Initiative Towards sustainable Kerosene for Aviation

Alternative Fuels for Aviation. Beyond ITAKA

Greening of Aviation - Alternative Aviation Jet Fuels
Inmaculada Gomez (SENASA) – Athens 7th November 2016
The **EU Advanced Biofuels Flightpath** set up the objective to achieve **2 million tons of sustainable biofuel per year in 2020**.

A **key point** is to promote and create an efficient **supply** chain, from **OFFER** - **biomass cultivation and conversion**- up to **DEMAND** (airlines and standards).

**ITAKA** will **link supply and demand** by connecting the **full value-chain**: feedstock grower, biofuel producer, distributor and airlines.

**R&D demonstrator**
Project structure

1. - PRODUCTION
   - Feedstock
   - Conversion technology

2. - LOGISTICS and LARGE SCALE USE
   - Logistics
   - Engine and fuel systems testing

3. - SUSTAINABILITY ASSESSMENT

4. - OUTREACH
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RESULTS

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PRODUCTION

Feedstock

4 camelina large scale plantations in Spain + 2 in Romania

• Selected and new camelina varieties adapted for Europe and with increased oil content
• Optimized camelina growing protocols
• Testing camelina cultivation in polluted land
• Marketing co-products (meal, husks, straw)
• Crushing improvement tests

UCO

• Market analysis (availability and costs)
• Innovative pre-treatment and upgrading methods studied, catalytic pyrolysis
Total potential sustainable land

Fallow

Sustainable < 5 t/ha
Potential production of camelina oil in EU (t)

- 2015: 79,828 t
- 2020: 350,557 t
- 2030: 1,072,685 t
Total potential biojet volume
ITAKA Scale-Up Model - ISUM

Conversion technology demand for base scenario

Biojet fuel tons

Millions


- HEFA
- FT
- DSHC
- ATJ
- HDCJ
Experimental setup

- **Continuous catalytic** multi-purpose/feed pyrolysis unit processing to **1.5 kg/h**;
- **400 – 550 °C**;
- **15 kWth** of power;
- **Modular** condensation line and bubbler (aerosols);
- **T, p, measures.**
- **WHSV = 2.5 – 4 h⁻¹**
  - mass flow rate of the reactants - catalyst mass ration
Summary on PO of VO/UCO/FA

- **Catalytic conversion** through pyrolysis of UCO was performed at 500° C with 4 different catalysts (WHSV = 4 l/h).

- The best result (CAT n.1 test) gave 63.6 %wt of bio-oil, with **lower Oxygen content, density, viscosity** and **higher HV** than original feedstock.

- Increasing catalyst mass, there were **no significant changes** in terms of **bio-oil yield**, but **higher** fractions of HCs classes were detected (from 24 to 35%wt).

- **Preliminary distillation** tests were carried out

- Further investigation concerned analytical issues in HC content quantification. This recent work concluded that **more than 70% of collected liquid are HCs**
Conversion technology

- **Improved refining facilities** (better adapted to biojet requirements)
- Adapted **protocol** for in house **quality testing**
- Coordination with the UCO catalytic pyrolysis tests
- HEFA vs. HEFA+? Lower production costs but lower blends
LOGISTICS and LARGE SCALE USE

2014 Biofuel @ Schiphol
- 18 KLM flights on A330 to Aruba
- Fully segregated biofuel logistics

2016 Biofuel @ Oslo
- Fully segregated biofuel logistics for 80 KLM flights on E190 to Amsterdam
- Non-dedicated airport logistics: Biofuel supply via airport tank farm & hydrant
ITAKA biojet was supplied via both segregated and non-segregated logistics

**Fully segregated biojet logistics**

1. **Bio jet production**
2. **Blending & Certification to Jet A-1**
3. **Distribution to airport**
4. **Airport logistics**
5. **Aircraft fueling & biofuel flights**

**Non-segregated logistics: use existing jet infra**

- ITAKA/AirBP 2016 supply via Oslo airport tankfarm

**Schiphol & Oslo:**
- KLM/Airbus flights in 2014
- KLM/Embraer flights in 2016
Biojet molecules end up in any aircraft – how to claim it is yours?

Biojet physically delivered to all aircrafts fueled from shared airport hydrant system

- No physical tracing of biojet possible
- No distinction in bio/fossil batches in airport administration
- Airline wants biojet to be attributed to its account because:
  - Airline paid for it
  - Airline wants to claim GHG emissions (e.g. EU ETS)

How it worked for Oslo deliveries...

1. Traceability & Proofs of biojet delivery up to airport:
   - Batch numbers & bio ratio on product quality certificates and transport documents forming closed chain

2. Proofs of Sustainability (PoS) up to airline:
   - PoS demonstrates EU RED compliancy of biojet (audited by independent certification bodies) and shows volumes transferred
   - PoS sent from producer to supplier to airline in Nabisy (the German biofuel accounting system)

Two document chains connected via declaration on identity by Neste linking volume registered in Nabisy with identical volume and batch number on their delivery documentation

Airline reported biojet consumption via Nabisy and claimed GHG reductions under EU ETS
LOGISTICS and LARGE SCALE USE

Engine and fuel systems testing

✓ **18 flights** AMS-AUA-BON [A330-200]:
  - no detrimental effects on operation, similar or slightly better fuel consumption
  - Gauging systems accuracy validated on biojet
  - water prediction model validated on biojet

✓ APU tests for **pollutant emissions**: reduction in fuel flow, reduction in the SAE smoke number and possible reduction in PMs. No changes NOx or UHC.

✓ **80 flights** OSL-AMS [E190] with biojet:
  - no detrimental effects on operation
  - Gauging systems accuracy validated on biojet
Water solubility of biofuels


Water Build-Up vs. Time

Volume of Water Build-Up

Time (s)

Conventional Jet A-1

50:50 Blend

Per flight...
E190 Engine Performance - Parameters

Data Collection: 177 flights (97 JET A1 + 80 BIOJET)

JET A1 (baseline) x BIOJET fuels comparison

Engine parameters

- Core Speed (N2): N21 (N2 Engine #1), N22 (N2 Engine #2)
- Exhaust Gas Temperature (EGT): EGT1 (EGT Engine #1), EGT2 (EGT Engine #2)
- Fuel Flow (FF): FF1 (FF Engine #1), FF2 (FF Engine #2)

Flight Phase: CRUISE (stability)

N2, EGT, FF parameters automatically corrected to account for ambient flight conditions

- Bleed status
- Ambient Air Temperature
- Altitude
- Air Speed
### Assessment Conclusion

<table>
<thead>
<tr>
<th>29 E190's</th>
<th>N21 (% rpm)</th>
<th>N22 (% rpm)</th>
<th>EGT1 (°C)</th>
<th>EGT2 (°C)</th>
<th>FF1 (KPH)</th>
<th>FF2 (KPH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JET A1 (97 flights avg)</td>
<td>88.68</td>
<td>88.64</td>
<td>734.81</td>
<td>732.82</td>
<td>2047.78</td>
<td>2047.30</td>
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<tr>
<td>BIOJET Fuel (80 flights avg)</td>
<td>88.67</td>
<td>88.63</td>
<td>734.95</td>
<td>732.86</td>
<td>2045.00</td>
<td>2044.07</td>
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<tr>
<td>Mean Deviation (%)</td>
<td>-0.02%</td>
<td>-0.01%</td>
<td>0.02%</td>
<td>0.01%</td>
<td>-0.14%</td>
<td>-0.16%</td>
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> There is no significant CF34-10E5 engine performance difference when operating with BIOJET fuel, if compared to the JET A1.
Emissions effects – APU tests

- ~ 500 engines in ICAO emissions database (good fleet representation from a subset of 30 engines)
- Combustion efficiency on all modern hardware (independent of OEM) is asymptotically approach 100% (e.g. GE90 is 99.6% at idle). Differences in hardware are increasingly second order effects; First order effects come from changes in fuel chemistry.
- An APU is a good model for main engine gas turbines.
  - Qualitative data and trends are very similar,
  - Considerably lower fuel usage (typically 30 g/s compared with 2000 g/s),
  - Ease of access and considerably lower costs (factor x10),
  - An APU is a critical safety device on all ETOPS aircraft & APU emissions contribute appreciably to AQ at airports.

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Effects with increasing blend ratio

Engine performance:
✓ A reduction in fuel flow (kg/sec)
✓ A small reduction in the engine EGT

Gaseous emission species:
✓ CO is slightly reduced.
✓ UHC is no change / slightly reduction.
✓ NOx remains approximately constant.
✓ CO₂ is linearly reduced.
✓ H₂O is linearly increased.

Particulate matter characterization:
✓ A pronounced and linear reduction in SAE smoke number.
✓ A significant reduction in nvPM mass & number emissions is accompanied by a move to smaller size.

ITAKA significantly different chemical composition to JetA1

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Results

3.- **SUSTAINABILITY ASSESSMENT:**

- **GHG savings** estimated to achieve 66%, RSB certification for the CCE camelina oil plantations

- **Low ILUC risk assessment framework**: fallow land rotation, no demand of additional land or substitution of crops

- Several **sustainability checks**, inc. LCIA and SEIA

4.- **OUTREACH:**

ITAKA worked to build-up a strong partnership to contribute to a worldwide effort.

*Detailed project results are available at [www.itaka-project.eu](http://www.itaka-project.eu)*
Beyond ITAKA

- Continue the efforts on R&D for aviation biofuels $\rightarrow$ aviation should not be out, climate optimization, fuel/engine database(s)

- Create a **level playing field** for aviation biofuels
  - Align bio-based economy policy objectives

- Actively **stimulate the aviation** sector by creating an attractive investment **climate** while at the same time setting ambitious stands for sustainability.

- Ensure feedstock **supply**: more regular and efficient production of feedstock under real market conditions, quality and sustainability.

- Structure **demand**, adequate volumes and logistics so that the long-scale use is ensured at a significant scale (i.e. bio-hub Oslo).
This project has received funding from the European Union’s Seventh Framework Programme for research technological development and demonstration under grant agreement No 308807
Partners

| SENASA          | SENASA  
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- demonstrate the readiness of SPK large-scale production & use