

project FLEXJET

Sustainable Jet Fuel from Flexible Waste Biomass

EU Horizon2020 Project

flexJET

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International Energy Agency

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UNIVERSITY OF BIRMINGHAM

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flexJET project

Project overview

- Total costs: 15 M Euro
- EU financing: 10 M Euro
- H2020 LCE-20 Programme
- Consortium with 13 partners from 5 EU countries
- Duration: 48 Months (2018-2022)

Kick –off	Plant Design	Demo Plant	SAF Delivery	End of Project
April 2018	Mid 2019	Mid 2020	End 2021	Mid 2022

project FLEXJET

Sustainable Jet Fuel from Flexible Waste Biomass



Partners

Fraunhofer UMSICHT

green fuels

UNIVERSITY OF BIRMINGHAM

susteen sustainable resources from waste

HYGEAR

The University Of Sheffield.

SkyNRG

LEITAT managing technologies PPT R&D 2017

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

WRG Europe Ltd Engaging with Research

etaflorence renewableenergies

- Management
- Technology (SABR-TCR / PSA)
- Products Tests
- Supply Chain
- Social Sustainability Analysis
- Environmental Sustainability Analysis
- Dissemination



Aim

- To build a **pre-commercial demonstration plant** for the production of **sustainable aviation fuel** (SAF) derived from **organic waste and waste vegetable oil** while mapping the full **economic social and environmental impact** of the technology.

Flexible sustainable process
Feedstock diversification



EU sustainable aviation vision

- Vision for a climate neutral economy by 2050
- Bound Paris agreement to keep global temperature rise to 1.5 deg C
- RED amended in 2015 to include a voluntary opt in for aviation taken up by UK
- EU has invested approx. Euro 5 Billion over last 10 Years to support these commitments
- In 2016 aviation accounted for 3.6% of all EU28 GHG emissions (13.4% from transport sector)
- Aviation emissions more than doubled since 1990 (will continue to become more significant as other sectors decarbonise)



- From feedstock diversification assessment
- Through environmental and social sustainability evaluation of the process
- To commercial uptake facilitation of cost-competitive aviation fuel

By contributing to the Renewable Energy Directive targets for renewable energy and to the fulfillment of the CORSIA targets



Objectives

- Demonstrate the technical viability of aviation fuel production from waste biomass compliant under ASTM D7566
- Evaluate the environmental and social sustainability of the process
- Contribute to the Renewable Energy Directive targets for renewable energy
- Facilitate towards commercial uptake of the technology



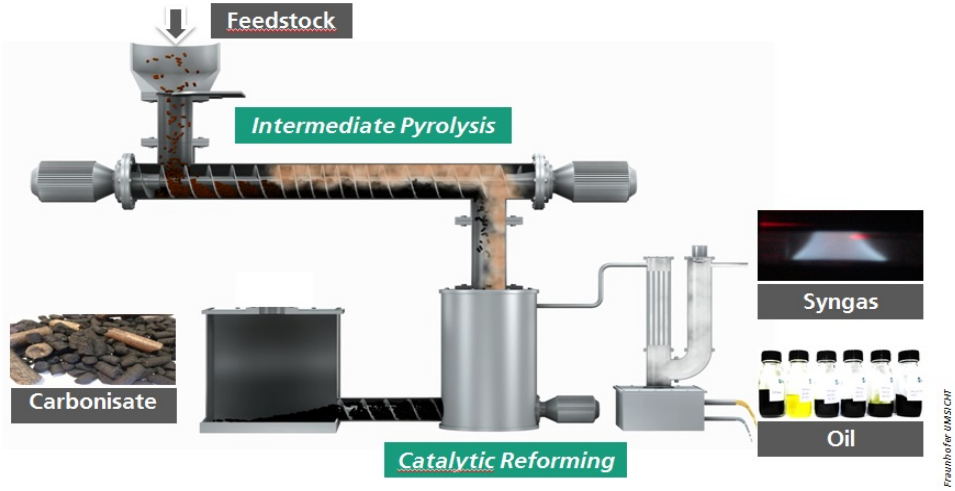
Direct Impacts

- GHG reduction
- Destination for waste biomass and UCO
- Decarbonisation of different sectors
- Jobs creation
- Innovation potential



Combination of Innovative Technologies

TCR® (Thermo-Catalytic Reforming)



Source:

susteen sustainable resources from waste





- TCR (Thermo-Catalytic Reforming)
- 500 Kg/h Biomass Plant

- TCR (Thermo-Catalytic Reforming)
- 30 Kg/h Biomass Plant





TCR Feedstock





TCR Crude Products

BIO-OIL



C	76.6 wt.%
H	7.7 wt.%
N	2.2 wt.%
S	0.6 wt.%
O (diff.)	11.2 wt.%
H_2O	1.7 wt.%
Ash	< 0.05 wt.%
TAN	4.9 mg KOH/g
HHV	33.9 MJ/kg

- miscible with fossil/bio fuels
- low tar content and acidity
- low fraction of non-volatiles

SYNGAS



H_2	35 ± 3 v/v%
CO	15 ± 2 v/v%
CO_2	25 ± 1 v/v%
CH_4	7 ± 2 v/v%
C_xH_y	2 ± 1 v/v%
N_2 (diff.)	16 ± 2 v/v%
HHV	11 MJ/m³

- tar and dust free gas
- H_2 over 30 v/v%

CHAR



C	65.0 wt.%
H	1.2 wt.%
N	1.5 wt.%
S	0.3 wt.%
O (diff.)	2.2 wt.%
H_2O	0.7 wt.%
Ash	29.1 wt.%
HHV	23.9 MJ/kg

- high mechanical stability
- transportable and storable
- low-odour



Combination of Innovative Technologies

SABR (Sustainable Aviation Through Biofuel Refining)



Source:

green fuels gfr



- SABR Plant Green Fuels
- Transesterification (50,000 Litres Per Day FAME Production)





HEFA Production

Fractional distillation results:

- Bio-naphtha
- Jet fuel
- Green diesel



Sample after HDO + HC

Source: green fuels gfr



HEFA Production

- SABR build on schedule
- Pilot plant stable and operating 24/7
- Key product parameters exceeding standards
- Little variability in product when varying conditions –very stable reaction
- Multiple feedstocks successfully tested at pilot scale

Source: green fuels gfr



Combination of Innovative Technologies

PSA (Pressure Swing Adsorption)





Source: HYGEAR



PSA Technology

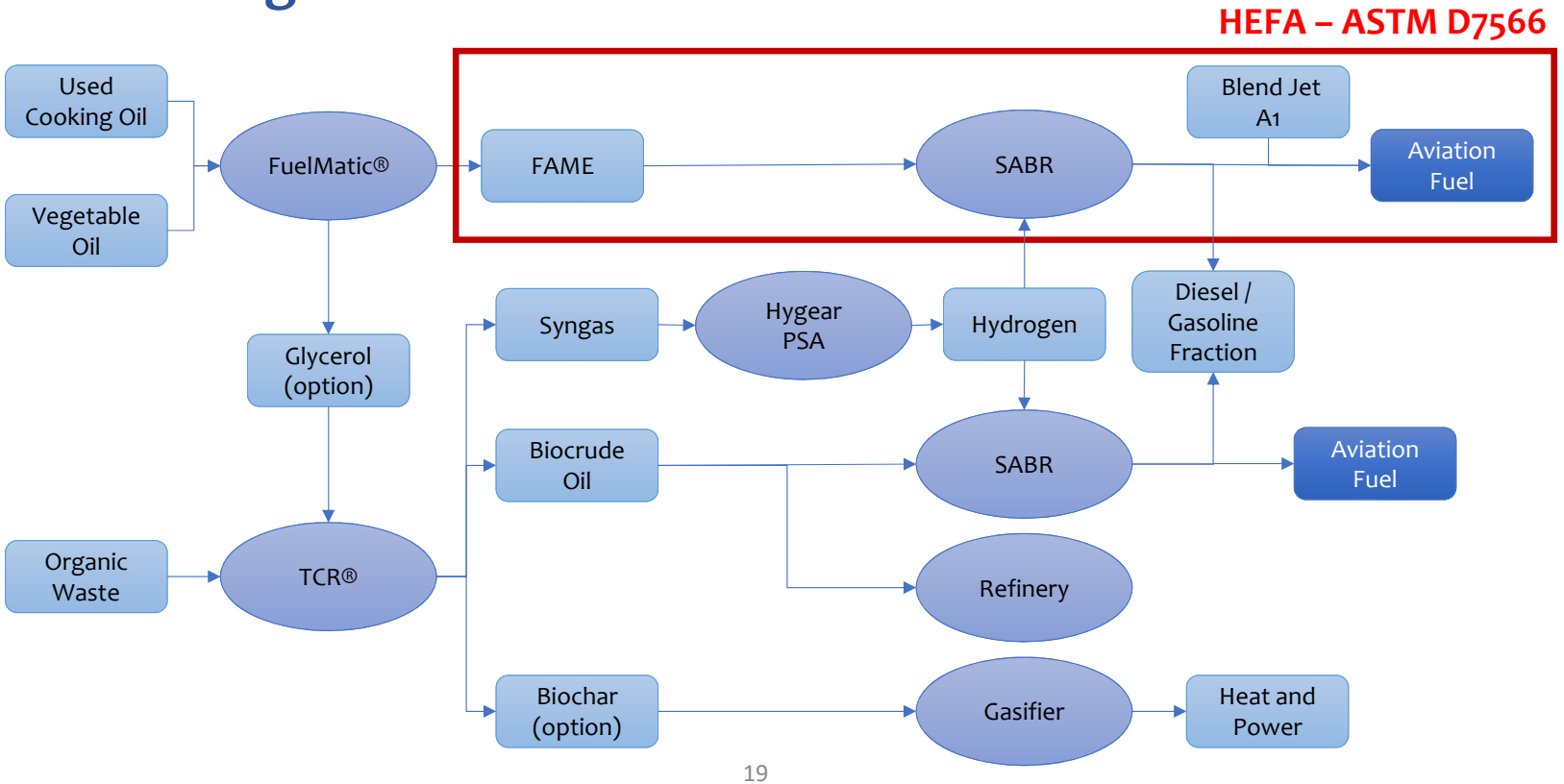
- Gas supply and cleaning: small scale, on-site
- Supply of hydrogen, oxygen, nitrogen and mixed gases
- PSA technology for multiple gas sources (SMR, biogas, waste gases)
- Patents in hydrogen production and cleaning technology

SYNGAS → **GREEN HYDROGEN**

Source: HYGEAR



Process Flow Diagram





flexJET Final Bio-jet Fuel

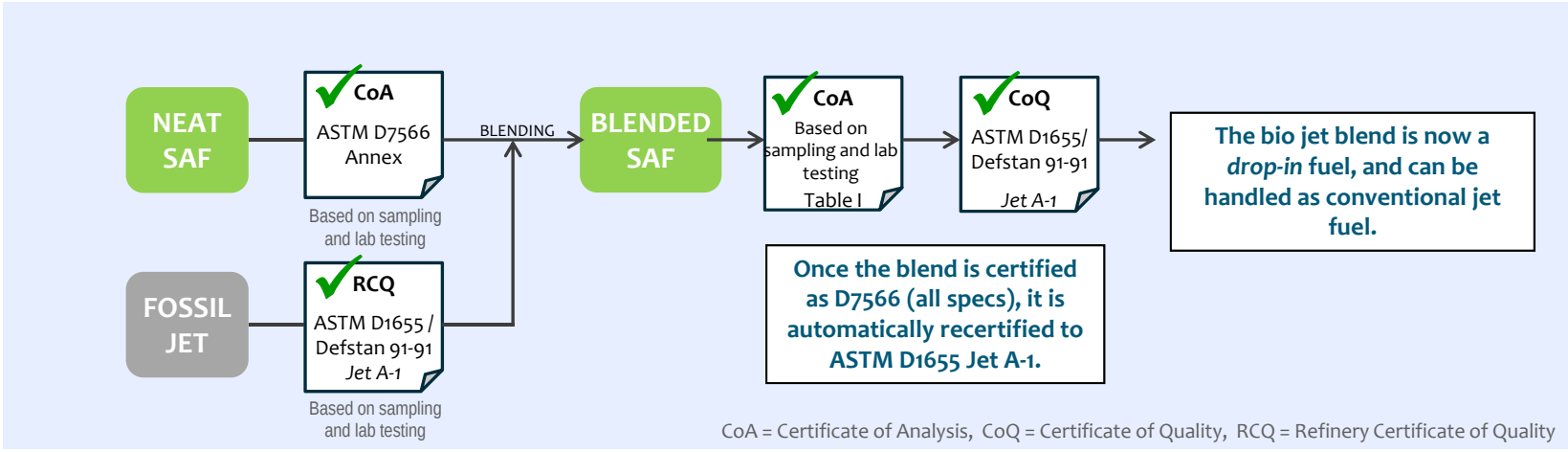
***Final product is a "drop-in" bio jet fuel blend meeting ASTM D1655/Defstan 91-91 specifications for Jet A-1**

ASTM D7566 is a specification for jet fuel containing synthetic hydrocarbons, with Annexes specific for the different types of neat SAF (i.e. HEFA). Defstan 91-91 references ASTM D7566 for synthetic jet fuel: therefore, certifying bio jet blends under Defstan 91-91 is identical to ASTM D7566.

Blended SAF meets ASTM D1655 and Defstan 91-91 and can be used on all equipment operating on jet fuel that need to meet ASTM D1655 or Defstan 91-91.

Since 2012 also JIG guidelines allow Jet A-1 to be blended with up to 50% of HEFA based SAF.

- Blended SAF may be used in hydrant systems as long as blending is done prior to arrival at airport.
- AFQRJOS allows the use of bio jet fuel as long as it meets the requirements (most stringent of ASTM D1655 and Defstan 91-91).



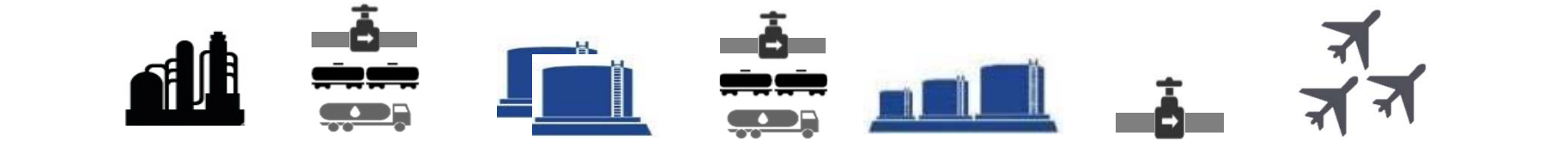
CoA = Certificate of Analysis, CoQ = Certificate of Quality, RCQ = Refinery Certificate of Quality

Source: SkyNRG



The flexJET supply chain

Developing the most efficient and sustainable way to get flexJET SAF into the wing



1. **SAF production**
   At the biorefinery
   The project will produce roughly 1,000 ton SAF over 15-18 months
2. **Blending**
   With conventional jet fuel
   Blending (at approx. 30%) & certification
3. **Storage at Airport**
   Preferable in the tank farm
   Once certified (D1655) the fuel can be offloaded in the commingled tank farm
4. **SAF flights**
   British Airways
   1,000 ton neat SAF used; up to 85% reduction in CO_2 emissions.
   Refuelling into-planers as usual

Source: SkyNRG



Sustainability and risk management

Life Cycle Assessment (LCA) for the sustainability evaluation of the integrated SABR-TCR technology and the comparison with alternative biofuel technologies or feedstock valorization routes.

Evaluation of socioeconomic impact expected on the local-regional economy and the community by the implementation of the proposed technology.

Preparation for the application for the **Roundtable for Sustainable Biomaterials (RSB) certification** of the **SAF** produced.

Evaluation and management of risks, represented in terms of health, economic, environmental loss/gains and capacity to achieve successful targets of the project.

Source:



flexJET Advantages

- High feedstock flexibility
- Green Hydrogen
  - Hydrogen separated from TCR Syngas by PSA to be used in HDO / HC
- Side and end products flexibility
- Highly scalable (small scale decentralised facilities can be built)
- It can be integrated into existing infrastructure



Some Results

flexJET Project, Sustainable Jet Fuel from Flexible Waste Biomass. Hornung, A., Ouadi, M., Galileu Speranza, L., Apfelbacher, A., Hornung, T., Hofmann, M., Hygate, J., Hilditch, P., Lima, S., Lieftink, D., Capaccioli, S., Grassi, A., Contin, A., Righi, S., Marazza, D., Quaranta, M., Vogli, L., Macrelli, S., Blakey, S.G., Lewis, C., Valk, M., Tuck, C., Langley, M., Ott, T., Winkel, M., Bastos, J., Claret, I., Carles, A. 27th European Biomass Conference and Exhibition, Proceedings.

Life Cycle Inventory of a pre-commercial demo plant using an innovative technology for the production of Sustainable Aviation Fuel (SAF) from flexible waste biomass. Luciano Vogli, Filippo Baioli, Martina Maines, Diego Marazza, Andrea Contin, Serena Righi. Life Cycle Management Abstract book, LCM 2019.

flexJET project: Converting flexible waste biomass into sustainable aviation fuel. Miloud Ouadi, University of Birmingham. Open Access Government.

Food and Market Waste–A Pathway to Sustainable Fuels and Waste Valorization. Miloud Ouadi, Muhammad Asif Bashir, Lais Galileu Speranza, Hessam Jahangiri, Andreas Hornung. Energy & Fuels 33/10.



Some Results

- EUBCE 2019 Lisbon, Portugal, 27 – 30 May
- EUSEW 2019 Brussels, Belgium, 20 June
- 9° Int. Conference LCM in Poznan, Poland, 3 Sept.



Miloud Ouadi, University of Birmingham, UK
flexJET project, Sustainable Jet Fuel from Flexible Waste Biomass
Session reference: 3BO.7.3, Tuesday 28 May



Where will we get our biojet? (side event)
Tuesday 28 May, 16:00 - 18:30
flexJET project: sustainable aviation fuel from waste biomass



Paving the way towards clean energy and fuels in Europe (side event) an initiative of the European Commission (with oral presentation and project poster) Wednesday 29 May



Luciano Vogli, University of Bologna, Italy
Life Cycle Inventory of a pre-commercial demo plant using an innovative technology for the production of Sustainable Aviation Fuel (SAF) from flexible waste biomass, Tuesday 3 September

CONSORTIUM

Coordinator

UNIVERSITY OF BIRMINGHAM

Partners

Fraunhofer UMSICHT

susteen sustainable resources from waste

WRG Europe Ltd Engaging with Research

green fuels

HYGEAR

BIGA

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SkyNRG

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PROJECT FLEXJET

Duration
April 2018 - March 2022

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