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Promising production technologies and value chains

Panel-II Introductory Presentation, CORE-JetFuel (EU)

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The CORE-JetFuel Approach

Research and Innovation Analysis

- Feedstock and Sustainability
- Radical Concepts and Conversion Technologies
- Technical Compatibility, Certification and Deployment
- Policies, Incentives and Regulation

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Cross-cutting: Methodology, Community Exchange, Communication

- Assessment Framework
- International Expert and Stakeholder Exchange
- Synthesis of Results, Recommendations and Communication

The CORE-JetFuel Approach – Focus of Panel II

Research and Innovation Analysis

- Feedstock and Sustainability
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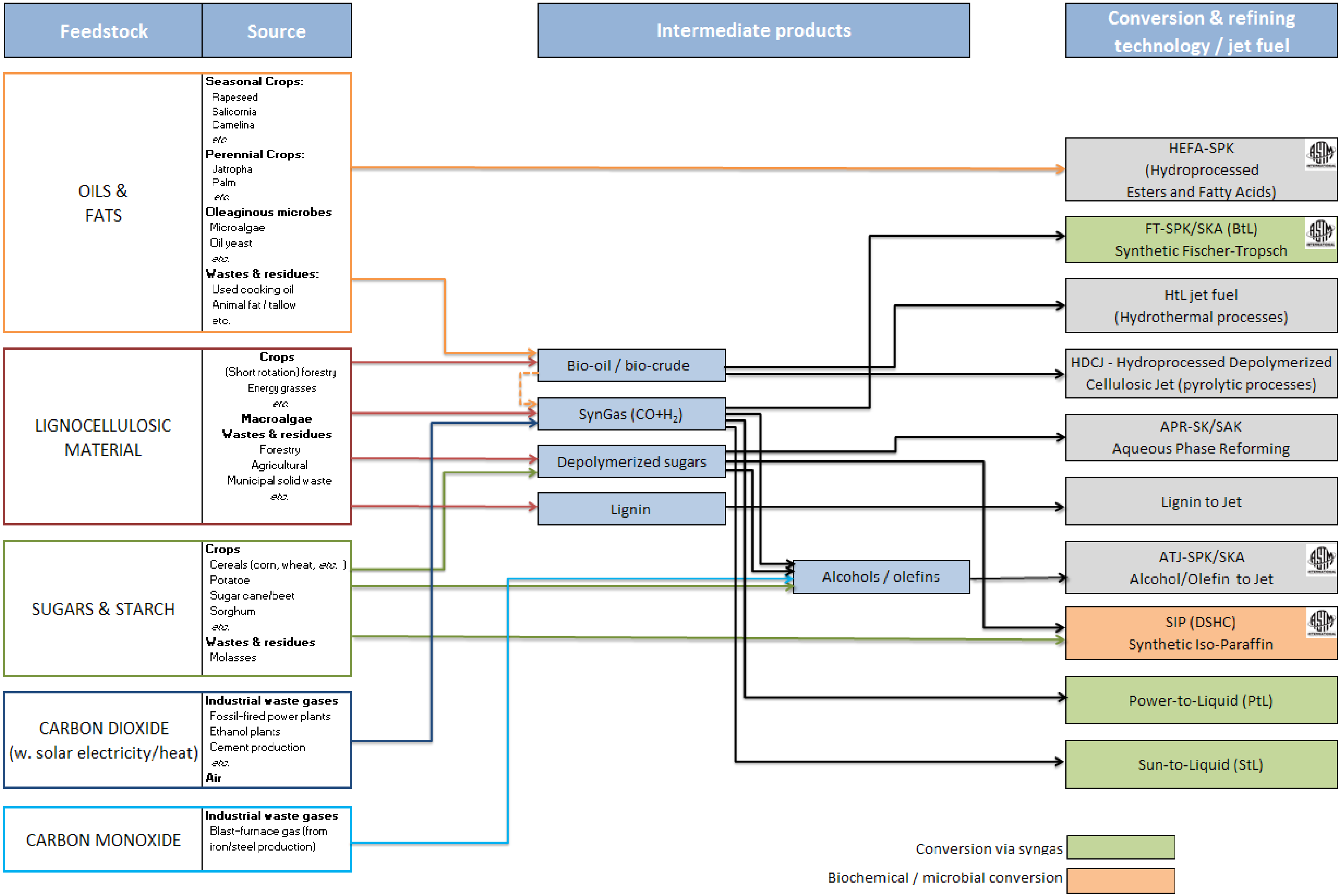
Technical Compatibility and Certification

5 pathways already certified in D7566-16 (April 2016)

- FT-SPK certified in 2009 (annex A1)
- HEFA-SPK certified in 2011 (annex A2)
- DSHC (Direct-Sugar-to-HydroCarbon), renamed SIP (Synthetic Iso-Paraffins from Hydroprocessed Fermented Sugars in June 2014 (annex A3)
- (FT-)SPK/A = FT-SPK + added mono-aromatics from alkylation of a benzene-rich cut (naphtha type) with light olefins from FT origin in Nov. 2015 (annex A4)
- ATJ-SPK through isobutanol + dehydratation/oligomerization to iC12/iC16 in April 2016 (annex A5)


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
Molasses
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
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Objectives of Research Analysis

- Technology assessment: identification of promising “clusters”
  - State of the art and potentials w.r.t.
    - environmental,
    - economic and
    - technical

    performance parameters

- Portfolio assessment: mapping of R&D landscape
  - Impact and balance of R&D portfolio at European level

Comparison of options: Technology assessment

- Relevant questions
    - How much can we make?
    - 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	$r_{Blend,Max}$ [%]
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 [%]

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Multiple-criteria assessment framework

- Definition of metrics

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> Technical maturity

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

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Multiple-criteria assessment framework

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> Global substitution potential

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

$$\sigma(\text{Fuel}) = \frac{\dot{M}(\text{Fuel})}{\dot{M}_{\text{Ref}}}$$

$\dot{M}$: annual production potential

$\dot{M}_{\text{Ref}}$: annual demand of conv. jet

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> GHG reduction potential

GHG emission reduction potential of the unblended fuel rel. to conv. jet

$$\varepsilon(\text{Fuel}) = \frac{\text{CI}(\text{Fuel}) - \text{CI}_{\text{Ref}}}{\text{CI}_{\text{Ref}}}$$

CI: equivalent carbon intensity of fuel

CI_{Ref}: equiv. carbon intensity of conv. jet

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Evaluation

- Evaluation of a typical risk-reward relation

Potential reward \ Risk in technology development	High	Moderate	Low
High	(Possibly) Good - Excellent	Good - Excellent	Excellent investment
Moderate		Acceptable - Good	Good
Low	Poor investment		Acceptable

Ph.S. Roussel, K.N. Saad, and T.J. Erickson, “Third Generation R&D”, Harvard Business School Press, Boston, MA, USA, 1991.

Evaluation

- „TRL“
  is related (but not identical!) to a **risk metric**

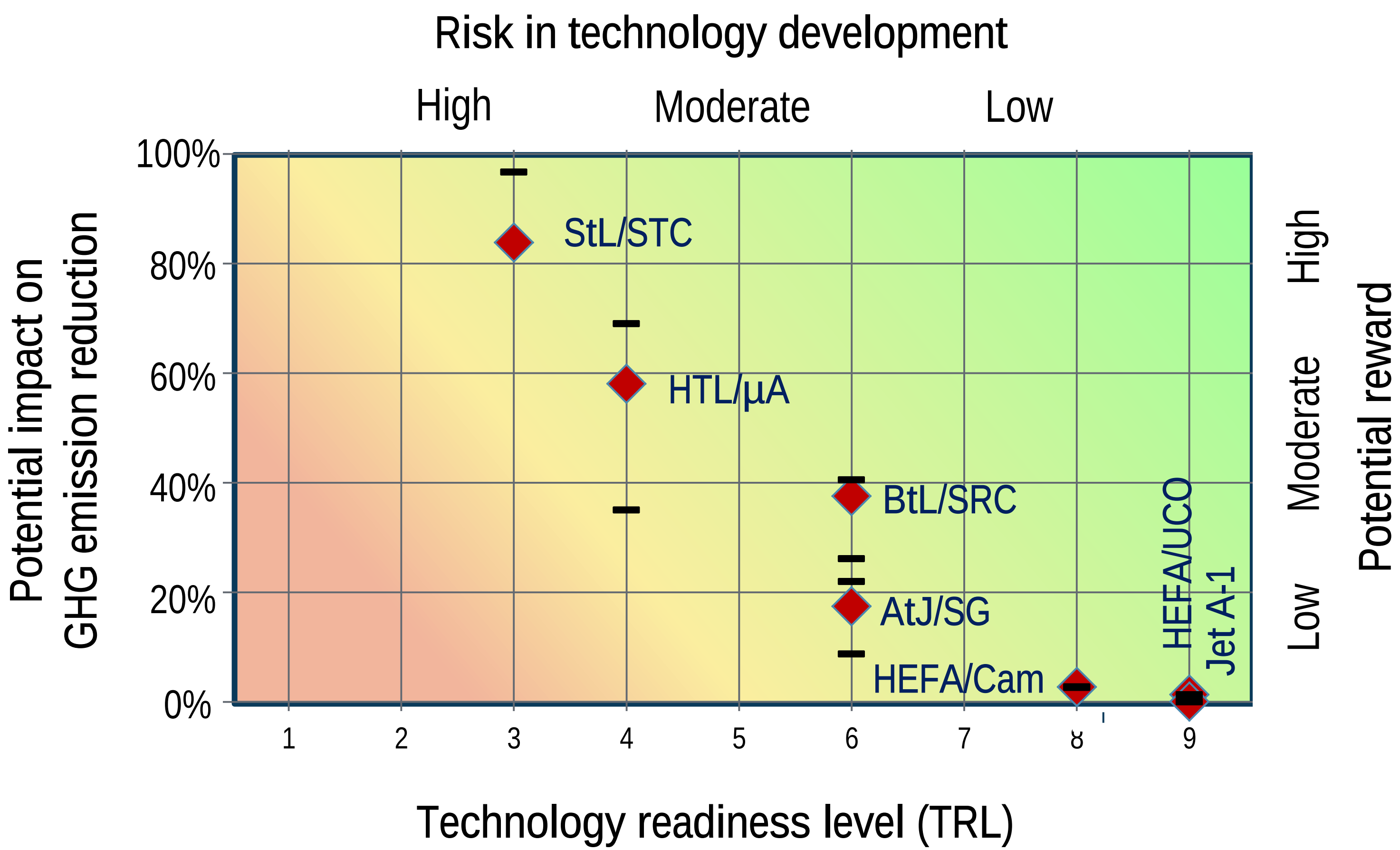
- „Potential impact on global GHG emission reduction“
  is an environmental **reward metric**
  - Calculate → the absolute annual carbon savings of alternative fuel
  - and compare it to → the absolute annual carbon emission of conventional jet fuel

$$\frac{\text{Absolute annual carbon savings}}{\text{Absolute annual reference emission}} = \frac{\dot{M}_{\text{Fuel}}(\text{CI}_{\text{Ref}} - \text{CI}_{\text{Fuel}})}{\dot{M}_{\text{Ref}}\text{CI}_{\text{Ref}}} = \sigma \cdot (-\varepsilon) \leq 1$$

  - Result: the product of global substitution potential σ and specific emission reduction ε

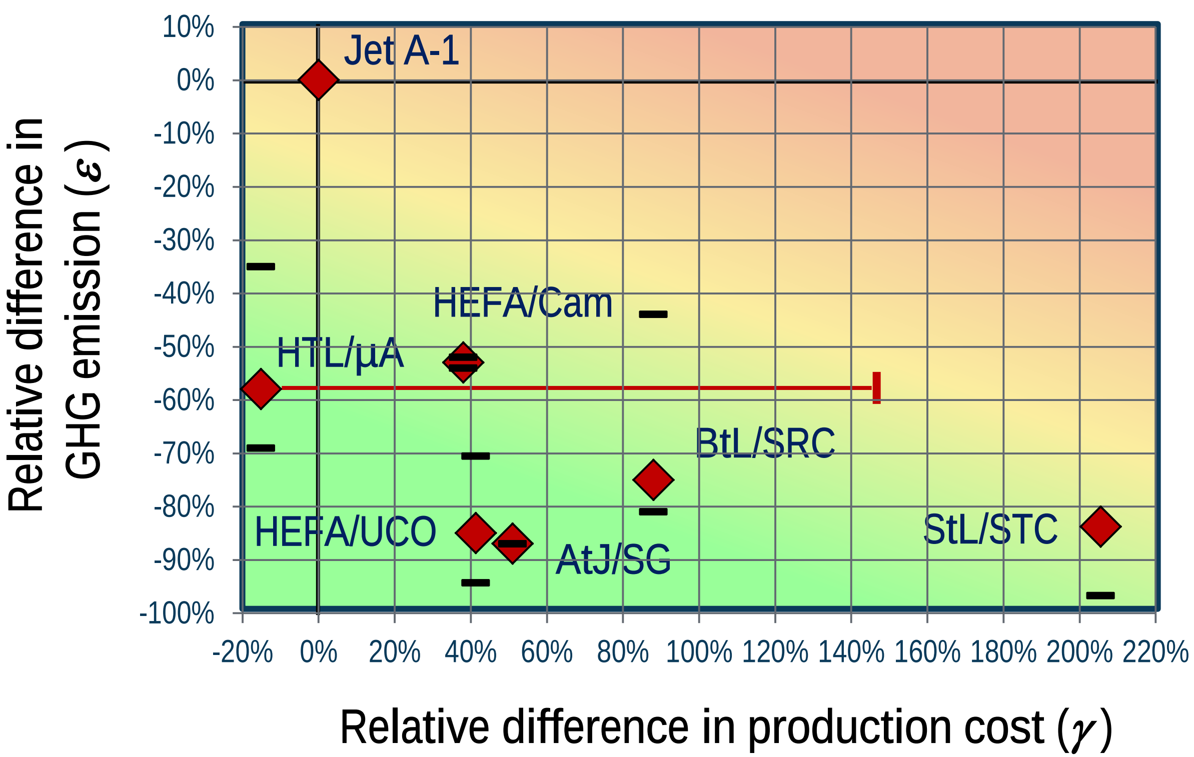
Evaluation – related to risk and reward

- Outline of first results:



Evaluation – related to cost & performance

- Outline of first results:



Preliminary conclusions

- Short-term application (2020)
  - Availability limited by maturity of conversion technology
  - HEFA from oils/fats, SIP from sugar
- 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

Questions for discussion

1. Renewable energy and feedstock potentials
   - Which fundamental bottelnecks and opportunities do you see for the development of a scalable long-term supply?
   - Which types of renewable feedstock/energy (algae, residues/waste, energy crops, lignocellulosics, sugre/starch, electricity, etc.) offer the highest potentials in North America, Europe or Southeast Asia?
2. Conversion technologies
   - Which conversion technologies should be primarily supported in their development towards industrial maturity? Why?
3. Research and innovation roadmap
   - Which priorities should be set today in an R&I strategy for renewable fuel production pathways for short, medium and long-term applications (2020/2035/2050)?
4. Technical certification
   - How can the approval procedure be accelerated and made less costly?