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DOMINICAN REPUBLIC

FEASIBILITY STUDY ON THE USE OF SUSTAINABLE AVIATION FUELS

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

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EXECUTIVE SUMMARY

The International Civil Aviation Organization (ICAO) is a United Nations agency working together with its 191 Member States and industry groups to reach consensus on international civil aviation Standards and Recommended Practices and policies in support of a safe, efficient, secure, economically sustainable and environmentally responsible international civil aviation sector.

In its efforts to help reduce carbon dioxide (CO_2) emissions, ICAO has developed partnerships with international organizations and states to develop assistance projects and promote a basket of measures designed to support member States as they work to achieve the global aspirational goals. These goals, adopted by the 37th Session of the Assembly in 2010, are to improve fuel efficiency by two per cent per year from 2020 and to keep net CO_2 emissions at the same levels (i.e. carbon neutral growth from 2020).

The ICAO-European Union project on Capacity Building for CO_2 Mitigation from International Aviation is the first ICAO assistance project on environment that provides selected Member States guidance and training to develop the States' action plans on CO_2 emissions reductions, a robust and fully operating CO_2 monitoring system, and assistance for the successful implementation of mitigation measures, including the coordination of stakeholders, preparation of feasibility studies, and facilitation to access financial resources through partnerships with interested parties. The Dominican Republic is one of fourteen Members States from Africa and the Caribbean selected to participate in this assistance project.

To contribute to the achievement of these international goals, the Dominican Republic has defined an Action Plan for CO_2 Emissions Reduction (APER), wherein one promising measure that has been identified is the development and use of sustainable aviation fuels (SAF), that can reduce life-cycle CO_2 emissions compared to conventional jet fuel.

Sustainability is a crucial element in the development of SAFs, such that during their production and use, the fuels do not produce negative environmental or social impacts, and should deliver a reduction in carbon emissions (greenhouse gases).

Aviation's focus is on "drop-in" fuels, a substitute for conventional jet fuel, that is completely interchangeable and compatible with conventional jet fuel. A drop-in neat fuel does not require adaptation of the aircraft/engine fuel system or the fuel distribution network, and can be used "as is" on currently flying turbine-powered aircraft in pure form and/or blended in any amount with other drop-in neat, drop-in blend, or conventional jet fuels (ICAO, 2017). Currently, there are five technologies or pathways that can transform biomass into drop-in fuels: Fischer-Tropsch (FT), Fischer Tropsch with aromatics, HEFA (can be blended up to 50 per cent in volume), Synthetic Iso-Paraffins (SIP) (blended up to 10 per cent) and Alcohol to Jet (ATJ) (blended up to 30 per cent).

For a country like the Dominican Republic, rich on sugarcane production, a sustainable pathway could be implemented using the SIP and ATJ technologies. Different scenarios using these technologies are presented in this report.

The highly regulated hydrocarbon fuels in the Dominican Republic make it simpler to implement a blending obligation for fuel suppliers that can guarantee demand, and further justifies the installation of a potential biorefinery in the country. This feasibility study report shows that such a model could be economically feasible, producing economic and social benefits in poor rural regions.

The stakeholders in the Dominican Republic have shown a great interest in this feasibility study developed within the ICAO – European Union project framework, as well as a predisposition to its implementation. The close collaboration among all the stakeholders, and in particular, the collaboration between the public and private sectors, will be critical to implementing a work plan for the deployment of a value chain for SAFs in the Dominican Republic. The progress being made by the Dominican Republic in this regard, exemplified by the collaboration agreement signed by key stakeholders, is an important example of their commitment to the production and use of SAFs.

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ABBREVIATIONS & DEFINITIONS

AAF Alternative Aviation Fuel
ACI Airports Council International
AES Aviation Environmental System
AFQRJOS JIG Aviation Fuel Quality Requirements for Jointly Operated Systems
AFTF ICAO CAEP Alternative Fuels Task Force
ANSP Air Navigation Service Provider
APER Action Plan on Emissions Reduction
APU Auxiliary Power Unit
ASTM ASTM International, standardization body that develops standards for civil aviation fuel that are recognized by the main Original Equipment Manufacturers (OEMs)
ATAG Air Transport Action Group
ATJ Alcohol to Jet (also used as AtJ)
AVGAS Aviation gasoline for piston engine aircraft
AVTUR Fuel for turbofans, usually Jet A1
bb barrels (Mbb: million barrels, also BBL or BB, b).
1 barrel = 43 US gal ~ 164 litres
CAA Civil Aviation Authority
CAEP Committee on Aviation Environmental Protection
CDM Clean Development Mechanism
CH Catalytic Hydrothermolisis
CNE National Energy Commission
CNCCMDL National Council on Climate Change and Clean Development Mechanism
CO Carbon monoxide
CO_2 Carbon dioxide
CoQ Certificate of Quality
CoSu Certificate of Sustainability
DEF STAN Defence Standard, United Kingdom body responsible for procedures and guidance on standardization issues, both nationally and internationally
DGII Directorate General of Internal Taxes
dLUC Direct Land Use Change
DRAPER Dominican Republic Action Plan on CO_2 Emissions Reduction
EU RED European Union Directive 2009/28/EC on the promotion of the use of energy from renewable sources, also called Renewable Energy Directive (RED)
EU European Union
FT Fischer-Tropsch, technology to produce fuels based on a syngas
gal (unit) gallon(s), usually noted as US gal
(1 US gal = 3.78541 litres)
GFAAF Global Framework for Aviation Alternative Fuels
GHG Greenhouse gas
GMBM Global Market Based Measure
GTAP Global Trade Analysis Project Model
GSE Ground Support Equipment
HDCJ Hydrotreated Depolymerized Cellulosic jet (liquefaction pyrolysis process)
HEFA Hydrotreated Esters and Fatty Acids, technology to produce fuels based on hydrotreatment of oil fractions, from animal or vegetal sources.
IATA International Air Transport Association
ICAO International Civil Aviation Organization
IDAC Dominican Institute of Civil Aviation
IDIAF Dominican Institute of Agricultural and Forest Research
iLUC Indirect (or induced) Land Use Change
IPCC Intergovernmental Panel on Climate Change
IPP Import Parity Price
JIG Joint Inspection Group. Set of standard/guidelines established by jet fuel infrastructure owners that dictate the operation of jet fuel at shared fuel infrastructures.
LCFS Californian Low-Carbon Fuel Standard
LHV Low Heating Value (energy content value)
LUC (direct) Land Use Change
MBM Market-based measure
MIC Ministry of Industry and Commerce
MoU Memorandum of Understanding
MSW Municipal solid waste
NOx Nitrogen oxides
OEM Original Equipment Manufacturer, representing in this document the aircraft and its equipment manufacturers, such as Airbus, Boeing, Embraer, Pratt & Whitney, Rolls-Royce, etc.
PAS Publicly Available Specification.
PBioC Final Price of the local Bio Fuel according to the Law 57-07.
OPEX Operational Expenditures
PM At the engine exhaust, particulate emissions mainly consist of ultrafine soot or black carbon emissions. Ultrafine particulate matter (PM) emissions are known to adversely impact both health and climate (ICAO, 2016b)
SAF Sustainable Aviation Fuel
SAFUG Sustainable Aviation Fuel Users Group
SCRC Special Circumstances and Respective Capabilities
SIP Synthetic Iso-paraffin from Fermented Hydroprocessed Sugar, formerly known as Direct-Sugar-to-Hydrocarbons (DSHC).
SOx Sulphur oxides
SPK Synthetic Paraffinic Kerosene
UN United Nations
UNFCCC United Nations Framework Convention on Climate Change

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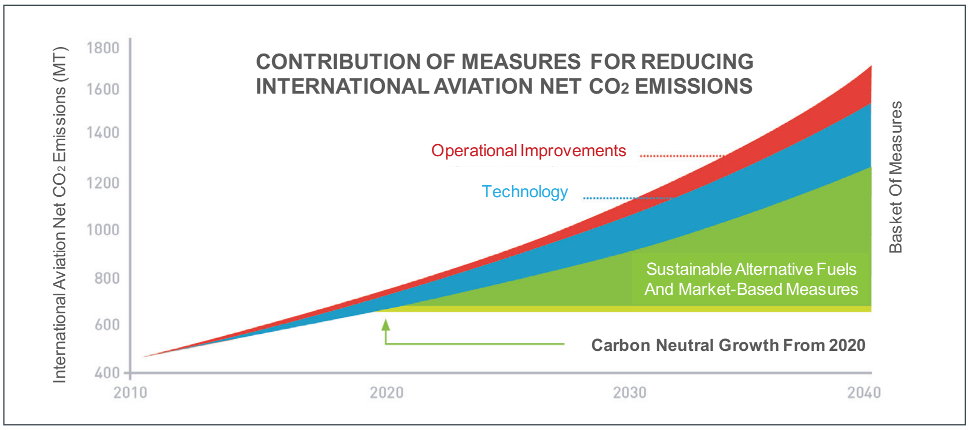
1. INTRODUCTION

International aviation emissions currently account for 1.3 percent of total global anthropogenic CO_2 emissions, and this is projected to increase as a result of the continued growth of air transport. ICAO and its member States recognize the critical importance of providing continuous leadership in order to limit or reducing its emissions that contribute to global climate change. The ICAO 39th Assembly reiterated the global aspirational goals for the international aviation sector of improving fuel efficiency by 2 per cent per annum and keeping the net carbon emissions from 2020 at the same level, as established at the 37th Assembly in 2010, and recognized the work being undertaken to explore a long-term global aspirational goal for international aviation in light of the 2°C and 1.5°C temperature goals of the Paris Agreement. The ICAO 39th Assembly also recognized that the aspirational goal of 2 per cent annual fuel efficiency improvement is unlikely to deliver the level of reduction necessary to stabilize and then reduce aviation's emissions contribution to climate change. More ambition goals are needed to deliver a sustainable path for aviation.

To achieve international aviation's global aspirational goals, as shown in Figure 1, a comprehensive approach, consisting of a basket of measures including technology and standards, sustainable aviation fuels (SAFs), operational improvements and market-based measures to reduce emissions is necessary.

FIGURE 1

Contribution of measures for reducing international aviation CO_2 emissions[1]. Source: ICAO Environmental Trends (GFAAF, 2016)



Mitigating the release of CO_2 emissions into the atmosphere is the main incentive for promoting the use and deployment of SAFs in aviation. CO_2 is emitted from the combustion of SAFs; however, this carbon came from plants and then will be absorbed by plants in a closed loop. Since that CO_2 is re-absorbed, SAF provides an environmental benefit on a life cycle basis, as opposed to the combustion of conventional jet fuel. Depending on the SAF pathway, SAF can provide up to an 80 per cent reduction in emissions compared to conventional jet fuel.

Beyond CO_2 emissions reductions, there could also be additional benefits, such as promoting new domestic industries and production systems, improving the competitiveness of the aviation and tourism sectors in the State in the long-term, and improving the local air quality by decreasing the particulate matter (PM)[2] emitted by aircraft (Christie, 2016).

With the interconnection between energy and sustainable development, bioenergy[3] is a prime example of how energy can link with other areas, including water quality and availability, ecosystems, health, food security, and education and livelihoods, and can harness multiple benefits, insofar as the development is properly planned and managed. Through the use of alternative fuels for transportation and bioelectricity, the development of sustainable and modern bioenergy can be promoted both on a small-scale for local use in stand-alone applications or mini-grids, as well as on a large-scale, for production and commoditization of bioenergy. At the same time, modern bioenergy can replace inefficient and less sustainable bioenergy systems (Nogueira, et al., 2015).

The Government of the Dominican Republic supported by the ICAO – European Union project updated and submitted an improved State Action Plan to reduce CO_2 emissions from International Aviation in 2015. The Dominican Republic Action Plan for CO_2 Emissions Reduction (DRAPER) provides a comprehensive approach with a basket of measures for the Dominican Republic to reduce aviation CO_2 emissions, including the initiative to explore the feasibility to develop and use of sustainable aviation fuels.

The following feasibility study is a result of ICAO – European Union support for the Dominican Republic's determination to contribute towards the sustainable development of its aviation sector, and specifically assessing the use of sustainable aviation fuels, including sustainable fuels for Ground Support Equipment (GSE). The main objective of this study is to provide a comprehensive overview on the potential for production and use of socially acceptable, environmentally friendly, and economically viable drop-in SAFs and sustainable fuels for GSE in the Dominican Republic. The findings presented will be those that could offer the greatest benefit to society and the environment, and that concur with the direction the National Government is taking to fulfil its responsibilities under the ICAO Assembly and the INDCs determined by the Paris Agreement.

1.1 ICAO AND ENVIRONMENT

The International Civil Aviation Organization (ICAO) is a UN specialized agency, established by States in 1944 to manage the administration and governance of the Convention on International Civil Aviation (Chicago Convention).

ICAO works with the Convention's 192 Member States and industry groups to reach consensus on international civil aviation Standards and Recommended Practices (SARPs) and policies in support of a safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector. These SARPs and policies are used by ICAO Member States to ensure that their local civil aviation operations and regulations conform to global norms, which in turn permits more than 100,000 daily flights in aviation's global network to operate safely and reliably in every region of the world[4].

During the 37th ICAO Triennial Assembly Session in 2010, Member States agreed to the collective global aspirational goals for the international aviation sector of improving fuel efficiency by two per cent per year from 2020 and keeping net CO_2 emissions at the same levels (i.e. carbon neutral growth from 2020). In order to achieve such goals, ICAO Assembly adopted a "basket of measures" to reduce aviation CO_2 emissions consisting of the following four categories[5] of mitigation measures:

1. Aircraft related technology and standards
2. Improved air traffic management and operational improvements
3. Development and deployment of sustainable alternative fuels
4. Market-based measures

ICAO launched a voluntary programme inviting States to develop a State Action Plan on CO_2 emissions reduction from international aviation incorporating the above mitigation measures through its implementation. This programme encourages States to report their CO_2 mitigation activities to ICAO and promotes improved communication on environmental matters within the aviation industry. SAFs were identified as an important mitigation measure to help States achieve ICAO's aspirational goals including Carbon Neutral Growth[6]. The specific focus of SAFs is on "drop-in fuels", which are fuels fully compatible with fuel certification requirements, existing fuel transport, distribution and storing infrastructure, as well as current aircraft engines. They are handled in exactly the same way as conventional jet fuel. ICAO is actively engaged in activities to promote and facilitate the emergence of drop-in SAFs by exchanging and disseminating information, fostering dialogue among States and stakeholders, and carrying out dedicated work as requested by ICAO Member States to inform decision making[7].

[1] ICAO Environment: GFAAF - Aviation Alternative Fuel Live Feed. Retrieved from https://www.icao.int/environmental-protection/GFAAF/Pages/default.aspx

[2] At the engine exhaust, particulate emissions mainly consist of ultrafine soot or black carbon emissions. Ultrafine particulate matter (PM) emissions are known to adversely impact both health and climate (ICAO, 2016b).

[3] Bioenergy refers to the energetic use out of a material of biological origin, such as biomass or biofuels.

[4] ICAO: About ICAO. Retrieved from http://www.icao.int/about-icao/Pages/default.aspx

[5] ICAO DOC 9988 - Guidance on the Development of States' Action Plans on CO2 Emissions Reduction Activities, paragraph 1.1.2. Order Number: 9988, ISBN 978-92-9249-223-6. March 17th, 2014.

[6] For more information on ICAO's Aspirational Goals, refer to http://www.icao.int/annual-report-2013/Pages/progress-on-icaos-strategic-objectives-strategic-objective-c1-environmental-protection-global-aspirational-goals.aspx

[7] ICAO Environment: Alternative Fuels: Questions and Answers. Retrieved from http://www.icao.int/environmental-protection/Pages/AltFuel-IcaoAction.aspx

ICAO Environment, within ICAO's Air Transport Bureau, provides guidance and support to Member States in their efforts to improve the environmental performance of aviation. ICAO developed a "range of Standards and Recommended Practices (SARPs), policies and guidance material for the application of integrated measures"[8] to achieve the following three main goals adopted by ICAO in 2004:

a) limit or reduce the number of people affected by significant aircraft noise;
b) limit or reduce the impact of aviation emissions on local air quality; and
c) limit or reduce the impact of aviation greenhouse gas emissions on the global climate.

The Committee on Aviation Environmental Protection (CAEP), a technical committee of the ICAO Council, is undertaking most of this work, assisting the ICAO Council in "formulating new policies and adopting new SARPs related to aircraft noise and emissions, and more generally to aviation environmental impact[9]. This technical committee is constituted by 24 Member States and 16 Observers from States and international organizations representing environmental interest of the aviation sector.

In addition to the work being carried out by CAEP, several tools and documents have been developed to assist participating States reach their emissions reductions goals, many of which are publically available at ICAO's website[10]. The following documents and tools are accessible specifically to support the Member States pursue State Action Plans[11] :

i. ICAO Doc 9988 - Guidance Document for the Development of States' Action Plans - Includes step-by-step guidance on the baseline scenario calculation, the basket of mitigation measures and the quantification of selected measures.
ii. Environmental Benefits Tool - Provides a framework to automatize the calculation of the baseline CO_2 emissions in international aviation, and the estimation of expected results obtained through the implementation of mitigation measures selected in ICAO's basket of measures.
iii. ICAO Carbon Emissions Calculator - Allows the States to estimate the CO_2 emissions attributed to air travel, using only a limited amount of input information.
iv. ICAO Fuel Savings Estimation Tool (IFSET) - Can be used to estimate fuel savings obtained through operational measures in a manner consistent with approved models.
v. ICAO Green Meetings Calculator - Can be used to support decision-making by selecting meeting location with minimum CO_2 footprint from air travel.
vi. Action Plan on Emissions Reduction (APER) website - Interactive website reserved to States' action plan focal points to assist them prepare and submit their Action Plans to ICAO.
vii. Aviation Environmental Systems (AES) - An efficient CO_2 emissions monitoring system for international aviation developed in each selected Member State.

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

On 17 December, 2013, ICAO and the European Union (EU) signed an agreement to implement an assistance project: Capacity Building for CO_2 Mitigation from International Aviation, to assist fourteen selected States in reducing CO_2 emissions from the aviation sector. Dominican Republic is one of the States emissions selected for inclusion in this programme.

The ICAO-European Union agreement on Capacity Building for CO_2 Mitigation from International Aviation, a subcomponent of ICAO Environment, is a four year program to support fourteen selected Member States in Africa and the Caribbean. It offers guidance, resources to prepare feasibility studies, and access to financial resources through partnerships with interested parties in support of the implementation of mitigation measures described in their Action Plans. The overarching objective is to contribute to the mitigation of CO_2 emissions from international aviation by implementing capacity building activities that will support the development of low carbon air transport and environmental sustainability . This program focuses on the following three areas of activity:

a) Improve capacity of the national civil aviation authorities to develop their Action Plan on CO_2 emissions reduction from international aviation;
b) Develop and efficient CO_2 emission monitoring system for international aviation in each selected Member State; and
c) Identify, evaluate, and partly implement priority mitigation measures, specifically those measures included within the States' Action Plans that can be replicated by other States.

The model can be replicated and adapted to additional countries creating a global system of cooperation to take actions to reduce CO_2 emissions.

1.3 AVIATION FUEL DEMAND IN DOMINICAN REPUBLIC

According to the Ministry of Industry and Commerce of the Dominican Republic, jet fuel demand (AVTUR) in the Dominican Republic reached almost 400,000 tonnes per year in 2015, meaning that the Dominican Republic's aviation sector is responsible for over 1.2 million tonnes of CO_2 per year. This figure includes all flights departing from the Dominican Republic without distinction of national or foreign airlines, and/or domestic or international flights. It also refers to supplied fuel, and not to actual consumption per flight.

From 2013 to 2014, the aviation sector in the Dominican Republic grew at a rate of 10.1 per cent in the number of passengers and at rate of 12.7 per cent in the number of flights (IDAC, 2015); this growth is expected to significantly increase the volume of jet fuel required in the coming years, as shown in Figure 2.

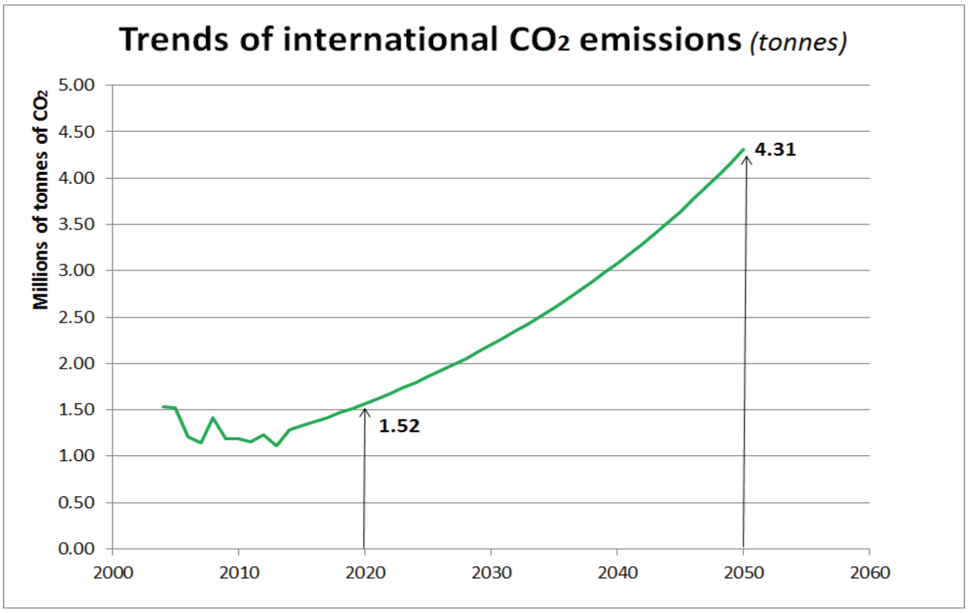


FIGURE 2

Trends of CO_2 emissions from international aviation in the Dominican Republic according to the IPCC[12] definition of international flights (IDAC, 2015).

According to IDAC data, the Dominican Republic receives from 6 million to 12 million tourists transported every year (IDAC, 2015), and there is a governmental goal of reaching at least 10 million tourists per year, by 2022. Importantly, alternative fuels offer a viable option for reducing CO_2 emissions from the aviation sector, without impacting the number of operations and allowing for the growth in tourism.

For the purpose of this feasibility study, a growth in air traffic, in terms of revenue tonne kilometres (RTK), directly resulting in a fuel consumption increase of a 5.2 per cent for the region, was considered (ICAO, 2011). This has been modulated considering the fuel efficiency targeted by ICAO of a 2 per cent annual improvement (ICAO, 2010), as measures (e.g. aircraft technology) other than alternative fuels are expected to be put in place. This would translate to a demand for 1.1 million tonnes of aviation jet fuel in 2050, equivalent to the emission of 3.4 million tonnes of CO_2.

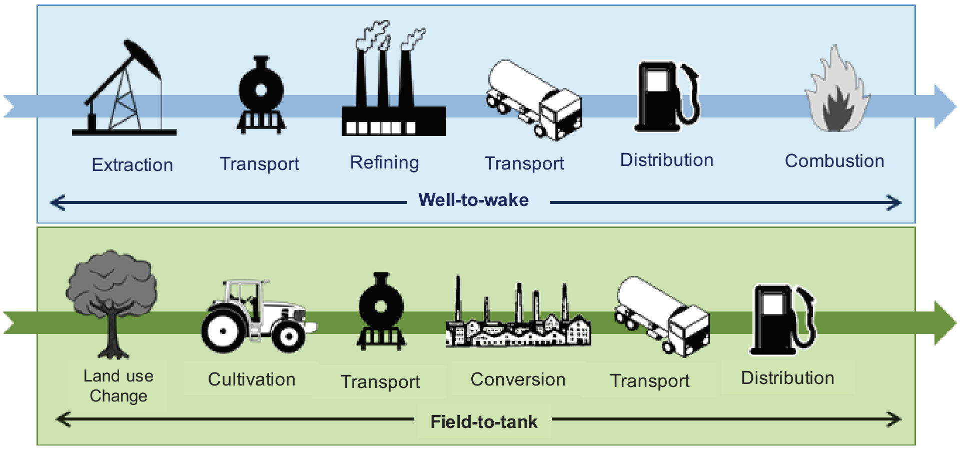
[8] ICAO Environment: Environmental Protection. Retrieved from http://www.icao.int/environmental-protection/Pages/default.aspx
[9] ICAO Environment: Committee on Aviation Environmental Protection (CAEP). Retrieved from http://www.icao.int/ENVIRONMENTAL-PROTECTION/Pages/CAEP.aspx
[10] ICAO Environment: Retrieved from http://www.icao.int/environmental-protection/Pages/default.aspx
[11] ICAO Environment: Retrieved from http://www.icao.int/environmental-protection/Pages/default.aspx
[12] The IPCC defines an international flight as any flight that departs from one State and arrives in another, irrespective of the nationality of the air carrier.

2. THE SUSTAINABILITY CONCEPTS

The multiple steps from feedstock production to final combustion of a fuel, constitute its life-cycle. To assess the emissions savings from the use of alternative fuels, a comprehensive accounting must be done of all emissions across all steps of the fuel's life-cycle, called a life-cycle analysis. 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 (GFAAF, 2016).

FIGURE 3

Fuel life-cycle emissions for fossil and biofuel (GFAAF, 2016).



For the aviation industry, assessing fuel life-cycle GHG emissions is a particular topic for which increased harmonization amongst aviation stakeholders is important. Therefore, the Alternative Fuels Task Force (AFTF) was created within the ICAO Council technical Committee on environment, the Committee on Aviation Environmental Protection (CAEP)[13] , and one of the tasks assigned was to develop a methodology to assess life-cycle emissions of sustainable aviation fuels.

When assessing the potential GHG savings of a fuel pathway, one key element to assess is land use change (LUC). Land-use changes can lead to CO_2 emissions or sequestration due to carbon stock[14] 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 direct land use change, but which occurs outside the product system being assessed" (ISO, 2013). Unlike dLUC, iLUC cannot be directly measured or observed; instead, it is projected with economic models which are only able to capture both effects together.

Feedstocks that do not require land for their production (such as municipal 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-04-001 have the ability to certify that a feedstock's production has a low iLUC risk. The AFTF is also undertaking work to define a methodology for the calculation of iLUC.

Induced land use change is defined as the sum of indirect and direct land use change. The quantification of induced LUC values is one of the main areas of work under CAEP AFTF. These values will be used to report SAF emissions in the ICAO Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

Overall, the sustainability of alternative fuels is broader than the life-cycle emissions. There are growing social and economic concerns over the sustainability of SAFs, which requires the appropriate tools to inform decision making. In this regard, the AFTF has been tasked with developing environmental, social, and economic sustainability criteria for the inclusion of SAFs in the CORSIA.

3. TECHNOLOGIES FOR SAF PRODUCTION

The commercial aviation industry adopts rigorous safety standards and procedures in its equipment, operation, and maintenance, with indicators closely monitored. Thus, also taking into consideration that aircraft can be fuelled in different States, international specifications have been adopted for jet fuels. Two of the more widely utilized standards to define the kerosene-type fuel for aircraft are the ASTM D1655 and the DEF STAN 91-91, setting requirements for composition, volatility, fluidity, combustion, corrosion, thermal stability, contaminants, and additives, among others. Moreover, the specifications produced by the Joint Inspection Group (JIG) Check List are relevant for supply into Jointly Operated Fuelling Systems[15]. The JIG Aviation Fuel Quality Requirements for Jointly Operated Systems (AFQRJOS) combines the most stringent requirements of DEF STAN 91-91 and ASTM D1655 (Chuck, 2016).

Under these conditions, the essential concept of 'drop-in' fuel was developed. A 'drop-in' neat jet fuel is defined by ICAO CAAF/2 WP/3 (2017) as:

a substitute for conventional jet fuel, that is completely interchangeable and compatible with conventional jet fuel. A drop-in neat fuel does not require adaptation of the aircraft/engine fuel system or the fuel distribution network, and can be used "as is" on currently flying turbine-powered aircraft in pure form and/or blended in any amount with other drop-in neat, drop-in blend, or conventional jet fuels (ICAO, 2016).

Therefore, the drop-in condition is a major requirement for the aviation industry. Any 'non drop-in' aviation alternative fuel[16] would present safety issues associated with risks of mishandling, and would require a parallel infrastructure to be implemented in all connected airports, creating unnecessary risks and costs (GFAAF, 2016).

The ASTM D7566 standard regulates which technologies, under which circumstances and characteristics, can be used for producing fuels that are considered compliant with ASTM D1655 (standard regulating Jet A1 – AVTUR fuels) and therefore with DEF STAN 91-91, indirectly. DEF STAN 91-91 includes a clause in its Annex D, which indicates that the use of alternative fuels is accepted as JetA1, provided that it complies with the ASTM D7566 standard.

Table 1 shows five technologies or pathways that can currently produce drop-in SAFs. These technologies are Fischer-Tropsch (FT), Fischer-Tropsch containing aromatics (FT-SKA), HEFA (these three can be blended up to 50 per cent in volume), Direct Sugars to Hydrocarbons producing Synthetic Iso-Paraffins (SIP) (blended up to 10 per cent), and Alcohol to Jet (blended up to 30 per cent). Many additional technologies are under evaluation by ASTM.

Technology	Maximum blend (v/v)	Feedstocks (examples)
Fischer-Tropsch (FT) & (FT-SKA)	50%	Wastes (as MSW), coal, gas, sawdust…
Hydroprocessed Esters and Fatty Acids (HEFA)	50%	Palm oil, camelina oil, jatropha oil, used cooking oil…
Synthetic Iso-Paraffin (SIP)	10%	Sugarcane, sugar beet
Alcohol To Jet (ATJ) (from isobutanol)	30%	Sugarcane, sugar beet, sawdust, lignocellulosic residues (i.e. straw)

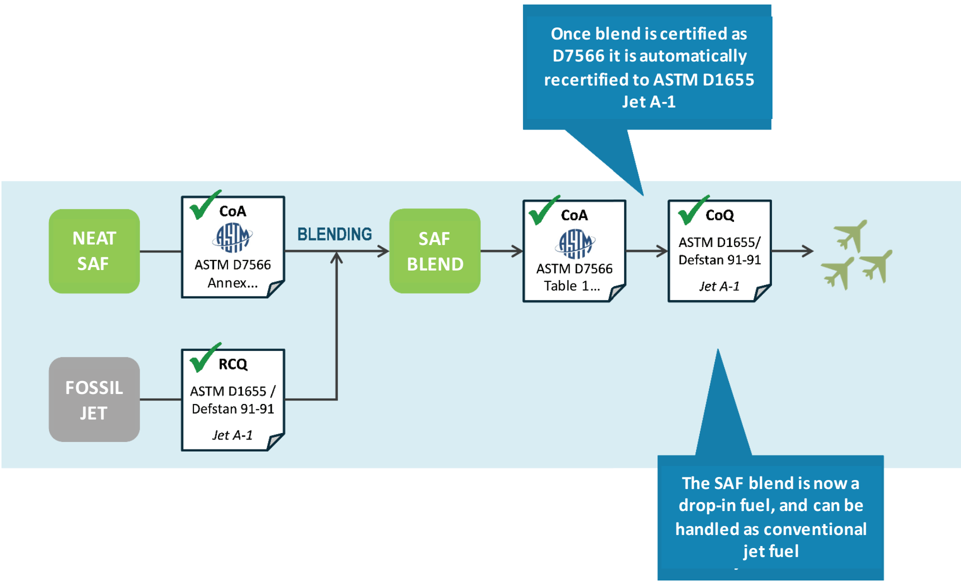
TABLE 1
Current technologies, maximum blend allowed and most common feedstocks for drop-in alternative fuels for aviation (Adapted from ICAO CAAF/2-WP/7).

[13] https://www.icao.int/ENVIRONMENTAL-PROTECTION/Pages/CAEP.aspx
[14] 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.
[15] Jointly Operated Systems are joint venture locations where jet fuel is supplied.
[16] Biodiesel/FAME or bioethanol are common examples of 'non drop-in' fuels.

ASTM D7566 defines the requirements for the neat product (i.e., SAF) and the blend. Once the blend has been certified against ASTM D7566, it is a drop-in, and can be considered conventional Jet A1 as per the standards ASTM D1655 and DEF STAN 91-91. Figure 4 illustrates the blending and use process for synthetic SAFs and the different quality standards SAFs meets at different steps. The blend ratio refers to the final product (that is considered 'drop-in') to be introduced to the market. The ASTM standards mark a maximum; however, lower blends can also be certified. Every AAF batch needs to be analysed and certified at the point of origin (where it is blended). Only after being certified can the fuel be considered and treated in the same way as any conventional jet fuel (i.e. being mixed in the airport fuel farm tanks). Therefore, an appropriate storage facility is required, where the blended batch can be stored separately from other batches until the certification has been completed[17].

FIGURE 4

Diagram showing the blending and use process for the synthetic fuels (in this case AAF) and the different quality standards AAF meets at different steps[18] (Source: ICAO).



Another key element to be considered regarding the AAF blending process is to find the suitable fossil blending component. As not only the pure AAF, but the final blend need to meet certain properties, the fossil blending component should have a high aromatics content. While jet fuel standards do not require a minimum content of aromatics for fossil jet (ASTM D1655/DEF STAN 91-91), they (ASTM D7566) do establish a minimum content of aromatics of 8 per cent for blends containing AAF. As most AAF types (except FT-SKA) do not contain aromatics, the aromatics content in the fossil blending component needs to be at least 16 per cent for blend ratios of 50/50, in order to achieve at least 8 per cent aromatics content in the final blend to be certified (ASTM D7566).

The performance of these blended fuels has been tested and has already been demonstrated through several thousand commercial flights worldwide[19]. In addition, that there are currently three airports distributing alternative fuel to aircraft on a regular basis, is significant: aviation alternative fuels are blended directly into the fuel farm and hydrant systems at Oslo (OSL/ENGM) and Stockholm (ARN/ESSA) airports; and SAFs are supplied to United Airlines flights at Los Angeles (LAX/KLAX) airport.

Even though the number of production facilities is still limited for these new technologies, new plants are under development, as a result of government policies and the off-take agreements established between producers and airlines (Table 2). Although there are no registered SAF flights to or from the Dominican Republic, some of the airlines that have used SAF and/or established agreements for SAF purchase, such as Air France-KLM, United Airlines or JetBlue, frequently fly to the Dominican Republic. The continuously growing number of projects and off-take agreements is a clear indicator that the SAF sector is rapidly growing and that it will continue developing.

A SAF's refinery is a long-term investment; therefore, longstanding strategies need to be considered in the decision concerning its implementation. The establishment of a new facility can only be made after a certain period of preparation, including ensuring the appropriate feedstock supply, the definition of the project and implementation and testing. Based on previous projects (as in Table 2), this process could potentially take longer if the feedstock is new or not sufficiently known in the area.

TABLE 2 List of main companies producing or aiming to produce aviation alternative fuels at commercial scale and off-take agreements announcements by the end of 2016 (ICAO, 2017b)

Process	Producer	Feedstock	Offtaker(s)	Amount	Years
FT	RedRock	woody biomass	Southwest	3M gpy	**7**
	RedRock	woody biomass	FedEx	3M gpy	**7**
	Fulcrum	municipal solid waste	United	90-180M gpy	**10**
	Fulcrum	municipal solid waste	AirBP	50M gpy	**10**
	Fulcrum	municipal solid waste	Cathay Pacific	37.5M gpy	**10**
HEFA	AltAir	agricultural wastes; non-edible natural oils	United	5M gpy	**3**
	AltAir	agricultural wastes; non-edible natural oils	SkyNRG / KLM	esti. 5M gpy	**3**
	Neste / AltAir	oils	SkyNRG / Oslo Airport / KLM / SAS / Lufthansa / AirBP	AirBP >330K gpy	**esti. 3**
	AltAir	agricultural wastes; non-edible natural oils	World Fuel Services / Gulfstream	esti. 5M gpy	**3**
	SG Preston	biomass (canola, rapeseed, brassica)	JetBlue	33M gpy	**10**
SIP	Total /Amyris	sugarcane	Cathay Pacific	esti. 2M gal	**2**
ATJ	Gevo	renewable isobutanol from carbohydrates	Lufthansa	up to 40M gal	**5**

This list only includes projects for the technologies currently included in the ASTM D7655.
M gal = Million US gallons, M gpy = Million US gallons per year.

[17] Continuous blending systems, where blending is done at the pipeline directly, and not in a tank, cannot be used for AAF blend-ing as the blended batch needs to be certified at the point of origin before coming into contact with any other batch. These sys-tems are sometimes used for other fuels like bioethanol because the only key parameter to ensure is the blend ratio; such systems cannot be applied to AAF.
[18] RCQ - Refinery Certificate of Quality. CoA - Certificate of Analysis. CoQ – Certificate of Quality.
[19] http://www.icao.int/environmental-protection/GFAAF/Pages/default.aspx

4. FEEDSTOCK

One of the primary criteria for assessing the feasibility of the local production of alternative fuels relates to access to adequate feedstock. A stable, reliable and cost-competitive supply of sustainably obtained feedstock is key for any SAF production facility. When the feedstock can be produced locally, there are additional local benefits (wages, taxes, rural development, etc.) that are highly valuable.

The feedstocks that can be used with the currently approved refining technologies are diverse. Almost any biomaterial can be used; yet, depending on the feedstock type, it could involve more or less pre-treatment and cost.

Vegetable oils constitute the feedstock type that can most easily be converted into fuel. However, the vegetable oil potential for use in fuel in the Dominican Republic is quite low, where the available volumes are more suitable for the production of biodiesel in small facilities.

Algae have not been considered as feedstock in this study, because production of fuel from this source has been found to be uneconomical in most bioenergy applications. Moreover, it is still in an early developmental stage. However, algae could be explored as an interesting feedstock in the future for Dominican Republic, due to territorial and weather conditions.

In the Dominican Republic, accessible volumes of unused wastes, including municipal solid wastes (MSW), are not available in sufficient quantities. The production of MSW is dispersed and lacks gathering systems in most rural areas. The main agricultural residues (in volume) are currently being used for other purposes (i.e., power generation). Therefore, in terms of the currently available technologies, wastes have not been considered as a viable feedstock for aviation alternative fuels production in the country. However, its potential should be monitored in the future, considering the changes in population, waste management, and industry. For the Dominican Republic, being an island, the management of wastes could become an environmental issue in the medium-term, which the production of sustainable aviation fuels could address, provided that the appropriate technologies are available.

Evidenced by its historic production, despite of the current potential for the feedstocks mentioned above being limited, the Dominican Republic has a significant potential for the production of SAF from sugarcane, that has being declining for the last 30 years (Figure 5). This production of sugarcane could be renewed to produce SIP or ATJ alternative aviation fuels.

In addition to the amount of land potentially available for sugarcane cultivation, it is concentrated in a region located between the major Dominican airports. This strategic location would help increase the efficiency of a new refinery for subsequent transportation and distribution, supported by the availability of storage in the port area of San Pedro de Macorís.

The aviation industry considers that it is crucial to avoid negative impacts from the cultivation of alternative fuel feedstocks, including competition with food. To avoid direct or indirect negative effects, fuel producers can take part in existing voluntary sustainability standards (i.e., RSB, ISCC, BONSUCRO, etc.). To the extent possible, the ICAO sustainability standard to be included in the CORSIA will build upon these existing requirements.

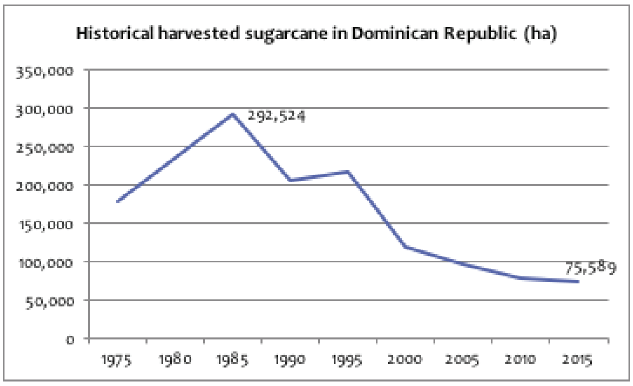


FIGURE 5

Changes in the surface of sugarcane crop considering the harvested sugarcane areas. Data obtained from INAZUCAR (www.inazucar.gov.do)

As Figure 5 indicates, in the last few years, sugarcane production in the Dominican Republic has experienced a rapid decline. The uniqueness of the crop makes it difficult to repurpose the land[20]; thus most abandoned sugarcane plots have no other productive uses, except perhaps low quality grazing. This has been pointed out by most of the stakeholders consulted in the Dominican Republic. However, prior to considering sugarcane use for SAF, specific studies would be required to confirm that sugarcane production in these areas would not negatively affect food /feed production or forest cover.

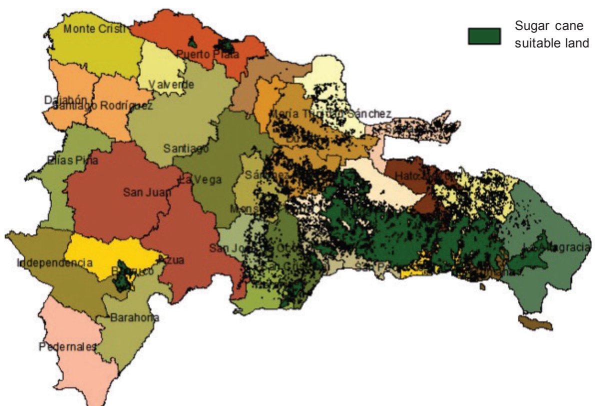


FIGURE 6

Suitable land for sugarcane cultivation (Nuñez, 2012)

5. THE REGULATORY FRAMEWORK

Current sugarcane production is devoted to sugar and alcohol production, under a market regulated by the government and closely linked to international trade agreements. In such a regulated framework, it may be possible for the government to regulate the additional sugarcane production required for AAF production without interfering with the sugar, furfural, molasses or alcohol markets.

According to available data, it is estimated that the cost of producing sugarcane would be higher than in the international market, due mainly to a reduced use of machinery and enhanced varieties. Reducing production costs should be addressed in the future.

The use of sustainable aviation fuels is currently at a comparative disadvantage concerning price when compared to conventional fuels, with less mature technology and higher costs. As a result, these alternative fuels need to be supported by policies and regulations in order to compensate for such disadvantages. Worldwide, there are several policy frameworks that incentivise the use of sustainable aviation fuels, including the US Renewable Fuel Standard (RFS2) or the EU Renewable Energy Directive (EU RED).

The Dominican Republic includes in its regulatory system relevant laws and decrees concerning benefits and incentives for the production of alternative fuels and renewable energy. These correspond to a national strategy driven by energy dependence and the countries' vulnerability to climate change. The most representative regulations are the Law 57-07 on Incentives for renewable energies and special regimes, and the Decree 202-08.

Mandates for the use of biofuels in the road transportation sector have been applied before in the Dominican Republic, under circumstances of fuel scarcity. When the oil prices were high, a mandated blend for road transportation was considered, but this was later abandoned due to the decrease in oil prices. While these blend mandates are not applied today, their earlier existence demonstrates that such a type of policy can be implemented in the State.

The Dominican Republic regulates prices and commercial margins for distributors of all hydrocarbons. This regulation helps to establish incentives and/or regulations for the introduction of alternative fuels, as stakeholders are already accustomed to a regulated market.

The Law 495-06 for ad-valorem taxes applies a 15 per cent rate for all hydrocarbons, except for the AVTUR, which is charged at 6.5 per cent. This is an indication of the relevance of the aviation sector in the country, being incentivized with a reduced tax. According to some stakeholders consulted, this tax reduction originated because the State offered higher jet fuel prices compared with other countries in the Caribbean region. This different taxation rate of jet fuel was therefore used to compensate this competitive disadvantage for the tourist sector, that is closely linked to the aviation sector.

Frequently, price incentives for alternative fuels include tax exemptions and reductions—in particular excise taxes—that are usually applied to fossil fuels (i.e., Directive 2003/96/EC). In some cases, the government can assume that this policy represents income loss. However, when the alternative fuels are locally produced (vs. imported fossil fuels), the taxes over the added value produced in the country and all the other socio-economic benefits can compensate for the losses. Therefore, a policy for price incentives should consider the potential income change or reduction to the national budget. In this case study for the Dominican Republic, the implementation of a tax policy can be an important instrument to regulate any price increase, or to incentivise early adopters.

[20] Sugarcane is a perennial crop which creates very resilient root systems (resisting even fire) that are difficult to eradicate. For sugarcane replanting, there is a mechanical preparation of the soil that is costly. A more intense soil preparation could be required for changing from sugarcane to other crops that can be uneconomical for the farmer, unless the other crop is more productive.

6. JET FUEL INFRASTRUCTURE

Jet fuel used in the Dominican Republic is either refined by Refidomsa (< 40 per cent) or imported. When imported, it arrives at the Refidomsa facilities located on the south coast of the Dominican Republic and the west of Santo Domingo city at 'Bajos de Haina', San Cristobal province. The Jet A1 is also imported from another terminal, close to Refidomsa, also in Haina, and is the property of InterQuimica. The jet fuel arrives by ship to either of the docks in Haina.

From there, the aviation kerosene is transported to the airports' fuel farms by truck. At the major airports, the fuel is uplifted by hydrant systems available at some gates, while others need to be served by refuelling vehicles (tanker trucks). At the remaining airports, the fuel is served by refuelling vehicles.

Each airport (group) in the Dominican Republic has a unique jet fuel supplier. This limits price competition, but as selling prices are regulated by the government, those managers consulted at major airports indicated that this system makes the management of the fuel supply simpler. The current fuel suppliers are: Sol aviation (ESSO group), supplies La Romana international airport (MDLR); GB Group supplies the Punta Cana (MDPC) and Cibao (MDST) international private airports; and Terpel supplies Las Americas (MDSD), Gregorio Luperon (MDPP), Presidente Juan Bosh (MDCY), Dr. Joaquin Balaguer (MDJB) and María Montez (MDBH) international airports, all of them concessioned by Vinci/Aerodom.

In addition to the fuel facilities in Haina, there is another import terminal, with storage capacity for AVTUR, located in San Pedro de Macoris (Figure 7). This storage owned by Coastal Petroleum Dominicana (Propagas group) has a capacity for 120,000 US barrels of AVTUR (5,040,000 US gal) and is not being fully used currently. The reason for this is related to the oligopoly for fuel supply in the country that is related to contracts with Refidomsa or InterQuimica, and therefore the market is limited for new contracts.

San Pedro de Macoris provides a potential advantage due its location between the two major airports. Haina is 50 km west of Las Americas (MDSD) and 213 km west of Punta Cana (MDPC); these two airports represent 70 per cent of the air operations in the Dominican Republic. San Pedro de Macoris is at a similar distance to Las Americas airport (60 km) as Haina, but is connected by a less congested road, out of the Santo Domingo area. In addition, the distance from San Pedro de Macoris to Punta Cana would be reduced by 50 per cent compared to Haina (100 km less). This change would not impact the fuel price directly, as the margin for distribution is regulated by the government. However, it could help the government consider such a change in order to improve the competitiveness of the final fuel price.

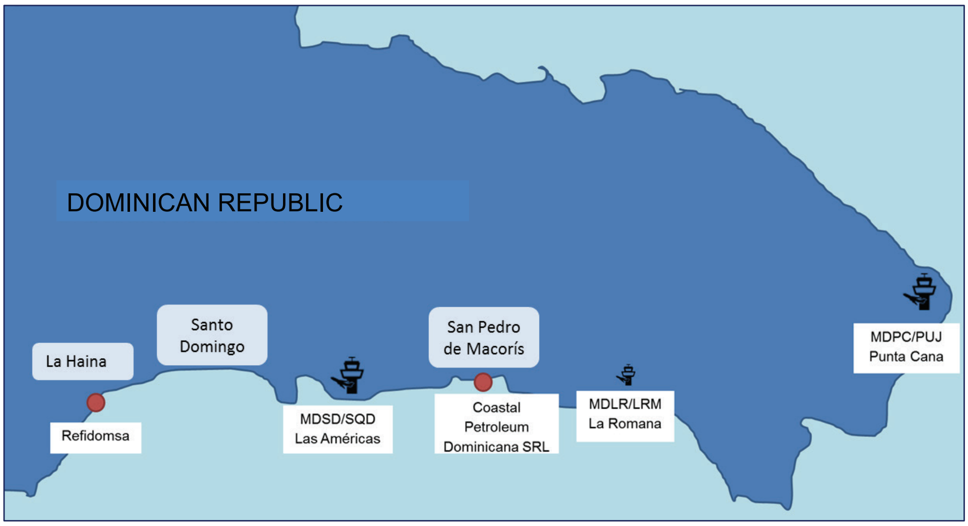
Despite the lack of actual data on transportation costs from the fuel suppliers, it is possible to consider 1.5 USD/km for a truck of 790 gals, and a fuel supply for Punta Cana airport of 9 Mgal; the changing the location of the fuel storage from Haina to San Pedro de Macoris could represent savings of up to 1.8 million USD per year.

At the same time, as pointed out by some fuel suppliers, diverting the imports to two different docks could increase the shipping costs, as it would imply reducing the scale of the fuel transported (scale economies). However, the fossil fuel for the blending could be either imported or produced in the Haina area, and provided that the blend would be made close to the AAF production facility, the transport savings would be significant, as indicated above, for the AAF portion.

It is important to point out that the facility for qualification and/or certification of the jet fuel is available only at Refidomsa. Therefore, if opting for blend production close to the biorefinery, such capabilities should also be built or developed there.

FIGURE 7

Location of the alternative import dock and storage owned by Coastal Petroleum Dominicana that could be available for JetA1. Source: (Author)



7. MARKET BARRIERS AND SOLUTIONS

The conventional thinking is that the price of AAF can be reduced if the costs of the feedstock and processing are lowered. However, this approach can succeed only if the production of AAF is isolated from other markets.

Usually, AAF production depends on feedstocks that are indexed commodities. This means that commodities' prices are dependent on market competition arising from uses other than AAF production. Some cosmetics, plastics, chemicals or even road fuels in strongly environment-regulated markets, such as in the United States or the European Union, usually have a higher selling price than jet fuel. Therefore, if an investor can produce a feedstock that can be used for these other markets, or a product that can be converted to them (e.g., ethanol), this will result in higher returns on the investment. This is a basic principle of market systems, and this is particularly the case in global markets.

In general, it is expected to be challenging for AAF to reach price parity with the price of conventional jet fuel even if production costs can be lowered, and regardless of the fossil fuel price, because when the cost of fossil fuel rises again, commodity prices will likely increase as well.

There are several possible 'solutions' to this challenge:

1. Confine the value chain. Restrict, by contract or regulation, the final destination of the possible final products to AAF fuel. In this scenario, the final product or the feedstocks should be devoted to producing only AAF fuel and cannot be used to supply other markets, decoupling the prices in the process. For example, if the sugarcane that is required to produce AAF cannot be used for bioethanol or sold for sugar, its prices would depend on the production costs and not on demand from alternate markets. This solution could only work if the critical mass (size) allows the system to be independent (e.g., no sugarcane imports are required), and by considering the opportunity cost (from not having a higher income from the other markets where the produce could value more). This is the way forward envisaged for the Dominican Republic under this study.

2. Use feedstocks and inputs that are not commodities (like some wastes). Here, neither the feedstock nor the intermediate products have a potential market other than AAF. This system is similar to the one above. The difference is that in the first case, the situation is policy/agreement driven, whereas in this case it is technologically specific. Using wastes that have no other destination, instead of being discarded, reduces the risk of a fluctuating feedstock price. Also, using refining technologies that can extract jet fuel directly from some feedstocks could also be a way of restricting the price interaction with other markets (i.e., intermediate products cannot be used by road vehicles). However, this approach lacks flexibility which is a disadvantage. Again, the opportunity cost needs to be considered.

3. Using low volume/high value chemicals to compensate price changes. Some high value chemicals could be produced during the refining process (saleable by-products as financial supporters to the global business case). These high value chemicals justify paying more for the feedstock required and as their value would also be market driven, such chemicals could help absorb price changes. This method follows the principle of biorefinery by cascade approach, where the most valuable products are produced first and help to sustain the whole production system.

4. Subsidizing. The market inefficiency in the form of a price gap can be offset through governmental support. The governmental support is justified because of the overall benefit for the national system (not just the value chain). The policy support can be voluntary or mandatory. The case of mandatory support has also been included in the case study.

The fourth solution, subsidizing, is usually recommended to be implemented by the government. However, many of the current developments of SAFs for aviation worldwide have been led by voluntary schemes. A particular example of this non-governmental application is the 'Fly Green Fund[21]' system that has been applied in Scandinavia. This non-profit organization presents companies and individuals with the opportunity to reduce their carbon footprint when flying by using aircraft fuelled with AAF, thereby contributing to the development of local value chains.

[21] http://www.flygreenfund.se/en/tjanster/

8. CASE STUDY

8.1 BLENDING MANDATE

Although alternative fuel technologies are advancing, commercial development is still in its infancy, making it difficult to arrive at accurate production cost estimates. Several studies that could provide a theoretical minimum selling price for the final product have been analysed (e.g., Klein-Marcuschamer et al. (2013) as reference for this feasibility study. Current prices for pilot and demonstration plants are expected to be reduced through technology improvement and economies of scale over time. The theoretical minimum selling prices refer to a theoretical refinery or refinery plants where the production costs can be optimized.

Using sugarcane as feedstock, two technologies have been considered applicable in the Dominican Republic: SIP and ATJ. Only ATJ from isobutanol is currently accepted by ASTM, but it is expected that other processes from ethanol can also be considered soon. The values (yield, selling prices) used in this study for ATJ are generic and do not correspond to any particular patented technology or trademark.

Using data from the work of Klein-Marcuschamer et al. (2013), the facility in this case study would be producing SIP fuel using sugarcane within a price range of 4.3 – 7.6 USD/gal. Based on other studies, using lignocellulosic materials instead of sugarcane could increase that price to 17.3 USD/gal (Wang, et al., 2016). There are also indications of the possibility of the cost decreasing to 4.0 USD/gal[22], by changing the variables considered in the studies. For ATJ, Yao et al. (2016) propose a reference price of 3.65-3.97 USD/gal, which is significantly cheaper than SIP. Both technologies can produce AAF and road transportation fuels.

In the case of SIP, the resulting iso-paraffins can also be used as a diesel substitute, thereby making it viable for use in aircraft, but also in road vehicles and Ground Support Equipment (GSE) at airports.

In the case of ATJ, the refining facility can be implemented by retrofitting an existing bioethanol plant[23]. This possibility is a significant advantage for adopting a flexible strategy, allowing a step-by-step process when building the value chain. First, a plant is built to produce bioethanol (with a better known market than AAF). Once the feedstock supply and other parameters are better known and established, the original bioethanol plant can be transformed to produce isobutanol (that can also be used to produce fuel for road transportation) and ATJ AAF. The feedstock cost used for these studies above is based on a global market price for sugarcane (and other consumables). Due to some internal characteristics and the existence of quota markets, these prices are cheaper than the current sugarcane cost in the Dominican Republic (according to the references provided by the stakeholders during the study). However, it is expected that production costs in the Dominican Republic could be reduced with investment in machinery and higher-yielding sugarcane varieties in the medium-term. Also, when feedstock is indexed to international commodity prices, its cost would rise when fossil fuel cost and demand rise. However, the Dominican Republic has, as an advantage, the option to control the production system to avoid such price variations. This is because the sugarcane market is controlled by a government agency, offering a protection against price peaks.

In order to make the comparison of the cost for AAF fuel easier, the fossil jet fuel import price (PPI) will be used as reference (Figure 8).

Jet fuel price variations are known to be significant. This study used the projections marked for jet fuel by the US Energy Information Administration (2016), marking an average growth ratio of 3.7 per cent. Also, during the period 2010-2015, monthly price variations had an average variation of about 10 per cent. Looking at these variations, some airlines have shown their capacity to adapt to significant price changes, even when the fuel cost can account for 20-25 per cent of the operational costs.

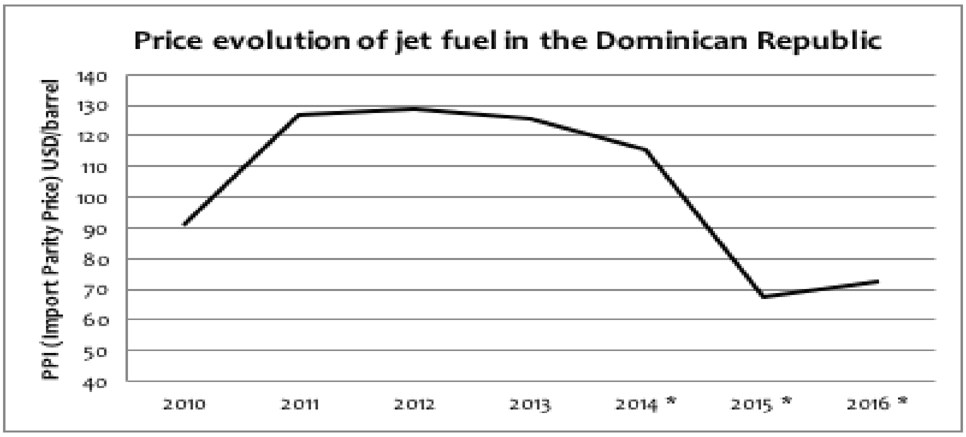


FIGURE 8

AVTUR import prices evolution (* denotes provisional value). Data source: Dominican Ministry of Industry and Commerce.

The price references for the AAF fuel are also linked to the cost of feedstock and consumables (like hydrogen) that are usually correlated to the growth of fossil fuel; thus the prices for AAF production grow annually. However, assuming that a decoupling of dependence on fossil fuel would occur in the coming years thanks to a substitution of dependence on fossil fuels for the required energy and materials, a lower inputs cost growth is expected. Hence, the scenario uses a 2.9 per cent growth for AAF prices (80 per cent of the fossil fuel growth ratio)[24].

As decarbonisation is one of the main elements driving the use of SAFs, carbon prices have also been considered in the study. As carbon markets are limited, and as technologies improve, it is logical to expect that the marginal abatement costs would be higher in the future. Therefore, a 7.3 per cent growth rate (double that of fossil fuel growth[25]) has been assumed for the cost of carbon credits, applying as reference the value used in the EU ETS (one example of a carbon market). The base cost for the emission allowance starts at 7 USD/t spot price (Bioqueroseno.com, 2016).

The value of the emission allowance has been used in the study to 'correct' the price premium of the fuel. That correction means that the price paid for the SAF is discounted with the cost saved on carbon credits. Hence, when Figure 9 mentions the 'Premium CO2 corrected' (on conventional jet fuel), it refers to the price difference between fossil and SAF after having considered the benefits of the emissions reductions in terms of emission allowance value.

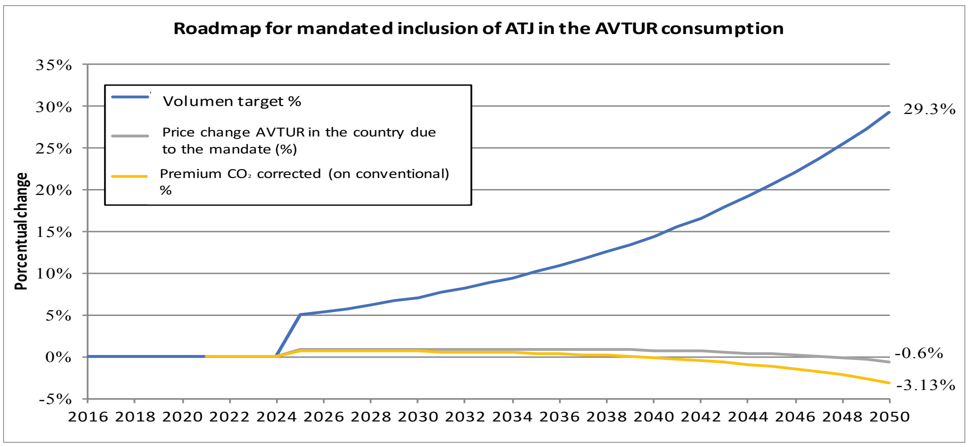


FIGURE 9

Roadmap for mandated inclusion of ATJ in the AVTUR consumption. Source: (Author)

[22] 2011 USD values

[23] There are no bioethanol plants in the Dominican Republic, even though there have been studies in this regard. This could be, however, a natural step towards AAF production, where a better known technology (bioethanol production) is installed to reduce the risks associated with feedstock supply; when established, it could be retrofitted for jet fuel production.

[24] The case is particularly sensitive to these changes between the growth of the fossil fuel and the growth of the AAF consumables. As reference, in the worst case scenario where the growth is even, jet fuel prices could be 7 per cent higher in 2050 with the mandated roadmap. However, some decoupling is expected, as not all the consumables are directly indexed to the oil price, especially those produced internally in the country.

[25] The 7.3 per cent figure is just an indicative hypothesis showing the expected trend.

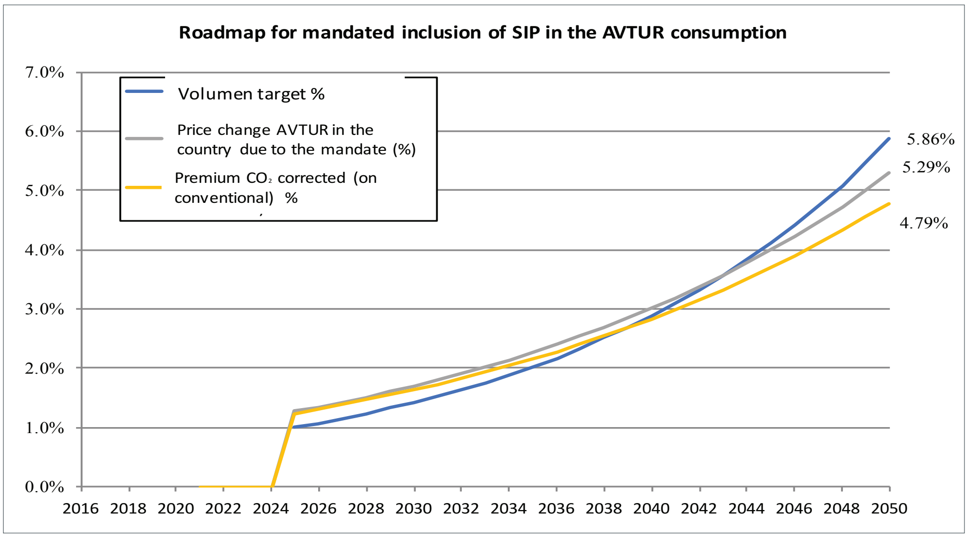
Even though the production costs for AAF could be lower than future fossil jet fuel prices, especially considering the carbon reduction, this case study establishes a need for a blending mandate from the government that would need to be linked to programs for sugarcane production in the country and the implementation of a production facility. The mandate would start from the moment the refining plant could reasonably begin operations (2025, 5 per cent), until achieving the maximum blend of almost 30 per cent in 2050. Under this scenario (Figure 9), the increase in the AVTUR costs and the benefits in terms of emission reductions and other benefits would be evaluated. The case does not consider the use of the extra production of the plant(s) if any, which could be either exported or used in the country for ground service equipment (GSEs) and road vehicles in a similarly mandated scheme.

The mandate is relevant in the country to ensure a solid business case for the investors and feedstock producers, while being compatible with the national regulations.

Applying this ATJ scenario (blending mandate), and without considering the potential benefits that the airlines could obtain in terms of emissions allowances, the price variation for the AVTUR in the Dominican Republic would be as indicated in Figure 9. It can be observed that, from 2030, the mandate could help to reduce jet fuel prices, achieving up to a 3.13 per cent reduction in 2050, considering the benefit of the CO_2 reduction. Considering then that the fossil fuel price will increase at a lower rate than the ATJ costs (as hypothesised), the price parity would be reached by approximately 2045. First, parity would be supported by the carbon reduction (credits); later, the lower price would imply a cost reduction.

Even for the SIP scenario, as indicated in Figure 10, the percentage price increase is relatively low, always below the usual average monthly variation (10 per cent) and the 'ad valorem' tax (6.5 per cent). Even if it is low, this increase would be unique in the region for the country that could influence the demand of flights (tourism sector competitiveness). This should be carefully studied with a price-elasticity model, considering the historical data available and in collaboration with the fuel suppliers and airlines.

FIGURE 10
Roadmap for mandated inclusion of SIP in the AVTUR consumption.
Source: (Author)



The above scenarios have been calculated on the basis of the import prices, without any taxes, supplier margins or transport costs. Looking at the regulated market for AVTUR described above, for the purpose of this study, distributor and logistics margins are considered fixed at 19.80 USD/BB (21.21 DOP/gal)[26] and the taxes marginal at 14.6 per cent (ad valorem Law 495-06 at 6.5 per cent and Law 112-00 at 8.1 per cent). It is to be assumed that these costs will be also included in the SAF cost.

As the calculations are similar for SIP and for ATJ, with the only difference being the price and the maximum blend ratios (10 per cent for SIP, 30 per cent for ATJ), the ATJ case is considered more favourably (with a lower price and the possibility of introducing higher volumes due to the higher blending limit). In the feasibility study, it has been concluded that even in the less favourable case of SIP, an active policy from the Dominican government, with the support of local stakeholders could make the case potentially achievable.

8.2 BENEFITS THROUGH ECONOMIC DEVELOPMENT

It is expected that an increase in the development of sugarcane production in the Dominican Republic would imply, directly and indirectly, various benefits for the country. These benefits can be summarized according to the tax revenues generated on imports (materials, machinery), on the generated added value, incomes from farmers and workers at the mills, transport, and storage.

As the study cannot delve into such elements, an overview of the potential impact from the agrarian perspective is considered[27].

The sugarcane selling price for the producers is regulated by Law 491, enacted in 1969. According to this law, the sugarcane producer receives (from the mill) 50 per cent of the average value from the molasses obtained from that sugarcane.

Fertilizers and biocides are imported, along with the machinery for the preparation of the land. Currently, about 50 per cent of the harvest is totally mechanized, 30 per cent is partially mechanized and the rest (20 per cent) is cultivated by hand. This last system is the most labour intensive.

Considering the scenario described above, and only the product associated with the AVTUR the number of additional sugarcane hectares needed would be as indicated in Figure 11.

The values in Figure 11 do not reflect refinery plant size or number; only the correspondence with the blending targets for each pathway. Available land for sugarcane production in the Dominican Republic is estimated to be at more than 150,000 ha, according to the available data.

The SIP and ATJ scenarios would be similar and linearly related for all the parameters in this analysis, the only differences being caused by the higher volumes considered for ATJ (Figure 11). For ATJ, the roadmap in 2050 could require around 120,000 hectares[28]. Such a large demand would require more than one facility and the country could experience supply issues for achieving those levels of production for 2050 (and more sustainability risks).

Considering that a farmer could economically depend on sugarcane production with a minimum of 8 ha, the direct employment could increase (without considering the transport, mill or later processing) to at least 3,000 stable jobs in 2050, considering the available hectares shown in Figure 11. In addition, considering approximately 1,900 working hours annually, the required labour force would be an additional 0.21 FTE/ha[29], increasing the above employment figure to 8,000 jobs (SIP scenario) (Japa, 2016). All these are direct jobs, and limited to the agrarian step of the value chain, would significantly increase if also taking into account the industrial phase and all the associated indirect jobs. If land for sustainable production is available, the ATJ scenario could create more than 40,000 direct jobs in the Dominican Republic.

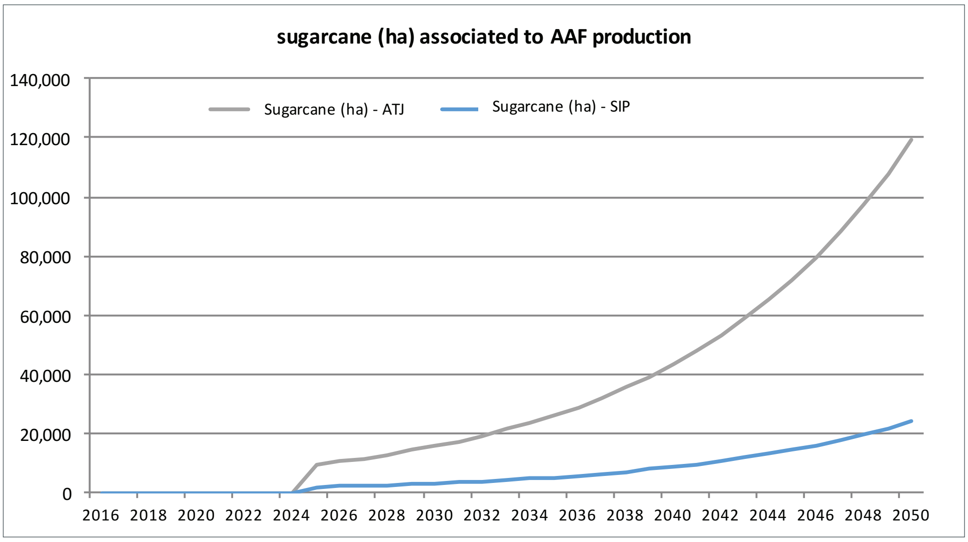


FIGURE 11
Sugarcane surface needed for cultivation for the scenarios considered for SAF production. Source: (Author)

[26] The distribution and transportation margins accounted for the date used as reference (22/10/2016) constitute up to a 27.5% addition over the import price.
[27] This data has been provided by Coopcaña, a sugarcane farmers association in the Dominican Republic.
[28] Note that, according to historical production presented in section 4, there would be at least 217,000 hectares available.
[29] FTE stands for Full-Time Equivalent as a workload indicator.

According to the above figures, the estimated accumulated wages would reach, considering an average income of 280.00 USD/ha, more than 6.7 million USD in 2050 (with an accumulated value of almost 65 M USD) for the SIP scenario. For the ATJ scenario, the value would reach 33 million USD in 2050 (accumulating more than 322 million USD in wages by then).

In addition to job creation, there is a potential benefit on tax revenue. Wages below 40,000 DOP are exempt, but additional fuel and lubricants that would be demanded for the AAF production would increase overall tax collection. Considering an average tax burden of 20 per cent for the diesel that would be required, the State would receive more than 0.8 million USD in 2050 as a result of the production of SIP planned in the scenario (4 million USD for the ATJ scenario).

This cost-benefit analysis is illustrative and is not intended to serve as a business case, as the available data is, in its detail, quite insufficient for such an analysis. However, it shows how there are not only costs, but also economic development benefits and GHG savings to be considered. GHG savings could probably be monetized in the future, considering the implementation of market-based mechanisms. Consistent with this argument, the ICAO Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) was recently agreed by the 39th Session of the ICAO Assembly.

8.3 CO_2 EMISSIONS SAVINGS

This study has considered that the use of the SIP or ATJ produced from sustainably produced sugarcane can save up to 80 per cent of CO_2 emissions compared with conventional jet fuel (GFAAF, 2016) (Hamelinck, et al., 2013). As the sugarcane land considered in the study is unused, and the sugarcane to be produced should be additional and not competing with sugarcane devoted to food production, no iLUC emission factor has been applied here. Should any of these premises change (type of land used or competition with the sugar market); the savings assessment should be redone to consider the potential iLUC.

When considering fuel supply in the country, it would be inaccurate to make a distinction between domestic and international flights, as the fuel would likely be equally available to all departing flights.

Table 3 summarizes the emissions savings (tonnes of CO_2eq) that could be obtained using the volumes described in the case study by applying a factor 80 per cent savings for any replaced tonne of jet fuel. The final savings could be lower depending on the efficiency of the production or processing, and the actual volume of fuel used.

Due to the lower costs and the higher blend limit, the volume targeted within the ATJ scenario is larger than that for the SIP. Therefore, the potential emissions savings are significantly higher for the ATJ than such savings for the SIP, even if the same unitary saving is considered. In 2050, applying the case study strategy for ATJ, the AAF used could save approximately 23 per cent of the total CO_2 emissions that would have resulted from the jet fuel supplied in the country.

According to the forecast made in the Dominican Republic Action Plan (IDAC, 2015), the emissions from international aviation (IPPC approach) in 2050 would be almost double (4.31 Mt) those from 2020 (1.52 Mt). Therefore, the use of SAFs can significantly reduce the impacts of emissions increasing, than using convention jet fuel.

The actual savings from the use of SAFs in aviation should be assessed, case-by-case, on the basis of sustainability standards (that calculate the CO_2 savings, and ensure the sustainability of production).

TABLE 3
Savings of CO2 equivalent due to the use of AAF according to the two different blending roadmaps analysed in the case study using a theoretical maximum GHG savings of 80%.

Pathway		2020	2030	2050
ATJ	Targeted blend %	5.0%	7.1%	29.3%
	GHG savings (t CO_{2eq})	63,281	104,983.07	795,259.03
SIP	Targeted blend %	1.0%	1.4%	5.9%
	GHG savings (t CO_{2eq})	12,656	20,996.61	159,051.81

9. STAKEHOLDERS

Cooperation among stakeholders is necessary for the implementation of the value chain. Production of alternative fuels requires collaboration of stakeholders from diverse sectors in order to facilitate implementation.

In particular, the development and implementation of policy measures for SAFs would require the participation and coordination of several stakeholders to cover all the areas of expertise required. As indicated in Figure 3, the life-cycle of sustainable aviation fuel is different to conventional fossil fuel, requiring the participation of more stakeholders.

Also, SAFs being something new, efforts towards capacity building may be required, e.g., the jet blending procedures or the analysis of the batch, according to the ASTM D7566 standard, would require specific capabilities that need to be developed in the country for producing SAFs.

9.1 NATIONAL STAKEHOLDERS

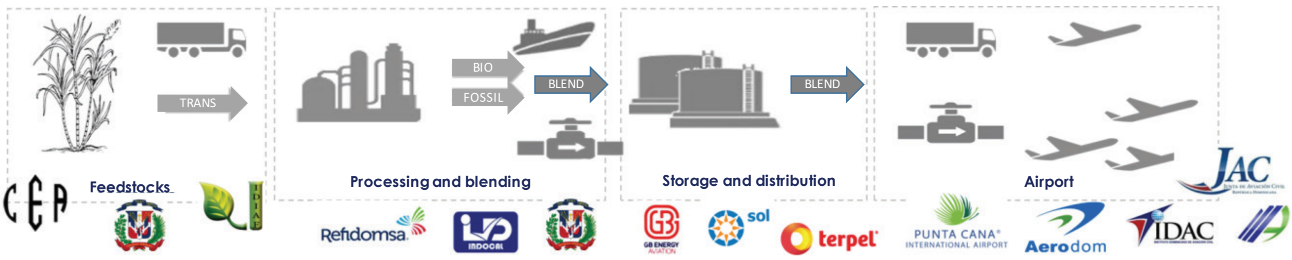


FIGURE 12 Value chain scheme with references to some of the stakeholders consulted that could support implementation in the country.

Table 4 includes the motivation of the stakeholders within the Dominican Republic, and their main role and contribution to the value chain. These roles are also detailed in section 10 where the roadmap is also detailed.

Entity	Motivation	Main role
IDAC (Dominican Institute of Civil Aviation)	Major objective is to mitigate CO_2 emissions from aviation, while guaranteeing competitiveness of the aviation sector.	To promote, initiate, and support. Monitor fuel supply and GHG savings associated with the use of AAF fuel.
COOPCAÑA (sugarcane producers cooperative)	Providing production options for sugarcane producers, generating employment and added value in rural areas.	Supports establishment of sugarcane production by controlling crop expansion and communicating with the farmers.
CNE (National Energy Commission)	Regulator of alternative /renewable energies, should promote security of supply and sustainability.	Support new regulations and its implementation, promote the use of renewable energies.
Ministry of Environment and Natural Resources	Reducing CO_2 and PMs emissions without affecting the forest or other uses negatively.	Minimize environmental impacts, monitor sustainability and LUC/ILUC.
Ministry of Agriculture	Providing alternatives to farmers, improving technological capacity and productivity.	Maximize yields and social impacts.
FAO (UN Food and Agricultural Organization)	Providing alternatives to farmers without affecting food security and water supply.	Monitor agricultural changes and water uses, as well as social impacts.
REFIDOMSA (fossil fuel refinery)	New hydrocarbon fuel to diversify the market to address the demand (+ flexibility).	Supervising blend and market operation. Providing suitable fossil jet fuel for blends.

TABLE 4 AAF value chain main stakeholders in the Dominican Republic.

TABLE 4 AAF value chain main stakeholders in the Dominican Republic. (continued)

Entity	Motivation	Main role
INAZUCAR (Dominican Institute regulating the sugar production)	There is no affection to INAZUCAR scope, but their expertise can support market evaluation.	Sugarcane business case model supervision. Monitor sugarcane market.
MIC (Ministry of Industry and Commerce)	Regulator of alternative energies; should promote security of supply and sustainability.	Support new regulations and its implementation, including standards.
Ministry of Energy and Mining	Regulator of alternative /renewable energies, should promote security of supply and sustainability.	Support new regulations and its implementation; promoting the use of renewable energies.
CNCCMDL (National Council on Climate Change and Clean Development Mechanism)	Mitigating GHG gases from national initiatives that could be accounted at national level.	Maximize the support to be obtained from the CO_2 reduction (credits).
IDIAF (Dominican Institute of Agricultural and Forestry Research)	Develop sugarcane varieties with higher yields specific for AAF production, not interfering with sugar production.	Support agrarian R&D to increase yields directed at alcohols (AAF) production.
PAWA (Main Dominican airline)	Support for mitigating CO_2 emissions (alt. to other options) and have a local supply.	Supervise the potential effect of fuel prices for airlines and help with the definition of the roadmap depending on the fuel prices evolution.
Fuel suppliers (i.e., GB group, Sol or Terpel)	Diversify their products portfolio to clients that could be interested in AAF.	Engage in the design of the fuel policy (mandate), roadmap and implementation regulations.
Airport managers	Diversify their products portfolio to clients that could be interested on AAF while improving the environmental profile of the airport (and Local Air Quality).	Become engaged in the design of the fuel policy (mandate), roadmap and implementation regulations. Monitor impacts to the aviation /touristic sector.

9.2 INTERNATIONAL COOPERATION

In Table 4, the local stakeholders are mentioned. However, stakeholders from other States could play a role too, complementing some of the elements in the value chain. For example, a memorandum of understanding (MoU) between the Dominican Republic and the Federative Republic of Brazil in the Area of the Technical Production and Use of Ethanol Fuel was signed in Guatemala on the 13 September, 2005 and is still binding. This MoU establishes that both countries undertake, on a reciprocal basis and when requested, to mutually cooperate on the development of production techniques and use of ethanol as fuel. No specific targets, roadmap or strategies are included in the MoU. This MoU with Brazil could serve as basis for a new agreement that could frame the SAFs, where Brazil already has experience with technological development and sugarcane production improvement.

Also, Trinidad & Tobago, which has abundant hydrogen sources but lacks land for producing significant amounts of feedstock, could be an interesting ally for production of SAFs. As hydrogen is needed for the refining of SAFs, a mutual supply agreement could be concluded.

In addition, there is special tariff treatment applicable to ethanol exported from the Dominican Republic to the United States, under the framework of the Free Trade Agreement between Central America, the Dominican Republic and the USA (DR -CAFTA). The United States already has regulations that consider the use of SAFs and receive incentives (Renewable Fuel Standard). It is also notable that more than 60 per cent of the non-resident visitors to the Dominican Republic come from the U.S. (Banco Central de la República Dominicana, 2016). Therefore, an agreement between the U.S. and the Dominican Republic would be beneficial for tourism.

10. KEY FINDINGS

This section summarizes the key findings of the feasibility study. Those findings are relative to the vision of design and implement a value chain for production and use of sustainable aviation fuels in the Dominican Republic, for reducing aviation CO_2 emissions, increasing rural jobs, foster local development and providing long term benefits to tourism.

CHALLENGES:

- Current fuel demand is of 400,000 t/year but it is projected to reach 1.4 Mt/year in 2050, increasing the need of energy imports and also increasing the CO_2 emissions.
- Highly regulated energy markets.
- Aviation fuel market dependent on imports.
- There are currently not significant sources of oils or wastes that could be used as feedstock without negatively affecting other markets.
- There are not production facilities that could be retrofitted to SAF production.
- Declining sugar industry. Surface dedicated to sugarcane production has declined from almost 300,000 hectares in 1985 to less than 100,000 hectares in 2015. Causes are diverse, but if that is showing land availability for sugarcane production, is also indicating that there is a lack of competitiveness in the sector.
- Highly regulated sugar industry, limiting sugar production to quotas, that acts as a barrier for expansion of the crop. Sugarcane production for SAF could overcome this barrier provided that the destination of the sugarcane is SAF and no sugar products.
- Lack of technological industry and research for aviation fuels. Even when there is a facility able to refine fuel to AVTUR, its capacity is compromised and below the current AVTUR demand. There are not stakeholders in the country with the technological knowledge for implementing a SAF approved technology (i.e. FT, HEFA, SIP, ATJ). Therefore, the country would need to develop such capacity or relay that step in an external experienced stakeholder.
- Poor land use planning and agricultural control. The data available about land cover and use is very limited, what could suppose a risk related to the expansion of a crop for generating the feedstock. This could affect to the sustainability of the value chain and would need to be monitored. However, there are projects ongoing in the country addressing the quality of that information, particularly for forested areas, that would help to overcome this challenge.

STRENGTHS:

- Skilled expertise on sugarcane production. The Dominican Republic is a country with a long tradition of sugarcane production, with research resources about its cultivation and varieties improvement.
- Sugarcane suitable land unused or available, surface dedicated to sugarcane production has declined from almost 300,000 hectares in 1985 to less than 100,000 hectares in 2015, and according to the consulted sources, most of those hectares would have been abandoned or substituted for less efficient crops like low quality pastureland. This abandonment has been linked to unemployment and poverty. The current government is analysing projects to revitalize those areas thorough sugarcane production, and SAF production could present a development opportunity, offering social benefits beyond the climate ones.
- There are available storage resources located closer to main airports and sugarcane production area, what could offer an opportunity for SAF production and distribution that would also help to diversify the supply, reducing risks of lack of supply to airports.
- Good location for supplying US or Caribbean markets. In case there is SAF surplus, the country could have potential to export it.
- Policy framework suitable for mandates implementation. There are precedents of mandate for the use of bioethanol. In addition, the current hydrocarbons market price is fixed by the government and there is an special taxation for AVTUR. Also, there is an policy interest in the growth of the aviation sector. These, altogether, could help to stablish a regulated market for SAF that would overcame market barriers for its development.
- There are precedents of international cooperation on alternative fuels (Brazil, USA).

11. THE RECOMMENDED ROADMAP (CONCLUSIONS)

According to the results obtained from the feasibility study summarized above, the recommended roadmap for the implementation of alternative fuels for aviation in the Dominican Republic is as follows.

First stage: enhance cooperation & capacity building (2017-2018).

The Dominican Republic has skills and advantages related to some steps of the value chain, in terms of the production of sugarcane as a feedstock. However, the Dominican Republic lacks experience in other areas, including technology where external support (more likely a technology provider or an experienced production company) will be required. Also, as mentioned in section 9, SAFs' value chains are more complex and require cooperation among more stakeholders. Therefore, an important first stage in the roadmap is to establish cooperation channels, both locally and internationally, to build adequate capacities and to avoid mistakes during implementation that could undermine the project's viability.

- Establish measures for increasing cooperation and information sharing regarding barriers and solutions for the implementation and deployment of sustainable aviation fuels, including capacity building.
  - This could include the establishment of cooperation agreements (such as the Agreement provided in Annex I) where different stakeholders commit to addressing the issue together.
  - Also, it is recommended that skills be developed through training courses and seminars. The main training areas include:
    - enhancing sugarcane yields while maintaining the highest levels of GHG savings (i.e., fertilizing, management, machinery, milling, wastes);
    - sustainability standards implementation and auditing;
    - SAFs refining technologies;
    - SAFs quality standards and blending;
    - SAFs markets (and CO_2 markets).

- Study the potential for cooperation with other countries on technology, supplies or market. In particular and as mentioned in section 9.2, with:
  - Brazil, which has traditionally cooperated with the Dominican Republic on bioenergy and is developing steps towards alternative jet fuel production.
  - Trinidad & Tobago, which has also shown interest, as part of the ICAO-EU project, in producing and using sustainable aviation fuels.
  - The United States, which has a strong policy supporting the development of alternative energies and has commercial agreements with the Dominican Republic in the area of alternative fuels.

Second stage: demonstrate potential (2018 a 2020).

Before initiating any investment, it is recommended that intermediate elements, that could help to demonstrate the actual potential for production of SAFs, be developed. This will help reinforce the production capacities (feedstock, infrastructure) while starting to address the market barriers, thereby potentially reducing the risks of the investment.

- Preparing the regulatory and logistic system for aviation fuels, considering international regulations that already include the use of these alternative fuels (ASTM, DEF STAN, AFQRJOS…).
  - At the airport level, airport managers should consider and allow the use of alternative fuels, giving clearance to the suppliers that decide to buy or import the alternative fuel. Even if there is no formal difference between the ASTM certified blend and the common fossil Jet A1, such clearance creates trust in users that the possibility of using alternative fuels is recognized.
  - The hydrocarbon quality certification standards for aviation fuel should consider the potential production and blends of alternative fuels in the national system.

- Public awareness. Creating advertisements about the effort towards the use of alternative fuels, mainly at airports, is important. This will help create public acceptance and will trigger benefits to the tourism sector and potential interest from investors.
  - A system where passengers arriving at the local airport can decide to voluntarily contribute to SAF development (e.g. buying 'green tickets') could be established as a pilot project. A certificate for offsetting CO_2 emissions could be provided in return, in particular, to businesses. In the beginning, with no alternative fuel produced in the country to offer, a fund to purchase or produce the fuel later can be set up.

- Increase dedicated research on feedstock capacity. Recommendations are to focus on the development of sugarcane and lignocellulosic wastes from sugarcane products. MSW could also be explored further at this stage, as the management of wastes of the country could change in the future, or the technologies used to process these wastes could reduce the required volumes.
  - Demonstration of feedstock production is needed prior to implementing the transformation (refinery) step. It is recommended that an intermediate phase of production is established in the roadmap, i.e., producing bioethanol for

road transportation, which is simpler in technology and with smaller risks than SIP or ATJ. It is recommended to stabilize volumes and costs of the feedstock (including for example sugarcane varieties improvement) and consumables before taking the final investment decision for a refinery.
- Ensuring that the required sugarcane can be produced in a sustainable way, without interfering with the production of sugar, other foods, alcohols or nature conservation (including water management) are key, and should be analysed and monitored in this step. The benefits for rural development, and their quantification, can be studied in this step.

- Macroeconomic research. Study the potential economic (and other) benefits from pathway implementation. For example, the new industry's indirect effects, resilience, different tax scenarios, and different tourism scenarios, to compare them with the costs needed to reduce the price gap.
  - Conduct economic studies for aviation jet fuel in the region, to analyse the risk of reduction of RTKs in case of fuel price increase (or potential benefits if it decreases) as consequence of introducing SAFs in the country.

Third stage: establish demand and deployment (from 2020 onwards).

Once the outcomes of the previous stages have been evaluated, define the potential implementation of an alternative fuel value chain, according to a recognized sustainability standard.

- Review the feedstock choice of sugarcane, the market situation and the forecast.
- Confirm that ATJ is (still) the best technology, analysing the feedstock available, infrastructure and the cost/energy efficiency of other available processes (if any). In four years' time, new technologies that could be more suitable could be approved, such as ATJ from simpler alcohols than isobutanol.
- Select the incentive measure to guarantee the implementation, where a mandate is recommended, considering the results of economic impact assessment studies.
- If the AAF refinery can be built, follow a per cent blend mandate according to the refinery capacity. Study the potential for exporting fuel to the region.

This roadmap can only be implemented with the close collaboration of stakeholders. Table 5 below indicates the potential activities and the role of the different stakeholders in its implementation.

The Dominican Republic has a long tradition of sugarcane cultivation, as well as land availability for its cultivation. It also has a strong aviation sector, owing to its significant tourism industry. This contrasts with a high vulnerability to climate change, a strong external energy dependency, and a highly-regulated hydrocarbons market. Altogether, these characteristics make the country an ideal candidate to produce and use sustainable aviation fuels.

TABLE 5 Potential activities and role of the different stakeholders in the roadmap implementation.

Stage	Action	Activity	Stakeholder-Role	Goals	By
1st	Increasing cooperation and information sharing	Signature of agreements	Recommended to sign: MIC, CNE, IDAC, Punta Cana, Vinci	• Signed agreements; • Annual report of alternative fuels related barriers and progress; • Discussion of the roadmap and activities.	2017
2nd	Preparing the regulatory and logistic system	Review of Law 57-05 for inclusion of provisions from SAFs (taxes, acceptance, quality/ sustainability and CO_2 accounting aspects regulated)	CNE, MIC, Refidomsa, Indocal, CNCCMDL	Adapt considering SAFs: • Hydrocarbon regulations; • Bioenergy regulations; • Logistic system regulations; • Quality regulations; • Taxation regulations;	2018
2nd	Public awareness	Advertising the effort towards the use of alternative fuels, mainly at airports	Vinci (Aerodom), Punta Cana, Airports Commission, IDAC	• Advertisement on SAFs at Santo Domingo and Punta Cana airports; • Voluntary contribution (bio-tickets) scheme for passengers, contributing to a fund.	2018
2nd	Increase dedicated research on feedstock capacity.	Develop the sugarcane and lignocellulosic wastes (particularly those from big agro-industries in the country). MSW could be also explored further	Ministries of Environment and Agriculture, IDIAF, COOPCAÑA	• Study for sustainable sugarcane production, maximum acreages, varieties, machinery, costs and yields; • Demonstration project with actual sugarcane production and transformation. Intermediate step for bioethanol is advised.	2019 2020
2nd	Macroeconomic research.	Study the potential economic (and other) benefits from pathway implementation.	MIC, with support of CNE, Ministry of Agriculture, COOPCAÑA	• Economic study on benefits; • Economic study for aviation jet fuel prices in the region (to prevent tankering or leakage of flights).	2019
3rd	Value chain implementation project, according to a recognized sustainability standard.	Review the feedstock choice to sugarcane and the market situation and forecast. Choose the best technology to be applied (starting from ATJ). Select the incentive measure to guarantee the implementation, where a mandate is recommended.	All stakeholders	• Project for installation of a SAFs refinery.	2021
3rd	Implement the incentive measure	If the AAF refinery can be built, establish a % blend mandate according to the refinery capacity. Study the potential for exporting fuel to the region.	CNE	• Incentive measure in place guaranteeing stability to the production; • Definition of the blending roadmap, coproducts use and potential for exports;	2022
3rd	Refinery built and running	Implementation of the project, tests and production.	Consortium with investors	• The refinery is built and running.	2025

Note: This list of activities and goals should be discussed with the stakeholders throughout the stages of implementation and development, to allow for the roadmap to be adapted as required. Events that could require a change would include the introduction of new technologies, changes to the sustainability conditions, and/or changes in the stakeholders' powers.

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13. ANNEX I
SUMMARY OF THE RECOMMENDED ROADMAP

DOMINICAN REPUBLIC ROADMAP FOR DEPLOYEMENT OF SUSTAINABLE AVIATION FUELS (SAFS)

VISION	Design and implement a value chain for production and use of sustainable aviation fuels in the Dominican Republic for reducing aviation C0₂ emissions, increasing rural jobs, foster local development and providing long term benefits for reducing aviation to tourism				
STRENGTH	Skilled expertise on sugarcane production	Sugarcane suitable land unused or available	Storage resources located closer to main airports and sugarcane production area	Good location for supplying US or Caribbeans markets	
CHALENGES	Highly regulated energy market	Aviation fuel market dependant on imports	Declining sugar industry, highly regulated	Lack of technological industry and research	Poor land use planning and agricultural control

FIRST STAGE (2017-2018) Enhance Cooperation & Capacity Building	SECOND STAGE (2018-2020) Demonstrates Potential	THIRD STAGE (FROM 2020) Establish Demand & Deployment
Local cooperation & capacity building: • Establish measures for increasing cooperation and information sharing • Capacity building on: feedstock, sustainability, refining, quality, testing and market **International.** Study the potential for cooperation with other countries on technology, supplies or market (i.e. Brazil, Trinidad & Tobago or USA)	**Prepare the regulatory and logistic system:** use of SAFs is foreseen in all regulation related for jet fuel, including quality standards. **Public awareness:** Disseminate the roadmap to create public acceptance and attract investors. **Increase research on feedstock capacity.** • Determine and demonstrate the potential capacity for producing sugarcane volumes in a sustainable way **Macroeconomic research.** Conduct economic studies for aviation jet fuel in the region, to assess the economic impact of introducing SAFs in the country.	**Review the feedstock choice of sugarcane,** the market situation and the forecast. • **Confirm that ATJ is (still) the best technology,** analyzing the feedstock available, infrastructures and the cost/ energy efficiency of other available processes (if any). **Select the incentive measure to guarantee the implementation**, considering the results of economic impact assessment studies. **Stablish a % blend mandate according to the refinery capacity.** Consider the potential for exporting fuel to the region.

14. ANNEX II

Below is included the joint declaration for the implementation of the roadmap presented in this guidance report, signed the 16th of December of 2016 in Punta Cana (Dominican Republic) during the third Seminar for the Caribbean 'Capacity Building for CO_2 Mitigation from International Aviation'.

DECLARACIÓN DE PUNTA CANA

IMPLEMENTACIÓN DE UNA HOJA DE RUTA PARA EL DESARROLLO Y USO DE COMBUSTIBLES ALTERNATIVOS SOSTENIBLES PARA LA AVIACIÓN EN LA REPÚBLICA DOMINICANA

Los representantes del Estado Dominicano, reunidos en Punta Cana, República Dominicana, el 16 de Diciembre de 2016, conscientes de la importancia y trascendencia de las cuestiones de medio ambiente y cambio climático, y alentados por las iniciativas globales para el desarrollo y uso de combustibles sustentables para la aviación, como una estrategia a largo plazo para el transporte aéreo;

Considerando: Que la aviación es una industria clave a nivel mundial, particularmente relevante en un estado insular como la República Dominicana. El sector turístico e industrial en el país depende enormemente de un transporte aéreo eficiente y sostenible, que apoye el desarrollo y crecimiento económico;

Considerando: Que el cambio climático es uno de los mayores retos a los que se enfrenta la humanidad y, particularmente, la República Dominicana como país en vías de desarrollo altamente vulnerable a los efectos resultantes de este fenómeno global;

Considerando: Que a nivel global, la industria de aviación ha establecido de forma proactiva un conjunto de ambiciosas metas para reducir sus emisiones, mejorando la eficiencia energética de la flota mundial en promedio un 1.5% anual, estabilizando las emisiones de CO_2 netas de la aviación a los niveles de 2020 (crecimiento neutro en carbono) y emitiendo en 2050 la mitad de las emisiones que se alcanzaron en 2005.

Considerando: Que una estrategia de sostenibilidad, seguridad e innovación energética a través de combustibles alternativos puede contribuir a alcanzar la visión de nación para largo plazo reflejada en la Ley 1-12 Estrategia Nacional de Desarrollo – END 2030, la cual, establece en dos de los cuatro ejes estratégicos: i) *Una economía articulada, innovadora y sostenible, con una estructura productiva que genera crecimiento alto y sostenido con empleo decente, y que se inserta de forma competitiva en la economía global*; y ii) *Un manejo sustentable del medio ambiente y una adecuada adaptación al cambio climático;*

DECLARACIÓN DE PUNTA CANA

Considerando: Que para fomentar el crecimiento sostenible de la aviación internacional y lograr las metas mundiales a las que se aspira, es necesario adoptar un enfoque integral que consista en un conjunto de medidas, que incluyen tecnologías y normas, combustibles alternativos sostenibles, mejoras operacionales y medidas basadas en el mercado para reducir las emisiones;

Considerando: Que la Asamblea de la Organización de Aviación Civil Internacional (OACI) pide a los estados que apliquen un enfoque coordinado en las administraciones nacionales respecto a medidas en materia de políticas e inversión para acelerar el desarrollo, introducción y uso apropiados de fuentes de energía nuevas y renovables para la aviación, incluido el uso de combustibles alternativos sostenibles, de acuerdo con sus circunstancias nacionales;

Considerando: Que la OACI estableció un Marco mundial para los combustibles alternativo de la aviación (GFAAF por sus siglas en inglés) mediante el cual se ha registrado el progreso; incluidos al menos cinco tecnologías de producción certificadas, más de 5,000 vuelos comerciales utilizando combustibles alternativos y dos aeropuertos abasteciendo combustibles alternativos de forma regular;

DECLARAN

Su interés y compromiso para avanzar conjuntamente hacia la facilitación del desarrollo y uso de combustibles alternativos más sostenibles para la aviación, que permita al sector seguir contribuyendo al desarrollo local de una manera sustentable a través de una hoja de ruta:

2017 a 2018:

1. Establecer mecanismos para incrementar la colaboración y compartir la información sobre las posibles barreras y soluciones para la implementación de los combustibles alternativos sostenibles para la aviación.

DECLARACIÓN DE PUNTA CANA

2017 a 2020:

2. Adaptar el sistema regulatorio y logístico para la recepción y uso de combustibles alternativos de aviación. Todas las regulaciones y normas aplicables internacionalmente a los combustibles de aviación consideran la posibilidad de la utilización de combustibles alternativos.

3. Socializar a todos los actores en la importancia del uso de combustibles más sustentables para el futuro del sector y el país.

4. Incrementar la investigación específica en la capacidad de materias primas, en particular sobre el uso de la caña de azúcar para la producción de biocombustibles de aviación. La caña de azúcar es un cultivo tradicional y abundante en la República Dominicana, que podría utilizarse de forma sustentable para generar combustibles alternativos para aviación sin interferir con la producción actual de azúcar, alcoholes o la conservación del medio ambiente, promocionando el desarrollo rural en zonas deprimidas.

A partir de 2020:

5. Promover la construcción e integración de una cadena de valor para la producción de combustibles alternativo de aviación, con una certificación de sustentabilidad reconocida.

6. Establecer medidas de incentivo para el uso de combustibles alternativos de aviación, que generen una demanda nacional y estable que permita la implementación de un centro productivo en el país.

DECLARACIÓN DE PUNTA CANA

Los firmantes y, aquellos que deseen adherirse posteriormente, se comprometen a evaluar, anualmente, el progreso alcanzado en la implementación de la hoja de ruta para tomar las acciones que pudiesen ser necesarias.

Punta Cana, República Dominicana, 16 de diciembre de 2016.

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