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ZIMBABWE

FEASIBILITY STUDY ON THE USE OF SUSTAINABLE AVIATION FUELS

ICAO-EUROPEAN UNION ASSISTANCE PROJECT: CAPACITY BUILDING FOR CO_2 MITIGATION FROM INTERNATIONAL AVIATION

PHASE II

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FOREWORD

In 2022, the 41st ICAO Assembly adopted a long-term global aspirational goal (LTAG) for international aviation of net-zero carbon emissions by 2050 in support of the UNFCCC Paris Agreement's temperature goal. Each ICAO Member State will contribute to achieving the goal in a socially, economically and environmentally sustainable manner and in accordance with its national circumstances. The ICAO Assembly also affirmed that specific measures to assist developing States as well as to facilitate access to financial support, technology transfer and capacity building should be initiated as soon as possible.

In support to these Assembly Resolution provisions, ICAO has launched the ICAO Assistance, Capacity-building and Training for Sustainable Aviation Fuels (ICAO ACT-SAF), which aims to provide tailored support for States in various stages of SAF development and deployment, facilitate partnerships and cooperation on SAF initiatives under ICAO coordination and serve as a platform to facilitate knowledge sharing and recognition of all SAF initiatives around the globe.

In line with the ICAO ACT-SAF objectives, ICAO has been actively partnering with the European Union (EU) to develop assistance projects that support Member States' initiatives to reduce the climate impacts of international civil aviation. The first phase of the ICAO Assistance Project with the European Union (EU) Funding was launched in 2013 and provided support to 14 participating States in Africa and the Caribbean. Among other results, this project led to development of four feasibility studies on the use of Sustainable Aviation Fuels (SAF) in Burkina Faso, Kenya, Dominican Republic, and Trinidad and Tobago. After completion of the first phase, in 2020 ICAO and the EU decided to add a second phase to the Assistance Project, in order to provide support to 10 African States. This Phase 2 of the project funded three feasibility studies on sustainable aviation fuels in Cote d'Ivoire, Rwanda, and Zimbabwe.

The following feasibility study assesses the potential for production and use of socially acceptable, environmentally friendly, and economically viable drop-in SAF in Zimbabwe. The study follows the general structure and information provided in the "Template for Feasibility Studies on Sustainable Aviation Fuels", developed in the context of the ICAO ACT-SAF programme. Such analysis includes:

- information on the specific circumstances of the State, explaining the unique characteristics and factors that could affect the development and deployment of SAF in the State;
- the identification of priority pathways for SAF production
- information on implementation support and financing needed for the implementation of the priority pathways identified; and
- recommendation of an action plan aligned with the State's governmental policies related to the SAF development, with a focus on the priority pathways identified.

EXECUTIVE SUMMARY

A. Background

In an effort to contribute towards the International Civil Aviation Organization's aspirational goals, Zimbabwe developed a State Action Plan for CO_2 Emissions Reduction from International Aviation. The following feasibility study is a result of the International Civil Aviation Organization's support for Zimbabwe's determination to contribute towards the sustainable development of its aviation sector, specifically assessing the use of sustainable aviation fuels a viable option to reduce emissions. This study was developed and financed under the International Civil Aviation Organization – European Union project framework and involved more than 25 relevant stakeholders from government, industry, and academia.

B. Key findings

This study provides an analysis of the development and deployment of SAF in Zimbabwe with the aim to identify opportunities for the establishment of a feasible SAF's supply chain. It provides a detailed evaluation along the SAF value chain including the availability of suitable feedstock sources and volumes, access to conversion technology, potential demand, implementation keys (policies, challenges, and alternatives), and the environmental, social, and economic development impact. Most importantly, this study intends to raise awareness and set a baseline from where to in mobilize industrial and financial support, as well as essential political support from the government of Zimbabwe.

After careful analysis, findings reveal that **Zimbabwe holds the technical capacity to deploy the production of SAF and co-products, particularly renewable diesel (RD) in the medium and long term**. The country's experience in feedstock production, and biofuel processing and promotion provides a great level of expertise applicable to the launch and operation of the industry. A necessary first step is to **set-up a framework** for organizational structuring and enabling the readiness level of the value chain. This includes government support to build knowledge and capacity on handling, regulation, and certification (safety, quality, and sustainability) of SAF and RD in the short term. Just as important is to **understand market uptake by local users as well as potential export markets**, and an effective way to scale up feedstock volumes to satisfy demand.

There are **fourteen potential feedstocks available in Zimbabwe for conversion to SAF**. While none of them is being produced in sufficient volumes to satisfy the input needs of a commercial SAF plant, the most promising feedstock is **ethanol produced from sugarcane**. Contingent to expansion plants currently under implementation by existing ethanol producers Green Fuel and Triangle Limited, in three to five years, enough ethanol may be available to secure the production of SAF. Sugar cane bagasse and oil seeds, primarily jatropha and sunflower oil, also make for attractive feedstocks once a significant increase in capacity for SAF production is achieved in the medium to long term.

Presently, there are ten approved feedstocks and conversion processes for SAF production certified for safety and quality by the American Society for Testing and Materials (ASTM), and seven under evaluation for approval. **The alcohol-to-jet fuel (ATJ) and hydroprocessed esters and fatty acids (HEFA) conversion processes are most suitable for deployment in Zimbabwe** congruent with currently available feedstock. Processing technology operating in existing biofuel plants cannot be retrofitted to the ATJ and HEFA conversion processes. Therefore, technology transfer and technical skill development is key to prepare the future workforce of Zimbabweans to lead the SAF industry and avoid dependence on foreign experts.

C. Policy implications

SAFs are currently more expensive than conventional fuels. The lack of a level playing field in commercial markets makes the deployment of sustainable aviation fuels in Zimbabwe economically unviable without dedicated government support. **Existing government policy** promoting the production and use of alternative fuels for transport as well as programs under implementation to optimize agricultural outputs offer some support to help unlock the potential of SAF. Yet, to secure the economic potential to deploy SAF, the government's support on implementation and mobilization of financing mechanisms makes for critical success factors. Similarly critical is **collaborating with neighbouring countries** to jointly develop a regional approach to facilitate the production of SAF under harmonized policy and shared markets.

D. Opportunities and Challenges

Zimbabwe is well suited to deploy the production of SAF within the next 3-5 years. Ethanol makes for the most suitable and immediately available feedstock for conversion into SAF conditional to the completion of expansion plans currently under implantation to produce sugar cane. The State holds extensive expertise in the conversion of ethanol to renewable fuels supported by national policy. Opportunity also lies in the use of jatropha for SAF conversion in the long term. This latter SAF pathway completely aligned with the State's energy independence directive as well as with job creation and poverty alleviation of rural communities.

Challenges remain in the overall stability of government's support to promote the sector, including feedstock production, with a needed first step of incorporating the SAF industry explicitly into existing supporting policy both for producers and users. Similarly, challenges remain on achieving the readiness level of the SAF value chain downstream, particularly on capacity building for responsible entities to understand the handling of SAF as today is done with conventional aviation fuel (quality, safety, pricing, logistics).

CONTENTS

METHODOLOGY

The Republic of Zimbabwe is one of the ten ICAO Members States selected to receive support in the first steps of implementation of the SAP under the ICAO Assistance Project with EU Funding, Phase II (2020-2023). A consultant has been provided to evaluate the feasibility of the State to develop and deploy SAF factoring in all variables within the value chain, including:

SECTION 1. State-Specific Information

1.1 Geography and Climate
1.2 Trade and Governance
1.3 Demographics
1.4 Vulnerability to Climate Change
1.5 Agriculture
1.6 Energy
1.7 Aviation Fuel Value Chain

SECTION 2. Evaluation of Feedstocks and Pathways for SAF Production

2.1 Feedstock and conversion processes
2.2 Summary of evaluated feedstocks
2.3 Feedstock Specific Assessment
- Economic/Market-related Issues
- Overall Assessment.

SECTION 3. Implementation and Financing

3.1 Implementation Support
3.2 Financing

SECTION 4. Action Plan

4.1 Key findings
4.2 Action Plan

The primary objective is to conduct a comprehensive study assessing the potential for production and use of socially acceptable, environmentally friendly, and economically viable drop-in SAF in Zimbabwe.

In addition, the feasibility study should serve to:

- Identify singularities and opportunities of a potential SAF Supply Chain,
- Define potential capacity: feedstock and conversion,
- Define demand, considering cost/benefit and prices,
- Evaluate the environmental impact (GHG, water, soil) and local social and economic development impact, and
- Look for implementation keys (policies, challenges, and alternatives).

LITERATURE REVIEW AND SECONDARY DATA

A literature review was conducted to assess national conditions in Zimbabwe as well as global development for the production and use of SAFs and sustainable fuels for ground support equipment (GSE).

Significant advances have been achieved by different ministries in Zimbabwe to address climate change concerns and GHG reductions from the transport sector. However, no specific work has been conducted that evaluates the GHG reduction potential and deployment viability of SAFs and sustainable fuels for GSE. Nonetheless, the Civil Aviation Authority of Zimbabwe's (CAAZ) decision to participate in ICAO Assistance Project with EU Funding, phase II (2020-2023), sends a clear message about the country's commitment to sustainable growth for the aviation sector.

Research material evaluating regional and local potential for deployment of SAFs is limited in Zimbabwe, similar to other regions of the world considering that this is a nascent industry. In this regard, secondary data was also collected on processing technology developments, feedstock generation, advanced conversion processes, and the entire supply chain.

INTERVIEWS AND ELECTRONIC DATA COLLECTION

Data collected during in-person and virtual interviews, as well as via email, helped reach more accurate and comprehensive conclusions for this study. In person meetings were conducted for two weeks from June 1st through June 15th, 2023. Virtual meetings and email exchanges took place for most of the length of the research beginning April 21st through September 8th, 2023. Table 1 shows the list of stakeholders who participated in in-person interviews.

Table 1. In-Person/Virtual Meetings Participants

LOCAL STAKEHOLDERS	
INSTITUTION	**REPRESENTATIVE**
ACZ	B. Mpanguri, Mr. Twanda Gusha, L. W. Ndlovu
Air Zimbabwe	Adonisio Hungwe, George Simoya, Ms. Mary Muli
Agricultural Marketing Authority (AMA)	Gerald Mashiri
Agricultural and Rural Development Authority (ARDAS)	Hillary Manditsvara
CAAZ	Mr. Elijah Chigosho, Ms. Bertha Muzangaza, Sherphard Machingauta, Prudence Mariwa, Haanyadzisi Batisai, John Hwata, Laura Chimwanengara
City of Harare	Charles Mabika
Environmental Management Agency	Mr. T. Chinogwenya
Fastjet	Felix Nyangani, Brighton F. Madzivire, Hart Gonzo
Finealt	P. Mpala, Ted Nyamayevu
Forestry Commission	Anderson Muchawona
Green Fuel	Alec Mupariwa, Gurai Mwadirawani
HAFS	Phillip Mukamura, Rangarirayi Mubvumbi
Matopos Research Institute	Grace Tambo
Ministry of Energy and Power Development	Isaac Chiridza, Sosten Ziuku
Ministry of Environment, Climate, Tourism and Hospitality	Tapiwa Kamuruko, Kudzai Ndidzano
Ministry of Industry and Commerce	Patrick Tuluzawu
Ministry of Lands, Agriculture, Fisheries, Water and Rural Development	Thabani Mathews Siziba, Esther Mashayamombe, John Taderera, Hilda T. Manditsvara
Ministry of Transport and Infrastructural Development	H. Masimba
National Handling Services	Clayton Mwanenyoko, George Marufu, Phillip Rambakudzibwa
Reserve Bank of Zimbabwe	Jeremiah Borerwe, Maxwell Chirozvi, Mrs. N. Mukura
City of Bulawayo	Nkanyiso Ndlovu
University – Chinhoyi University of Technology	Dr. Chihobo
University of Zimbabwe	A. Musarurwa, Clement Shoniwa, M. J. Masamvu, Mafios Takawira, Dr. Walter Svinurai
FOREIGN COLLABORATORS	
INSTITUTION	**REPRESENTATIVE**
Roundtable on Sustainable Biomaterials	Arianna Baldo
Emerging Fuel Technologies	Mark Agee
Global Bioenergy Partnership (GBEP)	Tiziana Pirelli
Qatar Airways	Carlos M. Garcia

In-person interviews were semi-structured, where stakeholders were asked to describe the work of their institutions and share their experiences and perceptions on SAF. According to their responses, the conversation went into greater detail on specific actions taken by their employers to reduce GHG emissions, any direct experiences with SAFs, their understanding and position on CAAZ efforts to sustainable growth in the aviation sector, and any additional challenges foreseen with the adoption of SAF. At the conclusion of the interview, stakeholders were asked to provide any additional pertinent information via email.

Several airline representatives were contacted via email or video-call conversation. Though the sample is small and limited to regional flights to give statistically significant results, their feedback gave important information on market size and specific requisites on price, quality, and delivery of SAF in Zimbabwe. Additional data was obtained from interviews with technology providers and professionals who play an active role promoting sustainable growth in the aviation sector.

Remaining stakeholders within the SAF value chain were contacted via email and video calls to ensure most data evaluated is primary data. All narrative developed using primary data was sent to the corresponding stakeholder for validation.

ANALYTICAL FRAMEWORK: QUALITATIVE AND QUALITATIVE DATA ANALYSIS

The objective of this study is to evaluate the potential for production and use of socially acceptable, environmentally friendly, and economically viable SAF and sustainable fuels for GSE in Zimbabwe. While gaining access to data specific to Zimbabwe was challenging at times, economic data that would allow a quantitative analysis were easier to obtain. Conversely, data obtained on social and environmental matters was only suitable for conducting a qualitative analysis. A suitable analytical framework to evaluate qualitative data is sequential data management and interpretation[1].

[1] Ritchie, Lewis, McNaughton Nicholls, & Ormston (2013)

ABBREVIATIONS AND ACRONYMS

ACZ	Airport Company of Zimbabwe
ATJ-SPK	Alcohol to jet synthetic paraffinic kerosene
CHJ	Catalytic hydrothermolysis jet fuel
SIP	Synthesized iso-paraffins from hydroprocessed fermented sugars
FT-SKA	Synthesized kerosene with aromatics derived by alkylation of light aromatics from non-petroleum sources
HC-HEFA-SPK	Synthesized paraffinic kerosene from hydrocarbon - hydroprocessed esters and fatty acids
ARDA	Agricultural and Rural Development Authority
ATM	Air Traffic Management
ATAG	Air Transport Action Group
ATJ	Alcohol-to-Jet derivative utilizing biochemical production of isobutene
ASTM	American Society for Testing and Materials
AFQRJOS	Aviation Fuel Quality Requirements for Jointly Operated Systems
AGS	Aviation Ground Services
BUQ	Bulawayo IATA airport code
CO2	Carbon Dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CAAZ	Civil Aviation Authority of Zimbabwe
co-processed HEFA	Co-hydroprocessing of esters and fatty acids in a conventional petroleum refinery
co-processed FT	Co-hydroprocessing of Fischer-Tropsch hydrocarbons in a conventional petroleum refinery
CAEP	Committee on Aviation and Environmental Protection
CAAF	Conference on Aviation Alternative Fuels
DAR	Dar Es Salaam IATA airport code
dLUC	Direct Land Use Change
DANTS	Directorate of Air Navigation and Technical Services
EV	Electric Vehicle
ERJ	Embraer
EU	European Union
FE	Finealt Engineering
FT	Fischer-Tropsch hydroprocessed synthesized paraffinic kerosene
CRI	Global Climate Risk Index
GFAAF	Global Framework for Aviation and Alternative Fuels
GOZ	Government of Zimbabwe
GMB	Grain Marketing Board
GHG	Greenhouse Gases
GDP	Gross Domestic Product
GSE	Ground Support Equipment
HRE	Harare IATA airport code
ha	Hectares
ILUC	Indirect Land Use Change
IATA	International Air Transport Association
IEA	International Energy Agency
IEA	International Energy Agency
IATA	International Air Transport Association

JNB	Johannesburg IATA airport code
BUQ	Joshua Mqabuko Nkomo International Airport IATA code
LUC	Land Use Change
LCA	Life-Cycle Analysis
LTAG-TG	Long-Term Aspirational Goal Task Group
LCFS	Low Carbon Fuel Standard
MW	Megawatts
MT	Million Tons
MEPD	Ministry of Energy and Power Development
MEWC	Ministry of Environment, Water, and Climate
MFIP	Ministry of Finance and Investment Promotion
MHTEISTD	Ministry of Higher and Tertiary education innovation Science and Technology Development
MIC	Ministry of Industry and Commerce
MLAFWRD	Ministry of Lands, Agriculture, Fisheries, Water and Rural Development
MTID	Ministry of Transport and Infrastructural Development
MSW	Municipal Solid Waste
NAPT	National Action Plan Team
NBP	National Biodiesel Project
NHS	National Handling Services
NDC	Nationally Determined Contributions
RD	Renewable diesel
RFSP	Renewable Fuel Standard Program
RN	Renewable Naphtha
RBZ	Reserve Bank of Zimbabwe
RTK	Revenue Tonne Kilometre
RSB	Roundtable o Sustainable Biomaterials
SAA	South African Airways
SARPs	Standards and Recommended Practices
SCS	Sustainability Certification Scheme
SAF	Sustainable Aviation Fuel
SDG	Sustainable Development Goals
HEFA	Synthesized paraffinic kerosene from hydroprocessed esters and fatty acids
ICAO	The International Civil Aviation Organization
ISCC	The International Sustainability and Carbon Certification
TL	Triangle Limited
UANC	United African National Council
UK	United Kingdom
USD	United States Dollars
USD	United States Dollars
USA	United States of America
VFA	Victoria Falls IATA airport code

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SECTION 1. STATE-SPECIFIC INFORMATION

"The name Zimbabwe is derived from the Shona language "*dzimba dzemabwe*," meaning houses of stone or stone buildings, today symbolized by the Great Zimbabwe Ruins near the present-day town of Masvingo. Zimbabwe holds a rich history, not only of achievements, innovation, co-operation, and economic prosperity, but also of conflict that reflects the dynamism of its peoples. Many scholars, past and present, have enhanced our knowledge of the Zimbabwean past through their works. Particularly important in understanding of the pre-colonial past have been the works of archaeologists, linguists, historians, oral traditions, and records of 16th century Portuguese traders that interacted with central and southern Africa during that time"[2].

1.1 GEOGRAPHY AND CLIMATE

<u>GEOGRAPHY</u>

Zimbabwe is a landlocked country in southern Africa, lying between latitudes 15° and 23° South of the Equator and longitudes 25° and 34° East of the Greenwich Meridian. Its area is 390,757 square kilometers. The country is bordered by Mozambique to the East, South Africa to the South, Botswana to the West and Zambia to the North and North-west. The Zambezi River to the north and the Limpopo River to the south, form Zimbabwe's borders with Zambia and South Africa, respectively.

Figure 1. Political map of Zimbabwe

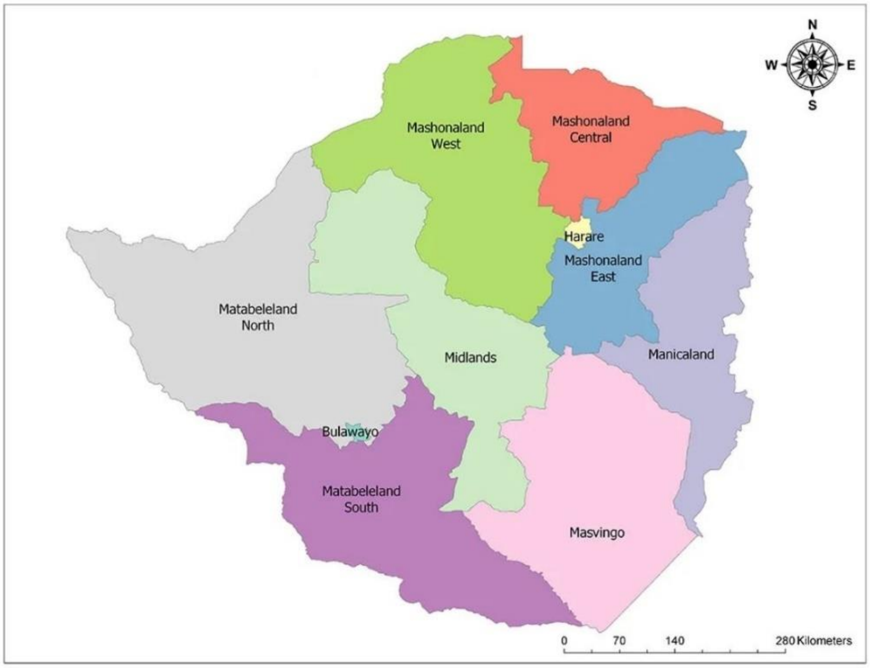
Source: MapsofIndia (2023)

[2] GOZ 2023

Most of the country is elevated in the central plateau (Highveld) stretching from the southwest to the northwest at altitudes between 1,200 and 1,600 m. The watershed is 650 kilometers long and 80 kilometers wide. The country's east is mountainous with Mount Nyangani as the highest peak in the country at 2,592 m. About 20 per cent of the country consists of the Lowveld at an altitude of 900 m. The remainder is comprised by the Zambezi and Limpopo river-valleys found in the north and south, respectively, having the lowest altitude of around 500 m above sea level.

The administrative map of Zimbabwe is divided into 10 provinces, consequently divided into 59 districts and 1,200 wards. The following map offers a clear illustration of the administrative political divisions of Zimbabwe:

Figure 2. Provinces of Zimbabwe



Source: Mappr 2023

Of the 10 provinces, 2 are cities with provincial status: Harare, the Nation's Capital and the largest city, and Bulawayo, the second largest city. The remaining provinces include Manicaland, Midlands, Mashonaland Central, Mashonaland East, Mashonaland West, Masvingo, Matabeleland North, and Matabeleland South.

CLIMATE

The climate in Zimbabwe is characterized as sub-tropical with four seasons:

- Cool dry season from mid-May to August,
- Hot dry season from September to mid-November,
- The main rainy season running from mid-November to mid-March, and
- The post rainy season extending from mid-March to mid-May.

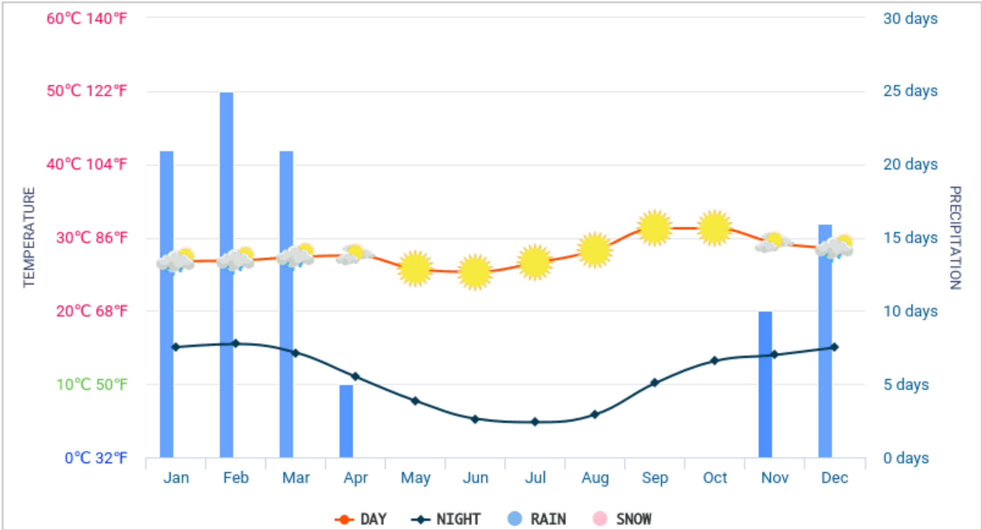
The climate is moderated by altitude where, on average, the higher-altitude areas in the north and east experience lower temperatures than low-lying areas in the west and extreme south.
Zimbabwe is a semi-arid country where the average annual rainfall amounts to 650 mm[3]. In fact, Zimbabwe has one of the most variable rainfall patterns in the world in terms of distribution across time and space, although dry spells and droughts are part of a normal cycle. The higher-altitude districts in the north and east

[3] MOECTH (2022)

typically experience greater amounts of rain above 1,000 mm per year in contrast to the low-lying areas in the south and west of the country that receive 350–450 mm per year. The western parts usually receive the first rains of the season, while the southern and south-eastern parts occasionally experience drizzles brought by south-easterly air masses.

The mean monthly temperature varies from 15°C in July to 24°C in November whereas the mean annual temperature varies from 18°C on the Highveld to 23°C in the Lowveld. The lowest minimum temperatures are recorded in June or July at around 7°C and the highest maximum temperatures in October at 29°C, or if the rains are delayed, in November[4]. The following graph offers a clear illustration of temperature and rainfall patterns distributions during the year:

Graph 1. Zimbabwe's average monthly temperature and precipitation



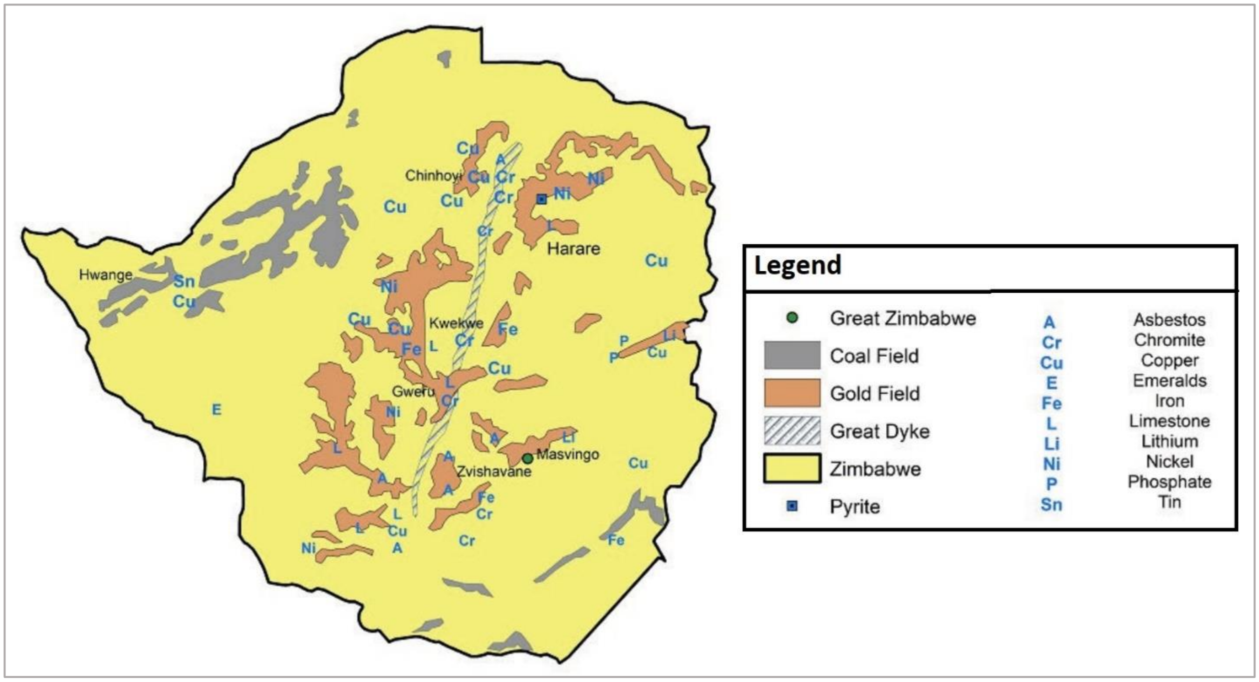
Source: MSD 2020

1.1.1 Natural resources

Zimbabwe holds abundant natural resources, including minerals, arable land, water, and unique flora and fauna. Urban and rural populations depend heavily on ecosystem services that provide a clean and reliable water supply, fertile soils, and trees for fuel, construction, and fencing, and the many and varied benefits to humans provided by the natural environment. In addition, wild fruits, nuts, and vegetables are an important source of food for many rural Zimbabweans during times when agricultural produce is out of season.
The following series of maps and pictures show the vast richness of Zimbabwe's natural resources:

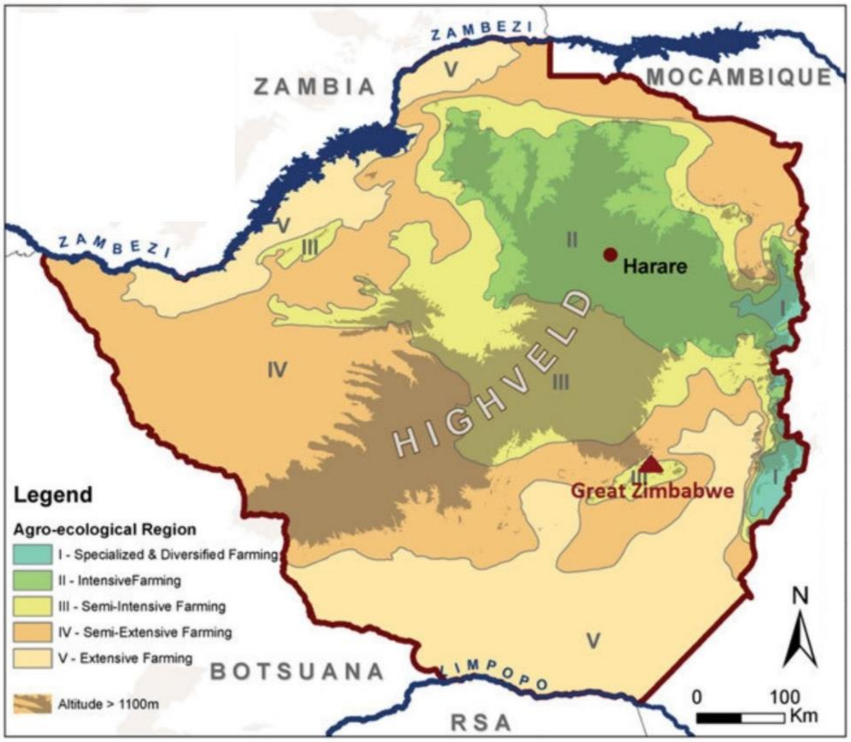
[4] MSD (2020)

Figure 3. Mineral resources - Zimbabwe



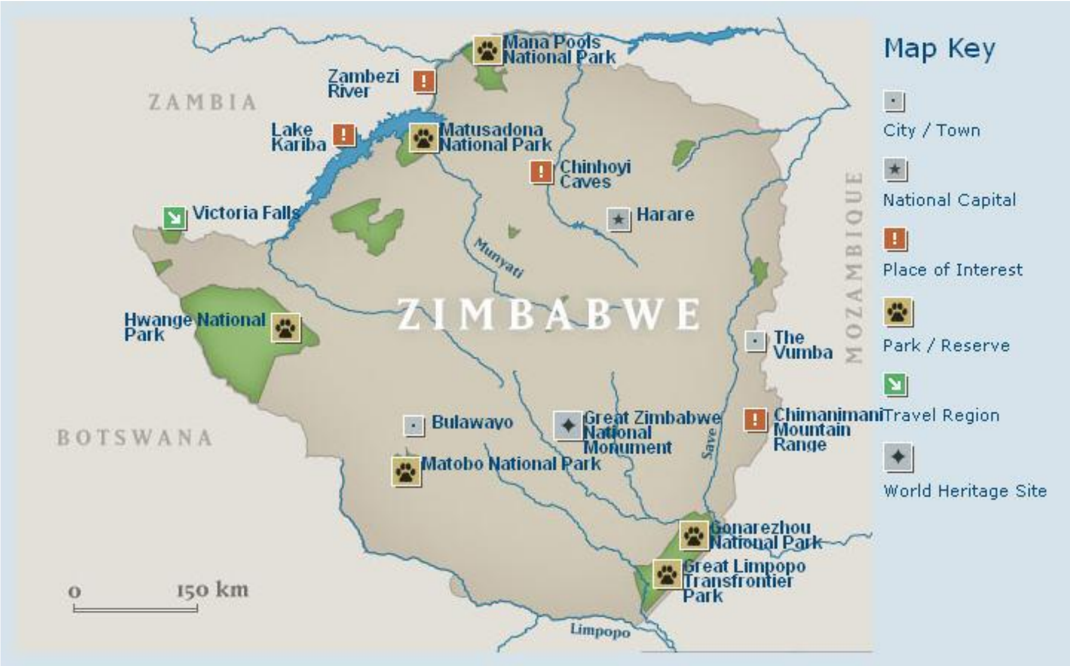
Source: Mtetwa I, ResearchGate

Figure 4. Agro-ecological regions -Zimbabwe



Source: Mtetwa II, ResearchGate

Figure 5. Protected areas and places of interest -Zimbabwe



Source: basic maps

Figure 6. Flora and Fauna – Zimbabwe

Source: go2africa

Figure 7. Victoria Falls - Zimbabwe

Source: go2africa

Unfortunately, these vital resources and services have been degraded over the years through human activities such as the accelerated erosion of soils resulting from annual ploughing, burning for land clearing, deforestation, and poor grazing management.

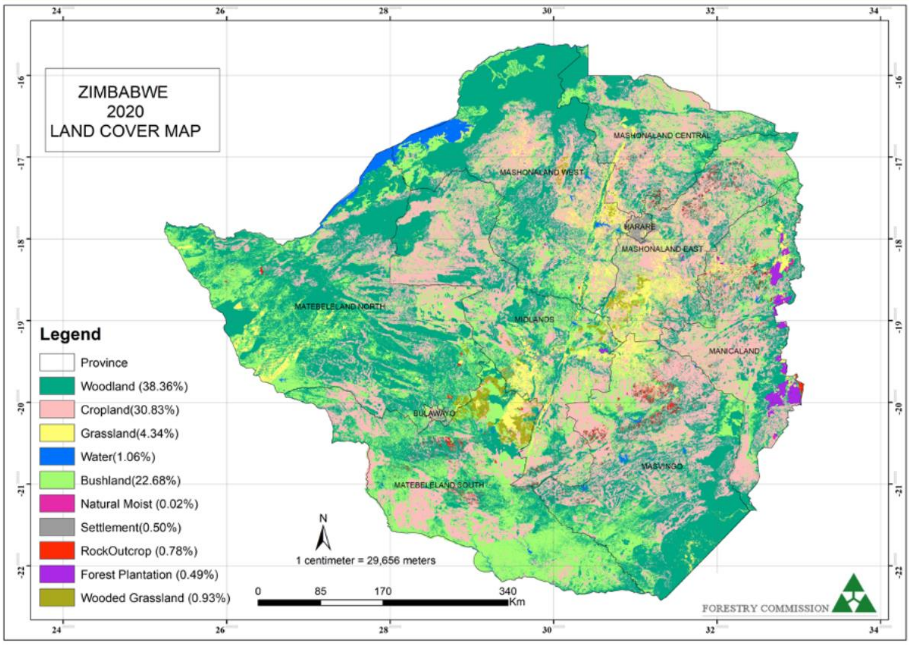
Uncontrolled open-cast mining adds greatly to the degradation of the Nation's natural resources. Deforestation has become a major problem in recent years as forests have been cleared in preparation for agriculture, for fencing, and for use as firewood mainly for tobacco curing and brick making. Between 1990 and 2015 Zimbabwe lost 36% of its forest cover at a rate of 9% per decade. Destruction of natural habitats, pressure from human settlements and poaching have decimated wildlife populations, particularly those of endangered species. Climate change can only accelerate the speed of degradation resulting in even more severe impacts[5].

1.1.2 Land Cover & Natural Regions

The land cover pattern of Zimbabwe is a consequence of natural and socio-economic factors. It is comprised primarily of woodlands making up 38% followed by 31% of cropland and 23% of bushland. The following map offers a clear illustration on land cover by type:

[5] UNEP (2023)

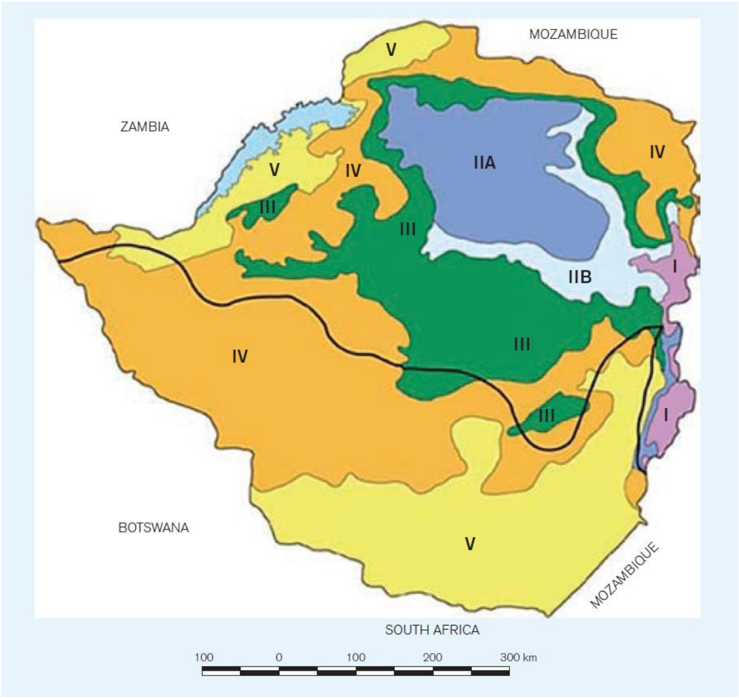
Figure 8. Land cover -Zimbabwe



Source: Forestry Commission (2023)

Land in Zimbabwe is divided into natural regions based on soil types, vegetation, and climate to better identify the optimum types of agricultural land use for each part of the country. As illustrated in the following map, five regions are plotted:

Figure 9. Natural regions of Zimbabwe



Source: WBG 2021

Natural region I: High rainfall (over 1,000 mm per year), low temperatures and steep slopes. It is suitable for high-value arable farming, diary, horticulture, and forestry.

Natural region II: Medium rainfall (750–1,000 mm per year). Temperatures are moderated and soils are generally fertile. It is suitable for intensive farming, including horticulture and dairy.

Natural region III: Lower rainfall (500–750 mm per year), with mid-season dry spells and high temperatures. This is a semi-intensive farming region suitable for field crops such as maize, soya, tobacco, and cotton as well as for raising livestock.

Natural region IV: Low rainfall (450–650 mm per year) with severe dry spells during the rainy season and frequent seasonal droughts. Suitable for raising livestock and drought-tolerant field crops such as sorghum, millet, jatropha, cowpeas, and groundnuts.

Natural region V: Very low rainfall (less than 650 mm per year) and highly erratic. Suitable for raising livestock, wildlife management, beekeeping, and non-timber forest products.

Communities living in natural regions IV and V (which make up about 64% of the land area) are at the mercy of climatic extremes, with few livelihood options. They tend to be the most vulnerable to poverty. These regions are already feeling the impacts of climate change and will be the hardest hit in the future. Many scientists propose that the natural region map be redrawn because of climate change, with regions IV and V taking up more area and I, III and IV less[6].

1.1.3 Climate-Related Hazards

Normal weather hazards experienced in Zimbabwe include tropical cyclones causing intense rainfall (more than 100 mm in 24 hours) and thunderstorms sometimes leading to hailstorms, floods, and flash flooding. The country is often affected by droughts lasting from one to three years, occurring in cycles every five to seven years[7].

This natural cycle is partly influenced by the climate pattern El Niño-Southern Oscillation, which originates in the Pacific Ocean. During some years of the cycle, temperatures in the Pacific Ocean rise and this causes rainfall fluctuations across the southern hemisphere. An El Niño pattern can last nine months. The correlation between El Niño events and droughts in Zimbabwe is very high. The past 10 drought years in southern Africa were all El Niño years[8].

Temperature extremes cause ground frost during the cold season and heat waves during the hot season. Climate change is expected to bring an increase in average temperatures across the country of between 1°C and 3.5°C. Rainfall variability and distribution are expected to increase and climate-related hazard events, such as droughts and floods, to become more frequent[9].

1.2 TRADE AND GOVERNANCE

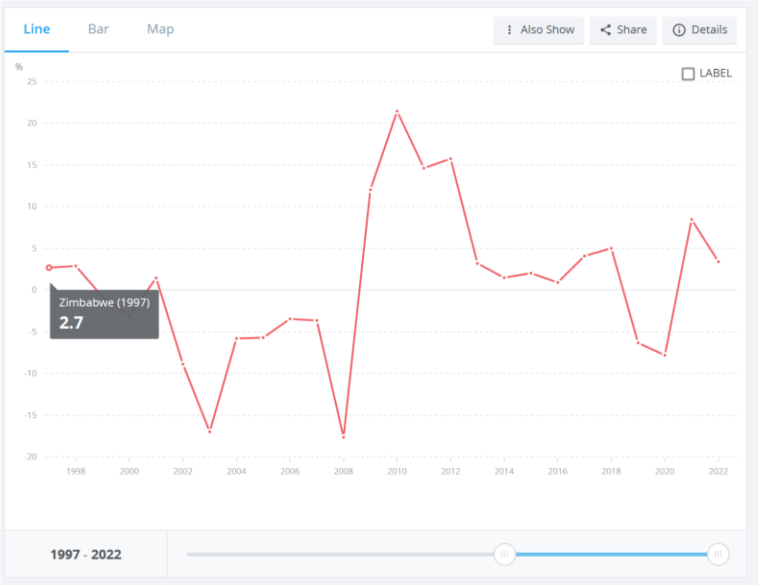
Zimbabwe's skilled labour, high literacy rate (89 %)10, mineral wealth, agricultural potential, bountiful wildlife, and stunning natural landscapes present many commercial opportunities for firms in the agriculture, mining, energy, infrastructure, health care, and tourism sectors. The government no longer subjects foreign direct investment to local ownership requirements in most sectors and has created special economic zones offering incentives to attract investment.

[6] Masarakufa (2020)
[7] World bank (2021)
[8] OCHA (1997)
[9] World bank (2021)
[10] Macrotrends (2023)

The future growth of market opportunities in Zimbabwe depends largely on whether the government follows through on long-promised political and economic reforms. While companies regularly praise Zimbabwe's bountiful natural resources and human capital, persistent economic instability are preventing Zimbabwe from living up to its tremendous economic potential.

After continuous negative growth between 1999 and 2008, the economy of Zimbabwe grew at an annual rate of 34% from 2008 to 2013, making it the fastest-growing economy in the world. Growth since then has been volatile but averaged 5% on an end-to-end basis,[11] as illustrated on the following gross domestic product (GDP) graph:

Graph 2. GDP growth (annual %) – Zimbabwe



Source: World Bank (2023)

According to Government figures, the economy grew by 7.8 % in 2021, underpinned by recovery in the agriculture, mining, and construction sectors. Authorities reduced year-on-year inflation from a peak of 838 % in July 2020 to 60.7 % by the closing of 2021. Year-on-year inflation accelerated during the first and second quarters of 2022 to reach 192 % by June thanks to the global increase in commodity prices attributable to current international geopolitical conflicts and the continued depreciation of the Zimbabwe dollar on the foreign exchange market, apparent in Graph 2 above.

The government debt in the period from 1991 to 2021 was between 1.7 billion and 22.0 billion united states dollars (USD). Based on the number of inhabitants, this is a debt of 1,187 USD per person. For comparison, the average debt per person in the same year in the European Union was 31,701 USD[12]. Zimbabwe recorded a Government Budget deficit equal to 0.90 percent of the country's Gross Domestic Product in 2022[13].

1.2.1 Market Challenges & Opportunities

Zimbabwe's high external debt limits its ability to access official development assistance at concessional rates and credit from international capital markets"[14]. De-risking by international banks has resulted in very few

[11] World Bank (2023b)
[12] WorldData.info (2022)
[13] TradeEconomics (2022)
[14] US DOS (2022a)

international correspondent banking relationships. Yet, in March 2022, the Financial Action Task Force's removed Zimbabwe from its grey list following an on-site evaluation in January 2022[15].
The government in office is making strides to improve the investment climate in Zimbabwe. To remediate the debt situation and improve the Nation's risk rating, the government started "making quarterly token payments to multilateral development banks and has offered such payments to some bilateral creditors.

Additionally, the risk of investing on land tenure on resettled farms has lowered since the Government of Zimbabwe (GOZ) "agreed to pay USD3.5 billion to commercial farmers for improvements made on expropriated farms during the government's Fast-Track Land Reform program in the early 2000s. As of June 2022, Zimbabwe paid a token USD1 million in compensation to former commercial farmers []"[16]. The tobacco industry is one of the biggest foreign currency earners in Zimbabwe. Investment in tobacco operations run by China National Tobacco Corporation via its subsidiary Tian Ze Tobacco Company, has greatly helped revive the industry since 2005. Aside from extension and input support, China provided tobacco farmers with access to loans[17].

Investment into the mining sector has also been a primary contributor to foreign currency in Zimbabwe President Mnanagagwa's administration. The latest investment involves the Dinson Chivhu iron and steel plant, a 1200 thousand tonnes per annum electric arc furnace steel plant under construction in Chivhu, Mashonaland, with an investment of USD1 billion venture by Chinese mining giant, Tsingshan Group Holdings[18].

The recent expansion and refurbishment of the Robert Gabriel Mugabe International Airport in Harare is also under the leadership of a Chinese company, a USD153 million concessionary loan from the China Exim Bank. It is estimated that this upgrade will allow the airport to handle more than double the current passenger traffic and promote more international airlines opening routes into Harare[19].

The strong presence and multibillion USD investments of China in the tobacco and mining sector as well as the broader political economy of Zimbabwe is a signal of the great potential the State holds to invite the interest of foreign investment.

Much potential for Zimbabwe to increase investment and expand the market economy relies on its transport infrastructure. The main transport modes contributing towards the Zimbabwean economy are roads, railways, and aviation. Inland water transport is limited and takes place mainly in man-made water bodies such as Lake Kariba[20].

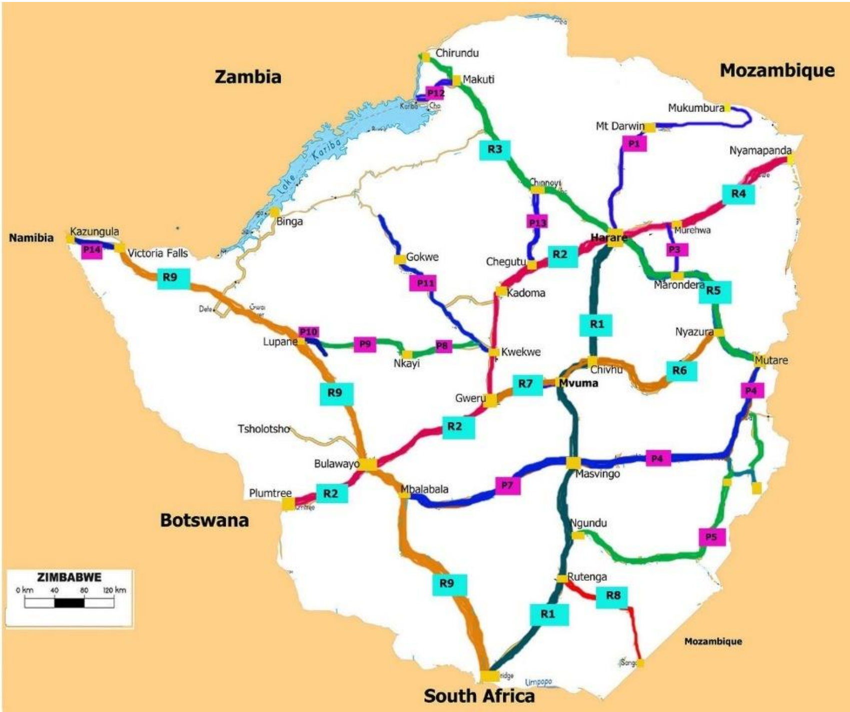
"The railway network connects Zimbabwe with all its four neighbours and beyond. It is a major factor in trade and economic growth within the region. Within Zimbabwe, it connects all major mining areas, heavy industrial centres as well as the major agricultural collection centres and provides much of the transport of mineral exports to seaports in South Africa. Zimbabwe has rail network of 2,583 km, all of which is narrow gauge. The use of rail for the transport of freight also improves road safety and reduces road damage and congestion.

[15] IMF (2022)
[16] US DOC (2021)
[17] Ruckert et al. (2022)
[18] Global Energy Monitor (2023)
[19] Razemba (2023)
[20] US DOS (2022c)

The aviation industry provides international and local air transportation links, with Robert Gabriel Mugabe International Airport as the main hub. The other important airports are Joshua Nkomo International Airport in Bulawayo, Victoria Falls International Airport, and Buffalo Range. In addition, more than 200 airports and aerodromes of diverse standards and capacities are scattered throughout the country. The airports are particularly important for the country's tourism industry. Air transport also provides essential services to the mining industry in Zimbabwe with links between Harare and the major mining provinces"[21].

Road transport is the dominant means of transport in Zimbabwe. Most of the traffic and trade (80% by volume) is transported by road. More than 70% of Zimbabwe regional trunk roads and primary roads were built in the 1960's and early 70's and most of them have exceeded their 20-year design life. Lack of financial resources to reconstruct or rehabilitate the aging road network and the unavailability of good quality gravel is compounding the problem[22].

Figure 10. Zimbababwe primary roads and corridors



Source: Logistics Cluster (2023)

Zimbabwean roads are managed, maintained, and operated by the Zimbabwe National Road Administration (ZINARA). ZINARA is responsible for managing the Road Fund and disbursing to the following road authorities: Department of Roads in the Ministry of Transport and Infrastructure Development, responsible for trunk roads; Rural District and Urban Councils, responsible for urban roads; and the District Development Fund, responsible for rural roads. The country's national highways are currently being re-designed to freeways for increased safety and commerce. The introduction of toll fees has provided additional resources for the maintenance and rehabilitation of the Zimbabwean road network. Paved roads link the major urban and industrial centres, but the condition of urban roads and the unpaved rural road network has deteriorated significantly over the years for lack of maintenance[23].

[21] Logistics Cluster (2022)
[22] Logistics Cluster (2023)
[23] African Development Bank (2019)

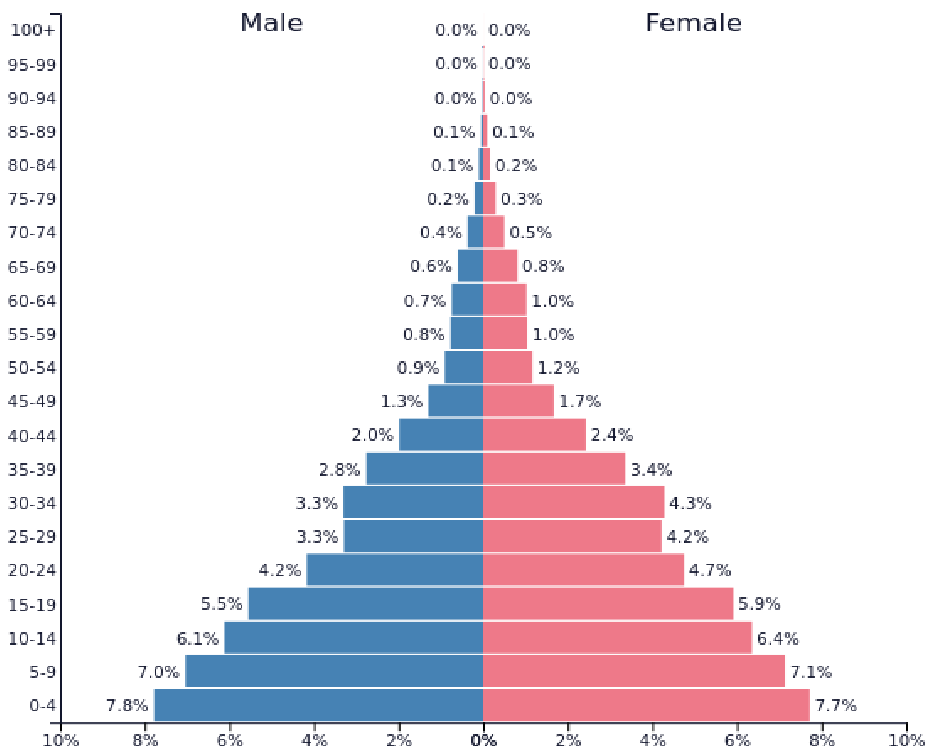
1.3 DEMOGRAPHICS

The latest population and housing census held in Zimbabwe in 2022 reported a total population of 15,178,979 people, of which 7,289,558 (48%) are male and 7,889,421 (52%) females, giving a gender ratio of 92 males for every 100 females. Since 2012, population has increased by 16.2%. The population is constituted by 3,818,992 households, resulting in an average of 4 persons per household. Given a land area of 390,757 square kilometers, the resultant population density stands at 39 people per square kilometer.
The distribution of the population by province for the year 2022 indicates that 16% of the total population resides in Harare Province, followed by Manicaland and Mashonaland West Provinces with 13.4 and 12.5% respectively. This in turn indicates that 2,427,209 people are registered as residents of Harare province, 2,037,762 reside in Manicaland, and 1,893,578 in Mashonaland West Provinces. For all provinces, the female population is higher than the male population.

AGE & GENDER STRUCTURE

The composition of population by age group and gender is presented in pyramid form under the following picture:

Figure 11. Zimbabwe population by age and gender



Source: ZINSTAT (2017)

An estimated 86% of the population falls within the age group between 0-35 years old making Zimbabwe a community of young people with much potential for growth and productivity.

EMPLOYMENT IN THE AVIATION SECTOR

Statistically, pre-COVID 19 figures according to the World Economic Forum, every USD 1 of value created from aviation activity supports USD 6 of economic activity elsewhere in Africa. Aviation Benefits Beyond Borders estimates that 16.5 jobs are created elsewhere from every job in the aviation sector. In Africa, the sector employed approximately 500,000 people in 2018, segregates as follows:

- 252,000 were employed by airlines of handling agents in roles such as flight crew, check-in staff, and maintenance crew or head office staff.
- 45,000 had jobs with airport operators such as airport management, maintenance, and security.
- 112,000 worked on-site in airport retail outlets, restaurants, and hotels.
- 17,000 were employed in civil aircraft manufacturing, including systems, components, airframes, and engines.
- 13,000 worked for air navigation service providers in jobs like air traffic control and engineering[24].

This translated into about USD 9 billion in contribution to the continent's GDP. Services contracted to supplying the needs to the aviation industry supported 500 million more jobs and about USD 5.5 billion in additional contribution to Africa's GDP. Furthermore, spending by those employed in aviation activities and its supply chain supported 333,000 more jobs resulting in an extra USD 4 billion contribution to GDP[25]. The aviation sector is also a major contributor to the development of the tourism sector which in 2019 accounted for 6.3% of GDP with a value of USD 1. 23 billion in Zimbabwe[26].

To increase the efficiency of operations and support the growth of the sector, approximately 80% of African countries have signed up for the Single African Air Transport Market (SAATM). A SAATM will help "harmonize aviation standards, lower air tariffs, open Africa to more flights and air carriers and boost air cargo competition[27]."

The trickling effect of benefits generated by the aviation sector is significant. Nevertheless, passenger load factor and flight traffic in Africa remain the lowest in the world. Passenger confidence and affordability as well as low interconnectivity between flight routes seem to dampen growth potential.

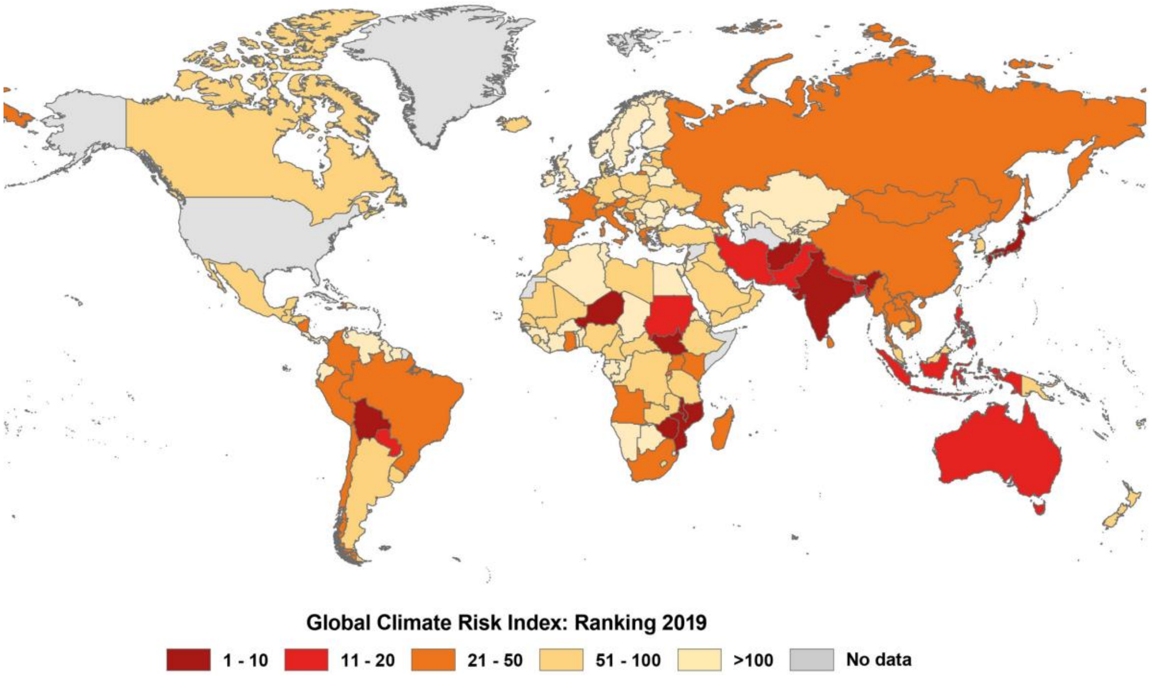
However, with the commitment from governments to collaborate at the regional level and implement best practices, forecasts for the future of aviation in Africa are positive. ICAO estimates a 4% growth for aviation activity in Africa and the International Air Transport Association (IATA) indicated that over the next 20+ years, passenger growth in Africa will be the world's fastest[28].

1.4. VULNERABILITY TO CLIMATE CHANGE

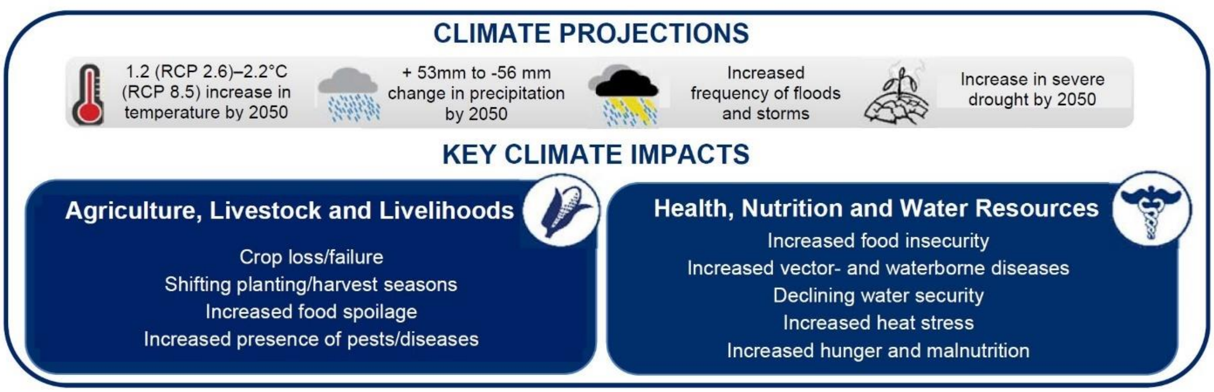
The Global Climate Risk Index (CRI) identifies the extent to which countries and regions have been affected by extreme weather events such as storms, floods, heat waves, etc., including resulting human and economic impacts[29]. Following is a map identifying the level of risk world nations are confronted with corresponding to the CRI:

[24] Kasibante 2022
[25] Kasibante 2022
[26] UNWTO 2022
[27] Kasibante 2022
[28] Kasibante 2022
[29] GCRI 2021

Figure 12. CRI 2021 - Map Raking 2019



Zimbabwe is ranked very high (in the top three in Southern Africa) in the 2021 CRI. Research conducted under the United States Agency for International Development (USAID) Climate Links program summarized the climate risk profile for Zimbabwe as follows:

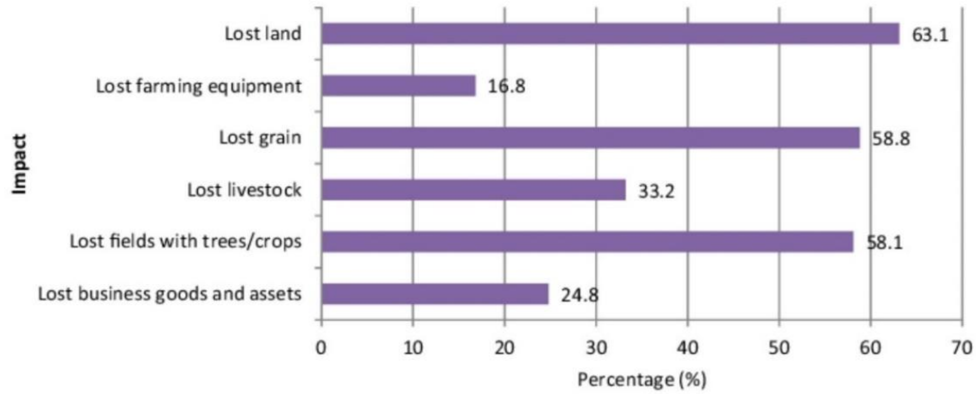


Source: USAID 2022

In the past two decades, the country was hit by three disastrous Cyclones: (Eline, 2000), Dineo (2017), Idai (2019), and Mavhura (2020)[30]. The following graph illustrates the impact cyclone Idai had on agriculture and natural resources:

[30] Mavhura 2020

Graph 3. Impacts of Cyclone Idai 2019



Source: Munsaka et al. 2022

Zimbabwe's high reliance on rain fed agriculture determines in great part the level of risk the country is faced with as a result of extreme weather events. These past cyclones pose a serious threat to the Nation's wider economy, the GOZ's ongoing efforts on poverty reduction, and food security. In fact, the last 'Crop, Livestock and Fisheries Assessment Report' developed by the Ministry of Lands, Agriculture, Fisheries, Water and Rural Development (CLAFA-2, 2022/2023) concludes that "it is imperative that Zimbabwe achieves perennial food security, away from the episodic, weather determined production base[31]." The livelihoods of rural communities are therefore highly vulnerable to erratic rainfall patterns, now being exacerbated by the fast-changing climate. As discussed under section '1.1.3 Climate Hazards,' droughts, dry spells, cyclones and yearly flood cycles are not new to Zimbabwe. What has changed is the strength, distribution, and duration of such occurrences which increase the severity of resulting damage.

Erratic weather patterns and increased temperatures are also likely to result in an upsurge in the presence of invasive species and pests affecting both agriculture and livestock production. The increased use of pesticides to combat this danger may in turn affect the quality of water due to runoff and the cost of food and earnings of farmers[32].

1.5 AGRICULTURE

The agricultural sector in Zimbabwe contributes 12% of GDP approximately and provides employment for some 70 % of the population and about 60 % of all raw materials for the agricultural industry. About 45 % of the country's exports are of agricultural origin"[33].

The country encompasses 4,130,000 hectares of arable land, most dependent on rain rather than irrigation for crops growth. Changes in weather patterns and more frequent droughts make the country susceptible to crop failures and unable to meet domestic demand.

Though the State owns enough natural resources to be self-sufficient, Zimbabwe's agricultural yields remain below the African average[34]. The low ratio of mechanization in crop management limits optimal production

[31] CLAFA-2 2023
[32] USAID 2020
[33] MOFAIT 2023
[34] Colombe Gbane 2023

volumes. The following table illustrates agricultural mechanization's shortcomings measured against identified needed requirements set under the Mechanization Development Plan ten years ago:

Table 2. Targeted National Farm Mechanization for 2022

Type of Equipment	National Requirement	Current National Status
Tractor	28,000	7,895
Combine Harvester	600	176
Planters	20,000	1,036

Source: adapted from CLAFA-2 2023

The introduction of sustainable production practices has nevertheless helped increase agricultural production yields. For the first quarter of 2023, "total cereal production is 2,579,247 MT against a national cereal requirement of 1,837,742 MT for human consumption and 450,000 MT for livestock[35]", as shown in the following table:

Table 3. Cereal Production Compared to National Requirements

Requirements (MT)		Available Grain and Cereals (MT)		Surplus (MT)
[1]Human	1,837,742	Maize	2,298,281	460,539
Livestock	450,000	Traditional Grains	280,956	-169,044
Strategic Grain Reserve (as of 09/04/22)		Maize	257,655	
		Traditional Grains	45,842	
Total	2,287,742		2,882,734	594,992

Source: CLAFA-2 2023 [1] Human consumption is computed from a consumptions rate of 120kg/person/year and a national population estimate of 15,146,657

As documented under the CALFA-2 report, the crops supported by the government under the Climate Proofed Presidential Inputs Scheme (Pfumvudza/Intwasa) proved resilient under conservation production principles, higher yields are shown on the following table:

Table 4. Conventional and Pfumvudza Yield Comparison: Sorghum and Maize 2022/2023

Average Yield	Sorghum 2022/2023		Maize 2022/2023	
	Conventional Yield (Mt/Ha)	Pfumvudza Yield (Mt/Ha)	Conventional Yield (Mt/Ha)	Pfumvudza Yield (Mt/Ha)
Total	0.6	**3.02**	1.17	**2.37**

Source: adapted from CLAFA-2 2023

An additional eight presidential programs are under implementation set to positively impact agricultural yields, "being a collective set of outcome-based and impact-oriented nationwide interventions to accelerate rural industrialisation and rural development. These interventions are expected to catalyse the attainment of Vision 2030[36]":

1. Presidential Climate-Proofed Inputs Scheme
2. Presidential Climate-Proofed Cotton Scheme
3. Presidential Rural Development Programme
4. Presidential Blitz Tick Grease Scheme

[35] CLAFA-2 2023
[36] CLAFA-2 2023

5. Presidential Community Fisheries Scheme
6. Presidential Poultry Scheme
7. Presidential Goat Scheme and
8. Vision 2030 Accelerator Model (V30 Accelerator)

The positive balance sheet on cereal production for the 2023 summer season ensued in the recommendation from the Ministry of Lands, Agriculture, Fisheries, Water and Rural Development to halt grain importation for the next 12 months.

1.5.1 Tobacco

Tobacco is Zimbabwe's most important cash crop. In 2021, it exported just over 210,000 tons of tobacco at an average price of US$2.80, earning the country USD588.7 million. Dominated by small-scale farmers, the tobacco industry is one of the Country's top employers. Most exports are directed to Asian countries, China being the biggest customer by volume[37]. Tobacco production during the summer season period 2022/2023 reached an estimated volume of 234,745MT compared to 212,703MT in the 2021/2022 season which is an increase of 9%[38].

1.5.2 Soya Bean

Local demand for soya bean is on the rise owing to its use as cooking oil and feed for cattle. Average soya bean production stands at an estimated 71,290 tons, which is only enough to meet 30 % of national demand. "Zimbabwe requires about 240,000 metric tons of soya beans annually for food, feed, and other industrial needs. At the farm level, soya beans are a short season crop with a lucrative return on investment of up to 200 %. The current instability in of the world economy and markets, has placed added pressure on farmers to grow more soya beans as soya bean oil-producing countries restrict exports"[39].
Soya production during the summer season period 2022/2023 reached an estimated volume of 93,086 MT, a 13% increase from 82,028MT estimated in the 2021/2022 season[40].

1.5.3 Cotton

Cotton, Zimbabwe's second most important cash crop, is usually grown under contract farming arrangements where contractors supply production inputs (seed, fertilizer, and chemicals) to farmers on loan. At harvest, the contractor buys back the contracted seed cotton, deducts costs of the inputs, and pays the contract farmer the remaining balance[41]. According to the Cotton Producers and Marketers Association, Zimbabwe produced 137,762 tonnes in the 2020/2021 season resulting from favourable rains and reduced costs for inputs subsidized by the Government. The 2021/2022 harvest experienced lower outputs totalling 57,000 tonnes (a 59% drop) as the late onset of rains forced farmers to delay planting[42].

Cotton production reached an estimated volume of 152,472 MT in the 2022/2023 season, a 31% increase from 116,521 MT produced in the 2021/2022 season[43].

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37 US DOS 2022c
38 CLAFA-2 2023
39 US DOS 2022c
40 CLAFA-2 2023
41 US DOS 2022c
42 F. Makopa & M. Nyoni2023
43 CLAFA-2 2023

1.5.4 Maize

Maize is Zimbabwe's primary food crop; it accompanies most meals and feeds the population across the economic classes. Crop outputs remain above "the 10-year average crop size of 1.3 million tonnes[44] ." Macro-economic challenges, sub-optimal weather, and high input costs have historically contributed to a drop on production, evident in the 2020/2021 harvest. To counter the effects, the GOZ "lifted a ban on Maiz imports introduced in May 2021 and announced a plan to import 400,000 metric tons. Production volumes of maize increased for the 2021/2022 season totalling 453,031MT. Furthermore, the latest harvest report for the season 2022/2023 reported 58% increase to an estimated 2,298,281 MT[45].

1.5.5 Sugarcane

Sugar cane in Zimbabwe is grown the lowveld area of Triangle and Hippo Valley, in the Chiredzi District, Masvingo Province. About 80 % of Zimbabwe`s sugar cane crop is produced utilizing canal irrigation practices by two large estates, namely, the Triangle Sugar Estate and Hippo Valley Estate. Private farmers produce about 20 % of the country's sugarcane crop[46].

Figure 13. Sugarcane harvesting by private farmers

Source: Green Fuel

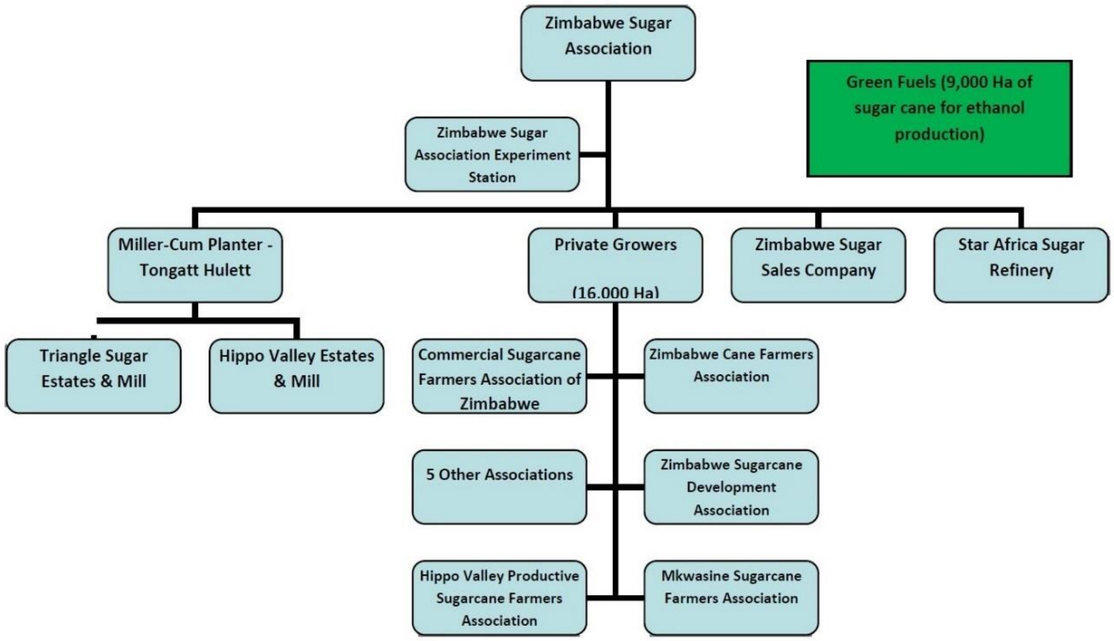
There are two sugar mills in Zimbabwe, the Hippo Valley Estates Ltd and Triangle Sugar Estates Ltd, with a combined sugar production capacity of about 640,000 million tons (MT) and installed milling capacity of 4.8 MT of sugar cane per annum. Currently, Zimbabwe has two sugar refineries; the Triangle Sugar Refinery, which is a back-end refinery, and Star Africa Sugar Refinery Ltd, an independent sugar refinery based in Harare.
Two companies in Zimbabwe are producing sugarcane for it processing into ethanol, Triangle Sugar Estate and Green Fuels[47].

The Zimbabwe Sugar Association is the highest decision-making authority in the industry on common issues of interest for sugarcane growers and sugar millers. In addition, the Zimbabwe Sugar Association Experiment Station conducts research for the industry and is funded from the sales of sugar based on a zero-budget basis. The Zimbabwe Sugar Sales Company was founded by growers and is the main organization that exports and

[44] Donley 2022
[45] CLAFA-2 2023
[46] US DOS 2022c
[47] US DOC (2021)

sells sugar domestically on behalf of the industry[48]. Following is a chart offering a clearer understanding of the structure of the sugarcane industry in Zimbabwe:

Figure 14. Sugarcane industry structure in Zimbabwe



Source: USDA 2022

Sugar cane production during the summer season period 2022/2023 reached an estimated volume of 6,537,204MT compared to 6,049,404MT in the 2021/2022 season which is an increase of 8%[49].

1.5.6 Cattle Farming

Zimbabwe's livestock production is led by small-scale subsistence farming. "Back in 1990, Zimbabwe's beef cattle herd topped 1.4 million and raked in about $50 million yearly from exports. For most beef-producing provinces of Zimbabwe, commercial beef sales accounted for about 80% of income."[50]

In 2018, a joint investment in the industry from Rwanda, Switzerland, and the United Arab Emirates amounting to $48 million together with a "$130 million investment partnership deal between Zimbabwe's state-owned beef processing firm CSC (formerly the Cold Storage Commission), and the UK-based company Boustead Beef, revived the industry. While production has a yet to reach 1990's levels, project like the 'Livestock production systems in Zimbabwe, "funded by the European Union, with the objective to develop more resilient livestock production systems,"[51] the industry is set to remain productive and resilient for the foreseeable future.

[48] US DOC (2021)
[49] CLAFA-2 2023
[50] Mwareya (2019)
[51] Bourgarel (2021)

1.6 ENERGY

Currently coal and hydroelectric power plants provide most of Zimbabwe's electricity. Both Zimbabwe's main hydropower plant at Kariba Dam and Hwange power station operate at one-third of their capacity, largely due to aging equipment. Zimbabwe currently imports electricity from Zambia and Mozambique to address the local production shortage. The Batoka Gorge hydroelectric power plant, a US$4.5 billion project that will generate 2,400 megawatts (MW), has been under development since 2012 precisely to help tackle, what were then, forecasted power shortages in Zimbabwe. The project was conceived for benefits to be shared equally between Zambia and Zimbabwe, with any leftover power diverted to the Southern Africa regional grid. The project, however, has been on hold since April 2021[52].

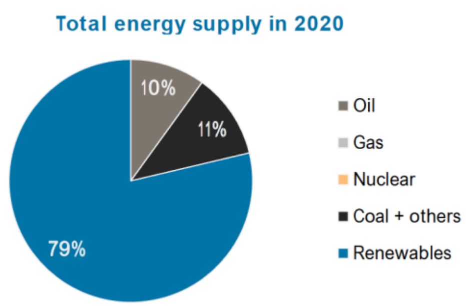
Currently, the power mix consists of hydropower (79%), coal (11%), oil (10%), and bioenergy sources as reported illustrated on the following figure:

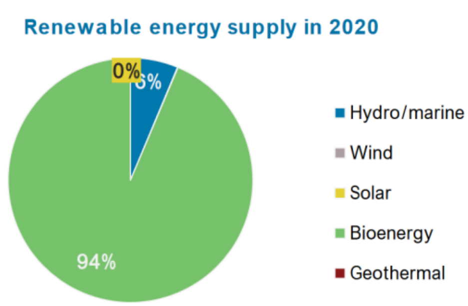
Figure 15. Power Matrix of Zimbabwe

Total Energy Supply (TES)	2015	2020
Non-renewable (TJ)	140 907	94 435
Renewable (TJ)	308 896	348 857
Total (TJ)	449 803	443 292
Renewable share (%)	69	79

Growth in TES	2015-20	2019-20
Non-renewable (%)	-33.0	-27.6
Renewable (%)	+12.9	+4.0
Total (%)	-1.4	-4.8

Primary energy trade	2015	2020
Imports (TJ)	57 974	53 339
Exports (TJ)	9 793	11 425
Net trade (TJ)	- 48 181	- 41 914
Imports (% of supply)	13	12
Exports (% of production)	2	3
Energy self-sufficiency (%)	95	87





Source: IRENA 2023a

Over the past five years, independent power producers (IPPs) have explored alternative energy sources such as solar, wind, geothermal, biofuels, and biomass. This was driven by the promulgation of the National Renewable Energy Policy in 2019, whose aim is to raise the share of renewables in the energy mix by creating incentives from supply to distribution and demand, in both urban and rural settings.

The introduction of alternative fuels in Zimbabwe dates to 1980. Back then, ethanol was produced from molasses and blended with gasoline at 12-15% primarily as a measure to support gasoline shortages. Albeit with interruptions, through the years, the use of biofuel blends expanded to include biodiesel produced from jatropha blended at 2% with diesel fuel[53]. Today, biofuels not only contribute towards Zimbabwe's energy independence but to support the Nation's NDC and environmental protection commitments.

52 Judy Bokao (2023)

53 Ministry of Energy & Power Development 2012

The GOZ supported de development and enactment of three crucial policies to ensure long term support to the biofuels industry, namely:

- 'Biofuels Policy of Zimbabwe: a policy framework for the production and use of liquid biofuels in the transport sector,' Ministry of Energy and Power Development of Zimbabwe,
- 'Vision 2023: Towards a Prosperous & Empowered Upper Middle -Income Society by 2030,' Government of Zimbabwe, and
- 'Zimbabwe's State Action Plan for CO_2 Emission Reduction from International Aviation,' Civil Aviation Authority of Zimbabwe

1.6.1 Biofuels Policy of Zimbabwe

Zimbabwe has a long history of production and use of renewable fuels. Ethanol from sugar cane has been used as a fuel blend for over 40 years. After the liberation war (1981-1982) the Ministry of Agriculture established the Agricultural and Rural Development Authority, (ARDA), with the primary mandate to plan, coordinate, implement, promote, and assist with agricultural development in Zimbabwe.

ARDA was given ownership over several properties in Zimbabwe and began to develop and farm the land in line with its mandate; the Macdom (Chisumbanje) and Rating (Middle Sabi) were transformed into successful sugarcane producing estates[54]. From the 1970s to the late 90s, ethanol blends in fuel were between 10-15%, some of Zimbabwe's vehicles ran on blends of up to 25% without compatibility issues. Blending with petrol was stopped during the severe drought of 1992 that reduced sugarcane production. In the year 2005 the government revamped the programme and an ad hoc cabinet committee on import substitution was set up which decided to embark on a National Biofuels Programme[55].

In 2011, the GOZ introduced a mandatory blending of fuel with ethanol, a mandate that propelled the enactment of the National Biofuels Policy under the National Energy Policy (2012) by the Ministry of Energy & Power Development (MEPD). This time, the promotion of biofuel production and use was designed not only to continue the support to the agricultural sector, but also to avert the dependence on foreign currency to import the Nation's fuel requirements and to contribute towards the GOZ's NDC in compliance with the Paris Agreement.

The scope of the Biofuels Policy covers the period up to year 2030 and focuses on liquid biofuels in the transport sector, initially ethanol from sugar cane and biodiesel from jatropha, while exploring the possibility of using other feed stocks for biofuel production. The Policy is structured around four interrelated pillars, namely the economic, agricultural, environmental, and social and institutional which identify and respond to the key issues that need to be addressed for successful sector development[56].

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[54] Green Fuel 2023
[55] Mukonza 2019
[56] Ministry of Energy & Power Development 2012

The Policy proposes that the country:

1. Achieves a consistent and sustainable ethanol blending ratio of up to 20% by 2030,
2. Introduces biodiesel at a blending ratio of up to 2% by 2030, and
3. Increases the number of players in the biofuels sector[57].

The Policy articulates specific strategies and key actions under each of its five policy objectives which are:

a) To improve the viability and long-term growth and sustainability of the bio-fuels sector,
b) To ensure the maintenance of bio-fuel product quality and standards,
c) To improve the productivity and economic viability of bio-fuel feedstock production,
d) To implement development trajectories that balance bio-fuel investments with biodiversity maintenance and water and air pollution; and
e) To implement production models that increase community benefits from bio-fuel investments and foster institutional cooperation and coordination[58].

Currently, minimum mandatory blending of vehicle fuels with ethanol is 2%, yet it varies depending on the domestic supply and availability of ethanol.

Post estimates of the total ethanol production in Zimbabwe range between 40 million liters to 120 million liters annually based on the changes in sugar cane production, quality of sugar cane and factory efficiencies. Green Fuel has about 12,000 ha under sugarcane for the sole production of ethanol, and a capacity to produce about 480 million liters of ethanol annually. Fuel grade ethanol produced by Triangle Sugar is a complementary product to sugar and is produced from molasses (by-product of sugar production). This makes ethanol produced by Triangle Sugar cheaper than the ethanol produced by Green Fuels from fermentable sugar. Triangle Sugar ethanol production is estimated to range from 20 to 50 million liters annually[59].

The jatropha biodiesel initiative was presented by the Reserve Bank of Zimbabwe (RBZ) to the government in 2004, the idea received considerable political scaffolding and financial resources were channeled to support the implementation of the project by late 2004. Today, biodiesel production is experiencing a major overhaul updating and expanding processing technology, instituting two strategies to ensure feedstock procurement, and developing suitable varieties of jatropha shrubs to optimize seed production along different agro-ecological regions of Zimbabwe, namely regions IV and V.

In 2012, the National Biofuels Policy identified petrol-ethanol blending as a Low Carbon Development pathway and mitigation measure to contribute towards Zimbabwe's NDCs. On December 2021, the Government of Zimbabwe further efforts to tackle the Republic's impact on climate and presented the "State Action Plan (SAP)" detailing additional measures to reduce CO_2 emissions, this instance exclusively for the aviation sector. With the financial and technical support of the Phase II ICAO-EU Assistance Project on Capacity Building for Reduction of CO2 Emissions from International Aviation, the Civil Aviation Authority of

[57] Ministry of Energy & Power Development 2012
[58] Ministry of Energy & Power Development 2012
[59] USDA 2012

Zimbabwe (CAAZ) in partnership with the Zimbabwean aviation industry and other Zimbabwean Government Departments developed the SAP to minimize the aviation's carbon footprint through measures such as, but not limited to, air traffic improvements, airport initiatives as well as aircraft emissions reduction measures.

1.6.2 Vision 2030

In 2018, the GOZ published their vision for 2030 geared "Towards a Prosperous & Empowered Upper Middle-Income Society by 2030[60]." Vision 2030 set out to fulfill the following priorities related to development, transport and energy:

- Redressing economic challenges,
- Championing investment and business,
- Improving the livelihoods of the ordinary citizenry, and
- Re-engaging with the international community.

The five strategic pillars to realize Vision 2030's priorities align with the goals and priority set out by African Union 50-year Vision and "takes into cognizance the United Nations' Sustainable Development Goals (SDG) covering the period 2016-2030."[61] Table 5 below illustrates the relationship between Vision 2023 pillars, the African Union Agenda, and the corresponding SDG, namely:

Table 5. Vision 2030 strategic pillars

Vision 2030 - Pillar	African Union 2016-2065 goals & priorities[62]	SDG
1. Governance	1. A high standard of living, quality of life and well-being for all citizens 7. Environmentally sustainable and climate resilient economies and communities. 11. Democratic values, practices, universal principles of human rights, justice and the rule of law entrenched	1-2-8–11 6-7-13-15 16
2. Macro-economic Stability and Financial Re-engagement	9. Continental financial and monetary institutions established and functional. 19. Africa as a major partner in global affairs and peaceful co-existence. 20. Africa takes full responsibility for financing her development Goals	 10 10-17
3. Inclusive Growth	4. Transformed economies 5. Modern agriculture for increased productivity and production	8-9 2
4. Infrastructure and Utilities	1. A high standard of living, quality of life and well-being for all citizens.	1-2-8-11

[60] Republic of Zimbabwe 2018
[61] Vision 2030
[62] African Union 2023

	4. Transformed economies. 7. Environmentally sustainable and climate resilient economies and communities.	8-9 6-7-13-15
4. Social Development	1. A high standard of living, quality of life and well-being for all citizens. 2. Well educated citizens and skills revolution underpinned by science, technology, and innovation.	1–2–8–11 4

#	SDG legend
1	End poverty in all its forms everywhere in the world.
2	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.
4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
6	Ensure availability and sustainable management of water and sanitation for all.
7	Ensure access to affordable, reliable, sustainable, and modern energy for all.
8	Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.
9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
11	Make cities and human settlements inclusive, safe, resilient, and sustainable.
13	Take urgent action to combat climate change and its impacts.
15	Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable, and inclusive institutions at all levels.
17	Strengthen the means of implementation and revitalize the global partnership for sustainable development.

Pillars 1-4 show the GOZ's commitment to powering the economy and bettering the livelihood of its citizens. Improving current agricultural practices and expanding production are well aligned with sustainability certification requirements for agricultural feedstock for conversion to SAF. The establishment of a SAF's industry is also conducive to the GOZ objectives to increasing access to clean and reliable energy, the incorporation of innovative technologies as well modern, efficient, reliable, well-developed infrastructure to catalyze Zimbabwe's economic transformation[63].

The expressed commitment under Zimbabwe's Vision 2030 to "make every Province attractive for both local and foreign investment by ensuring Ease of Doing Business and also lowering the costs of establishing business"[64] gives foreign investors a clear message of the opportunity to build trustworthy relations with the public sector and lower the risk of investing in the set-up of a SAF industry in an African nation.

[63] Vision 2030
[64] Vision 2030

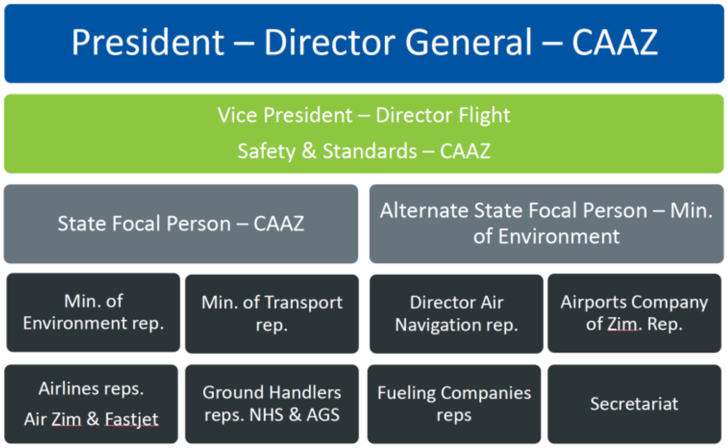
1.6.3 Zimbabwe's STATE ACTION PLAN for co2 Emission Reduction from International Aviation

Aviation activity in Zimbabwe represents a small fraction of total global operations. Nevertheless, aviation remains a key economic activity for Zimbabwe. In 2022, aviation facilitated an estimated contribution of USD 1.9 billion to Zimbabwe's GDP or 4.5% from tourism[65]. "Based on the ICAO Circular 333, the forecast air transport activity (measured in RTK) growth for the African region is 4% per annum." The recent expansion and modernization of the Robert Gabriel Mugabe International Airport, Zimbabwe's largest airport, is set to welcome 6.5 million passengers annually from the previous capacity sustaining 2.5 million[66].

Under business-as-usual conditions, growth in aviation activity means an increase in CO_2 emissions to the detriment of the environment, Zimbabweans, and the global population at large. In recognition of these effects and in alignment with the Nation's commitment the Paris Agreement's goals, in 2021, "the Civil Aviation Authority of Zimbabwe in partnership with the Zimbabwean aviation industry and other Zimbabwean Government Departments"[67] published a comprehensive 'State Action Plan' (SAP) to set a goal to reduce CO_2 emissions from aviation activities.

Supported by the ICAO-EU Assistance Project Phase II, on Capacity Building for CO_2 Mitigation from International Aviation, and under the directive of the Director-General of CAAZ, Mr. Elijah Chingosho, a National Action Plan Team (NAPT) was formed and assigned to develop the SAP. NAPT members (fig. 25) worked for a year and publish the SAP in December 2021. Since then, the NAPT has worked on raising awareness to all stakeholders on activities to reduce CO_2 emissions in international aviation and development of the implementation plan.

Figure 16. NAPT members and governance



Source: SAP 2021

There are five key measures identified under the SAP expected to offer the greatest environmental impact[68]:

1. Aircraft related technology development
2. Improved Air traffic management (ATM) and Infrastructure use

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[65] New Ziana 2022
[66] Karuwa 2023a
[67] SAP 2021
[68] SAP 2021

3. Operational improvements
4. Market based measures including the use of SAF
5. Airport improvements

Of relevance to this study is the identification and selection of the use of SAF as a measure to investigate further and build an effective implementation roadmap. CAAZ and NAPT members have since been working to support the development of this feasibility study through the following actions:

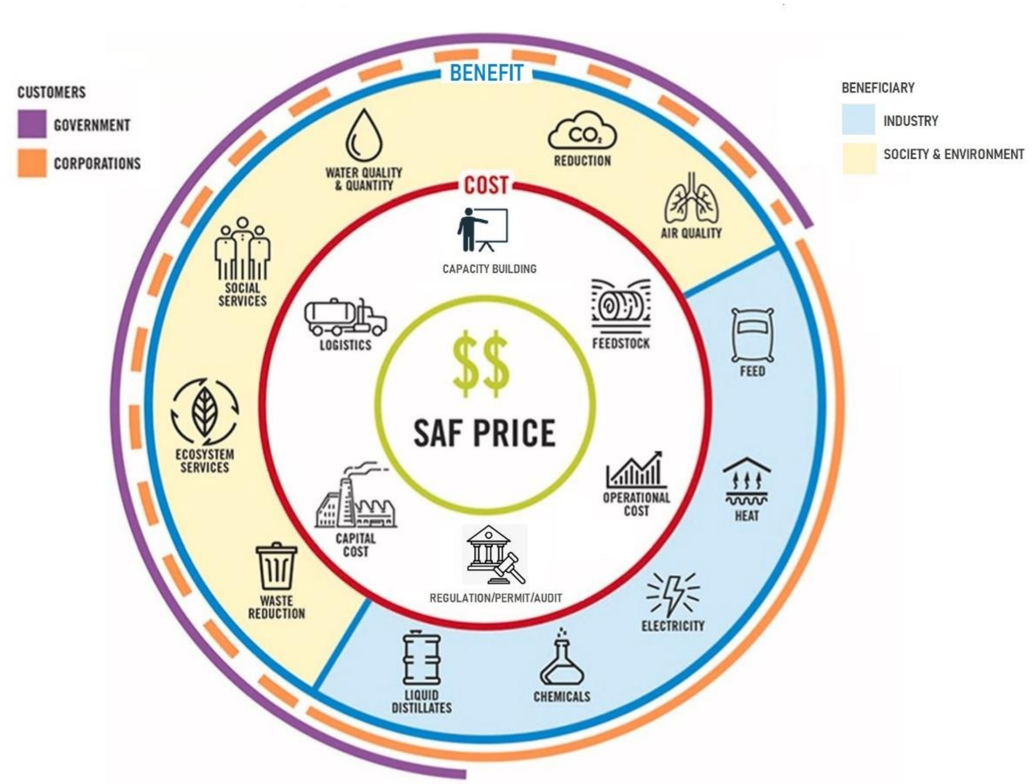
a) From April 3-5, 2023, CAAZ hosted and partially funded the second regional seminar offered by ICAO on capacity building for CO_2 mitigation from international aviation held in the City of Harare.
b) From June 1-15th CAAZ welcomed and partially funded the visit of the ICAO consultant selected to conduct this feasibility study. CAAZ provided the time and dedication of the focal point Sherphard Machingauta to organize and run the kick-off meeting, set up an agenda of in-person meetings with key local stakeholders, and provide primary data on the aviation sector. Similarly, CAAZ provided the consultant with a vehicle and dedicated driver to attend all meetings resulting in an estimated 72hrs and 2060km travelled.
c) Continuous and on-going active participation of Mr. Machingauta and his supporting team in ICAO regional seminars on Capacity Building for CO_2 Mitigation from International Aviation.
d) The Ministry of Environment, Climate, Tourism, and Hospitality (MECTH) provided valuable connections with crucial stakeholders in the agriculture, livestock, and forestry sectors, municipal solid waste (MSW) management, and environmental protection and regulatory bodies.
e) The National Handling Services (NHS) and Airport Company of Zimbabwe (ACZ) open their doors to their facilities and internal records to illustrate their role and commitment to contribute towards the SAP's objectives.
f) Airlines Fastjet and Air Zimbabwe granted valuable data on their fleet, operations, and fuel as well as expressed a strong desire to actively participate in the SAF value chain through a clear signal of demand.

The SAP sets a goal to reduce CO_2 emissions from aviation activities contributing to global efforts in line with the broad international consensus and with Zimbabwe's NDC. As a living document, it will be updated constantly to reflect advancements and incorporate new measures and considerations to ensure all angles of the industry are addressed to optimize CO_2 emissions reduction through time.

1.7 AVIATION FUEL VALUE CHAIN

The production of SAF requires that several actors within its value chain work in concert. The following illustration offers a snapshot of the SAF value chain actors represented within the lines of cost and benefit:

Figure 17. SAF Value Chain Actors



Source: adapted from Martinez Valencia et al. 2021

The up and downstream integration of SAF into the conventional aviation fuel (CAF) value chain will require close collaboration of several actors from the public and private sector. Mirroring Zimbabwe's current value chain for CAF combined with value chains for agricultural, residues, and waste products, a list of stakeholders was developed identified as crucial to support the development and operation of the SAF value chain.

Congruently, all stakeholders were invited to in-person meetings and virtual interviews to better understand their role and capacity related to SAF. Collaboration from important actors supporting the production, certification, use, and commerce of SAF outside of the value chain in Zimbabwe were also contacted and provided important information pertinent to determining the State's SAF readiness level, all portrayed under the following Table 6:

Table 6. Contributing stakeholders and collaborators

LOCAL STAKEHOLDERS		
SECTOR	**INSTITUTION**	**REPRESENTATIVE**
Aviation Industry	ACZ	B. Mpanguri, Mr. Twanda Gusha, L. W. Ndlovu
	Air Zimbabwe	Adonisio Hungwe, George Simoya, Ms. Mary Muli
	CAAZ	Mr. Elijah Chigosho, Ms. Bertha Muzangaza, Sherphard Machingauta, Prudence Mariwa, Haanyadzisi Batisai, John Hwata, Laura Chimwanengara
	Fastjet	Felix Nyangani, Brighton F. Madzivire, Hart Gonzo
	HAFS	Phillip Mukamura, Rangarirayi Mubvumbi
	National Handling Services	Clayton Mwanenyoko, George Marufu, Phillip Rambakudzibwa
Biofuel Producers	Finealt	P. Mpala, Ted Nyamayevu
	Green Fuel	Alec Mupariwa, Gurai Mwadirawani
Government	Agricultural Marketing Authority (AMA)	Gerald Mashiri
	Agricultural and Rural Development Authority (ARDAS)	Hillary Manditsvara
	City of Harare	Charles Mabika
	Environmental Management Agency	Mr. T. Chinogwenya
	Forestry Commission	Anderson Muchawona
	Ministry of Energy and Power Development	Isaac Chiridza, Sosten Ziuku
	Ministry of Environment, Climate, Tourism and Hospitality	Tapiwa Kamuruko, Kudzai Ndidzano
	Ministry of Industry and Commerce	Patrick Tuluzawu
	Ministry of Lands, Agriculture, Fisheries, Water and Rural Development	Thabani Mathews Siziba, Esther Mashayamombe, John Taderera, Hilda T. Manditsvara
	Ministry of Transport and Infrastructural Development	H. Masimba
	City of Bulawayo	Nkanyiso Ndlovu
	Reserve Bank of Zimbabwe	Jeremiah Borerwe, Maxwell Chirozvi, Mrs. N. Mukura
Academia	Matopos Research Institute	Grace Tambo
	University - Chinhoyi University of Technology	Dr. Chihobo
	University of Zimbabwe	A. Musarurwa, Clement Shoniwa, M. J. Masamvu, Mafios Takawira, Dr. Walter Svinurai
FOREIGN COLLABORATORS		
SECTOR	**INSTITUTION**	**REPRESENTATIVE**
NGO	Roundtable on Sustainable Biomaterials	Arianna Baldo
	Global Bioenergy Partnership (GBEP)	Tiziana Pirelli
Technology provider	Emerging Fuel Technologies	Mark Agee
Aviation Industry	Qatar Airways	Carlos M. Garcia

1.7.1 Aviation Industry

The civil aviation sector in Zimbabwe lies under the control of the Ministry of Transport and Infrastructural Development (MTID). Safety and security regulation is the direct responsibility of CAAZ, which also houses the Directorate of Air Navigation and Technical Services (DANTS) responsible for providing air traffic management and air traffic services in the state. The ACZ leads the operation of the airports in Zimbabwe[69].

A total of 1,272,811 passengers visited the State's airports in 2019 resulting in 24,697 international flights, including arrivals and departures[70]. Air transport growth estimate of 4% per annum for the African region will most certainly increase aviation activity in Zimbabwe, for which the State is already preparing to sustain by way of the recent expansion and modernization of the terminal at HRE, an investment of USD153 million[71].

a) Airports & Infrastructure

As illustrated on the following list, there are a total of eight airports in Zimbabwe from which three operate scheduled international flights, namely Robert Gabriel Mugabe International Airport in Harare, Joshua Mqabuko Nkomo International Airport in Bulawayo, and Victoria Falls International Airport in Victoria Falls:

1. Robert Gabriel Mugabe International Airport (HRE)
2. Joshua Mqabuko Nkomo International Airport (BUQ)
3. Victoria Falls International Airport (VFA)
4. Buffalo Range Airport (BFO)
5. Kariba Airport (KAB)
6. Masvingo Airport (MVZ)
7. Hwange National Park Airport (HWN)
8. Charles Prince Airport

The last five airports from the above list are predominantly used by private and general charter aviation operators to access tourist resorts. Charles Prince Airport on the western outskirts of Harare is mainly utilized by private charter operators that "provide air connectivity to the airports not serviced by the scheduled airlines and the many airstrips dotted around the country and mainly in or near the wildlife parks[72]."

Airports Company of Zimbabwe - ACZ

All airports in Zimbabwe are operated by ACZ. Previously housed under CAAZ, ACZ was established as an independent private company in 2018 through an Act of Parliament. Its mission is to "optimize the customer's travel experience through sustainable development and management of quality airports[73]." Today, ACZ offers

[69] SAP 2021
[70] SAP 2021
[71] Karuwa 2023a
[72] SAP 2021
[73] ACZ 2023a

a diversity of services (Table 7), several in concession to third party providers depicted under the following table, [74]:

Table 7. ACZ Airport Services

Aviation Services	Passenger Services
– Live Flight Information	– Car rentals and airport car parking
– Airport Tariffs	– Advertising
– Fueling Services	– Real Estate
– Aviation Fuel Services	– Food, beverages, and dining
– Passenger and Cargo Handling Companies	– Mobile operators and postal services
– Weather Forecast	– Banks and bureau de changes
	– Travel Agencies

Several of the above services are in concession to third party providers.

ACZ has set out to become the regional choice of airport services by 2030. Part of this commitment is to understand its role in reducing CO_2 emissions from the aviation industry. The company has taken the important step to join the Airport Carbon Accreditation (ACI) and began work to map and report a baseline of CO_2 emissions from services and operations[75].

In addition, under the leadership of ACZ and the Ministry of Transport and Infrastructural Development, the new terminal recently inaugurated at HRE and the modernization of the exiting terminal included the implementation of CO_2 mitigation measures identified under the SAP, particularly the following key measures:

1. Improved ATM and Infrastructure use,
2. Operational improvements, and
3. Airport improvements.

Incandescent lights have been replaced by energy saving LED lights with motion sensor in practical parts of the terminal buildings. Similarly, halogen runway and taxiway lights have been replaced by LEDs at HRE and BUQ. In addition, several airport "shuttles are 100% electric with the remainder being either hybrid vehicles or small engine capacity vehicles[76]." The ACZ has opened a tender inviting 'Expression of Interest for Development and Operation of Solar Farms at HRE, VFA and BUQ.'

As informed by ACZ Senior Eng. Mr. Billy Mpanguri, plans for the solar farms include the installation of three PV plants at HER, BUQ, and VFA with capacity to generate 10MW, 5MW, and 10 MW respectively. Currently, the maximum demand for HRE is 1,1MW which is expected to increase to more than 2MW with the completed expansion project. Power demand at BUQ is around 0.3MW and 0.5MW at VFA. All three solar

[74] ACZ 2023b
[75] In-person and virtual interview with Mr. Tawand Gusha, ACZ's CEO
[76] SAP 2021

farms are planned to cover current and near future needs of power demand, all surplus power is expected to meter into the national grid[77].

As an active member of the NAPT, ACZ remains committed to implementing all remaining selected mitigation measures, including the use of SAF if feasible. ACZ's CEO, Mr. Tawanda Gusha, expressed keen interest in understanding the different roles the organization may play along the SAF value chain in alignment with the company's business ambitions[78].

b) Aviation Handling Services

Aviation handling services at Zimbabwe's airports are provided by Aviation Ground Services (AGS) and National Handling Services (NHS).

Aviation Ground Services - AGS

AGS is a private company with a 21-year trajectory providing aviation services to Zimbabwe's airports. It employes 91 skilled employees who provide services in warehousing, aircraft and cargo handling, and ancillary amenities such as cold room and freezer facilities to ten airlines.

Specific services provided by the airside include the following[79]:

- Handling all aircraft types, loading, and unloading different categories of special loads
- Operate and connect Ground Services Equipment
- Cabin appearance
- Overall flight monitoring ensuring safe on-time performance

AGS was not available for an interview. The company's commitment and plans to align with the implementation of CO_2 emission reduction measures identified in the SAP are unknown.

National Handling Services - NHS

NHS "is a company wholly owned by the Government of Zimbabwe under the Ministry of Transport and Infrastructural Development, NHS is a fully licensed ground Aviation handler at the following airports HRE, BUQ, VFA, KAB, MVZ, and BFO[80]."
NHS suit of services include the following:

- Ground handling
- Dry port transshipment
- Ramp services
- Passenger handling
- Cargo handling
- Aircraft grooming

[77] In-person and virtual interview with Mr. Billy Mpanguri
[78] In-person and virtual interview with Mr. Tawanda Gusha
[79] AGS 2023
[80] NHS 2023

- Airport security services
- Airport lounges
- VIP / charter handling
- Passenger care services
- Automated baggage tracing systems

The company operates 69 vehicles that includes two electric forklift vehicles to work inside the warehouse. Though the reason to use electric vehicles (EV) indoors was taken primarily to care for the health of employees working in enclosed spaces, as active members of the NAPT, NHS is committed to contributing towards the implementation of CO_2 mitigation measures identified under the SAP. The company is looking to align the incorporation of more eVs to their overall fleet with ACZ's planned development of solar farms to ensure continuous, reliable, and renewable access to energy[81].

c) Airlines

The following airlines have been certified to fly to Zimbabwe and operate within the Nation's airports:

Figure 18. Airlines flying to Zimbabwe

Source: SAP 2021

From the 15 airlines above, the following are currently purchasing SAF, have conducted test flights using SAF, or have publicly announced their willingness to incorporate SAF as a CO_2 mitigation measure:

- **Qatar Airways**: in 2022, the airline partnered with Gevo on a 25 million US gallons of certified SAF purchase[82]. The latest news report that Qatar will be uplifting at least 5% of SAF in Amsterdam during the fiscal year 2023-2024 in compliance with EU SAF mandates[83]. The airline operates an estimated 55 destinations to the EU and 31 to Africa.
- **Ethiopian Airlines**: in May 2021, the Ethiopia SAF Steering Committee composed by the Ethiopian Civil Aviation Authority and the Environment, Forest and Climate Change Commission partnered with the RSB to develop a SAF roadmap, consequently published in May 2023[84]. In April 2023, Ethiopian Airlines received the delivery of an Airbus A350-900 aircraft, which conducted the flight powered by a blend with 30% SAF. The A350-900 is the most fuel efficient and therefore environmentally friendly

[81] In-person interview Mr. George Marufu
[82] Qatar Newsroom 2022
[83] International Airport Review 2023
[84] RSB 2022a

aircraft among Ethiopian Airline's fleet. The airline operates an estimated 15 destinations to the EU and 57 to Africa.

- **South African Airways (SAA)**: in 2014, SAA in partnership with aircraft manufacturer Boeing, feedstock developer SunChem, and biofuels aggregator and distributor SkyNRG launched project Solaris. The objective was to develop an environmentally friendly and economically feasible feedstock from a genetically modified tobacco seed variety denominated Solaris for conversion into SAF[85]. In 2016, SAA and its subsidiary Mango Airlines became the first airlines in Africa to operate commercial flights powered by SAF, consequently produced by Sunchem from a Solaris plantation[86]. The airline operates an estimated 2 destinations to the EU and 17 to Africa.
- **Eurowings Discover**: the Lufthansa Group, owner of the subsidiary Eurowings, "has been committed to researching, testing, and deploying SAF for more than ten years and has built up an extensive network of partnerships. As early as 2011, Lufthansa tested SAF in regular flight operations for about six months[87]." In 2022, the global aviation group signed a memorandum of understanding with Shell International Petroleum to explore the supply of 1.8 million metric tons of SAF for the years 2024-2030 airports across the world[88]. In 2023, Lufthansa Group joined the First Movers Coalition[89] to further efforts accelerating the deployment of SAF and, together with Eurowings, began offering green fares to travelers[90]. The airline operates destinations to 22 countries in the EU and 7 destinations to Africa.
- **Emirates**: in 2017, Emirate's operated its first flight powered by SAF from Chicago O'Hare airport on a Boeing 777. In 2020, it received its purchase order of a A380 delivered using SAF and uplifted 32 tonnes of SAF to power its flights departing from Stockholm. In 2023, the airline Emirates operated a milestone demonstration flight powered with 100% SAF and created a USD 200 million aviation sustainability fund[91]. The airline operates an estimated 22 destinations to the EU and 19 to Africa.
- **Kenya Airways**: in June 2023, Kenya Airways became the first African airline to power a long-haul flight with SAF. The flight conducted on a B787-8 Dreamliner aircraft took off from Jomo Kenyatta International Airport in Nairobi and landed at Amsterdam Schiphol. The fuel blend comprised 2% SAF supplied by ENI. The airline operates an estimated 3 destinations to the EU and 46 to Africa.

There are two local airlines certified to provide schedule flights in Zimbabwe, Air Zimbabwe and Fastjet. They cover national and regional routes across Zimbabwe and connecting passengers to regional destinations.

85 ABBB 2019
86 Bioenergy International 2014
87 Lufthansa Group 2023
88 Lufthansa Group 2022
89 World Economic Forum 2023
90 Surgenor 2023
91 Emirates Media Centre 2023

Air Zimbabwe

Air Zimbabwe offers flights to five destinations including Bulawayo (BUQ), Dar Es Salaam (DAR), Harare (HRE), Victoria Falls (VFA), and Johannesburg (JNB) in South Africa[92]. As shown on Table 8, the airline owns a fleet of nine aircraft, two of them operational:

Table 8. Air Zimbabwe's Fleet

Aircraft	In Fleet	Orders	Passengers			Notes
			C	Y	Total	
Airbus A320-200	2	—	18	142	160	both stored
Boeing 737-200Adv	2	—	12	93	105	both stored
Boeing 767-200ER	2	—	30	167	197	1 stored
Boeing 777-200ER	1	1	TBA			both stored
Embraer ERJ-145	2	—	TBA			1 on order
Xian MA60	1	—	—	52	52	all stored
Total	**10**	**1**				

Source: Wikipedia 2023

The ERJ-145 (fig 27) flies to national and regional destinations. The Boeing 777-200ER covers the same routes depending on demand.

Figure 19. Air Zimbabwe's ERJ-145

Source: Nowakowski 2023

According to an announcement by Air Zimbabwe's acting CEO Mr. Edmund Makona, the airline has devised a turnaround plan that begins with optimizing the use of existing assets and points to a future that includes the purchase of modern aircraft, international routes, and expansion of cargo services[93].

[92] Air Zimbabwe 2023
[93] Karuwa 2023b NOIC 2023a

Fastjet

fastjet is a privately owned company. The airline offers local flights to HRE, VFA, KAB, HWN and BUQ. At the regional level it offers flights between VFA-JNB and VFA-Kruger Nelspruit Mpumalanga Airport in South Africa and VFA-Maun Airport in Botswana[94]. Most passengers traveling with fastjet are tourists, as well as some corporate customers. Since the start of its activity in 2012, fastjet has transported an estimated 3.5 million passengers.

fastjet owns a fleet of two EMB-120 and five ERJ-145 (fig. 28).

Figure 20. fastjet ERJ-145 aircraft

Source: SAP 2021

In alignment with SAP and the current expansion of HRE, fastjet is planning to expand its fleet. Mr. Felix Nyangani, the Head of Safety and Security, also expressed fastjet's interest in incorporating SAF into their fuel mix to reduce the airline's carbon footprint following CAAZ recommendations.

d) Aviation Fuel Providers and Consumption

i. Aviation Fuel Providers - Upstream

The National Oil Infrastructure Company of Zimbabwe (NOIC) is a government entity responsible for ensuring the security of supply on the oil and gas industry. This includes the importation and purchasing of transportation refined petroleum products and biofuels. All petroleum fuels for transportation are imported from neighboring nations, with most volumes coming from oil terminals at Beira Port in Mozambique. NOIC's clients include production (blending), retail, procurement, and wholesale oil companies registered with Zimbabwe Energy Regulatory Authority (ZERA) and International Fuel Traders.

Specifically, NOIC provides its clients the following service:

- Bulk refined fuel transportation
- Storage and handling
- Blending
- Quality assurance

[94] Fastjet 2023

- Tariffs
- Tenders

"Petrol, diesel, and Jet-A1 are imported into the country via Beira-Feruka-Harare pipeline, a multiproduct pipeline[95] administered and operated by NOIC." Piped fuel is deposited and blended on tanks at depots situated in Bulawayo, Mutare, Beitbridge, Msasa, and Mabvuku. Feruka

Quality is tested at the company's own labs and assured via testing methods adapted from ASTM and the institute of Petroleum methods. Jet-A1 quality specifications as guaranteed under the 'Aviation Fuel Quality Requirements for Jointly Operated Systems (AFQRJOS)'[96].

Under the current value chain, the incorporation of SAF into Zimbabwe's fuel mix would be procured, stored, blended, and distributed by NOIC. The company would also be tasked with quality assurance aligned with ASTM standards for neat SAF (D7566) and SAF blended with conventional aviation fuel (D1655). ZERA would regulate pricing, and quality & safety as well as issue licenses to downstream suppliers like Puma Energy, Zuva, and Harare Airport Fueling Service (HAFS), both companies currently providing Jet A-1 fuel and Avgas to Zimbabwe's airports.

ii. Aviation Fuel Providers - Downstream

PUMA Energy

A company with a century long history working in the energy and crude oil industries, PUMA Energy was established in Zimbabwe in 2013 offering services primarily as retail fuel supplier for road transport. In 2014, their services expanded to the aviation industry under the 'Puma Aviation Zimbabwe' trade name. Today, the company services four airports in Zimbabwe (HRE, BUQ, VFA, and Charles Prince Airport), runs 79 retail service stations across the Nation, and owns one fuel terminal and four depots[97].

In relation to the incorporation of renewable energy into their portfolio of services, in May 2023, the company announced its intention to invest in "independent hydroelectric power facilities and solar-powered electricity installations" at their service stations, encouraged by Zimbabwe's energy policy[98].

ZUVA Petroleum - ZUVA

Zuva Petroleum supplies aviation fuel Jet A-1 and Avgas 100LL as well as related services to the following airports in Zimbabwe:

[95] NOIC 2023a
[96] NOIC 2023b
[97] Puma Energy 2023
[98] Mutongwiza 2023

Table 9. Zuva service hubs and product availability per location

LOCATION	AVGAS 100LL	JET A-1
Buffalo Range Airport	available	available
Bulawayo Airport	available	available
Charles Prince Airport	available	no
Kariba Airport	available	available
Thornhill Airport	available	available
Victoria Falls Airport	available	available

Source: Zuva 2023

The company serves the aviation fuel needs for commercial, private, corporate, and government aircrafts; both Jet A-1 and Avgass 100LL meet all standardized international specifications. There is no indication yet that the company is investing nor interested in supplying SAF.

Zuva's environmental commitments remain tied to their activities powering road vehicles. By the end of 2020, Zuva announced a multimillion-dollar project to deploy 180 solar plants across their service stations, part of the company's long-term strategy to reduce their CO_2 footprint and ensure reliable energy supply to their service stations. "After project completion Zuva plans to channel 30% of the power generated from the solar plants to the national power grid through a net metering system to support the National Agenda in Sustainable Development[99]."

To date, the only publicly available information confirmed in 2021 that from the 180 solar plant target, 65 were installed in different locations across Zimbabwe[100]; no updates are provided under the company's website.

In June 2022, Zuva in partnership with Electric Vehicle Center Africa (EVCA)[101] inaugurated in Harare city a first prototype for an EV charging station equipped with a 60 kW DC fast charger with CCS 2 connector. Encouraged by the 'Electric Vehicle Policy Framework' set forth by Zimbabwe's Ministry of Energy & Power Development, the partnership announced plans to extend the initiative by installing EV charging points at Zuva service stations on the highways and in other cities beyond Harare[102].

Harare Airport Fueling Service – HAFS

HAFS was established on the 20th of November 2002 as a Joint Venture operation between Zuva Petroleum Zimbabwe (Pvt) Ltd and TotalEnergies Zimbabwe (Pvt) Ltd. The company supplies aviation fuels and related services to aircraft at Robert Gabriel M International Airport.

99 Zuva 2020
100 Nekati 2021
101 EVCA assembles vehicles for the Chinese brand Build Your Dreams (BYD Company), principal provider of new EVs in Zimbabwe.
102 Wansi 2022

HAFS' on-site storage capacity equals 1.5 million liters of fuel distributed among five storage tanks. Total supply capacity amounts to 6 million liters into plane deliveries per month complete with segregated product receipt, settling, and withdrawal. Given the lack of a hydrant system, the company operates three tanker trucks to fuel planes.

Mr. Phillip Mukamura, General Manager at HAFS, expressed legitimate interest in understanding the opportunity for the company to take an active role in the supply of SAF. He pointed out that HAFS is not constrained in terms of both storage capacity and equipment for handling JETA-1. There is room to expand storage capacity of facilities at HRE to accommodate for the provision of SAF and that if needed, further capacity could be added by accessing the Msasa fuel storage depot (7.5 million liters storage capacity) located 20km away.

HAFS is currently upgrading the infrastructure at its depot to comply with both local regulation and international codes of best practice. Phase one of the investment planning includes inter alia, fire protection / fighting system, tank bund retention, a loading / offloading truck gantry, a new truck loading gantry, oily ware network, closed circuit sampling and overfill protection, and one direction traffic circulation. Phase two includes expanding existing storage capacity to accommodate the forecasted business growth in aviation activity and to align with the newly inaugurated airport expansion project.

iii. Consumption - Conventional Aviation Fuel

Last estimates on fuel consumption by the aviation industry in Zimbabwe are illustrated under table 10 below together with corresponding CO_2 emissions. Pre-covid 19 values are used as aviation activity has yet to recover from pandemic impacts.

Table 10. Aviation fuel statistics for Zimbabwe[103]

Year	Total Fuel Consumption (liters)	Total Fuel Consumption (tons)	Total CO_2 Emissions (tons)
2019	13,108,638.39	10,486.9	33.138.6

- density of fuel 0.8 kgs/liter
- mass of CO2 is 3.16 kgs of CO2 per kilogram of fuel
- calculation method: ICAO Doc 9988 and Environment Benefit Tool

e) Regulatory Framework

The Zimbabwe Energy Regulatory Agency is the only regulatory body for petroleum derived products in the Nation.

[103] SAP 2021

Zimbabwe Energy Regulatory Agency – ZERA

ZERA was established under the Energy Regulatory Act [chapter 13:23] in 2011. Such Act mandates the Agency to achieve the following key result areas[104]:

a) Increase Access and Security of Supply

- To promote the procurement, production, transportation, transmission and distribution of energy in accordance with public demand and recognized international standards,
- To ensure the maximization of access to energy by consumers that is affordable and environmentally sustainable, and
- To promote coordination and integration in the importation, exportation, and pooling of energy from any source in the Common Market for Eastern and Southern Africa (COMESA) and the Southern African Development Community (SADC) region.

b) Regulation and Licensing

- To regulate the procurement, production, transportation, transmission, distribution, and importation and exportation of energy derived from any energy source,
- To exercise licensing and regulatory functions in respect to the energy industry,
- To ensure that prices charged by licensees are fair to consumers in the light of the need for prices to be sufficient to allow licensees to finance their activities and obtain reasonable earnings for their efficient operation, and
- To establish or approve operating codes for safety, security, reliability, quality standards and any other sector related codes and standards for the energy industry or any sector thereof.

c) Energy Efficiency and the Environmental Protection

- To advise and educate consumers and licensees regarding the efficient use of energy, and
- To assess, promote studies of and advise the Minister and licensees on the environmental impact of energy projects before licensing.

d) Market Reform and Competition

- To maintain and promote effective competition within the energy industry, and
- To create, promote and preserve an efficient energy industry market for the provision of sufficient energy for domestic and industrial use.

e) Research and Development

- To promote, identify, and encourage the employment and development of sources of renewable energy,

[104] ZERA 2023

- To undertake such other things which it considers is necessary or convenient for the better carrying out of or giving effect to the functions of the Authority, and
- To promote and encourage the expansion of the energy industry and the advancement of technology relating thereto.

f) Key stakeholder Advisory

- To advise the minister on all matters relating to the energy industry
- To establish appropriate consumer rights and obligations regarding the provision of energy services
- To arbitrate and mediate disputes among and between licensees and consumers and
- To represent Zimbabwe internationally in matters relating to the energy industry

Most relevant to the development and deployment of SAF are ZERA's activities in the petroleum sub-sector. The agency regulates the sector through "licensing audits, monitoring of prices, setting standards and specification, fuel quality audits and compliance audits. The agency regulates any persons or private companies involved in the production, procurement, distribution, transportation and retailing of the following fuel products for commercial purposes in Zimbabwe:

- Petrol
- Diesel
- Paraffin
- Denatured ethanol and ethanol blends
- Liquefied Petroleum Gas
- Jet A1

Subject to applicants satisfying the terms and conditions, ZERA is responsible for issuing the following licenses:

- Production licenses authorizing the licensee to construct, own, operate and maintain facilities for the production of petroleum products, including blending ethanol.
- Procurement licenses authorizes the licensee to purchase fuel for the purposes of reselling it in bulk to one or more licensees.
- Wholesale license authorizes the licenses to purchase bulk petroleum products from any procurement licensee and production licensee.
- Retail license authorizes the licensee to supply petroleum products to customers.

In addition, ZERA conducts the following regulatory services:

- Infrastructural audits
- Fuel quality monitoring
- Price surveillance
- Licensing audits
- Training and demonstrations on safe use of products among operators and consumers

- Setting standards and continuous improvements
- Investment promotion

"The petroleum sub-sector in Zimbabwe is deregulated and comprised of private and state-owned companies[105]." Officially, prices of fuel are market driven and only monitored or surveilled as stated on the bullets above by ZERA. Yet, there is evidence that this government agency holds the authority and necessary tools to modify fuel prices when needed. The following fact sheet is a clear illustration how ZERA has the ability to influence the price of fuel paid by consumers at the pump through taxes, levies, and additional costs:

Table 11. Fuel pricing structure

Fuel pricing	Diesel 50	Petrol Blend E10
FOB price (USD)	0.64	0.62
Pipeline (USD)	0.11	0.11
Financing cost (USD)	0.01	0.01
Total landed cost (USD)	0.75	0.73
Exchange rate	4.61	4.61
Total landed cost (RTGS$)	**3.47**	**3.37**
Taxes & Levies		
Duty	0.90	1.15
Zinara road levy	0.02	0.06
Carbon tax	0.01	0.04
NOIC debt redemption	0.01	0.06
Strategic reserve levy	0.02	0.02
Total taxes & levies	**0.96**	**1.13**
Administrative costs		
Storage & Handling	0.02	0.02
Clearing agency fee	0.02	0.02
Total administrative costs	**0.04**	**0.04**
Total product costs landed Msasa Depot (wholesale)	**4.47**	**4.73**
Blending costs		
Ethanol cost		2.98
Blend ratio		10.00
Distribution costs		
Inland bridging cost	0.04	0.04
Storage and handling	-	-

105 ZERA 2023

Fuel pricing	Diesel 50	Petrol Blend E10
Secondary transport cost	0.05	0.05
Total distribution costs	**0.09**	**0.09**
Total costs	**4.56**	**4.64**
Oil company margin	0.15	0.15
Oil company gross proceeds	4.71	4.79
Retailer margin	0.18	0.18
FINAL PUMP PRICE	4.89	4.97
ROUNDED OFF PUMP PRICE	4.89	4.97

Source: ZimFact 2019

This table was published in May 2019 when Zimbabwe was experiencing a significant fuel shortage. In January 2019, the GOZ effected a 150%fuel price increase to discourage demand. In May of the same year, a new increase of 50% was enacted. Both rulings were processed and supervised by ZERA[106].

Unfortunately, there is not such fuel pricing data publicly available for aviation fuels. The above table shows that ZERA can adjust fuel prices under specific circumstances leveraging those variables it controls (duty, tax, etc.). The agency will take a central role at the time when SAF are launched to market and prices need adjustment to compete with conventional aviation fuels.

1.7.2. Existing Biodiesel Producers and Facilities

There are three leading producers of biofuels in Zimbabwe including ethanol producers Green Fuel and Triangle Limited, and biodiesel producer Finealt Engineering. Commonly, all biofuel volumes are sold to NOIC and after blended, they are commercialized with about 11 companies with licenses for retail sale at the pump[107].

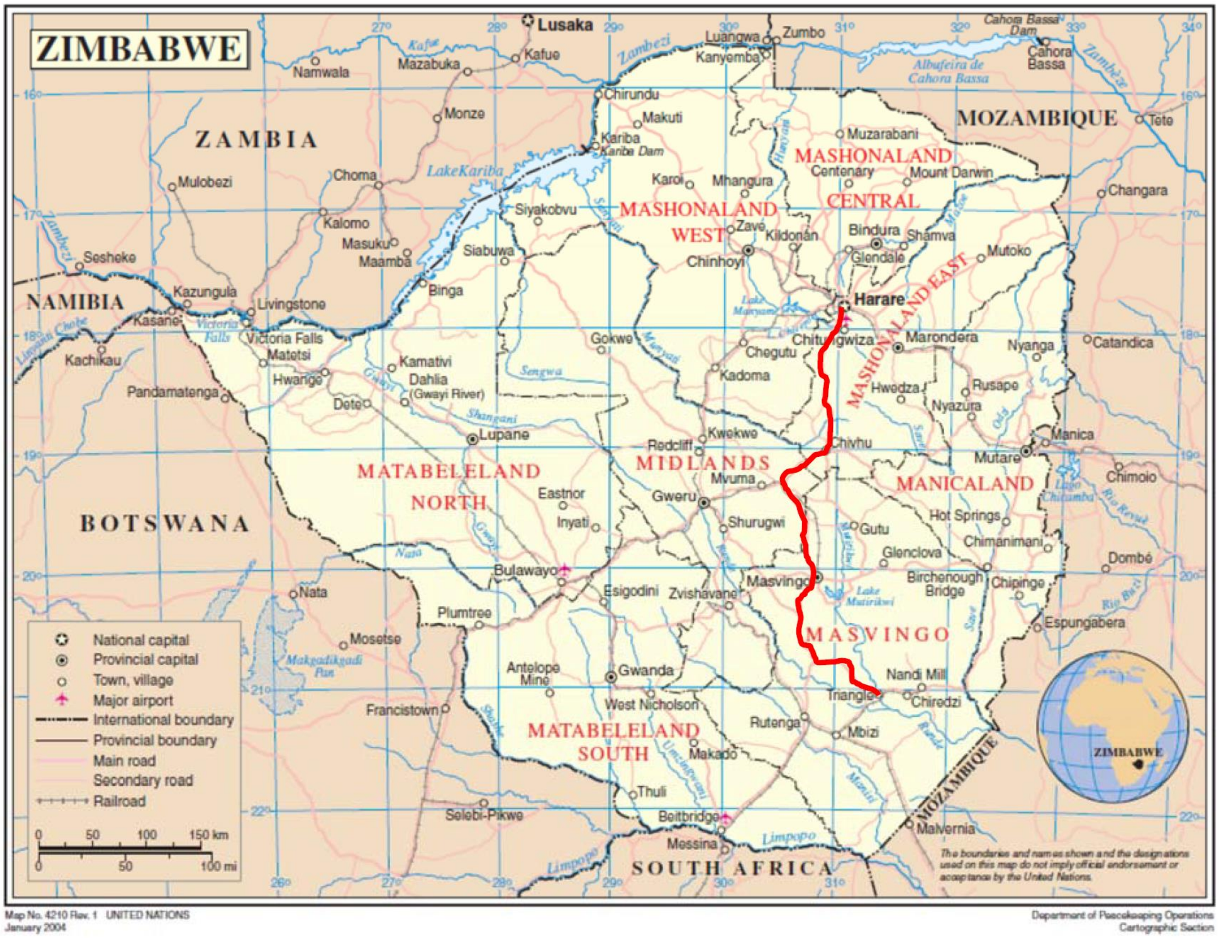
Triangle Limited

In 1951 the British Commonwealth sugar agreement guaranteed fixed prices to producers raising and stabilizing the world market price of sugar. This encouraged large investments from South African Sugar Company Hulett and the mining giant Anglo America in sugarcane farming and the establishment of the Tongaat Hulett Sugar Company in Zimbabwe[108].

Today, Tongaat Hulett Sugar Company operations in Zimbabwe is comprised by the wholly owned Triangle Sugar Estates Ltd and 50.5% ownership of the Hippo Valley Estates Ltd, and the Triangle Limited ethanol plant situated in the South lowveld of Zimbabwe approximately 450 kilometers from Harare[109] (figure 21).

106 ZimFact 2019
107 USDA 2012
108 JF Agwa-Ejon
109 USDA 2023

Figure 21. Triangle Limited ethanol plant location



Source: JF Agwa-Ejon

At its inception, the ethanol plant at Triangle converted molasses produced by the sugar factory into industrial ethanol. Market fluctuations in the sugar industry coupled with geopolitical challenges of the time opened the opportunity to produce and export anhydrous ethanol "through the South African port of Durban to Europe and the Middle East[110]."

In January 2019, due to recurring fuel shortages affecting Zimbabwe, NOIC issued a license to buy ethanol from the Triangle Estate Limited ending the exclusive rights to supply ethanol to government for blending by Green Fuel. By August 2019, production at the Triangle plant had "increased ethanol output to 26,1 million liters from 21,7 million liters in 2018[111]."

Production capacity of Triangle Estates Limited ethanol plant is estimated to "range from 20 to 50 million liters annually." The use of molasses, a co-product of sugar production, results in a less expensive anhydrous ethanol for use as a blend in road transport when compared with the cost of production using sugar.

Unfortunately, no representative at Triangle Limited was available to provide primary data so that expressed above was obtained from third party online sources.

[110] JF Agwa-Ejon
[111] ENN 2019

Green Fuel

The Green Fuel ethanol plant is located in Chisumbanje, district of Chipinge, with agricultural production sites both in Chisumbanje and Middle Sabi Estates (fig. 30). The USD 600 million project was established in 2011 under Government decree to help alleviate the fuel shortage crisis and to bring development to what was then considered one of the least developed districts in Zimbabwe, nicknamed 'Mugowa' (semi-desert), situated in agroecological region V with average rainfall average under 500ml per annum.

Figure 22. Green Fuel Plant and location

Source: Green Fuel

Green Fuel was awarded the National Project status due to the multifaceted benefits it brings to the State and surrounding community. Blending 20% ethanol (E20) into gasoline reduces fossil fuel imports increasing Zimbabwe's fuel independence and helping decrease its trade deficit. The price of ethanol per liter is less expensive than conventional gasoline transport fuel which allows for instant saving as the pump keeping more income into the hands of Zimbabweans. To optimize sugarcane production, the company invested heavily in advanced irrigation and drainage systems that today also serve to increase production yields from to the adjacent farming community (fig 31).

Figure 23. Chisumbanje and Middle Sabi Pump Houses

Source: Green Fuel

The ethanol plant presently employs over 3,000 people. Expansion plans currently under implementation initially projected that 36,500 fully trained, local Zimbabweans could be employed by 2025. “State of the art harvesting techniques have also been introduced and all local employees have been trained by experts from Brazil, ensuring that new skills are introduced into, and kept within the country.”[112]

The implementation of agricultural best practices has ensured the optimal use of natural resources. Conservation of water throughout the irrigation process is key so to apply water evenly, fields have been levelled using GPS land levelling systems. Additionally, the use of green cane harvesting practices leaves a trash blanket on the ground, resulting in up to 40% water saving. Over 2,000ha in the Chisumbanje estate use drip irrigation, and sprinkler irrigation is currently being replaced by drip irrigation in Middle Sabi[113].

“To ensure the ‘green’ cycle of ethanol from sugar cane, sustainable agricultural practices are in place in line with EU Guidelines published in June 2010 on the practical implementation of biofuels and bioliquids sustainability scheme, including:

- Mechanized harvesting with green cane – no burning
- Zero tillage and precision farming techniques used.
- No change to land use.
- By-products are re-used and waste is converted into biogas and fertilizer (vinasse).”[114]

Figure 24. Mechanized harvesting with green cane – no burning

There are 9,300ha under sugarcane production today within the Chisumbanje Estate with availability to expand to 40,000ha, a concession under a valid lease agreement between ARDA and the Rural District Council. In the Middle Sabi Estate, sugarcane fields cover 2,700ha with potential to extend to 10,000ha.

[112] SAP 2021
[113] Green Fuel 2023a
[114] Green Fuel 2023b

The ethanol plant holds a production capacity of 480,000 liters/day of anhydrous ethanol at an average 96% purity level. The storage capacity is 14,500,000 liters, with construction going on at the time to expand to 27,000,000 liters. Operations are energy self-sufficient. Fiber extracted from the sugar juice is utilized to produce 120 ton/hour of steam and 18 megawatts (MW) of power, with only 8MW of power used to operate operations and the plant site, the rest is injected in the national power grid. Excess fiber is diverted to produce feed for cattle. The plant site is equipped with its own laboratory for soil and plant growth testing, services are offered to contracted growers free of charge to ensure they optimize cane and sugar content yields.

Currently under implementation, expansion plans for ethanol production include an increase from an estimated 80,000 million liters a year to of about to 200,000 million liters. This involves the cultivation of an additional 20,000ha approximately.

The company has no immediate plans to produce drop-in sustainable fuels for transportation yet they have expressed much interest in SAF, actively participating the this study and interacting with CAAZ in relation to the SAP.

Finealt Engineering

In 2005, the Government of Zimbabwe (GoZ) launched the National Biodiesel Project (NBP) using jatropha as the major feedstock, an initiative promoted under the banner of rural development as well as a vehicle to reduce its reliance on expensive fossil fuel imports that weigh on its foreign exchange reserves. The programme quickly filtered across the country with the aid of the public media. The government encouraged smallholder farmers to cultivate some 10,000 hectares (ha) of jatropha feedstock throughout the country under an out-grower scheme. In this regard, the government established processing plants with capacities of 10,000 liters per day in Mutoko and 300,000 liters per day at Mt Hampden. Farmers in various parts of the country were mobilized to provide feedstock for the processing plants by the then National Oil Company of Zimbabwe and Finealt Engineering (FE), both government companies. FE was designated the Special Purpose Vehicle (SPV) to spearhead research and production of biodiesel production using jatropha seed as raw material.

Unfortunately, the out-grower scheme collapsed leaving both plants underutilized for several years.

The GoZ did not contemplate discontinuing the jatropha biodiesel project. Instead, it worked to redesign the business model to secure success without losing sight of the social goal to better the lives of local small-scale farmers. Consequently, in 2009 FE took over the production of jatropha under a privately run administration and complemented the out-grower scheme with the estate or plantation approach to secure feedstock volumes for biodiesel production, a scheme proven effective by the Chisumbanje Green Fuel ethanol project in the eastern part of the country.

To date biodiesel production maintains a national project status. Research expanded with an additional focus on finding the right varieties of jatropha seeds to extend the program to 8 provinces under different agroecological regions IV and V and a gene bank was set up adjacent to the Mutoko processing plant (fig. 33). Castor oil seed is incorporated as an inter-crop within the research agenda to diversify feedstock supply as a risk mitigation measure on account of extreme climate variations. A 6000ha company owned estate, for commercial jatropha plantations began to take shape in Nyakadecha area, in the district of Mudzi, Mashonaland East. Under irrigation and best practices, the Nyakadecha plantation can achieve yields of 8 tons/ha and 30% seed oil content.

Figure 25. Finealt's jatropha gene bank in Mutoko

Source: on-site visit

FE's continues its responsibility as SVP by supplying jatropha seeds to out growers, establishing new pick-up spots for seed collection in remote regions, and setting up demonstration projects for capacity building on agricultural best practices on castor and jatropha seed cultivation.

Today, biodiesel processing plants are being upgraded to sustain production capacities of 75,000 liters per day in Mutoko and 300,000 liters per day at Mt. Hampden. Purchased requests for advanced biodiesel conversion technology have been added to GoZ's procurement process. Investment is streaming in for new construction at the Mutoko site to expand seed storage capacity and add a new product line of refined sunflower oil for human consumption. It will also accommodate more efficient production of co-products (liquid and solid soap) and support trials to optimize the quality and quantity of organic fertilizer derived from the husks of jatropha seeds.

Figure 26. Expansion of Finealt's Mutoko biodiesel processing site

Source: on-site visit

Once the plantation scheme proves to be viable on a large scale, FE plans to have at least a jatropha estate and a processing plant in each of the country's eight provinces. The agricultural expansion plan for the near future includes the following:

- Development of 1000ha/year for feedstock production in 8 provinces
- A total of 100,000ha developed for feedstock production within a 12-year period
- Increase yields beyond 8 tons/ha through continuous R&D on best agricultural practices and seed genetics

The conversion expansion plan for the next years includes the installation of a biodiesel conversion plant contiguous to feedstock production plots and a favorable agreement on market price regulated by ZERA.

SECTION 2. EVALUATION OF FEEDSTOCKS AND PATHWAYS FOR SAF PRODUCTION

"SAF is defined as renewable or waste-derived aviation fuels that meets sustainability criteria. A SAF pathway is a specific combination of feedstock and conversion process or simply "a type of technology used to convert a feedstock into aviation fuel"[115]. SAF conversion processes are evaluated and approved by organizations such as the American Society for Testing and Materials (ASTM) International[116].

2.1 FEEDSTOCK AND CONVERSION PROCESSES

As of July 2023, 11 conversion processes for SAF production have been approved, depicted under the following table:

Table 12. Approved feedstocks and conversion processes – ASTM certified[117]

ASTM reference	Conversion process	Abbreviation	Possible Feedstocks	Maximum Blend Ratio
ASTM D7566 Annex 1	Fischer-Tropsch hydroprocessed synthesized paraffinic kerosene	FT	Coal, natural gas, biomass	50%
ASTM D7566 Annex 2	Synthesized paraffinic kerosene from hydroprocessed esters and fatty acids	HEFA	Bio-oils, animal fat, recycled oils	50%
ASTM D7566 Annex 3	Synthesized iso-paraffins from hydroprocessed fermented sugars	SIP	Biomass used for sugar production	10%
ASTM D7566 Annex 4	Synthesized kerosene with aromatics derived by alkylation of light aromatics from non-petroleum sources	FT-SKA	Coal, natural gas, biomass	50%
ASTM D7566 Annex 5	Alcohol to jet synthetic paraffinic kerosene	ATJ-SPK	Biomass from ethanol or isobutanol production	50%
ASTM D7566 Annex 6	Catalytic hydrothermolysis jet fuel	CHJ	Triglycerides such as soybean oil, jatropha oil, camelina oil, carinata oil, and tung oil	50%
ASTM D7566 Annex 7	Synthesized paraffinic kerosene from hydrocarbon – hydroprocessed esters and fatty acids	HC-HEFA-SPK	Algae	10%

115 ICAO Environment - SARPs - Annex 16 Volume IV

116 ASTM is one of the world's largest international standards developing organizations, encompassing about 150 major global industries.

117 ICAO Environment - Conversion processes

ASTM D7566 Annex 8	ATJ derivative starting with the mixed alcohols	ATJ-SKA		
ASTM D1655 Annex A1	Co-hydroprocessing of esters and fatty acids in a conventional petroleum refinery	co-processed HEFA	Fats, oils, and greases (FOG) co-processed with petroleum	5%
ASTM D1655 Annex A1	Co-hydroprocessing of Fischer-Tropsch hydrocarbons in a conventional petroleum refinery	co-processed FT	Fischer-Tropsch hydrocarbons co-processed with petroleum	5%
ASTM D7566 Annex (pending)	Alcohol-to-Jet (ATJ) derivative utilizing biochemical production of isobutene	*pending*	*pending*	50%

Various conversion processes are currently under evaluation for approval by ASTM as illustrated under Table 13. Work is also ongoing to allow the use of 100% SAF in aircraft, as well as to increase the maximum blending for co-processing from 5% to 30% unlocking further availability of SAF volumes.

Table 13. Conversion processes under evaluation[118]

Conversion process	Abbreviation	Lead developers
Synthesized aromatic kerosene	SAK	Virent
Integrated hydropyrolysis and hydroconversion	IH2	Shell
Single Reactor HEFA (drop-in Liquid Sustainable Aviation and Automotive Fuel)	DILSAAF	Indian CSIR-IIP
Pyrolysis of non-recyclable plastics	ReOIL	OMV
Co-processing of pyrolysis oil from used tires	*pending*	*pending*
Methanol to jet		*Exxon Mobil*

In addition to complying with approved conversion processes, to be eligible for use under CORSIA, SAF must meet a set of sustainability criteria[119].

CORSIA's sustainability criteria includes the following themes:

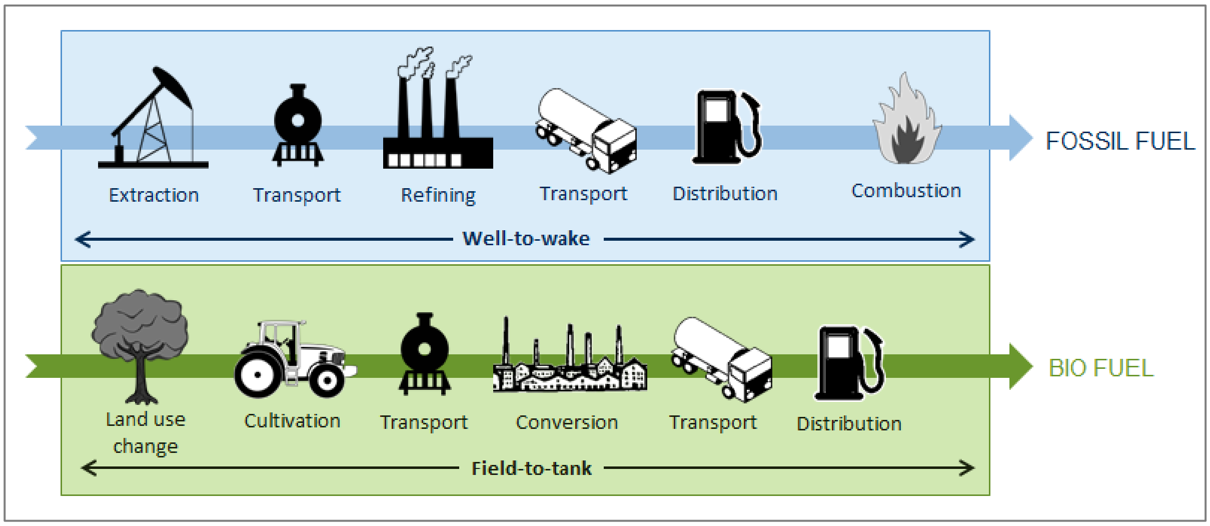
CORSIA Sustainability Criteria Applicable for batches of CORSIA SAF[120]	
1- Greenhouse Gases (GHG)	8- Waste and chemicals
2- Carbon Stock	9- Seismic and vibrational impacts
3- Greenhouse Gas Emission Reduction Permanence	10- Human and labour rights
4- Water	11- Land use rights and land use
5- Soil	12- Water use rights
6- Air	13- Local and social development
7- Conservation	14- Food security

118 ICAO Environment - Conversion processes
119 ICAO Environment – CORSIA Sustainability Criteria
120 ICAO Environment - Sustainability Criteria for CORSIA Eligible Fuels.

Compliance with the CORSIA sustainability criteria shall be certified and approved by a Sustainability Certification Scheme (SCS). RSB and ISCC are currently the only approved SCS. An aeroplane operator seeking to claim emissions reductions from the use of CORSIA SAF shall provide evidence of the SCS' certification in its emissions reporting.

To assess the emissions savings from the use of SAF, a comprehensive accounting must be done of all emissions across all steps of the fuel's life-cycle, called a life-cycle analysis (LCA). If the total emissions from an alternative fuel are less than the total emissions from fossil fuel, there is an environmental benefit attributable to that fuel[121]. Figure 27 illustrates life-cycle emissions from fossil fuels as they compare to emissions from biofuels.

Figure 27. Fuel life-cycle emissions for fossil and biofuel



Source: adapted from ICAO Environment – Fuel Life Cycle and GHG emissions

Unlike in the CAF life cycle, CO_2 in the SAF life-cycle is taken up from the atmosphere by the biological matter, temporarily sequestered in the liquid fuel, and then is re-released back to the atmosphere when the fuel is combusted. Therefore, no additional carbon would be released into the atmosphere, as would be the case with conventional aviation fuels.

In an effort to maintain harmonization in the calculation of fuel life-cycle GHG emissions, the CAEP developed two important documents: "CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels[122]" and "CORSIA Methodology for Calculating Actual Life Cycle Emissions Values[123]."

An additional key element to include when assessing the potential GHG savings of a SAF pathway, is the element of Land Use Change (LUC). Land use changes can lead to CO_2 emissions or sequestration due to carbon stock[124] changes in biomass, decomposing organic matter, and soil organic matter, which may translate into major impacts on the environmental profile of bioenergy. When dealing with LUC impacts, the distinction between direct (dLUC) and indirect LUC (iLUC) is frequently used, especially for certification purposes. ISO/TS 14067:2013, for instance, defines dLUC as a "change in the use or management of land within the product system being assessed", while iLUC is "a change in the use or management of land which is a consequence of

121 ICAO Environment: GFAAF
122 ICAO Environment (2022a)
123 ICAO Environment (2022b)
124 Carbon stock is the amount of carbon that is stored in a certain piece of land, i.e., carbon contained in the soil due to the decomposition of biomass (such as leaves) keeps carbon stored. This carbon stock can be reduced when the land is managed to cultivate; however, some crop management can help to increase the carbon stock by helping to integrate biomass.

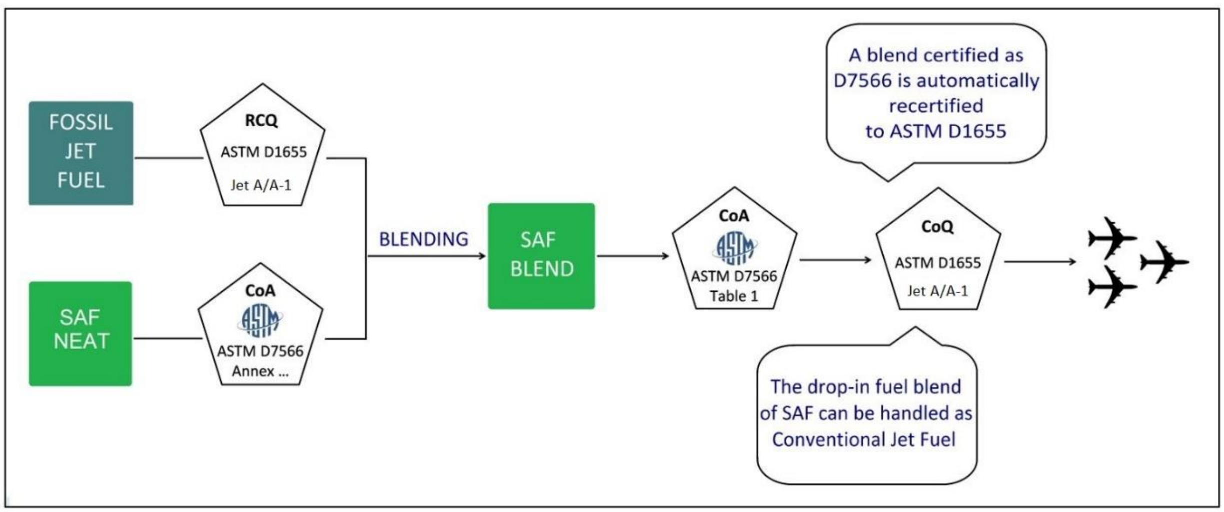
direct land use change, but which occurs outside the product system being assessed[125].” Unlike dLUC, iLUC cannot be directly measured or observed; instead, it is projected with economic models which capture both effects together.

Feedstocks that do not require land for their production (such as municipal, agricultural, or industrial waste), and those that do not require the substitution of crops or LUC, are estimated to have a low risk of inducing iLUC. Some LCA standards such as RSB-STD-04-001126 can certify that a feedstock’s production has a low iLUC risk.

In addition to ensuring that all SAF complies with sustainability criteria, rigorous international specifications have been adopted to ensure quality and safety. SAF, just as jet fuel, must comply to strict quality specifications to be eligible for use in the aviation industry. ASTM D1655 ‘Standard Specification for Aviation Turbine Fuels’ lays the foundation for jet fuel quality specifications and plays a crucial role in ensuring operational safety and reliability. ASTM D7566 is the ‘Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons’ and describes the fuel quality specifications for each qualified SAF production pathway[127].

All SAF production pathways undergo stringent testing for compliance with safety and quality specification requirements to receive its D7566 certification. The process is shown in detail in the following figure:

Figure 28. SAF ASTM certification process[128]



ASTM D7566 defines the requirements for the neat SAF as well as with the blend with conventional aviation fuel. Once the blend has been certified against ASTM D7566, it is a drop-in fuel and can be considered conventional Jet A1 as per ASTM D1655 standard.

The ‘drop-in’ condition is a major requirement for the aviation industry. Any aviation alternative fuel that doesn’t meet this condition requires a parallel infrastructure for handling and would present safety issues associated with risks of mishandling during transport, blending, storage, and aircraft refueling process.

Several actors and global efforts have spearheaded the development and use of SAF. The first test flight using a blended biofuel was conducted by Virgin Airlines in 2008 when its “Boeing 747-400 flew from London to

125 ISO/TS 14067 (2013)
126 RSB (2015)
127 SkyNRG (2021)
128 RCQ - Refinery Certificate of Quality. CoA - Certificate of Analysis. CoQ – Certificate of Quality.

Amsterdam carrying in one of its four fuel tanks a 20-percent mix of biofuel derived from coconut and babassu oil."[129] Pioneers along the SAF's value chain followed improving upon feedstock production, conversion technology, sustainability, and safety & quality certification as well as transport, storage, and supply chain logistics. This allowed more airlines to safely launch test flights awakening the demand to further support SAF deployment projects; illustrated under the following table is a list of those early adopters:

Table 14. Test flights and initial involvement with SAF trials

Carrier	Date of first SAF flight	Details
Air New Zealand	December 2008	Technical test flight on a Boeing 747
Japan Airlines	January 2009	Technical test flight on a Boeing 747
Finnair	July 2011	Series of flights on an Airbus A320-family aircraft between Amsterdam and Helsinki
Interjet	July 2011	Commercial flight on an Airbus A320 between Mexico City and Tuxtla Gutierrez
AeroMexico	August 2011	Commercial flight on a Boeing 777 between Mexico City and Madrid
Iberia	October 2011	Commercial flight on an Airbus A320 between Madrid and Barcelona
Thomson Airways	October 2011	Commercial flight between Birmingham and Arrecife on a Boeing 757
Air France	October 2011	Series of flights on an Airbus A320-family aircraft between Toulouse and Paris
Air China	October 2011	Technical test flight on a Boeing 747
Alaska Airways	November 2011	Series of commercial flights on Bombardier Q400 and Boeing 737 aircraft
Thai Airways	December 2011	Commercial flight on a Boeing 777 between Bangkok and Chiang Mai
Etihad Airways	January 2012	Delivery flight on a Boeing 777 from Seattle to Abu Dhabi
Latam Airways	March 2012	Series of flights in Latin America
Porter Airlines	April 2012	Demonstration flight on a Bombardier Q400 from Toronto to Ottawa
Jetstar Airways	April 2012	Commercial flight between Melbourne and Hobart on an Airbus A320
Air Canada	June 2012	Two commercial flights from Toronto to Mexico City
KLM	May 2014	Commercial flight from Amsterdam to Aruba on Airbus A330-200
GOL Lineas Aéreas	June 2014	Series of flights during the FIFA World Cup
Nextjet	June 2014	Commercial flight from Karlstad to Stockholm

Source: ABBB, 2023

129 Squatriglia (2008)

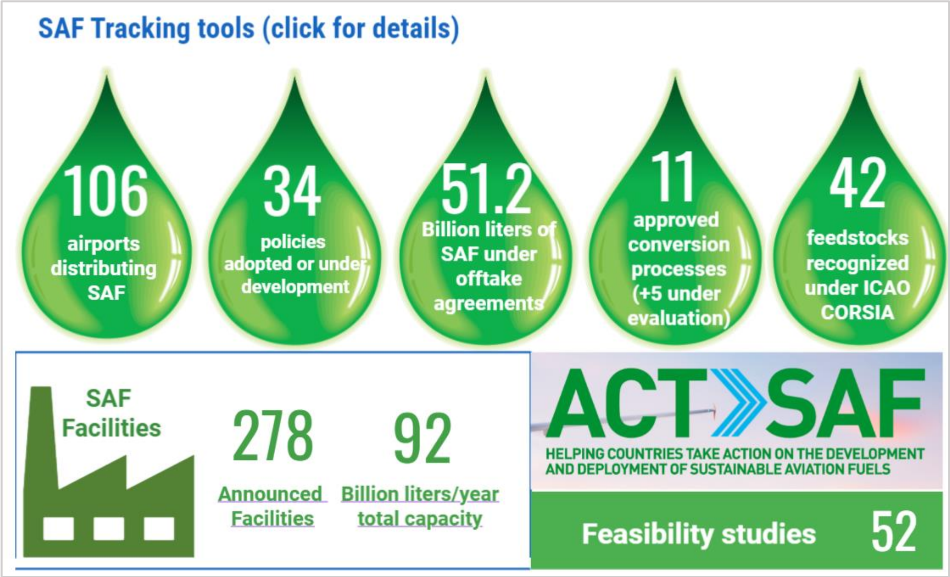
Leaping forward in time to June 21st, 2022, "aircraft manufacturer ATR, Swedish airline Braathens Regional Airlines, and SAF supplier Neste collaborated to enable the first-ever 100% SAF-powered test flight on a commercial regional aircraft"[130].ICAO's SAF tracking tool offers a valuable data on SAF related matters including distribution, policy development and adoption, volumes of SAF under off-take agreements, and approved conversion processes.

The use of SAF across the African Continent is slowly but surely keeping with pace:

- 2013-2019 & 2020-2023: Phase I of ICAO Assistance Project with EU Funding involved two feasibility studies on the development and deployment of SAF in Burkina Faso and Kenya, Phase II of the project is conducting such studies for 10 additional African States.
- May 23rd, 2023: WWF in collaboration with International Energy Agency (IEA) Bioenergy and UNIDO published a study on "Opportunities for SAF production in South Africa," concluding that "a domestic SAF industry could be a pillar of South Africa's low-carbon economy, playing a key role in the just transition process by creating over 90 000 green jobs"[131].
- May 25th, 2023: Kenya's national carrier Kenya Airways became the first African airline to use SAF after its Boeing 787-800 (B787-8) Dreamliner took off from Nairobi's Jomo Kenyatta International Airport to Amsterdam Schiphol[132].

Progress on SAF as of October 2023 is summed up on the ICAO SAF tracking tools.

Figure 29. SAF – A Tangible Reality Globally



Source: RSB 2022

Nevertheless, for the industry to progress at the pace needed to achieve net-zero CO_2 emissions by 2050, all world nations need to greatly increase incentives to support this nascent industry reach economies of scale. While CAEP identified SAF as having the greatest potential to help achieve such ambitious target[133], a major constraint to accelerate adoption remains. Depending on SAF pathway and production site, its price when compared to conventional jet fuel ranges from 2x for some waste-based sources to 6-10x for synthetic fuels

130 Bozyk (2022)

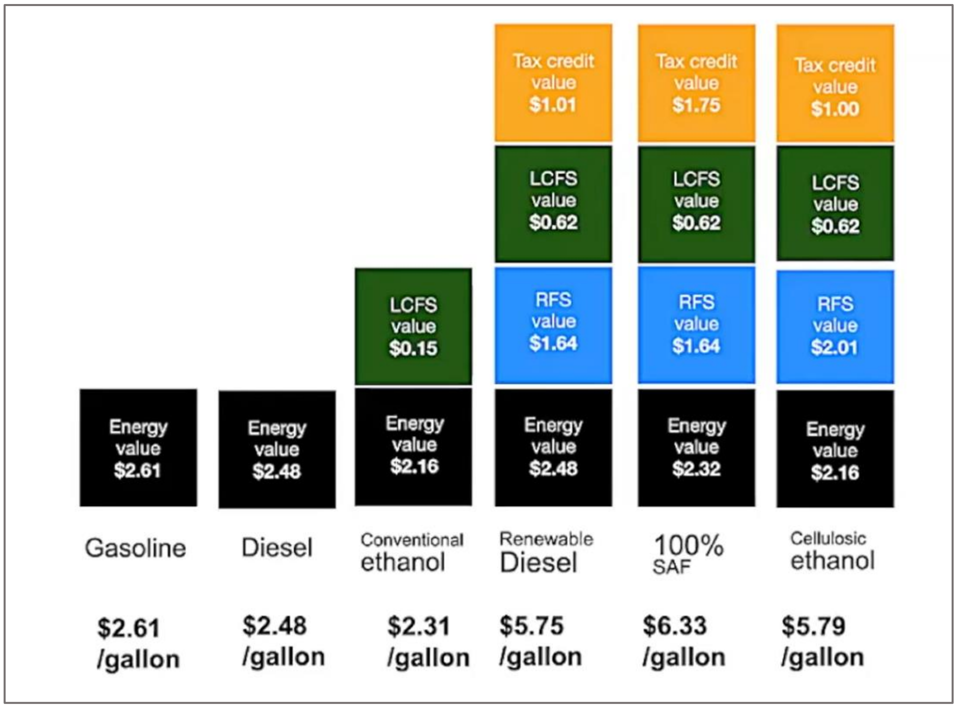
131 Chireshe (2023)

132 Eni (2023)

133 ICAO Environment - LTAG Report

using carbon capture[134]. Support from governments and international governmental associations is therefore critical to accelerate the use of SAF and reach net-zero CO_2 emissions from aviation by 2050. The following illustration exemplifies how a combination of federal and state incentives offered via the Low Carbon Fuel Standard (LCFS)[135], the Renewable Fuel Standard Program (RFS)[136], and targeted tax credits in the USA help cover the price differential between low carbon renewable fuels and conventional fossil fuels, it also positions all available liquid transport fuels on a level playing field for fair competition:

Figure 30. Incentives for competitive low carbon renewable fuels[137]



Source: ABLC CONNECT

The latest 2023 Market Outlook report published by SkyNRG[138], a leading SAF producer in Europe and now expanding to markets in the United States of America (USA), offers a clear scenario on those Nations that are leading the implementation of actions to support the expansion of SAF production and uptake, summarized under the following tables:

134 ABBB (2022)

135 LCFS (2023)

136 US EPA (2023)

137 Values are for delivery into a US market with a clean fuels standard. Since ethanol and biodiesel are traded commodities, those commodity prices include the assumed value of federal credits/RINs. For the others, quoted energy prices are for the equivalent fossil molecule. Note that conventional ethanol is modeled at a Carbon Intensity of 70, RD, SAF and CellEth at a CI of 20. Individual companies/processes may have better or worse CI scores that are used to calculate LCFS credits.

138 SkyNRG (2023)

Figure 31a. SAF 2023 Market Outlook Leading Actors – EU and United Kingdom (UK)

EUROPEAN UNION AND UK

1.

Mandated demand in both markets is expected to reach 4.2 Mt (1.5 Bgal) by 2030, excluding demand from voluntary commitments.

2.

SAF projects expected to reach operation are estimated to supply up to 3.3 Mt (1.2 Bgal) SAF by 2030, 0.6 Mt (0.2 Bgal) more compared to the analysis of last year. Announcements are predominantly HEFA-based (80%), with some facilities coming online post-2025 opting for more advanced pathways such as Alcohol-to-Jet (AtJ), Fischer-Tropsch (FT) and e-SAF. Various facilities are delayed compared to our previous outlook, leading to a slower ramp-up of SAF production in Europe.

3.

SAF supply is expected to meet mandated demand until 2030, with a supply gap of 0.9–2.1 Mt (0.3–0.7 Bgal) remaining until 2030 targets, depending on the growth in jet fuel consumption. Note however, that the voluntary market could potentially absorb production capacity in excess of what is needed to meet mandates.

4.

Supply gap to meeting 2030 targets can be closed by new announcements of projects currently in feasibility stage and imports of SAF from the US and Asia-Pacific. EU SAF projects with a total production capacity of ~1.5 Mt (0.5 Bgal) are currently in feasibility stage, while SAF capacity of ReFuelEU-eligible SAF capacity outside of Europe could provide ~7 Mt SAF to EU and UK markets by 2030.

5.

To reach a European SAF production capacity of 40 Mt (14 Bgal) by 2050 around 150 SAF refineries would have to be deployed, representing 250 billion EUR in CAPEX investment. Investment would be required mostly in the conversion of cellulosic/MSW feedstocks into SAF and clean hydrogen/CO_2 into e-SAF.

6.

SAF requirements based on European mandates until 2050 can be met with European SAF production capacity if jet fuel demand remains at pre-Covid levels (40 Mt, 14 Bgal). Growth in jet fuel consumption could drive up SAF needs to 69 Mt (24 Bgal), which would add further pressure on SAF capacity deployment and/or imports.

Source: SkyNRG 2023

Figure 31b. SAF 2023 Market Outlook Leading Actors – USA

UNITED STATES

1.

Aspirational production of SAF in the United States is 3 Bgal (8.5 Mt) by 2030 and 27–35 Bgal (77–100 Mt) by 2050. Getting on track to meeting these 2050 goals requires a more stable and long-term policy climate for SAF that delivers investment certainty.

2.

Based on current announcements, SAF supply could reach 2.2 Bgal (6.2 Mt) by 2030, based on current announcements. Announcements are predominantly HEFA (66%) and corn ethanol-ATJ based (27%).

3.

Waste and vegetable oil markets in the US are under pressure. The success of HEFA-based SAF projects is contingent on the US: evaluating scale of renewable diesel announcements to free up feedstock, or risk impacting global agricultural commodity markets by significantly expanding soybean oil production.

4.

SAF based on corn ethanol and cellulosic waste feedstocks could close the gap to meeting the US goal of 3 Bgal (8.5 Mt) SAF production by 2030. Attractive state and federal policies drive investments in cellulosic SAF while corn ethanol incentive eligibility still hinges on the selected greenhouse gas (GHG) methodology.

5.

By 2050, the US could have enough domestically based SAF capacity in place to substitute its pre-Covid jet fuel demand of 27 Bgal (77 Mt) with SAF. This is contingent on the rapid deployment of SAF refineries based around use of green H_2 and cellulosic feedstocks. Growing jet fuel demand beyond pre-Covid levels would increase competition for feedstock and may further challenge the feasibility of meeting the 2050 production goal.

6.

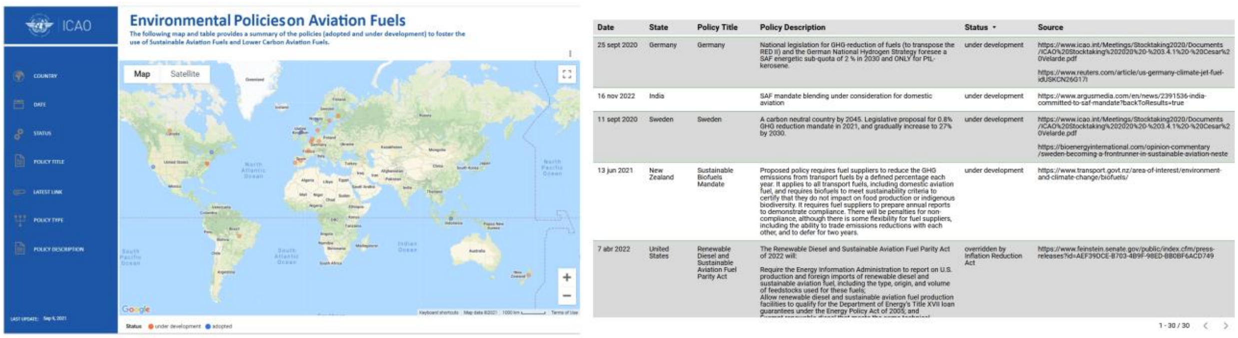
To reach a domestic SAF production capacity of 27 Bgal (77 Mt), the US would have to deploy around 250 SAF refineries by 2050, representing a cumulative CAPEX investment of 400 billion USD.

Source: SkyNRG 2023

The type of support governments offer is dependent on each Nation's peculiar circumstances (politics, economy, etc.) but the level of support is intrinsically tied to their Nationally Determined Contributions (NDC) and actions needed for compliance. As seen on the above tables, the EU and the UK chose mandates to promote the use of SAF while the USA is implementing different forms of incentives.

While the USA, EU, and UK are today are driving the growth of the SAF industry, additional governments across the world are also actively working either in the process of implementing measures or planning their support in the form of mandates, roadmaps, earmarked incentives, etc., including Brazil, Japan, Norway, and United Arad Emirates just to name a few. The ICAO Global Framework for Aviation and Alternative Fuels (GFAAF), an online database for sharing information related to sustainable aviation fuels, offers a comprehensive list on environmental policies on aviation fuels, including a map allowing to locate where in the world action is taking place[139]:

Figure 32. ICAO GFAAF SAF Policies tracker



Source: ICAO Environment – GFAAF

As policy support increases, the SAF industry grows in alignment. The iICAO tracker on SAF production facilities shows how supply is trying to catch up with current and future demand for SAF:

Figure 33. Global existing and announced production capacity

139 ICAO Environment - GFAAF

The number of airlines securing off take agreements for SAF volumes is also steadily increasing. Whether their motivation is to meet immediate voluntary demand or as a natural hedge against additional supply mandates from 2025 onwards[140], this push invites collaboration and investment across the SAF value chain, as depicted in the following picture:

Figure 34. Airlines' SAF off-take agreements (extracted from the ICAO Tracker of SAF offtake agreements, October 2023).

ICAO **Tracker of SAF Offtake agreements**

Filter by: Fuel producer | Fuel purchaser

	Date	Fuel producer	Fuel Supplier	Fuel User / Purchaser	total offtake volume (million liters)	Length of offtake agreement (years)	Source
1.	Nov 3, 2023	USA BioEnergy		Southwest Airlines	3255.5	20	https://www.hydrocarbonprocessing.com/news/2023/11/...
2.	Oct 21, 2023	Neste		Emirates	3.8	2	Emirates expands collaboration with Neste for the sup...
3.	Oct 19, 2023	World Energy	World Energy	DHL Express	668	7	DHL and World Energy announce giant SAF agreemen...
4.	Oct 3, 2023	Shell	Shell Aviation	Emirates	0.5		https://www.emirates.com/media-centre/emirates-and-...
5.	Sep 13, 2023	Cemvita		United Airlines	3785.4	20	https://www.businesswire.com/news/home/2023091398...
6.	May 31, 2023	Cleanjoule		Frontier Airlines, Wizz...	340.7	1	https://www.businesswire.com/news/home/2023053100...
7.	May 26, 2023	Petronas		Malaysia Airlines	287.3	1	https://aviationweek.com/air-transport/airlines-lessors/...
8.	May 23, 2023	Dimensional Energy		Boom Supersonic	18.9	1	https://www.prnewswire.com/news-releases/boom-sup...
9.	May 7, 2023	Repsol		Ryanair	196.8	6	https://biomassmagazine.com/articles/20003/ryanair-re...

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Summary per fuel producer

	Fuel producer	Total offtake volume (million liters)	Number of offtake agreements
1.	Gevo	9,550.03	14
2.	Fulcrum	6,719.1	3
3.	Alder Fuels	5,678.12	1
4.	Cemvita	3,785.41	1
5.	USA BioEnergy	3,255.45	1
6.	Shell	2,793.37	7
7.	Neste	2,456.13	18
8.	DG Fuels	2,206.97	2
9.	Raven SR	1,561.64	1
10.	OMV	1,433.45	5
11.	Aemetis	1,272.43	9
	Grand total	**51,216.55**	**114**

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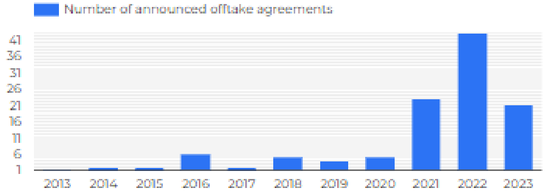
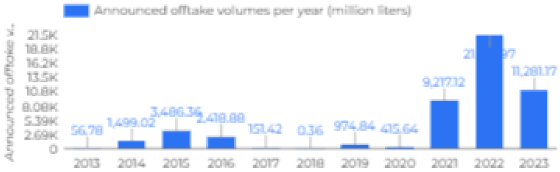
Summary per fuel purchaser

	Fuel purchaser	Total offtake volume (million liters)	Number of offtake agreements
1.	United Airlines	14,299.39	7
2.	Southwest Airlines	4,163.95	3
3.	Delta	3,862.25	8
4.	OneWorld	3,785.41	1
5.	Lufthansa	3,399.4	4
6.	Air France - KLM	2,998.34	3
7.	AirBP	2,192.71	2
8.	American Airlines	2,134.21	4
9.	Japan Airlines	1,661.95	2
10.	Cathay Pacific	1,477.07	2
11.	DHL Express	1,466.72	2
	Grand total	**51,216.55**	**114**

1 - 61 / 61





Advanced fuel technologies for SAF production have evolved in the past 15+ years from concept, prototype, and demonstration phase to full commercial scale. Wider commerciality of these facilities will reduce cost and increase the affordability for end users, but this is contingent on the continuous support from

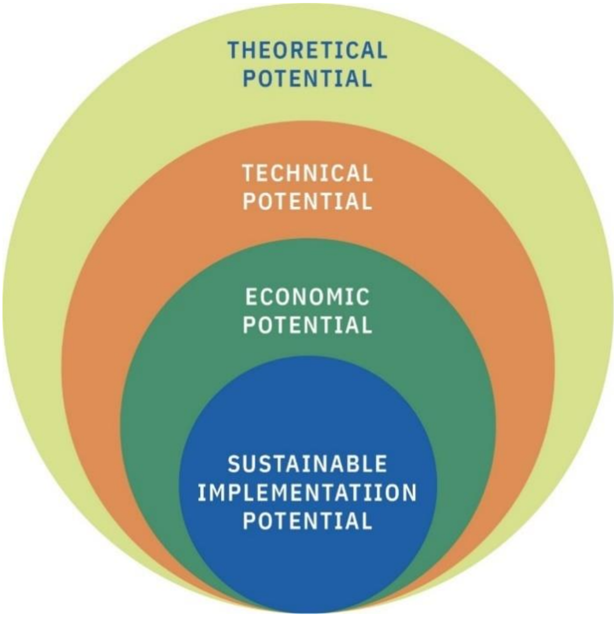
140 KPMG (2022)

government policy throughout the full trajectory to reach economies of scale bringing SAF prices to parity with conventional aviation fuels.

2.2 SUMMARY OF EVALUATED FEEDSTOCKS

The potential of a specific feedstock for conversion to SAF relies on four evaluation levels including theoretical, technical, economic, and sustainable implementation potentials[141], all in a 'scaling relationship' with each other as illustrated in the following figure provided by the International Energy Agency (EIA):

Figure 35. Biomass potentials evaluation levels



Source: IEA 2023

The theoretical potential is a first step to understand existing local geographical capabilities to supply the volumes of feedstock needed to supply demand. An important step to identify those feedstocks that are not feasible under current condition and investigate further if and what changes are needed to make it feasible.

The technical potential level identifies technology readiness level to handle the theoretical potential on feedstock volumes and conversion to SAF. Barriers are identified on possible limitations to achieve theoretical production volumes on account of outdated agricultural technology for planting, pest control, irrigation, fertilization, harvesting and pot-harvest operations as well as conversion and logistics for SAF supply.

The economic potential is evaluated taking into account "the share of the technical potential that meets economic profitability criteria within a given framework, namely all costs related to feedstock production and logistics, its conversion to SAF, storage, transport and delivery to the final user.

The sustainability implementation potential will define whether the final product qualifies as sustainable. In the case of SAF, this means that the output has achieved sustainability certification in compliance with all applicable principles and criteria specified under the ICAO Document CORSIA Sustainability Criteria for CORSIA Eligible Fuels.

141 IEA 2023 54.

The following table illustrates feedstocks currently under production in Zimbabwe potentially viable for conversion to SAF through approved ASTM pathways:

Table 15. Available feedstocks in Zimbabwe, current use, and applicable SAF conversion process

Feedstock		Current use	Primary SAF Conversion Process			
			HEFA	FT	ATJ	CHJ
Carbohydrates	Sugarcane	Food, ethanol			●	
	Bagasse	Energy (steam & heat), fodder		●	●	
	Sorghum	Food, biodiesel, fodder			●	
Oilseeds	Jatropha	Biodiesel	●		●	●
	Soya bean	Food, edible oil, fodder	●			●
	Sunflower	Edible oil, fodder	●			●
	Cotton	Edible oil	●			●
Residues	Agricultural	Fodder, field cover		●	●	
	Forestry	Timber, roofing, furniture				
	Woody biomass	Small scale carpentry		● ●	● ●	
Wastes	MSW	Landfill, biogas-to-energy		●	●	
	Tallow/Lard	Soap, oil, meat processing, stockfeed	●			
Other	CO_2	Vented to the atmosphere			●	

To add more precision to the theoretical, technical, and economic evaluation, ICAO's "SAF Rules of Thumb" is utilized to make order of magnitude estimations related to SAF costs, investment needs and production potential that could inform policymakers and project developers[142]. The following two tables summarize SAF feedstock and facilities information for nth and pioneer facilities per pathway[143]:

[142] DISCLAIMER: These SAF "Rules of Thumb" are intended to provide big picture trends for costs and processing technology/feedstock comparisons and could be utilized to make order of magnitude estimations. They do not provide precise cost or price information. As such, investment or policy decisions should be based on a dedicated analysis that captures specific details related to the investment or policy.
[143] ICAO Environment – CORSIA Sustainability Criteria

Table 16. SAF Rules of Thumb – Feedstock Information

Technology, feedstock type and price, yield, total annual distillate scale, annual SAF production for both nth and pioneer facilities.

Processing Technology	Feedstock	Yield (ton distillate/ton feedstock)	Feedstock Price	Total Capacity (million L/year)		SAF production (million L/yearr)	
				n^th^	pioneer	n^th^	pioneer
FT*	MSW	0.31	$30/ton	500	100	200	40
FT*	forest residues	0.18	$125/ton	400	100	160	40
FT*	agricultural residues	0.14	$110/ton	300	100	120	40
ATJ	ethanol	0.60	$0.41/L	1000	100	700	70
ATJ	isobutanol-low	0.75	$0.89/L	1000	100	700	70
ATJ	isobutanol-high	0.75	$1.20/L	1000	100	700	70
HEFA	FOGs	0.83	$580/ton	1000	-	550	-
HEFA	soybean oil***	0.83	$809/ton	1000	-	550	-
FT	CO2 from Direct Air Capture (DAC) , H2	0.24	$300/t, $6/kg	1000	-	200	-
FT	waste CO_2, H_2	0.24	$300/t, $6/kg	1000	-	200	-
Pyrolysis**	forest residues	0.23	$125/ton	400	100	180	40
Pyrolysis**	agricultural residues	0.21	$110/ton	400	100	180	40

*Feedstock price is for pre-processed feedstock/ **pyrolysis ASTM approval is pending/ ***2013-2019 average price of soyabean and canola oils

Two additional and equally important data pieces to keep in mind when evaluating feedstocks and pathways for SAF production in Zimbabwe are:

- Estimated total annual Jet A-1 consumption: 13.1 million liters for 2019
- Estimated total annual diesel consumption: 730 million liters of petrol and 1,095 million liters of diesel fuel for 2022[144].

The estimated total Jet A-1 fuel consumption in Zimbabwe helps recognize total volumes of SAF needed to supply a specific SAF blend to satisfy demand and to formulate projections on future expansion needs aligned with forecasted growth in aviation traffic and SAF demand. The following table illustrates this scenario for Zimbabwe:

[144] Data provided via email by the Ministry of Energy and Power Development, Energy Conservation and Renewable Energy Department.

Table 17. Scenario A: ethanol-ATJ-SAF

SAF Rule of Thumb **pioneer** plant millions of liters/year		ZW's Jet A-1 consumption millions of liters/year	Needed SAF volumes per blend cut millions of liters/year			SAF excess production		
total volume	SAF volume		50%	30%	10%	50%	30%	10%
100,000,000	70,000,000	13,108,638	6,554,319	3,932,591	1,310,864	63,445,681	66,067,409	68,689,136

Table 18 illustrates the scenario using the smallest commercial ATJ SAF conversion plant, with a total capacity of approximately 40 million liters a year of fuel, currently under construction[145]. Gevo is running a pilot to test their modular approach to ATJ conversion to SAF. The total capacity of this modular model is 0.26 million liters a year of fuel production. The following table presents a new scenario showing the suitability of technology and plant capacity sensible to Zimbabwe's annual CAF consumption (2019):

Table 18. Scenario B: ethanol-ATJ-SAF

Plant	total volume 100% fuel	SAF volume at 70%	ZW's Jet A-1 consumption millions of liters/year	Needed SAF volumes per blend cut million/liters/year			SAF excess production per blend cut		
				50%	30%	10%	50%	30%	10%
ICAO RoT* pioneer	100,000,000	70,000,000	13,108,638	6,554,319	3,932,591	1,310,864	63,445,681	66,067,409	68,689,136
LanzaJet	40,000,000	28,000,000	13,108,638	6,554,319	3,932,591	1,310,864	21,445,681	24,067,409	26,689,136
Gevo 1 module	260,000	182,000	13,108,638	6,554,319	3,932,591	1,310,864	(6,372,319)	(3,750,591)	(1,128,864)
Gevo 8 modules	2,080,000	1,456,000	13,108,638	6,554,319	3,932,591	1,310,864	(5,098,319)	(2,476,591)	145,136

RoT 'Rule of Thumb'

GEVO describes their modular approach of ATJ to SAF production as a "modularized, repeatable alcohol-to-jet kit that [commingles a] combination of existing technologies into a turnkey plant design[146]." For Zimbabwe, the idea of deploying small capacity plants may work well given the low volumes of yearly consumption of Jet A-1 spread among 8 airports. These types of plants may be set up in different locations, close to airports or feedstock sources, generate more and local jobs, and result in a more widespread distribution of earning across the State. According to Gevo, their modal approach is "a more cost-effective way of de-risking" investment in ATJ-SAF conversion plants, and allows for a "more rapid build-out of additional plants." A modular small capacity ATJ-SAF plant also allows for a more controlled expansion in production capacity.

It is worth noting though that Gevo's modular technology is still at its pilot stage of testing. Furthermore, under principles of economies of scale, a small plant like these modular examples have a proportionally higher CAPEX and OPEX than ATJ-SAF plants with production capacities in the millions of liters per year.

The significance of knowing the State's demand for conventional diesel fuel for road transport comes into place at this stage of the evaluation process: consider a smaller capacity production plant with a focus on SAF output or evaluate a larger capacity plant focusing in maximizing renewable diesel output. Co-products from the ATJ to SAF conversion process includes renewable diesel (RD), a drop-in fuel meeting ASTM D975.

Because renewable diesel is chemically the same as petroleum diesel, it may be used in its pure form—called R100—as a drop-in fuel, or it can be blended with petroleum diesel and/or with biodiesel in various amounts. The size of the aviation industry in Zimbabwe may not be large enough yet to justify investment in the deployment of ethanol-ATJ -SAF with currently available commercial conversion technology. RD could act as trigger to realize the positive economic potential of ethanol for SAF production instead. The following table illustrates this scenario:

[145] LanzaJet 2022
[146] Voegele 2023

Table 19. Scenario C: ethanol-ATJ-SAF (30%) -RD (70%)

Plant	total volume 100% fuel millions of liters/year	SAF production volume at 30%	ZW's Jet A-1 consumption millions of liters/year	Needed SAF volumes per blend cut millions of liters/year			SAF excess & deficit supply		
				50%	30%	10%	50%	30%	10%
ICAO RoT pioneer	100,000,000	30,000,000	13,108,638	6,554,319	3,932,591	1,310,864	23,445,681	26,067,409	28,689,136
LanzaJet	40,000,000	12,000,000	13,108,638	6,554,319	3,932,591	1,310,864	5,445,681	8,067,409	10,689,136
Gevo 1 module	260,000	78,000	13,108,638	6,554,319	3,932,591	1,310,864	(6,476,319)	(3,854,591)	(1,232,864)
Gevo 17 modules	4,420,000	1,326,000	13,108,638	6,554,319	3,932,591	1,310,864	(5,228,319)	(2,606,591)	15,136

Plant	total volume 100% fuel millions of liters/year	RD production volume at 70%	ZW's diesel fossil fuel consumption millions of liters/year	RD-100 supply deficit
ICAO RoT pioneer	100,000,000	70,000,000	1,095,000,000	(1,025,000,000)
LanzaJet	40,000,000	28,000,000	1,095,000,000	(1,067,000,000)
Gevo 1 module	260,000	182,000	1,095,000,000	(1,094,818,000)
Gevo 17 modules	4,420,000	3,094,000	1,095,000,000	(1,091,906,000)

Under scenario C, the investment into the construction of 16 modules of Gevo's technology provides enough supply of SAF to satisfy a 10% blend cut into current demand volumes while providing approximately 0.3% of total annual diesel fuel for road transport with RD, a drop in the bucket but the exercise to illustrate scenarios helps envision and identify the best investment option. Alternatively, Zimbabwe may choose to invest in large capacity conversion plants (nth plants) to maximize RD supply and export excess volumes of SAF.

All scenarios merit more in-depth evaluation to arrive at a rational investment decision but the above serve the purpose of this study to understand the type of technology currently available for SAF conversion, uses of co-products, and feasibility of the different feedstock evaluated available in Zimbabwe and those that may be worth studying in the future.

Considering feedstocks for SAF conversion already under production in Zimbabwe saves time and costs. Production inputs and processes, as well as transport and logistics supply chains are already established for such feedstocks. Investment risks are well understood by producers and much support has already been allocated by government agencies to improve efficiency, implement best practices, and begin the adaptation process to climate change. Feedstocks that are not currently produced in Zimbabwe but that offer added cost reductions and high market uptake to further improve the cost-benefit analysis for SAF conversion shall be worth considering in the future.

The following table offers an overall evaluation summary of available feedstocks for SAF conversion in Zimbabwe, utilizing a weighted indicator based on the four levels discussed above, theoretical, and technical potentials are combined into one indicator: 'feedstock evaluation'. A detailed evaluation of each feedstock is presented in the upcoming section '2.2. Detailed information per feedstock'.

Table 20. Summary: potential of considered feedstocks for SAF conversion

Feedstock Considered	Conversion pathway	Feedstock evaluation	Economic evaluation	Sustainability evaluation
Carbohydrates				
Sugarcane current volumes	ATJ	■■■□ (green)	■■□□ (green)	■■■□ (amber)
Sugarcane volumes via expansion plans*	ATJ	■■■■ (green)	■■□□ (green)	■■□□ (amber)
Bagasse	FT- ATJ	■■□□ (green)	■■■□ (green)	■■□□ (amber)
Sorghum	ATJ	■■■□ (amber)	■■□□ (green)	■■■□ (green)
Oilseeds				
Jatropha	HEFA	■□□□ (red)		■■■□ (green)
	Co-processing		■■□□ (amber)	■■□□ (green)
Soya bean	HEFA	■□□□ (amber)	■■■□ (green)	■■□□ (amber)
Sunflower	HEFA	■□□□ (amber)	■■□□ (green)	■■□□ (amber)
Cotton	HEFA	■■□□ (amber)	■■□□ (green)	■■□□ (amber)
Residues				
Agricultural	FT- ATJ	■■■□ (amber)	■■□□ (green)	■■■■ (green)
Forestry	FT- ATJ	■■■□ (red)	■■■□ (red)	■■■■ (green)
Woody biomass	FT- ATJ	■■□□ (red)	■■□□ (red)	■■■■ (green)
Wastes				
MSW	FT- ATJ	■■■□ (amber)	■□□□ (amber)	■■■■ (green)
Tallow/Lard	HEFA	■■□□ (amber)	■■□□ (amber)	■■■■ (green)
Other				
CO_2	FT- ATJ	■□□□ (amber)	■■■■ (green)	■■■■ (green)

* Expansion plans already under implementation to increase ethanol production volumes by 300%

2.3 FEEDSTOCK SPECIFIC ASSESSMENT

2.3.1. Carbohydrates

i. Sugarcane

As described under section 1.5, sugarcane is a well-established crop in Zimbabwe, first introduced in the Hippo Valley in 1959 and quickly turn into commercial production in the wake of the sugar marker crush in 1975. Irrigation programs to water sugar plantations were established to increase production volumes. Sugarcane is a tropical crop and needs about 1500 to 2500 mm of water evenly distributed over the growing season[147].

Today, irrigation systems have expanded across the lowveld area of Triangle and Hippo Valley, and cultivation practices have evolved to reduce inputs while maximizing outputs. Harvest volumes are further optimized based on an increase in the quantity and improvement in quality (sucrose content) of sugarcane delivered to the mills through the implementation of advanced agricultural technologies and plant genetics correspondingly, coupled with constant sugar mill efficiencies (sugar recovery rate). The following table illustrates production volumes for the past two years:

Table 21. Sugarcane harvest volumes from 2020 – 2023 harvest seasons

Crop	2022/2023	% growth compared to last season	2021/2022	% growth compared to last season	2020/2021
Carbohydrate (MT)					
Sugarcane	6,537,204	8	6,049,404	n/a	n/a

Source: CLAFA-2 2023

Ethanol production volumes in Zimbabwe for 2022 totaled an estimated 100 million liters a year[148], 40 million liters by Triangle Estates Limited[149], currently adding capacity to double annual production volumes. Additionally, on-going expansion plans at Green Fuel are set to increase the company's ethanol production volumes to 220 million liters per year. In 2022, ZERA announced an increase in the blending volume to a maximum of 20% (E20) yet the available blend ratio to users at petrol stations remains at a maximum of 10% (E10).

Using scenario C illustrated under table 19 above, the following table tests the opportunities for SAF production in Zimbabwe using current annual ethanol production volumes of 100 million liters per year:

[147] IDE-JETRO 2008 RFA
[148] RFA
[149] Matambo 2022

Table 22. SAF Production potential with current annual ethanol production volumes

Plant	total production capacity	SAF production volume at 30%	RD production volume at 70%	Ethanol volumes required	% of current ethanol production
ICAO RoT pioneer	100,000,000	30,000,000	70,000,000	166,666,667	166.67
LanzaJet	40,000,000	12,000,000	28,000,000	66,666,667	66.67
Gevo 1 module	260,000	78,000	182,000	433,333	0.43
Gevo 17 modules	4,420,000	1,326,000	3,094,000	7,366,667	7.37

All volumes in millions of liters per year

Zimbabwe is already producing enough ethanol volumes to satisfy demand needed to run plants of similar size to those of LanzaJet and Gevo. Nevertheless, when ethanol expansion plans already under implementation by Triangle limited and Green Fuel are completed (estimated 3-5 years), total annual ethanol production should amount to 300,000 million liters, more than enough to feed a pioneer plant of 100 million liters of fuel annual production. Additional ATJ technology providers include HoneyWell, Axens, Swidish Biofuels, and Lummus' ethanol to SAF technology; all industrial partners are worth exploring to find the most suitable conversion technology to convert ethanol to SAF in Zimbabwe.

Zimbabwe's technology readiness for extensive sugar cane production is advanced, so is the technology to process sugar cane to ethanol. Conversion technology for SAF production is a new concept in Zimbabwe. According to the Global Innovation Index, Zimbabwe ranks 117th out of 132 ranked nations in 2023[150], foreseeable R&D in advanced conversion technology for SAF production does not seem probable. Nevertheless, Zimbabwe is ranked among the top 10 most technological countries in Africa which gives a good indication of the country's capacity for technology development and ability to provide the technical expertise needed to operate a SAF plant.

When conducting the evaluation at the economic potential level, there is no clear publicly available data on the cost of production nor price, historical or current, for ethanol production in Zimbabwe. Neither ethanol producer nor regulatory bodies and ministries involved in matters related to transport fuels made the pricing data of ethanol available. Though not strong enough to a reach conclusive evaluation of the economic potential of ethanol to be a suitable feedstock for SAF production, some indicators, give precedent that ethanol prices may be lower in Zimbabwe than those from competing markets:

- Zimbabwe is recognized as one of the lowest-cost sugar producers in Southern Africa[151]. Considering that feedstock costs account for about 80 percent of ethanol's cost of production[152], one can assume that Zimbabwe could be also the lowest-cost ethanol producer in the region. Additionally, both Green Fuel and Triangle Estates Limited ethanol operations have a long enough trajectory as sugar cane and ethanol producers to have incorporated efficient production practices, if not state of the art technology production processes both at the feedstock and product level are advanced enough to ensure cost competitiveness.

[150] GHI 2023
[151] IDE-JETRO 2008
[152] USDA 2006

- In 2022, a publication by Zimbabwe's 'The Herlad' newspaper quoted Energy and Power Development Minister Mutsvangwa stating that "the blending of petrol at E10 had resulted in the reduction of petrol price by USD 4 cents per liter," and that the newly announced blending increase at E20 would reduce the price further by USD 7 cents per liter[153].

The sustainable implementation potential of ethanol may present a roadblock even if the economic potential is found to be factually positive. The inception of the Chisumbanje sugar-to-ethanol project resulted in several grievances documented and addressed by the Parliament of Zimbabwe (report S.C. 1, 2015[154]) on environmental pollution and health risks to neighboring communities from "discharging toxic effluent into Jerawachera stream, Musazvi River, and eventually Save River[8]." The report also addresses evidence on the company's non-compliance to the Indigenization policy by qualifying businesses and resettlement of local small-scale farmers.

Sugarcane, specifically sugar, is a food item and its use as feedstock for fuel production will require careful scrutiny of sustainability principles and criteria. 'Principle 14: Food Security' of ICAO Document "CORSIA Sustainability Criteria for CORSIA Eligible Fuels" - Third Edition, November 2022, sets as criterion that "*CORSIA SAF production will, in food insecure regions, strive to enhance the local food security of directly affected stakeholders".* According to the Global Hunger Index, the people of Zimbabwe are at serious risk of hunger[155]. The following illustration explains the criteria to evaluate when a food item is intended for use as feedstock for fuel production:

Figure 36. CORSIA Sustainability Criteria for CORSIA Eligible Fuels: Principle 14 on Food Security

14. Food security	Principle: Production of CORSIA SAF should promote food security in food insecure regions.	Criterion 14.1: CORSIA SAF production will, in food insecure regions, strive to enhance the local food security of directly affected stakeholders.

The fast-changing climate is lowering the levels of food security in Zimbabwe and across the world. The last report of agricultural production volumes cited in section '1.5 Agriculture,' shows some positive indicators where the 8 presidential programs designed to reduce poverty and food insecurity in Zimbabwe are making a difference. Small scale farmers have increased yields and found adequate access to markets to enhance their earnings. The positive balance sheet on cereal production for the 2023 summer season reported in the CLAFA-2 (2023) advised to halt grain importation for the next 12 months. It remains to be seen if such government sponsored agricultural programs can mitigate the negative impacts of a changing climate in Zimbabwe's agricultural sector for the long term to further support a change in Zimbabwe's global hunger index where the population is no longer at risk of food security.

Both, Green Fuel and the Triangle Estates Limited ethanol plants' expansion projects involve the further clearing of virgin land[156] and government investment into dams to enable water access for the production

[153] Zinyuuke 2022
[154] Veritas 2015
[155] GHI 2023
[156] The Herald 2020

food-for-fuel, notwithstanding its commercial use as a food product as well. From a sustainability point of view, it is important to consider the opportunity cost of the use of land and water for fuel production vs food production. For example, the land Green Fuel uses to produces sugar cane was previously dedicated, in 1988, to produce 10% of the country's wheat and 25% of its cotton by ARDA farmers[157].

The opportunity for Zimbabwe to produce SAF from sugar is noteworthy. Established supply chains, mature agricultural and processing technology options, and willing feedstock producers make ATJ an attractive option for SAF production in the short to medium term. More in-depth research is recommended to determine the full potential of ethanol as a suitable feedstock for SAF conversion in Zimbabwe to fully assert its economic and sustainability potential.

ii. Bagasse

Sugar and bagasse may be used for ethanol production through fermentation, and consequently converted into SAF by the ATJ process. Alternatively, bagasse can undergo thermochemical processing, such as gasification, and subsequently be processed via FT. Although fermentation is already a commercial practice worldwide, the use of ATJ and gasification for FT purposes have not been implemented.

"Sugarcane bagasse (SCB) is the main residue of the sugarcane industry, representing almost 30% (by weight) of the sugarcane agricultural product. SCB is commonly burned for energy production and/or used for low-value applications (such as animal feed)[158]." The following table illustrates an estimate on SCB volumes produced in Zimbabwe the past two harvest seasons:

Table 23. Estimated sugar cane bagasse volumes - Zimbabwe

Feedstock	2022/2023	2021/2022
Carbohydrate (MT)		
Sugar cane bagasse	1,961,161	1,814,821

Ethanol producers Green Fuel and Triangle Estates Limited utilize the bagasse resulting from sugar milling operations for energy generation in the form of electricity and heat. Bagasse-based cogeneration offers a reliable and continuous source of power for the ethanol plants minimizing potential losses from load shedding periods in Zimbabwe that can range from 4 to 8 hours a day and that follow an uncertain schedule. Any excess volumes are destined to the animal feed market.

The economic potential of diverting the use of SCB for cogeneration to a dedicated feedstock for ethanol production and consequent SAF conversion should include considerations on the economic impact of access and pricing of electricity from the Zimbabwe's national gird. Cost/kWh and cost of loadshedding will an important factor for decision making, not to forget possible social and environmental negative impacts.

The sustainability potential of SCB as feedstock for conversion into SAF does not have the potential barriers of sugarcane given that SCB is not a food item. Nevertheless, producers should keep in mind that the

157 Green Fuel 2023d

158 Melati et. Al 2017

sustainability certification process will look into the impact SBC to SAF may have on the overall livelihood of Zimbabweans if energy from the national grid is used under the scenario where there is no cogeneration. The installation of a dedicated renewable energy source of electricity (solar, wind) to avoid use of electricity on an national grid already under pressure may greatly help improve the sustainability credentials of SCB.

The opportunity for Zimbabwe to produce SAF from SCB can be significant. Similar to sugar cane, SCB production has established supply chains, mature agricultural and processing technology options, and willing feedstock producers making ATJ an attractive option for SAF production in the medium to long term. More in-depth research is recommended to determine the full potential of SCB as a suitable feedstock for SAF conversion in Zimbabwe to fully assert its economic potential and any environmental and social negative impacts resulting from the extension on land cover for the cultivation of sugar cane needed to produce enough volumes of SCB for the supply of a SAF conversion plant.

iii. Sorghum

In Zimbabwe, sorghum is used primarily for food (64%) or food processing (14%) with 19% for other non-food uses and just 3% for animal feed. It is commonly cultivated as a safeguard to the State's food security when unfavorable climatic conditions result in severe reductions of maize outputs. Low mechanization rates in its production result in less-than-optimal yields. The following table illustrates the fluctuation in production volumes in the past three harvest seasons:

Table 24. Sorghum harvest volumes from 2020 – 2023 harvest seasons

Crop	2022/2023	% growth compared to last season	2021/2022	% growth compared to last season	2020/2021
Oil Seed (MT)					
Sorghum	191,125	32	144,633	-59	244,063

Source: CALAF 2023

Current production volumes of sorghum are too low to supply the needs of a SAF production plant. Nevertheless, sorghum area is estimated to continue to expand as increasing pressure is placed of on farmers and the GOZ to adapt to the agricultural impacts resulting from the fast-changing climate.

The economic potential of sorghum as feedstock for SAF confronts structural and institutional constraints common to most food crops in Zimbabwe. Like maize, soya beans, wheat, and barley, sorghum is on the controlled produce list, which restricts farmers from selling to the grain marketing board (GMB) at government-controlled prices.

From a sustainability point of view, sorghum offers great potential given that nonedible parts like the stalk and bagasse may be used for ethanol production and consequent conversion to SAF via the ATJ process. Yet, and in commonality to other crops, if sorghum is produced as a monocrop, even if it provides food and fuel, the detriment to soil health may challenge its sustainability credentials.

The opportunity for Zimbabwe to use sorghum as feedstock for SAF may be an attractive option. Further evaluation is needed to fully comprehend how to raise uptake by farmers to significantly increase harvest volumes as well as introduce advanced agricultural mechanization in its cultivation, harvesting, and processing to optimize yields and reduce costs of production.

2.3.2. Oil Seeds

Oil seed crops are suitable for SAF production via the HEFA process, currently one of the lowest cost methods, commercially mature, and the most common method globally to produce SAF. The primary cost driver is the price of feedstock as with most SAF conversion processes. They are most suitable feedstocks for SAF production when cultivated in rotation with other crops, therefore avoiding any controversial rise in demand for cropland for fuel production.

The main oil seed crops produced in Zimbabwe include jatropha, soya bean, sunflower, and cotton. Demand for jatropha is tied to the production of biodiesel in compliance with Zimbabwe's Biofuel Policy. Soya bean, sunflower, and cotton oil are commonly used as cooking oil and other industrial needs.

The cultivation of oilseeds is not well-established, with their production, collection, and processing relying on outdated technologies and less efficient production practices. Nevertheless, both soya bean and sunflower are crops listed under the National Enhanced Agriculture Productivity Scheme (NEAPS), funded by AFC and CBZ, through Government performance guarantees. This brings some level of certainty that future productivity levels will increase.

iv. Jatropha

Jatropha was introduced in Zimbabwe around 1940 primarily to produce soap and glycerin. In 2005, the GOZ launched the National Biodiesel Project to help tackle fuel shortages and consequent steep price increases. The programme offered support to small-scale farmers for the cultivation of jatropha primarily on marginal lands with less than 600mm annual rainfall. About 35,000ha of jatropha were under production and plants were set up for oil extraction and biodiesel production to reach a total capacity of 80,000 liters per day of biodiesel.

Mismanagement, the discontinuation of financial support, price controls, inefficient production practices, and lack of policy to support the long-term production of jatropha and biodiesel brought the industry to a halt by 2008.

Lessons learned, the GOZ enacted the National Biofuel Policy in 2009 and today is investing via Finealt Engineering in R&D to optimize feedstock production processes as well as processing technologies to maximize biodiesel output. But uncertainty still remains on several important factors that help define the suitability of jatropha as a promising feedstock for SAF production.

No relevant volumes of jatropha are currently being produced. Research conducted by Finealt indicates that under irrigation and best practices, yields of 8 tons/ha and 30% seed oil content may be achieved. There is no certainty however on the availability of funding sources to ramp up its cultivation. Information is also missing on the economic model that will be implemented for the commercialization of the jatropha seed, previously under price controls and a buyer monopoly. There is no clear estimation on the cost of production per hectare planted, which leaves no room to estimate the cost of production for biodiesel and consequent impact on prices at the pump from blending it with conventional diesel.

From a sustainability point of view, jatropha offers much promise if the right varieties are found or developed to greatly increase yield on marginal lands. Finealt has set up a gene bank at its operation in Mutoko and has successfully identified the most suitable existing varieties to plant in the region. They will follow the same process on additional 7 provinces to ensure enough hectares are under production to satisfy biodiesel blending targets, a 12-year project with an ambition to develop jatropha plantations on 100,000ha according to Finealt's personnel[159]. As with any agricultural feedstock, using fertile lands currently occupied with food crops to optimize seed outputs requires a careful sustainability assessment vis a vis the food security criterion.

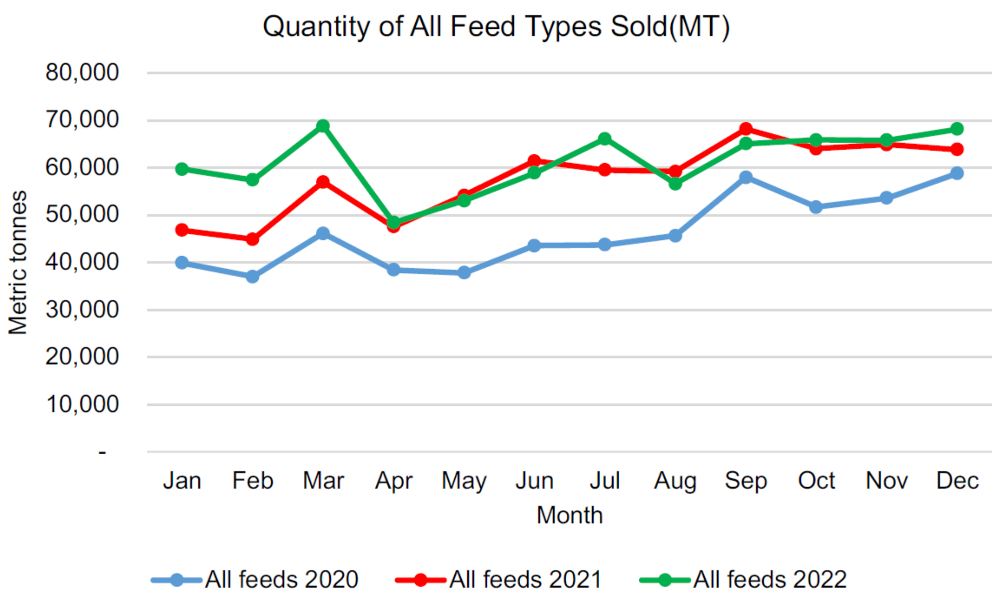
The opportunity to produce SAF from jatropha is an attractive proposition in the medium to long term. The State holds ample expertise in the conversion of jatropha oil to biofuel and has been investing in improving yields, securing feedstock volumes, and upgrading conversion technology. Yet the necessary increase in production volumes for its conversion into any biofuel will take several years of preparation until seed varieties are developed and introduced specific to farming regions and plantations reach optimal maturity levels. It is worth considering also that the diversion of jatropha oil for the production of SAF may be contingent to its liberation from current bioenergy use at biodiesel plants.

v. Soya Bean & Sunflower

Current demand for soya bean and sunflower in Zimbabwe far outstrips supply. This places a proxy lower limit on the availability of vegetable oil production which is unlikely to increase in the near term; a more comprehensive exploration of export markets and alternative local uses for the oil can reverse the situation sooner.

Soya bean protein meal plays an important role in the State's food security efforts. It is one of the richest crops providing high grade crude protein for animal feed. Demand for commercial animal feed has been growing slowly but steadily in Zimbabwe in the past years, illustrated on the following graph:

Graph 4. Commercial animal feed sales trend 2020 – 2022



Source: CLAFA 2023

The following table shows production volumes for the three oils seed crops under production in Zimbabwe for the past three harvest seasons:

[159] In person interview with Mr. Tadious Nyamayevu, head of innovation, research & business development at Finealt engineering

Table 25. - Production estimates for oil seed crops (MT)

Crop / Season	2022/23	2021/22	2020/21
Soya bean	93,086	82,028	71,296
Sunflower	90,479	11,117	14,198
Cotton	152,472	116,521	195,991
Total	336,037	209,666	281,485

Source: CLAFA 2023

vi. Cotton

Cotton is Zimbabwe's second most important cash crop; it provides raw materials for the textile industry, cooking oil, and animal feed. Production practices have evolved through time to increase harvest volumes. The following table shows production volumes for the past two years:

Table 26. Cotton harvest volumes from 2020 – 2023 harvest seasons

Crop	2022/2023	% growth compared to last season	2021/2022	% growth compared to last season	2020/2021
Oil Seed (T)					
Cotton	152,472	31	116,521	-68	195,991

Source: CLAFA 2023

Considered an economic staple, the GOZ has and continues to promote the expansion in production of cotton using incentives. For example, in 2018 cotton growers were paid an export incentive of 10% and $40 cash per each bale sold[160]. In 2023, nearly 350,000 farmers were contracted to grow cotton under the Presidential Inputs Scheme, totaling approximately 255,000ha for production. Additionally, the Climate-proofed Presidential Inputs Scheme (Pfumvudza/Intwasa) is providing small scale farmers with the necessary tools to adapt to climate change by supplying small scale cotton farmers with hybrid seed varieties adapted to lower water intake[161].

Targeted government support, continuous research in production efficiencies and climate change adaptation, and improved costs of production are all positive indicators for the future expansion and optimization of cotton production in Zimbabwe. Nevertheless, when evaluating the crop's suitability for SAF conversion, production volumes of cotton oil are far too low to approximately 1.3%[162] of needed volumes to operate a HEFA pioneer plant. Today, cotton oil may not be the most attractive feedstock for SAF production yet it offers potential for the future, particularly if agricultural best practices are introduced across all oil seed crops.

A wide variety of renewable raw materials available to produce SAF via the same conversion process can also lead to reduced risks of investment given that there are less dangers of crop failure, potential negative environmental and social impacts linked to the use of natural resources and food sources are lessened, the price is not as vulnerable to the volatility in global commodity markets.

160 Karume 2018
161 The 2022
162 Based on seed: oil ratio of 1:0.1

Together, oil seed crops can make for a suitable feedstock for the deployment of SAF in Zimbabwe after significant advances are achieved in the agricultural and processing mechanization and use of inputs, a rise in cultivation uptake by farmers, and an upgrade in all steps of the logistics value chain. A further technoeconomic analysis is recommended to ascertain their full technical, economic, and sustainability potential.

2.3.3. Residues & Wastes

The use of residues and wastes for SAF production comes with its pros and cons, those most relevant to Zimbabwe are illustrated in the following table:

Table 27. Pros and Cons on the use of residues and wastes for SAF production

Pros	Cons
A low-cost by-product	Depending on its condition, pre-treatment costs may outstrip feedstock's cost
Greater GHG emission reductions – transformation of residues/wastes to value added product	Diverting their use to fuel may increase the use of pesticides and fertilizers, and impact soil health
No additional/explicit technology is needed for their production	SAF's FT conversion process is a high-risk investment as none are currently operational at commercial scale (except for tallow/lard) which use HEFA)
By-product - no competition with food nor use of additional natural resources for production	Uncertainty in supply quantity and quality
Reduced risk of fire and soil and water pollution	Added complexity in the removal, collection, and haulage process.
	Low-density feedstock means greater volumes are needed; collection and use are likely to only be economical in high-density farming areas
	Decision making for its production is independent of benefits
	Competing uses: animal feed, fuel, field cover.

Main residues and wastes currently available in Zimbabwe potentially suitable for SAF production include the following:

- Agricultural residues (maize, wheat, cotton)
- Forestry residues
- Woody Biomass
- Municipal Solid Waste (MSW)
- Tallow/Lard

Their production volumes are uncertain, either because there is no regulation to keep track of them, costs do not justify the need, markets for value added products do not exist, deficiencies in supporting infrastructure grants them unfeasible as raw material (haulage), or there is no present research on ways to make viable use of them. For example, according to reports by the Ministry of Lands, Agriculture, Fisheries, Water and Rural

Development, “currently there are insignificantly but unknown quantities lard/tallow being generated/processed from slaughterhouses in the country.”[163]

Despite this uncertainty, there is competing uses for them in various industries. Agricultural residues are used as a “supplement for animal feed by most livestock farmers in the country (at least 80% are communal with each livestock household owning 4-6 animals)[164].” Forestry residues are currently used for furniture, fuel, and roofing[165]. Tallow and lard are used to manufacture candles, soap, skin care, and hair care products, as well as for edible preparations of animal or vegetable fats or oils[166].

MSW is not currently being used for any commercial purpose but in 2022, the city of Harare ran a tender for the transformation of the Pomona waste management facility to an energy plant. German investor Geogenix BV began negotiations with the city of Harare to invest €304 million in a massive waste-to-energy project at Pomona dumpsite expected to generate up to 22MW of electricity[167]. The deal did not close but following the initiative, Mr. Nkanyiso Ndlovu, responsible for waste management for the City of Bulawayo, is today developing a waste to energy roadmap for all MSW collected in the city, an estimated investment between USD 60-80 million, in the form of a triple PPP - private build, operate, and transfer after 30 years to public hands partnership.

The opportunity for Zimbabwe to produce SAF from residues is not currently very positive, much work needs to be done to economically collect, aggregate and upgrade them. A more in-depth techno-economic analysis is required to identify areas with high-density residues coupled with efficient supply chain and advanced technology evaluation.

2.3.4. Other – CO_2

R&D is currently being conducted to evaluate the potential of drop-in Electro-Sustainable Aviation Fuel or e-SAF. The production process for e-SAF can reduce the carbon footprint of both the aviation industry and heavy industrial emitters by more than 90%. E-SAF is produced using recycled CO_2, water, and clean energy, that is compatible with existing aviation infrastructure. They “are often considered a sustainable option in the long term, due to their low lifecycle emissions and other environmental impacts[168].”

According to SAF+, a Canadian consortium of experts in advanced technologies for the production of clean energy for aviation, the first commercial-scale facility, to be built and commissioned in Montreal by 2028, will have the capacity to recycle 270,000 metric tons of waste industrial CO_2. Over the next 30 years, approximately 2,000 to 3,000 plants will be needed to supply airlines around the world with e-SAF[169].

The ethanol industry is today venting waste CO_2 resulting from production processes. Volumes are negligible for the needs of a SAF production plant today. Furthermore, e-SAF still represent “a niche fuel type and major challenges need to be overcome in order to ensure their large-scale development and deployment[170].” For

[163] Data provided by Mr. Taderera, Livestock Specialist, Ministry of Lands, Agriculture, Fisheries, Water and Rural Development
[164] Data provided by Mr. Taderera, Livestock Specialist, Ministry of Lands, Agriculture, Fisheries, Water and Rural Development
[165] Data provided by Mr.
[166] Data provided by Ms. Esther Mashayamombe, Principal Crop Production Specialist, Ministry of Lands, Agriculture, Fisheries, Water and Rural Development
[167] Zhakata 2022
[168] ICAO Synthetic Fuels for Aviation
[169] SAF+ 2023
[170] ICAO Synthetic Fuels for Aviation

Zimbabwe, these challenges not only include available volumes of CO_2 but a significant scale-up in the production of renewable energy, cost competitiveness, and infrastructure widespread support.

Future scenarios where waste CO_2 volumes increase aligned with Zimbabwe's industrial capacity and smaller scale SAF plants reach commercial maturity, waste CO_2 may become a feasible and preferred feedstock to scale up SAF production in Zimbabwe.

SECTION 3. IMPLEMENTATION SUPPORT AND FINANCING

3.1. IMPLEMENTATION SUPPORT

SAF are currently more expensive than conventional fuels. Price disparity needs to be addressed to build a strong, vibrant, and competitive market. Governments play a significant role in developing supporting mechanisms commonly needed to support a nascent industry[171].

In commonality to most projects, investors decide their participation based on the level of certainty that they will earn an adequate return on investment. Governments can encourage their participation via public funding on strategic points of the value chain to help lower the risk of investment.

For Zimbabwe, the GOZ can make much strides in attracting investors for the deployment of SAF by implementing support measures at an ecosystem level along the entire aviation value chain. This includes the following:

1. Develop new management structures and building capacity in existing public institutions around low carbon technologies to facilitate their development and operation;
2. Fund high risk resource exploration and other high-risk pre-financing expenses;
3. Subsidize the higher cost of borrowing[172]; and
4. Develop regulatory incentives that drive demand for low carbon fuels and reduce their relative costs

1. Management structures and capacity building:

Supporting mechanisms to finance the construction of conversion plants is crucial for the deployment of SAF, but so is the support needed to develop the entire value chain. For Zimbabwe, this means every single institution and agency that today ensures the management, safety, and quality of CAF's handling.

As described on section 1, task 1.8 Aviation Value Chain, ZERA is the national agency in Zimbabwe tasked with the regulation of petroleum derived products. Its mandate includes the following responsibilities:

- Increase Access and Security of Supply
- Regulation and Licensing
- Energy Efficiency and the Environmental Protection
- Market Reform and Competition
- Research and Development
- Key stakeholder Advisory
- Infrastructural audits

[171] ICAO 2018
[172] ICAO 2017

- Fuel quality monitoring
- Price surveillance
- Licensing audits
- Training and demonstrations on safe use of products among operators and consumers
- Setting standards and continuous improvements
- Investment promotion

To incorporate SAF into its mandate, ZERA needs government support to amend existing policy as well as designated public funds to invest in capacity building on renewable and sustainable low carbon fuels. Just as ZERA today is able to conduct all tasks listed above for conventional fossil fuels for transport, it needs to prepare to handle SAF and co-products in the same manner.

Similarly, academic public institutions will require funding to develop curricula and capacity to train the future workforce to lead the SAF industry. It is in the hands of the GOZ to define the quantity and quality of benefits that Zimbabweans can gain from the establishment of this new industry. Greater investment in capacity building will result in greater benefits, where the population will be capable to take leading roles and guide the successful growth of the industry vs relying on foreign experts.

It is also essential for the GOZ to support the development of adequate awareness campaigns to promote public uptake of SAF. Several airlines offer programs that allow tourists, business travelers, and air cargo clients to sustain the added cost of using SAF as a measure to reduce individual carbon footprints and corporate scope 3 emissions. The participation of the GOZ in educating the population about the benefits resulting from the use of SAF is crucial.

The readiness level of the entire ecosystem that makes for a successful SAF industry is crucial for the efficient deployment of SAF and attract investment.

2. Fund high risk resource exploration and other high-risk pre-financing expenses;

The GOZ is already ahead on its commitment to support high-risk projects to secure feedstock volumes that will inherently foster the deployment of SAF. The eight presidential programs under implementation set to accelerate rural industrialization and development are achieving its objectives. Crop yields have improved to the point that the 2022/2023 summer harvest has provided enough grains for the State to be self-sufficient. The GOZ is extending support to continue the development and testing of strategies to drought proof agriculture including:

- Irrigation rehabilitation and expansion;
- Promotion and adoption of research that improves productivity of seed and animal varieties;
- Upscaling of climate smart agriculture practices such as Pfumvudza/Intwasa; and
- Capacity building for extension services;

As described throughout section 2, the GOZ is also actively supporting the optimization of sugar cane and jatropha cultivation as well as ethanol and biodiesel producers. The key to this support is continuance; investors need reassurance that commitments are maintained over time and that any changes in government support will be protected, for example, by penalties for non-compliance.

3. Subsidize the higher cost of borrowing;

Public financing policy is particularly critical in lower income States like Zimbabwe where risks to private sector investment are higher than in higher income countries. Risks include government instability, regulatory uncertainty, lack of local knowledge, lack of a technology and financial track record, and higher transaction costs. Finance policies that reduce risk, decrease costs of borrowing, and create market demand will lead to improved conditions that will attract private development[173].

The Zimbabwe Investment and Development Agency (ZIDA) is a good start. The promulgation of the ZIDA Act provides a clear, comprehensive, and binding legal and regulatory framework for conducting investment activities in Zimbabwe, by both domestic and foreign investors. While the agency does not directly subsidize the cost of borrowing, it has successfully integrated and abridged investment procedures thereby reducing the turnaround time for the deployment of projects in the country[174].

An important measure the GOZ may take to decrease the cost of borrowing for stakeholders interested in investing in the SAF industry is to lower interest on borrowings and finance charges from RBZ, as well as on exchange differences on foreign currency borrowings where they are regarded as an adjustment to interest costs.

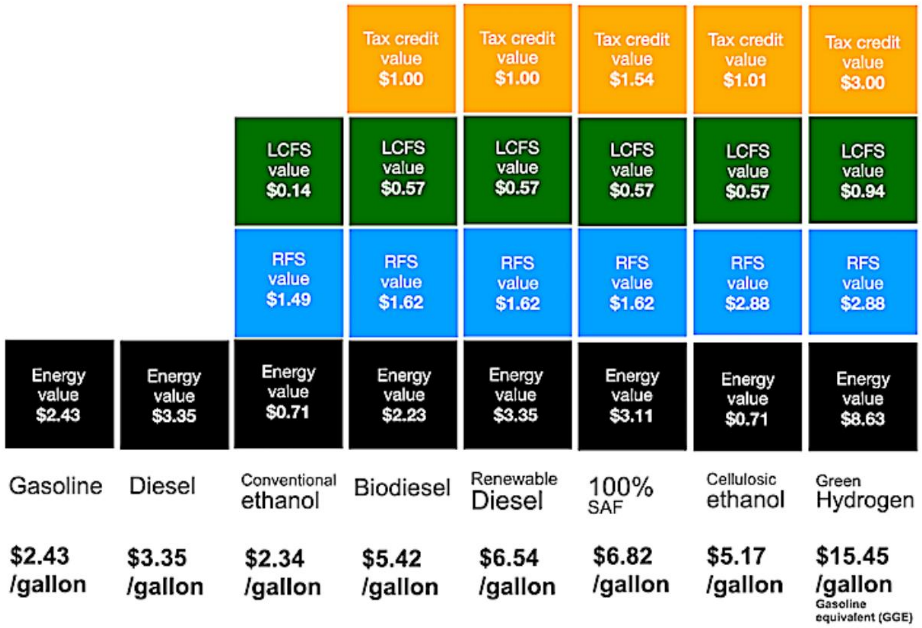
4. Develop regulatory incentives that drive demand for low carbon fuels and reduce their relative costs

A regulatory incentive worth exploring by the GOZ that may help drive demand for SAF pricing. As previously mentioned, ZERA has the ability to influence the price of fuel. It is important that the GOZ provides investors with full transparency on how ZERA will handle the pricing of SAF and co-products. While price controls may act as a barrier to investment, the GOZ may revert this limitation by offering a long-term pricing structure for SAF and co-products that includes a reduction or even an elimination of all taxes, levies, and administrative costs currently applied to conventional fossil fuels for transport. There is no publicly available fuel pricing structure for CAF but using 2019's road transport fuel pricing structure as an example (Section 1), if ZERA were to eliminate all taxes, levies, and administrative costs for handling diesel 50 as an incentive to help close the price gap with renewable drop-in diesel, the result would be an estimated price support of $1.04. This is similar to the tax USD 1 tax credit the US government currently offers to renewable diesel producers.

Following is the pricing support structure the US government currently offers to various low carbon fuel producers:

[173] ICAO 2017
[174] ZIDA 2020

Figure 37. Daily values of US low carbon fuels with Government tax credits and incentives



Source: TheDigest October 15, 2023

While the GOZ's support to fill the gap difference between conventional and low carbon transport fuels may not be enough for price parity, it seems evident that eliminating taxes, levies, and administrative costs can go a long way in lowering the risk on investment for the deployment of SAF.

An immediate and powerful existing incentive the GOZ can launch to promote investment in SAF is the 'Special Economic Zones (SEZ)'. Designating SAF projects as qualified for construction on SEZ across the State will offer the following benefits to investors:

1. Zero-rated Corporate Income Tax for the first 5 years of operation.
2. Special Initial allowance of 50% of cost from year one and 25% in the subsequent two years
3. Specialized expatriate staff will be taxed at a flat rate of 15%.
4. Exemption from Non-residents withholding tax on fees on services that are not locally available
5. Exemption from Non-residents withholding tax on Royalties.
6. Exemption from Non-residents withholding tax on Dividends
7. 100% rebate on customs duty for all imported equipment, machinery and raw materials[175]

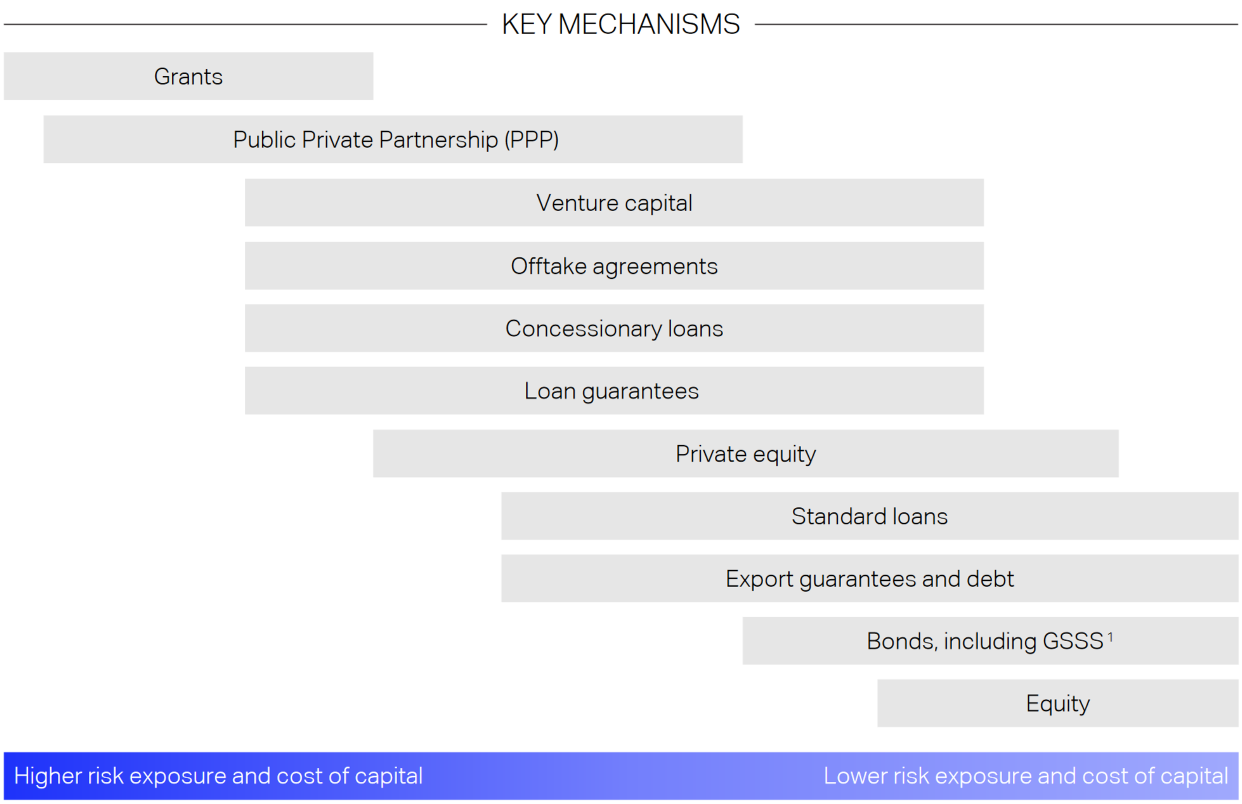
Today there is no SEZ classification specific to SAF and though it may qualify under other specifications (manufacturing, heavy and light industries), it is important for the GOZ to assign SAF projects their own classification to add transparency for investors.

[175] ZIDA 2023

3.2. FINANCING

Investment required to enable a net zero transition of aviation to 2050 has been estimated to USD 3.2 trillion[176]. The following picture illustrates different financing measures identified as suitable to finance the SAF industry:

Figure 38. Financing mechanism suitable to support the deployment of the SAF industry



Source: ICAO 2023

A few years ago, ICAO published an economic analysis with several examples to "demonstrate the sensitivity of a hypothetical SAF project to small changes in the input assumptions. Further, they highlight how policy can be effectively applied to influence a projects financial viability[177]." While most CAPEX and OPEX and all other numbers herein need updating to 2023 values, the analysis provides a simple and clear illustration on the critical factors needed to successfully finance a SAF project. Following are example 1 through 5:

Example 1 is a base case scenario. This is an example where purchasing land, equipment, and constructing a SAF refining plant costs $260 million. Both operating costs and revenues ramp up, then remain consistent from year 3. In a real-world scenario these are not likely to be linear but this does not impact the example. A discount rate of 9% is used. This is the rate that must be achieved to deliver a NPV of $0. This example delivers a forecast NPV of -$83.28 million or an internal rate of return on the funds employed of 3.82%. This does not meet the hurdle rate (of 9%) hence a rational firm would not undertake this project.

[176] ICAO Environment - LTAG Report
[177] ICAO Environment 2023

EXAMPLE: 1	Simplified cost-benefit example - base case project CBA										
Project analysis (Million USD)											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Capital costs											
Project construction	-250										187.5
Improvements						-25					17.5
Equiptment	-10					-10					5
Total	-260	0	0	0	0	-35	0	0	0	0	210
Operating costs											
Aggregate annual costs		-5	-15	-20	-20	-20	-20	-20	-20	-20	-20
Revenues											
Annual aggragate revenues		15	25	40	40	40	40	40	40	40	40
Net Cash Flow	-260	10	10	20	20	-15	20	20	20	20	230
Discount rate	9%										
NPV	**-$83.28**										
IRR	**3.82%**										

Example 2 replicates example 1, except in this case a project grant of $100 million is received. This could be a government grant. A grant is often contingent on satisfying certain criteria, however in this case it is assume this criterion is met and the funds are received without attached conditions.

While the aggregate of the grant is only 2.5 years of projected revenue, it represents 40% of the total assumed construction cost. The advantage of receiving these funds at project inception is significant, particularly with high discount rates.

This change to the project delivers a $16.72 million positive NPV at an IRR of 10.43%. A rational firm would undertake this project.

EXAMPLE: 2	Simplified cost-benefit example - project grant										
Project analysis (Million USD)											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Capital costs											
Project construction	-250										187.5
Project grant	100										0
Improvements						-25					17.5
Equiptment	-10					-10					5
Total	-160	0	0	0	0	-35	0	0	0	0	210
Operating costs											
Aggregate annual costs		-5	-15	-20	-20	-20	-20	-20	-20	-20	-20
Revenues											
Annual aggragate revenues		15	25	40	40	40	40	40	40	40	40
Net Cash Flow	-160	10	10	20	20	-15	20	20	20	20	230
Discount rate	9%										
NPV	**$16.72**										
IRR	**10.43%**										

Example 3 replicates example 1 except in this case the firm acquires an interest free loan for 10 years of $100 million. This could be provided from a government program and when the project is more mature this debt could easily be refinanced and repaid. Further, conceptually the idea of an interest-free loan could be substituted with non-dilutive equity.

While the project NPV remains negative at -$25.52 million it is substantially improved on example 1. Further, the IRR of 6.37% may be feasible for some investors.

EXAMPLE: 3	Simplified cost-benefit example - interest free loan										
Project analysis (Million USD)											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Capital costs											
Project construction	-250										187.5
Interest free loan	100										-100
Improvements						-25					17.5
Equiptment	-10					-10					5
Total	-160	0	0	0	0	-35	0	0	0	0	110
Operating costs											
Aggregate annual costs		-5	-15	-20	-20	-20	-20	-20	-20	-20	-20
Revenues											
Annual aggragate revenues		15	25	40	40	40	40	40	40	40	40
Net Cash Flow	-160	10	10	20	20	-15	20	20	20	20	130
Discount rate	9%										
NPV	**-$25.52**										
IRR	**6.37%**										

Example 4 replicates example 1 however in this case the SAF supplier receives a subsidy. While in this case the subsidy is not sufficient to generate a positive project NPV it demonstrates that the annual subsidy improves the forecast IRR from 3.82% in example 1 to 5.23% in example 4.

EXAMPLE: 4	Simplified cost-benefit example - revenue subsidy										
Project analysis (Million USD)											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Capital costs											
Project construction	-250										187.5
Improvements						-25					17.5
Equiptment	-10					-10					5
Total	-260	0	0	0	0	-35	0	0	0	0	210
Operating costs											
Aggregate annual costs		-5	-15	-20	-20	-20	-20	-20	-20	-20	-20
Revenues											
Subsidy		1.5	2.5	4	4	4	4	4	4	4	4
Annual aggragate revenues		15	25	40	40	40	40	40	40	40	40
Net Cash Flow	-260	11.5	12.5	24	24	-11	24	24	24	24	234
Discount rate	9%										
NPV	**-$61.16**										
IRR	**5.23%**										

Example 5 incorporates some of the policy features of the other examples. It includes a revenue subsidy of 10% of revenues, a project grant of $50 million and an interest free loan of $100 million repayable in 10 years.

This example clearly demonstrates how combining some policy mechanisms can make an otherwise unattractive project successful. Example 5 generates a forecast NPV of $46.59 million at an IRR of 15.1%. Even at a discount rate of 9% this project is comfortably acceptable. This shows how when connected stakeholders such as the project owner and operator, the government, product demand e.g. an airline and debt financiers work collaboratively, policy mechanisms can combine to build a strong business case.

EXAMPLE: 5	*Simplified cost-benefit example - project grant*										
Project analysis (Million USD)											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Capital costs											
Project construction	-250										187.5
Project grant	50										0
Interest free loan	100										-100
Improvements						-25					17.5
Equiptment	-10					-10					5
Total	-110	0	0	0	0	-35	0	0	0	0	110
Operating costs											
Aggregate annual costs		-5	-15	-20	-20	-20	-20	-20	-20	-20	-20
Revenues											
Subsidy		1.5	2.5	4	4	4	4	4	4	4	4
Annual aggragate revenues		15	25	40	40	40	40	40	40	40	40
Net Cash Flow	-110	11.5	12.5	24	24	-11	24	24	24	24	134
Discount rate	9%										
NPV	**$46.59**										
IRR	**15%**										

It is, and should be assumed that subsidies either reduce or 'fade out' over time. If this is articulated by policy makers it does not need to impact project feasibility. It is assumed that both the technology learning curve and project economies of scale will reduce the unit cost of production over time, thus reducing the reliance on subsidies. Interest free loans or project grants simply tackle the high discount rate conundrum at the start of a capital intense project in an embryonic industry[178].

The examples above clearly illustrate that financing is a critical success factor for the deployment and growth of the SAF industry.

Another financing option that may be of particular interest for the GOZ to explore is offering loan guarantees to support investment on SAF. LanzaTech Inc, a prominent ATJ technology provider in partnership with its partner LanzaJet, applied to receive public funds to build an ATJ plant with capacity to produce approximately 38 million liters of hydrocarbon fuels annually from ethanol at its Freedom Pines Biorefinery site in Soperton, Georgia, USA. Having only proven the economic, environmental, and social viability of LanzaTech's ATJ conversion process at the pilot level the jump to scale up to commercial production remained a risky investment; a loan guarantee from the US government helped to decrease the level of risk giving LanzaTech a lever to lure additional investors. The Freedom Pines Biorefinery is under construction and scheduled to begin operations in 2028. The application may serve as a guidance document for the GOZ and provide crucial aspects to consider when defining the structure of the financing support to offer to investors.

Estimated benefits of the LanzaTech project amount to the following figures[179]:

- 100 direct and 30 indirect jobs during construction
- 15 direct and 24 indirect jobs during ongoing operations
- USD 5 million total annual increase in local economic activity
- Every USD 1 million in spending on ethanol generates 5.9 jobs in the ethanol industry and 1.6 rural jobs from feedstock sourcing.

LanzaTech's estimated project benefits do not replicate directly to benefits that may be generated by a SAF project in Zimbabwe, but it is worth noting and using them to balance the risks the GOZ will be assuming by providing a loan guarantee to developers against potential benefits the project may bring to Zimbabweans.

[178] ICAO Environment 2023
[179] LanzaJet 2022

Additionally, the GOZ can evaluate the use of global public financing programs to support the deployment of SAF. ICAO Financing Aviation Emissions Reductions guide (annex 1) provides a directory of public financing programmes for mitigating international aviation emissions. The directory lists several public financing programmes that are available "to assist Member States in funding their international aviation emission reduction projects.[180]" While it is not a comprehensive list of funding opportunities, the GOZ and stakeholders along the value chain in Zimbabwe may be able to find the support they need to build capacity and leverage project financing to realize the deployment of SAF sooner.

As described, there are several supporting mechanisms and financing instruments available to decrease risk of investment in SAF and promote project implementation. A more detailed evaluation is recommended to determine those instruments best suited for Zimbabwe. There are already several supporting mechanisms in place for other related industries that if adapted and the scope extended, can already support the deployment of SAF. However, it is clear that as a nascent industry, without the support of the government, the deployment of SAF in Zimbabwe will be very challenging.

[180] ICAO 2018

SECTION 4. ACTION PLAN

4.1. KEY FINDINGS

The following key findings are based on the analysis from the previous chapters enabled by the participation and data provided by stakeholders as well as research from literary sources and secondary data collected. These key findings provide vision on the opportunities Zimbabwe holds and the challenges needed to overcome to enable the development and deployment of SAF.

Feedstock

- **A wide variety of feedstocks are available** for SAF production that align with approved SAF pathways. Presently, none provide sufficient volumes for conversion to SAF at commercial scale.
- Contingent to expansion plans now under implementation by Green Fuel and Triangle Limited, **ethanol produced from sugar is the most viable feedstock in the short term** to provide enough volumes to satisfy the demand for the production of SAF and co-products.
- If given the right and uninterrupted support, **oil seed crops jatropha, sunflower, and cotton** are well suited to become a viable and preferred feedstock for the production of SAF and RD in the medium to long-term. This is based on the fact that the corresponding conversion process HEFA is currently the least expensive and more widely used conversion process by commercial SAF producers.
- The introduction of **mechanization in agricultural processes and oil extraction** can help increase the needed volumes of oil seed crops to satisfy demand for SAF production faster.
- Low production volumes, the high complexity of the logistics supply chain, and competing markets for their use make **residues and wastes unsuitable feedstocks for the production of SAF in the short and medium term.** If action is taken to improve their suitability, they should be reconsidered in future evaluations given their greater GHG emission reduction potential and the economic benefits resulting from the production of a value-added product.
- **Further technoeconomic studies** are recommended to determine the economic and sustainability potential of ethanol and vegetable oils as qualifying feedstock for SAF production.
- **Much investment is needed** to improve and extend road, water, and power infrastructure to improve feedstock production, processing, and logistics costs against competing markets.

Technology

- There is an important **need to upgrade and/or introduce technology** into agricultural and industrial processes across the nation.
- Processing technology operating in existing biofuel plants cannot be retrofitted to produce drop-in renewable and sustainable transport fuels.
- **Overall knowledge** on drop-in transport fuels as well as conversion technology is recommended to complement existing expertise on biofuel handling and production
- Output volumes from current SAF commercial plants may produce some surplus of SAF volumes compared to local demand. The deployment of a SAF project will create **opportunities for an export market**. A focus on maximizing the output of RD can absorb SAF surplus volumes and contribute towards attaining the objectives set under Zimbabwe's Biofuel Policy and Vision 2023 strategies.

- To fully understand the ideal scale of the industry, **additional research is recommended** to identify potential export markets for SAF and RD.

Policy, implementation support, and financing

- **Existing policy that supports the deployment of transport biofuels needs to be adapted** to ensure similar support is offered to SAF and RD.
- Existing initiatives to promote industrialization and aimed at lowering the risk of investment (SEZ, ZIDA) can also act as incentives to support the deployment of SAF.
- The successful deployment and future growth of SAF and RD production is dependent on **implementation mechanisms and financing support** from the GOZ and foreign financial institutions.
- **Price controls on transport fuels may act as a disincentive to investment**. The opportunity exists though for the GOZ to utilize this challenge to create an incentive for investment in the deployment of drop-in renewable and sustainable transport fuels. Removing/reducing taxes, levies, and administrative costs for SAF and RD existent in the current pricing structure for transport fuels can help close the gap between the price disparity of conventional and drop-in renewable and sustainable transport fuels.
- The readiness level of all actors along the aviation value chain can help reduce risks and attract investors. This requires **investment in knowledge development and capacity for all stakeholders along the aviation value chain**, including academic institutions and regulatory government agencies like ZERA.

4.2. ACTION PLAN

Based on the results obtained from the feasibility study summarized above, the recommended roadmap for the development and deployment of SAF in Zimbabwe is as follows:

A- Short term 2023 – 2025	
National Structuring and Enabling Policy	**Stakeholders Involved Leaders - Participants**
1. Identify stakeholders: set up specific committees, work-groups, outline authorities, assign roles and responsibilities, and define accountability.	MEWC / MTID – ACZ, CAAZ, CUT, EMA, HAFS, MEPD, MIC, MLAFWRD, NHS, NOIC, RBZ, UZ, ZERA, HRE, BUQ, VFA, BFO, KAB, MVZ, HWN, NOIC, ZERA, Puma Aviation, Air Zimbabwe, Fastjet Zimbabwe, Airlink, Air Tanzania, Emirates, RwandAir, Kenya Airways, Ethiopian Airlines, Qatar Airways, South African Airways, Zimbabwe Farmers' Union, Green Fuel, Triangle Limited, Finealt Engineering, road transport fuel distributors and re-sellers.
2. Revisit existing policy and adapt or draft dedicated policy to support the development and deployment with a first focus on RD and long-term aspiration for the use of increasing volumes of SAF	MEWC / MTID - ACZ, AMA, ARDA, CAAZ, EMA, IDBZ, HAFS, MEPD, MIC, MLAFWRD, NHS, RBZ, HRE, BUQ, VFA, BFO, KAB, MVZ, HWN, NOIC, ZERA, Puma Aviation, Air Zimbabwe, Fastjet Zimbabwe, Airlink, Air Tanzania, Emirates, RwandAir, Kenya Airways, Ethiopian Airlines, Qatar Airways, South African Airways, Zimbabwe Farmers' Union, Green Fuel, Triangle Limited, Finealt Engineering, national road transport fuel distributors and re-sellers.
3. Develop and implement a monitoring framework and tool to track progress, and identify and correct instances when the project veers out of the proposed course of action.	MEWC / MTID – UZ, CUT, ZERA, CAAZ
Infrastructure, Technology, Skills, and a Business Plan	**Stakeholders Involved Leaders - Participants**
1. Identify development organization already operating in the country to research identified needs in infrastructure, technology, and skill sets and set up an implementation road map.	MEWC / MTID – UZ, CUT, MEPD, MIC, MLAFWRD
2. Develop a comprehensive business plan for deployment of RD and SAF to attract potential investors, unlock public funds – PPP, and apply for regional and global funding sources.	MTID/ MFIP/ MIC - UZ, CUT, MEWC, RBZ, IDBZ, CAAZ
3. Re-evaluate plans to upgrade the Feruka-Harare oil pipeline	NOIC/ MEPD
Markets	**Stakeholders Involved Leaders - Participants**
1. Evaluate the size and complexity (uptake) of the internal market for RD and SAF as well as potential regional and global export markets.	NOIC/ MEPD – CAAZ, HAFS, Puma Aviation, Air Zimbabwe, Fastjet Zimbabwe, Airlink, Air Tanzania, Emirates, RwandAir, Kenya Airways, Ethiopian Airlines, Qatar Airways, South African Airways

Feedstock	Stakeholders Involved Leaders - Participants
1. Support the expansion of sugar cane production for conversion into ethanol including a focus on sustainable use of natural resources, food security, and job creation.	MEWC / MLAFWRD / MFIP - AMA, ARDA, CUT, EMA, RBZ, IDBZ, UZ, Farmers' Union, Green Fuel, Triangle Limited
2. Mobilize funding to conclude existing research on the improvement and expansion of jatropha production across provinces.	MEWC / MLAFWRD / MFIP - AMA, ARDA, RBZ, IDBZ, Finealt Engineering, identified development organizations operating in ZW
3. Continue and improve existing programs on food security and implementation of climate resilient agricultural practices.	MEWC / MLAFWRD / MFIP - AMA, ARDA, CUT, EMA, RBZ, UZ, Farmers' Union, Green Fuel, Triangle Limited, Finealt Engineering, identified development organizations operating in ZW
Funding	**Stakeholders Involved Leaders - Participants**
1. Consider extrapolating and adapting financing practices used in Zimbabwe's most profitable industries (tobacco, mining) for deployment of SAF and RD including feedstock production and processing, technology transfer, import/export tariffs, etc.	IDBZ / RBZ - MFIP
2. Fund the development of curricula and capacity on academic careers apt to equip future generations with the skills needed to deploy and successfully grow the production of advanced renewable and sustainable transport fuels	MHTEISTD – MEWC, MTID
3. Apply for funding from development institutions: AFDB, UN Development Agencies, etc.	MEWC / MTID – RBZ, IDBZ, MFIP, CAAZ
4. Adapt existing policy and incentives promoting industrial development to include the SAF industry (ZIDA, SEZ)	MEWC / MTID – NOIC, MIC
5. Develop and publish a Request for Proposal (RFP) for an ATJ conversion plant	MEWC / MTID – NOIC, MIC

B – Mid Term 2026 - 2035

National Structuring and Enabling Policy	Stakeholders Involved Leader - Participants
1. Monitor for the suitable functioning of the national organizational structuring. Act where disfunction is identified and incorporate mitigation measures to avoid re-occurrence.	MEWC / MTID – UZ, CUT, ZERA
2. Enact dedicated policy to support the development and deployment of RD and SAF	MEWC / MTID - MEPD, MIC, MFIP, MLAFWRD, NOIC, CAAZ
Infrastructure, Technology, Skills	**Stakeholders Involved Leader - Participants**
1. Promote technology transfer and establish PPP for the implementation of infrastructure development	MEWC / MTID / MFIP – NOIC, MIC
2. Conduct a CBA for a planned transition of existing biodiesel plants to HEFA processing technology to production of drop-in renewable fuels for road and air transport.	MEWC / MTID – UZ, CUT, ZERA, MFIP, NOIC
3. Secure funding and launch the upgrade of the Feruka-Harare oil pipeline contingent to a positive outcome on the evaluation of available export markets for SAF and RD	NOIC/ MEPD - IDBZ, RBZ, MFIP
Markets	**Stakeholders Involved Leader - Participants**
1. Conduct/fund a study to forecast growth in aviation activity in southern African nations to understand potential of future demand for SAF at the regional level.	CAAZ – MEWC, MTID, HAFS, Puma Aviation, Air Zimbabwe, Fastjet Zimbabwe, Airlink, Air Tanzania, Emirates, RwandAir, Kenya Airways, Ethiopian Airlines, Qatar Airways, South African Airways
2. Establish export markets for RD and SAF with neighboring nations.	MFIP / MIC – MTID, MEPD, NOIC, HAFS, Puma Aviation, national and regional road transport fuel distributors and re-sellers.
Feedstock	**Stakeholders Involved Leader - Participants**
1. Support the expansion of use of sugar cane bagasse for ethanol production	MEWC / MLAFWRD / MIC - AMA, ARDA, CUT, EMA, RBZ, IDBZ, UZ, Farmers' Union, Green Fuel, Triangle Limited
2. Mobilize funding to implement research results on best practices for jatropha production extending across provinces	MEWC / MLAFWRD / MIC - AMA, ARDA, RBZ, IDBZ, Finealt Engineering, identified development organizations operating in ZW
3. Revise and improve existing programs on food security and implementation of climate resilient agricultural practices.	MEWC / MLAFWRD / MIC - AMA, ARDA, CUT, EMA, RBZ, UZ, Farmers' Union, Green Fuel, Triangle Limited, Finealt Engineering, identified development organizations operating in ZW
Funding	**Stakeholders Involved Leader - Participants**
1. Secure funding for the 1st stage of road infrastructure development and improvement to facilitate feedstock transport and logistics	MTID / MFIP – RBZ, IDBZ, MLAFWRD
2. Secure funding to support skills development specific to the SAF industry	MEWC / MTID – ZERA, UT, CUT

3. Consider setting up a market-based mechanism to value emission reductions from road transport	MEWC / MTID – UT, CUT, road transport fuel distributors and re-sellers.
4. Finalize RFP for an ATJ conversion plant	MEWC / MTID – NOIC, MIC
Deployment	**Stakeholders Involved Leader - Participants**
1. Launch construction of first ATJ plant	MEWC / MTID – MFIP, HAFS, Puma Aviation

C – Long Term 2036 - 2063

National Structuring and Enabling Policy	Stakeholders Involved Leader - Participants
1. Monitor for the suitable functioning of the national organizational structuring. Act where disfunction is identified and incorporate mitigation measures to avoid re-occurrence.	MEWC / MTID – UZ, CUT, ZERA
2. Revise and restructure if needed dedicated policy for the development and deployment of RD and SAF to ensure support	MEWC / MTID - MEPD, MIC, MFIP, MLAFWRD, NOIC, CAAZ
Markets	**Stakeholders Involved Leader - Participants**
1. In alignment to forecasted growth of aviation activity in southern African nations, develop in collaboration with neighbor countries an interregional plan to expand SAF production.	MIC/ MFIP – CAAZ, MTID, MEPD, NOIC, HAFS, Puma Aviation
2. Establish global export markets for SAF and RD.	MFIP / MIC – MTID, MEPD, NOIC
Feedstock	**Stakeholders Involved Leader - Participants**
1. Support R&D on additional feedstocks, including those for conversion into e-fuels, for processing and conversion into sustainable drop-in fuels for road and air transport.	MEWC / MLAFWRD / MIC - AMA, ARDA, RBZ, IDBZ, identified development organizations operating in ZW, Green Fuel, Triangle Limited
2. Support the expansion of jatropha production across provinces	MEWC / MLAFWRD / MIC - AMA, ARDA, RBZ, IDBZ, Finealt Engineering, identified development organizations operating in ZW
3. Revise and improve where needed on existing programs on food security and implementation of climate resilient agricultural practices.	MEWC / MLAFWRD / MIC - AMA, ARDA, CUT, EMA, RBZ, UZ, Farmers' Union, Green Fuel, Triangle Limited, Finealt Engineering, identified development organizations operating in ZW
Funding	**Stakeholders Involved Leader - Participants**
1. Support the fitting of existing biodiesel plants with HEFA/CHJ processing technology for production of drop-in sustainable fuels for road and air transport in all provinces producing sufficient volumes of oilseeds.	MEWC / MLAFWRD / MIC - AMA, ARDA, RBZ, IDBZ, Finealt Engineering, identified development organizations operating in ZW, HAFS, Puma Aviation, road transport fuel distributors and re-sellers.
2. Fund programs for skills development specific to the industry of sustainable drop-in fuels for transport	MEWC / MTID – ZERA, UT, CUT
3. Expand the reach of a market-based mechanism to value emission reductions specific to air transport	MEWC / MTID – UT, CUT, HAFS, Puma Aviation

4. Develop and publish RFP for additional processing plants for production of advanced sustainable drop-in fuels for road and air transport congruent with current volumes of feedstocks	MEWC / MTID – NOIC, MIC
Deployment	**Stakeholders Involved Leader - Participants**
1. Launch construction of HEFA/CHJ plant for conversion of jatropha oil to advanced sustainable drop-in fuels for road and air transport	MEWC / MTID – MFIP, HAFS, Puma Aviation, road transport fuel distributors and re-sellers.
2. Evaluate and expand feedstock production and processing plants as well as ATJ and HEFA/CHJ conversion plants to align with market growth and export markets' demand for drop-in sustainable road, air, and maritime fuels.	MEWC / MTID – UZ, CUT, MIC, NOIC, MIFP, AMA, ARDA, RBZ, IDBZ

Legend for Stakeholder acronyms:

ACZ - Airports Company of Zimbabwe
AMA - Agricultural Marketing Authority
ARDAS - Agricultural and Rural Development Authority
BFO - Buffalo Range Airport
BUQ - Joshua Mqabuko Nkomo International Airport
CAAZ - Civil Aviation Authority of Zimbabwe
CUT - Chinhoyi University of Technology
EMA - Environmental Management Agency
HAFS - Harare Airport Fueling Services
HRE - Robert Gabriel Mugabe International Airport
HWN - Hwange National Park Airport
IDBZ - Infrastructure Development Bank of Zimbabwe
KAB - Kariba Airport
MEPD - Ministry of Energy and Power Development
MEWC - Ministry of Environment, Water, and Climate
MFIP - Ministry of Finance and Investment Promotion
MHTEISTD - Ministry of Higher and Tertiary education innovation Science and Technology Development
MIC - Ministry of Industry and Commerce
MLAFWRD - Ministry of Lands, Agriculture, Fisheries, Water and Rural Development
MTID - Ministry of Transport and Infrastructural Development
MVZ - Masvingo Airport
NHS - National Handling Services
NOIC- National Oil Infrastructure Company of Zimbabwe
RBZ - Reserve Bank of Zimbabwe
UZ - University of Zimbabwe
VFA - Victoria Falls International Airport
ZERA - Zimbabwe Energy Regulatory Agency

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ANNEX 1

ICAO’S DIRECTORY OF PUBLIC FINANCING PROGRAMMES FOR MITIGATING INTERNATIONAL AVIATION EMISSIONS

The following section provides a summary table including a listing of public financing programmes that are available as of November 2017 to assist Member States in funding their international aviation emission reduction projects. For each programme, a short summary is provided, key information, and sources for collecting additional detail. This Annex is meant to provide suggestions on the kind of existing financing programme, and is not intended as a comprehensive e list of funding opportunities; researching these programmes may also lead to additional funding sources, available from both public and private organizations, as well as help build relationships with stakeholders who can provide support for the international aviation emission reduction efforts

No	Name	Administrator	Donors	Type of Funding	Amount	Recipients	Website
I	Clean Technology Fund	Climate Investment Fund, housed at the World Bank Group, working with Multilateral Development Banks	International Bank for Reconstruction and Development (IBRD) at the World Bank	Concessional financing, senior loans, convertible grants/contingent recovery grants, equity, local currency swaps and guarantees, contingent recovery loans, subordinated debt, plus technical assistance and capacity building.	USD 5.6 billion committed/ USD 3.8 billion approved which has attracted an estimated USD 46 billion in co-financing.	Chile, Colombia, Egypt, India, Indonesia, Kazakhstan, Mexico, Morocco, Nigeria, Philippines, South Africa, Thailand, Tunisia, Turkey, Ukraine, Vietnam	http://www-cif.climateinvestmentfunds.org/fund/clean-technology-fund
II	Scaling Up Renewables Energy in Low Income Countries	Climate Investment Fund, housed at the World Bank Group working with Multilateral Development Banks	International Bank for Reconstruction and Development (IBRD) at the World Bank	Concessional financing, senior loans, convertible grants/contingent recovery grants, equity, local currency swaps and guarantees, contingent recovery loans, subordinated debt, plus technical assistance and capacity building.	USD 780 million committed / USD 194 million approved which has attracted an estimated USD 1.2 billion in co-financing.	Armenia, Bangladesh, Benin, Cambodia, Ethiopia, Ghana, Haiti, Honduras, Kenya, Kiribati, Lesotho, Liberia, Madagascar Malawi, Maldives, Mali, Mongolia, Nepal, Nicaragua, Rwanda, Sierra Leone, Solomon Islands, Tanzania, Uganda, Vanuatu, Yemen, Zambia	https://www-cif.climateinvestmentfunds.org/fund/scaling-renewable-energy-program
III	GEEREF (Global Energy Efficiency and Renewable Energy Fund)	GEEREF	European Investment Bank Group, including the European Investment Bank and the European Investment Fund	Invests public and private risk capital in private equity funds which provide equity financing for small and medium sized renewable energy and energy efficiency projects in emerging markets.	Seeded by European Union, pledged funding of EUR 222 million through May 2016.	146 countries are eligible with funding directed through regional fund managers based in Central America, South America, Middle East and North Africa, Sub-Saharan Africa, Central Asia, Asia and Southeast Asia.	http://geeref.com

No	Name	Administrator	Donors	Type of Funding	Amount	Recipients	Website
IV	Global Environment Facility (GEF)	GEF	GEF with support from donor countries	Multilateral Grants, contingent loans, loan to grant, mitigate technology specific risks, microfinancing for residences.	A recent funding round, GEF-5, attracted USD 1.35m from 40 donor States.	Government agencies, civil society organizations, private sector companies, research institutions, among the broad diversity of potential partners, to implement projects and programmes in recipient countries.	www.thegef.org
V	Green Climate Fund	Climate Fund Board, an operating entity of the UNFCCC with the World Bank	Direct private sector engagement in transformational climate-sensitive investments through the Private Sector Facility (PSF)	Grants, concessional loans, subordinated debt, equity, and guarantees, giving flexibility to match project needs. Risk-bearing capacity, allowing the Fund to support innovation, and leverage and crowd in additional financing.	Developed countries will jointly mobilize USD 100 billion per year by 2020. 50% for mitigation, 50% for adaptation.	National Designated Authorities (NDAs) or focal points are supported with Readiness Funds. 138 NDAs have been certified through 2015.	www.greenclimate.fund
VI	Global Climate Change Alliance (GCCA)	European Commission	European Union	Budget support through grants delivered to the country in tranches, with supplemental funds delivered on completion of the previous programme.	EUR 316.5 million committed by the end of 2014.	30 country programmes, and 8 complementary regional programmes in the most vulnerable and poorest parts of the world as defined by the UN.	www.gcca.eu

No	Name	Administrator	Donors	Type of Funding	Amount	Recipients	Website
VII	Development Cooperation Instrument	European Commission Directorate-General for International Development	European Union	Grants to organizations or projects being developed by them. Contracts through tendering process for goods and services. Budget support to countries through financial transfers to national treasuries. Funding directly to specific in-country sectors.	Funds come from the European Development Fund (EDF) and the European Union general budget. EUR 82 billion committed during 2014-2020 period of which EUR 30.5 billion is from the EDF.	Countries and regions where aid is needed. Organized by regions including Africa, Asia, Central Asia, Latin America, Sub-Sahara, Caribbean, the Gulf, and the Pacific.	ec.europa.eu/europeaid/how/finance/dci_en
VIII	Pilot Auction Facility for Methane and Climate Change Mitigation	World Bank	Funded by Germany, Sweden, Switzerland, and the United States.	Performance based payments for carbon credits valued through an annual auction. World Bank issues a bond which is backed by donor countries. In a first phase, it will support projects that cut methane emissions at landfill, animal waste, and wastewater sites facing low carbon prices.	The facility has a capitalization target of USD 100 million.	Private companies developing energy projects in developing countries.	www.pilotauctionfacility.org
IX	Africa Climate Change Fund	African Development Bank	Governments of Germany, Italy, and Belgium, as well as multilateral climate funds (GEF, CIF, etc.)	Variety of financing measures from grants, to loans to technical assistance to support capacity building, strategic planning, policy development, project implementation.	Initial funding of EUR 4,725 million from Germany. Additional funding of EUR 4.7 million from the government of Italy and EUR 2 million from the government of Flanders, Belgium.	African governments, NGOs, Research Institutions, and Research Organizations	www.afdb.org/en/topics-and-sectors/initiatives-partnerships/africa-climate-change-fund

No	Name	Administrator	Donors	Type of Funding	Amount	Recipients	Website
X	Sustainable Energy Fund for Africa	African Development Bank	Governments of Denmark and the United States	Grant funding to target renewable energy development from feasibility to financial close. Grants for technical assistance and project preparation. Equity investments through the Africa Renewable Energy Fund, managed by Berkeley Investments. Grants to fund public activities that enable private investments.	Committed USD 50 million for private development.	Private companies, organizations	www.afdb.org/en/topics-and-sectors/initiatives-partnerships/sustainable-energy-fund-for-africa/africa-climate-change-fund
XI	International Climate Fund	Interdepartmental Team within the Government of the United Kingdom	Government of the United Kingdom	Project grants, investments in climate funds. Grants primarily provided for bilateral projects. Concessional loans provided to multilateral programmes.	GBP 5.8 billion between April 2016 and March 2021, including at least GBP 1.76 billion in 2020.	Funds directed through global multilaterally administered programs (such as the GCF) rather than towards specific country initiatives	www.gov.uk/government/publications/international-climate-fund/international-climate-fund
XII	International Climate Initiative	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety	Government of Germany	Grants support policy advisory, capacity building and appropriate training measures, and also technological lighthouse projects and technological cooperation scheme.	Funded through auctioning allowances under the emissions trading scheme and through the Special Energy and Climate Fund. Since 2008, a total of 264 mitigation projects with funding totaling around EUR 879 million have been approved.	Developing and newly industrialized countries, as well as countries in transition.	www.international-climate-initiative.com

No	Name	Administrator	Donors	Type of Funding	Amount	Recipients	Website
XIII	NAMA Facility	NAMA Board, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	Government of Germany with support from the UK, Denmark, and the European Commission	Grants, concessional financing, technical assistance for transformational changes in sector development driven by in-country planning and implementation.	EUR $60 million provided for 4th call for funding in 2016.	Developing countries and emerging economies.	www.nama-facility.or
XIV	Global Climate Partnership Fund (GCPF)	GCPF	Governments of Germany, Denmark, the UK, the International Finance Corporation, and the Dutch and Austrian Development Banks	Uses public funding to leverage private capital; local financial institutions through dedicated funding in the form of senior or subordinated debt; Mid to long-term financing; Total facilities usually amounting to USD 10 million – USD 30 million, with flexible funding schedules. Also provides technical assistance to financial institutions to build their green financing portfolios.	Through 2014, USD 100m committed to partner institutions with USD 300m in uncommitted funds.	Financial institutions and some private companies building projects in developing countries.	www.gcpf.lu
XV	Global Climate Change Initiative (GCCI) Low Emissions Development Strategy (LEDS)	US Agency for International Development (USAID)	Government of the United States	Technical assistance to advance countries plans and programmes to mitigate and adapt to climate change.	2014-2015 include: Mobilizing USD 647 million to fund LEDS action in 10 countries.	20 partner countries: Albania, Bangladesh, Cambodia, Colombia, Costa Rica, Ethiopia, Gabon, Georgia, Guatemala, Indonesia, Jamaica, Kazakhstan, Kenya, Macedonia, Malawi, Mexico, Moldova, Peru, Philippines, Serbia, South Africa, Thailand, Ukraine, Vietnam, Zambia	https://www.ec-leds.org

No	Name	Administrator	Donors	Type of Funding	Amount	Recipients	Website
XVI	Climate Technology Initiative's (CTI) Private Financing Advisory Network (PFAN)	United Nations Industrial Development Organization (UNIDO) and the Renewable Energy and Energy Efficiency Partnership (REEEP)	Governments of the United States, Sweden Australia and Norway	Identifies promising clean energy projects at an early stage and provides mentoring for development of a business plan, investment pitch, and growth strategy, significantly enhancing the possibility of financial closure.	87 projects have achieved financial closure with over USD 1.2 billion of investment raised.	Private companies	cti-pfan.net/
XVII	Powering Agriculture: An Energy Grand Challenge for Development (PAEGC)	Hosted by the US Agency for International Development (USAID)	Funding from the Governments of the Germany, Sweden, and the United States as well as Duke Energy, and the Overseas Private Investment Corporation (OPIC)	Grants, technical assistance to develop work plans, access to business technical firms and consultants, communication with investors, advisory services for business development and marketing.	Not available	Small agricultural companies and cooperatives	poweringag.org/
XVIII	UAE South Pacific Partnership Fund	Abu Dhabi Fund for Development	Government of the United Arab Emirates	Grants and technical assistance.	USD 50 million annually.	Governments of Fiji, Kiribati, Samoa, Tonga, Tuvalu, Vanuatu	www.mofa.gov.ae/EN/Pages/UAE-Pacific-Partnership.aspx

No	Name	Administrator	Donors	Type of Funding	Amount	Recipient	Website
X IX	IRENA/ADFD Project Facility	IRENA	Abu Dhabi Fund for Development	IRENA selecting and recommending promising renewable energy projects in developing countries. ADFD then offers sovereign funding through soft (concessional) loans to these projects. IRENA also provides capacity building, Renewable Readiness Assessments, resource assessments, grid stability studies.	USD 350 million over seven annual cycles.	Members of IRENA; about 120 countries.	adfd.irena.org
XX	Pacific Environment Community (PEC) Fund	Pacific Island Forum Secretariat	Government of Japan	Grants and technical assistance for sea water desalination and renewable energy projects.	USD 66 million committed.	Forum Island Countries (FIC): Cook Islands, Federal States of Micronesia, Fiji, Kiribati, Nauru, Niue, Palau, Papua New Guinea, Republic of the Marshall Islands, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu	www.forumsec.org/pages.cfm/strategic-partnerships-coordination/pacific-environment-community-pec-fund

No	Name	Administrator	Donors	Type of Funding	Amount	Recipient	Website
XXI	UAE-Caribbean Renewable Energy Fund	Abu Dhabi Fund for Development	Government of the United Arab Emirates	Grants and technical assistance.	USD 50 million annually.	Governments of Antigua & Barbuda, Bahamas, Barbados, Belize, Cuba, Dominica, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, St Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago	http://newenergyevents.com/wp-content/uploads/2017/02/UAE-Caribbean-Renewable-Energy-Fund-Guidelines.pdf

I. CLEAN TECHNOLOGY FUND (CTF)

ADMINISTERED BY THE CLIMATE INVESTMENT FUND AT THE WORLD BANK

PURPOSE
Increase the development of low carbon technologies including renewable energy.

FUNDING TYPES
Financing, senior loans, convertible grants/contingent recovery grants, equity, local currency swaps and guarantees, contingent recovery loans, subordinated debt, plus technical assistance and capacity building.

WEBSITE
www.climateinvestmentfunds.org/fund/clean-technology-fund

SUMMARY
The USD 5.8 billion Clean Technology Fund (CTF) is empowering transformation in developing and emerging economies by providing resources to scale up low carbon technologies with significant potential for long-term greenhouse gas (GHG) emissions savings.

Over USD 3.8 billion (66 percent of CTF resources) is approved and under implementation in clean technologies such as renewable energy, energy efficiency, and clean transport. This is expected to leverage another USD 38 billion in co-financing.

The Dedicated Private Sector Programmes, created under the CTF to finance large-scale private sector projects with greater speed and efficiency, have allocated a total of USD 467 million to geothermal power, mini-grids, mezzanine finance, energy efficiency, solar PV, and early-stage renewable energy programmes so far.

EXAMPLE
In Thailand, USD 100 million from the CTF administered by the Asian Development Bank, is supporting a number of pioneering projects under the Private Sector Renewable Energy Programme. These projects are expected to lead to over 430 MW installed capacity. Also in Thailand, the International Finance Corporation (IFC) blended USD 8 million in commercial financing from its own resources with USD 4 million in concessional finance from the CTF to support expansion of one of Thailand's earliest solar PV developers, female entrepreneur Wandee Khunchornyakong's Solar Power Company Group (SPCG.) This financing enabled SPCG to mobilize additional financing from local banks and bring 12MW in utility-scale solar power capacity over the finish line. Wandee received the prestigious Momentum for Change award from the United Nations' Climate Change Secretariat in 2014 for this groundbreaking initiative. By demonstrating the commercial viability of private sector utility-scale energy generation projects, the programme is overcoming risk perceptions. It does this by establishing replicable business models for renewable energy technologies - a track record of investments will catalyze market transformation.

II. SCALING UP RENEWABLE ENERGY IN LOW INCOME COUNTRIES (SREP)

ADMINISTERED BY THE CLIMATE INVESTMENT FUND AT THE WORLD BANK

PURPOSE

Increase the development of renewable energy in developing countries.

FUNDING TYPES

Concessional Financing, senior loans, convertible grants/contingent recovery grants, equity, local currency swaps and guarantees, contingent recovery loans, subordinated debt, plus technical assistance and capacity building.

WEBSITE

www-cif.climateinvestmentfunds.org/fund/scaling-renewable-energy-program

SUMMARY

The USD 839 million Scaling Up Renewable Energy in Low Income Countries Program (SREP), a funding window of the CIF, is empowering transformation in developing countries by demonstrating the economic, social and environmental viability of renewable energy. Channeled through five multilateral development banks (MDBs), SREP financing supports scaled-up deployment of renewable energy solutions to increase energy access and economic opportunities. To date, USD 264 million is approved and under implementation for 23 projects and programs, expecting USD 1.9 billion in co-financing from other sources.

EXAMPLE

Dhiffushi Solar Ice Project: The Maldives was selected for SREP financing in July 2010. Subsequently, the country prepared an investment plan that embraces SREP objectives. These include demonstrating the social and environmental viability of low-carbon development trajectories in the energy sector through a carbon-neutral policy that will result in a switch from fossil fuel to renewable sources of energy by 2020. Under the plan, this transformation will be achieved through large-scale generation of electricity using solar, wind, and waste-driven energy sources, in addition to hybrid systems. Such a transformation would also support socioeconomic development and contribute to poverty reduction and sustainable development. The Maldives' plan was endorsed by the SREP Sub-Committee in October 2012.

The project will result in the provision of 21 MW of new solar capacity, 27.6 GWh of annual electricity output, and 7 MWh of energy storage. About 4,600 households will benefit from increased access to electricity in the first five subprojects. The number of beneficiaries will increase as the programme covers more islands. In 2016, the Dhiffushi Solar Ice Project was completed on Dhiffushi Island in the Maldives. The project features the installation of a 40 kW grid-connected photovoltaic (PV) system and an ice-making machine.

III. GLOBAL ENERGY EFFICIENCY AND RENEWABLE ENERGY FUND (GEEREF)

ADMINISTERED BY GEEREF WITH SUPPORT FROM THE EUROPEAN INVESTMENT BANK GROUP

PURPOSE

Provide attractive, low risk financial investments that will produce economic, environmental, and social benefits.

FUNDING TYPES

Invests public and private risk capital in private equity funds, which provide equity financing for small and medium sized renewable energy and energy efficiency projects in emerging economies.

WEBSITE

geeref.com

SUMMARY

The Global Energy Efficiency and Renewable Energy Fund (GEEREF) is an innovative Fund-of-Funds, catalysing private sector capital into clean energy projects in developing countries and economies in transition. It invests in private equity funds which focus on renewable energy and energy efficiency projects in emerging markets. GEEREF's funds concentrate on infrastructure projects that generate clean power through proven technologies with low risk. GEEREF was initiated by the European Commission in 2006 and launched in 2008 with funding from the European Union, Germany and Norway, totaling EUR 112 million. GEEREF successfully concluded its fundraising from private sector investors in May 2015, which brought the total funds under management to EUR 222 million. GEEREF invests in private equity funds which, in turn, invest in private sector projects, thereby further enhancing the leveraging effect of GEEREF's investments. It is estimated that, with EUR 222 million of funds under management, over EUR 10 billion could be mobilised through the funds in which GEEREF participates and the final projects in which these funds invest.

EXAMPLE

Esidai Wind Project: This is a 50 MW wind project utilizing the wind resource generated by the Kenyan rift valley. The project is located along the rift valley escarpment in the area between Ngong Hills and Isinya, in Kajiado County, Kenya. The project will be connected to the Kenyan national grid via Isinya substation. The project is in in the mid-stage of development. DI Frontier Market Energy & Carbon Fund is substantial shareholder in the project company, Esidai Wind Power Generation Company Limited, with a view to contributing to the project development and providing equity for the construction of the project.

IV. THE GLOBAL ENVIRONMENT FACILITY (GEF)

ADMINISTERED BY THE GEF

PURPOSE
To help developing countries and countries with economies in transition to meet the objectives of international environmental conventions and agreements.

FUNDING TYPES
Multilateral grants, contingent loans, loan to grant, mitigate technology specific risks, microfinancing for residences.

WEBSITE
www.thegef.org

SUMMARY
The Global Environment Facility (GEF) administers several trust funds and provides Secretariat services, on an interim basis, for the Adaptation Fund.

The GEF Trust Fund was established on the eve of the 1992 Rio Earth Summit, to help tackle our planet's most pressing environmental problems. GEF funding to support the projects is contributed by donor countries. These financial contributions are replenished every four years. The funds have been provided by the 39 donor countries of the GEF.

EXAMPLE
Cook Islands Renewable Energy Sector Project: A GEF grant has been used to fund the development of over 3 MW solar PV including storage and energy management system in the Cook Islands. The project includes the installation of a battery energy storage system (BESS) with a preliminary capacity of 1 MW and 4 MWh, which will provide load shifting to offset renewable generation at the existing 1 MW solar PV facility at the Rarotonga Airport. The proposed BESS will allow 2 MW of additional solar PV generation, which is about 8 per cent progress towards the total estimated renewable generation. This funding allows the Cook Islands to develop additional solar PV generation and accelerate its timeline to meet 100 per cent renewable energy goals for the southern island group.

[1] ICAO, in partnership with GEF and the United Nations Development Programme (UNDP) have an initiative to support capacity building in developing States and SIDS for implementing concrete measures to reduce CO_2 emissions from international aviation.

V. GREEN CLIMATE FUND (GCF)

ADMINISTERED BY THE GCF BOARD UNDER THE UNFCCC, WITH SUPPORT FROM THE WORLD BANK

PURPOSE

To advance the goal of keeping the temperature increase on earth below two degrees Celsius by investing into low-emission and climate-resilient development.

FUNDING TYPES

Variety of financial instruments available, including grants, concessional loans, subordinated debt, equity, and guarantees, giving flexibility to match project needs. Risk-bearing capacity, allowing the Fund to support innovation and leverage and crowd in additional financing.

WEBSITE

www.greenclimate.fund

SUMMARY

The Green Climate Fund (GCF) is a new global fund created to support the efforts of developing countries to respond to the challenge of climate change. The GCF helps developing countries limit or reduce their GHG emissions and adapt to climate change. It seeks to promote a paradigm shift to low-emission and climate-resilient development, taking into account the needs of nations that are particularly vulnerable to climate change impacts. It was set up by the 194 States who are parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2010, as part of the Convention's financial mechanism. It aims to deliver equal amounts of funding to mitigation and adaptation, while being guided by the Convention's principles and provisions.

EXAMPLE

The Renewable Energy Financing Framework in Egypt: This project will help Egypt to its target of 20 per cent renewable energy generation by 2022, through two complementary components. The first is a comprehensive technical assistance programme to enhance renewable energy integration, policies, and planning. The second component is to scale up investments to support the development and construction of renewable energy projects totaling USD 1 billion. This will be done by blending GCF and European Bank for Reconstruction and Development (EBRD) financing to leverage debt financing from international and development financial institutions, and at a later stage, from commercial banks and private sector investments.

The Framework will launch the first wave of private renewable energy projects in Egypt, overcoming financial barriers due to uncertainty and high transaction costs, as well as the macroeconomic situation which has resulted in increased cost of capital and limited availability of debt. The Framework will use debt financing from EBRD and GCF of up to USD 500 million, including up to USD 150 million in loans from GCF. The projects to be implemented with co-financing from the Framework are expected to generate around 1,400 GWh electricity annually and result in avoided GHG emissions of about 800,000 tCO_2e annually once all projects are operational.

VI. GLOBAL CLIMATE CHANGE ALLIANCE (GCCA)

ADMINISTERED BY THE EUROPEAN COMMISSION UNDER THE EUROPEAN UNION (EU)

PURPOSE

To help the most vulnerable and least developed countries address climate change through support of their national programmes.

FUNDING TYPES

National budget support with funds sent directly to the country in tranches with supplemental funds delivered on completion of first programme.

WEBSITE

www.gcca.eu

SUMMARY

The Global Climate Change Alliance (GCCA) was established by the European Union (EU) in 2007 to strengthen dialogue and cooperation with developing countries, in particular least developed countries (LDCs) and small island developing States (SIDS). With a budget of more than EUR 300 million, it supports 51 programmes around the world and is active in 38 countries. It focuses on increasing the capacity of the poorest and most vulnerable countries to adapt to the effects of climate change, in support of the achievement of the UN Millenium Development Goals (MDGs). In 2014, a new phase of the GCCA, the GCCA+ flagship initiative, began in line with the European Commission's new Multiannual Financial Framework (2014-2020).

The GCCA+ aim is to boost the efficiency of its response to the needs of vulnerable countries and groups. Using ambitious and innovative approaches, it will achieve its goals by building on its two mutually reinforcing pillars:

- Under the first pillar, the GCCA+ serves as a platform for dialogue and exchange of experience between the EU and developing countries, focusing on climate policy and bringing renewed attention to the issue of international climate finance. The results feed into negotiations for a new climate deal under the UNFCCC.
- Under the second pillar, the GCCA+ acts as a source of technical and financial support for the world's most climate-vulnerable countries, whose populations need climate finance the most. Extra efforts will be made to strengthen the strategically important issues of ecosystems-based adaptation, migration and gender equality.

EXAMPLE

West Africa Capacity Building and Communication Strategy Project: This project seeks to mainstream climate issues into national decision-making. Funding is delivered through the African Biofuel and Renewable Energy Company (ABREC) to support its Member States in the development of projects in the areas of renewable energy and clean technology and in mobilising the required funds for their implementation. Support is mainly delivered through ABREC's Technical Assistance Facility. Currently, ABREC, in cooperation with West African Economic and Monetary Union (WAEMU), is planning to launch a Regional Program for the Development of Renewable Energy and Energy Efficiency in WAEMU Member States.

VII. DEVELOPMENT COOPERATION INSTRUMENT (DCI)

ADMINISTERED BY THE EUROPEAN COMMISSION DIRECTORATE GENERAL UNDER THE EUROPEAN UNION

PURPOSE

To support EU Development Policy and "Agenda for Change" including sustainability goals.

FUNDING TYPES

Grants to organizations or projects being developed by them. Contracts through tendering process for goods and services. Budget support to countries through financial transfers to national treasuries. Funding directly to specific in-country sectors.

WEBSITE

ec.europa.eu/europeaid/how/finance/dci_en.htm_en

SUMMARY

The objectives and general principles of the Development Cooperation Instrument (DCI) have been formulated in line with the Lisbon Treaty and the latest policies, notably the 'Agenda for Change' of EU development policy. Its prime objective is the reduction of poverty. It contributes also to the achievement of other goals of EU external action, in particular fostering sustainable economic, social and environmental development as well as promoting democracy, the rule of law, good governance and respect for human rights. Relevant funding comes from the DCI Thematic programmes benefiting all developing countries under the 'Global public good and challenges'. This programme addresses climate change, environment, energy, human development, food security and migration while ensuring coherence with the poverty reduction objective.

EXAMPLE

Facilitating India's transition towards low carbon development by implementing national policies and programmes for offshore wind: The specific objective is to create an enabling environment through resource mapping, policy guidance and capacity building measures to unlock the offshore potential of India. The action will utilise the EU offshore learning to reduce technical barriers and financial risks; it will also undertake techno-commercial studies to showcase offshore wind potential.

VIII. PILOT AUCTION FACILITY FOR METHANE AND CLIMATE MITIGATION (PAF)

ADMINISTERED BY THE WORLD BANK WITH FUNDING FROM THE GOVERNMENTS OF GERMANY, SWEDEN, SWITZERLAND, AND THE UNITED STATES

PURPOSE

To support a market for carbon credits.

FUNDING TYPES

Grants to organizations or projects being developed by them. Contracts through tendering process for goods and services. Budget support to countries through financial transfers to national treasuries. Funding directly to specific in-country sectors.

WEBSITE

ec.europa.eu/europeaid/how/finance/dci_en.htm_en

SUMMARY

The Pilot Auction Facility for Methane and Climate Change Mitigation (PAF) is an innovative mechanism that pioneers the use of auctions to allocate public financing for climate action efficiently. The PAF was initiated as a result of a report from the Methane Finance Study Group, an international group of experts convened at the request of the G8. The facility demonstrates a new pay-for-performance mechanism that takes advantage of existing tools and experience developed at the multilateral level under the Clean Development Mechanism (CDM) and related carbon markets to deliver financing, in the form of a price guarantee, to projects that address climate change. The guaranteed floor price will be delivered through the auctioning of put options supported by donor funding. The competitive nature of the auction used to allocate the price guarantee will reveal the minimum price required by the private sector to invest in climate mitigation projects, therefore maximizing the impact of public funds and achieving the highest volume of climate benefits per dollar. The PAF is backed by several government donors and has a capitalization target of USD 100 million. In a first phase, it will support projects that cut methane emissions at landfill, animal waste, and wastewater sites facing the challenge of low carbon prices.

EXAMPLE

First Auction Recipients: In July 2015, the World Bank's PAF conducted an online auction of put options, which gave winning bidders the right, but not the obligation, to sell future carbon credits to the facility at a price determined by the auction. Winners redeem these options annually, with the first payments made in November 2016.

In total, 28 firms participated in the auction last year, and 12 won options to sell carbon credits to the PAF at USD 2.40 per carbon credit over a 5-year period. The auction provided winners with approximately USD 20 million in options, or about USD 4 million per year. Over the past 17 months, the owners of these contracts have invested in and sustained projects that reduce methane emissions, relying on the guaranteed payment for carbon credits to back their investments. The options were structured in the form of World Bank bonds that pay zero interest and provide a final redemption amount of USD 2.40 per carbon credit, as long as the bondholder surrenders an eligible carbon credit. Citi Bank acts as Global Agent for the bonds. The first tranche of the bonds matured on November 30, 2016, and five investors chose to exercise their right to redeem, receiving a total payment of USD 3.1 million in exchange for carbon credits, representing the equivalent of over 1.3 million metric tonnes of reduced carbon dioxide (CO_2) emissions. The carbon credits came from four projects: the Jeram landfill gas recovery project in Malaysia, the Kamphaeng Saen West and East: Landfill Gas to Electricity Projects in Thailand, and the Central de Resíduos do Recreio Landfill Gas Project in Brazil.

IX. AFRICA CLIMATE CHANGE FUND (ACCF)

ADMINISTERED BY THE AFRICAN DEVELOPMENT BANK, FINANCED BY VARIOUS CLIMATE FUNDS AND DONOR COUNTRIES

PURPOSE
To support low carbon development and climate resiliency.

FUNDING TYPES
Grants for capacity building, strategic planning, policy development, project implementation.

WEBSITE
www.afdb.org/en/topics-and-sectors/initiatives-partnerships/africa-climate-change-fund/

SUMMARY
In 2011, the African Development Bank (AfDB) mobilised USD 596 million for its egional member countries (RMCs) to use on adaptation projects, and another USD 925 million for mitigation projects. This has been made possible thanks to climate finance instruments created and/or administered by the Bank, such as the Climate Investment Funds (CIFs), the GEF, and the Sustainable Energy Fund for Africa (SEFA). The scope of the ACCF is sufficiently wide to permit a broad range of activities, including: preparation for accessing climate funding; integration of climate change and green growth into strategic documents and/or projects; preparation and funding of adaptation and mitigation projects; climate change-related knowledge management and information sharing; capacity building; preparation of climate change-resilient and low-carbon strategies and policies; green growth analysis work; advocacy and outreach.

EXAMPLE
Advancing clean energy projects in Cabo Verde: The project aims to enhance capacity to access climate finance, while helping Cabo Verde to meet its proposed targets towards a low-carbon development pathway set out in its intended nationally determined contribution to the UNFCCC. The project will develop nationally appropriate mitigation actions (NAMAs) for the key strategic sectors of energy and waste. It will further support the mobilization of climate finance for the implementation of NAMAs.

X. SUSTAINABLE ENERGY FUND FOR AFRICA (SEFA)

ADMINISTERED BY THE AFRICAN DEVELOPMENT BANK, FINANCED BY THE GOVERNMENTS OF DENMARK AND THE UNITED STATES

PURPOSE

To support private sector-led small and medium scale renewable energy development in Africa.

FUNDING TYPES

Grant funding to target renewable energy development from feasibility to financial close. Grants for technical assistance and project preparation. Equity investments through the Africa Renewable Energy Fund, managed by Berkeley Investments. Grants to fund public activities that enable private investments

WEBSITE

www.afdb.org/en/topics-and-sectors/initiatives-partnerships/sustainable-energy-fund-for-africa/

SUMMARY

The Sustainable Energy Fund for Africa (SEFA) was designed to operate under three financing windows.

1) Poject preparation provides cost-sharing grants and technical assistance to private project developers/promoters to facilitate pre-investment activities for renewable energy and energy efficiency projects. Grant funding will target development activities from feasibility up to financial closure for projects with total capital investments in the range of USD 30 million – 200 million.
2) Equity investments seek to address the lack of access to early stage capital for small-and medium-sized projects, as well as the low managerial and technical capability of smaller entrepreneurs and developers. The SEFA equity capital combined with a dedicated technical assistance envelope will be deployed by the SEFA co-sponsored Africa Renewable Energy Fund (AREF), a pan-African Private Equity Fund (PEF) solely focused on small/medium (5-50 MW) independent power projects from solar, wind, biomass, hydro as well as some geothermal and stranded gas technologies. Investment decisions are the sole responsibility of AREF's Fund Manager –Berkeley Energy LLC.
3) Enabling environment support provides grants for public sector activities that create and improve the enabling environment for private sector investments in the sustainable energy space in Africa. This includes advisory and implementation of legal, regulatory and policy regimes that provide clear and predictable rules for project development, implementation and operation, capacity building activities to allow the public sector to act as a reliable and creditworthy counterparty in energy projects and programmes. This component is not bound by project size limits, and includes interventions spanning the off-grid, mini-grid, and grid-connected segments.

EXAMPLES

Wave-Driven Desalination Demonstration Project. Cabo Verde was awarded a US $930,000 grant by the AfDB-hosted SEFA on December 21, 2015 to develop the world's first wave-driven desalination system. Wave2O™, to be located in Praia Grande, Cabo Verde, will operate completely "off-grid" and supply more than 48,000 people with clean fresh water at a competitive cost. The system is expected to have a capacity of 4,000 m3/day of water, and will eliminate 5,400 metric tonnes of CO_2 per year.

XI. INTERNATIONAL CLIMATE FUND (ICF)

ADMINISTERED BY THE GOVERNMENT OF THE UNITED KINGDOM

PURPOSE

As the United Kingdom's primary source of climate finance, it funds existing multilateral and national programmes focused on supporting private sector innovation and public-private partnerships, including renewable energy development in Africa.

FUNDING TYPES

Project grants, investments in climate funds. Grants primarily provided for bilateral projects. Concessional loans provided to multilateral programs.

WEBSITE

www.gov.uk/government/publications/international-climate-fund/international-climate-fund

SUMMARY

The International Climate Fund (ICF) is the UK government's commitment to developing countries to help them address the challenges presented by climate change, and benefit from the opportunities. The ICF invests in a broad range of activities around the globe to support sustainable economic growth, build resilience to the impacts of climate change and help sustainably manage natural resources such as forests. The ICF helps make some of the poorest and most vulnerable communities more resilient to climate change, for example, by supporting the distribution of flood resilient crops and improving early warning systems. It is also helping create a reliable source of energy for communities, which improves health, education, and enables businesses to grow, creating jobs and improving incomes and standards of living for the poorest communities. It seeks to prevent emissions now or in years to come by demonstrating how countries can shift to cleaner, low carbon approaches and technologies.

EXAMPLES

The ICF often provides financial support to other climate funds and multilateral financing programmes. These include the NAMA Facility, Global Climate Partnership Fund, and the Climate Investment Funds. See those individual funds for specific project examples.

XII. INTERNATIONAL CLIMATE INITIATIVE (IKI)

ADMINISTERED BY THE GERMAN FEDERAL MINISTRY FOR THE ENVIRONMENT, NATURE CONSERVATION, BUILDING AND NUCLEAR SAFETY

PURPOSE
To mitigate GHG emissions, adapt to climate change, conserve carbon sinks, and conserve biodiversity.

FUNDING TYPES
Grants to support policy advice, capacity building and appropriate training measures, and also technological lighthouse projects and technological cooperation scheme.

WEBSITE
www.international-climate-initiative.com/en/

SUMMARY
Since 2008, the International Climate Initiative (IKI) of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) has been financing climate and biodiversity projects in developing and newly industrialising countries, as well as in countries in transition. In the early years of the programme, its financial resources came from the proceeds of auctioning allowances under the emissions trading scheme. To ensure financial continuity, further funds were made available through the Special Energy and Climate Fund. Both funding mechanisms are now part of the Federal Environment Ministry's regular budget.

The IKI is a key element of Germany's climate financing and the funding commitments in the framework of the Convention on Biological Diversity. The Initiative places clear emphasis on climate change mitigation, adaption to the impacts of climate change and the protection of biological diversity. These efforts provide various co-benefits, particularly the improvement of living conditions in partner countries. Projects are Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

EXAMPLES
Industrial and Commercial Solar Colling in Jordan: As part of a sectoral mitigation strategy, this project lays the foundations for largely CO_2-free air conditioning and refrigeration based on solar energy. To this end, it is establishing partnerships between German and Jordanian companies and institutes involved in cooling machines. A demonstration project is setting new energy efficiency standards, thus saving around 20,000 tonnes of CO_2, assuming systems have a 30-year life cycle. This roughly corresponds to the average annual CO_2 emissions of 5,500 Jordanian citizens. These standards feed into a sectoral approach for designing climate-friendly strategies and regulations for Jordan's air conditioning sector.

Other representative projects can be reviewed at:
www.international-climate-initiative.com/en/nc/projects/projects/

XIII. NAMA FACILITY

ADMINISTERED BY THE NAMA BOARD AND IMPLEMENTED BY DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT (GIZ) GMBH

PURPOSE
Implement ambitious mitigation projects in developing and emerging economies.

FUNDING TYPES
Funding for transformational changes in sector development driven by in-country planning and implementation.

WEBSITE
www.nama-facility.org

SUMMARY
In 2012, the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and the Department for Business, Energy and Industrial Strategy (BEIS) of the United Kingdom (UK) jointly established the NAMA Facility. The Danish Ministry of Energy, Utilities and Climate (EFKM) and the European Commission joined the NAMA Facility as new donors in 2015. In total, four calls for funding have been issued to date, totaling EUR 258 million.

NAMAs are country-driven and anchored in national development strategies and plans; are sector-wide programmes that are national in scope, even if regional or municipal elements could form part of the overall design; and consist of a combination of policies and financial mechanisms. Policies should serve to create an enabling environment and channel financial flows into low-carbon investments. Financial mechanisms should serve to address potential barriers for investment and leverage potential public support for mitigation activities; and be flexible in order to provide tailor-made solutions that are appropriate for the circumstances and capabilities of different countries. NAMAs are seen as concrete measures to achieve the objectives of Nationally Determined Contributions (NDCs) that were adopted through the Paris Agreement at the 21st Session of the Conference of the Parties (COP21) to the UNFCCC in December 2015.

EXAMPLES
Burkina Faso – Biomass Energy NAMA Support Project: The NAMA will contribute to more stable supply chains and continuous, more affordable energy access while addressing one of the main drivers of deforestation: biomass energy.

Chile – Self-supply Renewable Energy NAMA: The NAMA in the energy sector will contribute to increased energy security and independence by financing the expansion of decentralised renewable energy systems for self-supply.
Other representative projects can be viewed at: http://www.nama-facility.org/projects

XIV. GLOBAL CLIMATE PARTNERSHIP FUND (GCPF)

ADMINISTERED BY THE INVESTMENT FIRM RESPONABILITY INVESTMENTS AG, AND FINANCED BY THE GOVERNMENTS OF DENMARK, GERMANY, AND THE UK, THE INTERNATIONAL FINANCE CORPORATION, THE DEVELOPMENT BANKS OF AUSTRIA AND THE NETHERLANDS, AND PRIVATE INVESTORS

PURPOSE

Use public funding to leverage private capital in order to mitigate climate change and drive sustainable growth in developing and emerging markets.

FUNDING TYPES

Dedicated funding to local institutions in the form of senior or subordinated debt; mid- to long-term financing with flexible schedules; direct financing for projects in the late stage of development through direct funding primarily in the form of senior debt; maturities of up to 10 years; equity or mezzanine debt, provided in smaller amounts where this strengthens the funding package.

WEBSITE

www.gcpf.lu/investing-in-renewable-energy-and-energy-efficiency.html

SUMMARY

The Global Climate Partnership Fund (GCPF) is an investment company under Luxembourg law. It was established by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and KfW Entwicklungsbank in 2011. It is administered by responsAbility Investments AG, an asset manager focused on international development investments. As an innovative public-private partnership, GCPF uses public funding to leverage private capital in order to mitigate climate change and drive sustainable growth in developing and emerging markets. GCPF mainly invests through local financial institutions but also directly. Targeting small and medium-sized businesses and private household. Project size less than 15 MW.

EXAMPLE

A total of 25 companies are currently based in the Astro Nicaragua industrial park, which covers an area of 55 hectares. Astro Nicaragua meets 27 per cent of itsenergy needs using solar energy. The solar PV system has an installed capacity of 2.52 MW and generates electricity from dawn to dusk. The investment was partially financed by a 'Green Line' loan from the GCPF partner BanPro and the cost will be recuperated through energy savings within 8 years.

XV. GLOBAL CLIMATE CHANGE INITIATIVE (GCCI)

ADMINISTERED BY THE US AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID)

PURPOSE

Support plans and programmes to mitigate and adapt to climate change in developing countries.

FUNDING TYPES

Various measures from direct technical assistance, grant funding, and financial supports through partner agencies.

WEBSITE

www.usaid.gov/climate

SUMMARY

The Global Climate Change Initiative was launched in 2010. It helps countries pursue development goals and grow their economies in ways that reduce GHG emissions and increase climate resilience. It establishes climate-smart laws and policies including low emissions development plans, adaptation plans, disaster preparedness plans, policy incentives for renewable energy, coordinated and capable institutions, and social and environmental safeguards. It provides access the climate information including greenhouse gas inventories, vulnerability assessments, early warning systems, weather information and services, and high-quality and user-friendly climate information and analysis. There are six primary programmes addressing climate change mitigation that the GCCI supports.

- The Enhancing Capacity for Low Emissions Development Strategies (EC-LEDS) programme – a USAID administered programme that partners with more than 20 countries to develop robust and coordinated low emission development strategies (LEDS). These LEDS support sustainable, long-term development while slowing the growth of GHG emissions.
- Grid Integration of Renewable Energy – a USAID administered programme that supports projects seeking to transform small electricity grids powered by fossil fuels to renewable power.
- Greening the Grid, a USAID programme, is a toolkit of information and guidance materials to support developing countries in defining and implementing grid-integration road maps. Toolkit resources provide: 1) concise and comprehensive overviews of emerging practices for addressing grid-integration challenges through policy, market, and regulatory mechanisms; and 2) guidance on applying these mechanisms to develop robust grid-integration road maps. The programme also provides direct technical assistance tailored to the unique power system characteristics and priorities in each partner country. See http://greeningthegrid.org for more information.
- The Energy Toolbox, hosted by USAID, offers training and field support on a range of energy-related topics including energy efficiency, electricity sector reform, grid-connected renewable energy generation, and infrastructure training. Individual toolkits include additional resources, links to case studies, information on implementation approaches, and location information.
- The Private Financing Advisory Network (PFAN), hosted by the United Nations Industrial Development Organization (UNIDO), identifies promising clean energy projects at an early stage and provides mentoring for development of a business plan, investment pitch, and growth strategy, significantly enhancing the possibility of financial closure. See separate page description.
- The Powering Agriculture: An Energy Grand Challenge for Development (PAEGC) programme, hosted by USAID but with several funding partners, supports new and sustainable approaches to accelerate the development and deployment of clean energy solutions for increasing agriculture productivity and/or value in developing countries. See separate page description.

XVI. PRIVATE FINANCE ADVISORY NETWORK (PFAN)

ADMINISTERED BY THE UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION AND THE RENEWABLE ENERGY AND ENERGY EFFICIENCY PARTNERSHIP

PURPOSE

Provide free business consulting services to early stage clean energy development projects in emerging economies.

FUNDING TYPES

Free advisory services, networking to bring entrepreneurs in the developing world together with investors from the developed world.

WEBSITE

cti-pfan.net

SUMMARY

Launched in 2006, the Private Financing Advisory Network (PFAN) identifies promising clean energy projects at an early stage and provides mentoring for development of a business plan, investment pitch, and growth strategy, significantly enhancing the possibility of financial closure. In May 2017, PFAN was relaunched under a new hosting arrangement with UNIDO and the Renewable Energy and Energy Efficiency Partnership (REEEP). PFAN is a multilateral, public-private partnership initiated by the Climate Technology Initiative (CTI) in cooperation with the UNFCCC Expert Group on Technology Transfer. Under the new hosting, its operations will be scaled up by a factor of two to five by 2020. Partners include USAID, Swedish International Development Cooperation Agency (SIDA), Australian Government Department of Foreign Affairs and Trade, and the Norwegian Ministry of Foreign Affairs. PFAN has developed regional networks covering Latin America, Asia, Africa and the Commonwealth of Independent States (CIS) and Central Asia, as well as in-country networks of developers and investors.

PFAN is an alliance of private-sector companies that are experienced in providing investment and financial advisory services to climate-friendly projects. Network members include specialist investment funds, institutional investors, and financial advisers. PFAN provides a variety of services to clean energy businesses to help them secure financial closure. There is no direct cost to the project developer for the initial stage of mentoring.

EXAMPLE

ASEA One Biomass Power Plant: CTI PFAN Asia helped ASEA One develop its business plan, and provided deal facilitation support.

In summary:

- ASEA One Power Corporation, Biomass Power Plant
- Capacity: 12 MW
- Total Investment: USD 30M
- Annual GHG Mitigation Potential: 40,000 TCO squared eq
- Location: Banga, Aklan, Philippines

XVII. POWERING AGRICULTURE: AN ENERGY GRAND CHALLENGE FOR DEVELOPMENT

ADMINISTERED BY THE US AGENCY FOR INTERNATIONAL DEVELOPMENT

PURPOSE

Support new and sustainable approaches to accelerate the development and deployment of clean energy solutions for increasing agriculture productivity and/or value in developing countries.

FUNDING TYPES

Grants, technical assistance to develop work plans, access to business technical firms and consultants, communication with investors, advisory services for business development and marketing.

WEBSITE

www.poweringag.org/

SUMMARY

In 2012, Powering Agriculture: An Energy Grand Challenge for Development was launched by its Founding Partners, the United States Agency for International Development (USAID), the Government of Sweden, Duke Energy Corporation, the Government of Germany, and the Overseas Private Investment Corporation, to catalyze resources and focus attention on the lack of access by many farmers and agribusinesses in developing countries to reliable, affordable and clean energy. This limits their ability to adopt modern agricultural practices, increase food production, improve efficiency of their operations and benefit from broad-based, low-carbon economic growth.

The Powering Agriculture Founding Partners recognize that many farming communities face substantial barriers in incorporating clean energy solutions into their operations. Often farmers are not aware of what technology is available, the technology that is available does not match the performance characteristics or price points required in emerging markets, or there is little appropriate financing to assist in paying the relatively high, up-front capital costs of new technology.

Powering Agriculture: An Energy Grand Challenge for Development utilizes the financial and technical resources of its partners to promote new ideas and innovation at the point where clean energy and agriculture intersect, the clean energy/agriculture nexus.

EXAMPLE

Village Industrial Power (VIP), a firm that specializes in the development of innovative biomass fueled co-generation plants, has designed steam plants powered through the combustion of biomass waste produced at local agricultural processing facilities. The VIP plants generate mechanical/electrical/thermal energy for use in a diverse range of agricultural activities, such as processing fruit, palm, rice, and cocoa; dairy pasteurization; purifying water; and powering irrigation pumps.

To date, VIP, with its partner Camco Clean Energy, have installed five units in three locations. Three palm oil processing businesses in South Eastern Benin have tested the VIP unit in order to displace diesel consumption that is used in running the expeller press and the kernel and fiber separator. The VIP mini-grid in the village of Uchindile, Tanzania, has electrified over 15 shops, homes, and a hospital, and is looking to test the system for an agricultural application, such as an irrigation pump or a small mill. A rural clinic near Kigoma, Tanzania, tested the VIP unit to power a submersible pump and other equipment with the electricity produced by the unit. Training to operate and maintain the units has been provided at all sites.

XIX. IRENA / ADFD PROJECT FACILITY

ADMINISTERED THE INTERNATIONAL RENEWABLE ENERGY AGENCY (IRENA) AND FINANCED BY THE ABU DHABI FUND FOR DEVELOPMENT (ADFD)

PURPOSE
To overcome financial barriers to clean energy development.

FUNDING TYPES
IRENA provides technical assistance and capacity building, ADFD provides concessionary loans.

WEBSITE
adfd.irena.org

SUMMARY
The International Renewable Energy Agency (IRENA) and the ADFD have collaborated to create a joint Project Facility to finance transformative and replicable renewable energy projects in developing countries. The facility involves IRENA selecting and recommending promising renewable energy projects in developing countries. ADFD then offers soft (concessional) loans to these projects worth USD 350 million over seven annual cycles. Project eligibility includes membership in IRENA or similar agreements, renewable energy projects as defined by IRENA, supported by the host nation government, advanced past the feasibility stage, and provide socioeconomic and environmental benefits.

The first project selection cycle commenced in November 2012. Since January 2014, USD 189 million of ADFD loans have already been allocated to 19 renewable energy projects recommended by IRENA. Over USD 387 million has been leveraged through other funding sources to cover the rest of the project costs.

EXAMPLES
Ecuador, Tigrero Small Hydropower Project:
Small hydro project will bring clean energy to schools and medical facilities for Tigrero's rural community and reduce emissions by 4,213 tonnes per year.

Republic of the Marshall Islands, Renewable/Hybrid Microgrid Portfolio:
A transformative and potentially replicable 4.6 MW project will implement solar PV microgrids with advanced lithium-ion battery storage on four islands mitigation 5,000 tonnes of CO_2 emissions per year.

Other relevant projects are presented at: adfd.irena.org/Projectselected.aspx

XX. PACIFIC ENVIRONMENT COMMUNITY (PEC) FUND

ADMINISTERED THE PACIFIC ISLAND FORUM SECRETARIAT

PURPOSE

To install renewable energy and sea water desalination projects to solve energy and drinking water problems.

FUNDING TYPES

Grants for solar power generation systems and sea water desalination plants or a combination of both.

WEBSITE

www.forumsec.org/pages.cfm/strategic-partnerships-coordination/pacific-environment-community-pec-fund

SUMMARY

In May 2009 at the 5th Pacific Islands Leaders Meeting Forum, summit leaders launched of the Pacific Environment Community (PEC) Fund. Japan agreed to provide approximately USD 66 million to Forum Island Countries (FIC) to tackle environmental issues. Each FIC is provided with an indicative allocation of USD 4 million to support projects with a focus on the provision of solar power generation systems and sea water desalination plants, or a combination of both.

The Pacific Islands Forum Secretariat manages and administers the PEC Fund in accordance with the agreed PEC Fund Guidelines and Project Procedures. The PEC Fund has an established governance structure comprising a Joint Committee (JC), Project Management Unit and Technical Advisory Group. Access to the PEC Fund is a country-led process. Each FIC refers to the PEC Fund Project Procedures to guide the development of their proposal submissions. If a detailed project proposal is approved by the JC, the Pacific Islands Forum Secretariat then enters into a Financing Agreement with the recipient FIC to enable project implementation.

EXAMPLES

Nauru Sea Water Desalination and Solar Energy System

The project involves the supply and installation of a 131 kWp solar PV system (131.94 kWp grid-tie solar power generation system) and a desalination plant that will produce 100 m3/day of safe water. It is expected that the solar power generation system can meet 1.3 per cent of the energy demand in Nauru, doubling the existing energy production from solar energy. The lead time for RO water delivery is expected to reduce to three weeks with the addition of the proposed RO plant. The solar RO plant will be handed over to Nauru Utilities Authority (NUA) for continued operation and maintenance of the solar RO plant once installed. Nauru has identified Hitachi Plant Technologies Ltd as the Japanese Company. The project is expected to benefit the entire population of approximately 10,000 residents in Nauru by improving the energy and water supply. Installation of the solar power system and sea water desalination plant was completed in 2013 and the system is currently in use.