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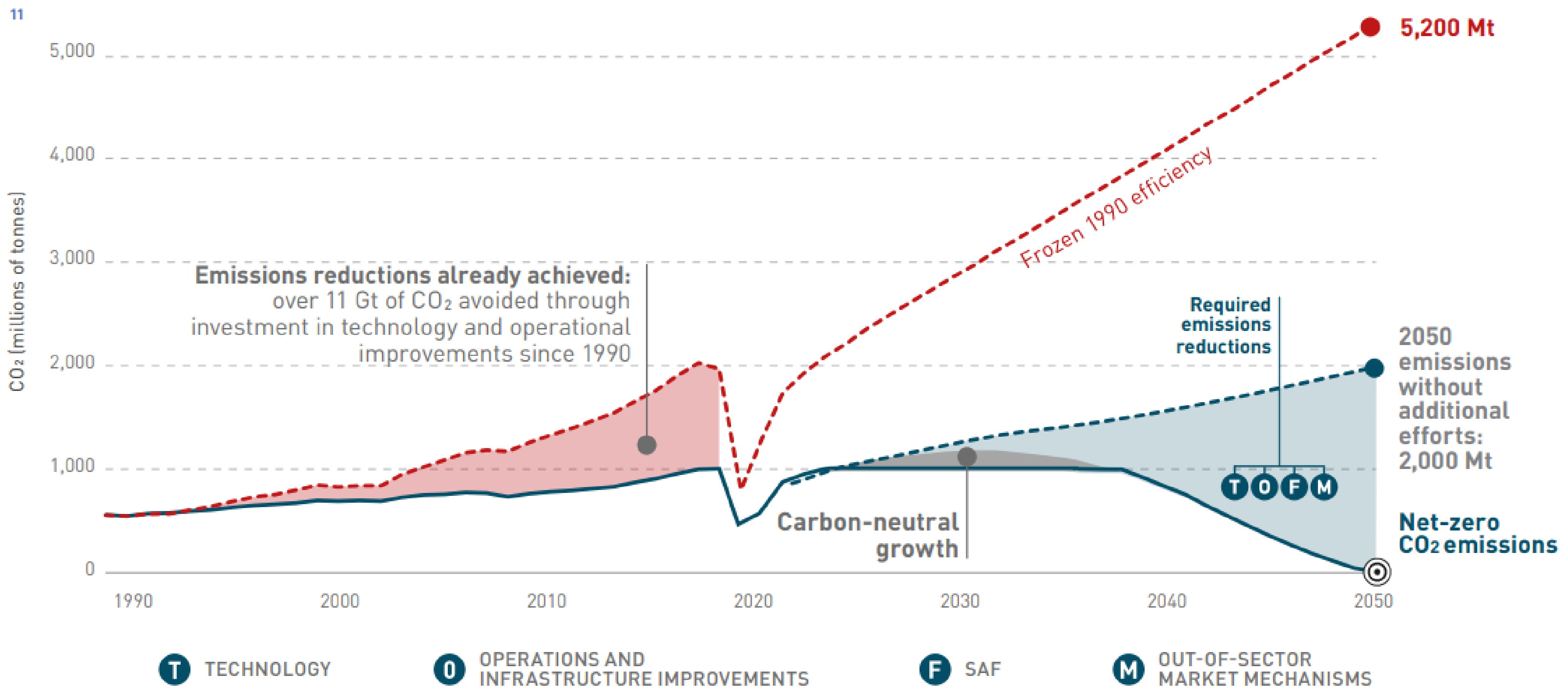
Todo carbono conta

Ou como reduzir as emissões na aviação

CAEP
FTG / WG5
CORSIA
SAF
LCAF
SBC
MRV

Abr/2025

A redução das emissões na aviação internacional



126 países na fase voluntária

Quem define como reduzir emissões na aviação internacional

- Homologação de rotas para produção de combustíveis sintéticos para aviação
- Especificações técnicas para combustíveis sintéticos de aviação
- Limites de mistura para combustíveis sintéticos de aviação
- Foco no desempenho das aeronaves e na segurança de voo

O que é SAF?

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SAF = Jet A/Jet A-1 + sustentabilidade

What really is the case:

Synthetic Blending Component (SBC) + Conventional Blending Component = SAF Blend

What is determined to be equivalent to Jet A/A-1 is the SAF blend, not the SBC;
SBC (which is what people refer to when they say SAF) is not necessarily Jet A/A-1 equivalent.

O que diz a ASTM D-7566

Designation: D7566 – 24b

Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons[1]

A2. SYNTHESIZED PARAFFINIC KEROSINE FROM HYDROPROCESSED ESTERS AND FATTY ACIDS

A2.1 Scope

A2.1.1 This annex defines synthesized paraffinic kerosine produced from hydroprocessed esters and fatty acids for use as a synthetic blending component in aviation turbine fuels for use in civil aircraft and engines. The specifications in this annex may be used for contractual exchange of synthetic blending components.

A2.1.2 The synthetic blending components defined in this annex are not satisfactory for aviation turbine engines unless blended with conventional fuel or conventional blending components in accordance with the limitations described in 6.1.2.

1.3.2 Any location at which blending of synthetic blending components specified in Annex A1 (FT SPK), Annex A2 (HEFA SPK), Annex A3 (SIP), Annex A4 synthesized paraffinic kerosine plus aromatics (SPK/A), Annex A5 (ATJ), Annex A6 catalytic hydrothermolysis jet (CHJ), Annex A7 (HC-HEFA SPK), or Annex A8 (ATJ-SKA) with D1655 fuel (which may on the whole or in part have originated as D7566 fuel) or with conventional blending components takes place shall be considered batch origination in which case all of the requirements of Table 1 of this specification (D7566) apply and shall be evaluated. Short form conformance test programs commonly used to ensure transportation quality are not sufficient. The fuel shall be regarded as D1655 turbine fuel after certification and release as described in 1.3.1.

1.3.3 Once a fuel is redesignated as D1655 aviation turbine fuel, it can be handled in the same fashion as the equivalent refined D1655 aviation turbine fuel.

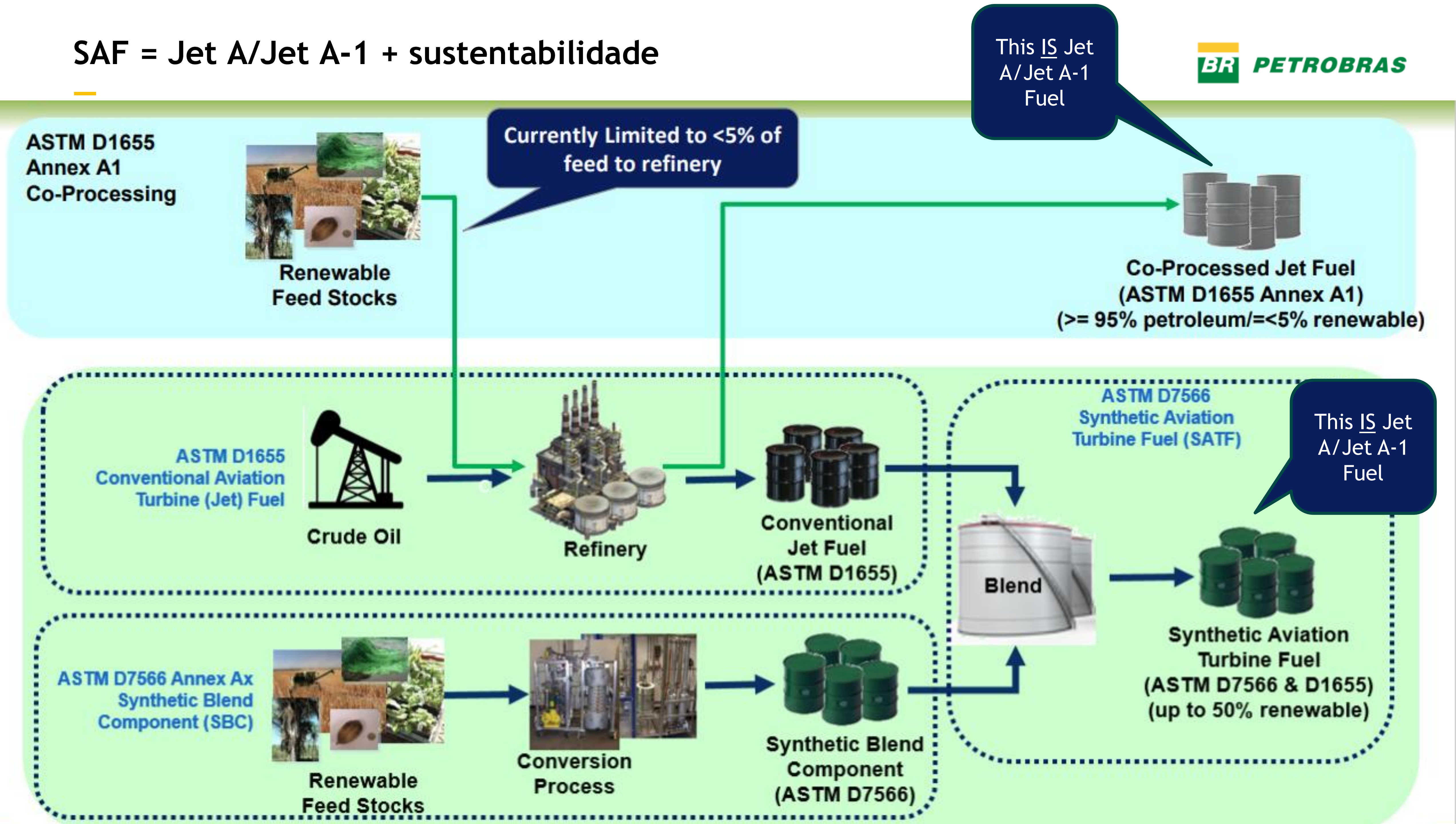
6. Materials and Manufacture

6.1 Aviation turbine fuel, except as otherwise defined in this specification, shall consist of the following blends of components or fuels:

6.1.1 Conventional blending components or Jet A or Jet A-1 fuel certified to Specification D1655; with up to 50 % by volume of the synthetic blending component defined in Annex A1.

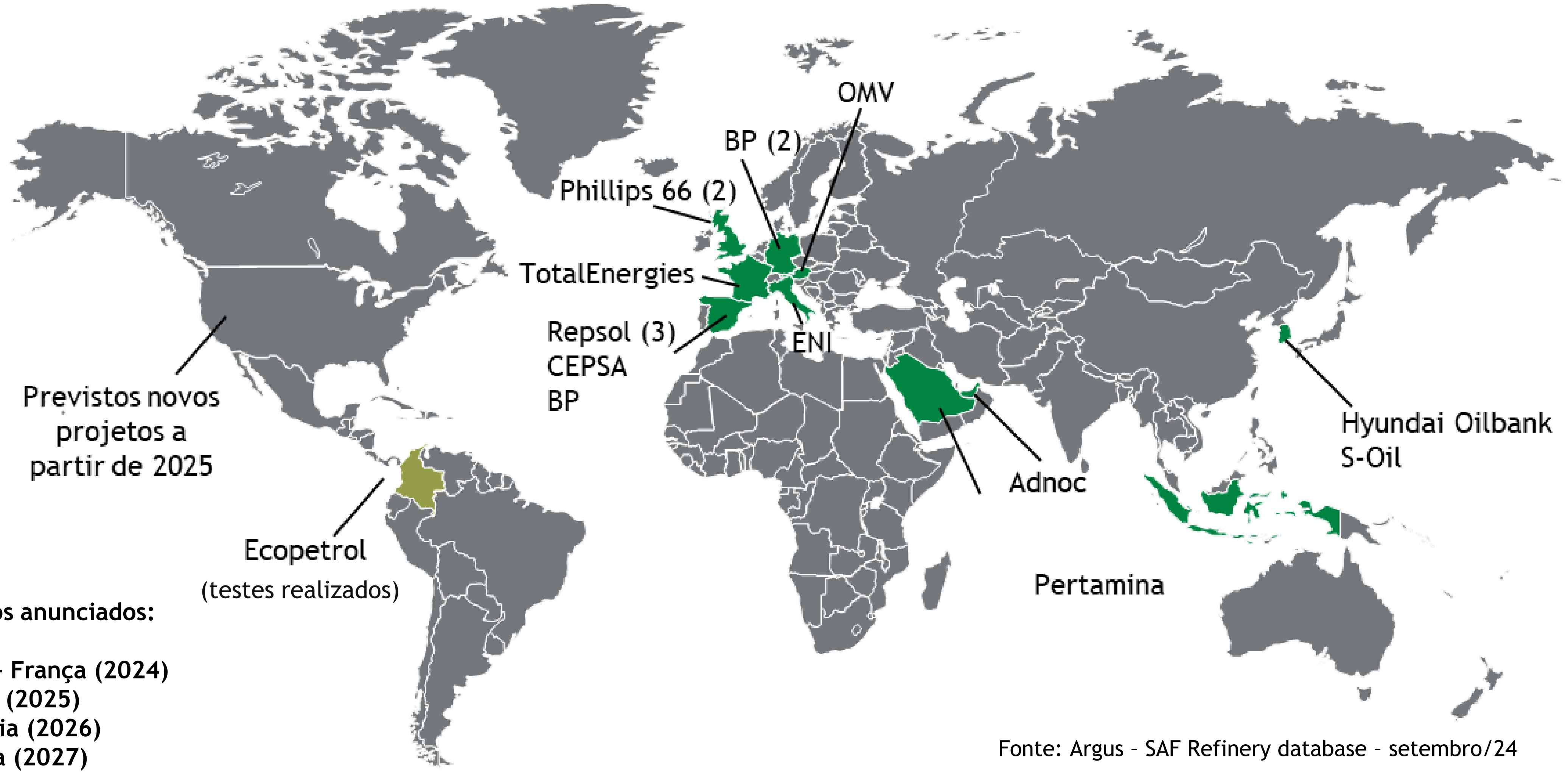
6.1.2 Conventional blending components or Jet A or Jet A-1 fuel certified to Specification D1655; with up to 50 % by volume of the synthetic blending component defined in Annex A2.

SAF = Jet A/Jet A-1 + sustentabilidade



Coprocessamento

Plantas de produção SAF por coprocessamento em operação



Outros projetos anunciados:

TotalEnergies - França (2024)
BP - Alemanha (2025)
Tupras - Turquia (2026)
Preem - Suécia (2027)

Fonte: Argus – SAF Refinery database – setembro/24

Quem define como reduzir emissões na aviação internacional

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ASTM

- Homologação de rotas para produção de combustíveis sintéticos para aviação
- Especificações técnicas para combustíveis sintéticos de aviação
- Limites de mistura para combustíveis sintéticos de aviação
- Foco no desempenho das aeronaves e na segurança de voo

ICAO 80

- Definição dos combustíveis elegíveis
- Padronização dos esquemas de certificação
- Aprovação de créditos de carbono
- Metas de IC na aviação internacional
- IC = iLUC + LCA
- Foco na sustentabilidade

Corsia Eligible Fuels (CEF)

CORSIA Sustainable Aviation Fuel – SAF → **Regulamentado e com processo de certificação ativo e definido**

- SBC, produzido por rota HEFA, ATJ etc, em mistura com combustível mineral (limites máximos variam com a rota até 50 %, no máximo)
- Carga renovável coprocessada com querosene de aviação derivado de petróleo (limite máximo = 5 %)

CORSIA Lower Carbon Aviation Fuel – LCAF → Regulamentado, mas com processo de certificação em definição → Combustível derivado de petróleo com menor intensidade de carbono (IC)

SAF = Jet A/Jet A-1 + sustentabilidade

As diversas rotas válidas para produção de SAF são definidas pela ASTM e reconhecidas pela ICAO

A visão da ICAO

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ICAO Global Framework for SAF, LCAF and other Aviation Cleaner Energies

(Adopted by CAAF/3 on 24 November 2023)

1. ICAO and its Member States will work together to strive to achieve a Vision of implementing the elements of this global framework in order to globally scale-up the development and deployment for SAF, LCAF and other aviation cleaner energies, as such fuels are expected to have the largest contribution to aviation CO_2 emissions reductions in the 'basket of measures' to achieve the LTAG. To support the achievement of the LTAG, ICAO and its Member States strive to achieve a collective global aspirational Vision to reduce CO_2 emissions in international aviation by 5 per cent by 2030 through the use of SAF, LCAF and other aviation cleaner energies (compared to zero cleaner energy use). In pursuing this Vision, each State's special circumstances and respective capabilities will inform the ability of each State to contribute to the Vision within its own national timeframe, without attributing specific obligations or commitments in the form of emissions reduction goals to individual States.

4. In addition, the Vision should:

   a) enable the increased production and supply of SAF, LCAF and other aviation cleaner energies across all regions;

   h) not exclude any particular fuel source, pathway, feedstock or technology, as long as it meets the CORSIA sustainability criteria;

A ICAO determina as intensidades de carbono dos SAF Blend Components

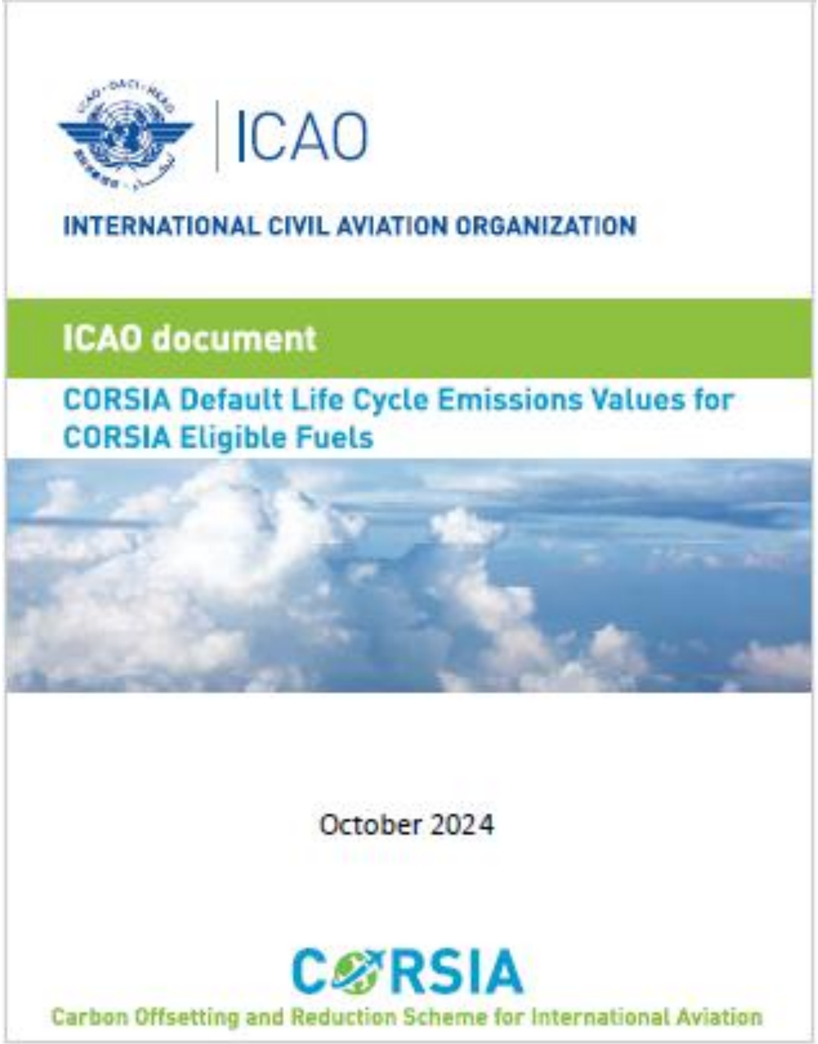

Table 2. CORSIA Default Core LCA Values for CORSIA Eligible Fuels produced with the HEFA Conversion Process

Fuel Feedstock	Pathway Specifications	Default Core LCA Value	Applicability Provisions
Tallow		22.5	This value can be applied to CEF batches produced until 31 December 2029.
Beef Tallow	relevant lifecycle starts with transportation from slaughterhouse to rendering facility	29.7	
Poultry fat	relevant lifecycle starts with transportation from slaughterhouse to rendering facility	33.7	
Lard fat	relevant lifecycle starts with transportation from slaughterhouse to rendering facility	27.8	
Mixed Animal Fats	relevant lifecycle starts with transportation from slaughterhouse to rendering facility	28.6	
Used cooking oil		13.9	
Palm fatty acid distillate		20.7	
Corn oil	Oil from dry mill ethanol plant	17.2	
Soybean oilseed		40.4	
Rapeseed/Canola oilseed		47.4	
Palm fresh fruit bunches	At the oil extraction step, at least 85% of the biogas released from the Palm Oil Mill Effluent (POME) treated in anaerobic ponds is captured and oxidized.	37.4	
Palm fresh fruit bunches	At the oil extraction step, less than 85% of the biogas released from the Palm Oil Mill Effluent (POME) treated in anaerobic ponds is captured and oxidized.	60.0	
Brassica carinata oilseed		34.4	
Camelina oilseed		42.0	
Jatropha oilseed	Meal used as fertilizer or electricity input	46.9	
Jatropha oilseed	Meal used as animal feed after detoxification	46.8	
Non-standard coconuts	The default value is valid if the hydrogen used is not produced from coal. If hydrogen is produced from coal, a correction value of 5.17 gCO2e/MJ needs to be added to the core LCA value.	26.9	

Incluindo a parcela coprocessada por hidrotratamento

Table 6. CORSIA Default Core LCA Values for CORSIA Eligible Fuels produced with the Coprocessing HEFA Conversion process *

Fuel Feedstock	Pathway Specifications	Default Core LCA Value*
Tallow	Maximum of 5% of tallow in volume Feedstock inserted at either the hydrotreater (HDT) or hydrocracker (HYK) points	27.2
Used cooking oil	Maximum of 5% of used cooking oil in volume Feedstock inserted at either the hydrotreater (HDT) or hydrocracker (HYK) points	16.7
Soybean oilseed	Maximum of 5% of soybean oil in volume Feedstock inserted at either the hydrotreater (HDT) or hydrocracker (HYK) points	40.7

*The default core LCA values in Table 6 refer only to the biogenic fraction of the fuel. The L_{CEF} of a finished co-processed fuel needs to be calculated as the sum of the L_{CEF} of the two components, weighted by their energy contributions, as provided in Section 3.1.1.

ICAO document - CORSIA Methodology For Calculating Actual Life Cycle Emissions Values

2.3 Actual core LCA calculation – specific provisions for co-processed CORSIA SAF

For co-processing, a fuel producer will measure/estimate all inputs and outputs of the facility for scenarios both with and without co-processing operations. Refinery configuration changes will be limited to adding the co-processing facility to rule out other confounding factors in emission changes. The inputs include crude oil, bio-feed, energy input by type (e.g., natural gas and electricity), and any materials. The outputs include fuel products and refinery emissions. Crude oil inputs are normalized (see Figure 11 of the CORSIA Supporting document "LCA methodologies" for additional details on normalization). By subtracting the base (petroleum only) case from the co-processing case, the fuel producer calculates the changes in inputs and outputs. First, the changes in refinery emissions are allocated to the changes in fuel production (MJ). Since biogenic carbon emissions need to be carbon-neutral, carbon balance will be used to estimate biogenic carbon emissions from the refinery, which is then subtracted from the total refinery emissions. In order to calculate the upstream emissions associated with the changes in energy inputs, an LCA tool (e.g., GREET) needs to be used. The upstream emissions of the energy inputs are then allocated to the changes in fuel production (MJ). Based on the calculated bio-feedstock input allocated to MJ fuel production, emissions associated with bio-feedstock production and transportation can be calculated using the LCA tool. Similarly, downstream (fuel transportation/distribution and combustion) emissions can be calculated. Note that co-processed SAFs are considered to be biogenic, so CO_2 emissions from fuel combustion are not accounted for. Sustainability certification schemes (SCS) may prescribe measurements techniques (including but not limited to C14 testing and mass balance) and protocol (based on energy allocation as described in Section 2.2 to assign biogenic carbon content among the product and co-products, in proportion to their contribution to the total energy content), as a means to verify the modelled changes in inputs and outputs.

A certificação considera toda a cadeia

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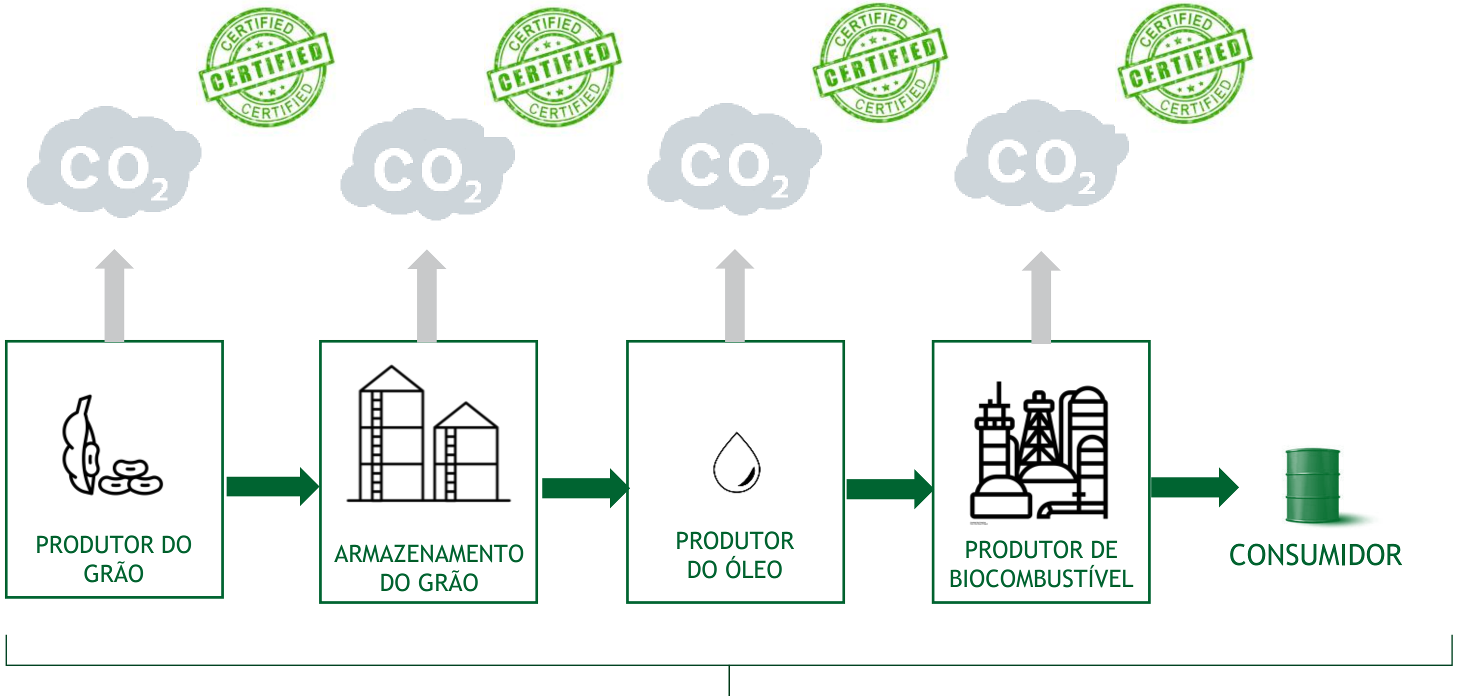
As informações de emissões de GEE são calculadas para cada agente certificado na cadeia de custódia



No esquema de certificação do CORSIA, todos os agentes devem ser certificados para garantir a rastreabilidade da matéria-prima

Opções da certificação - Balanço de massa

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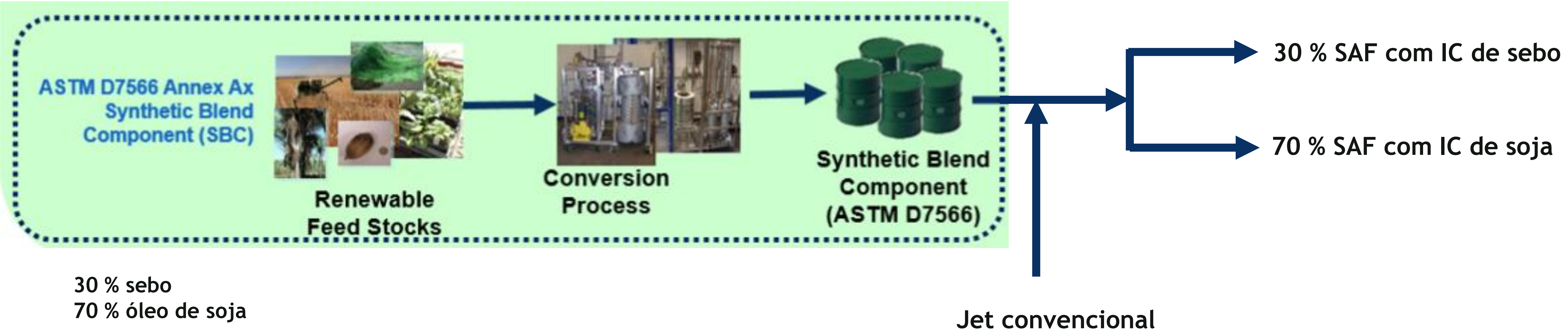
Table 3. Traceability requirements set by SCS on Economic Operators

THEME	REQUIREMENTS
1. Traceability: Mass balance	1.1 SCS requires economic operators to use a mass balance system that: a) Allows batches of sustainable materials with differing sustainability characteristics to be mixed. b) Requires information about the sustainability characteristics and sizes of the physical quantity (batches) referred to in point (a) to remain assigned to the mixture. c) Provides for the sum of all consignments withdrawn from the mixture to be described as having the same sustainability characteristics, in the same quantities, as the sum of all consignments added to the mixture, using correct conversion factors in the case of chemical conversion. d) Demonstrates that the product claims are linked correctly to the feedstock quantities claimed, using correct conversion factors in the case of chemical conversion.



No cenário doméstico, a lei 14.993, de 08/10/2024, define diretrizes para a redução das emissões na aviação

Ano	2027	2028	2029	2030	2031	2032	2033	3034	2035	2036	2037
Meta de Redução de CO^2	1%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%

Há ainda pontos a definir:

"Art. 8º A ANP estabelecerá os valores das emissões totais equivalentes por unidade de energia computados no ciclo do poço ***à queima de cada rota tecnológica de produção de SAF****, para fins de contabilizar a descarbonização em face do querosene de aviação fóssil.*

Parágrafo único. Além do disposto na RenovaBio, a ANP deverá observar as seguintes diretrizes na elaboração da análise do ciclo do poço à queima: (...)

II - busca pelo alinhamento metodológico à Organização de Aviação Civil Internacional em relação aos requisitos de elegibilidade e de certificação para o SAF.

Art. 10. Os operadores aéreos ficam ***obrigados a reduzir as emissões de GEE em suas operações domésticas por meio do uso de SAF****, conforme os seguintes percentuais mínimos de redução: (...)*

§ 2º Poderão ser admitidos meios alternativos para cumprimento da meta de que trata o caput deste artigo, nos termos do regulamento. (...)

§ 5º Caberá à Agência Nacional de Aviação Civil (Anac), no exercício da competência prevista no inciso X do caput do art. 8º da Lei nº 11.182, de 27 de setembro de 2005:

I - estabelecer a metodologia de cálculo de verificação da redução de emissões associadas ao uso de SAF e de outros meios alternativos a que se refere o § 2º deste artigo; e

II - fiscalizar o cumprimento das obrigações previstas neste artigo pelos operadores aéreos."

Considerações finais

Ainda há discussões em andamento para a aviação doméstica

- Reconhecimento das rotas e dos métodos aceitos pela ICAO para redução de emissões, como produto de coprocessamento, LCAF, avanços nos equipamentos
- Definição do cálculo de IC para diferentes processos e matérias primas
- Utilização da certificação por balanço de massa, conforme critérios de eligibilidade da ICAO
- Incentivo à produção de matérias-primas com menor impacto no meio ambiente (iLUC)
- Cuidados para evitar distorções na concorrência por matérias primas

Mas, certamente,

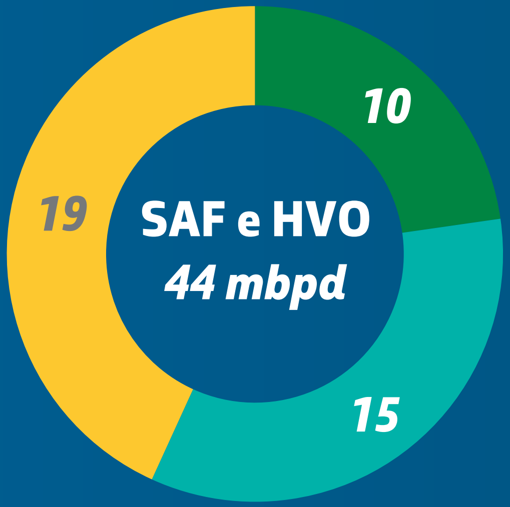
- Coprocessamento é uma importante opção para maior oferta / menor custo dos combustíveis de aviação de baixo carbono nos primeiros anos da jornada de descarbonização
- O coprocessamento depende da disponibilidade de hidrogênio e de folga de capacidade em HDT de alta severidade, o que torna sua produção limitada em volume e não dispensa a implantação de unidades dedicadas

Unidades de Produção de SAF no Plano de Negócios 2025-2029

Produção de SAF

HEFA BOAVENTURA
19 mbpd
(carteira em avaliação)

ATJ REPLAN
10 mbpd
em estudo
(carteira em avaliação)



HEFA RPBC
15 mbpd
(carteira em implementação)

Projetos em Parceria
Em Avaliação
ACELEN (20 mbpd)
Riograndense (15 mbpd)

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