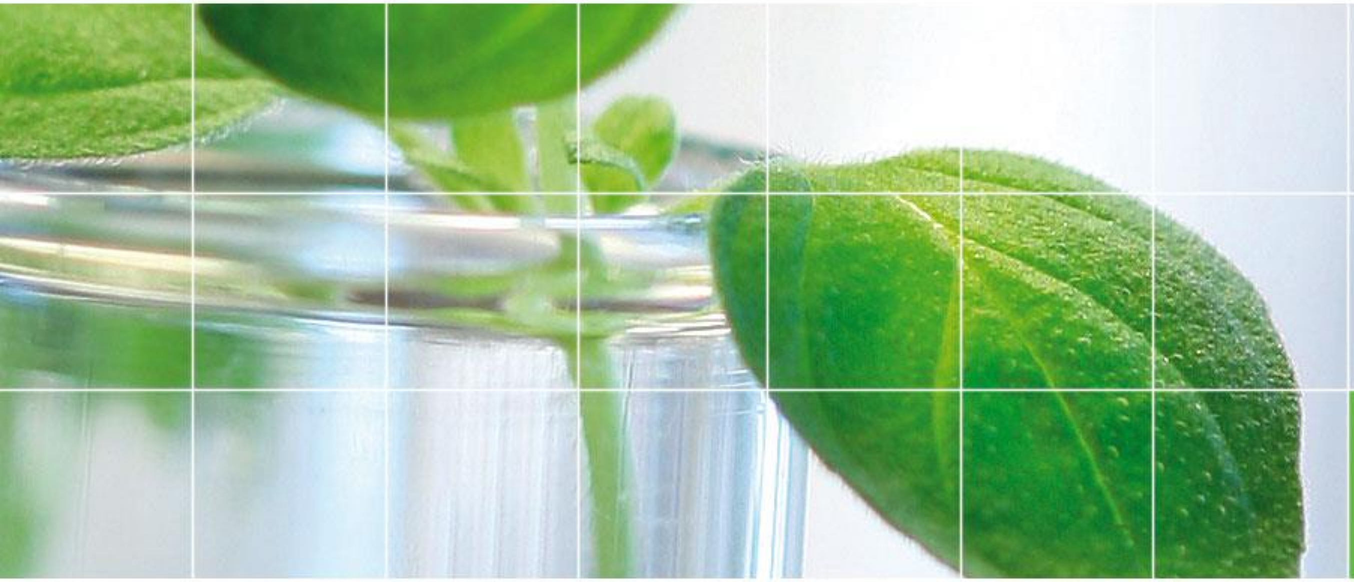
www.core-jetfuel.eu

CORE-JetFuel

CAAFI – CORE-JetFuel Cooperation Workshop

Alexandria, 28 April 2016

Johannes Michel - FNR



This project has received funding from the European Union's Seventh Programme for research technological development and demonstration under grant agreement No 605716

Bauhaus Luftfahrt Neue Wege.

SENASA

FNR Fachagentur Nachwachsende Rohstoffe e.V.

AIRBUS GROUP

IFP Energies nouvelles

WIP

Fachagentur Nachwachsende Rohstoffe e.V.

- Facts

Foundation:	October 1993
Main office:	18276 Gülzow-Prüzen (Mecklenburg–Vorpommern)
Support:	Federal Ministry of Food and Agriculture (BMEL) and State of Mecklenburg-Vorpommern
Employees:	87
Legal status:	Registered association with 78 members (7 voting members)
Tasks:	• Promotion of research, development and demonstration (project management) • Information & advice • Public relations • International and EU activities
Target groups:	Industry, SME, public and private research institutes, universities, government agencies

Outline

- Background
  - Project Partners
  - Objectives
- Description of Work
  - Work Scope and Approach
  - Methodology
- Evaluation of selected Production Pathways
  - Preliminary Conclusions
- Stakeholder Involvement

Project Partners

Duration: Sep 2013 – Aug 2016
Budget: 2.000.000 €

🇩🇪 Bauhaus Luftfahrt
Neue Wege.

🇩🇪 FNR
Fachagentur Nachwachsende Rohstoffe e.V.

PROJECT COORDINATOR

🇩🇪 WIP

🇫🇷 ifp Energies nouvelles

🇪🇸 SENASA

🇫🇷 AIRBUS
GROUP

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CORE-JetFuel

Background

- **CORE-JetFuel**: "**CO**ordinating **RE**search and innovation of **Jet** and other sustainable aviation **Fuel**"
  - Develop and implement a strategy for sharing information, for coordinating initiatives, projects and results
  - Identify needs in research, standardisation, innovation and policy measures at European level
  - Evaluate the research and innovation "landscape" with collection of the lessons learned in order to support decision makers in setting priorities for the European funding strategy.

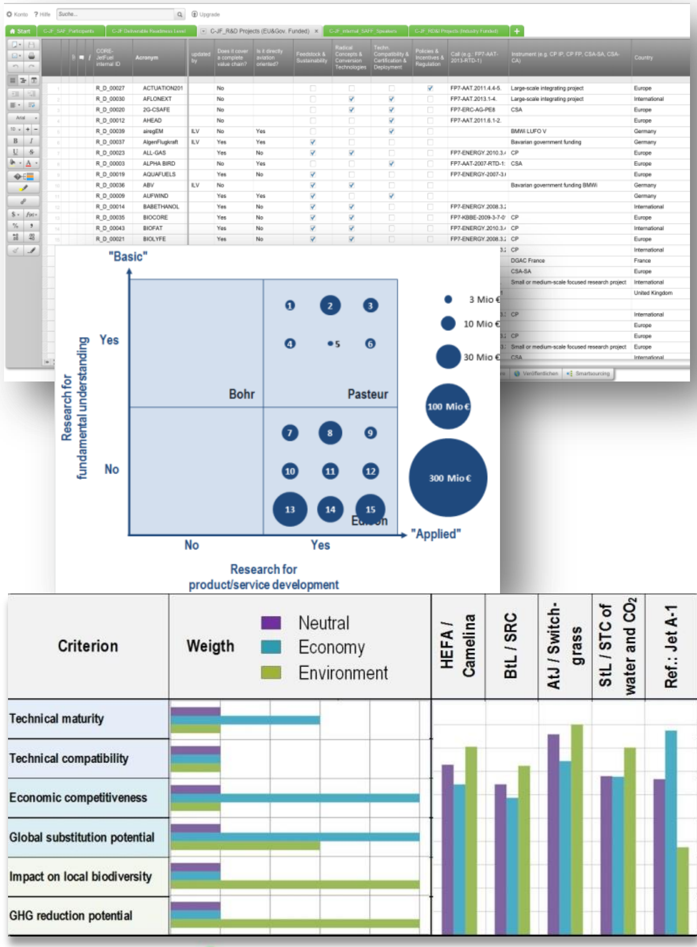
Description of Work

- The project covers the entire fuel production chain of alternative aviation fuels, divided into four thematic domains

1. Feedstock and Sustainability
2. Conversion Technologies and Radical Concepts
3. Technical Compatibility, Certification and Deployment
4. Policies, Incentives and Regulation

Work Scope and Approach

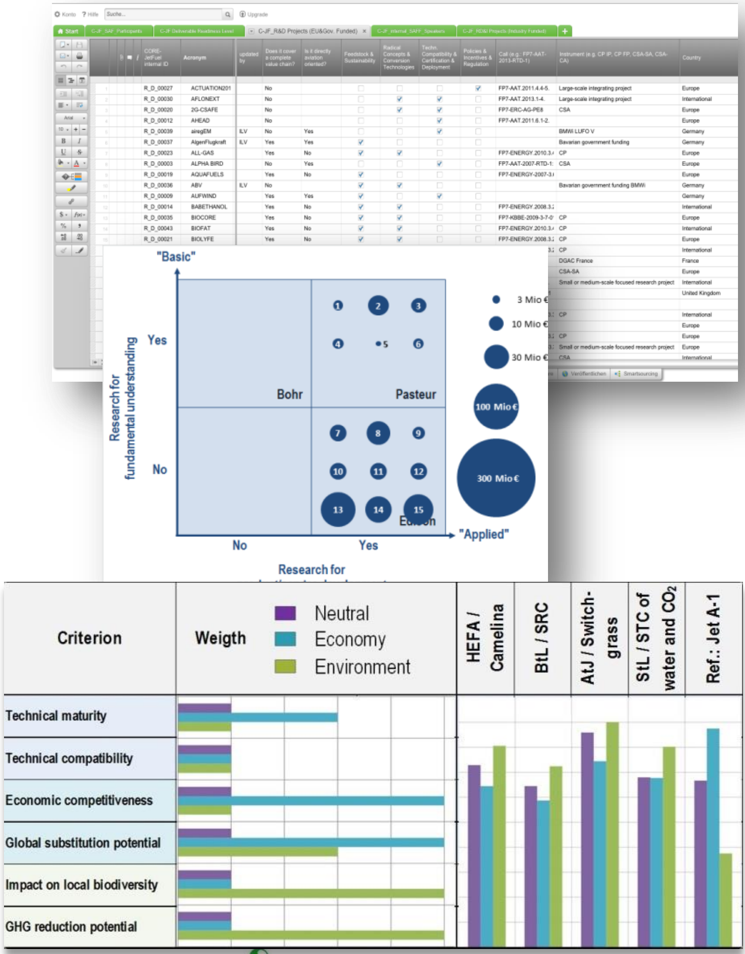
- The **working methodology** applied to each one of the four topics consists of:
    1. **Collection**: information gathering
    2. **Mapping** of data and results from identified projects: organization, classification of information
    3. **Analysis / evaluation** of gathered information and mapped projects / technology pathways



	CORE-JetFuel internal ID	Acronym	updated by	Does it cover a complete value chain?	Is it directly aviation oriented?	Feedstock & Sustainability	Radical Concepts & Conversion Technologies	Techn. Compatibility & Certification & Deployment	Policies & Incentives & Regulation	Call (e.g.: FP7-AAT-2013-RTD-1)	Instrument (e.g. CP IP, CP FP, CSA-SA, CSA-CA)	Country
1	R_D_00027	ACTUATION201		No		☐	☐	☐	☑	FP7-AAT.2011.4.4-5.	Large-scale integrating project	Europe
2	R_D_00030	AFLONEXT		No		☐	☑	☑	☐	FP7-AAT.2013.1-4.	Large-scale integrating project	International
3	R_D_00020	2G-CSAFE		No		☐	☑	☑	☐	FP7-ERC-AG-PE8	CSA	Europe
4	R_D_00012	AHEAD		No		☐	☐	☑	☐	FP7-AAT.2011.6.1-2.		Europe
5	R_D_00039	airegEM	ILV	No	Yes	☐	☐	☑	☐		BMWi LUFO V	Germany
6	R_D_00037	AlgenFlugkraft	ILV	Yes	Yes	☑	☐	☐	☐		Bavarian government funding	Germany
7	R_D_00023	ALL-GAS		Yes	No	☑	☑	☐	☐	FP7-ENERGY.2010.3.	CP	Europe
8	R_D_00003	ALPHA BIRD		No	Yes	☐	☐	☑	☐	FP7-AAT-2007-RTD-1	CSA	Europe
9	R_D_00019	AQUAFUELS		Yes	No	☑	☐	☐	☐	FP7-ENERGY-2007-3.		Europe
10	R_D_00036	ABV	ILV	No		☑	☑	☐	☐		Bavarian government funding BMWi	Germany
11	R_D_00009	AUFWIND		Yes	Yes	☑	☐	☑	☐			Germany
12	R_D_00014	BABETHANOL		Yes	No	☑	☑	☐	☐	FP7-ENERGY.2008.3.		International
13	R_D_00035	BIOCORE		Yes	No	☑	☑	☐	☐	FP7-KBBE-2009-3-7-0	CP	Europe
14	R_D_00043	BIOFAT		Yes	No	☑	☑	☐	☐	FP7-ENERGY.2010.3.	CP	International
15	R_D_00021	BIOLYFE		Yes	No	☑	☑	☐	☐	FP7-ENERGY.2008.3.	CP	Europe
											CP	International
											DGAC France	France
											CSA-SA	Europe
											Small or medium-scale focused research project	International
												United Kingdom
											CP	International
												Europe
											CP	Europe
											Small or medium-scale focused research project	Europe
											CSA	International

Work Scope and Approach

- The **working methodology** applied to each one of the four topics consists of:
  - → **Analysis / evaluation** of gathered information and mapped projects / technology pathways
    - With a **multiple-criteria approach**, applying 3 key high level criteria: **Suitability** (“Drop-in” capability), **Scalability** (production potential), **Sustainability** (GHG emission reduction potential)



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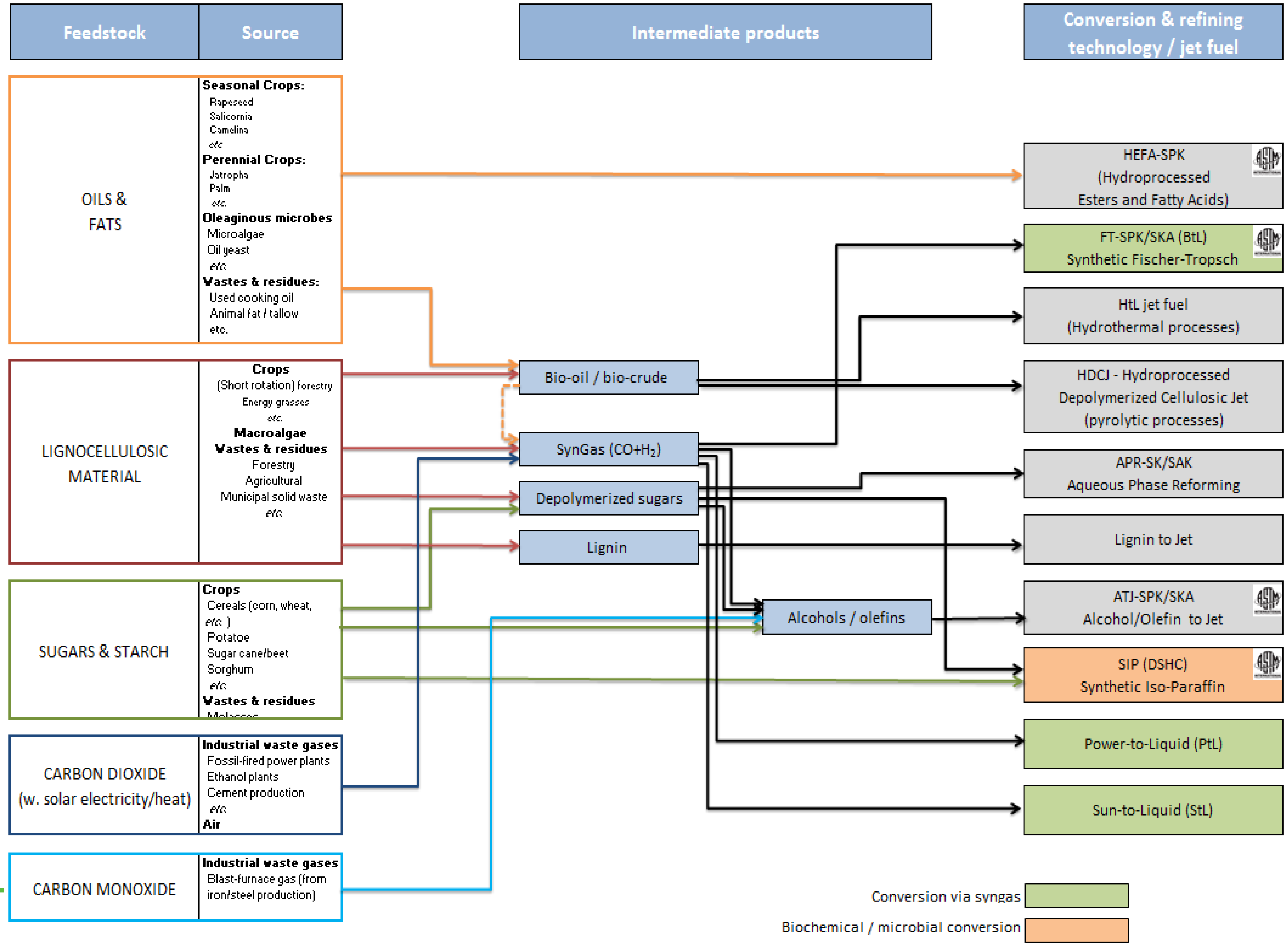
Feedstock
Source
Intermediate products
Conversion & refining technology / jet fuel
OILS & FATS
Seasonal Crops:
Rapeseed
Salicornia
Camelina
etc
Perennial Crops:
Jatropha
Palm
etc.
Oleaginous microbes
Microalgae
Oil yeast
etc
Wastes & residues:
Used cooking oil
Animal fat / tallow
etc.
LIGNOCELLULOSIC MATERIAL
Crops
(Short rotation) forestry
Energy grasses
etc.
Macroalgae
Wastes & residues
Forestry
Agricultural
Municipal solid waste
etc
SUGARS & STARCH
Crops
Cereals (corn, wheat, etc)
Potatoe
Sugar cane/beet
Sorghum
etc
Wastes & residues
CARBON DIOXIDE (w. solar electricity/heat)
Industrial waste gases
Fossil-fired power plants
Ethanol plants
Cement production
etc
Air
CARBON MONOXIDE
Industrial waste gases
Blast-furnace gas (from iron/steel production)
Bio-oil / bio-crude
SynGas (CO+H$_2$)
Depolymerized sugars
Lignin
Alcohols / olefins
HEFA-SPK (Hydroprocessed Esters and Fatty Acids)
FT-SPK/SKA (BtL) Synthetic Fischer-Tropsch
HtL jet fuel (Hydrothermal processes)
HDCJ - Hydroprocessed Depolymerized Cellulosic Jet (pyrolytic processes)
APR-SK/SAK Aqueous Phase Reforming
Lignin to Jet
ATJ-SPK/SKA Alcohol/Olefin to Jet
SIP (DSHC) Synthetic Iso-Paraffin
Power-to-Liquid (PtL)
Sun-to-Liquid (StL)
Conversion via syngas 🟩
Biochemical / microbial conversion 🟧

Comparison of Options: Technology Assessment

- Relevant questions
  - How much can we produce?
  - What is the potential environmental impact?
  - How much would it cost?
  - Drop-in capable or not?
  - What is the current state of development (maturity)?

- The assessment of alternative fuel technologies requires a multiple-criteria approach

Multiple-criteria Assessment Framework

- Criteria selection and definition of metrics (performance indicators)

Criterion	Metric	
Technical maturity	Technology Readiness Level	TRL (1-9)
Feedstock production maturity	Feedstock Readiness Level	FSRL (1-9)
Conversion technology maturity	Conversion Technology Readiness Level	CTRL (1-9)
Technical compatibility	Maximum blending ratio	$r_{\text{Blend,Max}}$ [%]
Economic competitiveness	WtT production costs relative to spot price in 2013	γ [%]
Global substitution potential	Production potential relative to demand in 2050	σ [%]
Impact on local biodiversity	Negative impact:	Yes/No
GHG reduction potential	Specific lifecycle GHG emissions relative to conventional jet	ε [%]

Multiple-criteria Assessment Framework

- Definition of metrics and scores (0 to 5)

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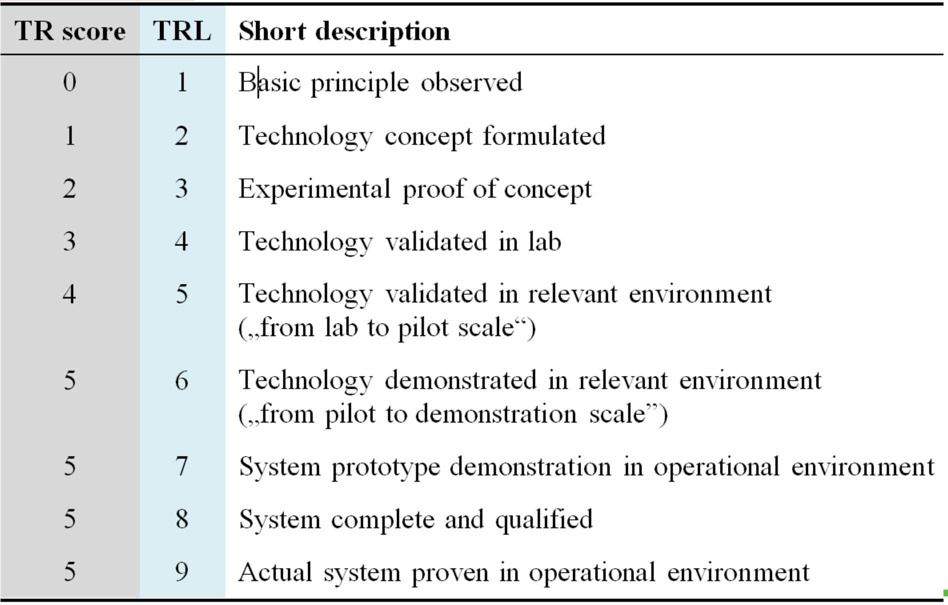
> Technical maturity

$$\mathrm{TRL} = \mathrm{Min}[\mathrm{FSRL}, \mathrm{CTRL}]$$



TR score	TRL	Short description
0	1	Basic principle observed
1	2	Technology concept formulated
2	3	Experimental proof of concept
3	4	Technology validated in lab
4	5	Technology validated in relevant environment („from lab to pilot scale“)
5	6	Technology demonstrated in relevant environment („from pilot to demonstration scale”)
5	7	System prototype demonstration in operational environment
5	8	System complete and qualified
5	9	Actual system proven in operational environment

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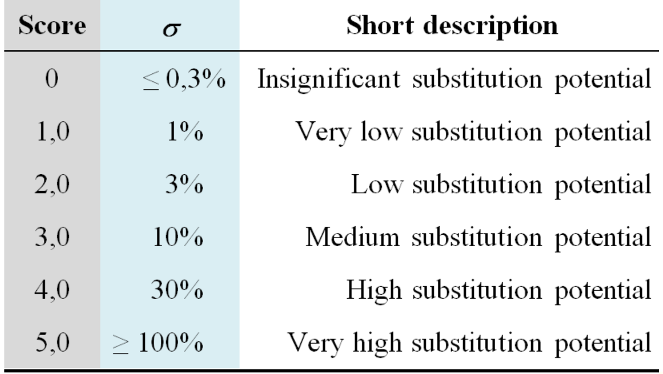
> European substitution potential

yr-2050 substitution potential relative to the demand of conventional jet fuel

M : annual production potential

M_{ref} : annual demand of conv. jet



Score	σ	Short description
0	$\leq 0{,}3\%$	Insignificant substitution potential
1,0	1%	Very low substitution potential
2,0	3%	Low substitution potential
3,0	10%	Medium substitution potential
4,0	30%	High substitution potential
5,0	$\geq 100\%$	Very high substitution potential

Evaluation

Criterion	Weigth		HEFA / Camelina	BtL / SRC	AtJ / Switch-grass	StL / STC of water and CO_2	Ref.: Jet A-1
Technical maturity	Technology Readiness Level	TRL (1-9)	5,0	5,0	5,0	2,0	5,0
Technical compatibility	Maximum blending ratio	$r_{\mathrm{Blend,Max}}$ [%]	2,5	2,5	5,0	2,5	5,0
Economic competitiveness	WtT production costs relative to spot price in 2013	γ [%]	2,5	0,0	2,5	2,5	5,0
Global substitution potential	Production potential relative to demand in 2050	σ [%]	2,4	4,4	3,5	5,0	5,0
Impact on local biodiversity	Negative impact:	Yes/No	5,0	5,0	5,0	5,0	0,0
GHG reduction potential	Specific lifecycle GHG emissions relative to conventional jet	ε [%]	4,4	2,4	4,8	3,4	0,0

Exemplary scores!

- Weighting adjusts relative importance of criteria in various scenarios

$$s(\mathrm{fuel}) = \frac{\langle S(\mathrm{fuel})\rangle_{\mathrm{criteria}}}{S_{\max}} = \frac{1}{S_{\max}} \frac{\sum_{i=1}^{6} W_i S_i(C_i)}{\sum_{i=1}^{6} W_i}$$

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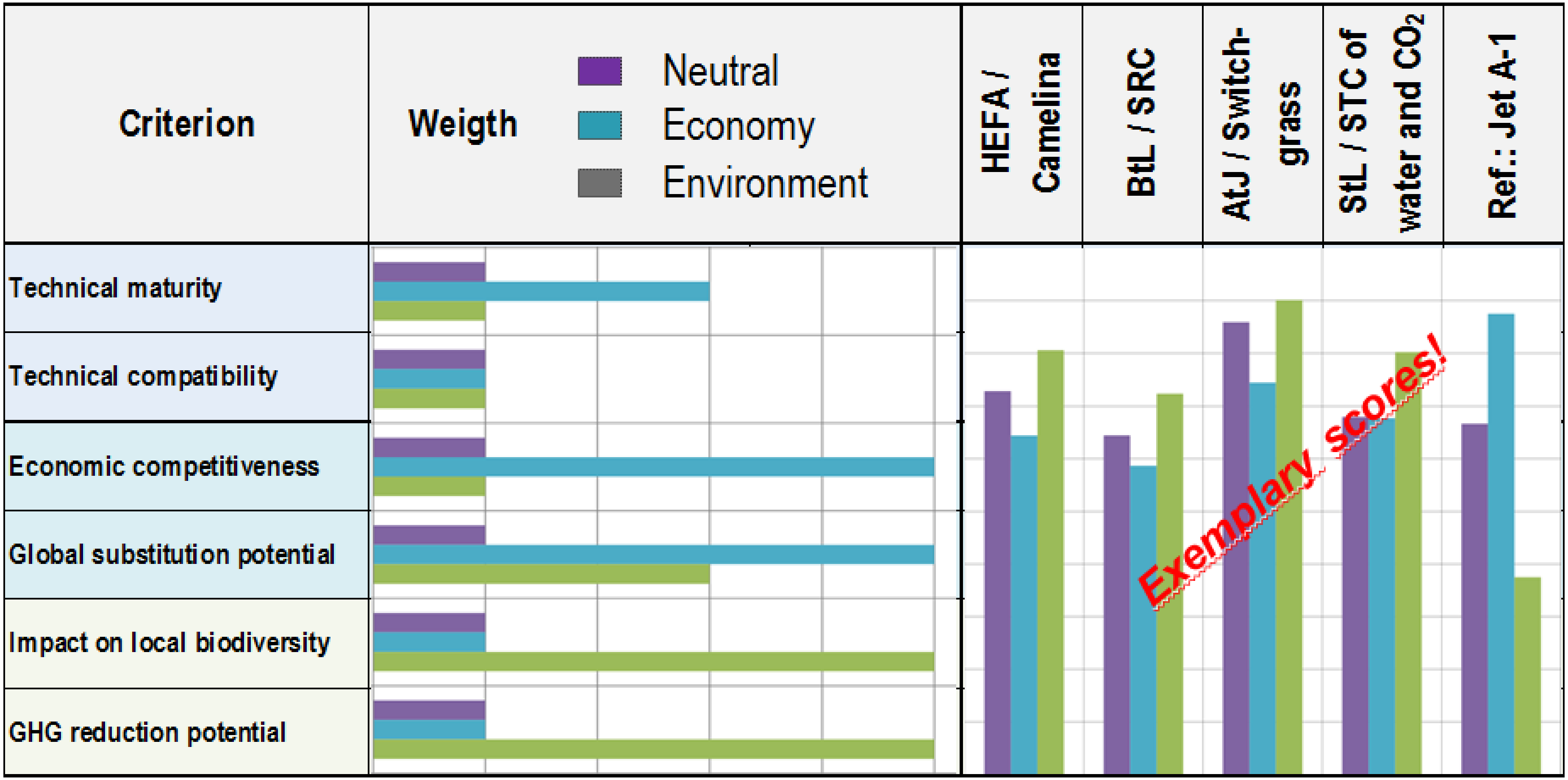
Evaluation



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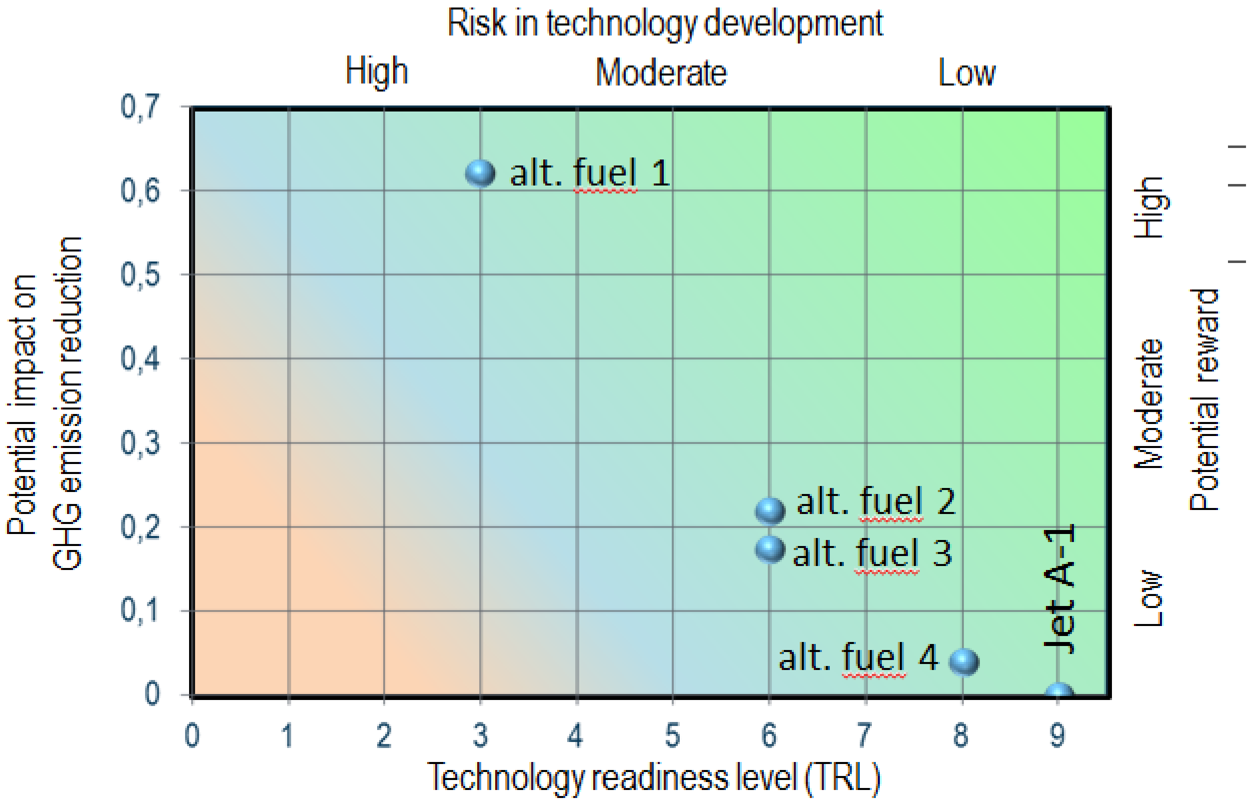
Evaluation – related to „Risk and Reward“

- Preliminary result:



  - *alt. fuel 1: high risk, high potential reward*
  - *alt. fuel 2 & 3: lower risk, moderate potential reward*
  - *alt. fuel 4: low risk, but minor potential reward*

Preliminary Conclusions

- Short-term application (2020)
  - Availability limited by maturity of conversion technology
  - HEFA from oils/fats, SIP from sugar (DSHC)
- Medium-term application (2035)
  - Maturing of pathways based on lignocellulosic feedstock (high “potential reward”: carbon footprint/production potential)
  - Development of renewable non-biogenic options proceeds
- Long-term application (2050)
  - Large quantities needed with high “potential reward”
  - Feedstock availability and specific environmental performance increasingly important
  - (High risk)/high gain options

Stakeholder Involvement

Recent communications:

- **SAFF** (Sustainable Aviation Fuels Forum) Madrid 20/10/2014: Perspectives of alternative fuels for aviation – Evaluation of existing and promising production pathways
- **ISAFF** (Italian Sustainable Aviation Fuel Forum) Rome 04/11/2014
- **Fuels of the future** Berlin 20/01/2015

Stakeholder Workshops:

- **EUCBE** (European Biomass Conference and Exhibition) Vienna 01/06/2015 – Workshop on innovative conversion technologies and deployment
- **IEA** (International Energy Agency) Bioenergy conference Berlin 29/10/2015 – Aviation Fuels Workshop on Policies and Value Chains for Large-scale Deployment of Alternative Aviation Fuels

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CORE-JetFuel

DRAFT AGENDA

Final International Conference

Sustainable Alternative Aviation Fuels – The Way Forward

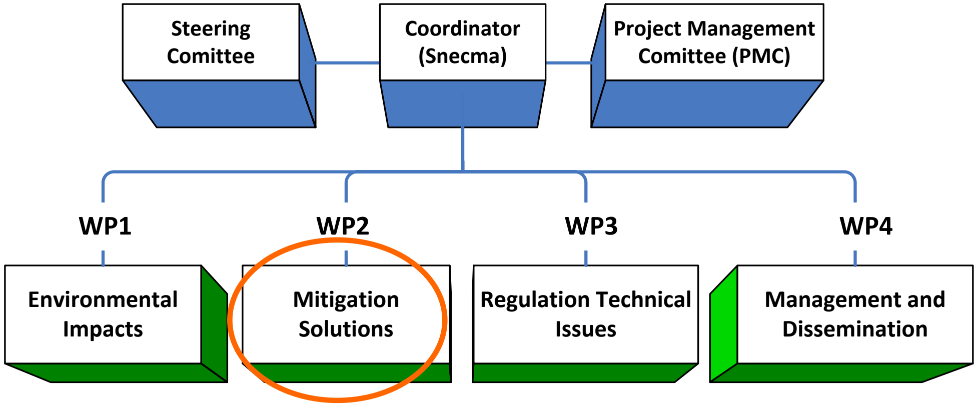
16-17 June 2016 in Brussels

Timing: 16 June 2016 (15:00 – 18:00), followed by an evening reception
17 June 2016 (09:00 – 16:00)
Venue: Thon Hotel EU, Rue de la Loi 75, Brussels

This conference takes place on the occasion of the **EU Sustainable Energy Week (EUSEW)** and follows up on a series of successful CORE-JetFuel events, namely the Sustainable Aviation Fuels Forum (SAFF) on 20-22 October 2014 in Madrid and CORE-JetFuel Workshops on 1 June 2015 in Vienna and on 29 October 2015 in Berlin.

FORUM on Aviation and Emissions

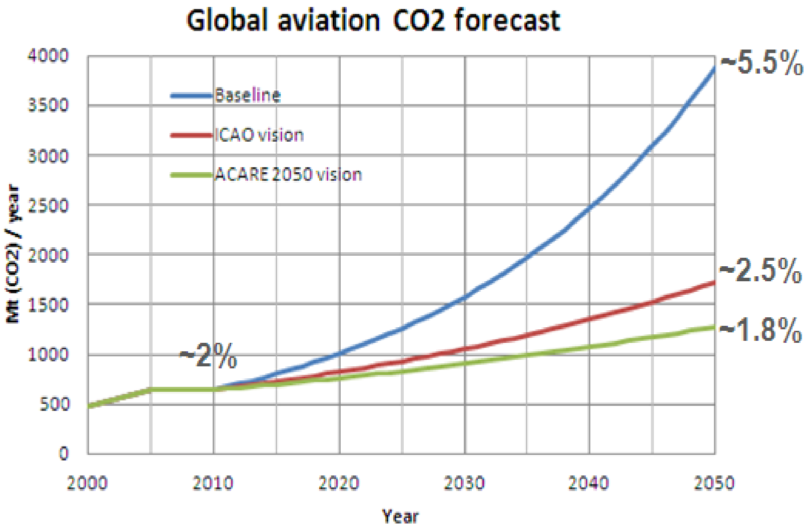
- Offers a European technical forum between main air transport actors
- Achieve a deeper understanding and larger visibility concerning:
  - emissions environmental impacts
  - most-promising mitigation solutions
  - technical recommendations on regulation issues
- Assess major European RTD programs progress against ACARE environmental goals. Recommends future RTD priorities



Complementary to CORE-JetFuel, FORUM-AE focuses on the assessment of environmental benefit of AJF, and addresses also ASTM technical issues

FORUM-AE recommendations on AJF

1) Harmonisation need to converge on a common and technically satisfactory CO2 LCA methodology in order to assess alternative jet fuel production pathways, and check for instance in Europe that they meet the RED requirement . It is also a necessary step to be able to estimate with realism the air transport CO2 reduction potential of alternative renewable jet fuels in 2050.



CO2 (2050/2005)	0,5	1,0	1,5
Mt Alternative Fuel (if LCA CO2 = 50%)	607	404	201
Mt Alternative Fuel (if LCA CO2 = 60%)	506	337	168

FORUM-AE recommendations on AJF

2) Interest in minimization of the aromatic content of future jet fuels (fossil or renewable) in order to reduce particles emission. Reduction of sulphur content may be also beneficial.

3) Optimisation of future jet fuels composition has become an emerging topic. It is true both for future renewable drop-in jet fuels and for fossil jet-A1 evolution. This optimization could permit to minimize particles and possibly other pollutant emissions. Although less obvious, it could also potentially permit to improve the fuel compatibility with the engine and the aircraft fuel system or even improve engine performances.

4) Improvement of the modeling of fuel interaction with the engine, and development of predictive tools is necessary. It is a prerequisite to permit the fuel optimization and in addition it will help, accelerate and reduce the cost of ASTM certification process.

Future European program addressing topics 3 & 4 expected

Thank you very much for your attention!

Johannes Michel
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