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THIRD CONFERENCE ON AVIATION AND ALTERNATIVE FUELS (CAAF/3)

Dubai, United Arab Emirates, 20 to 24 November 2023

Agenda Item 2: Supporting policies to promote the development and deployment of cleaner energy for aviation

UPDATE OF THE SAF SHORT-TERM PRODUCTION PROJECTIONS

(Presented by the ICAO Secretariat)

SUMMARY

As indicated in paragraphs 3.2 to 3.4 of CAAF/3-WP/4, this paper provides updated information on SAF and LCAF production facilities announced since 31 January 2023.

1. INTRODUCTION

1.1 CAAF/3-WP/4 Appendix D provides updated information on the short-term (up to 2030) geographic distribution and trends of existing and planned SAF production facilities. Such information was developed by the ICAO Committee on Aviation Environmental Protection (CAEP) based on the analysis of SAF facilities announced up to 31 January 2023; therefore the information in CAAF/3-WP/4 Appendix D does not include any of the SAF facility announcements made since then.

1.2 To complement this analysis, this Information Paper provides an update of the information on SAF and LCAF announcements made since 31 January 2023.

2. SHORT-TERM PROJECTIONS (ANNOUNCEMENTS MADE UP TO 31 JANUARY 2023)

2.1 The SAF short-term projections rely on the CAEP short-term projections database, which was initially developed during the CAEP/10 cycle (2016-2019) and has been maintained and updated since then. The database includes data and references from publicly-available production announcements from companies planning to produce alternative fuels by 2030.

2.2 The short-term projections provided in CAAF/3-WP/4 were based in a comprehensive update of the database, in which the existing entries were checked for relevance and accuracy, and changed or removed, where needed and in which additional entries were added.

2.3 Moreover, all entries were classified into four maturity levels: A- Very High; B-High; C-Moderate, and D-low. The definitions used by CAEP to perform this maturity classification are provided in Appendix A.

2.4 The short-term projections provided in CAAF/3-WP/4 considered 108 distinct facilities, out of which 25 with a maturity level of A, 20 with a level of B, and 27 with a maturity level of C. The 36 facilities which received a maturity level of D were not used in the analysis. The projections used the CAEP short-term projections database that was frozen on 31 January 2023, and announcements made since then were not included.

2.5 Following this maturity assessment, the information on the SAF facilities was used to develop short-term production scenarios which, in addition to the maturity level of the facilities, also consider assumptions on the SAF production ratio of each facility and assumptions on success rates of the announced facilities. These scenarios are representative of more optimistic or pessimistic developments of the SAF market in the short-term. These short-term production scenarios are associated with the LTAG scenarios IS1, IS2 and IS3, respectively. The definitions of these short-term production scenarios are provided in Appendix B.

2.6 The results of these short-term production scenarios are provided in CAAF/3-WP/4 and detailed on the ICAO website. These results are summarized in the Table 1 for the year 2030.

Table 1 - Projected SAF production volumes in kt for the year 2030, based on announcements made up to 31 January 2023

Short-term production Scenario	Projected SAF production quantities (kilo tonne)	global projected fuel demand* (kilo tonne)	SAF Replacement ratio
LTAG IS1	7,608	347,440	2.19%
LTAG IS2	13,713	344,618	3.98%
LTAG IS3	16,973	338,974	5.01%

** Note: information obtained from the LTAG fuel burn forecasts for 2030, as published in the "ICAO LTAG Data to support state analysis" for the medium traffic growth scenarios. Fuel demand forecasts for IS3 are smaller due to the increased contributions from improved technology and operations under this scenario.*

3. UPDATED INFORMATION ON ANNOUNCEMENTS MADE SINCE 31 JANUARY 2023

3.1 CAEP and the Secretariat have identified **90 additional facility announcements through publicly-available sources** made since 31 January 2023, which were not considered in the projections described in Section 2. These announcements are provided in Appendix C; further details on each announcement are available on the ICAO tracker for SAF production facilities, including their references.

The update of this information is an ongoing task for CAEP and the Secretariat. Any additional information can be provided to the Secretariat for inclusion in further analysis (officeenv@icao.int).

3.2 The announcements refer to facilities that could produce SAF and/or other hydrocarbons that could eventually be directed to SAF production (e.g. Renewable Diesel). One of those announcements also include a potential production of LCAF based on fossil-based natural gas. The following overarching indicators can be drawn from the analysis:

a) 41 of the announcements include specific SAF capacity numbers, summing up to 12,014 kT of SAF production capacity and 2,884kT of other hydrocarbons capacity on the same facilities. It should be noted that around 4,643 kT of this total refer to a single announcement regarding the production of algae-based SAF in Malaysia Sarawak State.

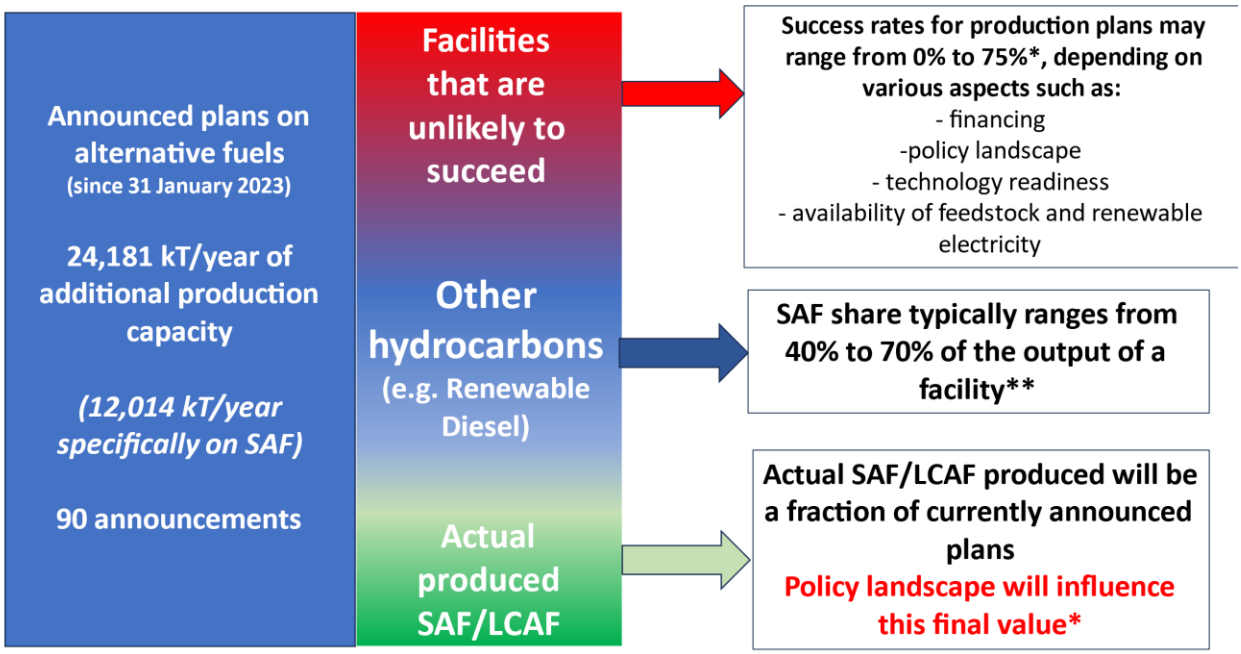
b) 16 announcements refer to SAF production and include total capacity numbers, which include SAF, LCAF and other hydrocarbons (e.g. renewable diesel). These announcements sum up to an additional 6,825 kT of fuel production capacity. It should be noted that 3,028 kt of this total refer to a single announcement from Nacero, regarding the production of SAF and LCAF from renewable and fossil-based natural gas in the United States.

c) 12 announcements do not refer to SAF production, but include specific production capacity of hydrocarbons that could be eventually directed to SAF production. These announcements sum up to 2,457 kT of hydrocarbons production capacity.

d) 20 announcements refer to potential SAF production but do not include any capacity numbers, and one (1) announcement refers generally to renewable fuel production, without any specification on which fuels. Therefore, no production capacity from these facilities were added to the total capacity numbers described above. Nevertheless, this indicates a clear interest in SAF production, including expected levels of investment in the sector.

e) 43 out of the 90 announcements refer to more mature SAF production technologies: ATJ, HEFA, and Fischer-Tropsch. 21 announcements refer to “Power to liquid” facilities that plan to convert CO_2 and renewable energy into hydrocarbons.

3.3 Due to the time available to perform the analysis of additional SAF facility announcements since 31 January 2023, it was not possible to perform a detailed assessment of the announcements (as described in section 2, paragraphs 2.2 to 2.5). Therefore, the capacity numbers stated in items 3.2 a), b) and c) above reflect an unlikely scenario with 100% realization of the production capacity announced. In practice, the execution of those production plans will depend on various aspects such as financing, technology readiness, availability of feedstock and renewable electricity, and policy landscape. These aspects are summarized in the following chart.



**ICAO short-term projections on SAF production", Tables 1, 2 and 3. Available at https://www.icao.int/environmental-protection/Pages/SAF-Projections.aspx*
*** ICAO SAF Rules of Thumb, available at https://www.icao.int/environmental-protection/Pages/SAF_RULESOFTHUMB.aspx*

3.4 Table 2 below provides the information of additional SAF facility announcements in the context of LTAG Fuel demand projections for the year 2030.

Table 2 - Additional SAF production capacity announced since 31 January 2023

Short-term Scenario	Additional SAF production capacity (kilo tonne)	global projected jet fuel demand* (kilo tonne)	Additional SAF Replacement ratio (only considering SAF announcements described in 3.2 a))
LTAG IS1	12,014	347,440	3.5%
LTAG IS2		344,618	3.5%
LTAG IS3		338,974	3.5%

** Note: information obtained from the LTAG fuel burn forecasts for 2030, as published in the "ICAO LTAG Data to support state analysis" for the medium traffic growth scenarios. Fuel demand forecasts for IS3 are smaller due to the increased contributions from improved technology and operations under this scenario.*

3.5 The most robust CAEP assessment based on the announcements until 31 January 2023, as reflected in Table 1, and the additional SAF production announcements since 31 January 2023 as reflected in Table 2, results in a potential SAF replacement ratio ranging from 2.2% (0% success rate of additional announcements) to 8.5% (100% success rate of additional announcements) in 2030. It is worth noting that this only encompasses the 41 additional announcements in item 3.2 a) which include specific SAF capacity numbers (representing 46% of the 90 additional announcements).

3.6 For illustrative purposes, an additional 4,641 kT of SAF/LCAF production capacity would be available if 50% of the additional hydrocarbon announced capacity stated in items 3.2 b) and c) above is directed to SAF, meaning an additional 1.3% replacement ratio for SAF/LCAF to the ratio in Table 2 above .

3.7 Also of note is that 21 of the announcements (23%) contained no quantified information in item 3.2 d) above and they could contribute further to this replacement ratio.

3.8 Finally, it should also be noted that, given permit and construction times, companies that want to produce SAF in 2030 may not necessarily have disclosed their plans to do so by 2023, especially for relative mature technologies such as HEFA or co-processing.

3.9 For information purposes, Table 3 below provides global distribution of these additional facility announcements.

Table 3 - global distribution of additional facility announcements.

Region	**number of announcements**
Africa	1
Asia/Middle East	17
Europe	40
Latin America/Caribbean	5
Oceania	2
North America	25
TOTAL	**90**

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APPENDIX A

MATURITY DEFINITIONS FOR NEW FACILITY ANNOUNCEMENTS

Maturity level	Criteria		Guidelines
A (VERY HIGH)		Company is already producing and selling renewable fuel that has ASTM approval	
B (HIGH)	or	Company has a plant under construction	Physical construction has started
		+ Company has already run a demo or pilot	Demo or pilot depends on the technology maturity (e.g. for HEFA a newcomer can build a plant)
			A demo should have been done by one of the partners
		+ Credibility of the partnership (e.g. financial backing)	
	and	Fuel is already certified for use by aviation	
C (moderate)		The company has not yet started to produce but has financial partners, off-take agreement and/or some government support for technology scale up to commercial demo	
	and	The fuel readiness level is greater or equal to 6	FRL >=6 is equivalent to saying under evaluation for approval
	and	Company has made some kind of communication and/or public information can be found on on-going activities over the last 12-18 months.	
D (low)		All other situations	

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APPENDIX B

SHORT-TERM SCENARIO DEFINITIONS

Scenario	Code	Maturity	Facility Jet Fuel Ratio	Overall Success Rate for A Maturity	Overall Success Rate for B Maturity	Overall Success Rate for C Maturity
Low	1	A, B	Actual or low %	25%	10%	0%
Moderate ***(associated with LTAG IS1)***	1-2	A, B, C	Actual or low %	50%	25%	10%
High ***(associated with LTAG IS2)***	1-3	A, B, C	Actual or high% for codes 1-2, Actual or low% for code 3	75%	50%	25%
High+ ***(associated with LTAG IS3)***	1-3	A, B, C	High%	75%	50%	25%

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APPENDIX C

LIST OF NEW SAF/LCAF PRODUCTION FACILITIES ANNOUNCED SINCE 31 JANUARY 2023

Company	ASTM	Country	City	Total Capacity (kt)	SAF capacity (kt)
Acelen	ASTM D7566 Annex 2 (HEFA)	Brazil	São Francisco do Conde	800.0	
AirCompany	Power to Liquid	United States	New York	0.0	
Alder Fuels	Pyrolysis	United States	Golden, CO	0.0	0.0
Arcadia eFuels	Power to Liquid	Denmark	Vordingborg	80.0	80.0
AVEBIO	Power to Liquid	France	Tartas		
Belize and Variodin Public-Private Partnership	Undisclosed	Belize			0.0
Bio-D	Undisclosed	Colombia		151.42	151.4
BioJ co.,ltd./Biomaterial in Tokyo	ASTM D7566 Annex 5 (ATJ)	Japan	Shikokuchuou-shi Ehime-ken, Japan	0	0
Biojet	ASTM D7566 Annex 1 (Fischer-Tropsch)	Norway	Hønefoss		
BioTJet	Power to Liquid	France	Lacq	110.0	110.0
BP	Undisclosed	United States	Blaine, WA		
Cap Clean Energy Corp	Undisclosed	Canada			
Cemvita	eCO2 oil via bacteria	United States	Houston	0.0	
Cepsa	Undisclosed	Spain	Palos de la Frontera	500.0	
Cepsa	ASTM D7566 Annex 2 (HEFA)	Spain	Cádiz, Spain	78.7	
CleanJoule	Undisclosed	United States	Salt Lake City		
Cosmo Oil	ASTM D7566 Annex 5 (ATJ)	Japan		176	176.0

Diamond Green	ASTM D7566 Annex 2 (HEFA)	United States	Port Arthur, TX	1423.3	711.7
Dimensional energy	Power to Liquid	Canada	Vancouver, BC	0.1	0.0
Dimensional energy	Power to Liquid	United States	Niagara Falls, NY	9.3	0.0
Dimensional energy	Power to Liquid	Greece		46.7	46.7
EcoCeres	ASTM D7566 Annex 2 (HEFA)	Malaysia	Johor Bahru	350.0	
EcoCeres	ASTM D7566 Annex 2 (HEFA)	China	Zhangjiagang	300.0	100.0
EDF	Power to Liquid	France	Pays de la Loire		
EDL	Power to Liquid	Germany	Leipzig	50.0	50.0
ENEOS	Undisclosed	Australia		400.0	
Engie	Power to Liquid	France	Dunkirk	100.0	0.0
Engie	Power to Liquid	France	Le Havre	70.0	70.0
Federated Co-operatives Limited (FCL)	ASTM D7566 Annex 2 (HEFA)	Canada	Regina	800.0	0.0
Firefly	Undisclosed	United Kingdom	Bristol		0.0
Flite	ASTM D7566 Annex 5 (ATJ)	Netherlands		30.0	30.0
Fuji Oil	Undisclosed	Japan	Sodegaura	144.0	144.0
Galp	ASTM D7566 Annex 2 (HEFA)	Portugal	Sines	455.7	193.0
Global Bioenergies	Fermentation	France	Pomacle		0.0
Granbio	ASTM D7566 Annex 5 (ATJ)	United States		6.1	6.1
Green Energy Transformation Inc	ASTM D7566 Annex 2 (HEFA)	Canada	Calgary	301.8	301.8
H2V and SAF+ Consortium	Power to Liquid	France	Marseille	80.0	80.0

Haffner Energy	ASTM D7566 Annex 1 (Fischer-Tropsch)	France		35.0	35.0
HCS Group	ASTM D7566 Annex 5 (ATJ)	Germany	Speyer	60.0	60.0
Helvoil	ASTM D7566 Annex 2 (HEFA)	Switzerland	Monthey	40.0	40.0
HH2E	Power to Liquid	Germany	Leipzig	200.0	200.0
HH2E	Power to Liquid	Germany	Leipzig	300.0	300.0
Honda	Undisclosed	Japan			0.0
Honeywell	Undisclosed	Egypt	Alexandria	120.0	120.0
Hy2gen France	Power to Liquid	France	Meyreuil/Gardanne	32.1	32.1
idunnh2	Power to Liquid	Iceland	HELGUVÍK	0.0	
Imperial Oil	ASTM D7566 Annex 2 (HEFA)	Canada	Edmonton	800.0	0.0
Ineratec	Power to Liquid	Netherlands	Amsterdam	35.0	0.0
Jet Zero Australia	ASTM D7566 Annex 5 (ATJ)	Australia	North Queensland	80.0	80.0
Lanzajet	ASTM D7566 Annex 5 (ATJ)	India	Haryana		
Lanzajet	ASTM D7566 Annex 5 (ATJ)	United States	Soperton, GA	30.3	
Lootah Biofuels	Undisclosed	Maldives			
Nacero	ASTM D7566 Annex 1 (Fischer-Tropsch)	United States	Penwell, TX	3028.3	
Neste Oil	ASTM D7566 Annex 2 (HEFA)	Netherlands	Rotterdam	2700.0	1200.0
Norsk e-Fuel	Power to Liquid	Norway	Mosjøen		
Par Pacific	ASTM D7566 Annex 2 (HEFA)	United States	Kapolei, HI	184.7	0.0
Pertamina	ASTM D7566 Annex 2 (HEFA)	Indonesia	Cilacap	278.4	0.0
Pertamina	ASTM D7566 Annex 2 (HEFA)	Indonesia	Cilacap	278.6	

Petrobras	ASTM D7566 Annex 2 (HEFA)	Brazil	Cubatão	557.1	348.2
Petronas	HEFA coprocessing	Malaysia	Malacca	0.0	
PKN Orlen	ASTM D7566 Annex 2 (HEFA)	Poland	Plock	300.0	300.0
Preem	ASTM D7566 Annex 2 (HEFA)	Sweden	Gothenburg	480.0	480.0
Raizen	ASTM D7566 Annex 5 (ATJ)	Brazil	Piracicaba		
Raven SR	ASTM D7566 Annex 1 (Fischer-Tropsch)	United States	Richmond, CA	200.0	200.0
Reformed Energy	ASTM D7566 Annex 1 (Fischer-Tropsch)	United States	Bellaire, TX	4.5	3.8
Reformed Energy	ASTM D7566 Annex 1 (Fischer-Tropsch)	United States	Colorado Country, TX	39.4	39.4
Repsol	ASTM D7566 Annex 7 (HC-HEFA)	Spain	Cdad. Real	200.0	0.0
Repsol	ASTM D7566 Annex 2 (HEFA)	Spain	Cartagena, Murcia	200.0	200.0
SAF+ consortium	Power to Liquid	Canada	Quebec	80.0	80.0
Sarawak State	Undisclosed	Malaysia	Bintulu	4642.8	4642.8
Satorp	HEFA coprocessing	Saudi Arabia	Jubail	0.0	
Shandong Haike Chemical	ASTM D7566 Annex 2 (HEFA)	China			
Sichuan Jinshang Environmental Protection Technology	ASTM D7566 Annex 7 (HC-HEFA)	China	Suining	300.0	300.0
SkyNRG	ASTM D7566 Annex 1 (Fischer-Tropsch)	Sweden	Småland	20.0	20.0
Strategic Biofuels	ASTM D7566 Annex 1 (Fischer-Tropsch)	United States	Columbia, Louisiana	99.9	0.0
Summit	ASTM D7566 Annex 5 (ATJ)	United States	US Gulf Coast	757.1	757.1
Synhelion	solar thermochemistry	Spain		1.0	

Tadweer	Undisclosed	United Arab Emirates	Abu Dhabi		
Taiyo Oil	ASTM D7566 Annex 5 (ATJ)	Japan	Okinawa	176.0	
Tidewater renewables	ASTM D7566 Annex 2 (HEFA)	Canada	Prince George	139.3	
Total	ASTM D7566 Annex 2 (HEFA)	France	Grandpuits-Bailly-Carrois	210.0	210.0
Total	ASTM D7566 Annex 2 (HEFA)	France	Grandpuits-Bailly-Carrois	75.0	75.0
Total	HEFA coprocessing	France	Gonfreville-l'Orcher	40.0	40.0
Twelve	Power to Liquid	United States	Moses Lake, WA	0.1	0.1
Uniper	ASTM D7566 Annex 1 (Fischer-Tropsch)	Sweden	Sollefteå		
UPM Biofuels	Undisclosed	Netherlands	Rotterdam	500.0	
UPM Biofuels	Not applicable (renewable diesel only)	Finland	Lappeenranta	130.0	
USA Bioenergy	ASTM D7566 Annex 1 (Fischer-Tropsch)	United States	Bon Wier, Texas	103.0	
Varo	Undisclosed	Germany		260.0	
Willis Sustainable Fuels	Power to Liquid	United Kingdom	Teesside		
			Total	**24,181**	**12,014**

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