has four building blocks, the third of which is implementation support. It expresses the importance of support for developing countries and States with particular needs, to be addressed through the ACT-SAF programme. This should be a robust and substantial capacity-building and implementation support programme designed to assist States, to foster partnerships and collaboration on SAF initiatives under ICAO's coordination and to serve as a global platform for knowledge exchange.

In 2022 the Netherlands made a voluntary financial contribution to the ICAO Environment Fund to fund three feasibility studies. At CAAF/3 it was announced that Jordan would be one of the states supported. This feasibility study assesses the potential for producing and utilizing sustainable drop-in Sustainable Aviation Fuel (SAF) in Jordan, ensuring alignment with the environmental and socio-economic sustainability criteria in ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). It follows the guidelines set out in the ICAO *Template for Feasibility Studies on Sustainable Aviation Fuels* and *Guide for Feasibility Studies on Sustainable Aviation Fuels* (Version 1, July 2023).[1]

[1] ICAO (2025), *ICAO Assistance, Capacity-building and Training for Sustainable Aviation* Fuels

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This feasibility study would not have been possible without the invaluable engagement and leadership of the Jordanian Civil Aviation Regulatory Commission (CARC) and in particular their appointed focal point for this ACT-SAF project, Ms Elham Al-Rawashdeh.

The instrumental role should also be acknowledged of the many national stakeholders, who have contributed to the development of this work by providing valuable information and guidance to identify SAF potential in the country. The author expresses his gratitude to all stakeholders listed in Appendix B.

EXECUTIVE SUMMARY

BACKGROUND

This feasibility study assesses the potential for developing Sustainable Aviation Fuel (SAF) in Jordan to reduce aviation-related greenhouse gas emissions and generate socio-economic benefits. SAF is globally recognized as the most effective way to decarbonize aviation and is central to ICAO's Global Framework for SAF, Lower Carbon Aviation Fuels (LCAF) and other Aviation Cleaner Energies, which aims for 5% aviation CO_2 emissions reduction by 2030, and to ICAO's Long-Term Aspirational Goal (LTAG) of net-zero carbon emissions by 2050.

This assessment evaluates Jordan's domestic feedstock potential, viable production pathways, infrastructure and policy readiness, and the enabling conditions needed to establish a domestic SAF market. It draws on international best practices, adapted to Jordan's socio-economic and environmental context and national priorities.

KEY FINDINGS

The study finds that Jordan has credible potential to develop a SAF industry that supports national climate goals, strengthens energy security, and creates long-term economic value. This potential is based on a combination of viable SAF feedstocks and production pathways. In the near term, biofuel pathways – drawing on harnessing the efficient use and potential of municipal solid waste (MSW), agricultural residues, and livestock manure – can make a meaningful contribution. In the long term, Jordan's exceptional solar and wind resources make it well-suited for Power-to-Liquid (PtL) SAF production, offering the potential to supply not only its growing domestic jet fuel demand but also regional and international markets.

Today, Jordan remains heavily reliant on fossil fuel imports. Developing domestic SAF production – both bio-based and PtL – could reduce this dependency, diversify the economy, and generate jobs and income. However, success will depend on addressing key challenges: water scarcity, limited infrastructure for agricultural residue collection and waste processing, and the need to build dedicated supply chains for green hydrogen and captured CO_2. To fulfil the requirements for a viable and sustainable SAF industry, Jordan must adhere to and establish strict environmental and social guardrails that protect food security, natural resources, and ecological integrity. This can be secured by adopting the ICAO CORSIA sustainability framework.

Further research is recommended, including a techno-economic analysis beyond the scope of this study's findings, to strengthen the evidence base and support implementation planning. A business implementation study could deliver this guidance – helping to maximize SAF output and minimize costs by identifying the most cost-effective pathways, optimal timing, and rollout scale.

Feedstock and conversion technologies

Jordan's severe water and agricultural land constraints limit the scalability of biomass-based SAF pathways. With only 5.4% arable land, crop cultivation is prioritized for food security. Thus, biomass feedstocks are largely restricted to non-edible agricultural residues and MSW. To be viable, SAF pathways must minimize land and water use while maximizing emission reductions and feedstock-to-SAF conversion efficiency.

Feedstocks: The study identifies MSW, agricultural residues (notably olive pits), and livestock manure as key domestic SAF feedstocks. MSW and manure have the highest potential due to availability, underutilisation, and alignment with waste reduction policies. MSW, with its rising volume and high organic content, is CORSIA-eligible. Olive residues and manure add feedstock diversity without impacting food production. Jojoba, suited to arid climates and marginal lands, offers limited SAF potential due to water constraints and currently supports the least favourable feedstock-to-SAF conversion pathway.

Pathways: The study assessed three SAF biofuel conversion pathway options – HEFA (Hydroprocessed Esters and Fatty Acids), Alcohol-to-Jet (AtJ), and gasification-Fischer Tropsch (FT) – in addition to the Power-to-Liquid (PtL) option, a renewable synthetic fuel made by combining green hydrogen with captured CO_2. HEFA is the most commercially mature, with a 73–84% carbon reduction potential but is constrained in Jordan due to limited feedstocks. AtJ and gasification-FT offer greater scalability and higher lifecycle emission cuts (85–94%). The findings suggest that gasification-FT is the most favourable option for its feedstock flexibility and its ability to help manage MSW.

Domestic biogenic feedstocks are insufficiently available for SAF biofuel to fully meet Jordan's jet fuel demand but can contribute meaningfully, while PtL aligns with national renewable energy and hydrogen strategies and could position Jordan as a global SAF hub. However, successful PtL deployment requires dedicated supply chains for green hydrogen and captured CO_2, likely involving international collaboration. By leveraging Jordan's comparative advantage in low-cost solar and wind energy, PtL can contribute to improving energy security and economic diversification – despite its higher cost compared to other biofuels.

Institutional framework and energy infrastructure

Jordan's national strategies, such as the Climate Change Policy (2022–2050), Green Hydrogen Strategy, and Energy Strategy, can create a strong institutional basis for SAF integration.

Jordan has strengthened key parts of its fossil fuel value chain – particularly refining and distribution infrastructure – to reduce reliance on imported energy. Facilities like the Zarqa refinery offer a solid platform for early SAF deployment. However, upstream systems for feedstock collection, processing, and conversion do not yet exist and will require substantial investment, coordination, and capacity building across the SAF value chain, along with continued upgrades to energy infrastructure.

Finance landscape

Developing a domestic SAF industry in Jordan will require sustained investment. Jordan has experience in crafting strategic roadmaps and attracting international support for large-scale industry projects. Its Economic Modernization Vision 2033 provides a framework for channelling investment into priority sectors – renewables, green hydrogen, transport, and the circular economy – all aligned with SAF. The country also has a strong record of mobilizing private and international capital through blended finance and public-private partnerships (PPPs), often with institutions like the World Bank's IFC. Notably, Jordan's PPP Unit has expressed interest in supporting SAF based on exchanges during this study.

However, investment barriers, including regulatory complexity and fragmented permitting, must be addressed, as they can undermine investor confidence and project bankability. In parallel, coordinated planning is required to prioritize and direct investment streams, with strategic decisions on when and to what extent different biofuel SAF and PtL pathways should be deployed. A credible, techno-economically grounded

SAF roadmap should guide this sequencing, reduce risk and capital costs, and enable smart investment. This feasibility study aims to provide the foundation for that next step.

POLICY IMPLICATIONS

Targeted financing, regulatory updates, and infrastructure planning will be essential for early project development. Jordan has policies and development strategies in place that can indirectly support SAF, but more direct and targeted support is needed. The following areas of action are recommended:

I. Organization & planning: establish strategic direction and institutional coordination.

- SAF Roadmap – defining timelines, pathways, and investment priorities.
- Stakeholder coordination – informing and engaging public and private sector stakeholders.
- Policy integration – including SAF in national climate and development strategies and regulations.

II. Funding & project inception support: reduce project risk to mobilize investments.

- Investment prioritization – highlighting SAF in national investment planning.
- Public-Private-Partnership (PPP) framework – launching SAF-focused PPPs.
- Development finance – securing support from development banks and donors.

III. Feedstock regulation & infrastructure: set up processing systems and policies.

- Logistics investment – supporting the establishment of collection and pre-treatment systems.
- Regulatory and legislative policies – establishing clear guidance for the efficient and safe processing of eligible feedstocks and CORSIA as the sustainability framework applicable for SAF.
- CORSIA eligible feedstock – proposing additional feedstocks to ICAO for CORSIA eligibility.

IV. SAF handling and distribution: prepare infrastructure and policies for SAF delivery.

- Infrastructure readiness – supporting the financing and establishment of blending and SAF storage systems and integrating SAF requirements in national infrastructure and grid planning.
- Handling standards – setting up SAF blending and quality protocols.

IV. Market creation: generate demand signals and ensure long-term market stability.

- Demand incentives – introducing mandates or market-based carbon pricing mechanisms.
- Regional collaboration – developing SAF trade links in the region.

These recommendations are designed to align with ICAO's principles of feasibility (building on existing structures), effectiveness (targeting key cost and risk barriers), and practicality (prioritizing near-term deployment while preparing for long-term scale-up). They are structured to support their integration as actionable items in Jordan's State Action Plan for the Reduction of CO_2 Emissions from Aviation.

OPPORTUNITIES AND CHALLENGES

The feasibility study highlights a clear opportunity for Jordan to establish a SAF industry as a strategic lever for climate action, energy transition, and industrial development. SAF offers a pathway to unlock new value chains, attract investment, and build regional leadership in low-carbon aviation. At the same time, turning this opportunity into reality will require overcoming critical challenges. These include mobilizing capital for early-stage projects, addressing cross-sector coordination gaps, and ensuring environmental sustainability under increasing resource pressures. Targeted policy support, institutional capacity-building, and international collaboration will be essential to move from feasibility to implementation.

CONTENTS

ABBREVIATIONS AND ACRONYMS

AOT	Aqaba Oil Terminal
ASEZA	Aqaba Special Economic Zone Authority
ASTM	American Society for Testing and Materials
AVTR	Amman Vision Treatment and Recycling
AtJ	Alcohol-to-Jet
CAEP	Committee on Aviation Environmental Protection (ICAO)
CAPEX	Capital Expenditure
CARC	Civil Aviation Regulatory Commission (Jordan)
CBA	Cost Benefit Analysis
CCU	Carbon Capture and Utilization
CEF	CORSIA Eligible Fuels
CO_2	Carbon Dioxide
CO_2eq	Carbon Dioxide-equivalent
DAC	Direct air capture
EMRC	Jordan Energy & Minerals Regulatory Commission
EMV	Economic Modernization Vision
EUR	Euro
EU RED-II	European Union's Renewable Energy Directive II
FDI	Foreign Direct Investment
FT	Fischer-Tropsch
GCC	Gulf Cooperation Council (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates)
GHG	Greenhouse Gas
HDI	Human Development Index
HEFA	Hydroprocessed Esters and Fatty Acids
H_2	Hydrogen
IATA	International Air Transport Association
ILUC	Induced Land-Use Change
ISCC	International Sustainability & Carbon Certification
JOTC	Jordan Oil Terminals Company
JPMC	Jordan Phosphate Mines Company
JPRC	Jordan Petroleum Refinery Company
JREEEF	Jordan Renewable Energy & Efficiency Fund
kWp	Kilowatt-peak
kt	Thousand metric tons
LCA	Life-Cycle Assessment
LCAF	Lower Carbon Aviation Fuel
LCOE	Levelised Cost of Electricity
LCOH	Levelised Cost of Hydrogen
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LTAG	Long Term Global Aspirational Goal (ICAO)
MEMR	Ministry of Energy and Natural Resources (Jordan)
MENA	Middle East and Northern Africa
MIT	Ministry of Industry, Trade and Supply (Jordan)
MOA	Ministry of Agriculture (Jordan)

MoU	Memorandum of Understanding
MOENV	Ministry of Environment (Jordan)
MOF	Ministry of Finance (Jordan)
MOHE	Ministry of Higher Education and Scientific Research (Jordan)
MOIN	Ministry of Investment (Jordan)
MOL	Ministry of Labor (Jordan)
MOLA	Ministry of Local Administration (Jordan)
MOPIC	Ministry of Planning and International Cooperation (Jordan)
MOT	Ministry of Transport (Jordan)
MRV	Monitoring, Reporting and Verification
MSW	Municipal Solid Waste
Mt	Million tonnes (metric tons)
MWI	Ministry of Water and Irrigation (Jordan)
NDC	Nationally Determined Contribution
OPEX	Operational Expenditure
NERC	National Energy Research Center (Jordan)
PPP	Public-Private Partnership
PtL	Power-to-Liquid
RJA	Royal Jordanian Airlines
RSB	Roundtable on Sustainable Biomaterials
SAF	Sustainable Aviation Fuels
SCS	Sustainability Certification Schemes
SSR	Self-Sufficiency Rate
TRL	Technology Readiness Level

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SECTION 1. STATE-SPECIFIC INFORMATION

Jordan is a central crossroads of cultural influence in the Middle East, shaped by its geography, history, and diverse demographics. Its name, derived from the Jordan River, reflects its deep historical roots, civilisation, and significant role in Islam, Christianity, and Judaism. Jordan is renowned for its cultural achievements, innovative architecture, and strategic role in regional trade and is home to archaeological treasures such as the Nabatean city of Petra and the well-preserved Roman ruins of Jerash.

This section analyzes Jordan's geographic, economic, industrial, and environmental landscape to assess key strengths, weaknesses, opportunities, and threats that influence its potential for SAF production.

1.1 GEOGRAPHY AND CLIMATE

On a regional level, Jordan borders Syria to the north, Iraq to the northeast, Saudi Arabia to the east and south, and Israel and the Palestinian territories to the west. On a broader, international level, Jordan lies at the crossroads of Europe, Asia, and Africa, positioning it centrally among key aviation business destinations and markets. Jordan is primarily landlocked, however, at its southwestern tip, it has a 25 km coastline along the Red Sea, with Aqaba as its only port city.[2]

Jordan, officially the Hashemite Kingdom of Jordan, gained independence in 1946 from the United Kingdom. Before that, it was known as Transjordan, a British mandate established after World War I. Today, the country is a constitutional monarchy with a representative government, organized into twelve administrative divisions, called governorates: Amman, Irbid, Zarqa, Balqa, Karak, Mafraq, Ma'an, Tafiela, Jerash, Madaba, Ajloun, and Aqaba. Each governorate functions under a system of decentralization and local administration, overseen directly by the Ministries of Local Administration and Interior Affairs. Figure 1 Figure 1 provides an illustration of Jordan's political division and location in the region.

Of Jordan's 11.5 million inhabitants, a significant 92% live in urban areas. The largest urban centre is the Greater Amman Region, which includes the capital, Amman—the fifth-largest city in the Arab world—home to 4 million people.[3]

Geopolitically, Jordan has maintained stability in a volatile region, often serving as a mediator in regional conflicts. Its 1994 peace treaty with Israel and its strong ties with both Western nations and Arab countries highlight its role as a key player in fostering dialogue and promoting security in the Middle East. More details on this aspect are provided in 1.3.

[2] Government of The Hashemite Kingdom of Jordan (2025), *About Jordan*
[3] Jordan Department of Statistics (2025), *Population*

Figure 1. Political map of Jordan and its neighbours.[4]

Key takeaways for SAF potential in Jordan

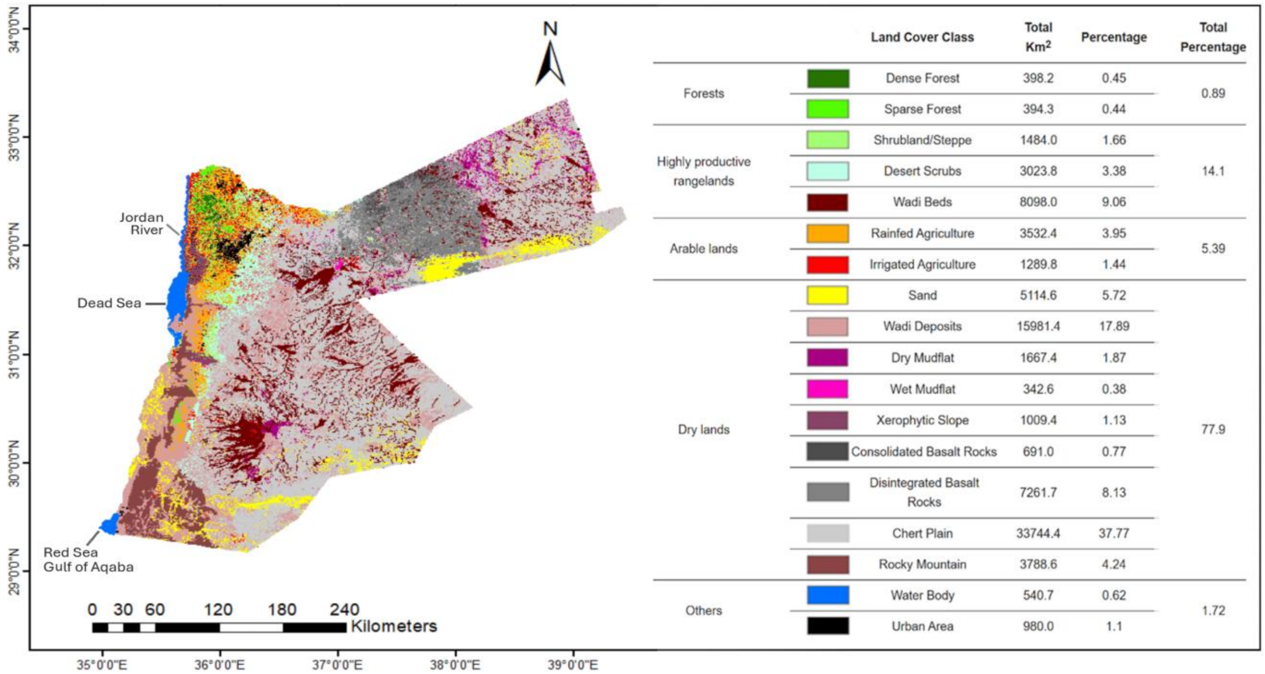
Jordan is strategically located at the crossroads of Europe, Asia, and Africa, offering proximity to major aviation hubs and global markets. This advantageous geographic position enhances its appeal for airline operations and trade. Additionally, Jordan's political stability and well-balanced diplomatic relations reinforce its reputation as a trusted and reliable regional player, which is an essential factor in attracting investments for large-scale industrial projects, such as SAF plants.

1.1.1 Topography and land coverage

Covering an area of 89,318 km^2, Jordan can be categorized into the following main topographic regions: The Jordan Valley, located along the Jordan River in the west, lies next to Jordan's northwestern tip that features fertile lands and Mediterranean forests. The central and western parts of the country are characterized by mountainous terrain. The southern region includes arid deserts and sandstone mountains, such as those in Wadi Rum and Petra, as well as Jordan's access to the Red Sea. The eastern region consists of a vast, sparsely populated desert.

The landscape spans elevations from its highest point at Jabal Umm ad Dami in the south, which reaches 1,854 m, to the Dead Sea, the lowest terrestrial point on Earth at 430 m below sea level. The Dead Sea is also one of the world's saltiest bodies of water. While the country has a total of 541 km^2 of water surface, it is predominantly covered by dry and desert regions, which make up approximately 78% of its area. These areas, known as Badia, are arid and semi-arid deserts that stretch across southern, eastern, and northern Jordan, supporting pastoral communities and being primarily inhabited by Bedouins.[3] Figure 2. Land cover map of Jordan. provides a detailed overview of the different land cover classes and their surface areas.

[4] Map from Geoatlas (2018), *Political Map of Jordan*



	Land Cover Class	Total Km²	Percentage	Total Percentage
Forests	Dense Forest	398.2	0.45	0.89
	Sparse Forest	394.3	0.44	
Highly productive rangelands	Shrubland/Steppe	1484.0	1.66	14.1
	Desert Scrubs	3023.8	3.38	
	Wadi Beds	8098.0	9.06	
Arable lands	Rainfed Agriculture	3532.4	3.95	5.39
	Irrigated Agriculture	1289.8	1.44	
Dry lands	Sand	5114.6	5.72	77.9
	Wadi Deposits	15981.4	17.89	
	Dry Mudflat	1667.4	1.87	
	Wet Mudflat	342.6	0.38	
	Xerophytic Slope	1009.4	1.13	
	Consolidated Basalt Rocks	691.0	0.77	
	Disintegrated Basalt Rocks	7261.7	8.13	
	Chert Plain	33744.4	37.77	
	Rocky Mountain	3788.6	4.24	
Others	Water Body	540.7	0.62	1.72
	Urban Area	980.0	1.1	

Figure 2. Land cover map of Jordan.[5]

Jordan's arable land accounts for 5.4% of its total area – well below the global average of 10.7% – reflecting the country's arid climate, scarce water resources, and challenging terrain for agriculture.[6] Supported by the Jordan River, roughly 70% of Jordan's agricultural output per year comes from the Jordan Valley region, which enables year-round farming under the support of irrigation.[7] However, extensive water diversions and overuse in neighbouring countries have significantly reduced the river's flow – exacerbating Jordan's already severe water scarcity and further threatening agricultural sustainability.

Nationwide, Jordan's per capita water availability stood at 61 m³ per year in 2021, in contrast to the global median at 8,915 m³ in 2019 and far below the threshold of 500 m³ that the UN Food and Agriculture Organization (FAO) considers as the absolute water scarcity threshold. Projections suggest an even more dire future, with levels expected to decline to 35 m³ by 2040. For reference, this availability stood at 3,600 m³ per capita in Jordan in 1946.[8] As a result, Jordan is now among the most water-scarce countries in the world, a situation that is expected to deteriorate further due to climate change and a growing population.

[5] Own changes, map and data based on Taifour et. al. (2022), *A State-of-the-Art Vegetation Map for Jordan: A New Tool for Conservation in a Biodiverse Country*
[6] UN FAO (2022), *SOLAW21 Technical background report*
[7] Al-Omari et. al. (2015), *Irrigation Water Management in the Jordan Valley under Water Scarcity*
[8] Jordan Ministry of Water and Irrigation (2023), *National Water Strategy 2023-2040*

Figure 3 Jordan's landscape is characterized by the Jordan River in the west[9], but dominated by arid regions like the Wadi Rum desert in the south[10] and the eastern Badi desert and rangelands[11]

One of the deterioration consequences of climate change is land degradation, presenting a major threat to Jordan's biosphere, directly impacting water availability and food security. The growing occurrence of extreme weather events, including sandstorms and heatwaves, intensifies the rate of land degradation across the country. For example, Jordan's rangelands – covering approximately 14% of the country's land area and serving as a vital resource for livestock grazing and pastoral activities – especially in its Badia regions – have experienced a 50% decline in edible dry matter for animals between 1990 and 2010. While studies suggest that this development is primarily driven by climate change, deforestation and overgrazing also contributed to this problem.[12]

Consequently, Jordan pursues an array of initiatives to combat land degradation. These include land restoration and afforestation efforts, sustainable land management practices such as rangeland rehabilitation, and water-saving agricultural techniques. Thereby, in 2018, the Jordanian Ministry of Environment set a target to prevent further damage and achieve land degradation neutrality by 2030 in the National Action Plan to Combat Desertification.[13] There are positive examples that the country is on a good way to approach this target. For example, the long-term Badia Ecosystem and Livelihoods Project (2013–2017) aimed to restore degraded rangelands in Jordan's eastern desert Badia region and enhance biodiversity. It also supported local livelihoods through community-centred ecotourism and sustainable rangeland management. The project demonstrated improved water harvesting as a key result, increased income opportunities, and strengthened environmental and rangeland resilience.[14]

Key takeaways for SAF potential in Jordan

Jordan's land use potential is complex. On the one hand, the dominance of arid landscapes limits feedstock availability for aviation biofuels, as only a small portion of land is dedicated to agriculture, such as the Jordan Valley. Further exacerbating this issue, climate change poses the risk of significant land degradation, potentially reducing biomass feedstock availability and worsening food security concerns. Sustainable land

[9] Photo from Tripadvisor (2025), *Photo de Jordan Valley : The Jordan river*
[10] Photo from Fotocommunity (2013), *Aerial Photo of Wadi Rum*
[11] Photo from IUCN ROWA (n.a.)
[12] Jordan Ministry of Environment (2015), *The Aligned National Action Plan to Combat Desertification in Jordan*
[13] Jordan Ministry of Environment (2018), *Final Country Report of the Land Degradation Neutrality Target Setting Programme*
[14] World Bank (2017), *Badia Ecosystem and Livelihoods Project - Implementation Completion and Results Report*

management practices – as demonstrated in projects – and innovative agricultural solutions could help mitigate these risks. On the other hand, Jordan's vast and unpopulated arid regions can offer ample space for solar and wind energy infrastructure, benefitting renewable energy projects like PtL SAF.

1.1.2 Climate

Jordan's topographic variety and location between the Mediterranean, desert, and subtropical climate zones result in diverse climatic conditions. The maps in Figure 4
Figure 4 illustrate this.

The northern highlands, including cities like Irbid and Ajloun, experience a Mediterranean climate characterized by mild, rainy winters and warm, dry summers. This region receives the highest rainfall in the country, with the Governorate of Ajloun benefiting from annual rainfall. The northern purple shading (>500 mm of rain) on the annual rainfall map above roughly corresponds to the Ajloun Governorate. The northwestern tip is the sole region with significant forest cover, which nationwide covers less than 1% of Jordan's total area.

Central Jordan, including Amman, has a semi-arid climate with moderate winter rainfall and warm, dry summers. In contrast, the Jordan Valley and Dead Sea areas to its west exhibit a hot desert climate with limited precipitation and high summer temperatures. Similarly, the southern desert regions endure arid conditions with scorching days, chilly nights, and scarce rainfall, while the eastern desert is the driest region, marked by strong temperature fluctuations and minimal precipitation.

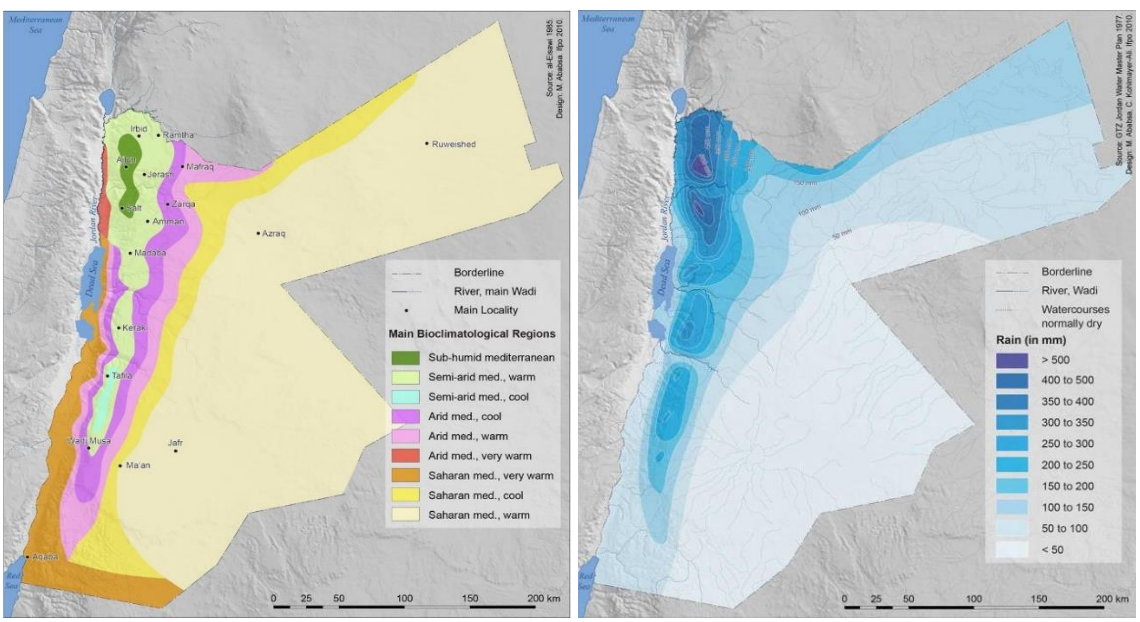


Figure 4. Climatic regions of Jordan and average rainfall.[15]

The country lies in the Global Solar Belt, receiving approximately 316 days of sunshine annually, with the sun reaching an optimal elevation angle of 83 degrees for solar power systems, such as photovoltaic panels,

[15] Maps from Palmer (2013), *Atlas of Jordan*

during the summer.[16] This results in direct solar radiation intensity ranging from 5 to 7 kilowatt-hours per square meter (kWh/m²). On average, the annual daily global solar irradiance on a horizontal surface is about 5.6 kWh/m² per day, offering abundant and low-cost solar energy potential, making Jordan highly competitive for energy-intensive industries.[17]

Jordan is also an ideal location for wind turbine installations, thanks to its consistently warm temperatures and clear air year-round, combined with wind speeds typically ranging between 7 and 11 m/s. According to the Ministry of Energy and Mineral Resources, approximately 16% of the country's total land area is suitable for wind energy generation, and the kingdom significantly expanded wind power capacity in the last decades.[98] Figure 5 illustrates both solar and wind availability.

These conditions result in low electricity generation cost: levelized cost of energy (LCOE)[18] is roughly USD 0.025 per kWh[19], thereby significantly lower than the global average of ~USD 0.044 per kWh for solar electricity.[20] With such low lifetime cost of electricity generation – expected to decline further – the real cost of realising renewable energy projects in Jordan lies in the upfront capital investment required for constructing and setting up solar and wind farms.

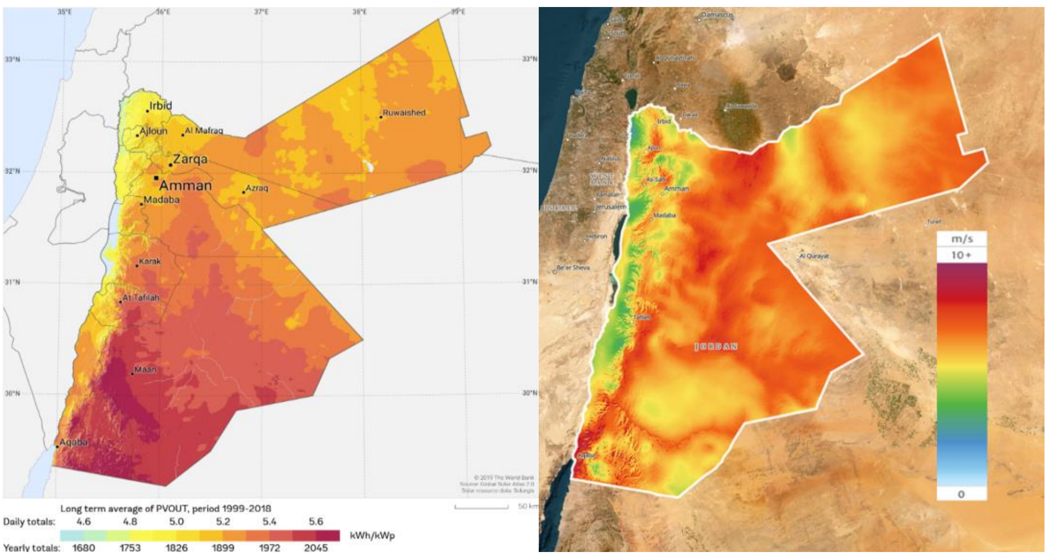


Figure 5. Jordan solar irradiation in kWh/kWp[21] (left)[22] and mean wind speed at 100 m height over ground in m/s (right).[23]

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[16] The Global Solar Belt, located between approximately 35°N and 35°S latitude, includes North and Sub-Saharan Africa, the Middle East, South and Southeast Asia, southern U.S., Mexico, Central America, the Caribbean, northern and central South America, Australia, and several Pacific islands.

[17] Salah et. al. (2022), *The status and potential of renewable energy development in Jordan: exploring challenges and opportunities*

[18] LCOE represents the average cost per unit of electricity generated over a powerplant's lifetime, including capital expenditures (CAPEX), operational expenses (OPEX), and financing costs.

[19] WoodMackenzie (2024), *Global competitiveness of renewable LCOE is on the rise*

[20] IRENA (2024), Renewable Power Generation Costs 2023

[21] kWh/kWp (kilowatt-hours per kilowatt-peak) provides a standardized measure to compare solar systems' efficiency; higher values indicate greater energy production per installed capacity.

[22] Map from Global Solar Atlas (2025), *Jordan*

[23] Map from Global Wind Atlas (2025), *Jordan*

Key takeaways for SAF potential in Jordan

Jordan’s hot and dry climate presents challenges for large-scale biomass cultivation, but its high solar irradiation offers a significant advantage for cheap energy-intensive SAF production processes. However, as one of the most water-scarce countries in the world, Jordan is highly dependent on efficient water use strategies, such as wastewater recycling and desalination – water is particularly relevant for PtL SAF production.

1.1.3 Mineral resources

Jordan has mineral resources, but large-scale mining is mainly limited to a few economically viable materials. Figure 6 highlights these resources. Jordan possesses significant potash resources, primarily extracted from its central region near the Dead Sea, while large-scale phosphate mining operations are predominantly located in the southern region. These materials dominate Jordan’s mining activities, making it one of the world's leading producers and exporters of potash and phosphate – both essential raw materials for fertilizer production. Resources like gypsum, building stone, and glass sand are primarily used domestically.

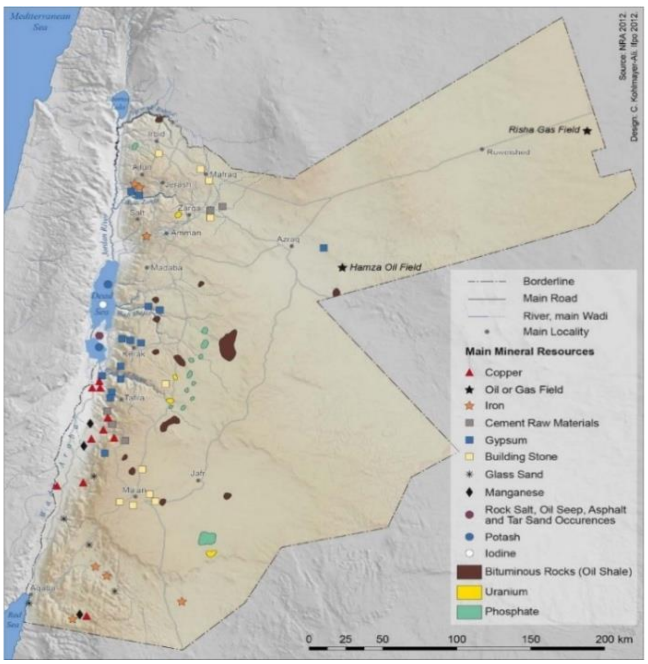

Figure 6. Jordan’s mineral resources and mining sites.[15]

Efforts to develop a large-scale uranium mining industry in Jordan, leveraging domestic uranium reserves to support a nuclear energy fleet, have been hampered by financial limitations and the high costs associated with water desalination. However, with the prospect of lower costs from a domestic Small Modular Reactor fleet, Jordan is reconsidering the economic viability of utilizing its uranium reserves. At the same time, recent initiatives are driving forward plans for large-scale copper mining.[24,25]

[24] The Jordan Times (2024), *Central region holds estimated 41,000 tonnes of yellowcake-JAEC*

[25] The Jordan Times (2025), *Energy Ministry signs MoU for copper ore exploration in Ghor Fifa*

Jordan possesses the eighth-largest oil shale reserves; however, they remain largely untapped due to economic and technological challenges.[26,27] High processing costs and fluctuating global energy prices hinder large-scale commercial extraction. Nevertheless, in 2024, the country opened the world's first oil shale power plant, which is capable of supplying approximately 15% of Jordan's annual electricity demand.[26] Built to address Jordan's energy security concerns, large-scale oil shale extraction remains unlikely in the near future, compounded by the global trend toward decarbonization.

Key takeaways for SAF potential in Jordan

Jordan's potash and phosphate industry is a major carbon emitter, but carbon capture and utilization (CCU) may provide an opportunity to mitigate this effect.[28] Captured CO_2 from phosphate processing can be combined with green hydrogen in PtL technology to produce SAF.

1.2 TRADE AND GOVERNANCE

Jordan's political geography, cultural landscape, climate, and mineral resources are the key determinants shaping the composition and development of its economy, and overview of which is provided in the following figure.

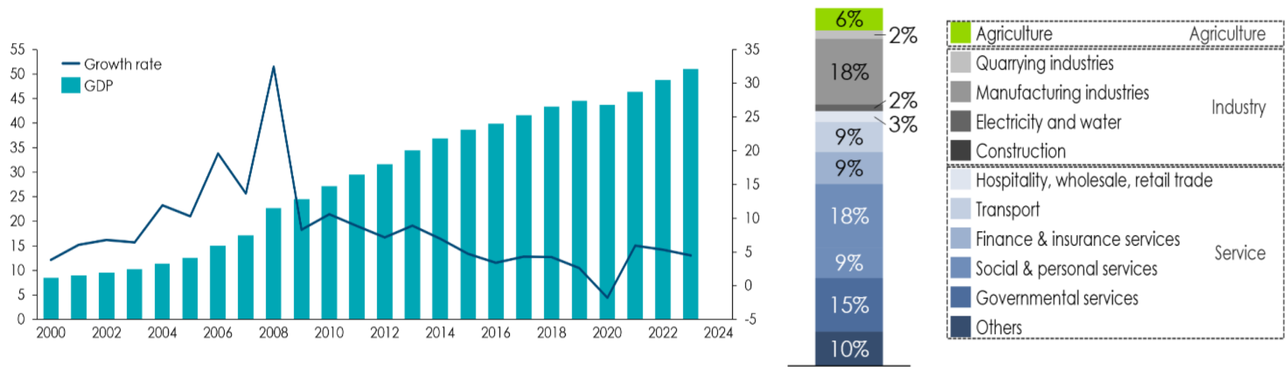

Figure 7. Jordan's GDP development in billion USD (left axis) & annual GDP growth (right axis) in %[29] and 2023 GDP breakdown on the right-hand side.[30]

Since 2000, Jordan's economy has grown nearly sixfold, despite facing significant challenges. The 2008 global financial crisis hurt remittances and foreign aid inflows, while past and ongoing regional conflicts, including the Syrian civil war and the Israel-Gaza and Lebanon conflicts, have severely affected important sectors like tourism, hospitality, and transportation.[31]

Key takeaways for SAF potential in Jordan

Jordan has historically demonstrated its ability to provide stable economic conditions. A robust economic environment plays a key role in attracting stakeholders for large industry projects and scaling disruptive technologies like SAF. Looking ahead, the country's economic stability will rely on its ability to navigate

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[26] Power MAG (2024*), Attarat Power Plant Unlocks Domestic Energy Source for Jordan*

[27] Oil is extracted by heating the fossil material trapped inside the shale, but this process is energy intensive, expensive, and harms the environment.

[28] Carbon Capture and Utilization (CCU) captures CO_2 from industries, converting it into fuels and materials, but remains in early commercial stages, limited by high costs and energy demand.

[29] Own chart, raw data from World Bank (2024), *GDP (current US$) - Jordan*

[30] Own chart, raw data from Department of Statistics (2024), *GDP growth of 2.3% in the fourth quarter of 2023*

[31] Reuters (2024), *Jordan's tourism industry struggling as Gaza war deters visitors*

regional geopolitical challenges, openness for innovation-driven industries, and managing its integration into global trade and financial flows.

1.2.1 Trade

Jordan's economy is highly dependent on its trade relationships with other countries, both in terms of exports, primarily driven by its limited yet valuable natural resources, and imports, which are primarily driven by its relatively small domestic market and lack of key resources.

Imports

In terms of imports, Jordan's heavy reliance on mineral resources and agricultural products is noteworthy. In 2023, Jordan imported agricultural products valued at USD 5.1 billion, accounting for about 10% of its GDP. The country is a net food importer, driven by a growing market that has nearly doubled in size over the past decade, now reaching approximately 11 million people. Most agricultural imports originate from Saudi Arabia, the United Arab Emirates, and Egypt, including vegetables, processed foods, and animal products.[32]
In the same year, Jordan's mineral resource imports totalled USD 4.38 billion. About two-thirds of these imports were fossil fuels, highlighting Jordan's significant dependency on external energy sources. Following disruptions to natural gas supplies from Egypt in the early 2010s, Jordan diversified its fossil fuel sources. Nowadays, it mainly imports fossil energy from Israel, Saudi Arabia, India, the United Arab Emirates, and the United States through the Port of Aqaba and pipelines. Figure 8 provides an overview of all imports.

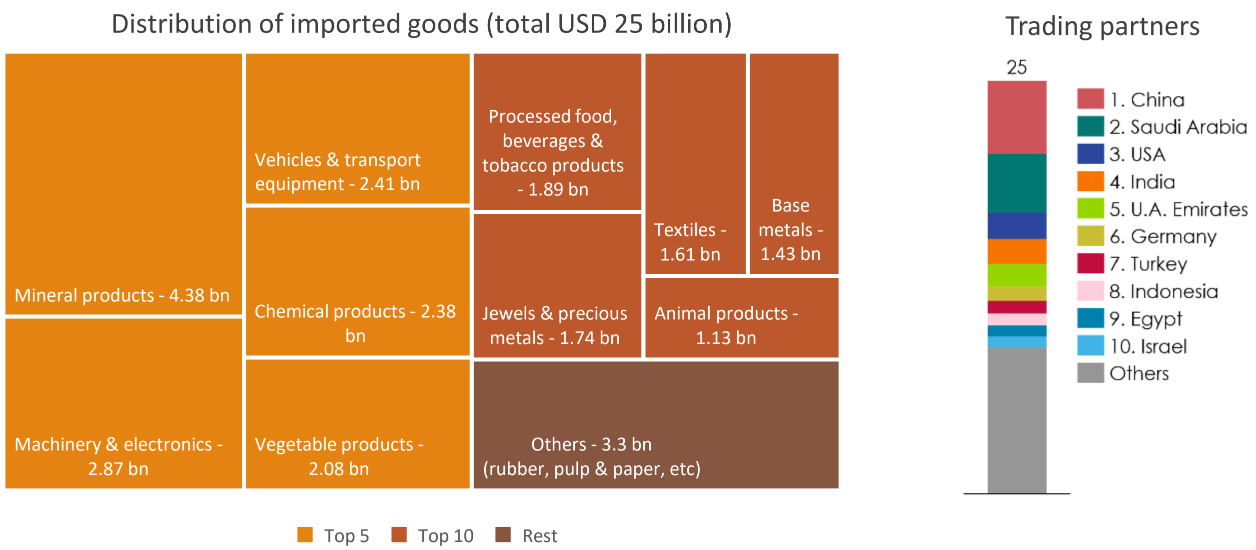

Figure 8. Distribution of imported goods and import partners in 2023.[32]

Exports

Important lessons for SAF production capabilities can be drawn from Jordan's current export landscape. The country accumulated a trade deficit of USD 13.7 billion in 2023.[32] This income shortfall places a high-cost burden on Jordan's economy – driving public debt and the risk of higher inflation. However, Jordan is partially offsetting the imbalance through remittances from expatriate Jordanians, as well as by leveraging its political influence in the Middle East and maintaining strong diplomatic ties, which help to secure substantial foreign aid from major partner countries. Figure 9 shows an overview of all exports.

[32] Own chart, raw data from Department of Statistics (2025), *External trade*

Internally, Jordan’s government strategically targets increasing domestic production by investing in key industries, creating economic zones with regulatory benefits for businesses, establishing free trade agreements with its major trading partners, and fostering ties with international financial institutions and development banks to attract foreign direct investment (FDI) and mobilize capital for local projects.

<u>Key takeaways for SAF potential in Jordan</u>

Jordan's high import dependency on essential goods, particularly agricultural products and fossil energy, has direct consequences for its SAF potential. Scaling up domestic SAF production has the potential to reduce Jordan's reliance on fossil fuel imports, strategically strengthening its energy security. However, this theoretical potential depends on the country’s ability to produce SAF through sufficient quantities of biofuel and PtL feedstocks. This potential will be analysed in detail in SECTION 2.

Producing SAF for domestic use and potential export could help reduce Jordan’s trade deficit by lowering its reliance on energy imports, supporting local industries, and diversifying the economy. The current trade deficit increases Jordan’s reliance on external financial support to kickstart funding large-scale industrial projects.

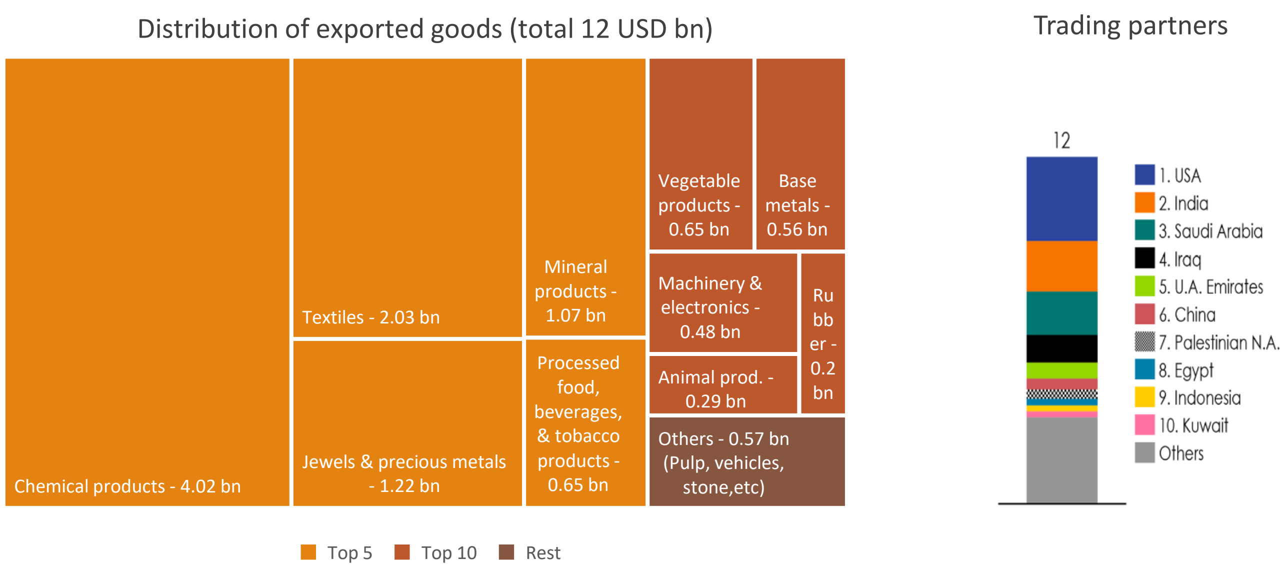

Figure 9. Distribution of exported goods and export partners in 2023.[32]

1.2.2 Governance

Jordan ratified the Paris Agreement and submitted its initial Nationally Determined Contribution (NDC) in 2016, followed by its updated NDC 2.0 in 2021. In NDC 2.0, Jordan has increased its greenhouse gas emission reduction target from 14% to 30% by 2030, compared to business-as-usual.[33] Of this target, 26% is conditional and subject to the availability of international funding support, while the remaining 5% is unconditional.[34] At the time of this report’s publication, the Jordanian government is working on its NDC 3.0.

[33] Compared to 2012 greenhouse gas emission baseline.

[34] Ministry of Environment (2021), *Updated submission of Jordan’s 1st Nationally Determined Contribution (NDC)*

Jordan's NDC is underpinned by its National Climate Change Policy (2022-2050), which aims to set out a strategic framework for industrial development, with the aim to guide the country's transition towards a low-carbon and climate-resilient economy. The policy aims to achieve net-zero carbon emissions by 2050 through a set of initiatives. It comprises:

1. **Increasing renewable energy's share to 31% of electricity generation by 2030**, reducing reliance on imported fuels and supporting grid modernization.
2. **Improve energy efficiency by 9% across all sectors by 2030**, with targeted measures in residential, industrial, and public infrastructure to optimize energy consumption.
3. **Developing a hydrogen economy** by integrating hydrogen into domestic energy systems and positioning Jordan as a key exporter of green hydrogen, leveraging its renewable energy potential.
4. **Advancing sustainable waste management, circular economy solutions, and urban greening**, including biogas recovery from landfills and wastewater, large-scale composting, and nature-based solutions to enhance urban greening and resilience.
5. **Enhancing water efficiency in agriculture and promoting climate-smart practices**, such as precision irrigation, rangeland restoration, and afforestation, and supporting innovative smart agriculture practices like hydroponics[35], to address water scarcity and improve food security. Other potential lies in AgriSolar (farming under the shade of solar panels, for efficient land use and soil dehydration protection).
6. **Introducing and promoting the use of bioenergy and alternative renewable fuels**, integrating biogas from wastewater sludge, agricultural residues, and municipal solid waste as alternative fuels in industry, while exploring future opportunities in biofuels.
7. **Transforming the transportation sector** by scaling intelligent transport systems, including a Bus Rapid Transit system (BRT) between urban centres, while promoting the adoption of electric and hybrid vehicles through policy incentives and infrastructure expansion.

The target of promoting alternative fuels is directly relevant to the aviation sector and SAF. The policy also highlights Jordan's commitment to align its ongoing and future aviation decarbonization policies with recommendations from ICAO to ensure a coordinated and effective approach to reducing the industry's environmental footprint. Participating in CORSIA will be mandatory in its third phase from 2027 onwards, while Jordan has not yet joined the scheme during its voluntary phase.[36] Its last State Action Plan for Aviation Emissions Reduction was submitted in 2013 and is currently under revision. In summary, while Jordan aspires to decarbonize its aviation system through technology adoption and global collaboration, a clear strategy to achieve these ambitions has yet to be established.

However, major building blocks for aviation decarbonization can be derived from the targets set in the National Climate Change Policy and national development strategies shown in Table 1, which offer a holistic roadmap to achieving these targets across key sectors.

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[35] Hydroponics is a water-efficient, soil-free farming method ideal for arid countries like Jordan, enabling year-round crop production with minimal water use

[36] ICAO (2025*), CORSIA States for Chapter 3 State Pairs*

Table 1. Key industry development strategies pursued by Jordan and their relation to SAF inputs.

Initiative	Aim[37]	SAF inputs
National Solid Waste Management Strategy (currently under revision)	Aims to modernize Jordan's municipal solid waste management, focusing on waste reduction, as well as increasing the currently low 7% waste recycling rate[38] and waste reuse.	Municipal Solid Waste (MSW)
National Agricultural Development Strategy (currently under revision)	Aims to develop Jordan's agricultural sector through digitalization, restructuring and increasing sustainable agriculture practices to boost productivity and food security.	Biomass
Jordan Energy Strategy[39] (currently under revision)	Aims to achieve a 31% share of renewables in total electricity generation and 14% of the total energy mix by 2030.	Renewable Energy
Green Hydrogen Strategy[40] (draft)	Aims to establish a sustainable and competitive green hydrogen economy that supports both domestic energy needs and export opportunities.	Hydrogen

Table 2 outlines the main Jordanian government entities responsible for implementing the National Climate Change Policy (2022-2050), detailing their potential roles and levels of potential involvement in scaling SAF in Jordan.

Table 2. Key public governance stakeholders and their potential role for SAF in Jordan.[41]

	Ministry of Local Administration (MOLA)	Oversees municipal governance and implements the National Solid Waste Management Strategy, a key to potential feedstock availability. It supports sustainable infrastructure at the local level. It could help identify local SAF feedstock sources from waste and coordinate local permitting and siting of SAF projects.
Ministry of Transport The Hashemite Kingdom of Jordan	Ministry of Transport (MOT)	Oversees national transport policy and coordinates with MEMR and others for fuel strategy. It supports clean mobility projects. It could incorporate SAF into aviation strategy and coordinate cross-ministerial infrastructure planning for SAF distribution.
CARC	Jordanian Civil Aviation Regulatory Commission (CARC)	Regulates Jordan's aviation sector and is responsible for air safety and environmental standards. It engages with decarbonization in aviation. It might establish SAF blending targets and streamline SAF certification and airport distribution compliance.

[37] Latest available targets, considering that some strategies are currently revised.
[38] Data from exchange with GIZ (2025), which works on Jordan's updated National Solid Waste Management Strategy.
[39] Summary of old version: https://www.memr.gov.jo/EBV4.0/Root_Storage/EN/EB_Info_Page/Summery_of_the_Comprehensive_Strategy_of_the_Energy_Sector_2020_2030.pdf
[40] Draft: https://www.memr.gov.jo/EBV4.0/Root_Storage/AR/EB_Info_Page/GH2_Strategy.pdf
[41] Logos from respective websites (2025).

Ministry of Environment	Ministry of Environment (MOENV)	Responsible for Jordan's carbon emission tracking. Could play a central role in launching market-based instruments such as carbon pricing that can support the scale-up of a SAF industry.
	Ministry of Agriculture (MOA)	Manages agricultural policy, land use, and crop/livestock development. Supports sustainable farming and promotes rural renewable energy use. Could enable SAF scale-up by facilitating access to agricultural residues, promoting energy crops, and integrating farmers into SAF supply chains.
Ministry of Energy and Mineral Resources The Hashemite Kingdom Of Jordan	Ministry of Energy and Mineral Resources (MEMR)	Oversees renewable energy expansion and initiatives like Jordan's Green Hydrogen Strategy. It could embed SAF within national energy and hydrogen strategies and support infrastructure development.
	Energy and Minerals Regulatory Commission (EMRC)	Licenses energy/fuel projects and regulates tariffs, compliance, and market rules. It ensures legal conditions for renewable fuel deployment. It could create SAF-specific licensing frameworks and integrate SAF into fuel market regulation.
MINISTRY OF FINANCE	Ministry of Finance (MOF)	Manages national budgeting, taxation, and incentives. Can provide fiscal tools for green investments. It could introduce tax incentives, subsidies, or grants to de-risk SAF investment and stimulate market demand.
وزارة الاستثمار MINISTRY OF INVESTMENT	Ministry of Investment (MOIN)	Oversees investment attraction and PPP facilitation; engages private sector and donor coordination. It promotes green investment projects. It could drive SAF market entry by facilitating FDI, PPPs, and targeted investment promotion for SAF plants.

<u>Investment landscape for realizing Jordan's strategic industrial policies and climate action</u>

The initiatives shown in Table 1 are underpinned by Jordan's Economic Modernization Vision 10-year roadmap. Launched in 2022, it is designed to attract USD 60 billion in investments, to drive economic growth, and to enhance living standards through sustainable and green development by 2033.[42] As Jordan's central investment roadmap, the vision outlines strategic priorities to expand the country's vast renewable energy potential, address water and food security by advancing agriculture, and tackle waste challenges.

At least 72% of the USD 60 billion required to turn those targets into reality is expected to come from private investments, both domestic and foreign. To facilitate this, Jordan enacted its Investment Environment Law No. 21 of 2022, empowering the Ministry of Investment to serve as the central hub for investors, streamline government services, offer investment incentives, and maintain a competitive and sustainable investment climate.[43] Article 7(B)(2) of the law states that projects are put on an investment map that gives investors a clear view of available opportunities across sectors and governorates, including private sector partnership projects, and is updated regularly to reflect new investment prospects.[44] The preparation of the investment map must comply with the Kingdom's general policy, economic vision, and development plans. The following table provides an overview of the Economic Modernization Visions planned USD 60 billion spending, their sources and planned spending areas.

[42] Raw data from Ministry of Planning and International Cooperation (2022), *Jordan Economic Modernization Vision.*
[43] Jordan Ministry of Investment (2022), *Invest in Jordan*
[44] Jordan Ministry of Investment (2022), *Environment Law No. 21 of 2022*

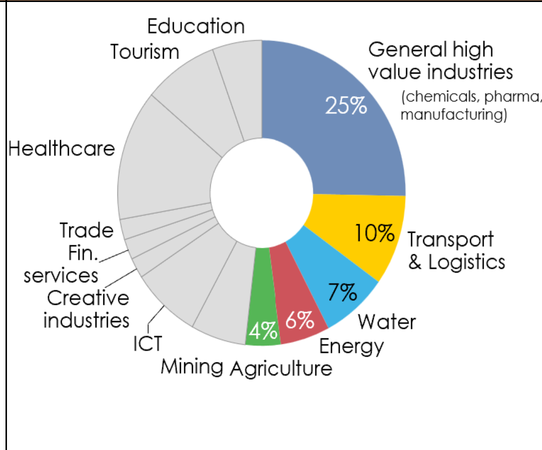
From Jordan government (USD 12.8 billion)	From private investors (USD 47.2 billion)
General high-value industries: stimulating chemicals, pharma, manufacturing expansion **Transport & logistics:** investments into infrastructure public transit, logistics network **Water:** launch national desalination projects, establishing food security governing body and research centre, investments into water distribution **Energy:** expanding renewables, stimulating renewable fuels & hydrogen, upgrading transit pipelines, building out smart grid & reforming energy tariff structure **Agriculture:** modernizing and supporting innovative and sustainable agriculture (AgTech) **Others:** national mining strategy, digitalization, tourism, ... *Note: exact share per sector not outlined.*	 *Note: the shares consider targeted investment volumes per sector.*

Figure 10. Planned spendings of Jordan's Economic Modernization Vision and their sources.[45]

<u>Past major transport and energy investment projects</u>

Jordan is a key market for significant industry investment projects. From nearly no investments in solar and wind energy a decade ago, the country successfully attracted over USD 4 billion by 2023, with the majority coming from international sources.[46] Table 3 provides an overview of major transport and energy investment projects.

Table 3. Major energy and transport projects in recent years and their investment backgrounds.

Sector	Project		Form of Funding & Key Investors	Description
Aviation		[47] **Queen Alia Intl. Airport expansion**	**FDI/PPP/development bank** AIG (Aéroports de Paris, Paris), EDGO Group (Jordan) With Jordan government With World Bank IFC, providing USD 68 million in loans for private capital mobilization[48]	**USD 750 million invested** Expanded capacity from 3.5 to 12M passengers/year[49]
Railway		[50] **Jordan-UAE Railway Network**	**FDI** Etihad Rail (UAE) With Jordan Phosphate Mines Company (Jordan) and Arab Potash Company (Jordan)	**USD 2.3 billion invested** To link phosphate & potash mines to Aqaba Port, transporting 16 Mt/year[51]
Shipping		[52] **Aqaba Container Terminal Expansion**	**FDI/PPP** APMT (Netherlands) With Aqaba Development Corporation (Jordan state-owned)	**USD 242 million invested**

[45] Own chart, raw data from Ministry of Planning and International Cooperation (2022), *Jordan Economic Modernization Vision*
[46] World Bank IFC (2024), *Powering up Jordan's Renewable Energy Market*
[47] Foster and Partner (n.a.), *Queen Alia International Airport*
[48] World Bank (2016), *Multilateral Development Banks' Collaboration: Infrastructure Investment Briefs - Jordan: Queen Alia Airport*
[49] Ministry of Transport (2021), *Public Private Partnership in Jordan*
[50] Railway Technology (2024), *Etihad Rail to oversee $2.3bn rail project in Jordan*
[51] The Jordan Times (2024), *UAE sign agreements for $2.3b railway project connecting Aqaba to mining sites*
[52] APM Terminals (2024), *APM Terminals extends concession for ACT in Jordan*

			To expand capacity from 1.3 to 1.7 TEUs[53], by 2031[54]
Energy	 [55] **Attarat Power Plant**	**FDI** YTL Power International (Malaysia), Guangdong Energy Group Co. (China), Eesti Energia (Estonia)	**USD 2.1 billion invested** 470 MW, 1st oil shale power plant in Jordan, ~15% of Jordan's electricity, commissioned in 2023[55]
	 [56] **Baynouna Solar Power Plant**	**FDI/development bank** Masdar (UAE), Taaleri Energia (Finland) With World Bank IFC financing, providing USD 54 million, and USD 134 million as loan from the Japan International Cooperation Agency[57]	**USD 260 million invested** 200 MW near Amman, powers ~4% of Jordan's electricity, operational since 2020[57]
	 [58] **Tafila Wind Farm**	**FDI/development bank** InfraMed Infrastructure (France), Masdar (UAE), EP Global Energy (Cyprus) With World Bank IFC and EIB, providing roughly 50% each of total project investment through loans[59]	**USD 287 million invested** 117 MW, powers ~2% of Jordan's electricity, operational since 2015[59]

Key takeaways for SAF potential in Jordan

SAF could become a significant building block, both to serve the country's industrial development and decarbonization targets. Jordan's Economic Modernization Vision provides a principal framework from which scaling a SAF industry could benefit. In addition, Jordan's national strategies on agriculture, waste management, renewable energy, and hydrogen can provide a solid foundation for developing a SAF industry, which could both benefit from and contribute to these strategies. Adding SAF value chain projects to the investment map would expand the range of strategic, sustainable investment opportunities available to both domestic and foreign investors, help attract initial investment into supporting the development of SAF in Jordan and draw greater attention to SAF within Jordan's central investment planning.

Jordan has extensive experience in securing funding for major industry projects through various public and private, as well as domestic and international, financing channels. Building up a potential SAF industry can benefit from the experiences made in those projects and from the reputation that Jordan gained as a safe harbour for successful large industry projects.

1.2.3 Investment climate

Table 4 provides key statements on the investment climate in Jordan in 2024, according to the US Department of State.

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[53] Twenty-foot Equivalent Units (TEU), standard shipping container
[54] The Jordan Times (2024), *ADC, APM Terminals sign $242m agreement to develop, manage Aqaba Container Terminal*
[55] Photo from Attarat Power (2025), *Company profile*
[56] Photo from Arabian Construction Co (2025), *Baynouna Solar Energy Project, Jordan*
[57] NS Energy (2018), *IFC arranges $188m financing for 248MW Baynouna solar project in Jordan*
[58] Photo and data from European Investment Bank (2017), *EIB Investments in Renewable Energy outside the EU*
[59] European Investment Bank (2016), *Multilateral Development Banks' Collaboration: Infrastruture Investment Project Briefs - Jordan: Tafila Wind Farm*

Table 4. Investment climate in Jordan.[60]

Investment climate in Jordan in 2024 – strengths (left) and challenges (right) **According to the US Department of State 2024 Investment Climate Statements (quotes)**	
Vast renewable energy investment potential "Jordan's vast solar resources provide opportunities for cutting-edge energy technologies such as green hydrogen."	**High energy costs & water scarcity** "Businesses cite the high cost of electricity and water scarcity as significant challenges..."
Economic growth plan & investment incentives "The Economic Modernization Vision aims to attract $60 billion in investments in the next 10 years", "Aqaba Special Economic Zone offers a flat 5% income tax…"	**Regulatory & bureaucratic inconsistencies** "Implementation of government policies sometimes frustrates foreign investors."
Skilled workforce & high-growth sectors "Many in Jordan's underutilized workforce are college-educated… making Jordan an attractive destination for investment in technology subfields."	**Investment restrictions & legal uncertainty** "Foreigners are prohibited from wholly or partially owning certain sectors… and businesses sometimes complain about judicial decisions being technically incorrect."
Strategic location & trade agreements "Jordan's numerous free trade agreements make it an attractive environment to manufacture products that would otherwise be subject to high tariffs."	**A stable country in a volatile region of conflicts** "Jordan is politically stable. While the region faces ongoing conflicts [there have been more demonstrations] in response to the Gaza conflict."

Key takeaways for SAF potential in Jordan

Jordan offers a favourable investment climate for investors; however, previous experiences of foreign investors have highlighted certain challenges that may pose obstacles to investment. These challenges are expected to be mitigated through targeted measures outlined in Jordan's Economic Modernization Vision.

1.3 DEMOGRAPHICS

1.3.1 Population

Jordan, with 11.7 million inhabitants in 2024, has the second-largest population in the Eastern Mediterranean after Syria.[61] About 70% of its population are Jordanian citizens, split between native Jordanians and Jordanians of Palestinian origin, the latter stemming from the world's largest Palestinian refugee population. Most of these refugees arrived after the 1948 and 1967 Arab-Israeli conflicts and have since then gained Jordanian citizenship. The remaining 30% of Jordan's population includes 1.5 million migrant workers, mainly from Egypt and Southeast Asia, and up to 1.5 million refugees from more recent regional conflicts.[62] While UNHCR registers 660,000 refugees, many more remain unregistered, mostly stateless Palestinians and Syrians.[63]

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[60] US Department of State (2025), *2024 Investment Climate Statements: Jordan*

[61] World Bank (2023), *Population, total - Jordan*

[62] International Organization for Migration (2021), *Jordan Country Trends Report*

[63] UNHCR (2025), *Jordan Operational Data Portal*

Figure 11. Jordan's 2024 population pyramid, showing age distribution and share relative to total.[64]

In total, Jordan has 691,000 more men than women, a 12.5% surplus. This imbalance can be attributed to the large number of male migrant workers and refugees, many of whom arrive alone in search of work before their families join them. Across genders, 70% of Jordan's population is under 34, making it a young country, offering a demographic edge for growth and innovation.

The more people live in one area, the more waste they produce. The following close-up provides a focused assessment of municipal solid waste (MSW) development in Jordan. SAF can be produced from it through the process of gasification-Fischer-Tropsch, as detailed later in 2.1.1.

Close-up: municipal solid waste (MSW)

In the last quarter century, Jordan's population has doubled, with direct consequences for annual generation volumes of MSW.

Key driver of MSW generation: population

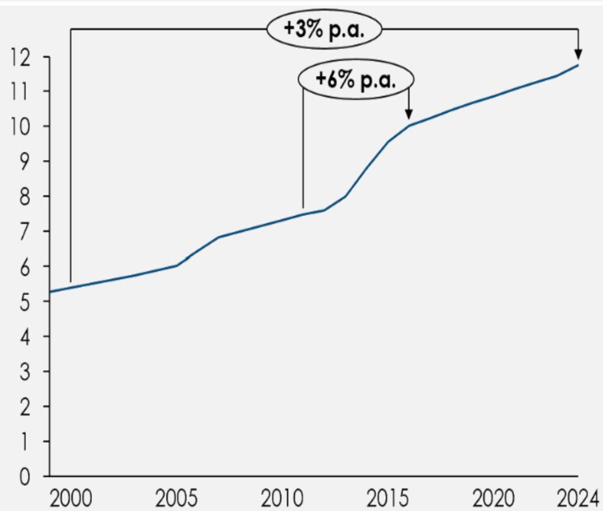

Figure 12. Jordan population development, in million.[61]

MSW development

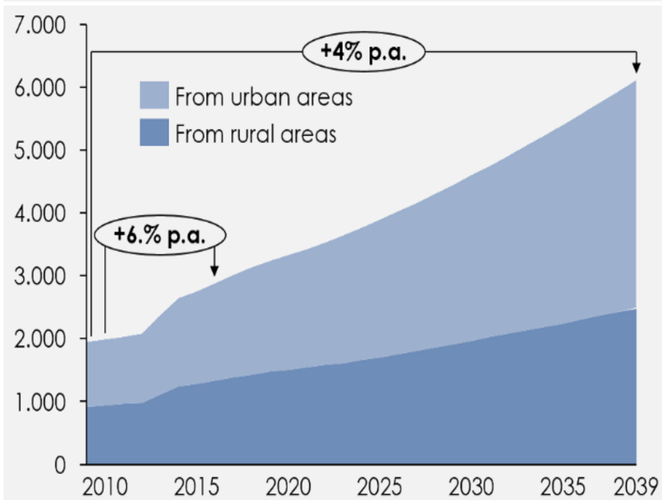

Figure 13. Jordan's past and expected future MSW generation, in kilotons (kt).[65]

MSW growth can be directly linked to Jordan's population growth development. More people generate more waste, especially illustrated in the disproportionately high spike for both population and MSW

[64] Own chart, raw data from Department of Statistics (2025), *Population*

generation between 2011 and 2016, when Jordan welcomed 1.3 million refugees that fled the war in Syria. MSW generation is higher in urban areas, characterized by a higher per capita waste generation of 1.21 kg per day compared to 0.96 kg per day in rural areas.[65]

Jordan's future development should be seen as a dynamic process, which was shaped historically by fluctuating migration patterns driven by regional conflicts, such as the Syrian civil war and the Israel-Gaza conflict. Ceasefires and the resolution of wars have played a significant role in influencing demographic trends. Despite these fluctuations, the country anticipates overall population growth.

Overall, MSW management already today presents a significant environmental and organizational challenge for Jordan. Rapidly growing cities, like Irbid, encounter major challenges in efficiently collecting and managing MSW. There is only limited landfill capacity, financial constraints, and a lack of alternative waste disposal methods (such as waste-to-energy facilities). As a result, only 7% of waste is currently recycled, while the rest is disposed of in landfills.[65] To address this issue, the National Solid Waste Management Strategy (NSWMS) aims to enhance MSW management, increase recycling rates, and promote greater reuse. In this regard, MSW reuse as feedstock for SAF production presents a significant opportunity.

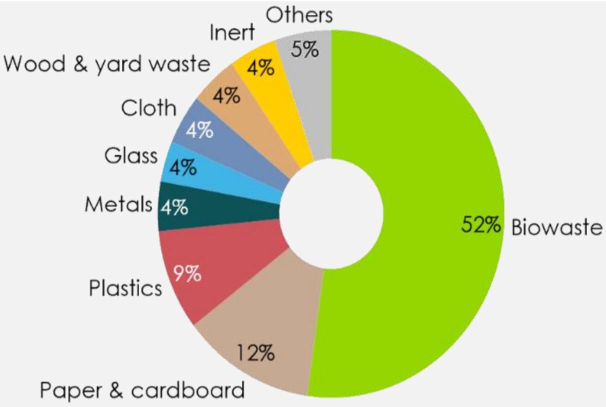

Figure 14. Jordan's rough MSW composition.[65]

Figure 15. Jordan's largest landfill Al-Ghabawa, near Amman, receiving about 40% of Jordan's MSW.[66]

It is crucial to note that, currently, only MSW of organic content is eligible as feedstock for SAF production in CORSIA. This excludes plastic, metals, glass, cloths made of synthetic materials, and inert waste – thereby reducing MSW CORSIA eligible feedstock to biowaste, paper & cardboard, and wood & yard waste, representing 68% of total MSW. Additionally, regarding the following parts of this feasibility study, it is equally important to differentiate biowaste in MSW from waste and residues derived from the agriculture and forestry industries. These will be examined separately in SECTION 2.

Key takeaways for SAF potential in Jordan

Jordan's population growth may lead to a high availability of MSW, which can be used as a SAF feedstock. Waste reuse could be a strategic solution to mitigate the country's pressing waste challenge while serving SAF raw material supply.

[65] Own charts, raw data from Jordan National Solid Waste Management Strategy (2025)
[66] European Bank for Reconstruction and Development (2018), *Al-Ghabawi Landfill, Amman, Jordan Photostream*

1.3.2 Human capital

Jordan ranks 99th globally in the Human Development Index (HDI) and has a highly educated population, with nearly half of young adults pursuing tertiary education.[67] The country has a strong academic foundation, with universities offering programmes in chemical engineering, environmental science, and biotechnology, producing graduates equipped with high levels of technical expertise – crucial for scaling renewable energy projects. There are international universities like the German Jordanian University and the American University of Madaba, and Jordan's academic system has partnerships and research collaborations with European and international organizations through programmes like Erasmus+ and DAAD. Research collaborations with foreign organizations, play a crucial role in supporting innovation in renewable fuels through funding and sharing technical expertise. For example, GIZ has contributed to Jordan's National Solid Waste Management Strategy, the Netherlands supports Jordanian agricultural entrepreneurs in making their businesses water- and climate-smart, and the UAE promotes high education in the country. Jordan is also a valuable EU partner in science initiatives such as the Partnership for Research and Innovation in the Mediterranean Area (PRIMA).[68]

Jordan's labour force is divided into a professional segment (academics, engineers, and business professionals), a significant blue-collar workforce (construction, manufacturing, and energy), and a declining agricultural sector. Unemployment remains high at around 22%, particularly among youth and women.[69] Gender disparities in the labour market are significant, with female participation among the lowest globally (14–15%), hindered by wage gaps, social norms, and childcare shortages, despite Jordan's ongoing efforts to improve inclusion.[70]

Key takeaways for SAF potential in Jordan

While the country's skilled workforce presents an opportunity to integrate workers into the SAF value chain in research, refining, logistics, and plant operations, limited disposable income and high living costs constrain consumer purchasing power. This may present challenges regarding increasing future airfares from SAF use.

1.4 VULNERABILITY TO CLIMATE CHANGE

Jordan emitted 34.54 million tonnes (Mt) of CO_2eq greenhouse gas emissions in 2022. This positions Jordan as the 102nd largest emitter globally.[71] Concerns about the effects of climate change are growing as the country faces severe water shortages and land degradation but also more frequently recurring droughts, flash floods, and landslides. Rising temperatures, declining precipitation, and increased evapotranspiration due to climate change will further deplete water resources. These developments threaten the well-being of Jordan's population, its natural ecosystems, and the overall stability of its economy.

The United Nations Development Programme (UNDP) refers to the ND-GAIN Country Index to evaluate a nation's vulnerability to climate change and other global challenges, along with its readiness to strengthen resilience. In this ranking, Jordan comes in at place 72 for the 2022 ranking, indicating the significant climate risks that Jordan is facing, alongside the decisive actions the country is taking to bolster its resilience.[72] These

[67] UNDP (2024), *Countries and Territories – Human Development Index*

[68] The Jordan Times (2025), *Jordanian Delegation explored forward looking solutions for climate resilient, urban water management in Netherlands.*

[69] World Bank (2024), *The World Bank in Jordan*

[70] World Bank (2023), *Increasing Women's Economic Participation is Key to Jordan's Long-Term Growth and Development*

[71] EDGAR (2023), *Emissions Database for Global Atmospheric Research*

[72] University of Notre Dame (2025), *ND-Gain Country Index*

steps include the targets of Jordan's National Climate Change Policy (2022-2050), described under 1.2. The initiatives aim to strengthen climate resilience, protect natural resources, and safeguard communities from extreme weather events.[34] Without effective intervention, these pressures could lead to projected GDP losses of approximately 2% annually by 2050, highlighting the urgent need for sustained adaptation efforts that Jordan pursues.[172]

Key takeaways for SAF potential in Jordan

Jordan's severe water shortages, declining precipitation, and rising temperatures present significant challenges for biofuel SAF production. With arable land shrinking and water resources under strain, expanding biofuel production could intensify competition for essential resources. However, these risks must be considered alongside Jordan's proactive efforts to mitigate climate impacts and enhance resilience.

1.5 AGRICULTURE

Agriculture is a strategic sector for the Jordanian government, contributing to food security for its growing population against the country's arid climate and severe water scarcity. These conditions define Jordan's low 5.4% share of arable land. Jordan's soil is characterized by reduced soil moisture, increased salinity, and lower nutrient levels.[73] As a result, Jordan relies heavily on external food supply, importing 70% of its staple food needs from global markets. This makes Jordan vulnerable to fluctuations in global food supply and prices, incentivizing the country to maximize domestic food production through strategic agricultural practices and irrigation.[74]

As shown in the rainfall map in Figure 4 approximately 90% of Jordan receives less than 200 mm of rainfall per year, making rainfed agriculture extremely challenging. The UN Food and Agriculture Organization (FAO) states that crop cultivation is not viable in areas receiving less than 450 mm of annual rainfall without irrigation. Staple food crops like wheat, barley or rice require 450 mm of rainfall per year, vegetables like tomatoes 400 mm, and fruit trees like olives roughly 500 mm for fruit production.[75]

The northwestern region of Jordan, particularly around Ajloun, receives rainfall within these ranges, but its mountainous terrain limits large-scale agriculture. Consequently, agricultural activities are primarily concentrated in the next most suitable location, the Jordan Valley along the River Jordan, where annual rainfall reaches around 250 mm, making irrigation essential for sustaining crop production. This underscores the critical role of strategic water management in irrigation and strategic crop selection to optimize agricultural sustainability in Jordan's arid climate.[76] The following close-up provides an overview of biomass availability in Jordan.

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[73] Approximately 25% of Jordan's cultivated land lies fallow, allowing it to recover soil fertility, conserve moisture, and restore productivity after depletion from water scarcity, low soil fertility, or land degradation. (data from 2023, from Jordan Department of Statistics)

[74] Foresight4Food (2023), *An overview of the Jordanian food system: outcomes, drivers & activities*

[75] UN FAO (n.a.), *Management of dryland*

[76] UN FAO (n.a.), *Chapter 2: Crop Water Needs*

Close-up: biomass

Biomass availability in Jordan is closely linked to the irrigation need and economic value of crops, which determines crop selection. Both crop-derived biomass and livestock manure can be utilized in various biofuel production pathways.

Key driver for crop production: water

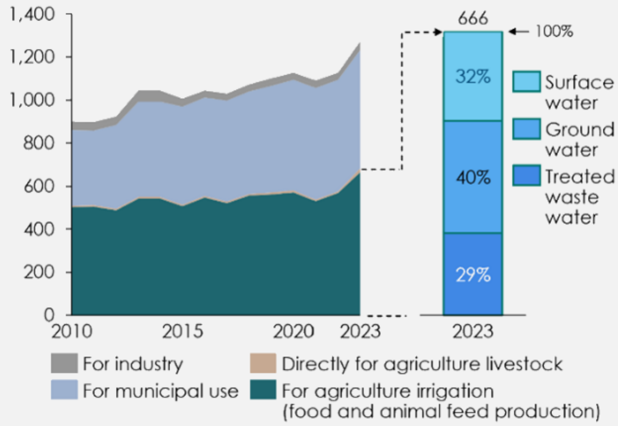

Figure 16. Jordan's water use per sector, in m³.[78]

Biomass development

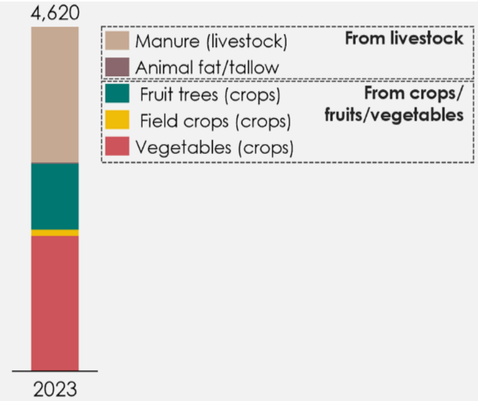

Figure 17. Jordan's biomass availability development from different sources, in kt.[77]

Around 50% of Jordan's water is used for agriculture, primarily for irrigation to produce food and animal feed. Roughly one-third of this water is surface water, 40% groundwater, and 29% treated wastewater. Almost 100% of the treated wastewater is dedicated to agricultural use. This high prioritization of water for agriculture underscores Jordan's significant efforts to extract every drop of water possible to support food security through local production. However, this effort increases production costs, prompting Jordan to prioritize growing strategic crops that can either adapt well to its arid climate and/or offer high economic value to justify their irrigation needs.[78] For example, tomatoes are Jordan's most widely produced food crop and are exported on a large scale, constituting around 65% of Jordan's total exported agricultural produce, making it one of the top ten tomato exporters in the world. While they require more water for cultivation than fruit trees or field crops, their high economic value justifies the investment in irrigation.[79] According to the UN FAO and Jordan's Department of Statistics, the country produces approximately 4.6 Mt of agricultural biomass annually (livestock farming, fruits, field crops, and vegetables).

Figure 18. Irrigation system in the Jordan Valley.[80]

[77] Own analysis and chart, raw data from Department of Statistics (2025), *Production of fruit trees, field crops, vegetables*, data is aligned with UN FAO's 2022 agricultural production list in Figure 19 data. Conversion factor to dry biomass residues and energy content from Al-Bawwat et. al. (2023), *Biomass Resources in Jordan*

[78] Jordan Department of Statistics (2025), *Environment statistics – Resources and their use: Water Resources*

[79] The Jordan Times (2015), *Jordan among top 10 countries in tomato exports*

[80] Photo from The Arab Weekly (2021), *Environmental diplomacy helps match Jordan-Israel interests*

1.5.1 Overview of current agricultural market

A stock take of Jordan's agricultural production and food products is required to identify possible feedstocks for biofuel SAF production. This forms the basis for the evaluation of each feedstock in SECTION 2. Figure 19 lists the full inventory of agricultural products that were produced in Jordan in 2022. Its raw data is from the UN FAO. The list also shows the amount of food products that were imported for consumption in Jordan and food exports.

Thereby, the list highlights Jordan's significant reliance on imports for certain staple foods and the contribution of local production to mitigate this dependency. For example, barley is the most used food product in Jordan, however, it is largely imported (red bar in Figure 19), compared to the smaller share of domestically produced barley (green bar).

This food import dependency is expressed in the Self-Sufficiency Rate (SSR), which highlights the proportion of domestic production in meeting total consumption needs per food item. A lower SSR indicates a higher reliance on imports to serve domestic food needs, while a higher SSR suggests a greater degree of food security through local production. In the case of barley, the SSR remains low. It is important to note that the SSR not just depends on domestic agriculture production output but also on the level of domestic consumption. This becomes important for evaluating the vulnerability of Jordan's agricultural sector to climate change further down in this chapter. The list[81] is sorted by the highest consumed goods in Jordan, in kt (production – domestically used + import).

[81] Own list, raw data from UN FAO (2025), *FAO STAT – Food Balances Database*

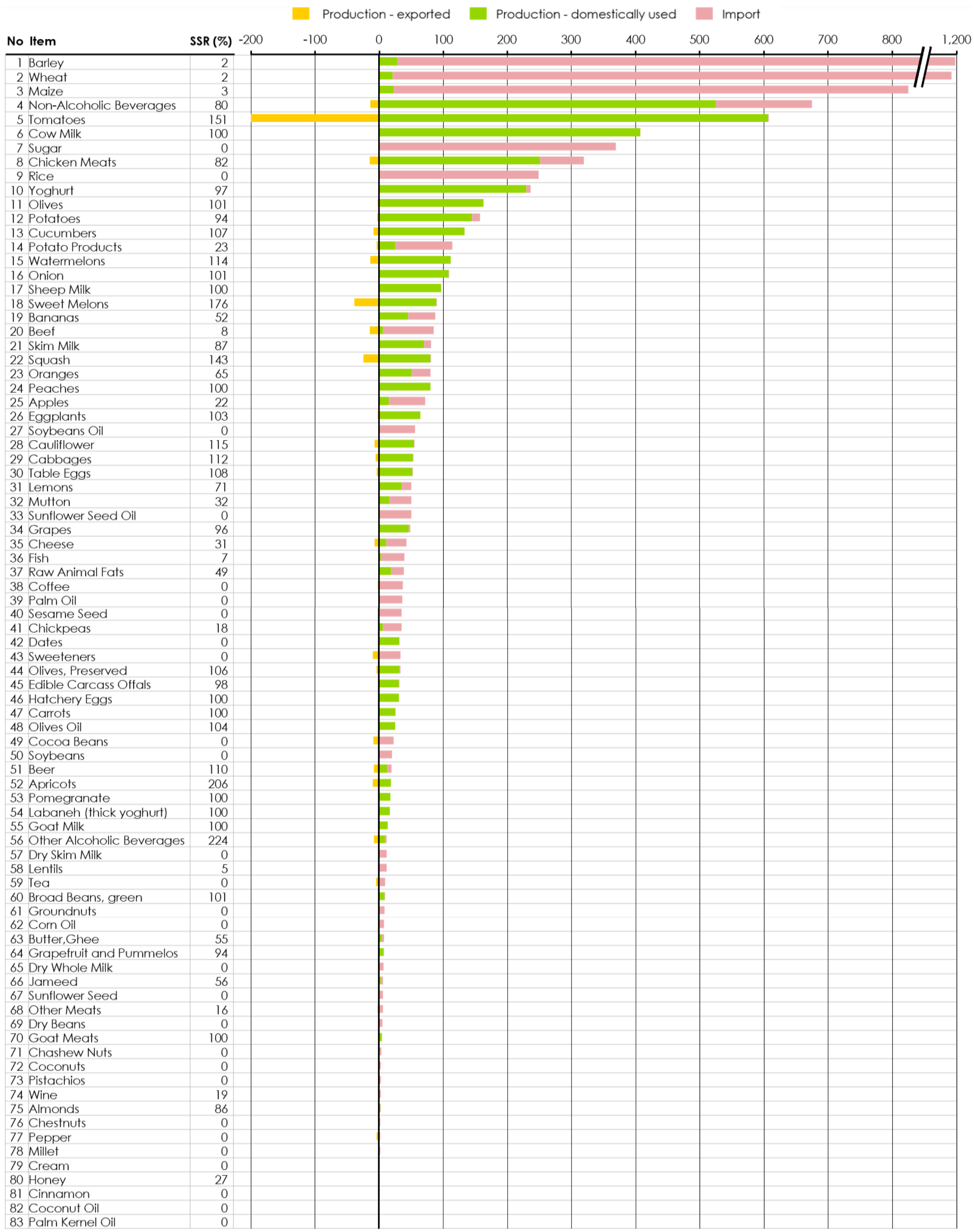

Figure 19. Jordan's 2022 crop and livestock production, import, and export volumes of food products in kt, and their Self-Sufficiency Rates (SSR). Note the logarithmic scale given the high import volumes of barley and wheat.[81]

Jordan's agriculture and food products can be classified into the following groups:

- Processed food products (such as yoghurt, butter, skim milk)
- Fruit tree products (such as olives, citrus fruits, apples, etc.)
- Field crop products (such as wheat, barley, lentils, etc.)
- Vegetable products (such as tomatoes, watermelon, etc.)
- Livestock products (such as beef, eggs, goat milk)

Only biomass that does not compete with food needs can be used as SAF feedstock. This excludes processed food products and limits the use of fruit tree products, field crops, vegetable products, and livestock products to their residues – such as olive pits, wheat straw, husks, stalks, pulp, and pomace for biofuel production.

<u>Key takeaways for SAF potential in Jordan</u>

Jordan relies heavily on imported agricultural goods and prioritizes the cultivation of strategic crops to enhance food security. As a result, SAF feedstock must come from agricultural and livestock residues rather than diverting resources from food supply.

1.5.2 Biomass availability from farming

The following figure breaks down and describes how many kilotons of different fruits, field crops, and vegetables have been produced over the course of one decade in Jordan. In a second step, it highlights how many kilotons of dry residues can be obtained from this total production volume. The raw data comes from Jordan's annual agricultural inventory by the national Department of Statistics.

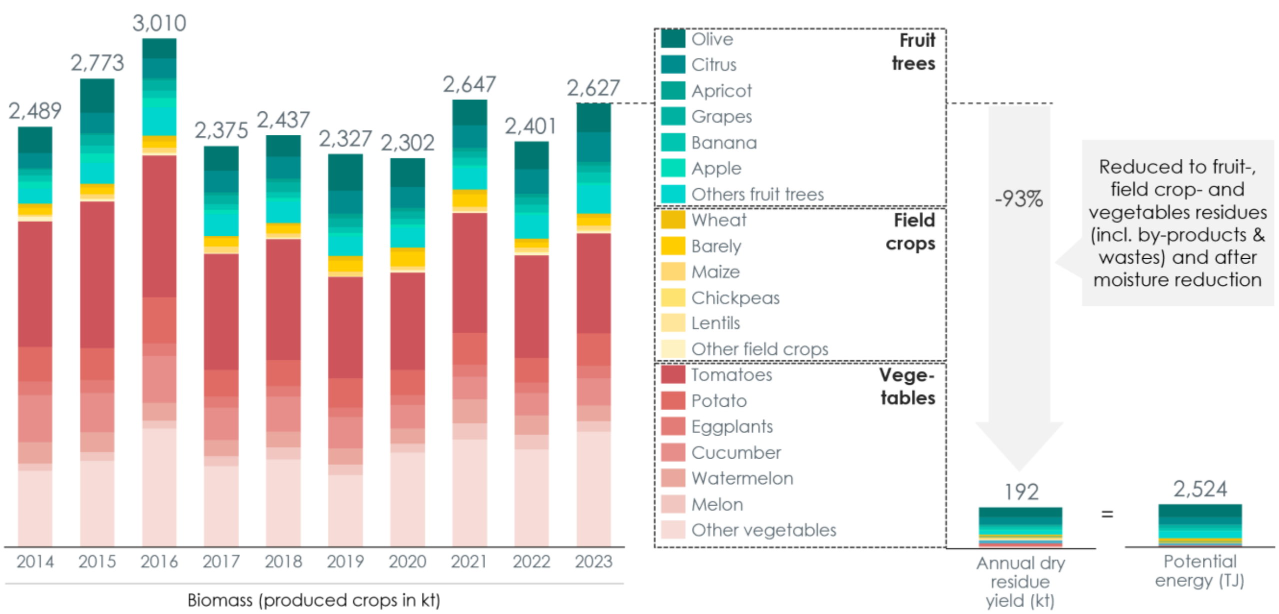

Figure 20. Jordan's fruit, field crop, and vegetable production and its dry residue yield in kt, and resulting annually available energy content in TJ.[82] Annual dry residue yield refers to 2023.[83]

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[82] Own analysis and chart, raw data from Department of Statistics (2025), *Production of fruit trees, field crops, vegetables*, data is aligned with UN FAO's 2022 agricultural production list in Figure 19 data. Conversion factor to dry biomass residues and energy content from Al-Bawwat et. al. (2023), *Biomass Resources in Jordan*

[83] Biomass to dry biomass residue conversion reduction factor – in % - depending on the crop, can range from 68% to 98%, notably higher for vegetables. Factors from Al-Bawwat et. al. (2023), *Biomass Resources in Jordan*

Dry biomass forms the basis for biomass-to-biofuel processing, and Jordan's fruit, field crop, and vegetable production could yield roughly 192 kt of dry biomass residue raw material annually (2023 as reference) that can be potentially used for biofuel production, equivalent to 2,524 TJ of energy content. Of this, 80% comes from fruit tree crops, 12% from field crops, and 8% from vegetables. The following figure shows the availability of manure biomass from livestock farming in Jordan.

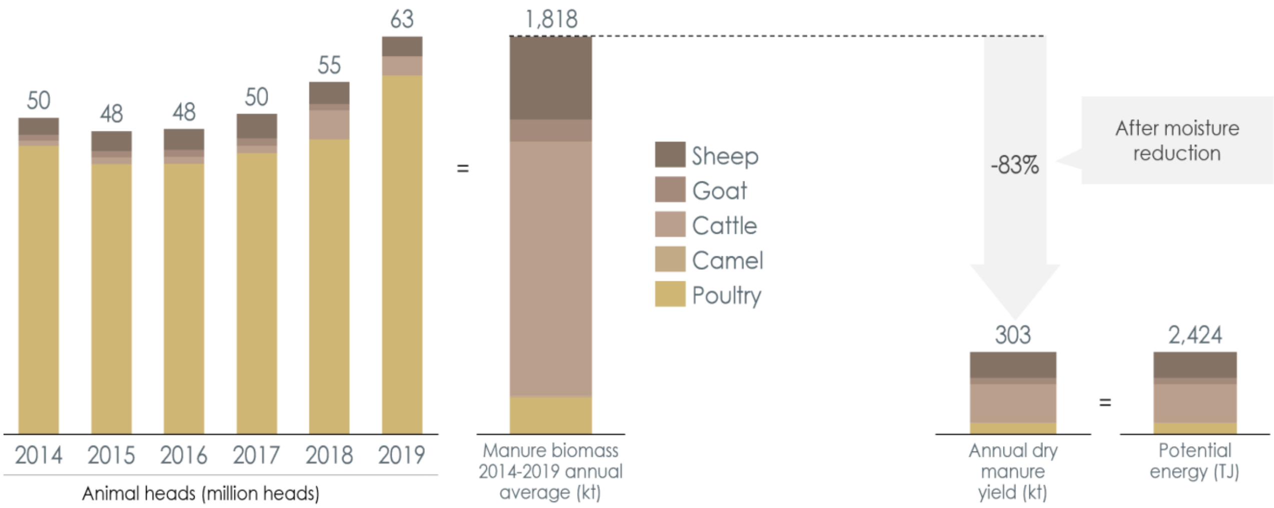

Figure 21. Jordan manure biomass (in kt), its dry biomass content (in kt), and resulting annually available energy content, in TJ.[84] Annual dry manure yield refers to 2014-2019 annual average.

Dry manure, after significant moisture reduction, can yield 303 kt of dry biomass annually (2023 as reference), equivalent to 2,424 TJ of energy content.[85] Geographically, manure availability in Jordan is relatively equally distributed, with 37% coming from animal farms in northern governorates, 34% from the central region, and 29.4% from the south. The Ministry of Agriculture expects that manure generation will increase due to rising food demand and government initiatives to expand Jordan's livestock.[86]

Key takeaways for SAF potential in Jordan

It can be concluded that dry biomass from manure represents the largest potential biofuel feedstock group from agriculture. Below this, the combined dry biomass from crops – primarily fruit tree residues, with olive residues being the most dominant – also holds potential. However, this statement offers only a preliminary understanding and identification of feedstocks from Jordan's domestic livestock farming and crop production. SECTION 2 will build on this foundation, providing a more detailed analysis of biomass feedstocks and exploring additional feedstocks that could be sourced outside agriculture.

1.5.3 Vulnerability of agricultural sector to climate change

The future availability of biomass from Jordanian livestock and crop production must be critically assessed in light of climate change. The Jordanian government expects agricultural production to face significant challenges, with rising temperatures and decreasing rainfall posing major threats. The following table provides an overview of how key crops are expected to be affected, according to the Jordanian government:

[84] Own chart, raw data and conversion factor to dry biomass and energy content from from Al-Bawatt (2023), *Biomass Resources in Jordan*

[85]Manure to dry manure conversion reduction factors – in %: 88% for cattle manure, 75% for sheep, goat, and poultry. Factors from MWPS (2012), *Manure Characteristics*

[86] The Jordan Times (2023), *Agriculture Ministry meeting discusses Jordan's livestock exports to Saudi Arabia*

Table 5. Impact of climate change and increasing food demand on cultivation of key crops in Jordan.[87]

Crop type	Impact of climate change by 2100
Olives	Yield reductions of up to 50-60% possible; self-sufficiency rate could decrease from 101% to 15%.
Fruit trees (other than olives) & citrus fruits	Self-sufficiency drops expected: from 97% to 20% (for fruit trees) and from 67% to 12% (for citrus fruits) possible.
Field crops	Self-sufficiency could fall from 4% to below 1%
Rangelands & animal feed resources	Self-sufficiency in livestock could decline from 31% (in 2017) to 15% (in 2050).
Vegetables	Irrigation expansion may sustain production until 2050; self-sufficiency could decline from 144% to 39%
Irrigated crops (tomatoes, grapes, peaches, apricots, …)	Potential yield increase from carbon fertilization, however, only if irrigation can keep pace with increasing water needs.

The government anticipates a decline in self-sufficiency for key crops. A similar trend is expected in rangeland productivity, which is essential for meeting the country's growing demand for meat and dairy. Consequently, Jordan will likely become more reliant on food imports, placing additional pressure on the economy and exacerbating food security challenges. It is important to note that total production volume development is not easy to predict, as a decreasing self-sufficiency can be driven by growing demand for an increasing population, a decreasing domestic production, or both occurring at the same time.

The government acknowledges that climate change adaptation efforts are essential but faces challenges in implementing them effectively. Vulnerable agricultural regions, particularly those with already overexploited water resources, require urgent interventions. Proposed measures include shifting to more water-efficient, yet less economically valuable crops, enhancing irrigation systems, and increasing the use of treated wastewater face economic and institutional barriers. Without substantial policy support and investment in climate-resilient agriculture, sustaining productivity is expected to be increasingly difficult. The following chapter Cultivation of energy crops will dive deeper into this. In addition, SECTION 3 will revisit these points, exploring the mutual benefits of agricultural production and renewable energy initiatives. It will highlight how innovative agricultural practices, such as integration of photovoltaic solar projects within an agricultural activity, could enhance and create synergies between food production and renewable energy expansion.

Key takeaways for SAF potential in Jordan

As climate change and population growth put increasing strain on Jordan's agricultural sector, the country may become more reliant on food imports, which could limit the availability of agricultural biomass if domestic production levels cannot be maintained. While there is no resilient data on the availability of biomass from agriculture, its development should be viewed with caution.

[87] Own chart, raw data from Government of Jordan (2022), *Jordan's 4th National Communication on Climate Change – Submitted to the UNFCCC*

1.5.4 Cultivation of energy crops in Jordan

A 2013 study estimated that allocating 10% of Jordan's arable land to energy crops[88] could generate significant bioenergy, potentially reducing natural gas imports by about 5%.[89] However, since this would come at the expense of food production, it is not a viable option unless arable land could be significantly expanded to decrease the food security pressure or energy crops are grown on marginal land.

Since the 1980s, the Jordanian Ministry of Agriculture has explored the potential of cultivating oil-producing crops that can thrive in Jordan's arid climate and grow on marginal lands.[90] Jojoba emerged as a promising candidate due to its resilience in harsh desert conditions, tolerance to extreme temperatures, high oil content (up to 50% of seed dry weight) and the ability to grow this non-edible crop on marginal lands.[168] Marginal lands are areas with poor soil quality that make crop cultivation economically unfeasible. In Jordan, this refers to the vast Badia regions, which are used as rangeland but are unsuitable for crop cultivation.

A pilot project launched in 2019 in the eastern Badia region, spanning 1,000 hectares with 1,666 trees per hectare, demonstrated its feasibility with an annual jojoba oil yield of 1,812 tonnes. While this highlights the potential for expanding jojoba cultivation across Jordan's Badia regions, the study also underscores the high investment costs required, particularly for irrigation. Despite its low water needs, large-scale jojoba farming in the Badia still requires a drip irrigation system. This limits jojoba's scalability potential, making their cultivation on marginal land dependent on addressing water resource challenges.[91] SECTION 2 will further analyze jojoba, given that it bears feedstock potential.

Recent efforts to approach the systemic issue of increasing water availability in Jordan include the Sahara Forest Project. It aims to generate freshwater and restore vegetation in arid desert regions – including Jordan. As a public-private partnership (PPP) it brings together NGOs, private sector contributions, governments, including backing from the Jordanian Government, and funding support by the EU. The project launched pilot projects in Qatar and Aqaba to demonstrate its potential.[92]

Both pilots have shown the viability of sustainable desert agriculture, showcasing successful crop cultivation, freshwater production through desalination, and carbon sequestration, while also highlighting challenges such as high operational costs, energy-intensive desalination, and scalability constraints. This highlights the need for continued innovation, policy support, and significant investment in renewable technologies to ease food security pressures for unlocking the potential for cultivating energy crops.[93] It is still important to note that even with increased water availability, energy crop cultivation may not necessarily benefit from it, as the additional water could be more efficiently allocated to grow edible crops for food production unless a sufficient and sustainable water supply is ensured.

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[88] Energy crops fall into the category of "Main Products" in the CORSIA framework of eligible feedstock: purposefully grown crops for targeted biofuel production.

[89] Momani and Shawaqfah (2013), *Agriculture Solide Waste in South of Jordan: Facts and Figures*

[90] Marginal land is low-quality land with limited agricultural or economic use for crop cultivation.

[91] Al-Hamamre and Sandouqa (2021), *Economical evaluation of jojoba cultivation for biodiesel production in Jordan*

[92] EEAS – Diplomatic Service of the European Union (2017), *EU-funded Sahara Forest Project provides Jordan with solar energy, water & food security*

[93] Nordic Energy Research (2020), *Sahara Forest Project*

Key takeaways for SAF potential in Jordan

Jordan's potential for biofuel production from energy crops is significantly limited by scarce arable land, high water demands, and substantial investment costs, making large-scale expansion dependent on future advancements in water delivery technologies. However, cultivating jojoba in Jordan's vast rangelands could become a viable option if these challenges are effectively addressed.

1.6 ENERGY

1.6.1 Energy supply

In 2022, Jordan imported 91% of its energy supply, primarily in the form of fossil fuels. As a result, oil and natural gas dominate the country's energy mix.

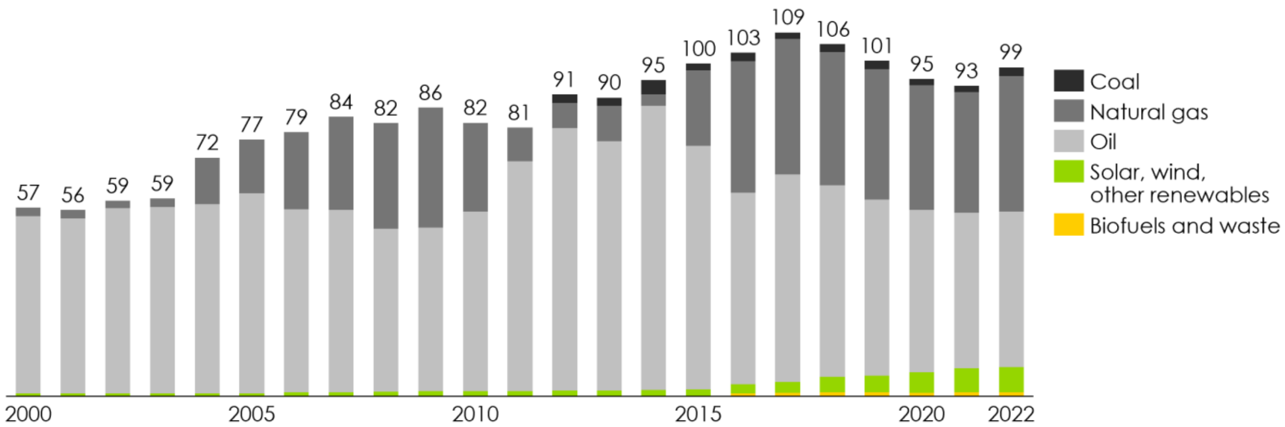


Figure 22. Jordan's energy mix since 2000, in TWh.[94]

The kingdom has consistently maintained this high level of energy dependency over the past decades, making it one of the most energy import-dependent countries in the world. This dependency has two major consequences: economically, Jordan faces higher energy costs than many of its neighbouring Arab nations due to longer supply chains. Strategically, its energy dependency makes it vulnerable to geopolitical instability and foreign market price fluctuations.

1.6.2 Fossil energy

The shifting role of natural gas illustrates this challenge. When the Arab Gas Pipeline was built in the early 2000s, its purpose was to bolster Jordan's energy security through an efficient natural gas supply from Egypt. This hope diminished when the pipeline became the target of strategic attacks in 2011, which ever since have disrupted the supply through this infrastructure. Today, the Aqaba LNG terminal and Israeli gas imports have become more significant in meeting Jordan's gas demands.

These challenges highlight Jordan's strategic efforts to reduce energy dependency. Such efforts date back to the 1950s when the Jordan Petroleum Refinery Company (JPRC) was founded to enhance national revenues by retaining value-added refinery processes. The following overview shows JPRC's position and other key stakeholders in running Jordan's fossil energy system[95], followed by a map of the energy infrastructure.

[94] Own chart, raw data from IEA (2023), *Countries & Regions - Jordan*

[95] Logos from respective company websites (2025)

A. Upstream - Extraction and initial production of energy resources (oil, gas, shale, wind, solar)

Abroad	**Foreign companies**		Extract and export natural gas to Jordan, mostly from Israel and Egypt.
In Jordan	APCO	Attarat Power Company	Oil shale extraction and power generation. (see its limited role as described under 1.2.)
	MANASEER GROUP	Manaseer Group	Concerned with fossil fuel import management from abroad.

B. Midstream - Transport, storage, and distribution infrastructure (pipelines, transmission lines)

In Jordan	JOTC JORDAN OIL TERMINALS COMPANY	Jordan Oil Terminals Company (JOTC)	Provides storage and handling services for petroleum imports. The company operates several terminals, including facilities in Aqaba.

C. Downstream- Final processing, power generation, and delivery of energy to consumers.

In Jordan		Jordan Petroleum Refinery Company (JPRC)	Supplies the local market with various petroleum products. Operates Jordan's sole refinery.
	JO Petrol	JoPetrol	A subsidiary of JPRC. Engages in the oil marketing and distribution of petroleum products across the country. It operates a chain of fuel stations.
	MANASEER GROUP	Manaseer Group	Engages in oil marketing and distribution through imports. It operates a chain of fuel stations.
	TotalEnergies	Total Jordan	Engages in oil marketing and distribution. It operates a chain of fuel stations.

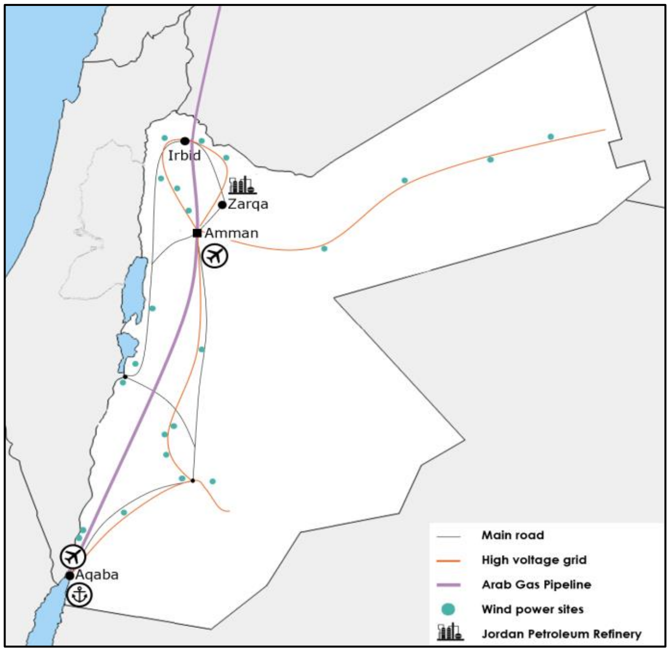


Figure 23. Key energy and transport infrastructure in Jordan.[96]

Fossil fuels reach Jordan either through its pipeline system or via the Port of Aqaba. A significant share, roughly 42%, is imported crude oil, which is transported to the Jordan Petroleum Company refinery in Zarqa

[96] Own map design, based on Jordan blank map from D-Maps.com (n.a.)

for processing before being distributed to end users. The other 58% are imports of already refined oil products (1% kerosene, 1% jet fuel, 21% gasoline, 24% diesel, 11% LPG) that are directly distributed to end users.[111]

In addition to the processing of fossil fuels from abroad, the map illustrates Jordan's wind power plants, which, alongside solar energy, showcase the country's commitment to leveraging its advantageous location for cost-effective renewable energy generation. This commitment has driven a substantial expansion of solar and wind capacity, now contributing to roughly 10% of Jordan's energy mix – or 26% of its electricity generated in 2024.[97] The kingdom undertakes efforts to update its grid to support the further expansion of wind and solar power capacity.

Key takeaways for SAF potential in Jordan

While Jordan is currently heavily dependent on fossil fuel imports, its advantageous location with low renewable energy costs presents an opportunity to enhance energy security via expanding renewable energy capacity and clean energy projects. SAF production can play a key role in this and may benefit from the country's well-built-out energy infrastructure.

1.6.3 Renewable energy expansion through solar and wind power expansion

The following close-up examines renewable energy as a key input for SAF feasibility.

Close-up: renewable electricity

Jordan's heavy reliance on fossil fuel imports can be reduced by leveraging its renewable energy potential.

Key driver: high energy dependency

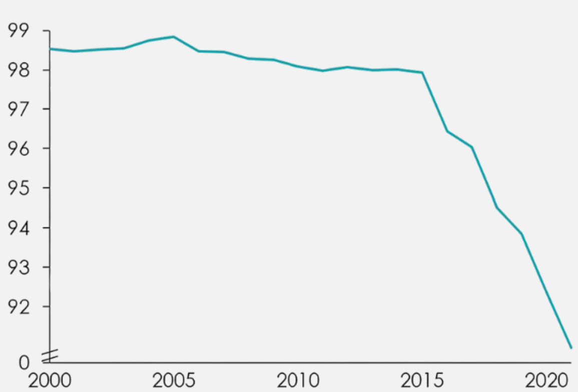


Figure 24. Jordan's energy import dependency in %.[97]

Renewables expansion

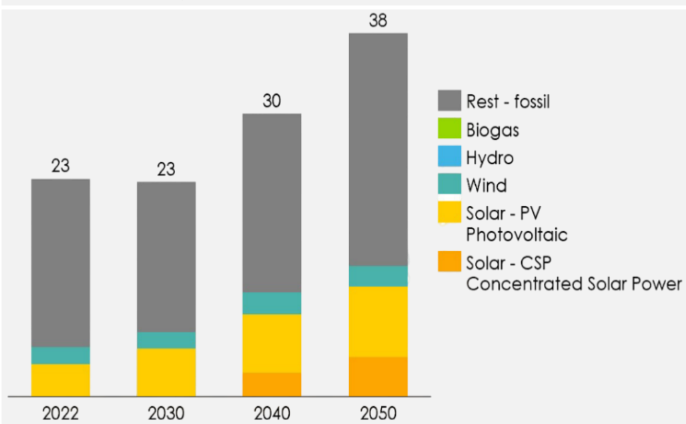


Figure 25. Projected share of currently planned renewable electricity generation expansion relative to total electricity demand by 2050 in TWh.[97]

Expanding renewable electricity is a strategic goal of the Jordanian government, which aims to increase its share to 31% by 2030, up from the current 26% in 2024.[98] The 31% is enshrined in the National Energy Strategy. To reach this target, the country particularly focuses on the expansion of solar capacity, both

[97] Data request, data from Jordan Ministry of Energy and Mineral Resources (2024)
[98] Own chart, data from Jordan Ministry of Energy and Mineral Resources (2025)

through photovoltaic panels and in the form of Concentrated Solar Power[99] projects. The National Energy Strategy is currently being revised. While not an official target, Jordan formulated a 50% renewable electricity penetration aim by 2030.[100] This highlights that the country's renewable expansion may happen quicker and on a more ambitious basis than anticipated.

Figure 26. South Amman Solar Power Plant, a 46 MW facility, began operations in 2019.[101]

Figure 27. Tafila Wind Farm, Jordan's largest wind farm with a capacity of 117 MW, currently covers roughly 2% of Jordan's electricity demand. Operational since 2015.[102]

<u>Jordan Hydrogen Strategy</u>

As part of the nation's efforts to build out renewable energy, the Jordanian government aims to position the kingdom as a global hub for hydrogen production and export. For this, Jordan is working on a Green Hydrogen Strategy. The following close-up provides insights on green hydrogen production in Jordan.

To realize the Green Hydrogen Strategy, Jordan plans to invest USD 28.5 billion by 2030, USD 78.7 billion by 2040, and USD 175 billion by 2050. Major investments in this project come from abroad, for instance from the European Bank for Reconstruction and Development, the World Bank, but also private sectors investments like from China Three Gorges International.[99]

The strategy acknowledges the potential "to produce SAF at a hydrogen hub at or near the Port of Aqaba and distribute it to domestic airports or export it to markets, for example, Europe." It highlights the need of green hydrogen for SAF conversion processes like HEFA, and at an even larger scale, for Power-to-Liquid SAF. Against this, the strategy indicates that domestic green hydrogen use for aviation in Jordan is not expected to become economically viable before 2035.

<u>Close-up: green hydrogen</u>

Jordan's favourable geography provides abundant, low-cost solar and wind energy, enabling competitive green hydrogen production at a low cost. A Green Hydrogen Strategy has been formulated. It envisions domestic production of hydrogen derivatives like ammonia and SAF.

Key driver for green hydrogen potential: low green hydrogen production cost (LCOH[103])	*Jordan's green hydrogen production potential*

[99] Concentrated Solar Power (CSP) uses mirrors or lenses to focus sunlight to generate heat for electricity generation, while PV directly converts sunlight into electricity using semiconductor materials.
[100] The Jordan Times (2024), *Jordan aims for 50% electricity from renewables by 2030 — EMRC chairman*
[101] PV Europe (2020), *Utility-scale PV plant on mountainous site in Jordan*
[102] Photo from Egypt Oil & Gas Group (2015), *Jordan Launched First Utility-Scale Wind Farm*
[103] Levelized Cost of Hydrogen (LCOH) is a metric for comparing hydrogen production costs, reflecting total capital, operational, and energy expenses per kilogram over a project's lifetime.

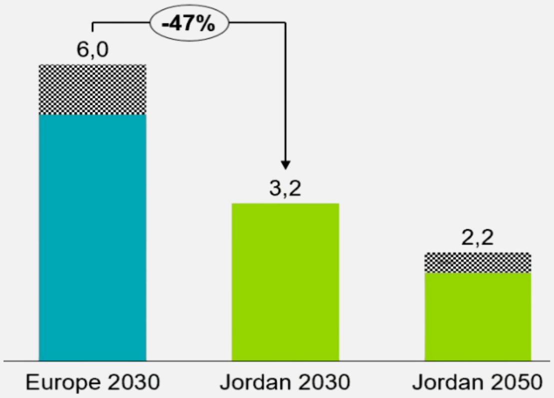


Figure 28. Jordan's projected production cost of green hydrogen, LCOH, in USD/kg. The grey areas represent a range from upper and lower cost estimates.[104]

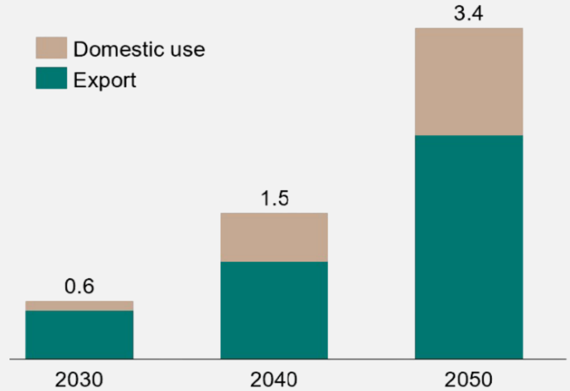


Figure 29. Jordan's envisioned green hydrogen production volumes and their export rate, in million metric tonnes per year (MMTA).[104]

Jordan has a comparative cost advantage for green hydrogen production from its ample and cheap solar and wind power potential, which is expected to result in significant green hydrogen production volumes in the next decades. To realize this potential, the kingdom pays particular attention to water provision amid its increasing water stress. While the country is currently on the way to construct its first desalination plant in Aqaba, a USD 2.9 billion investment – planned to go online and targeted to provide 300 million cubic meters of freshwater annually – this water is earmarked for agricultural, civilian and industrial needs in Amman and Aqaba. To ensure a stable water source for electrolyzers, Jordan's Green Hydrogen Strategy, therefore, prioritizes an independent, renewably powered desalination plant. The strategy lays out the required desalination capacity that this, or additional facilities needed to provide.

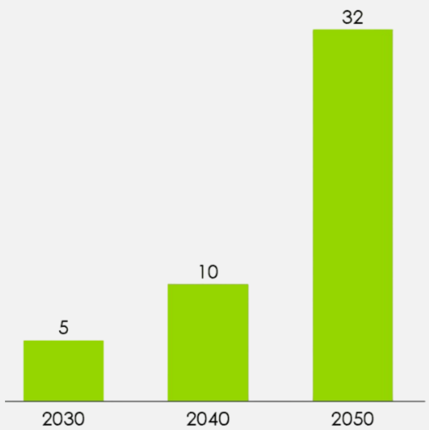


Figure 30. Jordan's Green Hydrogen Strategy: planned desalination capacity in million m^3 per year.

Figure 31. For reference, the world's largest desalination plant, Jebel Ali Power Plant & Desalination Complex in Dubai, UAE, can desalinate 2.2 million m^3 per day.[105]

Beyond this additional national desalination capacity, a dedicated "green grid" is also planned to supply renewable energy, made to ensure truly green hydrogen production.[106]

[104] Jordan Ministry of Energy and Mineral Resources (2023), *Draft National Green Hydrogen Strategy for Jordan*

[105] Middle East Utilities (2015), *Photos: the Jebel Ali Power and Water Complex*

[106] Hydrogen can be produced through different pathways, each giving it a different color label: from renewable electricity (Green, costly, emission free), natural gas (Blue, mid-cost; Grey, cheap, polluting), coal (Brown/Black, dirtiest, low-cost), and nuclear (Purple/Pink, mid-cost, low emissions).

Key takeaways for SAF potential in Jordan
Jordan's renewable energy expansion and green hydrogen strategy create strong potential for SAF production, not just to support bio-based SAF but also to scale domestic SAF production further through Power-to-Liquid. However, water resource challenges, infrastructure timelines, and economic feasibility issues must be overcome to fully unlock this potential.

1.7 AVIATION FUEL SUPPLY CHAIN

Jordan's aviation sector is a crucial component of its economy, connecting the country to major global destinations. The national carrier, Royal Jordanian Airlines, is the national flag carrier airline, operating both domestic and international routes from its hub at Queen Alia International Airport (AMM) in Amman, the country's largest and busiest airport. Other key airports include King Hussein International Airport (AQJ) in Aqaba, which supports tourism along the Red Sea, and Amman Civil Airport (ADJ), mainly serving regional and private flights. Jordan's strategic location in the Middle East makes it an important transit hub.
The following tables provide an overview of Jordan's key airlines and airports.

Table 6. Main airlines and airports in Jordan.

	Major airports	(IATA/ICAO airport code)	Passengers in 2023[107]	Location
1		Queen Alia International Airport (AMM/OJAI)	9,201,269	
2		King Hussein International Airport (AQJ/OJAQ)	309,000	
3		Amman Civil Airport (ADJ/OJAM)	10,435	

	Major airlines	(IATA/ICAO airline code)	Passengers in 2023	Based at
1		Royal Jordanian (RJ/RJA)	3,700,000[108]	AMM
2		Jordan Aviation (R5/JAV)	356,754[109]	AMM

Jordan's aviation system is a central pillar of the country's transportation system that also provides 2,805 km of highways, 2,679 km of rural roads, and 1,999 km of secondary roads, as well as 509 km of railways.[110] Together with its airports, national and international airlines flying to and from Jordan, and Aqaba port, Jordan's transport system provides reliable regional and global connections.

[107] CARC (2024)
[108] The Jordan Times (2025), *RJ holds virtual ordinary, extraordinary annual general meeting, issues 2024 financial results*
[109] Data request, data from Jordan Aviation (2025)
[110] WFP Logistics Cluster (2025), *2.3 Jordan Road Network*

In 2023, Jordan's transport sector accounted for the largest share of the country's total energy consumption (278,129 TJ), making up 42% of Jordan's final energy use. This translates to approximately 115,322 TJ consumed by the transport sector alone, of which 10% is for aviation.[111]

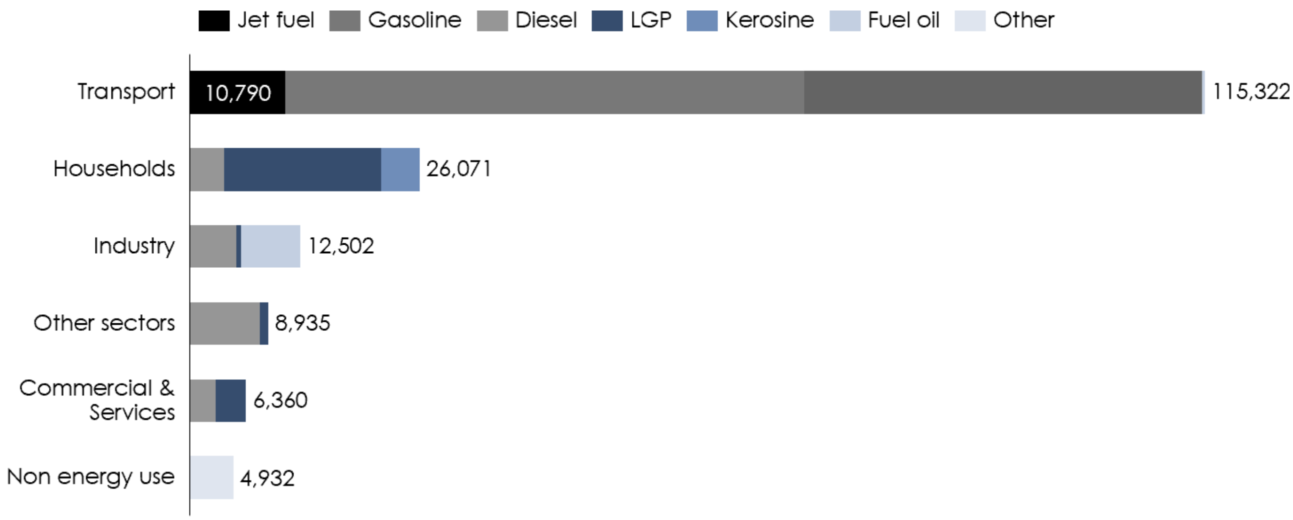


Figure 32. Final fossil energy consumption per sector and fuel type in 2023, in TJ.[112]

Jordan's 2023 aviation energy consumption of 10,790 TJ from conventional fossil-based Jet A1 translates to approximately 260 kt of Jet A1 fuel. This demand is expected to grow at an annual rate of 3.6%, reflecting the increasing role of aviation in Jordan's transportation system.[113]

1.7.1 Fossil jet fuel value chain

In January 2025, airlines paid USD 955.15 per tonne of Jet A1. This price is the result of the following aviation fuel pricing structure, provided by Jordan's Ministry of Energy and Mineral Resources.

Table 7. Aviation fuel in Jordan, Jet A1 pricing breakdown.[114]

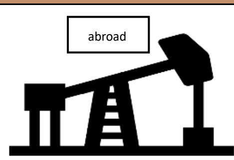
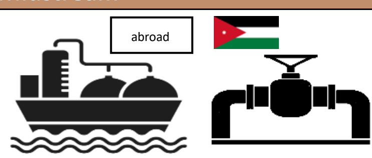
No	Cost item	% share of final price	Cost block in USD/tonne
1	Price CIF[115] Offshore	86.6%	827.40
	a. Aqaba Port Charges	*0.9%*	*+8.60*
	▪ *Custom cost*	*0.06%*	*+0.65*
	▪ *Aqaba Port Transit Charges*	*0.79%*	*+7.64*
	▪ *Vessel Demurrage*	*0.03%*	*+0.31*
2	Price at Aqaba Terminal	87.5%	836.00
	a. Aqaba Terminal Charge	*0.9%*	*+8.77*
	▪ *Aqaba Terminal Transit Charge*	*0.74%*	*+7.08*
	▪ *Aqaba Terminal Losses Charge*	*0.18%*	*+1.70*

[111] Own chart, raw data from Jordan Ministry of Energy and Mineral Resources (2024), *2023 Energy Balance*
[112] Jordan Ministry of Energy and Mineral Resources (2024), *2023 Energy Balance*
[113] IATA (2023), *Global Outlook for Air Transport*
[114] Own chart, raw data (converted from Jordan dinar (JD) to US Dollar (USD) with exchange rate of 1.41 JD/USD from data 17 January 2025) from Jordan Energy and Minerals Regulatory Commission (2025), *IPP Formula For Jordan – Jan 2025*
[115] Cost, Insurance, and Freight (CIF): combines fuel costs, insurance, and freight to the offshore delivery point, where the buyer assumes responsibility.

	b. Transportation charge	*2.9%*	*+27.52*
	▪ *Transportation charge, including insurance*	*2.7%*	*+26.21*
	▪ *Transportation losses*	*0.14%*	*+1.31*
3	Refinery Gate Price	91.3%	872.30
	a. Transportation Charge for Distribution	*0.9%*	*+8.46*
	b. Losses between refinery gate and gas station	*0.4%*	*+2.65*
	c. Distribution margin for marketing	*2.2%*	*+21.50*
4	Wholesale Price or OMC[116] Sale Price	94.7%	904.90
	a. Retail fuel leak and evaporation losses	-	-
	b. Retail margin	-	-
	c. Airport fees	*0.9%*	*+9.05*
	d. Service charge	*4.3%*	*+41.20*
	e. Fixed tax	-	-
Σ	**Retail Price or Consumer Price**	**100%**	**955.15**

The pricing structure reflects the dependency of Jordan's energy system on fossil fuel imports, with its jet fuel supply chain illustrated in the following table.

Table 8. Supply chain of jet fuel in Jordan, from external extraction to local use at Jordanian airports.

Fuel type	Upstream	Midstream[117]	Downstream[117]
Conventional Jet Fuel			
	Jordan's limited fossil reserves (aside from uneconomic oil shale) lead to no involvement in upstream exploration.	Jordan focuses on importing and transporting oil and natural gas, relying on ports, pipelines, and storage facilities.	Jordan has oversight over domestic refining and distribution of jet fuel to airports.

The key supply chain link that Jordan can fully control is the downstream part. All fuel handling in Jordan follows international standards such as ASTM and DEFSTAN 91-91[118] and is subject to regular inspections. The two most widely used and recognized standards ensuring jet fuel is fit for purpose are ASTM D1655 (developed by the American Society for Testing and Materials – ASTM), which defines the properties of Jet A and Jet A-1, and DEF STAN 91-91, a United Kingdom Ministry of Defence standard for Jet A-1. Both, used worldwide, serve as primary references to ensure aviation turbine fuels meet strict safety, composition, and performance requirements.[119, 120]

[116] Oil Marketing Company (OMC): companies active in the downstream fuel sector, responsible for the marketing, distribution, and sale of petroleum products like jet fuel. In Jordan: JoPetrol, Total, Manaseer.

[117] Icon from TheNounProject (n.a.), Creative Fabrica (n.a.) and 123RF (2025)

[119] IATA (n.a.), *Fact Sheet 2 – Sustainable Aviation Fuel: Technical Certification*

[120] ASTM D1655 can also cover SAF, in the case where it has been blended with conventional jet fuel and the final mixture matches the properties of traditional petroleum-based jet fuel. In contrast, ASTM D7566 is specifically designed for SAF. It outlines quality standards for bio-derived and synthetic aviation fuels.

Jet A1 is produced at JPRC's Zarqa refinery – based on the share of imported crude oil, the remaining Jet A1 is imported.. For five decades refining, storing, and transporting jet fuel to airports had been solely under the control of the JPRC. JPRC continues to provide Jet A-1 fuel to Jordan's three main airports: Queen Alia International Airport (QAIA), Amman Civil Airport (ACA), and King Hussein International Airport (KHIA) in Aqaba. Additionally, it supplies Avgas 100LL to Amman Civil Airport and the northern King Hussein Military Air Base.

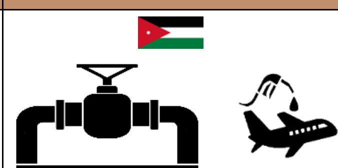
Since 2008, the Jordanian government has pursued liberalization of the downstream petroleum sector to foster competition and enhance economic and logistical efficiency in jet fuel provision. In 2015 it founded the Jordan Oil Terminals Company (JOTC) as the first independent, open-access storage provider in Jordan. Planned and ongoing projects under JOTC to support the liberalization target include:[121]

- Amman Strategic Terminal for Petroleum Products (ASTPP), increasing strategic fuel storage capacity.
- Aqaba Oil Terminal (AOT), with a capacity of 100 kt for petroleum products and 6 kt for liquefied petroleum gas (LPG), improving fuel logistics and regional connectivity with neighbouring countries.
- Development of new pipeline networks to enhance fuel security and transportation efficiency.

1.7.2 Potential SAF value chain

While Jordan's influence on the jet fuel value chain is limited to the downstream part, domestic SAF production could enable Jordan to extend its control across the full jet fuel value chain. The following table expands the previous supply chain picture for fossil fuels.

Table 9. Supply chain overview for SAF.

Fuel type	Upstream	Midstream[122]	Downstream[122]
SAF			
	Renewable electricity, incl. hydrogen, and biomass and MSW feedstocks can be predominantly sourced and processed to SAF in Jordan.	Domestic refining	Transportation via domestic pipelines and storage facilities, and distribution of SAF to airports.

A more detailed understanding of the different SAF production steps, depending on the differences in each conversion pathway, can be found in Table 10 below. More information on the individual production steps 2-8 can be found under 2.1.1.

<u>Key takeaways for SAF potential in Jordan</u>

In summary SAF production may allow Jordan to expand its control of the jet fuel value chain beyond the downstream part. This can serve as a strategic goal for the Jordanian government to increase its energy dependency in line with its national energy strategy.

[121] Icon from TheNounProject (n.a.), Creative Fabrica (n.a.) and 123RF (2025)

[122] JOTC (2025), *Terminals Overview*

Table 10. SAF value chain steps.

	Upstream					Midstream		Downstream			
Step per SAF conversion pathway	**1 Feedstock Collection**	**2 Pre-treatment**	**3 Conversion to Intermediates**	**4 Dehydration**	**5 Fischer-Tropsch Synthesis**	**6 Refining**	**7 Refining**	**8 Blending**	**9 Compliance with SAF certification**	**10 SAF distribution**	**11 SAF use MRV**
		(essential for HEFA only)	(AtJ & gasification-FT only)	(AtJ only)	(Gasification-FT & PtL only)	(adjusting hydrocarbons)	(fractionation into jet fuel range)	(for standalone processed SAF)		(to airports & sales)	(Monitoring, Reporting, Verification)
HEFA	Collection of lipid-rich biomass (fats & oils)	Cleaning oils & fats to remove impurities	-	-	-	Hydroprocessing and upgrading[123] of pre-treated oils & fats. Available as a coprocessing or standalone option[124]	Separation into jet fuel-range[125] fractions	Blending with fossil fuel prevents exceeding limit for SAF share in final fuel	Produced fuel must comply with ASTM or Def-Stan certification standards	Transport and selling of jet fuel	Airlines report SAF use to authorities to claim emission reductions
AtJ	Collection of biomass rich in fermentable sugars	-	Fermentation into alcohols (ethanol or butanol)	Removing water from alcohols to form olefins[126]	-	Oligomerization and hydrogenation of olefins[127]	Separation into jet fuel-range fractions[125]	Blending with fossil fuel prevents exceeding limit for SAF share in final fuel	Produced fuel must comply with ASTM or Def-Stan certification standards	Transport and selling of jet fuel	Airlines report SAF use to authorities to claim emission reductions
Gasification-FT	Collection of carbon-rich materials	-	Gasification of feedstock into syngas	-	Converting syngas into hydrocarbons	Upgrading hydrocarbons.[123] Available as a coprocessing or standalone option[124]	Separation into jet fuel-range fractions[125]	Blending with fossil fuel prevents exceeding limit for SAF share in final fuel	Produced fuel must comply with ASTM or Def-Stan certification standards	Transport and selling of jet fuel	Airlines report SAF use to authorities to claim emission reductions
PtL	Green H_2 and captured CO_2	-	Producing syngas from H_2 and CO_2	-	Converting syngas into hydrocarbons	Upgrading hydrocarbons[123]	Separation into jet fuel-range fractions[125]	Blending with fossil fuel prevents exceeding limit for SAF share in final fuel	Finished fuel to adhere to ASTM or Def-Stan certification standard	Transport and selling of jet fuel	Airlines report SAF use to authorities to claim emission reductions

[123] Upgrading: Breaking (hydrocracking), restructuring (isomerization), and purifying (hydrotreating, fractionation) hydrocarbons to aviation fuel standards.
[124] Co-processed means that renewable feedstock or intermediates are processed together with fossil feedstock in existing refinery units to produce SAF and other fuels. This is available for HEFA and gasification-FT SAF. Standalone processing, in contrast, uses dedicated facilities that process only renewable feedstocks to produce SAF.
[125] Jet fuel range refers to the proportion of a fuel mixture that is converted into fuel suitable for airplane engines during the refining process. It typically accounts for 30% to 50% of the original input material, depending on the crude type and refinery setup. This jet fuel portion forms part of the refinery's product slate—the full mix of outputs like gasoline, diesel, and other petroleum products.
[126] Olefins are small, reactive molecules made from alcohols by removing water, they act as the building blocks for making jet fuel.
[127] Olefins are linked together into longer chains (oligomerization), stabilized by adding hydrogen (hydrogenation), and sometimes rearranged to improve cold-weather performance (isomerization), creating the final fuel.

1.8 SUMMARY OF JORDAN'S STATE-SPECIFIC CONDITIONS

Category	Strengths	Weaknesses	Opportunities	Threats
Geography & Climate	**Strategic central location** close to key markets in Asia, Africa, and Europe could make Jordan a strategic hub for SAF production and export. **Vast desert areas and high solar radiation** make ideal conditions for large-scale solar & wind energy generation.	**Limited arable land** restricts biomass cultivation for biofuels. **Extreme water scarcity.** Jordan ranks among the most water-scarce countries globally, impacting biomass availability.	**The cement, potash & phosphate industry may offer a rich source of captured carbon** for PtL SAF.	**Political instability in neighbouring countries** may disrupt supply chains, foreign investment interest, and SAF production and export potential.
Trade & Governance	**Stable economic policies**: Jordan has demonstrated consistent economic stability. **Active climate policies and emission reduction targets** provide a framework for industrial decarbonization, investment, and a favourable environment for alternative fuel projects. **Strong international partnerships**: Jordan has trade agreements and relationships with the EU, US, and GCC countries, which could support SAF exports.	**Heavy reliance on imports/trade deficit** limits domestic investment capability and puts pressure on foreign investment dependency to realize large-scale industry projects.	**SAF aligns with Jordan's energy security goals**: reducing fossil fuel imports through SAF production can strengthen economic resilience. **Foreign investors made successful project realization experiences with** large-scale industry projects in Jordan.	**Bureaucratic challenges and slow administration** could constrain foreign investment appetite.
Demographics	**Young and educated workforce** with a high proportion of college-educated individuals, especially in engineering and environmental sciences. **Growth of urban centres:** Rising waste production in cities can provide feedstocks for waste-to-fuel SAF processes.	**High unemployment,** particularly among youth and women, which may create economic instability.	**Job creation in the SAF industry**: SAF production could integrate Jordan's workforce into new sectors such as biofuel processing, hydrogen production, and SAF logistics. **Integration into global research programmes:** Jordan's universities collaborate with international institutions on renewable energy projects.	**Regional conflicts affecting migration**: Jordan has large refugee and migrant worker populations, which could put pressure on infrastructure and economic stability.

Vulnerability to Climate Change	**Strong environmental awareness** translates into national policies and industry strategy action.	**Rising temperatures and declining precipitation levels** could further limit biomass cultivation.	**Expansion of PtL SAF**: Power-to-liquid (PtL) SAF, based on renewable hydrogen and CO_2, is the more viable long-term option compared to biofuels. **Investment in desalination**: Jordan's desalination efforts as planned may unlock water availability for industrial processes, including SAF production.	**Economic losses due to climate change** could reach 2% annual GDP loss by 2050, which could further constrain domestic investment capability.
Agriculture	**Government support for agricultural expansion**: Jordan aims to increase agricultural efficiency through digitalization and sustainable farming practices. **Expected rising availability of key biomass output,** esp. manure.	**Rising food import costs**: Increased dependency on imported food may divert resources away from SAF-related agriculture.	**Biomass extraction from imports:** Jordan could generate a significant amount of biomass from wheat import residues (husks), extracted in Jordan. **Agrivoltaics**: Combining solar energy production with agriculture could optimize land use.	**Declining self-sufficiency**: By 2100, self-sufficiency in key crops is projected to decline, increasing pressure on food security.
Energy	**Strong energy infrastructure**: Jordan has well-developed downstream pipelines, refineries, and fuel distribution networks.	**High energy dependency**: currently heavily dependent on fossil fuel imports.	**Energy security:** SAF production can decrease Jordan's fossil energy dependency. **Synergies from green hydrogen production potential for SAF:** desalination projects can lead to added value for SAF and beyond (e.g. mineral extraction from brine).	**Competition over desalinated water** with other use cases, esp. for food security.
Aviation Fuel Value Chain	**Established fuel distribution network**: Jordan has a strong transport and fuel infrastructure.		**SAF can enhance energy security** and decrease import reliance	

SECTION 2. EVALUATION OF FEEDSTOCKS AND PATHWAYS FOR SAF PRODUCTION

Today, global aviation is responsible for approximately 2-3% of worldwide CO_2 emissions,[128] a share that could significantly increase if no decarbonization actions are taken within the sector.[129] For commercial aviation to reach its goal for net-zero carbon emissions by 2050,[130] SAF is essential, in addition to fuel-saving improvements to aircraft technology and operational measures such as more direct air routes. SAFs can offer an immediate reduction in lifecycle emissions without requiring technological or operational changes to the current aviation system. Alternative technologies, such as electric and hydrogen-powered planes, face significant hurdles, including scalability challenges for widespread and economic adoption, inferior energy density compared to conventional jet fuels and SAFs, and technology readiness levels that are too low to overcome these challenges within the required time frame.[131]

Each tonne of SAF used in place of conventional jet fuel can reduce life-cycle emissions by 73-100%.[132] These emission reductions cover the full lifecycle of SAF: from CO_2 absorption during feedstock growth to distribution and final combustion in flight – ultimately reducing its net carbon footprint. The scale of this reduction depends on the specific SAF type, which varies based on the feedstocks used and the processes applied to convert these feedstocks into jet fuel.

For a renewable fuel to qualify as SAF under ICAO's CORSIA, it must have life-cycle CO_2-equivalent emissions reduced at least 10% compared to fossil jet fuel. This includes both core life-cycle assessment (LCA) emissions – covering feedstock production, processing, and combustion – and induced land-use change (ILUC) emissions, which account for environmental impacts from land conversion. The SAF must meet ICAO's sustainability criteria, use approved feedstocks and production pathways (already included in CORSIA documents), be certified by an ICAO-recognized scheme (e.g. RSB, ISCC), and ensure accurate emissions accounting to prevent double counting, allowing airlines to use it for CORSIA compliance and carbon offsetting.

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[128] Aviation contributes 2-3% of global CO_2 emissions, but its total climate impact is larger due to non-CO_2 effects like contrails, nitrogen oxides, and aerosols. Studies suggest that SAF can mitigate these effects by producing fewer soot particles and altering contrail formation, in addition to reducing life-cycle CO_2 emissions.

[129] Dolšak and Prakash (2022), *Different approaches to reducing aviation emissions: reviewing the structure-agency debate in climate policy*

[130] At its 41st Assembly in 2022, ICAO adopted the Long-Term Aspirational Goal (LTAG), committing worldwide commercial aviation to achieve net-zero carbon emissions by 2050, in line with the Paris Agreement targets.

[131] Lower energy density means that batteries for electric aircraft and hydrogen storage systems— liquid or compressed—for hydrogen-powered planes store less energy per volume compared to fossil jet fuel or SAF.

[132] Depending on the SAF type (feedstock and conversion process, induced emission reduction effects such as land use for feedstock growing).

All SAF types have the same operational characteristics as conventional fossil jet fuels (incl. freezing point and flash point), allowing seamless operation without any performance drawbacks. Currently, SAFs can be blended up to 50% into existing jet fuel infrastructure without operational or maintenance drawbacks. This limit ensures system compatibility, as conventional fuel contains aromatics that help seal onboard aircraft fuel systems. Research is underway to raise the blending ratio of SAFs to 100%, with solutions expected to overcome this challenge in the near future.

Overall, there are two categories of SAF:

I. Biofuel SAF

This SAF type is derived from biomass that is either rich in lipids (oil and fats), in fermentable sugars, or in carbon content. There are different conversion processes, from commercially available technologies to technologies that are still not sufficiently mature.

II. Power-to-Liquid (PtL) SAF

This SAF type combines green hydrogen and captured carbon, both powered by renewable electricity. It has a higher emission reduction potential and may enable a 100% blending ratio; however, it still has a low technology readiness level.

The evaluation of feedstock will begin with an analysis of biofuel SAF, examining the available conversion processes and feedstock options in Jordan. Following this, the assessment will focus on PtL SAF, equally evaluating the availability conversion process and feedstock for this process in Jordan.

2.1 BIOFUEL SAF

Table 11 provides an overview of the currently CORSIA eligible conversion processes for biofuel SAF (as of March 2025). These processes are distinct based on (a) the different types of feedstock groups they utilize and (b) the various conversion methods used to transform a feedstock group into SAF and the maximum blending ratios that result from that.

2.1.1 Summary and evaluation of biofuel SAF conversion processes

Table 11. ASTM-certified feedstock-to-SAF conversion pathways.[133]

ASTM doc	Conversion process	Abbreviation	Possible feedstocks	Maximum blend
ASTM D7566 Annex A1	Fischer-Tropsch hydroprocessed synthesized paraffinic kerosene	FT	Coal, natural gas, biomass	50%
ASTM D7566 Annex A2	Synthesized paraffinic kerosene from hydroprocessed esters and fatty acids	HEFA	Vegetable oils, animal fats, used cooking oils	50%
ASTM D7566 Annex A3	Synthesized iso-paraffins from hydroprocessed fermented sugars	SIP	Biomass used for sugar production	10%
ASTM D7566 Annex A4	Synthesized kerosene with aromatics derived by alkylation	FT-SKA	Coal, natural gas, biomass	50%

[133] Own charts, data from ICAO (2025), *Conversion processes*

	of light aromatics from non-petroleum sources			
ASTM D7566 Annex A5	Alcohol to jet synthetic paraffinic kerosene	ATJ-SPK	Ethanol, isobutanol and isobutene from biomass	50%
ASTM D7566 Annex A6	Catalytic hydrothermolysis jet fuel	CHJ	Vegetable oils, animal fats, used cooking oils	50%
ASTM D7566 Annex A7	Synthesized paraffinic kerosene from hydrocarbon - hydroprocessed esters and fatty acids	HC-HEFA-SPK	Algae	10%
ASTM D7566 Annex A8	Synthetic Paraffinic Kerosene with Aromatics	ATJ-SKA	C2-C5 alcohols from biomass'	
ASTM D1655 Annex A1	Co-hydroprocessing of esters and fatty acids in a conventional petroleum refinery		Vegetable oils, animal fats, used cooking oils from biomass processed with petroleum'	5%
ASTM D1655 Annex A1	Co-hydroprocessing of Fischer-Tropsch hydrocarbons in a conventional petroleum refinery		Fischer-Tropsch hydrocarbons co-processed with petroleum	5%
ASTM D1655 Annex A1	Co-Processing of HEFA	Hydroprocessed esters/fatty acids from biomass'		10%

For the evaluation of feedstocks, the detailed list of ASTM certified conversion processes can be categorized into three main groups as shown in Table 12.

Table 12. Three main groups of ASTM certified conversion processes.[134]

	HEFA (Hydroprocessed Esters and Fatty Acids)	AtJ (Alcohol-to-Jet)	Gasification-FT (Gasification-Fischer Tropsch)
a. CORSIA eligible conversion processes for SAF biofuels	▪ **HEFA:** Synthesized paraffinic kerosene from hydroprocessed esters and fatty acids ▪ **CHJ:** Catalytic Hydrothermolysis Jet Fuel ▪ **HC-HEFA-SPK:** Synthesized Paraffinic Kerosene from Hydrocarbon - Hydroprocessed Esters and Fatty Acids ▪ **CO-HEFA:** co-hydroprocessing of Esters and Fatty Acids in a Conventional Petroleum Refinery ▪ **Hydroprocessed esters/fatty acids from biomass:** co-Processing of HEFA	▪ **AtJ SIP:** Synthesized Iso-Paraffins from Hydroprocessed Fermented Sugars ▪ **AtJ-SPK:** Alcohol to jet synthetic paraffinic kerosene ▪ **ATJ-SKA:** Synthetic Paraffinic Kerosene with Aromatics	▪ **FT-SPK:** Fischer-Tropsch hydroprocessed synthesized parrafinic kerosene ▪ **FT SKA:** synthesized Kerosene with Aromatics ▪ **CO-FT:** co-hydroprocessing of Fischer-Tropsch hydrocarbons in a conventional petroleum refinery

[134] ICAO (2025), *SAF Feedstocks*

	First, natural oils and fats are cleaned through pre-treatment to remove impurities. Those processed hydrocarbons are then refined by hydroprocessing (removing oxygen, cracking, and isomerizing molecules[135]) and fractionation to separate the jet fuel range,[136] producing renewable aviation fuel.	First, biomass is converted into alcohols (such as ethanol or butanol) via fermentation. These alcohols then undergo dehydration to form olefins,[137] which are subsequently refined through oligomerization and hydrogenation (and optionally isomerization) to produce jet-range biofuels.[138]	First, carbon-rich materials (such as biomass or waste) are converted into a syngas (a mixture of carbon monoxide and hydrogen) through gasification. This syngas is then processed via Fischer-Tropsch synthesis to form hydrocarbons, which are subsequently refined by upgrading[139] and fractionation (and optionally isomerization) to produce jet-range fuels.
b. eligible feedstocks	Requires lipid-rich[140] biomass (such as plant, animal, or algae oils and fats, waste fats and greases).	Requires lignocellulosic biomass[141] that includes and is rich in fermentable sugars (such as agricultural residues, wood, or energy crops).	Requires lignocellulosic biomass[141] that is carbon-rich (such as forestry residues or municipal solid waste).

HEFA, AtJ, and gasification-FT are distinct from each other in terms of (1) commercial availability, including technological maturity, cost and scalability; (2) energy and hydrogen requirements during SAF production; and (3) their distinct emission reduction potential. The following summary represents the status quo in 2024:

(1) <u>Commercial availability: technological maturity, cost, and scalability of biofuel conversion pathways:</u>

HEFA is the most commercially mature pathway with a TRL[142] of 9.[143] There are roughly 56 HEFA plants operating, planned, or under construction worldwide. The cost level of final fuel output is similar to that of AtJ and lower than that of gasification-FT.[144] HEFA benefits from commercial experience in refining and feedstock supply chains as part of the broader family of HVO fuels.[145] This group of lipid-based biofuels became commercially available in recent decades for road transport fuel

[135] Isomerizing means slightly reshaping fuel molecules from straight to branched forms, helping the fuel stay smooth and liquid at very cold, high altitudes; it is especially needed for HEFA because its straight molecules would otherwise freeze too easily.
[136] Jet fuel range refers to the proportion of a fuel mixture that comes out of the refining process as fuel suitable for use in airplane engines, typically making up about 30% to 50% of the material that was originally input into the refining process.
[137] Olefins are small, reactive molecules made from alcohols by removing water, they act as the building blocks for making jet fuel.
[138] Olefins are linked together into longer chains (oligomerization), stabilized by adding hydrogen (hydrogenation), and sometimes rearranged to improve cold-weather performance (isomerization), creating the final fuel.
[139] Upgrading: Breaking (hydrocracking), restructuring (isomerization), and purifying (hydrotreating, fractionation) hydrocarbons to aviation fuel standards.
[140] Lipid-rich means full of oils and fats.
[141] Lignocellulosic biomass means plant-based material made up of tough fibres (cellulose, hemicellulose, and lignin).
[142] Technology Readiness Level (TRL) is a scale used to assess the maturity of a technology, guiding investment and development decisions from research to full commercial deployment. From
1 (Basic Principles Observed) to 9 (Actual System Proven in Operational Environment)
[143] EASA (2025), *SAF Developments*
[144] RMI (2024), *A Roadmap for SAF in the Rocky Mountain Region*
[145] Hydrotreated Vegetable Oil (HVO): Impurities are removed from vegetable oils, animal fats, and other lipids via hydrotreatment -a hydrogen-based process that produces hydrotreated vegetable oil (HVO), a diesel-like renewable fuel. HVO can then be further refined through isomerization, cracking, and separation to yield SAF.

production. This poses a use-case competition. Based on the limited availability of waste fats and oils (~34,000–42,000 kt/year globally), it is estimated that HEFA could only supply about 10% of global SAF demand.[146]

AtJ primarily is nearing commercial status with a TRL of 8-9.[143] There are roughly 21 facilities operating, planned, or under construction worldwide.[146] The cost level of final fuel output is similar to HEFA but lower than gasification-FT. The pathway benefits from flexible feedstocks like sugarcane, corn, and lignocellulosic materials. With technological advancements and policy support, AtJ could become a key SAF contributor.

Gasification-FT is also progressing toward commercialization with a TRL of 6-8.[143143] There are roughly 20 facilities operating, planned, or under construction worldwide. The cost level of final fuel output is moderate compared to HEFA and AtJ. This pathway offers greater scalability compared to HEFA and AtJ due to its versatile feedstock utilization, including agricultural residues and forestry by-products (currently at commercial pilot scale), as well as MSW (in pilot stage). MSW provides even higher feedstock availability from the potential use of non-biogenic materials and offers additional co-benefits by improving waste management. In contrast, gasification-FT requires strong logistics and supply chain management and high initial investments.[146]

(2) <u>Production: feedstock, hydrogen, and energy requirements of conversion pathways:</u>

HEFA has relatively low feedstock requirements, low energy and the highest hydrogen requirements compared to AtJ and gasification-FT: Roughly 2.2 tonnes of lipid feedstock are required to produce one tonne of SAF.[146, 147] Hydrogen is primarily used for deoxygenation, which removes oxygen from feedstocks, and for final hydrocarbon saturation, with an estimated demand of approximately 47 kg per tonne of HEFA SAF produced.[144] The process is highly energy-efficient because, once initiated, the reaction is exothermic, meaning it generates heat, reducing the need for external energy input to a minimum compared to AtJ and gasification-FT.

AtJ has moderate feedstock, energy and moderate hydrogen requirements compared to HEFA and gasification-FT: Roughly four to six tonnes of dry lignocellulosic biomass are required to produce one tonne of SAF.[146,147,148] This process requires around 22 kg of hydrogen per tonne of AtJ SAF produced.[144] Due to its additional conversion steps, AtJ consumes more energy than HEFA. AtJ is more energy-intensive compared to HEFA because it involves multiple processing steps, including fermentation to produce ethanol or isobutanol and dehydration to convert these alcohols into final hydrocarbons.

Gasification-FT has high feedstock and energy requirements but low to moderate hydrogen requirements compared to HEFA and AtJ: Roughly eight tonnes of dry municipal solid waste or 18 tonnes of agricultural residues are required to produce one tonne of SAF.[146, 147] In addition, roughly 16 kg of hydrogen are required per tonne of gasification-FT SAF produced.[144] Gasification involves

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[146] IEA (2024), *Progress in Commercialization of Biojet/Sustainable Aviation Fuels (SAF): Technologies and Policies*

[147] Based on a total conversion rate that considers both (a) the conversion yield from dry feedstock to total distillate, and (b) the product slate from the refining process, which determines how much of that distillate can finally become SAF. It is worth noting that the product slate can be adjusted to produce higher volumes jet fuel (which is shorter hydrocarbon chain lengths) through the process of hydrocracking.

[148] Four to six tonnes of dry lignocellulosic biomass corresponds to roughly 2.4 tonnes of ethanol or 1.33 tonnes of isobutanol.

high temperatures and pressures to convert biomass into syngas, followed by Fischer-Tropsch synthesis and is highly energy intense compared to HEFA and AtJ.

(3) Emission reduction potential compared with conventional jet fuel:[149]

HEFA has the lowest carbon intensity reduction among biofuel SAF pathways, at 73% up to 84%.[144]

AtJ has a moderate/high carbon intensity reduction among biofuel SAF pathways at 85% up to 94%[144]

Gasification-FT has a moderate/high carbon intensity reduction among biofuel SAF pathways at 85% up to 94%[144]

In conclusion, as of 2025, HEFA is the only fully commercialized SAF technology and is expected to dominate production volumes until 2030. HEFA offers the highest SAF production yields per tonne, followed by AtJ; however, the limited global supply of lipid feedstocks significantly constrains HEFA's overall output potential. AtJ is advancing rapidly with growing investments, while gasification-FT remains at a lower TRL due to feedstock logistics and high upfront costs. However, the higher carbon intensity reduction potential of AtJ and gasification-FT positions them for long-term dominance. Ultimately, future policy incentives and technological advancements will determine the adoption pace of each pathway.

2.1.2 Summary of biofuel SAF feedstocks

Feedstocks are categorized into four groups under the CORSIA framework based on their sourcing and economic characteristics, as defined by ICAO. This classification helps determine their sustainability and impact on aviation fuel production. The four groups are shown in the following table, with the CORSIA eligible feedstocks in each group underneath.[150]

Table 13. Overview of CORSIA feedstock classification.

I. Main products These are the main outputs of a production process. These products have significant economic value and elastic supply, (i.e., there is evidence that there is a causal link between feedstock prices and the quantity of feedstock being produced).					
• Brassica carinata oilseed	• Camelina oilseed	• Corn grain	• Jatropha oilseed	• Miscanthus (herbaceous energy crops)	• Palm fresh fruit bunches
• Poplar (short-rotation woody crops)	• Rapeseed oilseed	• Soybean oilseed	• Sugar beet	• Sugarcane	• Switchgrass (herbaceous energy crops)
II. By-products These are secondary products with inelastic supply and economic value.					
• Palm fatty acid distillate	• Technical Corn oil	• Non-Standard Coconuts	• Molasses	• Tallow	• Beef Tallow
• Poultry Fat	• Lard Fat	• Mixed Animal Fat			

[149] Please note that these emission reduction figures represent overall reduction potentials per SAF conversion pathway and are not specific to individual feedstocks, which do vary and further influence the final reduction figures.
[150] ICAO (2024) *SAF Feedstocks*

III. Wastes These are materials with inelastic supply and no economic value. A waste is any substance or object which the holder discards or intends or is required to discard. Raw materials or substances that have been intentionally modified or contaminated to meet this definition are not covered by this definition.		
• Municipal Solid Waste (MSW)	• Used Cooking Oil (UCO)	• Waste gases

IV. Residues These are secondary materials with inelastic supply and little economic value.					
Agriculture Residues	• Bagasse	• Cobs	• Husks	• Manure	• Nutshells
	• Stalks	• Stover	• Straw	•	•
Forestry Residues	• Bark	• Branches	• Cutter shavings	• Leaves	• Needles
	• Pre-commercial thinnings	• Slash	• Tree tops		
Processing Residues	• Crude glycerine	• Crude Tall Oil	• Empty palm fruit bunches	• Forestry processing residues	• Palm oil mill effluent
	• Sewage sludge	• Tall oil pitch			

These feedstocks can fulfil CORSIA sustainability criteria in terms of sustainability in feedstock production, traceability of sustainable materials through the supply chain, and verified reduction of life cycle emissions, and can be assessed and certified under ICAO-approved Sustainability Certification Schemes (SCS) such as RSB (Roundtable on Sustainable Biomaterials) and ISCC (International Sustainability and Carbon Certification). The list is regularly being updated by ICAO adding new feedstock options eligible under CORSIA.

Across the different groups, this evaluation assesses the potential of various feedstocks for SAF production in Jordan, based on quantitative characteristics across multiple categories. The analysis systematically evaluates all CORSIA-eligible feedstocks, one by one, while also extending to other relevant feedstock types that are both available at scale in Jordan and fulfil sustainability criteria. The latter group may be considered as candidates that could be included in the CORSIA framework.

2.1.3 Evaluation method for biofuel SAF feedstocks

Step 1: exclusion of feedstocks that are not suitable for Jordan

The first step involves excluding feedstocks that are not suitable for Jordan due to country-specific conditions that marginalize their suitability. These feedstocks are either incompatible with the arid climate or do not provide sufficient production value to justify their cultivation and irrigation, particularly in relation to food security concerns. Summarizing this step, the following list outlines all eligible feedstocks, along with the exclusion criteria for those that do not qualify. Feedstocks selected for further detailed assessment are highlighted in **bold** with a tick mark. Data not marked with footnotes is based on previous sources.

Table 14. Assessment of feedstocks that are suitable to Jordan's state-specific conditions.

Category	Feedstock	Justification for exclusion or inclusion
Main product	Brassica carinata oilseed	Needs at least 600 mm of annual rainfall to flower and set fruit. No region in Jordan can offer this level of precipitation. Irrigation would be uneconomical against crops that are required for food security.[151] In addition, while it can withstand temperatures up to 30°C, prolonged temperatures above this threshold may reduce yield – which can make it difficult to grow in Jordan. Thereby it is not relevant.[152]

[151] Government of Canada (2025), *The Biology of Brassica carinata*

[152] PFAF (2023), *Brassica carinata*

	Camelina oilseed	Needs a minimum of 250 mm of annual rainfall, which is available in some areas of Jordan; however, the plant is sensitive to temperatures above 30°C, especially during flowering and seed development, which significantly reduces oil quality and yield and their suitability in Jordan. Thereby it is not relevant.[153]
	Corn grain	9.6% of total final agricultural biomass in Jordan is corn; however, it is not relevant, as all of it is exclusively imported and needed for food security.[154]
	Jatropha oilseed	✓ **Suitable feedstock for Jordan that doesn't have key constraints. To be further evaluated.**
	Jojoba oilseed	✓ **Suitable feedstock for Jordan that doesn't have key constraints. To be further evaluated.**
	Miscanthus (herbaceous energy crops)	Needs 500-700 mm of rainfall per year to grow successfully.[155] No region in Jordan can offer this level of precipitation. Since irrigation would be uneconomical against crops required for food security, it is not relevant.
	Palm fresh fruit bunches	From oil palm trees, which require a consistent humid and hot tropical climate, which makes Jordan unsuitable for their cultivation. Jordan imports 99.4% of its palm oil needs.[154]
	Poplar (short-rotation woody crops)	Needs min 750 mm of annual rainfall to thrive. As no region in Jordan can offer this level of precipitation, it is not relevant.[156]
	Rapeseed oil	Not relevant, as there is no listed production in Jordan.[154]
	Soybean oilseed	Not relevant, as it is exclusively imported to Jordan and required for food security. Only 0.2% of total final available agriculture biomass.[154]
	Sugar beet	Not relevant, as there is no listed production in Jordan. 99.997% of Jordan's sugar needs are imported.[154]
	Sugarcane	Not relevant, as there is no listed production in Jordan. 99.997% of Jordan's sugar needs are imported.[154]
	Switchgrass (herbaceous energy crops)	Needs at least 500 mm of annual rainfall to thrive; below that, its biomass yield may be reduced. No region in Jordan can offer this level of precipitation. Irrigation would be uneconomical against crops that are required for food security.[157] Thereby not relevant.
By-product	Palm fatty acid distillate	Not relevant. Production is insignificant, as Jordan lacks palm oil production.[154]
	Technical corn oil	Not relevant. Exclusively imported to Jordan, as Jordan lacks domestic corn and corn derivative production.[154]
	Non-standard coconut	From coconut palm trees, which require a consistent humid and hot tropical climate, which makes Jordan unsuitable for their cultivation.[158]
	Molasses	Not relevant. As Jordan lacks domestic sugar production, it does not produce molasses. All imported molasses is used for culinary, agricultural, and industrial purposes.[154]
	Tallow	✓ **Suitable feedstock for Jordan that doesn't have key constraints, assessed in one group. To be further evaluated.**
	Beef tallow	
	Poultry fat	
	Mixed animal fat	
	Lard fat	Not relevant. Cultural and religious practices in Jordan restrict the availability of pig-derived products
Residues (Agriculture)	Bagasse	From sugarcane processing. As Jordan has no domestic sugarcane production, bagasse is not produced locally.[154] Thereby not relevant.
	Cobs	From corn, which is exclusively imported to Jordan. Cobs are removed in the harvesting process before being imported.[154]
	Husks	✓ **Suitable feedstock for Jordan that doesn't have key constraints. To be further evaluated.**
	Manure	✓ **Suitable feedstock for Jordan that doesn't have key constraints. To be further evaluated.**
	Nut shells	Although a theoretical 260 tonnes of almond nut shells could be sourced from domestic production, the limited volume makes efficient collection challenging.[154]

[153] United States Department of Agriculture (n.a.), *Natural Resources Conservation Service - Camelina Sativa*
[154] Department of Statistics (2025), *External Trade & Agricultural Food Balance Sheet - Self-Sufficiency Rate of Products*
[155] Novabiom (n.a.), *Growing miscanthus: making the right choices*
[156] Meiresonne (n.a.), *Nutrient cycling in a poplar plantation*
[157] Bughrara et. al. (2007), *Switchgrass as a Biofuel for Michigan*
[158] Grow Veg (n.a.), *Coconut Growing Guide*

	Stalks	From crops like barley, wheat, sugarcane, corn, rice, and sunflowers – which are exclusively imported to Jordan – stalks are removed during the harvesting and processing stages before being shipped to Jordan.[154] Thereby not relevant.
	Stover	From crops like barley, wheat, sugarcane, corn, rice, and sunflowers – which are exclusively imported to Jordan – stover is removed at the site of harvesting before the crops are shipped to Jordan.[154] Thereby not relevant.
	Straw	From crops like barley, wheat, and corn – which are exclusively imported to Jordan – straw is removed at the site of harvesting before the crops are shipped to Jordan.[154] Thereby not relevant.
Residues (Forestry)	Bark	Collecting tree residues is difficult due to Jordan's limited forest cover (1% of land), which leads to high collection costs, further aggravated by strict regulations on tree cutting to prevent deforestation and land degradation. The low quantities of woody biomass are used in biofuel pilots, which must be expected to further constrain additional use cases.[159]
	Branches	
	Leaves	
	Needles	
	Pre-commercial thinning	
	Tree tops	
	Cutter shavings	The wood processing industry is not significant in Jordan [154], thereby not relevant.
	Slash	Due to Jordan's limited forest cover, the country lacks a significant logging industry. As a result, there is minimal production of slash.[154] Thereby not relevant.
Residues (Processing)	Crude glycerine	From biodiesel production, soap manufacturing, and fatty acid processing, all not significant industries in Jordan. Thereby not relevant.
	Crude tall oil	From the pulp and paper industry that Jordan lacks. Due to the country's limited forest resources, it focuses on converting imported paper rather than processing raw wood. [154] Thereby not relevant.
	Empty palm fruit bunches	From oil palm trees, which require a consistent humid and hot tropical climate, which makes Jordan unsuitable for their cultivation. Jordan imports 99.4% of its palm oil needs.[154]
	Forestry processing residues	Due to Jordan's limited forest cover, the country lacks a significant logging industry. As a result, there is minimal production of forestry processing residues.
	Palm oil mill effluent	From oil palm trees, which require a consistent humid and hot tropical climate, which makes Jordan unsuitable for their cultivation. Jordan imports 99.4% of its palm oil needs.[154]
	Sewage sludge	✓ **Suitable feedstock for Jordan that doesn't have key constraints. To be further evaluated.**
	Tall oil pitch	From the pulp and paper industry that Jordan lacks. Due to the country's limited forest resources, it focuses on converting imported paper rather than processing raw wood.[154] Thereby not relevant.
Waste	Municipal Solid Waste (MSW)	✓ **Suitable feedstock for Jordan that doesn't have key constraints. To be further evaluated.**
	Used Cooking Oil (UCO)	✓ **Suitable feedstock for Jordan that doesn't have key constraints. To be further evaluated.**
	Waste gases	✓ **Suitable feedstock for Jordan that doesn't have key constraints. To be further evaluated.**

<u>Step 2: detailed assessment of feedstocks that are suitable for Jordan</u>

The second step goes through each identified suitable and shortlisted feedstock to describe their SAF production potential in Jordan. The feedstock rating reflects their relative performance within Jordan's context, based on availability, sustainability, feedstock collection, economic/market viability, and spillover effects. This internal rating indicates which feedstocks may be best suited for biofuel production in Jordan and is not intended for global benchmarking. Please see APPENDIX A: for a description of the individual metrics used for this evaluation in the underlying Feedstock Evaluation Matrix. Please note that *CORSIA Eligible* in the following assessment refers to feedstock that is included in the CORSIA framework as of August 2025.

[159] Tostado-Véliz et. al. (2025), *Review of bioenergy potential in Jordan*

2.1.4 Main products

For the following evaluation of Jojoba please consult 1.5.4. for further background information on energy crop cultivation in Jordan. In summary, the cultivation of energy crops – main products for bioenergy – is limited due to Jordan's priority of utilizing land as much as possible for food security purposes.

Jojoba

[160]

Included in the CORSIA framework: yes / **no**

Pathway: ✓ HEFA | AtJ | ✓ Gasification-FT

Dry biomass share:

Potential:

Jojoba is an oil-rich, desert-adapted energy crop whose potential for biofuel production has been explored in Jordan since the 1980s. It offers high oil content (up to 50% by weight of the seed) and demonstrates strong resilience in arid climates. While it can survive on as little as 300 mm of annual rainfall, a minimum of 400 mm is typically needed for moderate yields, limiting rain-fed cultivation to only a few regions.[161] Commercial-scale production in Jordan would require supplemental irrigation and significant investment in large-scale planting initiatives to realize its full economic feasibility.

Availability	
▪ Potential:	Low/moderate – pilot studies in Jordan indicate that jojoba oilseed yields range from 2 to 3.5 tonnes per hectare annually, with approximately 50% extractable oil content (1,812 tonnes p.a.). Data on total potential cultivable hectares is lacking; however, a lower/moderate availability must be expected considering land-use constraints with food crops.[162]
▪ Regions	Spread out – Jojoba is suitable for arid and semi-arid zones in Jordan, particularly along the Jordan River Valley and the Badia areas, where soil conditions and precipitation levels (though low) can be supplemented by irrigation.[163]
▪ Scalability	Moderate growth potential – Jojoba plantations require significant initial investment and long-term commitment. In addition, drip irrigation is required.
Sustainability	
▪ LCA	Not listed in ICAO CORSIA Document[163]
▪ ILUC	Not listed in ICAO CORSIA Document[163]
▪Social/use case contest	Moderate – Jojoba is a non-edible crop; however, potential land-use competition with food crops should be carefully assessed.
Feedstock collection	
▪ Supply chain	Challenging – due to fragmented and dispersed locations of farms, which necessitate a complex processing infrastructure.
Economic/market viability	
▪ Per tonne	N.A. – no price data available, but cultivation effort must be accounted for, which makes a moderate to high price realistic.

Spillover effects from feedstock use for SAF – supporting key UN SDGs

High – Supports SAF but can also generate alternative income streams for farmers, enhance efficient supply chain infrastructures, promote crops in the economically weak Badia, and drive innovative practices for economic diversification, where traditional crops struggle.

Action needed to materialize the feedstock potential:

▪ Establishment of a centralized collection system and a financial compensation scheme.

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160 Apotheken (n.a.), *Naturheilkunde - Jojoba*

161 In ICAO CORSIA Document: CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels

162 Sandouqa & Al-Hamamre (2021), *Economical evaluation of Jojoba cultivation for biodiesel production in Jordan*

163 Advanced Biofuel Center (2025), *Jojoba: A Potential Desert Oil Crop*

Jatropha

[164]

Included in the CORSIA framework: **yes** / no

Pathway: **✓ HEFA** / AtJ / ✓ Gasification-FT

Dry biomass share:

Potential:

Jatropha is a drought-tolerant oilseed energy crop explored in Jordan since the early 2000s for biodiesel production. Its seeds contain 30–55% non-edible oil, and it grows on marginal lands with little competition with food crops. While it can survive on 300 mm of annual rainfall, at least 600 mm is needed for moderate/viable yields, a challenge in Jordan's arid climate.[165] Supplemental irrigation could boost productivity, but water scarcity and the priority of food production limit its feasibility. Large-scale adoption would require improved farming methods and careful alignment with national water and land-use priorities.

Availability	
▪ Potential:	Low/moderate – Moderate yields can range from two to four tonnes per hectare annually under favourable conditions. The seeds can yield approximately 1,000 to 2,000 litres of biodiesel per hectare per year under these conditions.[166]
▪ Regions	Limited - Only the northern Ajlloun Governorate receives over 500 mm of annual precipitation. However, this governorate is highly populated and only covers 1% of Jordan, making Jatropha cultivation challenging. Only sufficient irrigation could further expand this potential.
▪ Scalability	Moderate growth potential – Jatropha plantations require significant initial investment and long-term commitment. In addition, drip irrigation is required.
Sustainability	
▪ LCA	46.8[163]
▪ ILUC	- 48.1 up to -24.8 t[163]
▪ Social/use case contest	Moderate - Jatropha is a non-edible crop; however, potential land-use competition with food crops should be carefully assessed.
Feedstock collection	
▪ Supply chain	Challenging – Due to fragmented and dispersed locations of farms and marginal lands, which necessitate a complex processing infrastructure.
Economic/market viability	
▪ Per tonne	N.A. – no price data available, but cultivation effort must be accounted for, which makes a moderate to high price realistic.

Spillover effects from feedstock use for SAF – supporting key UN SDGs

High – Supports SAF but can also generate alternative income streams for farmers, enhance efficient supply chain infrastructures, promote crops in the economically weak Badia, and drive innovative practices for economic diversification, where traditional crops struggle.

Action needed to materialize the feedstock potential:
▪ Establishment of a centralized collection system and a financial compensation scheme.

[164] UN FAO (2010), *Jatropha - a bioenergy crop for the poor*
[165] Rajaona et. al. (2012), *Potential of Waste Water Use for Jatropha Cultivation in Arid Environments*
[166] FOSFA (2014), *Jatropha*

2.1.5 By-products

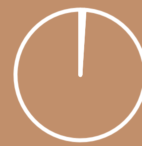
Animal fat/tallow

[167]

Included in the CORSIA framework: **yes** / no

Pathway: **✓ HEFA** / AtJ / Gasification-FT

Dry biomass share:



Potential:

Animal fats and tallow are generated as byproducts of the meat and livestock processing industry, primarily sourced from slaughterhouses, meat processing plants, and dairy farms. Given Jordan's dependence on meat imports, these byproducts are available in moderate quantities. Overall, this gives it a moderate potential.

Availability	
▪ Potential:	Low – Jordan produced roughly 19 kt of animal fat and tallow in 2023.[154]
▪ Regions	Focused on rural areas – especially in Mafraq, Karak, Zarqa.
▪ Scalability	Moderate growth – in line with the 25% livestock growth that the Ministry of Agriculture expects by 2040.[168]
Sustainability	
▪ LCA	22.5 up to 28.6 [163]
▪ ILUC	0 (Listed in ICAO CORSIA document, as a waste[163])
▪ Social/use case contest	Difficult – Competes with use in cooking and as an ingredient in traditional cuisine; for instance, it is added in the preparation of Mansaf, Jordan's national dish.
Feedstock collection	
▪ Supply chain	Moderate – Collection of animal fats and tallow is relatively well-integrated within the meat industry but requires efficient logistics and processing facilities.
Economic/market viability	
▪ Per tonne	N.A. – A higher price can be assumed, given competing use cases.

Spillover effects from feedstock use for SAF – supporting key UN SDGs

High – Supports SAF but can also generate alternative income streams for slaughterhouses and farmers, enhance efficient supply chain infrastructures, and promote responsible consumption of animal fat/tallow as a valuable by-product.

Action needed to materialize the feedstock potential:

▪ Establishment of a centralized collection system and a financial compensation scheme.

2.1.6 Residues

For the following evaluation of manure, fruit residues, and field crop residues, please consult 1.5 for further background information on the agriculture sector in Jordan. Note that vegetables are not included in the evaluation given their low dry biomass availability.

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[167] Steemit (2017), *Rendering Tallow from Sheep Fat for Sustainable Cooking*
[168] Jordan Ministry of Agriculture (2025)

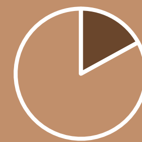
Manure

[169]

Included in the CORSIA framework: **yes** (selected) / no

Pathway: HEFA | AtJ | **✓ Gasification-FT**

Dry biomass share:



Potential:

Manure is a carbon-rich biomass with significant potential as a viable feedstock due to its high availability in Jordan and low-cost potential. However, challenges associated with the supply chain logistics and competing use cases must be considered and addressed. Overall, this gives it a high potential.

Availability	
▪ Potential:	High availability – 303 kt of dry biofuel feedstock can theoretically be obtained from 1,818 kt of annual livestock manure, mainly from poultry (55%), sheep (26%), and cattle (19%), yielding around 2,424 TJ of biofuel energy. [170, 171]
▪ Regions	Focused on rural areas – especially in Mafraq, Karak, Zarqa.
▪ Scalability	Moderate growth – Jordan's Ministry of Agriculture expects 25% growth by 2040.[172]
Sustainability	
▪ LCA	Not listed in ICAO CORSIA Document[163]
▪ ILUC	0 (Listed in ICAO CORSIA Document, as a waste[163])
▪ Social/use case contest	Manageable – Competes with manure use as heating material in rural households (mostly in Zarqa and Ajloun). In addition, manure is regarded as a viable feedstock for other waste-to-bioenergy pilots.[172] Therefore, clear coordination is required.
Feedstock collection	
▪ Supply chain	Manageable – But the fragmented and dispersed locations of farms necessitate a complex processing infrastructure.
Economic/market viability	
▪ Per tonne	Low price – at USD 15-20[172]

Spillover effects from feedstock use for SAF – supporting key UN SDGs

High - Supports SAF but can also generate alternative income streams for farmers, enhance efficient supply chain infrastructures, encourage a responsible use of raw material manure, and reduce soil and water contamination from manure currently disposed of in open and uncovered areas, where it is washed into the soil and creates environmental harm.

Action needed to materialize the feedstock potential:

- Establishment of a centralized collection system and a financial compensation scheme.
- Government support for alternative heating solutions is essential to mitigate potential social conflicts and the establishment of clear coordination between manure-to-bioenergy projects.

[169] Gardening Know How (2021), *Best Manure For Gardens – What Are Different Types Of Manure*
[170] Al-Bawwat et. al. (2023), *Availability and the Possibility of Employing Wastes and Biomass Materials Energy in Jordan*
[171] Conversion factors of manure biomass to dry manure biomass: 12% for cattle manure, 25% for sheep, goat, and poultry, data from MWPS (2012), *Manure Characteristics*
[172] Jordan Ministry of Agriculture (2025)

Fruit residues

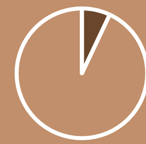
(fruit pomace/pits, pulp, skin)


[173]

Included in the CORSIA framework: yes | **no**

Pathway: HEFA | **✓AtJ** | **✓ Gasification-FT**

Dry biomass share:



Potential:

Fruit residues are biomass from fruit processing that are not converted into food products, juices, or oils. Primarily composed of olives and citrus fruits, the feedstock is dominated by carbon-rich olive pits – ideal for gasification-FT - followed by sugar-rich citrus fruit peels, which are well-suited for AtJ conversion. Key challenges include limited scalability and the need for effective collection measures. Overall, this gives it a moderate to high potential. This potential should be considered, as it is currently not a CORSIA eligible feedstock group, making it a potential candidate to be added.

Availability	
▪ Potential:	High availability – 125 kt of dry biomass can be obtained from the 886 kt of fruits harvested in 2023.[174] Mainly from olive pomace/pits (35%) and citrus fruit skins (28%) – Jordan's key fruits, followed by apricots – together yielding 1,875 TJ of energy as biofuel feedstock.[175]
▪ Regions	Focused on rural areas – mainly from the Jordan Valley and northern agricultural areas. More specifically, Jordan's olive trees grow in the north and in the rain-fed western mountains.
▪ Scalability	Low - A 2023 University of Jordan study predicts olive self-sufficiency will drop to 55% by 2050, indicating declining production, with similar declines in other fruits and residues due to climate change and water scarcity.[176]
Sustainability	
▪ LCA	Not listed in ICAO CORSIA Document[163]
▪ ILUC	0 (Listed in ICAO CORSIA Document, as a waste)[163]
▪ Social/use case contest	Moderate - Competes with the agricultural use of fruit residues. E.g. olive residues, locally known as "Jift", are used for animal feed, soil enrichment, and household heating.[177]
Feedstock collection	
▪ Supply chain	Moderate – Fruits are processed at centralized facilities, but new supply chains are needed to transport residues under updated waste regulations, including licensing for treatment.[178]
Economic/market viability	
▪ Per tonne	Moderate price – at USD 84.5 for olive residues[179]

Spillover effects from feedstock use for SAF – supporting key UN SDGs

High – Supports SAF but can also generate alternative income streams for farmers, enhance efficient supply chain infrastructures, and encourage a responsible use of fruit residues beyond "Jift", thereby preventing soil degradation, water contamination, and emissions from burning.

Action needed to materialize the feedstock potential:

- Establish a centralized collection system and a financial compensation scheme
- Implement government support for alternative heating solutions
- Development of legal frameworks for fruit residue management licensing, establish standards for fruit residue processing

[173] Alamy (n.a.)

[174] This data on dry fruit residues covers only industrial processing byproducts, while consumer-generated residues fall under Municipal Solid Waste.

[175] Khraisha (2022), *Energetic Study on Jordanian Olive Cake and Woody Biomass Materials*

[176] University of Jordan, by Prof. Jawad Al-Bakri (2023), *Changing Times For Olive Groves: The Impact Of Climate Change On Olive Cultivation in Jordan*

[177] Ayoub (2017), *Management of Olive By-Products in Jordan*

[178] The Jordan Times (2022), *Experts warn of dangerous effects of olive mill waste*

[179] Al-Bawwat et. al. (2023), *Biomass Resources in Jordan*

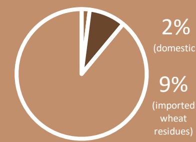
Field crop residues
(incl. husks, cobs, stalks, stover, straw)


[180]

Included in the CORSIA framework: **yes** / no

Pathway: HEFA / AtJ / **✓ Gasification-FT**

Dry biomass share:



Potential:

Rich in carbon-rich lignocellulosic materials, crop residues are available on a small scale as leftovers from local crop production and on a larger scale through husk extraction from wheat imports—the country's most processed and imported food raw material. However, husk is used in animal feed and food processing, limiting its availability. Unlocking the existing potential requires major investment in logistics for biofuel sites and farmer compensation. Overall, this gives it a moderate to high potential.

Availability	
▪ Potential:	From domestic production: low availability – 28 kt of dry biomass can be obtained from 119 kt of field crops produced in 2022, 29% from barley, 24% from wheat, 25% from maize, and 22% from other field crops such as lentils or chickpeas. From extracting husks from imported wheat: high availability – up to 170 kilotons of dry husks can be theoretically extracted from the 1,171 kilotons of wheat imported in Jordan in 2022 (imported with husks to protect the grains during transport).[181] Husk from barley – of which 1,169 kt were imported in 2022 – cannot be obtained, as the full grain is used as animal feed.[154]
▪ Regions	From domestic production: spread out – mainly grown in the northern highlands, eastern desert, and Jordan Valley. From extracting husks from imported wheat: centralized - in wheat and barley processing sites. See more info under *Supply Chain.*
▪ Scalability	Moderate growth – demand expected to rise due to Jordan's growing population and food needs. In addition, as barley husks are currently not removed before being fed to livestock, implementing this step could increase their utilization for biofuel production, though at the cost of reducing animal feed.
Sustainability	
▪ LCA	7.7 up to 29.3[163]
▪ ILUC	0 (Listed in ICAO CORSIA Document, as a waste[163])
▪ Social/use case contest	Challenging – Field crop residues, rich in fibre and minerals, are currently used as an important animal feed source and as soil enrichment and mulching material, which could pose a competition problem.[182] In addition, wheat husks, also known as bran, when milled down, are used in food processing.
Feedstock collection	
▪ Supply chain	From domestic production: Challenging – Collection and processing of crop residues for biofuel production is challenging due to the widespread and fragmented distribution of farms across the country, necessitating an efficient and well-structured collection and processing infrastructure.[183] From extracting husks from imported wheat: Manageable – Wheat is primarily milled for food production (esp. bread) in Amman (Marka Mill), Aqaba (Ayla Mill), and multiple locations in Irbid, where husks can be efficiently extracted using existing infrastructure.[184]
Economic/market viability	
▪ Per tonne	N.A. – a moderate price can be assumed given competing use cases.

Spillover effects from feedstock use for SAF – supporting key UN SDGs

High – Supports SAF but can also generate alternative income streams for farmers and wheat mills and open up new business cases from utilizing imported wheat residues, enhance efficient supply chain infrastructures, and encourage a responsible use of the raw material field crop residues.

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[180] Can Stock Photo (n.a.)

[181] Assuming that 145 kg of dry husk can be obtained from one tonne of wheat grain. From Barbieri et. al. (2019), *Recycling of raw wheat husk to manufacture magnesia cement based lightweight building materials.*

[182] FAO (n.a.), *The importance of crop residues as feed resources in West Assia and North Africa*

[183] Al-Momani and Shawaqfah (2013), *Agricultural Solids Waste in South of Jordan: Facts and Figures*

[184] Dun & Bradstreet (2025), *Grain and Oilseed Milling Companies in Jordan*

Action needed to materialize the feedstock potential:
- Establishment of a centralized collection system and a financial compensation scheme.

2.1.7 Wastes

For the following evaluation of Municipal Solid Waste (MSW), please consult 1.3 for further background information on MSW in Jordan.

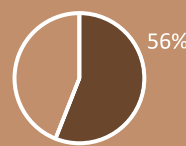
Municipal Solid Waste (MSW)

[185]
[186]

Included in the CORSIA framework: **yes** / no

Pathway: HEFA / **✓ AtJ** / **✓ Gasification-FT**

Dry biomass share:



Potential:

Municipal Solid Waste (MSW) is composed of both biogenic and non-biogenic materials, with biogenic waste accounting for approximately 68% of the total: biomass MSW, paper & cardboard MSW, and wood & yard waste. Only this biogenic fraction qualifies as CORSIA-eligible feedstock. As Jordan's population continues to grow, the volume of MSW will rise accordingly, increasing the availability of this affordable, mostly carbon-rich feedstock. This not only creates new income opportunities but also supports sustainable waste management, positioning MSW as a highly promising resource for future SAF development.

Availability	
▪ Potential:	In total: high availability – roughly 1,013 kt of dry biogenic MSW could be obtained from the 2,472 kt of biogenic MSW.[187] From biowaste: 517 kt dry waste from 1,892 kt undried biowaste, mostly food waste From paper & cardboard waste: 395 kt dry waste from 437 kt undried paper & cardboard waste From wood & yard waste: 101 kt dry waste from 143 kt undried wood & yard waste
▪ Regions	Focused on urban centres – especially Amman (which produces roughly 40% of Jordan's MSW)
▪ Scalability	Moderate/strong growth – Expected to increase in accordance with Jordan's projected population growth.
Sustainability	
▪ LCA	5.2 for biogenic MSW[188]
▪ ILUC	0 (Listed in ICAO CORSIA Document, as a waste[163])
▪ Social/use case contest	Not problematic – Jordan has a low 7% recycling rate of MSW, opening up strong use case potential of MSW for SAF biofuel production.[189]
Feedstock collection	
▪ Supply chain	Manageable – Although municipal solid waste (MSW) collection is well-established, the overwhelming reliance on landfill disposal may hinder the development of the necessary infrastructure for diverting valuable waste toward biofuel production. Additionally, the challenge of sorting different types of MSW to ensure their proper allocation to appropriate conversion processes would further complicate this effort. Extensive awareness programs and strict enforcement of regulations are required.
Economic/market viability	

[185] Photo from Green Office (n.a.)
[186] Photo from Reel (2023), *Paper Waste: Why It Matters & How to Reduce It*
[187] Data from Jordan Department of Statistics (2025), *Crops statistics*
[188] ICAO (2024), *CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels*
[189] Data from exchange with GIZ (2025)

▪ Per tonne	Low price – USD 28, weighted average across all biogenic MSW types:[190] Biowaste: low – USD 14.11 (food waste) Paper & cardboard waste: moderate – USD 84.66 (mixed paper waste), 70.55 (cardboard) Wood & yard waste: moderate – USD 42.33 (wood waste), 35.28 (compost)

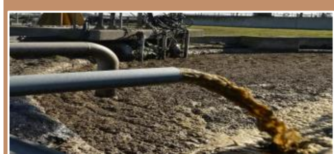
Spillover effects from feedstock use for SAF – supporting key UN SDGs

High – Supports SAF but can also: generate income from value extraction of MSW instead of disposing of it, enhance efficient supply chain infrastructures, contribute to solving Jordan's waste management problem, and promote an efficient use of biogenic waste for value and sustainable use cases.

Action needed to materialize the feedstock potential:

▪ Implementation of Jordan's National Solid Waste Management Strategy.

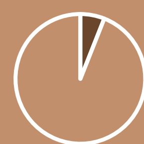
Sewage Sludge


[191]

Included in the CORSIA framework: **yes** / no

Pathway: HEFA / AtJ / **✓ Gasification-FT**

Dry biomass share:



Potential:

Sewage sludge is a carbon-rich biomass produced in large volumes and mostly disposed of in landfills, causing significant environmental issues, including high methane emissions. Repurposing it as a low-cost biofuel feedstock is a promising solution but requires extensive supply chain efforts for processing. Overall, this gives it a moderate to high potential.

Availability	
▪ Potential:	Moderate to high availability – 105 kt of dry sewage sludge can be obtained from wastewater treatment plants as a feedstock.[192] Jordan already has substantial experience using sewage sludge for biogas and methane production. The As Samra Wastewater Treatment Plant, which treats nearly 70% of the country's wastewater, generates biogas from sludge for energy recovery. Similar practices are also in place at the Shallaleh and Aqaba plants.[193]
▪ Regions	Primarily concentrated in urban centres – sourced from 29 wastewater treatment plants.[192]
▪ Scalability	Moderate growth potential – According to GIZ projections, the availability of dried sewage sludge is expected to increase to 139 kt by 2035.[192]
Sustainability	
▪ LCA	Not listed in ICAO CORSIA Document[163]
▪ ILUC	0 (Listed in ICAO CORSIA Document as a waste[163])
▪ Social/use case contest	Not problematic – In Jordan, most sewage sludge is currently stored, landfilled, or minimally used for biogas, without significant social or alternative use challenges.
Feedstock collection	
▪ Supply chain	Manageable - Sewage sludge is already aggregated in wastewater treatment plants, simplifying logistics for collection. Requires dewatering and drying, which is already considered essential steps in all wastewater treatment plants in Jordan.
Economic/market viability	
▪ Per tonne	Low price – at USD 24-30[192]
Spillover effects from feedstock use for SAF – supporting key UN SDGs	

[190] Data from exchange with Amman Vision Treatment & Recycling (2025)
[191] Green Cape (2020), *City of Cape Town's wastewater sludge quality and quantity*
[192] GIZ (2023), *Unlocking the potential of using sludge as a resource in Jordan*
[193] Data from exchange with Jordan Ministry of Environment (2025)

High – Supports SAF but can also generate income from value extraction of sewage sludge, enhance efficient supply chain infrastructures and promote innovative reuse, supporting clean water extraction and sanitation while reducing environmental costs, water contamination, and methane emissions from the dominant practice of sewage disposal in landfills.

Action needed to materialize the feedstock potential:

- Policy & Investment Support: Establish clear regulations, incentives, and public-private partnerships to promote sewage sludge-to-biofuel conversion, including subsidies and tax benefits.
- Infrastructure & Awareness Building: Invest in processing technologies, pilot projects, and stakeholder education while fostering research and innovation in sludge-to-energy conversion.

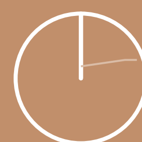
Used Cooking Oil


[194]

Included in CORSIA framework: **yes** / no

Pathway: **✓ HEFA** / AtJ / ✓ Gasification-FT

Dry biomass share:


n.a.

Potential:

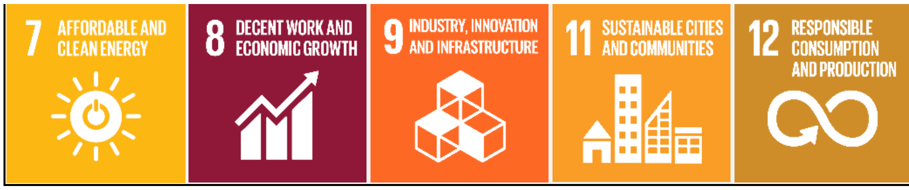
Waste vegetable oil, an oil-rich resource collected from households, restaurants, and the food industry, is expected to be available in relatively moderate quantities in Jordan. While a collection system is in place, all UCO is currently exported to the EU, limiting its potential for domestic use in sustainable fuel production.

Availability	
▪ Potential:	No data available; all exported for biofuel production outside of Jordan. Around 23 kt of UCO could be expected, based on estimated per capita output of 2.08 kg.
▪ Regions	Major urban centres – such as Amman, Zarqa, and Irbid are significant contributors to UCO production, given their dense populations and high concentration of food establishments.
▪ Scalability	Future population growth and rising food demand in Jordan are likely to significantly increase UCO output.
Sustainability	
▪ LCA	13.9 gCO_2eq/MJ[188]
▪ ILUC	0 (Listed in ICAO CORSIA Document as a waste[163])
▪ Social/use case contest	All UCO is currently exported, for higher profit.
Feedstock collection	
▪ Supply chain	The collection of UCO is feasible but necessitates the establishment of organized systems. Challenges include the need for infrastructure to collect and transport UCO from numerous small-scale producers and ensuring the quality.
Economic/market viability	
▪ Per tonne	N.A.

Spillover effects from feedstock use for SAF – supporting key UN SDGs

High – Supports SAF but can also: generate income from value extraction, enhance supply chain infrastructures and promote innovative reuse, contribute to efficient use of waste streams, and promote an efficient use of biogenic waste for value and sustainable use cases.

[194] The Western Producer (2024), *Used cooking oil seen as canola risk*



Action needed to materialize the feedstock potential:

▪ Policy & Investment Support: Introduce incentives or subsidies to make local UCO collection competitive with EU exports, or export quotas to boost local UCO collection and processing.

2.1.8 Summary of biological feedstock assessment

The following table summarizes the feedstock assessment tables in one overview. Note: Total Potential Score is the average of all category scores in the feedstock evaluation matrices, more information on calculations can be found in APPENDIX A:

Table 15. Summary of biological feedstock assessments.

#	Feedstock	Availability	Sustainability	Feedstock collection	Econ./market viability	Spillover effects	Total Potential Score
1	**Municipal Solid Waste (MSW)**	■■■■	■■■■	■■■□	■■■■	■■■■	■■■■ 3.8
2	**Manure**	■■■■	■■■□	■■■□	■■■■	■■■■	■■■■ 3.6
3	**Sewage Sludge**	■■■□	■■■□	■■■□	■■■■	■■■■	■■■□ 3.4
4	**Fruit Residues**	■■■□	■■□□	■■■□	■■■□	■■■■	■■■□ 3.0
5	**Field Crop Residues**	■■■■	■■□□	■■■□	■■■□	■■■□	■■■□ 3.0
6	**Used Cooking Oil**	■■□□	■■■□	■■■□	■□□□	■■■■	■■■□ 2.6
7	**Jojoba**	■■□□	■■■□	■□□□	■□□□	■■■□	■■□□ 2
8	**Jatropha**	■■□□	■■□□	■□□□	■□□□	■■■□	■■□□ 1.8
9	**Animal fat/tallow**	■□□□	■□□□	■■□□	■□□□	■■■□	■■□□ 1.6

<u>Feedstock to SAF pathway matching</u>

The following Table 16 assigns each shortlisted feedstock to its most suitable SAF conversion pathway, based on its biomass characteristics. For reference on the relationship between biomass characteristics and SAF conversion pathways, see Table 12.

Table 16. Matching of analysed promising feedstocks to production pathways.

Category	Feedstock	Pathway(s)	Notes
Main product	Jatropha oilseed	HEFA	Please note that given the lack of data on availability, Jatropha is not included in further quantitative modelling.
	Jojoba oilseed	HEFA	Please note that given the lack of data on availability, Jojoba is not included in further quantitative modelling.
By-product	Tallow	HEFA	

	Beef tallow	HEFA	
	Poultry fat	HEFA	
	Mixed animal fat	HEFA	
Residues (Agriculture)	Field crop residues (incl. husks)	AtJ	
	Manure	AtJ	
	Fruit residues	AtJ / Gas-FT	
Residues (Processing)	Sewage sludge	AtJ	
Waste	Municipal Solid Waste (MSW)	AtJ / Gas-FT	
	Used Cooking Oil (UCO)	HEFA	Please note that given the lack of data on availability, UCO is not included in further quantitative modelling
	Waste gases	-	Assessed under 2.2.

The following Figure 33 summarizes the attribution of feedstock to the most suited SAF feedstock-to-fuel conversion pathway. This attribution is based on the availability results of the previous individual feedstock-by-feedstock analysis and the composition of the feedstock, making them more suited to one pathway or another.

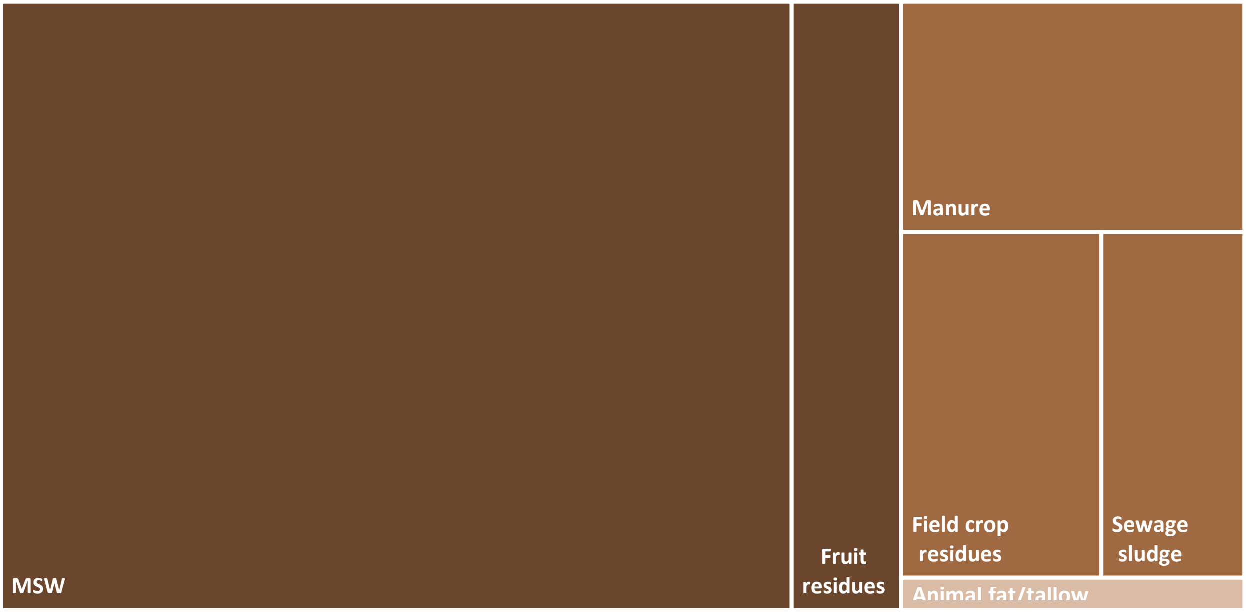


Figure 33. Distribution of feedstock availability per feedstock characterization.

Table 17 further classifies the share of the three main technology pathways in Jordan's biomass feedstock potential.

Table 17. Attribution of feedstock groups to suitable SAF conversion pathways.

Feedstock group	Suitable pathway(s)	Share of total biomass (1,804 kt)[195]
Biomass rich in lipids	→ HEFA	2%
Biomass rich in carbon	→ Gasification-FT	34% to 98%
Biomass rich in carbon and fermentable sugars	→ Gasification-FT	
	→ AtJ	0% to 64%

Gasification-FT emerges as the most suitable conversion pathway due to the high availability of carbon-rich biomass feedstock, such as manure, field crop residues, and sewage sludge, accounting for about 34% of total biomass. The largest feedstock groups, MSW and fruit residues, are more heterogeneous, containing both carbon-rich and sugar-rich fractions. This allows up to 98% of total feedstock to be suitable for gasification-FT, while potentially unlocking 34% for AtJ. In contrast, HEFA lags due to the limited availability of lipid-rich feedstocks like animal fat and tallow.

While the dominance of carbon-rich feedstocks suggests that prioritizing gasification-FT could support the scale-up of SAF production, further analysis is needed. Concentrating efforts on this single pathway may enable economies of scale – such as reduced unit production costs, more efficient infrastructure use, and simplified logistics. However, this assessment is based solely on feedstock availability and does not account for differences in feedstock-to-SAF conversion efficiencies or the cost of SAF production per pathway. Additional analysis is needed to evaluate the techno-economic feasibility of gasification-FT compared to alternative pathways, considering regional feedstock distribution, lifecycle emissions, and potential policy or market incentives.

At this stage, the analysis proceeds with a high-level assessment of total biomass feedstock availability against Jordan's annual jet fuel demand for biofuel production, while 3.2.1 will provide a broad indicative outlook on production cost per pathway.

<u>Summary of available biomass for SAF biofuel production</u>

In total, the feedstock assessment evaluation concludes that Jordan has roughly 8,144 kt of biomass available per year from domestic production, yielding roughly 1,634 kt of dry biomass with potential to be used for SAF biofuel production. In addition, the potential of 1,171 kt of wheat imported, resulting in possible 171 kt of wheat husk residues, could also be used. In total, this study estimates than an annual biomass inventory of approximately 9,315 kt is available in Jordan. This estimation aligns closely with the approximately 9,500 kt that the International Renewable Energy Agency (IRENA) suggests as Jordan's total annual biomass availability.[196] It is important to note that some biomasses have a higher yield after moisture reduction and the reduction to their residue and waste fractions.[197]

[195] Only considers the feedstock groups for which reliable data on annual quantify could be retrieved (this excludes Jojoba, Used Cooking Oil)

[196] Interpolation, based on data from IRENA (2024), *Energy Profile Jordan*

[197] The biomass to dry biomass residue & waste conversion factors for fruit trees, field crops, vegetables, and for manure are based on Al-Bawwat et. al. (2023), *Biomass Resources in Jordan, for more information see Figures 20 and 21.* For

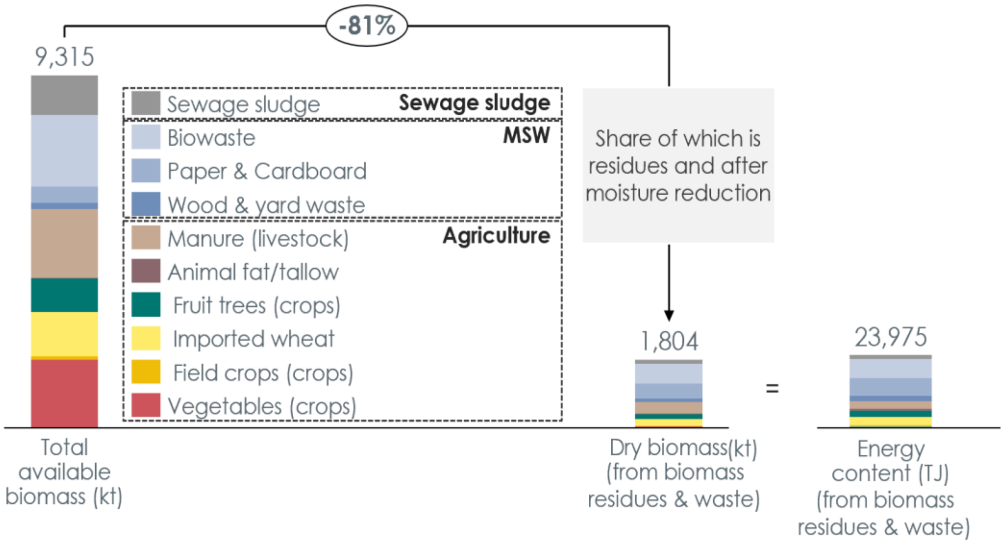


Figure 34. Jordan's 2023 biomass availability and its dry biomass yield for SAF production, in kt.[198,199]

A total of 1,804 kt of dry biomass roughly translates to an energy content of 23,975 TJ. In comparison, the country's jet fuel demand in 2023 (roughly 260 kt) had an energy content of approximately 10,790 TJ. This suggests that, in theory, Jordan could produce about half of its annual jet fuel needs through biofuel SAF. It is important to note that this scenario assumes an ideal situation where the entire biomass potential is utilized exclusively for SAF production.

However, not all of this jet fuel energy potential can be used for biofuel SAF production, given losses in the collection, storage & transport, and feedstock-to-fuel conversion processes. The following Table 18 provides an overview of the extent of losses in each value chain step for the different biofuel SAF conversion pathways.

MSW only the moisture reduction is relevant/considered: MSW to dry MSW conversion reduction factors – in %: for biowaste 65 - 80%, for paper & cardboard 5 – 15%, for wood & yard waste 30%. Factors from Sensing (2017), *Application of Remote Sensing Technologies for Assessing Planted Forests Damaged by Insect Pests and Fungal Pathogens: a Review*; EPA (2025), *National Overview: Facts and Figures on Materials, Wastes and* Recycling; Siddiqui (2022), *Seasonal Characterization and Possible Solutions for Municipal Solid Waste Management in the City of Patna, Bihar, India.* For sewage sludge only moisture reduction is relevant/considered, conversion reduction factor – in %: 90%. Factor from Home Engineering (n.a.), *Sludge processing and disposal*

[198] See sources on previous pages.

[199] Conversion of dry biomass to energy content: Sewage Sludge (~12 GJ/t) data from from IEA (2017), *Energy from Sewage Sludge: Overview of policies and opportunities*; Biowaste MSW (~12 GJ/t) data from EEA (2013), *Technical report No 2/2013, Managing municipal solid waste—a review of achievements in 32 European countries*; Paper & Cardboard MSW (~15 GJ/t) data from UN FAO (2004), *FAO Forestry Paper 154, Unified bioenergy terminology;* Wood & Yard Waste MSW (~18 GJ/t) data from The Engineering Toolbox (n.a.), *Biomass Energy Units;* Manure (~8 GJ/t) data from Kuligowski and Luostarinen (2011), *Thermal Gasification of Manure;* Dry Animal Fat (~38 GJ/t) data from Feedtables (n.a.), *Tallow Values;* Fruit Tree Crops (~15 GJ/t) Field Crops (~17 GJ/t) Vegetables (~14 GJ/t) data from Karaca (2022), *The potential of agricultural residues in the districts of Adana;* Wheat Husks (~15 GJ/t) data from the Energy Transitions Commission (2021), *Bioresources within a net-zero emissions economy.*

Table 18. Feedstock-to-SAF conversion losses.

Step Per SAF conversion pathway	1 Feedstock Collection	2 Pre-treatment	3 Conversion to Intermediates	4 Dehydration	5 Fischer-Tropsch Synthesis	6 Refining	7 Refining	8 Blending	9 Compliance with SAF certification	10 SAF distribution	11 SAF use MRV
		(essential for HEFA only)	(AtJ & gasification-FT only)	(AtJ only)	(Gasification-FT & PtL only)	(adjusting hydrocarbons)	(fractionation into jet fuel range)	(for standalone processed SAF)		(to airports & sales)	(Monitoring, Reporting, Verification)
Losses	Losses during collection, storage, and treatment of feedstock		Processing losses, from feedstock to distillate through SAF conversion processes			Share of jet fuel that (jet fuel range) that can be obtained from distillate		Not considered to maintain comparison to measurement of fossil jet fuel availability in conventional value chain			
HEFA	**Loss rates vary by feedstock and method:** agricultural residues face higher losses than centralized waste (e.g., MSW). **Collection inefficiencies** include incomplete recovery and environmental degradation. **Storage losses** stem from microbes, moisture, and pests. **Transport losses** include spillage, compaction, and degradation—worse for low-density feedstocks.		**Relatively high, ranging from 60% to 80%.**[146]			**Roughly 55%**[146]					
AtJ			**Conversion efficiencies typically ranging from 60% to 75%** (influenced by factors such as the type of feedstock ethanol or isobutanol), the specific microorganisms used for fermentation, and AtJ process execution)[146]			**Roughly 70%**[146]					
Gasification-FT			**Typically ranges from 14% (for agriculture residues) to 31% (for MSW).** (Significant losses occur during syngas production and cleaning, as well as during the Fischer-Tropsch synthesis, where a broad distribution of hydrocarbon products is generated, necessitating further refining to obtain the desired jet fuel fraction.)			**Roughly 40%**[146]					
Losses per step	**Total assumed loss: 20%** (conservative estimate)		**Total assumed loss: 50%** (conservative estimate that considers an equally weighted average across HEFA, AtJ, gasification-FT)			**Total assumed loss: 55%** (conservative estimate that considers an equally weighted average across HEFA, AtJ, gasification-FT)					
Losses of all steps	Total loss across all steps: 82%										

In total, an energy loss of 82% can be assumed (depending on the share of HEFA, AtJ, gasification-FT), resulting in a drop from 23,975 TJ to 4,316 TJ. 4,316 TJ correspond to 40% of Jordan's 2023 jet fuel demand.

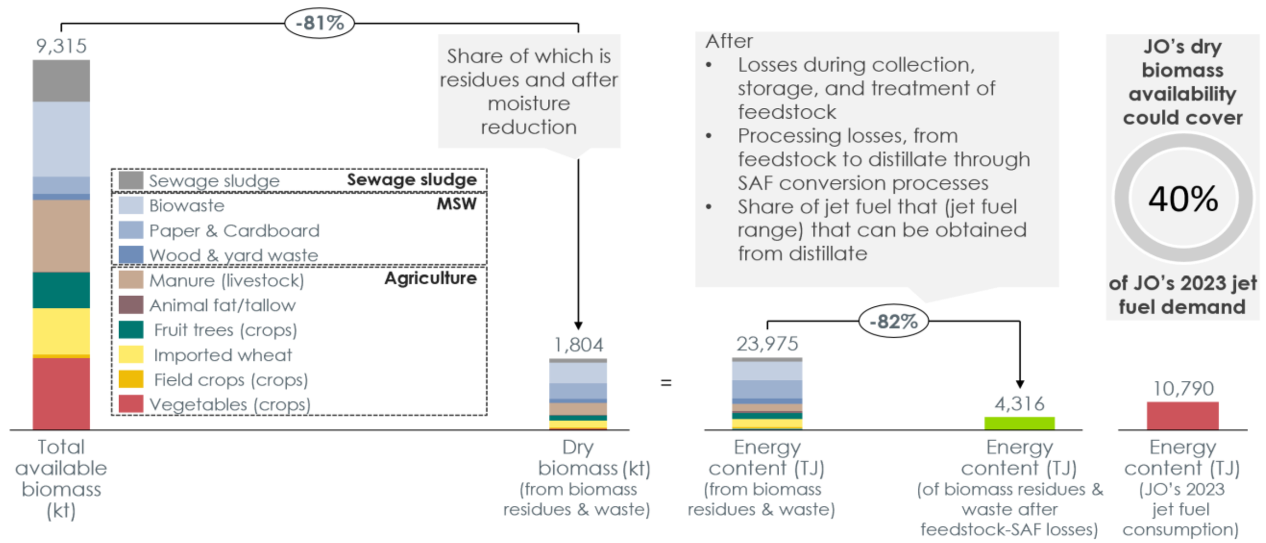


Figure 35. Summary of potential biomass availability for jet fuel.

Against the 2023 jet fuel demand energy content of 10,790 TJ: out of the 23,975 TJ energy content from total biomass residues and waste, roughly 4,316 TJ remain after losses. Based on this it can be summarized, that Jordan's total biomass availability – after (1) the reduction to its dry biomass residue & waste share, and (2) after losses – can cover roughly 40% of its 2023 jet fuel demand, when converted to biofuel SAF.

Key takeaways for SAF potential in Jordan

It can be summarized that biofuel SAF holds strong potential to support the decarbonization of Jordan's aviation sector and to make a significant contribution while generating added value through co-benefits such as improved MSW and the creation of new income streams from feedstock utilization and supporting UN SDGs. However, to achieve a more scalable and sustainable long-term solution, Jordan should also harness its abundant renewable energy resources to develop PtL SAF, thereby further maximizing added value across the energy and aviation sectors.

2.2 POWER-TO-LIQUID SAF

Power-to-Liquid (PtL) fuels, also known as synthetic fuels[200] or e-fuels (with "e" representing electricity), are fuels produced from green energy rather than biomass.

2.2.1 Summary and evaluation of PtL SAF conversion processes

PtL requires electricity (renewable electricity to be labelled sustainable), water for electrolysis to produce hydrogen, and carbon dioxide (CO_2) captured from industrial sources, direct air capture, or biomass. The hydrogen and CO_2 form a syngas that is synthesized via Fischer-Tropsch or methanol synthesis to produce synthetic fuels like kerosene, diesel, gasoline, or SAF.

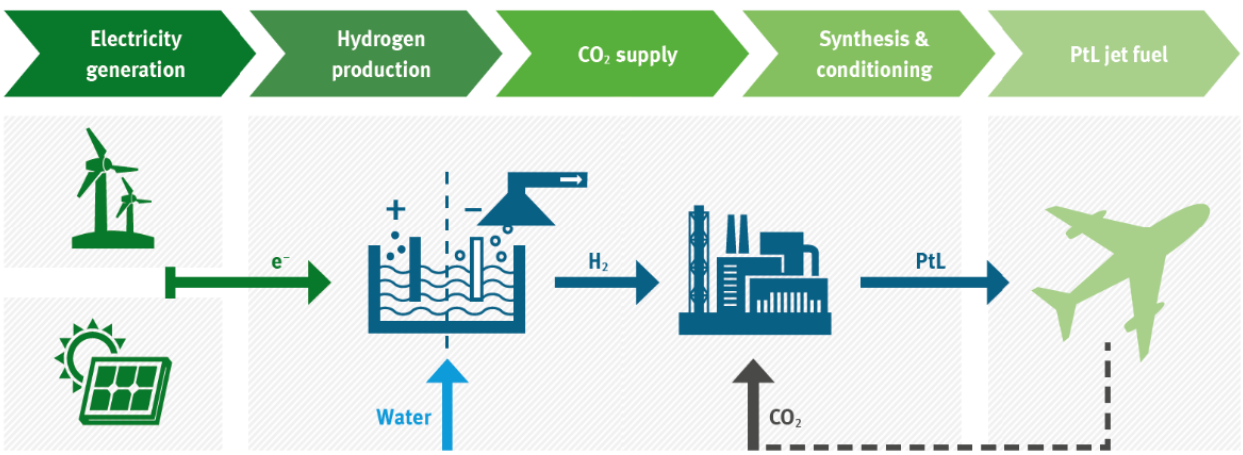


Figure 36. Production process of PtL SAF.[201]

PtL SAF produced through this process is drop-in compatible and, when produced via the Fischer-Tropsch conversion method, is already approved for aircraft use by ASTM. Given Jordan's high-level renewable energy potential, PtL is a promising pathway for domestic SAF production. However, this potential must be viewed

[200] Synthetic is a technical term that does not originally refer to renewable fuels, for example jet fuel synthesised from natural gas or coal. For clarity, in this report PtL is used.

[201] ICAO (2025), *GFAAF – Initiatives & Projects*

with respect to PtL's (1) commercial availability, including technological maturity, cost, and scalability (2) energy and hydrogen requirements during PtL SAF production and (3) its distinct emission reduction potential. The following summary represents the status quo in 2024:

1. **Commercial availability: technological maturity, cost, and scalability of biofuel conversion pathways:**

   PtL is in a commercial development phase, with a TRL of 5-8.[202, 203] There are roughly 27 PtL plants operating, planned, or under construction worldwide.[146] The cost level of fuel output remains high compared to SAF biofuel pathways given the lower commercial maturity. Feedstock availability is significantly higher than for SAF biofuel pathways given their biomass constraints. The primary challenge for scaling up PtL production commercially remains its higher production cost and sourcing of CO_2.

2. **Production: operating energy and hydrogen requirements of conversion pathways:**

   PtL has much higher energy- and hydrogen requirements compared to biofuel SAF pathways: Significant amounts of renewable electricity are needed for electrolysis, which splits water into green hydrogen and oxygen. CO_2 – whose provision requires significant energy for the underlying carbon capturing process – along with H_2, is then combined in the Fischer-Tropsch process to produce synthetic fuel. Roughly 540-750 kg of hydrogen are required per tonne of PtL SAF produced[144] and roughly three tonnes of captured CO_2.[204]

3. **Emission reduction potential compared with conventional jet fuel:**

   PtL SAF offers a significant life-cycle emission reduction of up to 99%[144] compared to conventional fossil aviation fuel while utilizing water and land more efficiently than biomass-based aviation alternatives. It is important to note that for this emission reduction, green hydrogen is required. Additionally, PtL fuels can burn cleaner as they contain fewer impurities compared to conventional jet fuels and biofuel SAFs, producing fewer particulate emissions that contribute to contrail formation. Contrails, short for condensation trails, are streaks of cloud that can form behind airliners when water vapor from jet engine combustion freezes at high cruising altitudes on soot or nitrogen particles, which originate from the jet engine. These contrails are being assessed[205] as a non-CO_2 key factor in aviation's net warming effect on the climate.[206]

In conclusion, PtL SAF has the highest energy and hydrogen demand compared to other pathways. However, it offers a highly scalable and feedstock-flexible long-term solution for SAF when powered by renewable energy.

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[202] EASA (2025), *SAF Developments*
[203] TRL of PtL has 5-8 spread because its underlying process technologies, such as electrolysis and carbon capture, have varying TRLs. For instance, more advanced electrolyzer technology, like Solid Oxide Electrolyzer Cells (SOEC), has a lower TRL of 6 compared to commercially available Protone Exchange Membrane Electrolysis (PEM).
[204] UKRI (2025), *Sustainable Aviation Fuel: Power-to-Liquids*
[205] ICAO (2025), *Non CO_2 Aviation Emissions*
[206] Contrails can significantly impact the climate by trapping outgoing infrared radiation, deflecting it back toward Earth's surface and thereby heating the atmosphere. According to a 2024 study from Imperial College London, which analyzed comprehensive 2019-2021 data from EUROCONTROL, the warming effect of contrails can be up to three times greater than the global warming effect of aviation CO_2 emissions alone. From
Teoh et al (2024), *Global Aviation Contrail climate effects from 2019 to 2021*

2.2.2 Evaluation of PtL SAF feedstocks

PtL requires both green hydrogen and captured carbon as input materials, analyzed below.

Green Hydrogen

[207]

Included in the CORSIA framework: yes / no

Pathway: ✓HEFA, ✓AtJ, ✓ Gasification-FT, ✓ PtL

Potential:

Hydrogen is required for all SAF conversion processes, with the highest demand in PtL production. Jordan offers a cost-effective and scalable opportunity for green hydrogen production. However, due to long lead times, high investment costs, and complex safety requirements, Jordan is unlikely to tap into its significant low-cost hydrogen production potential before the 2030s. Once operational, environmental concerns must be addressed, including the impact of desalination on ecosystems, the prioritization of water use, and ensuring sufficient renewable electricity to produce truly green hydrogen. If these challenges can be effectively managed, Green Hydrogen presents significant potential as a key SAF feedstock for Jordan.

Availability	
▪ Potential:	High – Jordan plans to produce 600 kt of green H_2 by 2030, 1,500 kt by 2040, and 3, 400 kt by 2050, out of which 100 kt, 500 kt, and 1,100 kt respectively are earmarked for domestic use and processing.
▪ Regions	Concentrated in the South – Jordan's Green Hydrogen strategy plans locate desalination and electrolysis for green hydrogen production in Aqaba.
▪ Scalability	Highly scalability from a Green H_2 production point of view – But dependent on sufficient renewable electricity and water supply.
Sustainability	
▪ LCA	Not listed in ICAO CORSIA Document[163]
▪ ILUC	Not listed in ICAO CORSIA Document[163]
▪ Water/marine life impact	Challenging – The GIZ warns that large-scale water extraction from the small Gulf of Aqaba could lead to salinization if countermeasures are not taken to reduce salt inflow from desalination, if no appropriate countermeasures are taken to dispose of the highly concentrated saline residue (brine) from desalination.[208, 209]
▪ Social/ competing use	Production: not challenging – The green hydrogen strategy plans for dedicated desalination capacity to serve its 5 million cubic meters (MCM) of water required by 2030, 10 MCM by 2040, and 32 MCM by 2050. This shall avoid use case competition over the precious resource water that can come from additional desalination capacity to serve Jordan's growing water needs to serve agricultural, civilian, and industrial needs. On the demand side: challenging – Green hydrogen in Jordan can be exported without added value or used domestically for higher-value applications like green ammonia for agriculture or alternative shipping fuels, creating competing use cases against its use for PtL SAF production.
Feedstock collection	
▪ Supply chain	Manageable – Desalination capacity is planned in Aqaba, in addition to local electrolyze capacity. This could make local hydrogen-to-SAF production suitable. Long-distance hydrogen transport faces challenges from high costs, energy losses, storage issues, and current infrastructure limitations.
Economic/market viability	

[207] Photo from Vernick (n.a.),

[208] Information from call with GIZ/PtX Hub (2025)

[209] The Gulf of Aqaba only has a narrow outflow connection to the Red Sea, which restricts water exchange and facilitates the gradual accumulation of salt over time

▪ Price per tonne	Low – The Green Hydrogen Strategy targets levelized cost of hydrogen production of 3.2 USD/kg by 2030 and 2.2 USD/kg by 2040, which can provide Jordan an edge in cheap green H_2 production. However, substantial initial capital expenditures are required to scale hydrogen production (USD 28.5 billion by 2030, USD 78.5 billion by 2040, USD 175 billion by 2050).

Spillover effects from feedstock use for SAF – supporting key UN SDGs

Supports SAF but can also: strongly support Jordan's energy dependency and thereby economic diversification and prosperity, drive innovative technologies like electrolysis, benefit from additional value extraction from desalination residue "brine" contains valuable raw materials that could be gathered (including Lithium, and Vanadium),[210] and enhance international cooperation (green hydrogen endeavour is supported by international partners like the EU and development banks).

Action needed

▪ Policy and investment support: SAF should be implemented as a key development pillar in Jordan's Green Hydrogen Strategy

Captured CO_2


[211]

Included in the CORSIA framework: yes / no

Pathway: ✓HEFA | ✓AtJ | ✓ Gasification-FT | ✓ PtL

Potential:

CO_2 for PtL SAF can come from three main sources: industrial emitters, biogenic sources, and atmospheric capture. In Jordan, industrial sources are the most practical option, offering steady, high-volume CO_2 that is relatively easy to capture. Biogenic sources like wastewater treatment, landfill gas, and agricultural renewable are renewable but smaller and more scattered, making collection more complex and challenging considering competing biomass use cases. Direct Air Capture (DAC) is a future possibility but remains too costly and energy-intensive for now.

Availability	
▪ Potential:	Moderate - Jordan's CO_2 emissions are concentrated in key industrial sectors, offering promising capture opportunities. The cement industry alone contributes a significant share of national emissions. Additional potential exists in fertilizer production, oil shale processing, and possibly biogenic sources like wastewater treatment and agricultural waste digestion.
▪ Regions	Jordan's major CO_2 sources are clustered around Zarqa, Fuheis, and Rashadiyah (cement), and in the south near Ghor Al-Safi and Al Shidiya (potash and phosphate). These sites are ideal for co-locating PtL facilities. Smaller, distributed biogenic sources exist near Amman, Irbid, and the Jordan Valley.
▪ Scalability	Potentially challenging – Large PtL SAF production in Jordan may require CO_2 beyond domestic industrial sources to meet full-scale PtL domestic production and export-oriented demand.
Sustainability	
▪ LCA	Not listed in ICAO CORSIA Document[163]
▪ ILUC	0 (Listed in ICAO CORSIA Document as a waste[163])
▪ Social/use case competition	Biogenic CO_2 capture in Jordan may create competition with biofuel production, as limited biomass availability constrains the supply of feedstocks for both pathways.
Feedstock collection	
▪ Supply chain	Jordan lacks CO_2 pipelines and capture facilities, so PtL plants might need to be co-located with major emitters to keep transport costs low. For now, CO_2 can only be transported by road.
Economic/market viability	

[210] Khalil et. al. (2022), *Lithium recovery from brine: Recent developments and challenges*

[211] Pentair (n.a.), *Liquid CO_2 Storage Tanks*

▪ Price per tonne	Prices vary - Reflecting the dynamic development potential and variations in commercial readiness: <u>From industrial point sources:</u> 25–100[212] depending on the process/industry <u>From biogenic sources:</u> 150–300[213] <u>From DAC</u> 600–1,000[213]
Spillover effects from feedstock use for SAF – supporting key UN SDGs	
Supports SAF but can also: accelerate net-zero emission efforts and promote the development of low-carbon technologies, enable circular carbon use by turning emissions into valuable inputs, directly cut emissions in hard-to-abate sectors like aviation and cement, and contribute to a cleaner energy mix through integration with renewable hydrogen.	

Action needed
▪ Policy and investment support: captured carbon capacity and import potential should be investigated in line with assessing Jordan’s long-term PtL potential.

<u>Key takeaways for SAF potential in Jordan</u>

PtL SAF has the potential to provide Jordan with a highly scalable, low-emission aviation fuel solution by leveraging the country’s strong renewable energy and green hydrogen potential. However, its success depends on overcoming high production costs, energy and water demands, CO_2 sourcing and transport challenges, and the timely implementation of Jordan’s Green Hydrogen Strategy, including infrastructure, policy support, and environmental safeguards. As a rapidly evolving field, with PtL plants beginning to emerge globally, it requires continuous monitoring of technological, regulatory, and market developments.

[212] NETL (2022), *Cost of Capturing CO_2 from Industrial Sources*
[213] ICIS (2023), *Next generation of fuels to be made out of thin air*

SECTION 3. IMPLEMENTATION SUPPORT AND FINANCING

SAF holds significant potential to reduce emissions in the aviation sector. However, realizing this potential requires coordinated action from policymakers, financiers, and stakeholders across the entire SAF value chain.

On a global level, stakeholders in both the energy and aviation industries have currently limited hands-on technical experience with SAF, given its status as an emerging technology. This limited experience is further complicated by the inherent complexity of SAF, which spans feedstock sourcing, conversion, and distribution, and is subject to stringent criteria for qualifying as CORSIA Eligible Fuels (CEF). This requires robust monitoring, reporting, and verification (MRV) practices to ensure sustainability across the full value chain. To manage these challenges, stakeholders need to build technical knowledge and establish clear regulations, both essential for developing functional and sustainable SAF value chains. It is also crucial to mobilize private sector actors and secure funding to realize projects. While many measures to address SAF challenges are broadly applicable across countries, it is essential that responses are also customized to reflect Jordan's unique circumstances.

To address these specific circumstances, the feasibility study project included a series of in-person and online meetings with a wide range of stakeholders, both within Jordan and internationally. Participants included representatives from research institutions, government ministries and public authorities, as well as the energy and aviation sectors, and potential financiers. A complete list of these interactions is provided in. Building on the outcomes of these discussions and supported by further research, the findings in SECTION 3 are structured in two steps. Step one assesses the level of technical knowledge and the readiness of policy support for SAF implementation, forming the basis for identifying appropriate implementation support options. Step two provides an approximation of the investment volumes required for SAF deployment, based on a cost analysis of SAF in Jordan, serving as the foundation for actionable policy recommendations to address financing needs in this feasibility study.

3.1 IMPLEMENTATION SUPPORT FOR SETTING UP A FUNCTIONAL SAF VALUE CHAIN

On a general level, renewable fuels currently only play a negligible role in Jordan's energy mix. According to the IEA, biofuels and waste as energy sources accounted for just 1.1% of Jordan’s total final energy consumption in 2022. Of this, approximately 75% was used in the residential sector, primarily through traditional practices such as burning firewood, agricultural residues, or animal manure - particularly for cooking and heating in rural and low-income communities.[214] While these are long-standing methods of biomass use, large-scale biomass-to-energy solutions, such as biofuels, remain untapped in Jordan. Nonetheless, Jordan is actively exploring opportunities to expand the use of biomass for energy. Recent

[214] IEA (2023), *Countries & Regions – Jordan: Share of Renewables in Energy Consumption*

feasibility studies on the use of agricultural residues and manure for biogas production have shown promising potential for further development.[215]

With this background, Jordan stands at the starting point of shaping its SAF future. The country can leverage a series of actions to optimize its development pathway, starting with building technical expertise across stakeholders and extending to securing funding for the full build-out of a SAF value chain: from feedstock collection and renewable fuel production to infrastructure development, delivery to airports, and end use.

3.1.1 Implementation support needed

Jordan can benefit from assistance to drive the following actions towards setting up a SAF value chain:

I. **Capacity building and technical training** to develop knowledge on feedstock collection logistics, SAF conversion processes and blending with conventional jet fuel, and SAF end use and reporting.
II. **Support for regulatory frameworks and legislative policies** to steer the effective and safe processing of feedstocks and handling of SAF up to end use.
III. **Public-Private Partnerships** to mobilize resources and kickstart the development and operation of SAF infrastructure and services.
IV. **International cooperation** to draw on lessons learned from neighbouring countries and to build a regional pool of expertise and collaboration benefiting multiple nations.
V. **Investment support** to finance the set-up of a SAF value chain.

I. Capacity Building and Technical Training

With SAF being a nascent technology that brings together stakeholders across the value chain – many of whom have not traditionally worked together (e.g. agriculture producers or MSW landfill operators with airlines) – it is important to develop a common understanding across stakeholders of:

- The logistical processes and technical equipment requirements for feedstock collection and handling.
- The technical principles behind different conversion technologies, along with their advantages and disadvantages.
- The blending process and transport logistics to deliver SAF to end users.
- The final use and reporting mechanisms of SAF consumption by airlines.
- The economics behind feedstock sourcing and the SAF cost premium compared to conventional jet fuel, as well as the technical properties of SAF.

These aspects span the entire SAF value chain, with some steps requiring new technical skills and equipment, while others can build on existing infrastructure and knowledge of the existing fossil jet fuel value chain. The following chart provides a step-by-step overview of the SAF value chain and takes stock of which new competencies and equipment needs exist in Jordan at each step. Please find more information and explanation of the individual production steps 2-8 under 2.1.1.

[215] Examples include a *Feasibility Study for a Biogas Plant in Jordan*, conducted by Alhammad (2019), from the Department of Animal Production in Jordan's Ministry of Agriculture

Table 19. Competence needs across SAF value chain steps, existing capabilities in bold/green and new capabilities in italics/red.

Existing competencies & equipment — **New competencies & equipment needed**

Step Per SAF conversion pathway	1 Feedstock Collection	2 Pre-treatment	3 Conversion to Intermediates	4 Dehydration	5 Fischer-Tropsch Synthesis	6 Refining	7 Refining	8 Blending	9 Compliance with SAF certification	10 SAF distribution	11 SAF use MRV
		(essential for HEFA only)	(AtJ & gasification-FT only)	(AtJ only)	(Gasification-FT & PtL only)	(adjusting hydrocarbons)	(fractionation into jet fuel range)	(for standalone processed SAF)		(to airports & sales)	(Monitoring, Reporting, Verification)
HEFA	*Collection of lipid-rich biomass (fats & oils)*	*Cleaning oils & fats to remove impurities*	-	-	-	Hydroprocessing and upgrading of pre-treated oils & fats. Available as a **coprocessing** or *standalone* option	**Separation into jet fuel-range fractions**	*Blending with fossil fuel prevents exceeding limit for SAF share in final fuel*	**Produced fuel must comply with ASTM or Def-Stan certification standards**	**Transport and selling of jet fuel**	*Airlines report SAF use to authorities to claim emission reductions* *reductions*
AtJ	*Collection of biomass rich in fermentable sugars*	-	*Fermentation into alcohols (ethanol or butanol)*	*Removing water from alcohols to form olefins*	-	*Oligomerization and hydrogenation of olefins*	**Separation into jet fuel-range fractions**	*Blending with fossil fuel prevents exceeding limit for SAF share in final fuel*	**Produced fuel must comply with ASTM or Def-Stan certification standards**	**Transport and selling of jet fuel**	*Airlines report SAF use to authorities to claim emission reductions*
Gasification-FT	*Collection of carbon-rich materials*	-	*Gasification of feedstock into syngas*	-	*Converting syngas into hydrocarbons*	Upgrading hydrocarbons. Available as a **coprocessing** or *standalone* option	**Separation into jet fuel-range fractions**	*Blending with fossil fuel prevents exceeding limit for SAF share in final fuel*	**Produced fuel must comply with ASTM or Def-Stan certification standards**	**Transport and selling of jet fuel**	*Airlines report SAF use to authorities to claim emission reductions*
PtL	*Green H_2 and captured CO_2*	-	*Producing syngas from H_2 and CO_2*	-	*Converting syngas into hydrocarbons*	*Upgrading hydrocarbons*	**Separation into jet fuel-range fractions**	*Blending with fossil fuel prevents exceeding limit for SAF share in final fuel*	**Finished fuel to adhere to ASTM or Def-Stan certification standard**	**Transport and selling of jet fuel**	*Airlines report SAF use to authorities to claim emission reductions*

The conversations with stakeholders, supported by further research, served as the basis for assessing their knowledge levels and readiness at each step of Table 19.

Steps 1-5: feedstock collection and treatment into SAF conversion processes are not established in Jordan, and technical expertise in those fields is not widespread. Table 20 provides an overview of actions that can be taken within step 1. It is important to note that further techno-economic analysis is recommended to provide further refinement and details on how each step can be implemented in practice.

Table 20. Guidelines for establishing a system to collect, sort, and evaluate feedstock.

Feedstock Type	**1. Feedstock Collection** (description of sub-steps)			Characteristics		
	1.1. Collection	1.2. Sorting/ Processing	1.3. Quality Check	Seasonal availability	Processing duration	Synergies across feedstocks?
Sewage Sludge	Collected from wastewater treatment facilities (e.g As-Samra) in covered containers, transported by trucks	Remove unwanted items (e.g. waste & sand), then squeeze out water (most common technique is centrifuges)	Test moisture level & unwanted material residues. Follow Jordanian regulation[216]	Year-round	Short-term – process quickly or store in sealed tanks	Low – Needs specific equipment & safety steps
MSW – Biowaste	Collected from green bins in residential areas, markets & restaurants, offices. Esp. in urban centers	Remove unwanted items (esp. plastics, cans) at waste processing center and separate from other MSW for SAF use	Ensure material is predominantly plant or food waste at required level	Year-round – peaks during periods of high tourist activity	Short-term – process quickly	High – Collection & transport similar to paper & cardboard MSW. Sorting equipment & testing for moisture/quality similar to vegetable waste
MSW – Paper & Cardboard	Collected from bins in residential areas, shops & offices. Esp. in urban centers	Remove plastics, coatings, & dirty or wax-covered paper at waste processing center and separate from other MSW for SAF use	Ensure paper fiber quality & max moisture level	Year-round	Medium-term – keep dry until processed	High – Collection & transport similar to biowaste MSW. Sorting can share wood & yard waste infrastructure
MSW – Wood & Yard Waste	Picked up from homes, landscaping work, & green waste drop-off points	Remove paint, nails, stone, plastic. Chip to smaller pieces at waste processing	Check water content, chemical contamination, & piece size	Year-round,	Medium- to long-term – store dry	High – Collection, sorting, & quality checks are similar to paper & cardboard waste MSW

[216] Jordan Ministry of Agriculture (2022), *Instructions and Conditions for the Use of Treated Wastewater, Brackish Water, and Saline Water for Agricultural Uses, No. 16 of 2022)*

		center and separate from other MSW for SAF use				
Agricultural Residues – Manure	Collected from livestock farms (esp. in Mafraq, Karak, Zarqa). Compensate farmers for supply	Remove bedding, stones, plastic, & other unwanted items	Check moisture, cleanliness, & odor, & follow safe handling rules. Follow Jordanian regulation[217]	Year-round	Short-term – cover to limit odor & loss	Low – Wet, messy, & germ-heavy, so it's handled differently from plant materials
Agricultural Residues – Animal Fat/Tallow	Collected from slaughterhouses (esp. in Mafraq, Karak, Zarqa). Keep cold during transport. Provide compensation for supply	Heat & filter to remove unwanted items (bones & meat particles)	Check fat quality, ensure water level & contamination with unwanted materials is low	Year-round, peaks during Eid al-Adha	Short-term – process quickly or keep cool	Low – Needs specific heating, filtering, Cold storage & dedicated tanks. May share this with future jojoba & jatropha collection, processing, & quality control
Agricultural Residues – Fruit Tree Crop Residues	Collected from harvesting & subsequent crop processing sites (mostly in Jordan Valley & northern agricultural areas	Separate hard woody bits from softer waste. Grinded to smaller pieces	Check water content, natural chemicals, & signs of pests or rot	Seasonal, during harvesting season. (e.g. Olive & Citrus fruits: Oct-Dec)	Medium-term if dry; Soft: very short-term	High – Collection & transport steps are similar to field crop residue. Sorting & processing is similar to wood waste MSW & field crop residues
Agricultural Residues – Field Crop Residues	Collected from harvesting sites & subsequent crop processing (mostly in Jordan Valley, northern agricultural areas), & processing sites of imported barley.	Remove dirt, stones. Grind into smaller pieces.	Check water content, ash (dirt) level, & mold	Seasonal, during harvesting season (barley & wheat around Jun)	Medium-long-term if kept dry	High - Collection & transport steps is similar to fruit tree residues. Sorting & processing is similar to fruit tree crop residues
Agricultural Residues – Vegetable Residues	Collected from harvesting & processing sites, as well as wholesale markets like the central Amman markets	Remove packaging & soil. Separate leafy vegetables from heavier ones	Test moisture level and signs of rot	Year-round, peaks in harvest months per crop	Short-term – process soon	Medium – Collection & processing is similar to biowaste MSW.

Steps 6-7: Jordan has technical experience and refinery infrastructure thanks to its refinery in Zarqa, operated by the Jordan Petroleum Refinery Company, which produces Jet A1 and supplies this via JoPetrol

[217] Jordan Ministry of Agriculture (2024), *Instructions for Collecting, Treating, Storing, and Transporting Untreated Animal Manure for the Year 2024*

and Total to Amman Queen Alia, Amman Civil Airport and to King Hussein Airport in Aqaba. This infrastructure and technical expertise can be used for co-processing SAF production of HEFA and gasification-FT. [218]

Steps 8: There is limited established blending infrastructure. While Jordan has established technical expertise in fuel blending, additive injection[219], and filtering – primarily through the Jordan Oil Terminals Company (JOTC) – there is currently limited local experience with the infrastructure and procedures required for blending SAF with conventional jet fuel.

Step 9: Jordan follows the international DEF-STAN specifications for Jet-A1. There is no separate Jordanian certification. The same procedure can be anticipated when adhering to international SAF certification standards such as ASTM or DEF-STAN.

Step 10: SAF action for airports is mostly limited to arranging effective and efficient supply chain viability with producers. SAF, particularly when produced via the currently more economical coprocessing route [220], does not require blending facilities. Queen Alia International Airport in Amman is making significant progress in decarbonizing its operations[221], however, SAF has not yet been incorporated into its plans. King Hussein International Airport in Aqaba is planning to expand its fuel farm and include SAF in future planning processes.

Step 10: Airlines in Jordan are currently in the preparatory phase of implementing SAF initiatives, with an interest in supporting broader adoption and potential future domestic production. At an early stage, current efforts are focused on preparing to meet foreign SAF use requirements, including those set out under the EU SAF blending (see 0 C) for return flights from EU airports to Jordan from 2025. In this context, Jordanian carriers are engaging in steps toward establishing the necessary compliance frameworks, including considerations around systems for MRV.

3.1.2 Capacity building needs

Jordan demonstrates foundational strengths in Steps 6 and 7 (Conversion and Refining), largely due to existing refinery infrastructure and operational experience. However, building a fully functional and sustainable SAF value chain will require targeted efforts to deepen technical knowledge and institutional capacity across several other critical areas.

In Steps 1–2 (Feedstock collection and treatment - upstream). There is a pressing need to develop the technical know-how required to establish efficient, scalable feedstock collection systems. This includes

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[218] In co-processing, up to 5% renewable feedstock can be blended into conventional crude oil streams and directly processed through existing refinery infrastructure. The 5% share is set under ASTM D1655 (limited by the properties of the resulting fuel, such as the reduced level of aromatics in the blend, from the share of renewable fuel in it), however, efforts are underway to raise this to 30% or more. Co-processing is relevant for HEFA and gasification-FT pathways and can offer a 10-13% OPEX and 28–39% CAPEX reduction for those pathways according to Tanzil et. al. (2021). In contrast, standalone plants, that produce 100% SAF - certified under ASTM D7566 - are less common, require more investment, and depend on supplementary blending infrastructure to mix the pure SAF with conventional jet fuel (until aircraft can use 100% SAF directly in the future).

[219] Additive injection is the precise delivery of chemical agents into fuel to enhance performance, stability, and safety.

[220] ICAO (2024), ACT-SAF Series: *Co-processing and revamping: how to use existing refineries to produce SAF and SAF Logistics*

[221] Achieved Level 3+ 'Neutrality' status under the Airport Carbon Accreditation (ACA) program, becoming the first airport in the Middle East to attain carbon-neutral certification.

training on raising awareness for CORSIA-eligible feedstocks, logistics planning, engagement with collectors, and efficient preprocessing techniques. It also involves designing and operating decentralized collection hubs tailored to Jordan's need to source feedstock from multiple, dispersed locations.

It is equally important to be able to strategically locate these hubs close to SAF production facilities. One related tool that further analysis could utilize in this regard, is the Freight and Fuel Transportation Optimization Tool (FTOT)[222] from the US DOT Volpe Center. It can model optimal transport routes, facility locations, and supply chain resilience for collecting, processing, and distributing feedstock using data on roads, rail, and other infrastructure locations.

For Steps 3–5 (Conversion pathways to produce SAF - upstream). As a first step, building decision-making capacity is essential to enable stakeholders to select and plan for the most appropriate SAF conversion pathway. While this feasibility study has preliminarily identified gasification-FT as a promising near-term option and PtL as a long-term solution based on Jordan's feedstock availability, further techno-economic analysis is required to confirm whether gasification-FT can be the most cost-effective biofuel option. Stakeholders must be equipped to compare conversion technology options based on feedstock processing efficiency, economic viability, and environmental performance. Developing this analytical capability will allow Jordan to make informed, context-specific decisions that balance investment cost, scalability, and sustainability outcomes. A Business Implementation Study could serve as the first step on this path.

In Step 8 (SAF blending - midstream). While Jordan has established expertise in conventional fuel blending, it lacks local experience in SAF blending infrastructure and procedures. However, this existing foundation provides a solid platform to build upon. Expanding into SAF blending will require targeted technical training on blending technologies, fuel certification standards, quality control protocols, and ensuring compatibility with airport fuelling systems.

Step 10 (SAF distribution and use – downstream) Jordan requires enhanced technical and institutional readiness to effectively integrate SAF into airport operations and airline compliance frameworks. Stakeholders can benefit from support in adapting airport fuel systems where needed and developing expertise for MRV. Airline operators must also build capacity to meet emerging international SAF mandates, such as the EU's blending requirements (see Appendix C), and to align with global sustainability standards.

Bridging these knowledge and capability gaps is key to enabling Jordan to participate meaningfully in the global SAF transition. Stakeholders across the value chain can benefit from sustained, targeted capacity-building – including technical training, hands-on demonstrations, peer learning, and policy support. ICAO's ACT-SAF programme offers a strong platform to deliver such support and advance Jordan's long-term SAF readiness.

ACT-SAF offers access to feasibility studies and business implementation studies to learn from experiences gathered in other countries, training sessions (both virtual, in-person, and recorded), and expert guidance to support technical, regulatory, and operational advancement in SAF initiatives. ACT-SAF also facilitates partnerships and knowledge-sharing among States, organizations, and experts to coordinate efforts globally.

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[222]https://www.volpe.dot.gov/our-work/policy-planning-and-environment/volpe-tool-evaluates-freight-and-fuel-transport-options

Participants may also benefit from targeted support for SAF Certification, and support for policy implementation.

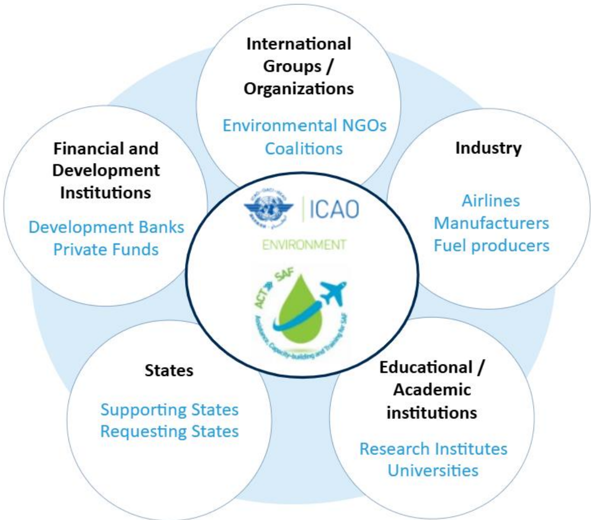

Figure 37. Possible participants of the ICAO's ACT-SAF programme and QR code to access the website.[223]

One potential next step, as part of possible support through ACT-SAF, is the development of a Business Implementation Study. During consultations, multiple stakeholder groups expressed interest in leveraging such a study to advance the practical planning and execution of SAF initiatives in Jordan. Beyond ICAO, multiple public authorities around the world, as well as private sector organizations offer capacity building initiatives.

<u>II. Support for regulatory frameworks and legislative policies for feedstock processing and SAF handling</u>

Regulatory frameworks and legislative policies are critical to ensure the sustainable, safe, and compliant processing of feedstocks and the subsequent handling, production, and distribution of SAF. With biofuels currently playing no relevance in Jordan's energy system, there are little to no policies in place to guide feedstock processing for renewable fuels now. Nevertheless, the country has implemented policies for the management of biomass in broader applications.

Two notable examples include the *Instructions for Collecting, Treating, Storing, and Transporting Untreated Animal Manure for the Year 2024*,[224] which aim to protect public health and ensure proper waste management practices in livestock farms, and the *Instructions and Conditions for the Use of Treated Wastewater, Brackish Water, and Saline Water for Agricultural Uses, No. 16 of 2022*,[225] which regulate the safe use of non-traditional water sources in agriculture to safeguard food safety and water resources. These frameworks, while not directly targeting renewable fuel production, reflect Jordan's broader commitment to sustainable biomass and waste resource management.

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[223] ICAO (2025), *ICAO Assistance, Capacity-building and Training for Sustainable Aviation Fuels*

[224] Jordan Ministry of Agriculture (2022), *Instructions and Conditions for the Use of Treated Wastewater, Brackish Water, and Saline Water for Agricultural Uses, No. 16 of 2022*

[225] Jordan Ministry of Agriculture (2024), *Instructions for Collecting, Treating, Storing, and Transporting Untreated Animal Manure for the Year 2024*

Establishing a SAF value chain requires clear regulation to ensure the safe, efficient, and traceable collection, transport, and pre-processing of feedstocks in compliance with sustainability and safety standards.

All ICAO States adopted on 24 November 2023 (CAAF/3) the ICAO Global Framework for SAF, LCAF and other Aviation Cleaner Energies, which includes under its Building Block 2 – Regulatory Framework (paragraph 12): *"In the interests of providing regulatory transparency, certainty, stability and assurances of environmental integrity to feedstock producers, fuels producers and financial institutions, **the CORSIA sustainability criteria, sustainability certification, and the methodology for the assessment of life cycle emissions used for 'CORSIA eligible fuels', should be used as the accepted basis for the eligibility of SAF**, LCAF and other aviation cleaner energies used in international aviation."*[226]

CORSIA methodologies ensures that feedstocks are sourced in an environmentally responsible manner, prohibits the use of materials from land with high biodiversity or carbon stock, and mandates traceability throughout the supply chain via a mass balance system.[227] It also requires certification through approved schemes and regular auditing, thereby fostering a transparent and verifiable SAF value chain across ICAO member states. Jordan may adopt the CORSIA regulatory framework for biomass collection and implement it by drawing on capacity-building support from other countries, ACT-SAF, and other relevant entities.

SAF Production and Distribution

Regulatory action is required to ensure that the establishment of SAF production and distribution infrastructure (Steps 2-10 from Table 18) meets national standards for safety, environmental protection, and fuel quality. Licensing by energy authorities is essential to authorize and oversee the development and operation of SAF facilities and related distribution systems. In Jordan, the Jordan Energy & Minerals Regulatory Commission (EMRC) is responsible for regulating and licensing activities related to energy and mineral resources in Jordan. This encompasses overseeing the licensing and granting of permits for fuel production and distribution. For instance, The application fee for a license to operate renewable energy generation projects is 10,000 Jordanian dinars, plus 0.25% of the project's paid-up capital.[228]

In the context of SAF in Jordan, the EMRC's responsibilities would extend to:

1. **Licensing and Regulation for SAF Infrastructure Development**: EMRC can issue licenses to entities involved in the production and distribution of SAF. This ensures that all players in the SAF supply chain operate within the legal framework and adhere to established standards.
2. **Quality and Safety Standards**: EMRC can set up and enforce national standards related to the quality and safety of SAF, ensuring that the fuel meets international benchmarks (DEF-STA or ASTM) and is safe for use in aviation.
3. **Environmental Compliance**: EMRC might also monitor and ensure that SAF production and usage align with Jordan's environmental regulations and commitments to reduce greenhouse gas emissions.

[226] ICAO (2023), *ICAO Global Framework for SAF, LCAF and other Aviation Cleaner Energies*
[227] A mass balance system tracks sustainable materials through the supply chain, allowing mixing with non-sustainable ones as long as certified quantities and characteristics are accurately accounted for.
[228] Data from exchange with EMRC (2025)

By fulfilling these roles, the EMRC is instrumental in promoting the adoption of SAF production and processing in Jordan.

III. Public-Private Partnerships

Public-Private Partnerships (PPP) share the project risk and financial investments associated with large-scale industry projects by involving private partners in funding, constructing, and operating the projects while the government provides oversight, regulatory support, and sometimes partial funding or guarantees. Jordan has developed a track record in leveraging PPPs to deliver critical infrastructure and services, particularly in sectors such as water, transportation, and healthcare, and over 30 energy projects. [229] The country established a dedicated PPP unit under the Ministry of Finance and has enacted comprehensive legislation to govern and promote PPPs. An example of key PPP projects was provided in Table 3.

The PPP Unit is the central body responsible for organizing, developing, and overseeing PPP projects in Jordan. It was established under the *Public-Private Partnership Law No. 19 of 2023*, which outlines the legal and regulatory framework for implementing these initiatives and operates under the Ministry of Investment.[229] With this mandate, it plays a key role in advancing the Kingdom's Economic Modernization Vision (see 1.2 for more information) by fostering effective collaboration between the public and private sectors. It supports projects throughout all stages - from identification and feasibility studies to contract structuring and execution. The PPP Unit is supervised by the Higher PPP Committee, ensuring stakeholder coordination and maintaining high standards of transparency and efficiency.

During the feasibility study, the outcomes of SECTION 2 have been presented to the director of the PPP Unit. The director believes that SAF aligns well with Jordan's Economic Modernization Vision and is interested to support SAF project developments and investments. To qualify a SAF plant project for a PPP under the PPP Unit, two main steps must be taken:

1. Project Sponsorship by a Government Entity

A government institution must assume ownership of the SAF plant project to enable its registration as a potential PPP. In the case of SAF, this may be the Ministry of Energy and Mineral Resources or the Ministry of Transport.

The purpose of this step is to evaluate a project's commercial viability through a dedicated business plan study – including assessing metrics such as Net Present Value (NPV) and Internal Rate of Return (IRR). A Business Implementation Study for SAF in Jordan may be commissioned to support this evaluation (subject to ongoing efforts and confirmation).

2. PPP Registration and Tendering Process

Once a sponsoring entity is confirmed, the PPP Unit can proceed with initiating the PPP process. This includes:

- Registering the project on the National Registry for Investment Projects (NRIP) at the Ministry of Planning and International Cooperation (MoPIC), along with a Project Concept Note.
- Upon registration, the project becomes a PPP candidate and must undergo a comprehensive feasibility study.
- If approved by the Higher Committee for PPPs, the tendering phase can begin.

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[229] Jordan Ministry of Investment Public Private Partnership Unit (2025), *About PPPU*

In collaboration with industry stakeholders, the PPP Unit can then issue a tender and offer various forms of government support such as grants, concessional loans, tax incentives.

IV. International Cooperation

Countries around the world are ramping up the development of SAF as a key strategy to achieve global decarbonization targets, and the Middle East is emerging as an increasingly active player in this transition. For Jordan, examining SAF developments in neighbouring countries offers valuable insights into preferred feedstocks, conversion technologies, and policy frameworks. It also reveals opportunities for harnessing regional synergies, particularly among nations with similar environmental and economic conditions:

In Saudi Arabia, Nordic Electrofuel, in partnership with the Royal Commission for Jubail and Yanbu, is building a PtL SAF facility in Jubail with plans to produce 350 million litres (≈ 281 kt) annually by 2029.[230]

Egypt has launched the Egyptian Sustainable Aviation Fuel (ESAF) company, aiming to produce 120 kt of SAF annually from used cooking oil and waste oils, backed by feasibility work with the EBRD (Egypt Oil & Gas).[231]

In Israel, the government and private sector are investing in SAF through a USD 28 million R&D program, regulatory support and a USD 2.4 million demonstration plant by CarboNGV.[232]

In Pakistan, South Asia's first large-scale HEFA-based SAF facility is being set up to convert 250 kt of Used Cooking Oil into 200 kt of SAF annually, cut 500 kt of CO_2, create over 20,000 jobs, and boost exports — with support from World Bank IFC through USD 35 million in equity and debt financing, including blended climate finance.[233]

Cross-border collaboration in SAF development can present a strategic opportunity for Jordan. By aligning with its neighbours' SAF initiatives, Jordan could tap into technical expertise, shared infrastructure, and common supply chains - especially around feedstocks and logistics. This cooperation could reduce production costs, stimulate innovation, and enhance feedstock availability. Moreover, integrating with regional efforts can allow Jordan to contribute meaningfully to ICAO-aligned decarbonization goals and position itself as a key player in the Middle East's transition to sustainable aviation.

V. Finance and investment support

To meet the financial requirements for establishing a SAF value chain, a diverse mix of investment instruments and policy tools can be utilized. These should be tailored to align with the unique characteristics and risk profiles of SAF-related investments in Jordan. In conjunction with the previously discussed implementation support options, finance and investment support represents a critical area of intervention. Given its importance, a detailed analysis of this support action will be presented in the following dedicated subchapter. It begins by offering an overview of the cost and investment scope needed to develop SAF production capacity. It then explores ongoing financial considerations, encompassing the total operating expenditures

[230] Nordic Electrofuel (2024), *Making E-SAF in Saudi Arabia – Royal Commission, Nordic Electrofuel and Jump reach milestone for ramp-up of e-fuel production*

[231] SAF Investor (2024), *Egypt 120K TPA SAF site progresses forward*

[232] SAF Investor (2024), *Isreal pushes for SAF with new committee, incentives*

[233] World Bank IFC (2024), *IFC Project Information & Data Portal - SAF Pakistan*

over the lifetime of a SAF production facility, as well as the costs related to securing and processing SAF feedstock. Following this, the analysis turns to financing instruments tailored to the specific investment needs of SAF projects, strategies to reduce cost burdens, and support mechanisms that Jordan can implement during the development and financing phases.

3.2 FINANCING NEED AND FINANCE OPTIONS

Scaling SAF production is a capital-intensive undertaking, requiring large upfront investments to build out a largely first-of-its-kind infrastructure. At the same time, demand remains constrained by SAF's significant price premium over conventional jet fuel, limiting market pull and slowing commercial momentum. Bridging this dual cost gap will require financing mechanisms that can reduce investment risk for mobilizing capital, to accelerate project development, and to support SAF uptake by airlines.

The first part of this subchapter provides an estimate of the capital expenditure required to establish a SAF plant in Jordan, along with a levelized cost estimate for producing one tonne of SAF to describe the cost premium against conventional jet fuel for airlines. The second part builds on these estimates to assess the scale of investment and policy support needed, the financing options available for Jordan, and how these options could be implemented to help attract investment and enable cost-competitive SAF production.

3.2.1 Cost projection of SAF in Jordan

As a basis for comparing production costs and market value of SAF in Jordan, the following figure illustrates the demand for jet fuel over time.

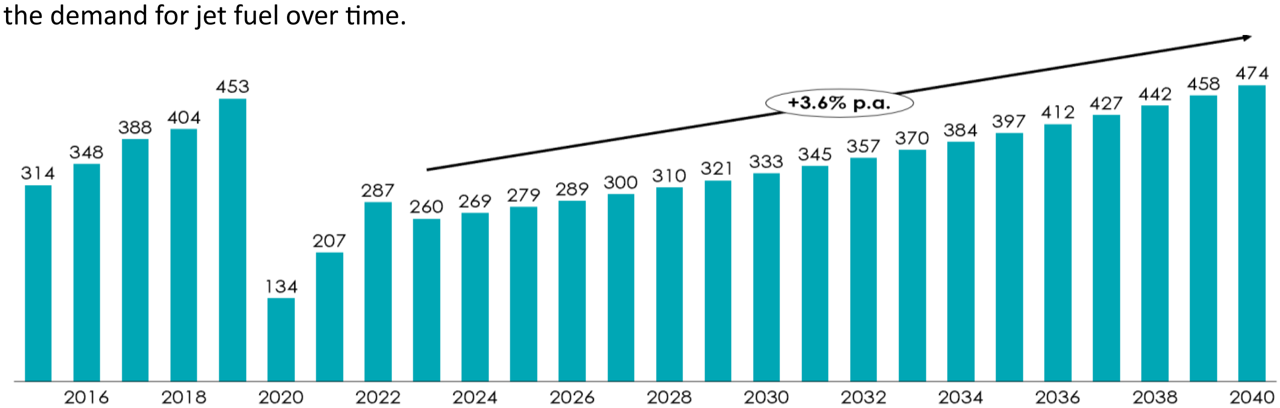

Figure 38. Jordan's recorded[234] and projected[235] annual jet fuel demand, in kt.

<u>Capital required to build a greenfield SAF plant in Jordan</u>

Total Capital Investment (TCI) refers to the upfront capital expenditure, or CAPEX plus working capital, required to develop a SAF plant. It encompasses all capital-related costs necessary to build an entirely new facility from the ground up, including the procurement of equipment, installation, construction of facilities, and other expenses required to bring a greenfield plant into full operation. This helps clarify the financial requirements for deploying SAF in Jordan.

[234] Own chart, data from Ministry of Energy and Mineral Resources (2024), 2023 *Energy Balance*

[235] According to IATA (2023), *Global Outlook for Air Transport* commercial aviation in the Middle East will grow at an annual rate of 3.6% until 2040.

A SAF plant typically has a lead time of 4-6 years, with 3-4 years usually required for construction and an additional 1-2 years for pre-FID[236] activities like permitting. The more complex PtL SAF fuel plants may take up additional 2 years – meaning countries must act now to have SAF capacity online in the 2030s.[237] SAF plants vary in scale, with typical commercial facilities producing between 100 and 250 kt per year. Larger industrial-scale plants can exceed 500 kt annually. 250 kt roughly corresponds to Jordan's current annual jet fuel demand, or a rough SAF to conventional jet fuel share of ~50% by the 2040s, a share that Jordan needs to aim for to stay on track for 2050 net-zero emission targets.

The following figure illustrates the CAPEX requirements for a 250 kt plant across different SAF production pathways: HEFA, AtJ, gasification-FT, and PtL. Note the PtL SAF output shares are conservative estimates. The data is drawn from global benchmark assessments for the techno-economic analysis of SAF pathways, conducted by Washington State University for ICAO, in collaboration with ICAO's Committee on Aviation Environmental Protection (CAEP)[238] and supported by experts from Hasselt University. For this feasibility study, the data has been adapted to Jordan-specific parameters for local fixed capital investment (FCI) and working capital conditions, such as lower cost for land.[239]

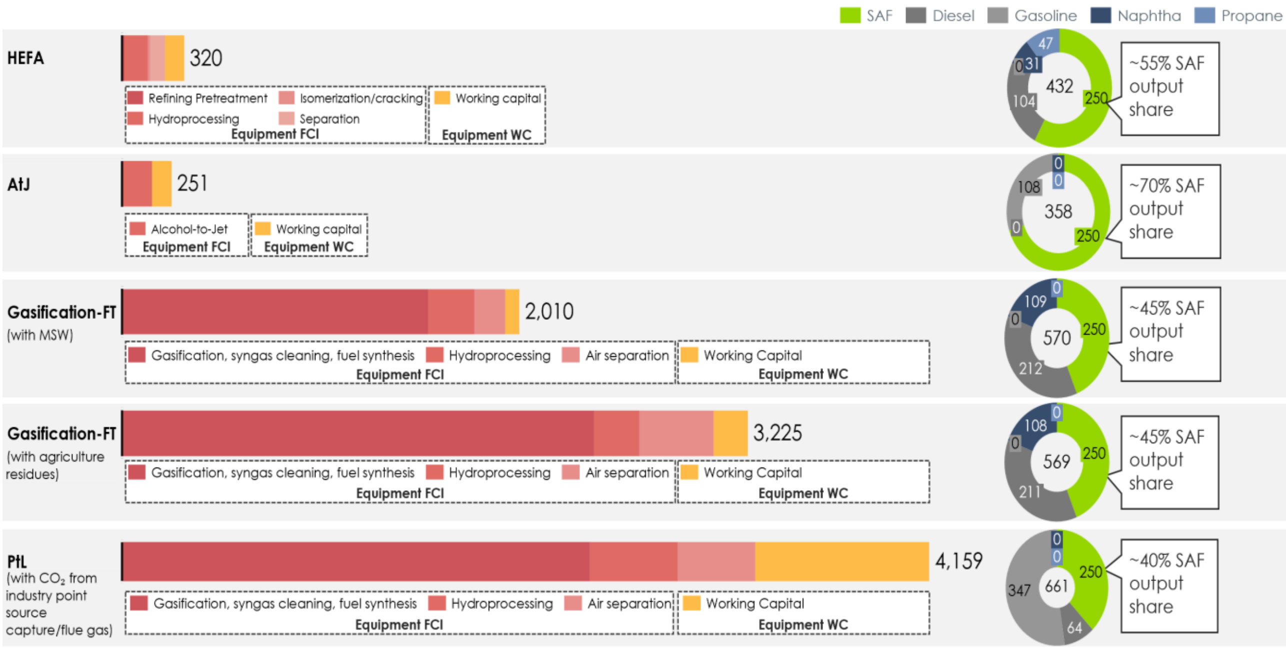

Figure 39. Projected Total Capital Investments/CAPEX breakdown, in million USD, for a SAF plant with an annual SAF output of 250 kt, and additional refinery outputs.[240]

236 Final Investment Decision (FID) is the point at which an entity formally commits to funding and executing a project.
237 ICCT (2023), *Meeting the SAF Grand Challenge: Current and Future Measures to Increase U.S. Sustainable Aviation Fuel Production Capacity*
238 CAEP is the technical committee of the ICAO Council, established in 1983, that advises on policies and standards for aircraft noise, emissions, and aviation's environmental impact.
239 The author of this feasibility study has been in contact with Brandt et. al. from the Washington State University, who granted permission to use and adapt their techno-economic assessment to Jordan specific input factors.
240 Own chart and analysis, enriched with Jordan specific factors such as minimization of land cost, raw data from Washington State University (2025), *Techno-Economic Assessment*

CAPEX consists of Fixed Capital Investments[241] and planned Working Capital.[242] The CAPEX requirements reflect the advanced commercial maturity of HEFA and AtJ, in contrast to the significantly higher initial investments needed for gasification-FT and PtL. These emerging technologies are still developing and have not yet reached the scale needed to unlock their full potential for cost reductions in equipment and other upfront investments.

The CAPEX estimation provides a clear understanding of the direct costs associated with SAF production in Jordan. However, it offers only a temporal snapshot and does not provide sufficient insight to support long-term strategic decisions when evaluating different SAF production options over a plant's full lifetime. Jordan has country-specific conditions that influence the cost of domestic feedstock, labour, electricity, and other operating expenses. Each plant type involves different operational expenditure (OPEX), which must be considered in any SAF plant investment prioritization process that reflects Jordan's specific parameters.

SECTION 2 has demonstrated the availability and price levels of different feedstocks for biofuel SAF production. It made clear that the country does not have sufficient biomass to fully meet its jet fuel demand via SAF. However, biofuel SAF can still contribute to this demand while adding additional value - such as reducing municipal solid waste pressure, serving broader sustainability targets, and creating new income streams. At the same time, the analysis highlights Jordan's abundant and low-cost renewable energy resources, and consequently, its good potential for PtL production. These strengths and limitations must be considered to guide investment decision-making processes. The next section supports this with a levelized cost analysis, reflecting CAPEX over the plant's lifespan along with OPEX.

<u>Levelized cost of SAF production</u>

The levelized cost of SAF is a metric used to assess and compare the cost of different SAF production technologies. It represents the average total cost of building and operating a SAF plant over its lifespan, divided by the total amount of SAF it is expected to produce. Essentially, it's the minimum selling price at which SAF must be sold for the project to be viable. Therefore:

$$\text{Levelised Cost of SAF} = \frac{\text{Total Lifetime Cost in USD (which means CAPEX + OPEX over a plant's lifetime)}}{\text{Total Lifetime SAF Output in Tonnes of SAF (produced over a plant's lifetime)}}$$

The analysis is again based on the data from the Washington State University model and enriched with Jordan specific input parameters.[243] The levelized cost represents the average net present cost per tonne of a SAF type produced in Jordan. OPEX is calculated as the annual operating expenses divided by the annual SAF output, giving the cost per tonne. CAPEX is the initial capital investment allocated per tonne of SAF and spread

[241] Fixed Capital Investment (FCI): includes fixed capital costs for land purchase, purchase of equipment for production, its construction, installation, along with related indirect costs (like engineering and project management), escalation for inflation, and contingency for equipment-related uncertainties

[242] Working Capital (WC): pre-allocated capital for inventory maintenance, spare parts, and cash reserves for a plant's operation, across its lifetime, is estimated at 20% of one year's operating expenses (OPEX). WC can alternatively be attributed to annual OPEX.

[243] The WSU model considers the US as the benchmark. Jordan electricity prices, labor costs, inflation, and feedstock price adjustments have been factored into the Levelized Cost of SAF production assessment of this feasibility study to account for Jordan-specific production costs.

over a 20-year plant lifetime using a 10% discount rate to reflect its net present value.[244] The CAPEX share is the same data as in the previous CAPEX analysis. In addition, the following five figures illustrate the price of Jet A1 in Jordan as of January 2025 (refer to 1.7 for a breakdown of the price), along with the resulting price premium per tonne for each type of SAF compared to the cheaper Jet A1.

HEFA

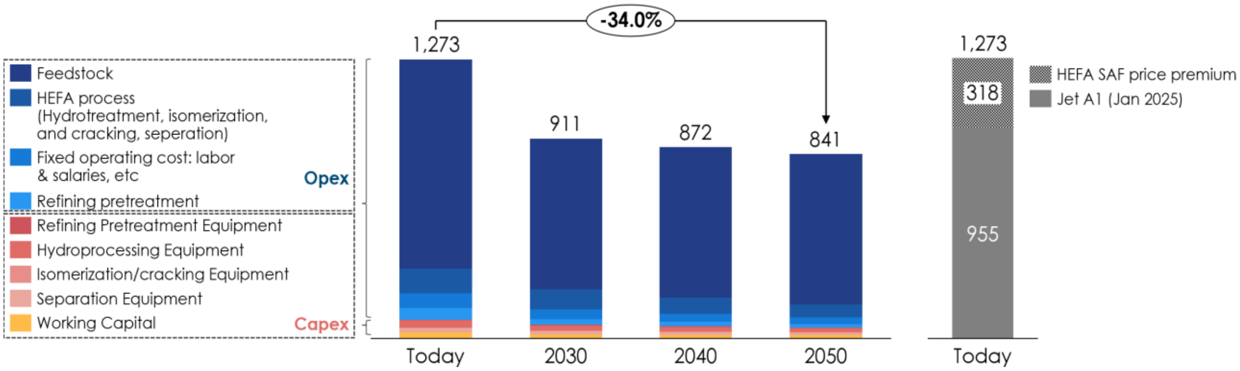

Figure 40. Projected levelized cost of a tonne of HEFA SAF produced in Jordan, [240, 245] in USD, with conventional fossil Jet A1 fuel price in Jordan shown on the right for comparison with SAF price.

AtJ

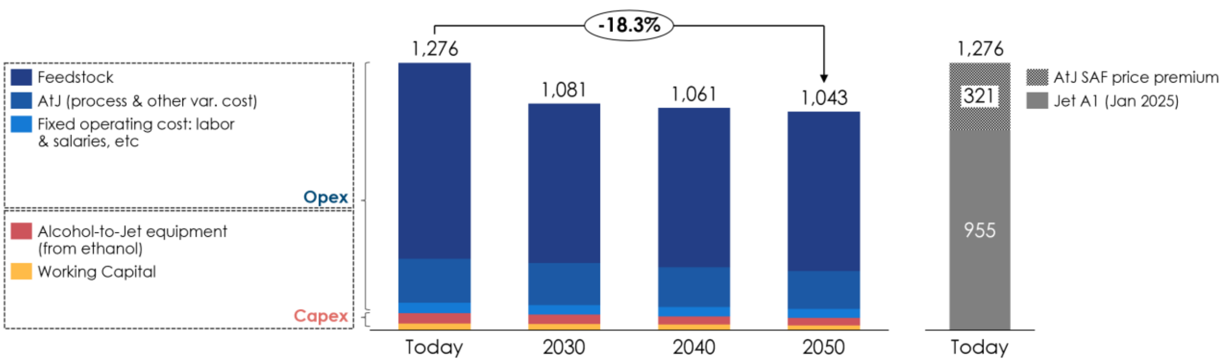

Figure 41. Projected levelized cost of a tonne of AtJ SAF produced in Jordan,[240,245] in USD, with conventional fossil Jet A1 fuel price in Jordan shown on the right for comparison with SAF price.

For Feedstock Cost Fraction: cost spectrum of feedstock available in Jordan: only qualitative, relative to AtJ feedstock types (see data in 2.1).

[244] This real discount rate reflects the cost of capital, investment risk, and the time value of money over the lifetime of the plant CAPEX investment. Jordan holds a sovereign credit rating in the BB range (Standard & Poor's, March 2025 reference), indicating a moderate to high level of investment risk. In this context, a 10% discount rate is considered conservative, as suggested by the country's credit risk profile and the level of investment risk typically associated with SAF plants.

[245] Trend analysis adjusted for Jordan's electricity price development, raw data from World Economic Forum (2020), *Clean Skies for Tomorrow Sustainable Aviation Fuels as a Pathway to Net-Zero Aviation*

Gasification-FT

With MSW as feedstock:

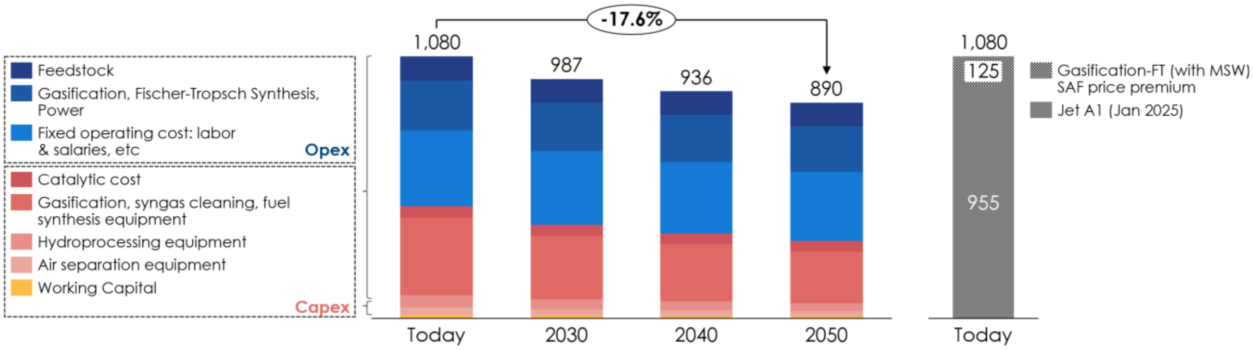

Figure 42. Projected levelized cost of a tonne of gasification-FT SAF produced in Jordan with MSW as feedstock,[240,245] in USD, with conventional fossil Jet A1 fuel price in Jordan shown on the right for comparison with SAF price.

With agriculture residues as feedstock:

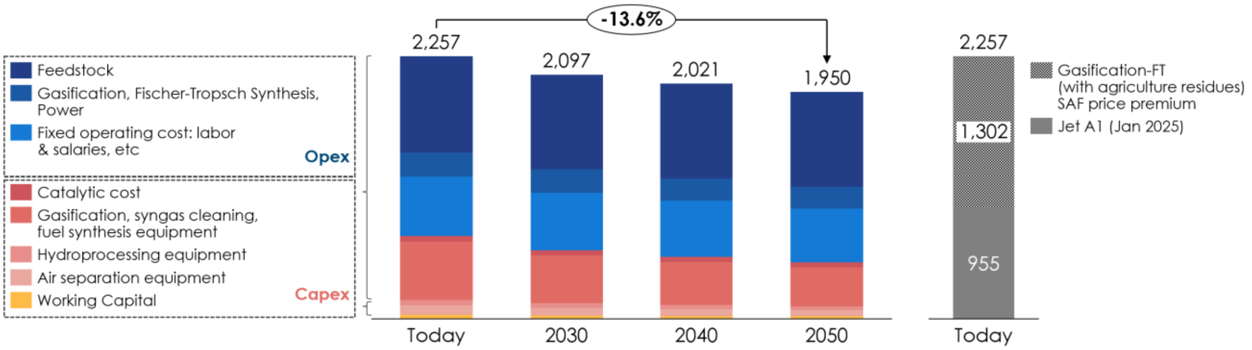

Figure 43. Projected levelized cost of a tonne of gasification-FT SAF produced in Jordan with agriculture residues as feedstock,[240,245] in USD, with conventional fossil Jet A1 fuel price in Jordan shown on the right for comparison with SAF price.

PtL

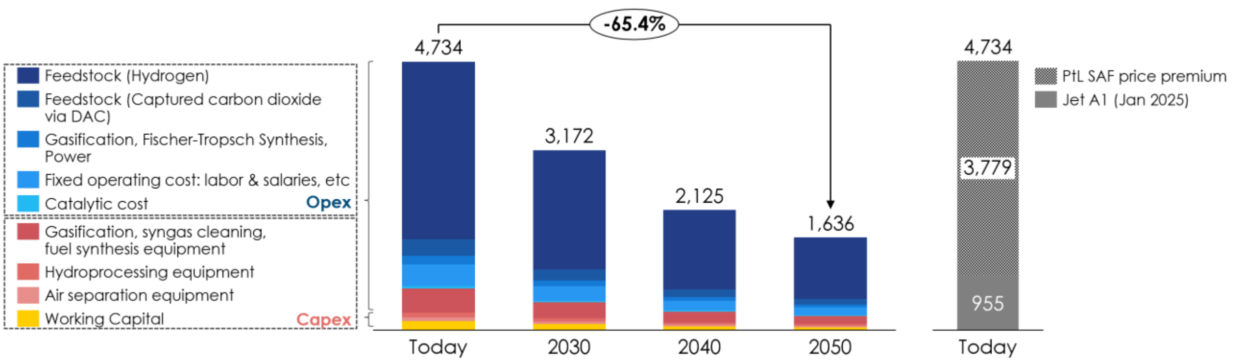

Figure 44. Projected levelized cost of a tonne of PtL SAF produced in Jordan,[240,245] in USD, with conventional fossil Jet A1 fuel price in Jordan shown on the right for comparison with SAF price.

The analysis indicates the differences in levelized cost levels of SAF conversion pathways, particularly between the two groups of biofuel pathways (HEFA, AtJ, gasification-FT) and PtL SAF. However, in contrast to the previous standalone CAPEX analysis, it must be noted that the levelized cost analysis shows that the cost gaps across pathways are getting smaller with OPEX included.

Biofuel options, especially HEFA, AtJ, gasification-FT from MSW, remain the cheapest option. However, HEFA, AtJ, and gasification-FT pathways that rely on agricultural residues are likely to face future scalability challenges due to the impacts of climate change and growing water scarcity on crop production. In contrast, more significant cost reductions are anticipated for gasification-FT from MSW, manure, and sewage sludge as feedstock. PtL, in particular, is expected to see a dramatic drop in price per tonne, largely driven by the falling costs of renewable electricity, which is essential for hydrogen production, carbon capture, and powering the Fischer-Tropsch synthesis process. As a result, the cost per tonne across the different pathways is expected to align closer by 2050. This long-term projection has direct implications for investment decisions today, as a plant reaching FID today could begin operations in the 2030s and remain active through 2050.

Key takeaways for SAF potential in Jordan

The cost analysis highlights the need to evaluate different production pathways with a long-term perspective when making strategic investment decisions. SAF projects require this long-term view because building facilities and infrastructure takes time, the technology is still developing, and it takes years to recover initial investments. These factors make SAF projects risky and expensive, which increases the hesitation of private investors to get involved. Therefore, it is important to highlight the necessity of comprehensive financial analysis to determine the cost of capital for SAF investments and the need to de-risk investments for private capital mobilization. ICAO highlights that policy interventions are required to spur investments "as long as the cost of production for SAF is greater than conventional kerosene".[246] The following subchapter provides and understanding of which actions Jordan could take.

Before this, it is important to conclude the cost evaluation estimate by highlighting the need for further analysis beyond the scope of this feasibility study. Such analysis is essential to enable more granular SAF investment decisions through a comprehensive cost-benefit assessment. This should expand further on input parameters such as the cost of capital, equity-to-debt ratios, the scope of public financial support, and income streams that can be expected from SAF sales.

Moreover, economic and strategic benefits not captured in this analysis should be integrated. These include the socio-economic value-added of using municipal solid waste as feedstock, is supporting reducing Jordan's MSW management problem. Additional unaccounted benefits lie in the potential for job creation and the multiplier effects that extend beyond the SAF realm – such as advancing Jordan's Economic Modernization Vision, supporting the Green Hydrogen Strategy, and contributing to a less geopolitically dependent energy system. These wider impacts, particularly relevant for capital-intensive pathways like PtL and gasification-FT. A Business Implementation Study may provide this added value.

3.2.2 Financing possibilities and sources

ICAO states that, "as long as *barriers including significantly higher costs of production for SAF in comparison to conventional kerosene; limited feedstock and fuel production infrastructure; and, perceived high risks and costs to finance SAF infrastructure exists, policy intervention will be required to develop SAF production beyond its current small scale*".[246] Governments are encouraged to explore and implement a broad set of policy and financial measures to kickstart investments in SAF. These measures should target both the supply and demand sides of the SAF market to address current market barriers.

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[246] ICAO (2024), *ICAO Guidance on Policy Measures for Sustainable Aviation Fuels (SAF) Development and Deployment*

Historically, one of the main challenges to scaling the SAF market has been the lack of transparent and consistent pricing signals between suppliers and buyers.

On the supply side, production has not scaled due to insufficient demand certainty from airlines. This creates a feedback loop without clear demand signals. Producers cannot justify capital-intensive investments, leaving out harnessing economies of scale cost reduction potential, keeping SAF prices high. These higher prices, in turn, discourage airlines from purchasing SAF, creating a classic "chicken-and-egg" dilemma.

On the demand side, jet fuel accounts for approximately 25–30% of an airline's operating costs – the largest single cost block.[247] With tight profit margins (on average around 2.7%, according to IATA),[248] airlines struggle to absorb the additional cost of SAF. Furthermore, in a competitive global market, there is the risk that some airlines may act as free riders, benefiting from the sustainability leadership of others without investing in SAF themselves. In summary, this kind of market asymmetry prevents sending predictable demand signals to SAF producers.

Multiple financing possibilities exist to overcome these issues and to build a viable SAF value chain:

I. **Providing Public Funding** to reduce financial barriers for early-stage projects.
II. **Creating Financing Incentives** to reduce risk and attract private investors.
III. **Strengthening SAF Price Signals** to increase stable SAF market demand.

The following policy options fall into those three categories and are based on ICAO[246] and the World Economic Forum[249].

I. Providing Public Funding

Aims to reduce early financial barriers and accelerate the build-out of SAF production capacity by de-risking investment in infrastructure and innovation. It does this by providing public funding to support early-stage projects, infrastructure development, and feedstock supply chains.

Research and Innovation Grants		**Supply side focused**	**Demand side focused**
Capital grants provide non-repayable financial support to lower upfront costs for directed research and development, as well as for demonstration and deployment activities. Typically funded by governments as part of broader climate or innovation agendas, grants can de-risk the cost and technology profile of SAF projects - making SAF viable for a wider range of financing options from private investors and commercial capital providers.			
Where on the project lifecycle?	**① Conceptualization & Stakeholder Alignment Phase**	**② Setup of Regulatory Framework & Funding Mobilization Phase**	③ SAF Production Scale-up & Market Integration Phase
Example	The 2024 US Fueling Aviation's Sustainable Transition (FAST) grants, provide USD 291 million to advance cleaner aviation in the US. This includes USD 244.5 million for 22 projects that produce, transport, blend, or store SAF, as well as scoping studies for SAF infrastructure.[250] Another example is the UK Advanced Fuels Fund (AFF) competition, launched in 2022, which awards over GBP 135 million to first-of-a-kind SAF projects in the UK, with the aim of building domestic SAF capacity and supporting up to 10,000 jobs by 2035.[251]		

[247] IATA (2024), *Unveiling the biggest airline costs*
[248] IATA (2023), *Airlines set to earn 2.7% Net Profit Margin on Record Revenues in 2024*
[249] World Economic Forum (2021), *Clean Skies for Tomorrow: Sustainable Aviation Fuel Policy Toolkit.*
[250] US FAA (2024), *Biden-Harris Administration Announces Nearly $300 Million in Awards for Sustainable Aviation Fuels and Technologies as part of Investing in America Agenda*
[251] UK Department of Transport (2023), *Advanced Fuels Fund (AFF) competition winners*

Applicability in Jordan	Jordan faces budgetary constraints that limit its ability to provide national grants for early-stage SAF projects. However, international funding and donor partnerships could play a vital role in supporting their development. For example, US-based Breakthrough Energy contributed EUR 30 million to help finance Europe's first PtL pilot plant in Germany.[252]

Concessional/Low-Interest Loans	**Supply side focused**	Demand side focused	
Provision of debt financing at below-market interest rates and/or with favorable terms, such as extended grace periods or longer repayment horizons. Concessional loans are designed to improve the financial viability of SAF projects by lowering borrowing costs and reducing repayment pressure during early stages.			
Where on the project lifecycle?	① Conceptualization & Stakeholder Alignment Phase	**② Setup of Regulatory Framework & Funding Mobilization Phase**	③ SAF Production Scale-up & Market Integration Phase
Example	The US Department of Energy has approved nearly USD 3 billion in conditional loans in 2025 to support two biofuel projects aimed at significantly boosting US-based SAF production in line with national climate goals.[253]		
Applicability in Jordan	High – Jordan has extensive experience securing loans for large industry projects. Institutions like the World Bank IFC, and Jordan's Ministry of Investment are already backing renewable energy projects (see 1.2 for more information).		

II. Creating Financing Incentives: Aims to reduce investment risk and make SAF production investments financially attractive by improving their competitiveness with fossil fuel and alternative investment options. It does this by offering financial mechanisms that enhance the financial viability and reduces risk of SAF projects to encourage private investor participation.

Loan Guarantees Programs	**Supply side focused**	Demand side focused	
A government or public institution guarantees part or all of a loan in the event of borrower default, reducing risk for the lender. This lowers the perceived investment risk, enhances project bankability, and reduces the cost of capital, ultimately making it easier and more affordable for the borrower to access financing and mobilizing private investment.			
Where on the project lifecycle?	① Conceptualization & Stakeholder Alignment Phase	**② Setup of Regulatory Framework & Funding Mobilization Phase**	③ SAF Production Scale-up & Market Integration Phase
Example	The US Department of Energy (DOE) has approved up to USD 1.46 billion in loan guarantees to secure funding and creditworthiness of a Gevo SAF biofuel plant.[254]		
Applicability in Jordan	Jordan has experience in loan guarantees through the dedicated services of the Jordan Loan Guarantee Corporation (JLGC), which supports Small and medium-sized enterprises (SMEs) and could similarly back SAF projects, although the scope of support would likely go beyond the size of SMEs.		

Accelerated Depreciation / Bonus Depreciation	**Supply side focused**	Demand side focused	
Accelerated or bonus depreciation allows businesses to write off capital investments more quickly, enabling larger tax deductions in early years and improving early cash flow and faster recovery of investment costs.			
Where on the project lifecycle?	① Conceptualization & Stakeholder Alignment Phase	**② Setup of Regulatory Framework & Funding Mobilization Phase**	③ SAF Production Scale-up & Market Integration Phase
Example	N.A.		

[252] European Investment Bank (2025), *Germany: INERATEC's e-fuel demo plant in Frankfurt gets €70 million from EIB, EU-Commission and Breakthrough energy*
[253] Reuters (2025), *Trump administration approves sustainable aviation fuel refinery loan*
[254] Reuters (2024), *US offers conditional loan guarantees worth about $3 bln for two sustainable aviation fuel projects*

Applicability in Jordan	Although Jordan typically uses straight-line depreciation, accelerated depreciation - up to three times the standard rate – is allowed for certain assets, such as those used in renewable energy projects. However, this benefit applies only to locally sourced equipment, not to imports.[255] Nevertheless, this option could be applied to SAF.

Tax Incentives	**Supply side focused**	**Demand side focused**
Tax relief instruments – investment tax credits (ITC), performance-based tax credits, excise tax credits, producer tax credits (PTC), blender tax credits (BTC), and reduced income tax incentives – may support both the SAF supply and demand side by providing tax credits that directly reduce the tax liabilities of producers, blenders, and consumers.		
Where on the project lifecycle?	① Conceptualization & Stakeholder Alignment Phase; **② Setup of Regulatory Framework & Funding Mobilization Phase**; **③ SAF Production Scale-up & Market Integration Phase**	
Explanation	<u>Supply Side:</u> ▪ ITC offers tax deductions for SAF project construction to reduce capital costs. ▪ A performance-based tax credit rewards higher SAF GHG reductions with larger credits. ▪ PTC directly lowers tax burden for SAF producers, regardless of the final end product's performance <u>Demand Side:</u> ▪ BTC provides credits to blenders who mix SAF with conventional fuel, encouraging uptake. ▪ An excise tax credit reduces or removes fuel taxes on SAF to make it more competitive.	
Example	<u>Supply Side:</u> ▪ PTC: The US Clean Fuel Production Credit (CFPC) offers USD 0.20 per gallon for low-emission fuels and USD 0.35 per gallon for SAF as tax relief, increasing to USD 1.00 and USD 1.75 per gallon respectively for facilities that meet prevailing wage and apprenticeship requirements.[256] <u>Supply/demand Side:</u> ▪ BTC: The US SAF Fuel Credit offers a sliding scale tax credit starting at USD 1.25 per gallon for SAF produced with a 50% lifecycle GHG improvement, increasing up to USD 1.75 per gallon with better performance.[246]	
Applicability in Jordan	Under Jordan's Renewable Energy and Energy Efficiency Law, the country offers tax incentives to promote investment in renewable energy - most notably, exemptions from customs duties and sales tax on renewable energy systems and equipment.[257] The Aqaba Special Economic Zone, designed to attract a wide range of businesses - from manufacturing and logistics to tourism and ICT - offers a flat 5% income tax rate to encourage companies to establish their operations there. These initiatives can form a good basis for application in SAF.	

Green Bonds	**Supply side focused**	Demand side focused
Green Bonds can be issued by private companies, public entities including local and regional governments, and supranational institutions. Designed with flexibility, Green Bonds can be structured to match the specific cash flows and timelines of projects, reducing investor risk and financing costs. Their aim is to provide stable, long-term, low-interest funding to accelerate SAF development.		
Where on the project lifecycle?	① Conceptualization & Stakeholder Alignment Phase; **② Setup of Regulatory Framework & Funding Mobilization Phase**; **③ SAF Production Scale-up & Market Integration Phase**	
Example	Air France–KLM has issued a EUR 1 billion sustainability-linked bond tied to its commitment to reducing Scope 1 and 3 emissions, with a focus on SAF.[258]	
Applicability in Jordan	Green bonds in Jordan are an emerging investment avenue, supporting sustainable projects in energy, water, and infrastructure, with growing international backing but limited local market maturity.	

III. Strengthening SAF Price Signals: Aim to stimulate long-term domestic demand for SAF and shift market behaviour toward low-carbon fuels by increasing SAF's price competitiveness against fossil jet fuel. This is

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[255] Climatescope by BloombergNEF (2021), *Energy Transition Factbook - Jordan*
[256] US Department of Energy (2025), *Clean Fuel Production Credit*
[257] IRENA (2021), *Renewable Readiness Assessment - The Hashemite Kingdom of Jordan*
[258] Kearney (2025), *With SAF demand on track to outpace supply, strategic financing of new capacity can close the gap*

achieved by fostering predictable, demand-side market signals that influence purchasing decisions and fuel choices - creating a level playing field against fossil fuels by internalizing their environmental costs and recognizing SAF's climate advantages.

SAF Blending Mandate	Supply side focused		**Demand side focused**
A policy that requires a certain percentage of aviation fuel used by airlines to be made up of SAF, intended to send clear demand signals to SAF suppliers.			
Where on the project lifecycle?	① Conceptualization & Stakeholder Alignment Phase	② Setup of Regulatory Framework & Funding Mobilization Phase	**③ SAF Production Scale-up & Market Integration Phase**
Example	The EU SAF Blending Mandate starts with a 2% SAF blend in 2025, rising to 6% by 2030 and 70% by 2050, with a PtL fuel sub-target of 1.2% in 2030 and 35% by 2050.[259] Fuel suppliers face penalties of at least twice the price gap between SAF and fossil kerosene for non-compliance. Aircraft operators must refuel at least 90% of their annual fuel needs at EU airports to prevent "tankering," while airports are required to provide infrastructure for SAF delivery, storage, and refueling.		
Applicability in Jordan	The implementation of a blending mandate is not viable before domestic SAF production is secured, in addition to the challenges it would pose for Jordan's aviation sector in competing internationally and the current policy focus on other energy priorities.		

Recognizing SAF Benefits Under Cap-and-Trade Systems or Carbon Taxation	Supply side focused		**Demand side focused**
The price premium of SAF over conventional jet fuel can be reduced through mechanisms like carbon taxation and cap-and-trade systems, which lower carbon-related financial obligations. Additionally, revenues generated from the taxation of conventional fossil jet fuel or the auctioning of emission allowances in cap-and-trade systems can be redirected to support SAF production, infrastructure, and R&D.			
Where on the project lifecycle?	① Conceptualization & Stakeholder Alignment Phase	② Setup of Regulatory Framework & Funding Mobilization Phase	**③ SAF Production Scale-up & Market Integration Phase**
Explanation	<u>Carbon taxation:</u> If aviation is subject to a carbon tax, airlines must pay a fee based on the amount of carbon dioxide they emit. Using SAF can lower airlines carbon tax liability. <u>Cap-and-trade system:</u> When aviation is included in a cap-and-trade system, airlines are required to hold emissions allowances for the carbon they emit. Using SAF reduces the need for airlines to purchase allowances and may even generate surplus allowances or credits that can be sold or traded.		
Example	<u>Cap-and-trade system:</u> The EU ETS SAF support scheme is revised to boost the uptake of SAF by covering part of their higher cost through free emissions allowances, reducing the price difference to conventional jet fuel that needs to bear the full emission pricing. By tying support to fuel type and uplift location, and enabling price transparency, the scheme aims to create strong market incentives to scale SAF production and use across Europe. Revenues generated from the auctioning of EU ETS allowances are directed to the EU Innovation Fund, the Modernization Fund, and national governments. These funds are then reinvested into clean technology projects. For instance, the EU Innovation Fund has already awarded over EUR 3.6 billion to 41 large-scale clean tech projects.[260] In addition, the EU ETS Directive provides a support mechanism for the use of SAF. To incentivise early uptake of the best-performing alternative fuels in terms of emissions reduction potential, 20 million EU ETS allowances, estimated at around €1.6 billion, are set aside from 1 January 2024[261] to cover all or part of the remaining price differential between fossil kerosene and the eligible aviation fuels used by individual		

[259] Detailed info on blending targets of EU SAF Blending Mandate under Appendix C
[260] European Commission (2023), *Innovation Fund: EU invests €3.6 billion of emissions trading revenues in innovative clean tech projects* and *adoption* (2025) *of EU ETS support system to accelerate the use of sustainable aviation fuels*.
[261] European Commission (2025), *Reducing emissions from aviation.*

	commercial aircraft operators on their flights covered by effective carbon pricing through the EU ETS. A level playing field is ensured, with all airlines that operate on these routes being treated equally.
Applicability in Jordan	As of 2025, Jordan has neither a carbon tax nor a cap-and-trade system in place. Moreover, integrating aviation into a cap-and-trade system remains highly complex and is difficult to implement unless multiple countries cooperate to ensure fairness and effectiveness for the local aviation market.

Book & Claim System	Supply side focused	**Demand side focused**
A system that allows the environmental benefits of SAF to be claimed by a buyer, even if the fuel is physically used elsewhere, enables more flexible and efficient SAF adoption. By using shared tracking systems and clear rules, it ensures transparency about who produces, uses, and claims SAF benefits. This approach supports a more cost-effective rollout by allowing companies to invest in centralized SAF infrastructure and benefit from economies of scale, rather than needing to supply SAF at every airport equally from the start.		
Where on the project lifecycle?	① Conceptualization & Stakeholder Alignment Phase ② Setup of Regulatory Framework & Funding Mobilization Phase	**③ SAF Production Scale-up & Market Integration Phase**
Example	Industry coalitions and governments around the world are working on the implementation of Book and Claim systems. For instance, RSB together with SAF producer SkyNRG,[262] or Brazil's GOL Airlines together with SAF distributor Vibra are piloting such systems[263]	
Applicability in Jordan	Jordan's commercial aviation is primarily centralized at Queen Alia International Airport in Amman and King Hussein International Airport in Aqaba. This concentration reduces the logistical complexity typically associated with SAF distribution, making direct SAF supply more feasible compared to decentralized aviation markets. Nevertheless, the implementation or integration in Book and Claim systems would be valuable to drive SAF uptake as the locations for domestic SAF production and supporting infrastructure are yet to be confirmed in the future.	

These options can help Jordan to narrow the cost gap between SAF and conventional jet fuel. Specifically, the policy actions outlined *I. Providing Public Funding* and *II. Creating Financing Incentives* are designed to boost investment by lowering the capital requirements and reducing the risk profile of SAF projects for investors. Crucially, these options are not intended to function in isolation, but rather to function partially or fully together to create the conditions necessary to unlock private investment. For this purpose, the following sub-chapter outlines how they can be effectively applied within Jordan's specific investment support framework.

<u>Investment support</u>

The World Economic Forum stipulates that by 2030, USD 19-45 billion of investment are missing worldwide to keep SAF financing on track for meeting aviation decarbonization targets.[264] Closing the investment gap will require that the majority of funding comes from private rather than public sources, as public financing alone is insufficient to meet the scale of investment needed. In the specific case of Jordan, this is especially true given the country's budgetary constraints, necessitating greater reliance on development institutions and the mobilization of private sector investments. This emphasizes the importance of creating both favourable conditions to attract private investments in Jordan, as well securing support from development institutions for funding targeted large-scale industry projects.

In terms of Jordan's positioning as a favourable investment destination: the country attracted USD 1.637 billion in FDI in 2024, equivalent to a substantial 3.1% of its GDP, and representing a 47.6% increase from 2023. Foreign Direct Investments (FDI) can provide a good indication of a country's attractiveness to

[262] RSB (2025), *RSB marks first approved Book & Claim Unit registration with SkyNRG's co-processed SAF*
[263] Reuters (2024), *Brazil's Gol, Vibra complete first SAF 'book-and-claim' in Latin America*
[264] World Economic Forum (2025), *Financing Sustainable Aviation Fuels: Case Studies and Implications for Investments*

investor.[265] This growing investor confidence is largely attributed to the positive perception of Jordan's Investment Environment Law and its close ties to the goals Jordan's Economic Modernization[266] (see 1.2 for more information). The majority of these investments originated from Arab countries, followed by Europe and other global regions.[267] SAF is well positioned to benefit from this strengthening investment climate, supported by growing investor appreciation for Jordan's economic development agenda. The government could further build on this momentum by positioning SAF development as a strategic priority.

Lastly, the country can leverage a comprehensive framework it established to fund major projects. In April 2025, the World Bank approved USD 1.1 billion in new financing to help Jordan advance its Economic Modernization Vision, reaffirming international confidence in the country's development agenda.[268] Jordan has a strong track record in delivering large-scale energy and infrastructure initiatives, supported by close partnerships with international development finance institutions. A prime example is the Tafila Wind Farm project, where the World Bank's IFC, the European Investment Bank, and other public partners provided approximately 50% of the total project capital through loans (see 1.2 for more background information on the project). Their involvement was instrumental in securing the remaining USD 150 million from private investors.

Similar actions are underway to deliver Jordan's hydrogen strategy, which can become a key pillar to realize SAF in Jordan. Drawing on its track record, Jordan is well-positioned to de-risk investments and mobilize substantial private capital to support this emerging sector. However, in contrast to this potential, the Baynouna Solar Power Plant case[269] - a development bank-backed project co-financed by the World Bank's IFC - highlights the need for Jordan to strengthen the execution of development finance-supported infrastructure. This case underscores the necessity for Jordan to ensure that future investment projects are not only financially viable but also socially inclusive and compliant with international environmental and social standards.

Directly focused on driving aviation decarbonization investments, Jordan may also benefit from the ICAO Finvest Hub, a global platform connecting sustainable aviation projects with public and private investors. The Hub is designed to accelerate funding for initiatives such as SAF, clean energy infrastructure, and related technologies critical to achieving net-zero carbon emissions by 2050. It emphasizes support for developing countries through technical assistance, capacity building, and policy guidance to attract investment. By engaging with the Finvest Hub, Jordan can position itself to scale up SAF deployment, access innovative financing.

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[265] FDIs are important to realize SAF projects, as most SAF producers are concentrated in a few countries, leading to major project developments abroad. Key SAF FDIs include Finland-based Neste's USD 1.65 billion expansion in Singapore, UK-based Velocys' biorefinery project in Mississippi, U.S.-based LanzaJet's global SAF initiatives with partners like Japan's Mitsui and the UK's British Airways, and France-based TotalEnergies' EUR 200 million investment in domestic SAF production.

[266] Arab News (2023), *Jordan's new investment law prompts 47.6% rise in funds into the country*

[267] The Jordan Times (2024), *Jordan attracts$1.637b worth of foreign direct investments in 2024*

[268] World Bank (2025), *Jordan and World Bank Deepen Partnership for Private Sector-Led Growth, Jobs, and Innovation*

[269] The project faced criticism for failing to adequately consult local communities, particularly members of the Al Balqa tribes, and for not recognizing their traditional use of the land for grazing and seasonal livelihoods in Jordan's central highlands – issues that led to a formal complaint to the IFC's Compliance Advisor Ombudsman.

Beyond international finance support, Jordan established the Jordan Renewable Energy & Energy Efficiency Fund (JREEEF) in 2015, which operates under the Ministry of Energy and Mineral Resources. The fund serves as a national mechanism to promote and finance renewable energy and energy efficiency projects across various sectors, including residential, educational, health, and public institutions. Between 2015 and 2023, JREEEF invested approximately USD 141 million in programs and projects throughout the Kingdom.[270]
While the fund does not specifically target large-scale industrial projects, it highlights Jordan's commitment to fostering sustainable energy development. This framework offers a foundation for targeted, on-the-ground support that could be leveraged to help realize a SAF value chain.

[270] The Jordan Times (2024), *100m invested in renewable energy from 2015 to 2023, Energy Fund says*

SECTION 4. ACTION PLAN

This chapter builds on the findings of the preceding analysis in this feasibility study, providing a structured action plan for its consideration by the State, to support the development and deployment of SAF in Jordan. It presents a series of targeted policy recommendations aimed at translating potential into implementation. These measures are designed to address key challenges identified in the feasibility assessment - such as feedstock availability, infrastructure gaps, and investment barriers – while leveraging Jordan's strategic advantages, including its renewable energy potential and institutional capacity.

The actions aim to support Jordan's national objectives for energy security, economic diversification, climate resilience, and the decarbonization of its own aviation sector in line with global decarbonization efforts.

Vision for SAF globally and in Jordan: basis for policy implementation

Global vision: Jordan endorses ICAO's global vision, as outlined in the ICAO Global Framework for SAF, Lower Carbon Aviation Fuels (LCAF), and other Aviation Cleaner Energies, which aims to foster a transition toward cleaner energy sources in international aviation. This vision aspires to achieve a collective global reduction of CO_2 emissions by 5% by 2030, compared to a baseline scenario without the use of cleaner energy sources, and sets a long-term aspirational goal of achieving net-zero carbon emissions by 2050.

Vision for Jordan: Jordan can position itself as a regional leader in SAF by leveraging its strategic location, abundant solar and wind resources, and growing innovation ecosystem to drive SAF production that enhances its energy security, supports economic diversification, and contributes to global climate goals.

4.1 POLICY AND REGULATORY FRAMEWORK

The following key takeaways from this feasibility study provide the policy and regulatory framework within which Jordan can develop its SAF future.

4.1.1 Organizational state: policy background & institutional landscape

Jordan's institutional and policy landscape reflects a growing readiness to support SAF development, driven by energy security concerns, climate goals, and a strategic focus on economic diversification, along with experience in large-scale industrial projects.

Energy context

Jordan is heavily dependent on energy imports, covering over 91% of its energy supply through fossil fuels. This energy vulnerability can create strategic interest in domestic SAF production as part of Jordan's energy security and economic diversification agenda. Jordan is already a regional frontrunner in renewable energy, and recent developments indicate growing momentum in the sector. Its abundant solar and wind resources provide a strong foundation for accelerating the development of clean energy solutions, including SAF.

Policy frameworks

The country has made strong commitments to decarbonization through policies such as:

- Updated NDC (2021) – with a 30% emissions reduction target by 2030 (26% conditional on international finance).
- National Climate Change Policy (2022–2050) provides a strategic framework to guide the transition to a low-carbon, climate-resilient economy.
- Sectoral strategies relevant to SAF include the Green Hydrogen Strategy, National Solid Waste Strategy, and Jordan's agricultural modernization agenda.
- Jordan's Aviation State Action Plan is currently being updated, with the aspiration of making SAF a central element in the country's efforts to reduce aviation emissions and support a more sustainable air transport sector.

While SAF is mentioned in the broader climate and waste management discourse, a concrete SAF policy roadmap, mandates, or market-based measures like book-and-claim are not yet in place. The CORSIA sustainability criteria, sustainability certification, and the methodology for the assessment of life cycle emissions used for 'CORSIA eligible fuels', should be incorporated into the national policy framework as the accepted basis for the eligibility of SAF.

<u>Implementation landscape</u>

Jordan has a strong track record in managing large-scale infrastructure projects through PPPs, including airport expansion, renewable energy, and freight rail. This makes it a promising destination for SAF investment, especially with supportive policies and a de-risked investment framework.

4.1.2 Feedstock availability, conversion pathways & infrastructure

<u>Feedstock availability</u>

Jordan is not a biomass-rich country, primarily due to severe water scarcity and limited arable land. These challenges are further compounded by climate change, with declining rainfall and rising temperatures reducing the reliability and productivity of biomass sources. To avoid competition with food crops, Jordan must focus on non-food-based feedstocks, offering meaningful potential. Municipal solid waste (MSW) is particularly promising. Utilising it for SAF production could simultaneously alleviate pressing waste management challenges and stimulate economic activity in urban centres. Agricultural residues, though much smaller in scale, add further potential, particularly in rural areas, where they could support income diversification and reinforce circular economy practices.

At the same time, the actual availability of biomass feedstocks will depend heavily on how they are prioritized across sectors – with SAF standing in competition with biogas, road transport biofuels, or other bioenergy uses. In addition, to the disadvantage of potential feedstock-for-SAF use, used cooking oil (UCO) is currently exclusively exported to Europe for biofuel production there.

In the long-run, PtL SAF promises a significant lever that Jordan can pull, leveraging its exceptional solar and wind resources for large-scale green hydrogen production. Despite its reliance on desalinated water for electrolysis and the need for further technological advancements in carbon capture, PtL SAF has the potential to position Jordan as a regional leader in next-generation, climate-resilient aviation fuels.

<u>Infrastructure readiness</u>

Currently, Jordan has no existing operational infrastructure for SAF production. However, the country's experience with large-scale energy logistics, successful investment projects, and its strategic Aqaba Port infrastructure provide a solid foundation to build on. Jordan also operates its own petroleum refinery, which could potentially be leveraged or adapted as part of future SAF production efforts. Nonetheless, scaling SAF will require the development of entirely new value chains – from establishing reliable feedstock collection systems to organizing dedicated SAF transport and distribution logistics.

SAF conversion processes

Biomass-based SAF conversion processes (HEFA, AtJ, and gasification-FT) present viable near-term options for Jordan, each with unique strengths and challenges. HEFA is the most commercially mature but is constrained by the country's limited supply of lipid feedstocks like used cooking oil or animal fats. Among the remaining options, AtJ and particularly gasification-FT show stronger alignment with Jordan's context. Particularly gasification-FT stands out for its feedstock flexibility and ability to convert MSW into SAF – addressing Jordan's pressing urban waste challenges – and for its capacity to make use of rural agricultural and livestock residues.

Though these biomass-based pathways are ultimately constrained in scale by feedstock availability, they should not be dismissed. On the contrary, they may play a critical transitional role by enabling early SAF production, building local infrastructure, and developing supply chain and technical capacities. PtL holds the greatest long-term promise for Jordan, leveraging its abundant solar and wind resources for scalable green hydrogen production.

To fully optimize Jordan's SAF strategy, further analysis is needed to determine the most effective allocation of available feedstocks across the different conversion pathways – such as through a Business Implementation Study-. A carefully coordinated approach can ensure that each pathway plays to its strengths while laying the groundwork for a sustainable, long-term SAF ecosystem.

4.1.3 Emission reduction potential & broader sustainability benefits

PtL offers the greatest potential for reducing greenhouse gas emissions for SAF production in Jordan, which can exceed 90% reductions when utilizing green hydrogen. MSW also demonstrates high carbon emission reduction potential alongside broader co-benefits. Other feedstocks can offer similar emission reduction potential, but falls behind PtL's potential.

Harnessing feedstocks for SAF production in Jordan can support progress toward several UN Sustainable Development Goals (SDGs), including SDG 7 (Affordable and Clean Energy), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). In particular, the use of MSW presents a strategic opportunity to tackle one of Jordan's most urgent environmental challenges. Repurposing organic waste – such as food scraps, paper, and yard trimmings – not only alleviates pressure on overcrowded landfills but also reduces methane emissions and improves overall waste management. This approach can stimulate investment in recycling infrastructure, create green jobs, and promote circular economy practices. In parallel, leveraging agricultural and livestock residues supports sustainable land use and boosts rural livelihoods. Together, these feedstock pathways can offer Jordan a holistic route to cleaner energy, stronger environmental stewardship, and inclusive economic development.

4.1.4 Attractiveness of large-scale investments in Jordan & SAF-specific investment conditions

Jordan's ability to realize a SAF industry hinges not just on policy ambition or technological potential, but crucially on the mobilization of capital. The establishment of SAF projects requires significant funding due to the high capital intensity along the entire value chain. This includes investment in feedstock collection and logistics, such as MSW separation systems and agricultural residue handling, the construction of processing facilities, the development of distribution infrastructure, and the deployment of utility-scale renewable energy plants to support production. Jordan is experiences in bringing large-industry projects online, through the support from international development organizations. In addition, the country has established dedicated green investment channels, which provide the potential to attract capital for SAF.

4.2 CRITICAL SUCCESS FACTORS

A functional SAF value is established when Critical Success Factors (CSFs) are successfully met across key areas of action identified to build a national SAF value chain. These areas of action are:

	Organization & Planning
	Funding & Project Inception Support
SAF	**Feedstock Processing Regulation & Infrastructure Setup** (Upstream SAF Value Chain)
SAF	**SAF Handling & Distribution** (Downstream SAF Value Chain)
	Market Creation

These areas of action provide the framework for policy recommendations in 4.3, outlining the specific SAF-related measures that Jordan can implement as part of its State Action Plan. Prior to this, the current status and readiness of each area of action are assessed using the following traffic light metric:

+	**Ready for action:** strong alignment and systems in place.
±	**Action needed to strengthen and scale:** initial steps exist, but key gaps persist.
-	**Action required:** foundational elements are missing or fragmented.

Organization & Planning Policy & Institutional Readiness		
Rating	Critical Success Factor (what must be reached)	Justification of rating, where Jordan stands today
±	SAF is embedded in national strategies, supported by a dedicated roadmap, empowered lead institution, inter-ministerial coordination, clear regulatory mandates, and stakeholder engagement mechanisms.	SAF is mentioned in Jordan's strategies (climate, energy, hydrogen), but lacks formal prioritization. There is no SAF task force, coordination platform, or defined roles for ministries. Regulation exists for processing biomass like manure and sewage sludge for waste management and sanitation, but not for conversion into biofuels, leaving SAF applications outside current legal definitions and permits.
To do:	Establish a coordinated national roadmap to guide, regulate, and oversee SAF development with clearly assigned responsibilities, supporting policies, and timelines.	

Investment & Project Inception Support Funding Readiness		
Rating	Critical Success Factor (what must be reached)	Justification of rating, where Jordan stands today
±	Dedicated SAF finance tools are established, access to concessional funds and guarantees, streamlined registration in national pipelines (e.g., PPP Unit, Investment Map), and early-stage risk mitigation frameworks are in place.	Jordan has a robust PPP framework and proven international finance access and well performing FDI environment. However, SAF-specific incentives, or financial programs are not yet in place. SAF projects are not registered as national investment priorities.
	To do: Enable SAF project development through SAF-specific finance instruments, blended public-private models, concessional finance, and integration into national investment priorities.	

Feedstock Processing & Infrastructure (Upstream SAF Value Chain) Readiness of policies and infrastructure setup for upstream value chain.		
Rating	Critical Success Factor (what must be reached)	Justification of rating, where Jordan stands today
-	Established feedstock hubs, traceability, sustainability certification (in line with ISCC/RSB), preprocessing infrastructure, collection incentives, and integrated logistics planning.	Jordan generates SAF-relevant biomass (e.g. MSW, agriculture residues), but lacks centralized collection systems, preprocessing facilities, and any SAF-specific traceability or certification mechanisms. Current logistic chains are fragmented.
	To do: Ensure efficient, traceable, and sustainable feedstock collection and preprocessing systems, including biomass and green hydrogen infrastructure readiness.	

SAF Handling & Distribution (Downstream SAF Value Chain) Readiness of policies and infrastructure setup for downstream value chain.		
Rating	Critical Success Factor (what must be reached)	Justification of rating, where Jordan stands today
±	Established and certified SAF distribution infrastructure, functional SAF blending infrastructure.	Jordan's fuel infrastructure is technically capable of developing towards a functional SAF value chain, but SAF blending is not in use, SAF airport integration remains undeveloped.
	To do: Build infrastructure and protocols to blend, store, and deliver SAF in line with international standards (ASTM, DEF-STAN).	

Market Creation Readiness of clear price signals and demand-supply side interaction.		
Rating	Critical Success Factor (what must be reached)	Justification of rating, where Jordan stands today
-	Clear and credible demand signals - such as blending mandates, pricing incentives, and Book and Claim systems are in place to activate domestic SAF markets and stimulate investment in SAF production.	Jordan has no market creation policies or offtake agreements in place. While Jordanian airlines are preparing for foreign SAF mandates and reporting, there are no domestic incentives online or obligations to drive SAF demand.
	To do: Design and implement demand-side instruments - such as SAF blending mandates, pricing incentives, and Book and Claim systems - and support airline offtake agreements to activate domestic SAF markets. Advocate for SAF use in foreign markets.	

4.3 ACTION PLAN

The following Action Plan builds on the insights gathered throughout this feasibility study. It combines the foundational analysis of Jordan's specific conditions from SECTION 1 with the results from the feedstock and conversion pathway evaluation for the most suitable pathways in SECTION 2 and takes the implementation support and financing needs from SECTION 3 into account. The proposed action steps are placed on a timeline and clustered into the following three consecutive phases:

①	**Conceptualization & Stakeholder Alignment Phase**	**Short-Term** 2025-2027
②	**Setup of Regulatory Framework & Funding Mobilization Phase**	**Medium-Term** 2027-2033
③	**SAF Production Scale-Up & Market Integration Phase**	**Long-Term** From 2033

The resulting roadmap for each phase focuses on the concrete steps required to realize an individual SAF plant project, including the necessary upstream, midstream, and downstream activities, and distinguishes between biofuel-based and PtL production pathways.

The following key ministries are addressed.

Table 21. Key public governance stakeholders and their potential role for SAF in Jordan.[271]

	Ministry of Local Administration (MOLA)	Oversees municipal governance and implements the National Solid Waste Management Strategy, a key to biomass feedstock availability. It supports sustainable infrastructure at the local level. It could help identify local SAF feedstock sources from waste and coordinate local permitting and siting of SAF projects.
	Ministry of Transport (MOT)	Oversees national transport policy and coordinates with MEMR and others for fuel strategy. It supports clean mobility projects. It could incorporate SAF into aviation strategy and coordinate cross-ministerial infrastructure planning for SAF distribution.
	Jordanian Civil Aviation Regulatory Commission (CARC)	Regulates Jordan's aviation sector and is responsible for air safety and environmental standards. It engages with decarbonization in aviation. It might mandate SAF blending targets and streamline SAF certification and airport distribution compliance.
	Ministry of Environment (MOENV)	Responsible for Jordan's carbon emission tracking. Could play a central role in launching market-based instruments such as carbon pricing and ETS that can support the scale-up of a SAF industry.
	Ministry of Agriculture (MOA)	Manages agricultural policy, land use, and crop/livestock development. Supports sustainable farming and promotes rural renewable energy use. Could enable SAF scale-up by facilitating access to agricultural residues, promoting energy crops, and integrating farmers into SAF feedstock supply chains.
	Ministry of Energy and Mineral Resources (MEMR)	Oversees renewable energy expansion and initiatives like Jordan's Green Hydrogen Strategy. It could embed SAF within national energy and hydrogen strategies and support infrastructure development.
	Energy and Minerals Regulatory Commission (EMRC)	Licenses energy/fuel projects and regulates tariffs, compliance, and market rules. It ensures legal conditions for renewable fuel deployment. It could create SAF-specific licensing frameworks and integrate SAF into fuel market regulation.

[271] Logos from respective websites (2025)

MINISTRY OF FINANCE	Ministry of Finance (MOF)	Manages national budgeting, taxation, and incentives. Can provide fiscal tools for green investments. It could introduce tax incentives, subsidies, or grants to de-risk SAF investment and stimulate market demand.
وزارة الاستثمار MINISTRY OF INVESTMENT	Ministry of Investment (MOIN)	Oversees investment attraction and PPP facilitation; engages private sector and donor coordination. It promotes green investment projects. It could drive SAF market entry by facilitating FDI, PPPs, and targeted investment promotion for SAF plants.

① Conceptualization & Stakeholder Alignment Phase

2025-2027

Goal: Gathering of all relevant stakeholder behind the shared vision for SAF production and use in Jordan, economic assessment of SAF implementation action, and development of a roadmap.

Area of action	Recommended Action	Success reached when/targeted condition:	Recommended timeline	Recommended participants	Risk of Failure & Management
	National SAF Vision: Develop and communicate a shared, evidence-based national vision for SAF in Jordan that reflects feedstock realities, climate goals, trade opportunities, and compliance with ICAO-CORSIA.	Alignment of stakeholders behind one shared, periodically updated vision.	Q3 2025 – Q2 2026 (~12 months)	Lead: CARC Involved: MOT, MEMR, MOENV, MOA, MOIN, MIT, RJA, NERC, JVA, ICAO	Risk of misaligned political will. Mitigate through senior leadership guiding vision development and active ICAO involvement.
	Business Implementation Study: Commission a techno-economic and cost–benefit analysis (potentially ICAO supported), including infrastructure and feedstock siting using FTOT[272], and use findings to draft and adopt a national SAF Roadmap. To provide guidance on which role biofuels should take against long-term potential of PtL.	Outputs that establish guardrails for private sector engagement, business planning, early financing strategies, and investment scope estimates and analyses to determine optimal locations for SAF infrastructure development.	Q2 2026 – Q4 2026 (~9 months)	Lead: CARC Involved: ICAO, MEMR, EMRC, MOT, MOLA, MOA, NERC and research institutes, international partners such as GIZ, ICAO	Risk of lack of financing and/or low prioritization for study execution and limited stakeholder input. Mitigate through broad engagement, alignment with global benchmarks, and engagement with ICAO to secure funding.
	Define the Role of SAF Biofuels and Launch a long-term Jordan PtL SAF Readiness and Integration Roadmap (2025–2040): Building on insights from the Feasibility Study, the Business Implementation Report and global SAF developments, Jordan should advance efforts for biofuel SAF that are viable under current conditions. In parallel, it should closely	Prioritization of biofuel SAF for short-term and medium-term development. Creation of a national PtL monitoring unit, the completion of a comprehensive techno-economic feasibility study by 2028, formal integration of PtL SAF into Jordan's national SAF roadmap once	Q4 2026 onwards	Lead: MEMR, CARC Involved: EMRC, MOLA, MOA, MOENV, NERC and research institutes, SAF producers and partners from abroad	There is a risk that Jordan may underestimate the long-term potential of certain biofuel pathways despite feedstock and resource constraints, or overestimate their near-term role and economic viability. Similarly, PtL may be overestimated in terms of short-term readiness or underestimated in its long-term strategic value for decarbonization and energy security. Further analysis beyond

[272] Freight and Fuel Transportation Optimization Tool (FTOT) from the US DOT Volpe Center, more information on it under 3.1.2.

	monitor the development of PtL technology. PtL may enable Jordan to harness its abundant renewable energy resources and reduce dependence on imported fuels. This will require sustained engagement with international developers, research institutions, and certification bodies to ensure Jordan is ready to adopt PtL SAF once it, and its underlying technologies (green hydrogen, carbon capture) becomes cost-competitive, and commercially mature.	international readiness is confirmed post-2035.			this feasibility study is needed to define the cost-optimal roles among biofuel pathways and between biofuels and PtL over time.
	Memorandum of Understanding (MoU) with Private Sector Players: establish a public-private task force and initiate alignment workshops to develop a shared SAF vision and outline initial roles and collaboration areas. Develop a monitoring framework and deliver targeted capacity-building to empower private stakeholders.	Informed by the Business Implementation Study, public and private stakeholders. Align on coordinated action, with defined roles and a joint, time-bound action plan supported by a monitoring framework established by the public-private task force.	Q3 2026 – Q2 2027 (~12 months)	Lead: MEMR, CARC Involved: MOT, EMRC, MOIN, MIT, JOTC, RJ, JVA, SAF producers and partners from abroad	Risk of unclear mandates or limited stakeholder buy-in. Mitigate through formal MoU, high-level political backing, early engagement of SAF experts, strong business cases, and targeted capacity-building support.
	Implementation in National Strategies: Integrate the SAF roadmap into relevant cross-sectoral national strategies, including energy, Green Hydrogen Strategy, National Solid Waste Management Strategy, Economic Modernization Vision, investment, and climate policy.	Establish SAF as a high-relevance priority and synchronize it with Jordan's national strategies to benefit from them and strengthen their targets of enhancing energy security, attracting investment, boosting climate resilience, creating green jobs, and driving economic diversification.	Q1 2026 – Q4 2027 (~18 months)	Lead: MENV, MOLA, MEMR, MOIN, MOA Involved: MoPIC, MoITS, MoF,	Risk of fragmented updates or weak integration of SAF across strategies. Mitigate by embedding SAF in cross-sectoral priorities (e.g. hydrogen, climate, aviation), securing senior-level commitment, and coordinating through an inter-ministerial process.

	Propose Additional Feedstocks to ICAO for CORSIA Eligibility: Confirm the sustainability of jojoba oil and fruit residues (pomace, pits, pulp, and skins) identified in this feasibility study. Based on results, submit a formal proposal to ICAO for their inclusion as CORSIA-eligible feedstocks under ICAO-approved Sustainability Certification Schemes (SCS).	Broaden the global list of CORSIA-eligible feedstocks to include arid-climate-suitable resources, increasing flexibility for countries like Jordan.	Q1 2026 – Q4 2027 (~24 months)	Lead: CARC, MOENV, MOA Involved: ICAO, NERC and research intstitutes, RSB/ISCC certifiers	ICAO may require extensive data and validation for new feedstock inclusion, delaying approval. Support feedstock proposal with local LCA studies and early dialogue with ICAO to pre-empt validation delays and align with RBS and ISCC as the CORSIA-approved SCS.
	Domestic Workforce Training: Launch and strengthen academic and vocational programs in SAF-relevant disciplines (e.g., renewable energy and biofuels, biochemical engineering, SAF policy), strengthen international research collaboration, and provide ongoing workforce upskilling.	Creation of a skilled workforce ready to scale SAF production, alignment of academic output with industry demand, increased innovation capacity in sustainable fuels, enhanced international collaboration and knowledge transfer.	Starting Q4 2026 (ongoing)	Lead: MOHE, NERC Involved: MOL, research institutes	Lack of funding, slow curriculum adaptation, limited international collaboration. Mitigation measures can include government incentives, university capacity-building, global SAF alliances, and industry-academia councils

② Setup of Regulatory Framework & Funding Mobilization Phase **2027-2033**

Goal: Secure and scale investment for SAF infrastructure setup, feedstock systems rollout, technology deployment, and establish regulatory frameworks for feedstock processing and SAF handling.

Area of action	Recommended Action	Success reached when/targeted condition:	Recommended timeline	Recommended participants	Risk of Failure & Management
	Establish Regulatory Framework for Feedstock Processing: Establish national legal and procedural rules for the collection and handling of CORSIA-eligible biomass feedstock and implement traceability standards. The CORSIA sustainability framework should be incorporated in the national regulation as the accepted basis for the eligibility of SAF.	Regulatory and legislative frameworks governing the safe, efficient, and sustainable management of each biomass feedstock type throughout its entire value chain - from collection to conversion to ensure biomass integrity and sustainability.	Q1 2027 – Q4 2028 (~24 months)	Lead: MoEnv, MOLA, MEMR, MOA Involved: Municipalities, MOLA	Institutional overlap may delay enforcement. Resolve through an inter-ministerial task force with defined roles. Lack of certification expertise may hinder compliance. Mitigate through exchange with ISCC/RSB.

	Optimize SAF Plant Location: Identify SAF production sites based on proximity to sustainable feedstock, renewable electricity sources (solar, wind), water availability (especially for hydrogen production), and export infrastructure.	SAF plants and broader upstream and downstream infrastructure are optimally placed to minimize production costs, reduce supply chain emissions, and enable export competitiveness.	Q1 2027 – Q4 2030 (~48 months)	<u>Lead:</u> MEMR, EMRC; MOLA <u>Involved:</u> EMRC, MOENV, JPRC, JOTC, ASEZA, CARC, MWI, municipalities, SAF developers, ICAO technical support, application of tools like FTOT	Risk of poorly located plants, increasing logistics costs. Mitigate by conducting multi-criteria site assessments early, involving energy, agriculture, and logistics experts and feedstock-source location mapping.
	Put SAF on Jordan's Central Investment Map of the Environmental Investment Law: Include SAF value chain projects as priority investment opportunities.	Encourage investment in the development of SAF in Jordan and elevate the visibility of SAF within Jordan's central investment planning framework.	Q1 2027 - Q2 2028 Review Environmental Investment Law (~0–9 months) Finalize registration and promotion (~9–18 months)	<u>Lead:</u> MOIN <u>Involved:</u> MOPIC, MEMR	Limited awareness, competing priorities, or lack of technical expertise for SAF, which can be mitigated by strong coordination among key ministries, early stakeholder engagement, and clear demonstration of SAF's strategic value to Jordan's green economy goals.
	Launch SAF PPP process: Launch SAF-specific PPP process with official government sponsor and PPP Unit registration	Leverage Jordan's PPP framework to share investment risk, coordinate public and private stakeholders, and enable scalable SAF project execution aligned with the Economic Modernization Vision.	Q1 2027 - Q4 2028 Identify sponsor and register with PPP Unit (~0-12 months) Launch procurement and tender process. (~12-24 months)	<u>Lead:</u> MOIN (PPP Unit), MEMR or MOT (project sponsor), <u>Involved:</u> private investors, MOPIC	Project may face delays in sponsorship or approval. Secure early government sponsorship; Request and use an ICAO-supported Business Implementation Study to strengthen business case viability. Engage PPP Unit from the start for technical guidance.
	Engage Development Banks to Finance SAF Projects: Identify aligned funding windows, initiate early consultations, and prepare a full proposal including feasibility, impact, and financial models.	Leverage the financial and technical resources of development banks to fund SAF infrastructure and supply chain projects, ensuring alignment	Q1 2027 onwards	<u>Lead:</u> MOIN, Development Banks (e.g. World Bank IFC, EIB, etc.) <u>Involved:</u>	Complex application procedures and co-financing requirements, lengthy approval processes. Engage early with development banks, streamline internal processes, and explore broad blended finance models,

		with national sustainability goals and international standards.		CARC, philanthropic funding organizations	including co-financing through philanthropic funding.
	Agriculture Residues Mobilization Program for SAF biofuel production: Establish a nationwide system for collecting and valorizing agricultural and livestock residues by developing regional biomass hubs in agricultural zones (esp. Jordan Valley, Ajloun). Enable residue traceability and sustainability certification, such as through a QR-based traceability system, and equip these hubs with pre-treatment infrastructure.	A significant share of agricultural residues (~70%, primarily from fruit- & field crops-, and manure) are aggregated with traceable origin, preprocessed, and supplied to SAF projects or intermediaries.	Q1 2027 onwards Mapping and stakeholder engagement (~6–12 months) Pilot collection hubs in Jordan Valley (~12–18 months) Scale-up to national network with traceability (~18–36 months)	Lead: MOA, MOENV Involved: MIT, Agri-cooperatives, SAF developers, digital logistic solution providers	Agriculture residue mobilization action is critically important to kickstart feedstock supply chain establishment. Farmers may hesitate diverting residues from traditional uses like cooking or heating, may be mitigated by offering payments or credit-based incentives (e.g. per-tonne bonus). Residue quality may vary significantly across regions, so drying and sorting stations may be essential to remove moisture and contaminants for consistent SAF production. Logistics in rural areas could be fragmented, which can be addressed by using mobile aggregation units and co-locating hubs near existing irrigation infrastructure.
	Municipal Solid Waste Mobilization Program for SAF biofuel production: Modernize waste management by equipping major landfills and transfer stations with pre-sorting, drying stations, and digital tracking solutions to capture biowaste, paper & cardboard, wood & yard waste (currently CORSIA-eligible MSW). Partner with Amman Vision Treatment and Recycling, operating Jordan's main landfill Al-Ghabawi.	Recovering an impactful share of Jordan's annual ~2 Mt of CORSIA-eligible MSW as feedstock for SAF, which can create the positive spillover effect of easing Jordan's growing waste burden and help raise its currently low 7% recycling rate.	Q2 2027 onwards Define sorting standards and digital tagging protocols (~0–6 months) Equip key landfills (Al-Ghabawi) with sorting systems (~6–24 months) Fully integrate MSW into SAF supply chains (~24–57 months)	Lead: MOLA, MOENV, AVTR Involved: Municipalities, MEMR	MSW mobilization action is critically important to kickstart feedstock supply chain establishment. Sorting compliance may be low at the household or municipal level, which can be mitigated by launching citizen incentive programs for waste separation and investing in optical sorting systems at the processing sites. Contamination of organic feedstocks is another risk, which can be addressed through sealed collection channels and standardized pre-processing protocols and tracking solutions like QR-based tracking.
	Initiate Green Hydrogen Mobilization Program for PtL SAF production: Ensure that a dedicated share of green hydrogen under Jordan's Green Hydrogen Strategy is reserved for domestic SAF production. Use water from	A scalable green hydrogen and desalination cluster with sustainable water sourcing and renewable electricity use is established to supply PtL SAF production at	Q2 2027 onwards Confirm location (e.g., Aqaba), define SAF link. (tbd)	Lead: MEMR, EMRC, MWI, ASEZA Involved: CARC, water utilities, renewable	High upfront costs, permitting delays, and technology or commercial readiness bottlenecks could slow deployment. These risks could be managed through blended finance and international climate funding, early-stage public-private partnerships,

	non-agricultural sources (desalination) for intermediate hydrogen production, in alignment with strict environmental safeguards to protect ecosystems such as the Gulf of Aqaba and to safeguard food security by avoiding competition with agricultural water needs.	commercial scale. Desalination by-products are managed sustainably, with added value generated through the extraction of minerals from the by-product brine.	Obtain permits, funding, build electrolysers, train teams. (~24+ months) Start green hydrogen production for SAF; manage brine. (~50+ months)	energy developers, hydrogen project developers, private sector investors and financiers	streamlined approvals, and phased project design that allows for scaling as infrastructure and market demand mature.
	Initiate Carbon Circularity Incentive Scheme for PtL SAF production: Establish a national initiative to capture, transport, and reuse high-purity CO_2 flue gas emissions from Jordan's phosphate, cement, and chemical industries, supplying this CO_2 to PtL SAF facilities, where it is combined with green hydrogen.	Jordan operates a carbon circular SAF system where high-purity industrial CO_2 is captured, tracked, and reused in PtL fuel production with green hydrogen. A connected network of domestic emitters enables continuous supply, with additional CO_2 imports covering domestic shortfalls. This supports deep decarbonization and industrial modernization.	Q2 2027 onwards Identify top point-source emitters, define CO_2 purity benchmarks (tbd) Deploy pilot capture systems and secure SAF off-take deals (~24+ months) Operationalize logistics and long-term CO_2 capture contracts (~60+ months)	<u>Lead:</u> MOENV, EMRC, MEMR, MIT <u>Involved:</u> JPMC and other industrial emitters	Low technology readiness of CCU and the even higher costs and complexity of DAC (as alternative) limit near-term viability. Captured CO_2 may need to be imported partially. The Jordan–UAE Railway Network may enable cost-effective CO_2 transport from domestic phosphate and potash sites (from Jordan Phosphate Mines Company) to Aqaba, supporting PtL SAF production near green hydrogen infrastructure.
	Develop Standards for SAF Handling and Infrastructure Operations: establish regulatory processes for approving and operating SAF production, storage, blending, and distribution facilities, including licensing aligned with national and international standards.	Ensure a safe, streamlined, and internationally compliant SAF supply chain that enables infrastructure development and market entry. Including SAF-specific emergency handling and safety protocols.	Q1 2028 - Q4 2029 Benchmark international standards (~6–12 months) Draft and implement standards (~12–24 months)	<u>Lead:</u> EMRC <u>Involved:</u> CARC, MOT, JOTC, airport authorities	Lack of existing SAF-specific protocols could delay infrastructure development and industry uptake. Benchmark international success stories and consult industry stakeholders during policy design.

③ SAF Production Scale-Up & Market Integration Phase

From 2033

Goal: Support SAF plant construction, develop a self-sustaining SAF market by stimulating demand, ensure full supply chain readiness, and explore opportunities to leverage Jordan's SAF PtL export potential.

Area of action	Recommended Action	Success reached when/targeted condition:	Recommended timeline	Recommended participants	Risk of Failure & Management
	Stimulate Demand: Introduce one or more of the following instruments to accelerate SAF market uptake: Option A: SAF blending mandate, Option B: Book and Claim system, Option C: integration into carbon pricing or offsetting mechanisms.	Stimulation of long-term demand and market behaviour favouring SAF by enhancing its price competitiveness with fossil jet fuel.	Q1 2034 onward	Lead: MOF, MOT Involved: CARC, MEMR, RJA, JVA and other airlines, carbon market bodies, ICAO	Risk of limited airline uptake. Mitigate through early stakeholder consultations, strong compliance incentives, and transparent certification of SAF volumes.
	Ensure Full SAF Supply Chain Readiness: Build and certify a downstream SAF supply chain - covering blending, storage, airport fuelling, and export logistics - optimized for likely long-term conversion pathways (gasification-FT and PtL), with full traceability and sustainability certification.	SAF is reliably delivered from production sites to airports and export points through a fully operational, certified downstream infrastructure.	Q1 2034 onward	Lead: MEMR, EMRC, MOT Involved: CARC, JPRC, airport authorities, SAF developers	Risk of misaligned infrastructure for future SAF types. Mitigate by designing flexible downstream systems and updating standards to accommodate PtL fuels.
	Develop Regional SAF Expansion Plan: Establish partnerships with MENA countries to jointly scale SAF feedstock sourcing, production capacity, logistics, and market access. Integrate PtL once commercially available and position Jordan as a regional PtL-export hub in the future.	Jordan is integrated into a regional SAF supply and demand network, enabling economies of scale, shared infrastructure, and cross-border SAF trade. Jordan utilizes its PtL potential.	Q1 2034 onward	Lead: MEMR, MOPIC Involved: CARC, international partners	Risk of fragmented or competing regional strategies. Mitigate by formalizing regional cooperation through MOUs, harmonized certification standards, and coordinated SAF infrastructure investment plans.

List of parties implicated in action plan

- ASEZA — Aqaba Special Economic Zone Authority
- AVTR — Amman Vision Treatment and Recycling
- EMRC — Energy and Minerals Regulatory Commission
- JAV — Jordan Aviation
- JPMC — Jordan Phosphate Mines Company
- JPRC — Jordan Petroleum Refinery Company
- MEMR — Ministry of Energy and Mineral Resources
- MIT — Ministry of Industry, Trade and Supply
- MOA — Ministry of Agriculture
- MOENV — Ministry of Environment

- MOF Ministry of Finance
- MOHE Ministry of Higher Education and Scientific Research
- MOIN Ministry of Investment
- MOL Ministry of Labour
- MOLA Ministry of Local Administration
- MOPIC Ministry of Planning and International Cooperation
- MOT Ministry of Transport
- MWI Ministry of Water and Irrigation
- NERC National Energy Research Centre
- RJA Royal Jordanian

APPENDICES

APPENDIX A: FEEDSTOCK EVALUATION MATRIX

	Feedstock type	
Summary	**CORSIA eligibility:** Indicates CORSIA eligibility. "No" means it was deemed relevant and sustainable in Jordan and may be a candidate for eligibility later. **Pathway:** Describes the suitable feedstock-to-SAF-biofuel conversion pathways for each feedstock. Please note that some feedstocks have multiple pathway options. **Feedstock share:** Indicates a feedstock's % share of total dry biomass availability, offering a magnitude comparison to other suitable feedstocks. **Summary text:** Summarizes the overall potential.	**Overall potential (1-4):** ■■■■ Rounded arithmetic average potential rating based on sub-category potential rating.
Subcategories	**Availability:** Describes annual availability of a feedstock in kt, if annual availability data is available. Otherwise, an alternative metric is provided.	■■■■
	Sustainability: Describes both life cycle emission reduction potential and information on social sustainability issues.[273] Life Cycle Emission Value is calculated as: Measures the greenhouse gas emissions of a fuel over its entire lifecycle in grams of CO_2 per Megajoule of fuel burned (gCO_2eq/MJ)[274] Burning one MJ of jet fuel results in roughly 100 g CO_2eq.[275] L_{CEF} below Jet A1's reference value for a feedstock to qualify as SAF, where: ▪ LCA Value: The total greenhouse gas emissions of a fuel, measured from raw material extraction to end-use. Conventional fossil jet fuel reference is 89 gCO_2e/MJ for jet fuel = an LCA Value of 89 for Jet A1. For feedstock that can be used in more than one feedstock-to-SAF conversion pathway, the LCA value can be different per pathway. ▪ ILUC - Indirect Land Use Change Value: The estimated emissions impact of converting land for fuel production, considering displacement of existing land uses. Zero for conventional jet fuel since fossil fuels, unlike biofuels, do not involve land-use change ▪ Emission Credit: A reduction in reported life cycle emissions granted when specific sustainability criteria, such as waste utilization or carbon sequestration, are met. Not part of this feasibility study's evaluation. LCA and ILUC values are given per CORSIA eligible feedstock.	■■■■
	Feedstock collection: Describes how easy it is to collect and process feedstock to SAF production, supply chain obstacles, and further constraints that minimize the feedstock availability potential.	■■■■
	Economic/market viability: Describes if there is an existing market for feedstock trading, incl. price data.	■■■■
	Spillover effects from feedstock use: Describes broader positive economic, environmental, and social impacts.	■■■■
	Actions needed to materialize the potential: Not part of feedstock potential assessment. Suggests which actions are required to remove obstacles to materialize feedstock potential.	

[273] ICAO (2024, October), *CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels*

[274] One tonne of Jet A1 corresponds to roughly 42,900 MJ

[275] CO_2eq refers to Carbon Dioxide equivalent, a measure that equalizes multiple greenhouse gases, which have different warming effects, by converting them into a common CO_2-based unit.

$$\text{Total Potential Score} = \frac{\text{Availability} + \text{Sustainability} + \text{Feedstock Collection} + \text{Economic Market Viability} + \text{Spillover Effects}}{5}$$

This is then calculated per feedstock type and represented visually.

APPENDIX B: MEETINGS THAT TOOK PLACE DURING THE STUDY

Meeting		Stakeholder
#	Date of meeting(s) And in written exchange during study	Name
1	21 Nov 2024 12 Dec 2024[276]	National Energy Research Centre (NERC)
2	12 Dec 2024	German Jordanian University (GJU)
3	12 Dec 2024	Tafila Technical University (TTU)
4	12 Dec 2024	Isra University (IU)
5	12 Dec 2024	Amman Arab University (AAU)
6	12 Dec 2024	Al-Hussein Technical University (HTU)
7	12 Dec 2024	Philadelphia University (PU)
8	12 Dec 2024	Jordan University of Science and Technology (JUST)
9	17 Dec 2024	Queen Alia Airport Amman (OJAI)
10	18 Dec 2024	King Hussein Airport Aqaba (OJAQ)
11	18 Dec 2024	Jordan Aviation (JAV)
12	19 Dec 2024 29 Jan 2025	Ministry of Agriculture (MOA)
13	02 Jan 2025 23 Jan 2025	Ministry of Local Administration (MOLA)
14	08 Jan 2025	Amman Vision Treatment & Recycling (AVTR)
15	08 Jan 2025	Ministry of Transport (MOT)
16	13 Jan 2025	Ministry of Environment (MENV)
17	20 Jan 2025	Ministry of Energy and Mineral Resources (MEMR)
18	20 Jan 2025	Energy and Minerals Regulatory Commission (EMRC)
19	04 Feb 2025	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
20	05 Feb 2025	International PtX Hub
21	06 Feb 2025	POIL Group
22	11 Feb 2025	Royal Scientific Society – Water, Energy and Environment Center (RSS WEC)
23	14 Feb 2025	US Department of Transport - Volpe National Transportation Systems
24	27 Mar 2025	Ministry of Investments (MOIN)
25	02 Apr 2025	Washington State University (WSU)
26	23 Apr 2025	Royal Jordanian (RJA)
27	28 Apr 2025	World Bank IFC
28	29 Apr 2025	Manaseer
29	-	JoPetrol/Jordan Petroleum Refinery Company
30	-	Jordan Oil Terminals Company

[276] 12 Dec 2024: Workshop with multiple research centres and universities

APPENDIX C: EU BLENDING MANDATE TARGETS

Note: All SAF blending mandates per year in the following table can be found under „Annex I“, referring to Article 4, in the Regulation (EU) 2023/2404.[277]

Timeframe	Each year a minimum share of	
From 1 Jan 2025 to 31 Dec 2029	2% SAF	
From 1 Jan 2030 to 31 Dec 2031	6% SAF	With PtL SAF sub-target of total fuel: • average share over the period of 1.2 % • of which each year a minimum share of 0.7 %
From 1 Jan 2032 to 31 Dec 2034	6 % SAF	With PtL SAF sub-target of total fuel: • an average share over the period of 2 % • of which each year a minimum share of 1.2 % • of which a minimum share of 2 % in 2034
From 1 Jan 2035 to 31 Dec 2039	20% SAF	With PtL SAF sub-target of total fuel: • of which a minimum share of 5 %
From 1 Jan 2040 to 31 Dec 2044	34% SAF	With PtL SAF sub-target of total fuel: • of which a minimum share of 10 %
From 1 Jan 2045 to 31 Dec 2049	42% SAF	With PtL SAF sub-target of total fuel: • of which a minimum share of 15 %
From 1 Jan 2050 onwards	70% SAF	With PtL SAF sub-target of total fuel: • of which a minimum share of 35 %

[277] EUR-LEX (2025), *Regulation (EU) 2023/2405 of the European Parliament and of the Council of 18 October 2023*

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