Biojet fuels – technologies and status of commercialisation Task 39 report

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International Energy Agency Bioenergy Task 39

Task 39
IEA Bioenergy

UBC

Structure of report (50% completed)

- General technologies for drop-in biofuel production
- ASTM certification status of technologies
- Status of commercialization of biojet
- Companies involved in biojet production and production capacity
- Factors/criteria for technology evaluation
- Fuel use at airports
- Techno-economic analyses
- Sustainability and carbon intensity of fuels
- ICAO and CORSIA (carbon offset and reduction scheme for Int aviation)

Opportunities and challenges of technology platforms

Technology platform	Opportunities	Challenges
Oleochemical technologies	Low oxygen Commercial scale	Feedstock cost, sustainability & availability
Thermochemical - gasification based	Low carbon intensity Can use waste feedstocks such as MSW	Syngas cleanup High capital cost Economies of scale
Thermochemical - liquefaction (pyrolysis & HTL)	Liquid intermediate can be used for coprocessing HTL can use wet feedstocks	Hydrogen requirement Complexity of biocrudes High oxygen and low pH
Biochemical technologies	High specificity and purity of products	High value of biochemical products Low yields
Hybrid	Can use feedstocks such as waste gases (Lanzatech) Alcohol to jet an established technology	Alcohol to jet uses expensive feeds such as butanol (Gevo)

Technology platforms - certification and commercialisation

- ASTM certification of pathways

APPROVED

- Fischer-Tropsch SPK & SKA (2009)
- HEFA SPK (2011)
- Synthesized Iso-paraffins (SIP) (previously DSHC) (2014)
- Alcohol to jet SPK (isobutanol(2016), ethanol (2018))
- Catalytic hydro-thermolysis of lipids to jet fuel – ARA (2020)
- Co-processing of lipids (5%)

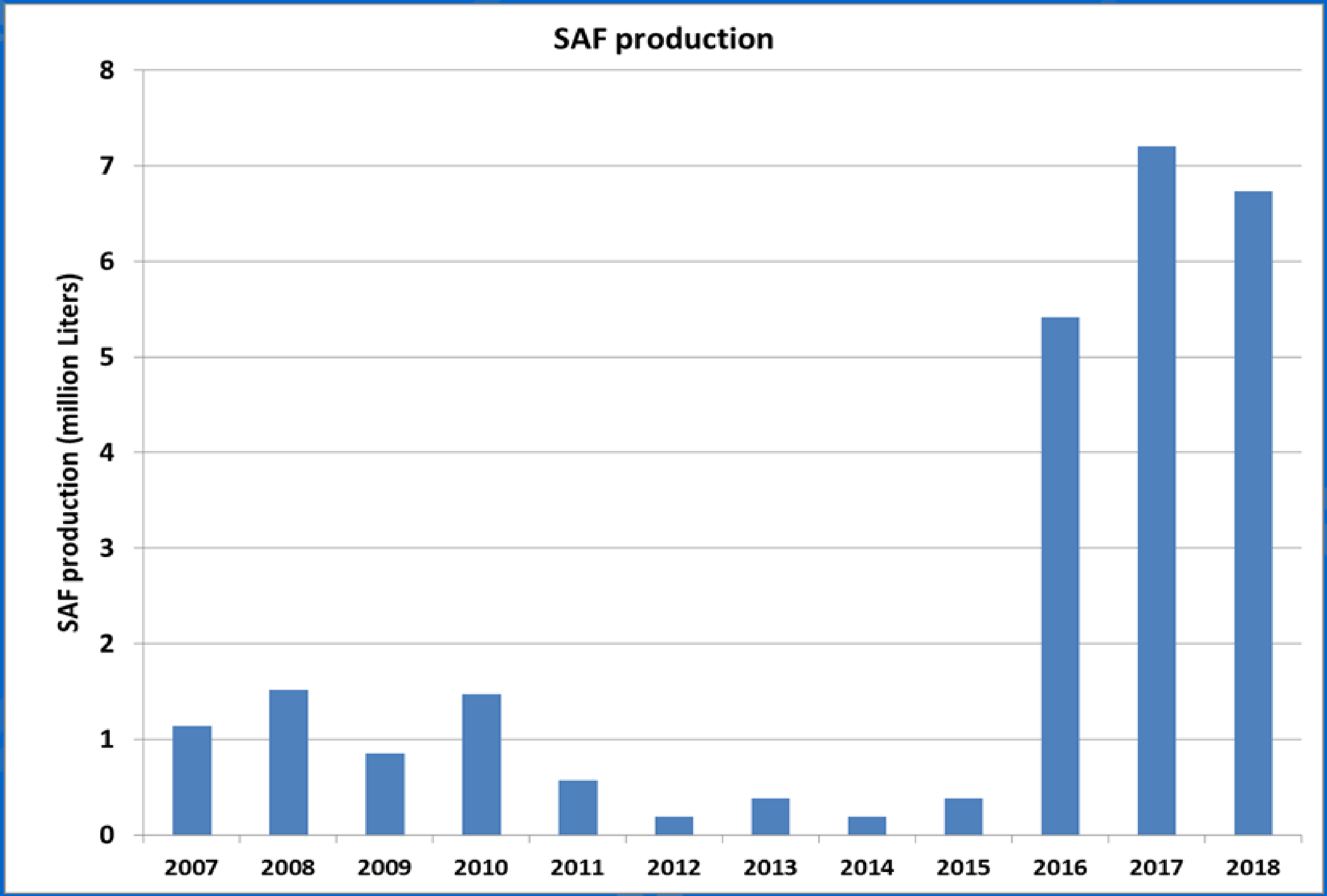
In progress

- Synthetic kerosene/synthetic aromatic kerosene – Shell/Virent
- HEFA+ - HEFA with improved cold flow properties – Boeing
- Pyrolysis from lignocellulosic feedstocks – UOP, Kior (stalled)

- & 15 others in pre-certification stage

Current & past production of biojet

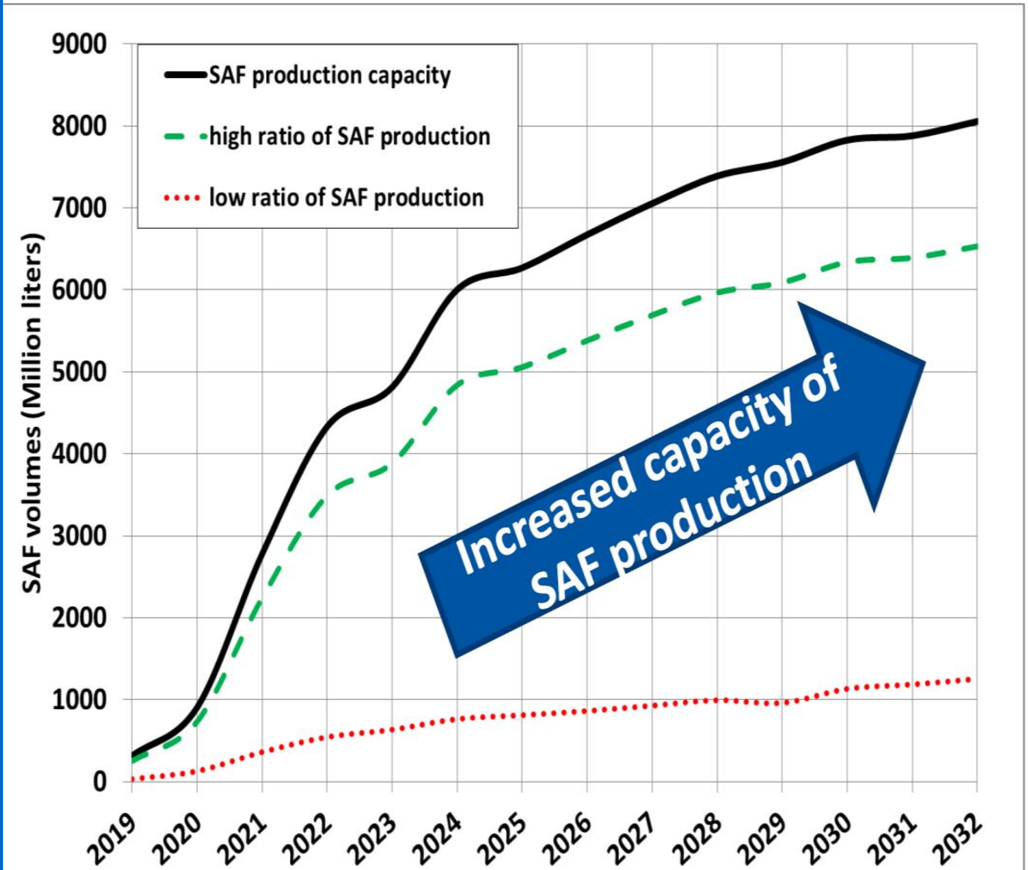
Average of 0.29 million litres per year (2013-2015) to 6.45 million litres per year (2016-2018).



Future production capacity (SAF)

ICAO ENVIRONMENT

ICAO STOCKTAKING SEMINAR
TOWARD THE 2050 VISION FOR
SUSTAINABLE AVIATION FUELS



8 Billion litres (6.5 MT) of SAF production capacity available by 2032, and 6.3 Billion litres (5 MT) in 2025.

ICAO Vision is based on the assumptions of a **progressive increase in the use of SAF.**

Looking to the future - Capacity for SAF production will continue to increase.

Techno-economic analysis

Conversion process	Feedstock	Cost (feedstock contribution)	Reference
HEFA	Camelina oil	$0.80/L	(Natelson and others 2015)
	Palm oil	$0.70–0.79/L (75% of OPEX)	(Hilbers and others 2015)
	Soybean oil	$1.01–1.16/L (up to 70%)	(Pearlson and others 2013)
	Yellow grease Tallow	$0.88–1.06/L (MSP)* $1.05–1.25/L (MSP)* (65%–76%)	(Seber and others 2014)
	Waste oil	$1,03/L (70%)	(De Jong and others 2015)
FT	Corn-stover (gasification)	US$ 0.90/L	(Agusdinata and others 2011)
	Switchgrass (gasification)	US$ 1.10/L	
	Lignocellulose (gasification)	US$ 1.96/L (MSP)*	(Diederichs and others 2016)
	Wood (gasification)	US$ 1.14–1.22/L (MSP)*	(Zhu and others 2011)
	Wood (gasification)	US$ 1.13/L	(Ekbom and others 2009)
ATJ	Sugarcane (ethanol) Corn (ethanol) Switchgrass (ethanol)	US$ 1.56/L (MSP)* US$ 1.75/L (MSP)* US$ 2.30/L (MSP)*	(Staples and others 2014)
	Lignocellulose (syngas)	US$ 1.80/L (MSP)*	(Atsonios and others 2015)
	Lignocellulose (syngas)	US$ 2.00/L (MSP)*	(Diederichs and others 2016)
	Sugarcane (ethanol)	US$ 2.76/L (MSP)*	(Diederichs and others 2016)

* MSP = Minimum Selling Price

ICAO Sustainable Aviation Fuels guide

Sustainability issues - default CI values under CORSIA

Table 1. CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels

Fuel Conversion Process	Region	Fuel Feedstock	Core LCA Value	ILUC LCA Value	LS_f (gCO_2e/MJ)
	Global	Agricultural residues	7.7		7.7
	Global	Forestry residues	8.3		8.3
Alcohol (isobutanol) to jet (ATJ)	Brazil	Sugarcane	24.0	7.3	31.3
	USA	Corn grain	55.8	22.1	77.9
	USA	Miscanthus (herbaceous energy crops)	43.4	-54.1	-10.7
	EU	Miscanthus (herbaceous energy crops)	43.4	-31.0	12.4
	USA	Switchgrass (herbaceous energy crops)	43.4	-14.5	28.9
Alcohol (ethanol) to jet (ATJ)	Brazil	Sugarcane	24.1	8.7	32.8
	USA	Corn grain	65.7	25.1	90.8
Synthesized iso-paraffins (SIP)	Brazil	Sugarcane	32.8	11.3	44.1
	EU	Sugar beet	32.4	20.2	52.6

Technology	Total LCA (gCO2e/MJ) (includes ILUC)
Fischer-Tropsch	-22.5 to +8.3
HEFA	13.9 to 99.1
Isobutanol to jet	-10.7 to 77.9
Ethanol to jet	32.8 to 90.8
Synthesized iso-paraffins (farnesane)	44.1 to 52.6

Policies

- Policies are essential for bridging the gap between fossil jet and biojet
- Different jurisdictions have implemented policies to incentivize production of biojet
  - U.S. both RINs and credits under the California Low Carbon Fuel Standard
  - Netherlands (biotickets)
- Carbon Offset and Reduction Scheme for International Aviation (CORSIA) – agreed at the International Civil Aviation Organisation (ICAO) with implementation from 2021
- Individual airlines offer corporate packages or individual purchase of carbon offsets