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an der Johannes Kepler Universität Linz

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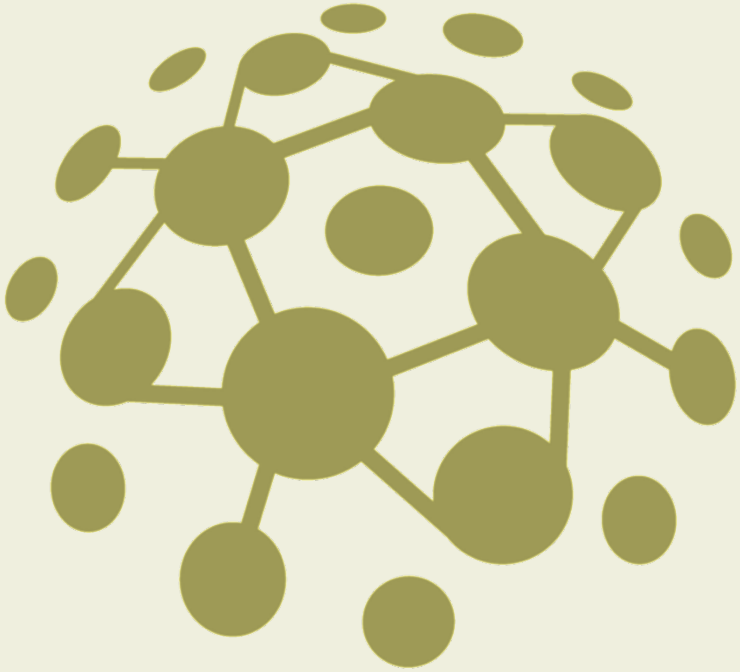

Stakeholderdialog „Biobased Industry“, 23.November 2016

Umsetzungsstatus und Bewertung der Umweltperformance von Zelluloseethanol im europäischen Kontext

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content

- Project profile SUNLIQUID EU-FP7
- Our role - Sustainability & Life Cycle Assessment
- Project profile LIGNOFLAG H2020-BBI
- Status and progress of cellulosic ethanol
- Future prospects

Coordination

CLARIANT

Clariant Produkte (Deutschland) GmbH, Munich, Germany

sunliquid® FP7

Project partners

BayWa

BayWa AG, Germany

ENERGIE INSTITUT an der Johannes Kepler Universität Linz

Energy Institute at the Johannes Kepler University Linz, Austria

ExportHungary We generate business

ExportHungary, Hungary

IBB Netzwerk GmbH

Industrielle Biotechnologie Bayern Netzwerk GmbH, Germany

Bavarian Research Alliance

Bavarian Research Alliance GmbH, Germany

www.sunliquid-project-fp7.eu

SEVENTH FRAMEWORK PROGRAMME

This project receives funding from the European Union's Seventh Framework Programme under grant agreement no. 322386.

sunliquid® - large scale demonstration plant for the production of cellulosic ethanol

sunliquid® FP7

The aim of the EU project SUNLIQUID is to confirm the commercial maturity of the sunliquid® process used to produce cellulosic ethanol from agricultural residues

Project duration
April 2014 – March 2018

EU contribution
EUR 23 million

Source: Clariant's sunliquid® demonstration plant in Straubing

SUNLIQUID covers the entire value chain:

- Supplying feedstock to the plant
- Logistics system for feedstock transportation
- Design, construction and commissioning of the plant, as well as training qualified staff
- Fuel testing and distribution, including the development of sales and marketing models
- Life cycle analysis to obtain a full-scale assessment of the product´s sustainability over the entire value chain
- Information campaigns to promote public acceptance of cellulosic ethanol

Main features of the sunliquid® process

sunliquid® FP7

- Simple & stable equipment set-up and **chemical-free pretreatment** (steam)
- Process can be **flexibly adapted to different feedstocks** (e.g. wheat straw, corn stover, sugarcane bagasse)
- efficient process thanks to feedstock-specific enzymes and **efficient co-fermentation** organisms
- **Energy self-sufficient** production of cellulosic ethanol with greenhouse gas savings of up to 95 % compared with fossil fuel
- Expansion of regional feedstock base with no conflict of use due to utilising agricultural residues

CLARIANT

Our role in the FP7-sunliquid®-project..

sunliquid® FP7

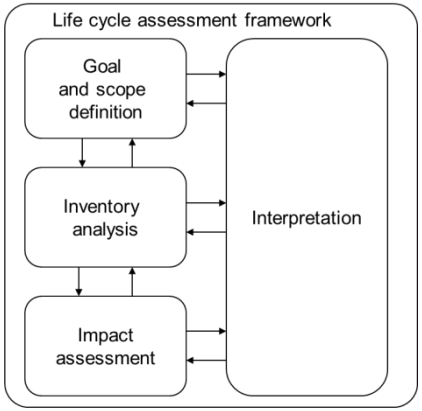
WP5 **Sustainability & Life Cycle Assessment**

Objective: Elaborate the environmental impacts of the cellulose-based integrated sunliquid®-process and comparison to fossil gasoline and other renewable fuels

Method: Life Cycle Assessment

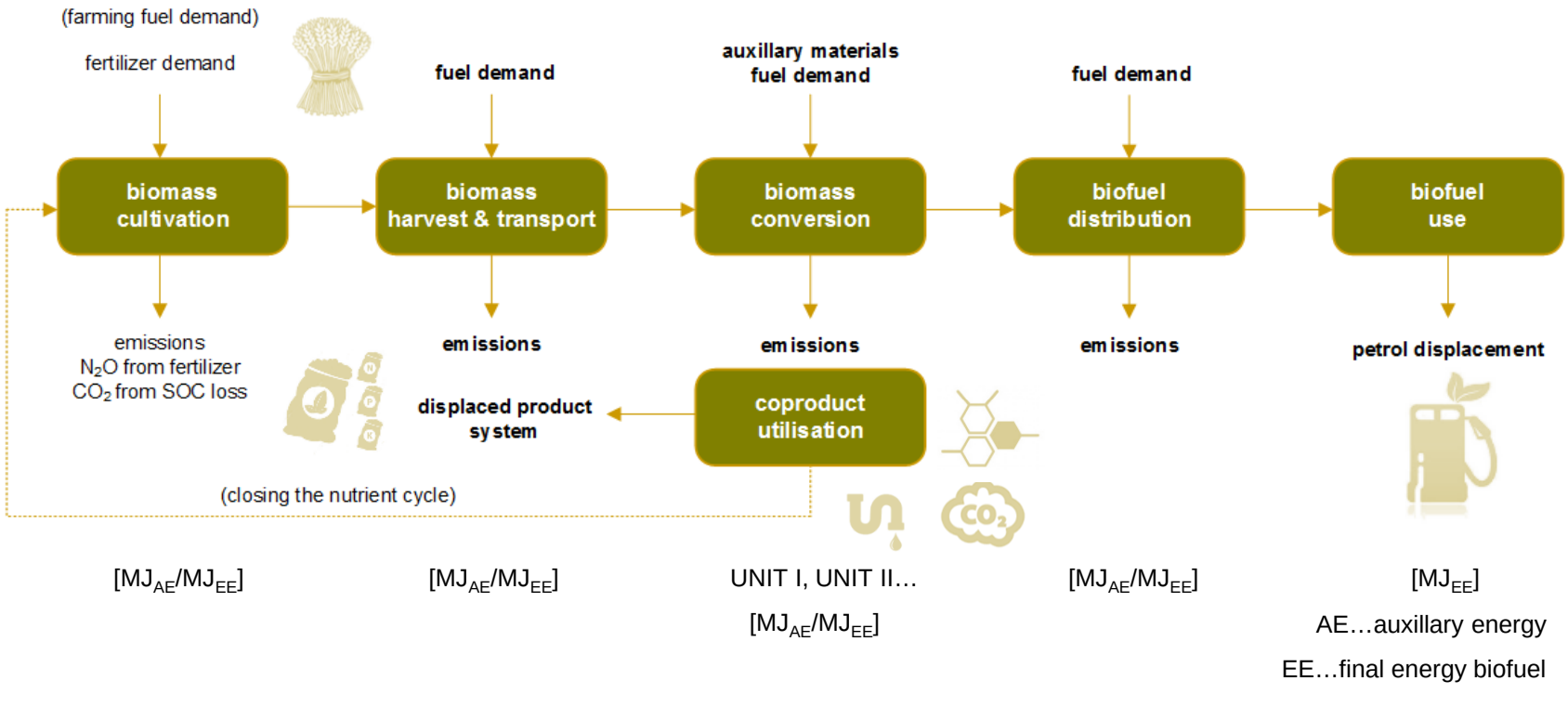
Activities:

- Definition of goal, scope and system boundary
- Life Cycle Inventory (LCI)
- Evaluation of the environmental impact of this biorefinery
- Comparison with other renewable fuels and fossil reference systems
- Sensitivity analysis and parameter variation ⇨ optimisation



Source: own representation according ISO 14000 ff

System boundary Life Cycle Assessment



Source: own representation

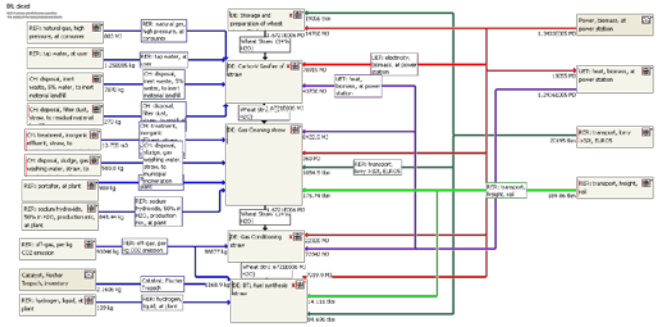
- **Inventory of harvest and transport options**: Trade-off between maximising energy density and conditioning effort
- Testing of different approaches for **impact allocation problems** for co-products

Assessed benchmarks in ecological evaluation

- Petrol according to DIN EN 228
- Diesel according to DIN EN 590
- CNG – Natural gas

Access to
> 90,000 LCA data sets
via various databases

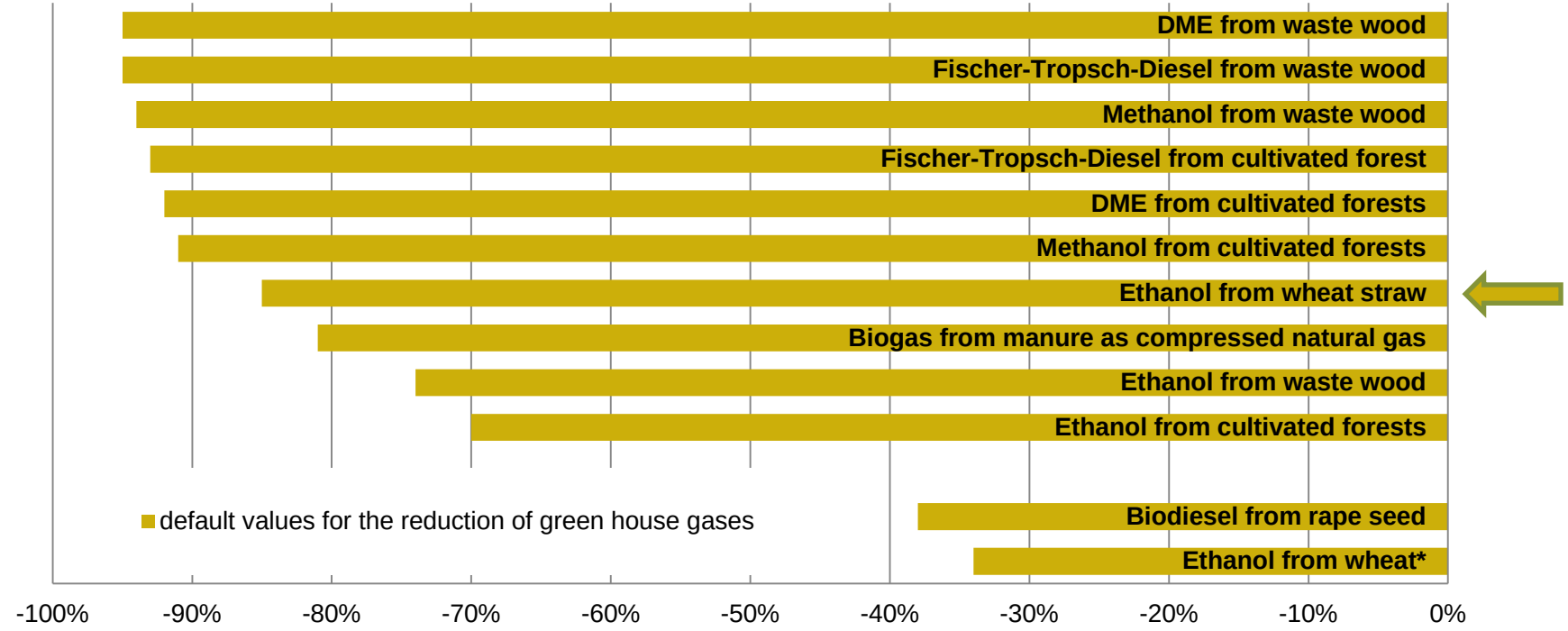
- Bioethanol from wheat (1st G. with various process energy sources)
- Bioethanol from corn (1st G. with various process energy sources)
- Biodiesel (RME)
- BTL - fuels from agicultural residues and forest biomass
- Biomethane (from maize and biowaste)
- Electric Mobility (EU-27 mix, renewables, ...)
- Electrofuels (power-to-gas, power-to-liquid)



Source: own representation screenshot LCA software GaBi

Renewable Energy Directive RED, Annex V

Default values for green house gas reduction of advanced biofuels



** Natural gas as process fuel in a conventional plant*

Source: own representation based on EU (2009) Richtlinie 2009/28/EG zur Förderung der Nutzung von Energie aus erneuerbaren Quellen

- 95 % CO_2eq for cellulosic ethanol with renewable process energy input & optimal setup

LIGNOFLAG

Coordination

Clariant Produkte (Deutschland) GmbH, Munich, Germany

Project duration
June 2016 – May 2021

Project partners

- FLIEGL AGRARTECHNIK, Germany
- ExportHungary, Hungary
- GEOSOL, Hungary
- MATRAI, Hungary
- **Energy Institute at the Johannes Kepler University Linz, Austria**
- Industrielle Biotechnologie Bayern Netzwerk GmbH, Germany
- Bavarian Research Alliance GmbH, Germany

This project receives funding from H2020 European Union funding for Research and Innovation under Bio Based Industries Joint Undertaking project number 709606.

LIGNOFLAG objectives in a nutshell

- Build and operate a commercial flagship production plant with a yearly **production capacity of 60.000 tonnes/year** based on Clariant's process
- Implementing highly innovative technology based on Clariant's patent portfolio including: **integrated enzyme production,** use of feedstock **specific enzymes** in biofuel production, **fermentation of C5 and C6** sugars to ethanol, sustainable **energy integration**
- Produce cellulosic ethanol at large scale with **maximum greenhouse gas (GHG) emission savings** and ensuring to reach **sustainable practice and usage of agricultural residues and co-products**
- Focusing the innovation on the **whole value chain** from raw material to product to bring lignocellulosic ethanol to the market
- Optimized and **integrated use of co-products** for energy or material use enabling the replacement of fossil alternatives
- Shorten time to market and successfully penetrate market with 2nd generation bioethanol made in the EU

This project receives funding from H2020 European Union funding for Research and Innovation under Bio Based Industries Joint Undertaking project number 709606.

Our role in the H2020 LIGNOFLAG-Project..

Life Cycle Analysis

Methodological challenges
EU RED 2009/28/EC & ISO guidelines 14040/14044

Broad set of environmental impacts
Acidification, Eutrophication, Ecotoxicity, natural land transformation, Impacts on human health and resources

Site-specific feedstock sourcing & co-product utilization

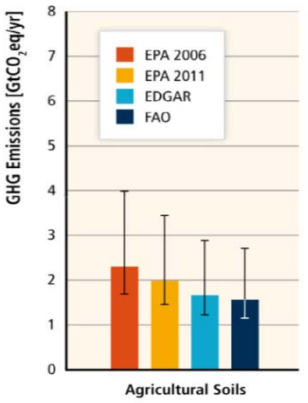
Evaluation of socio-economic effects and policy

Local benefits and social acceptance
Sustainability considerations along the entire biorefinery value chain

environmental and socio-economic sound product performance & market-uptake

Sustainability assessment of renewable resource extraction

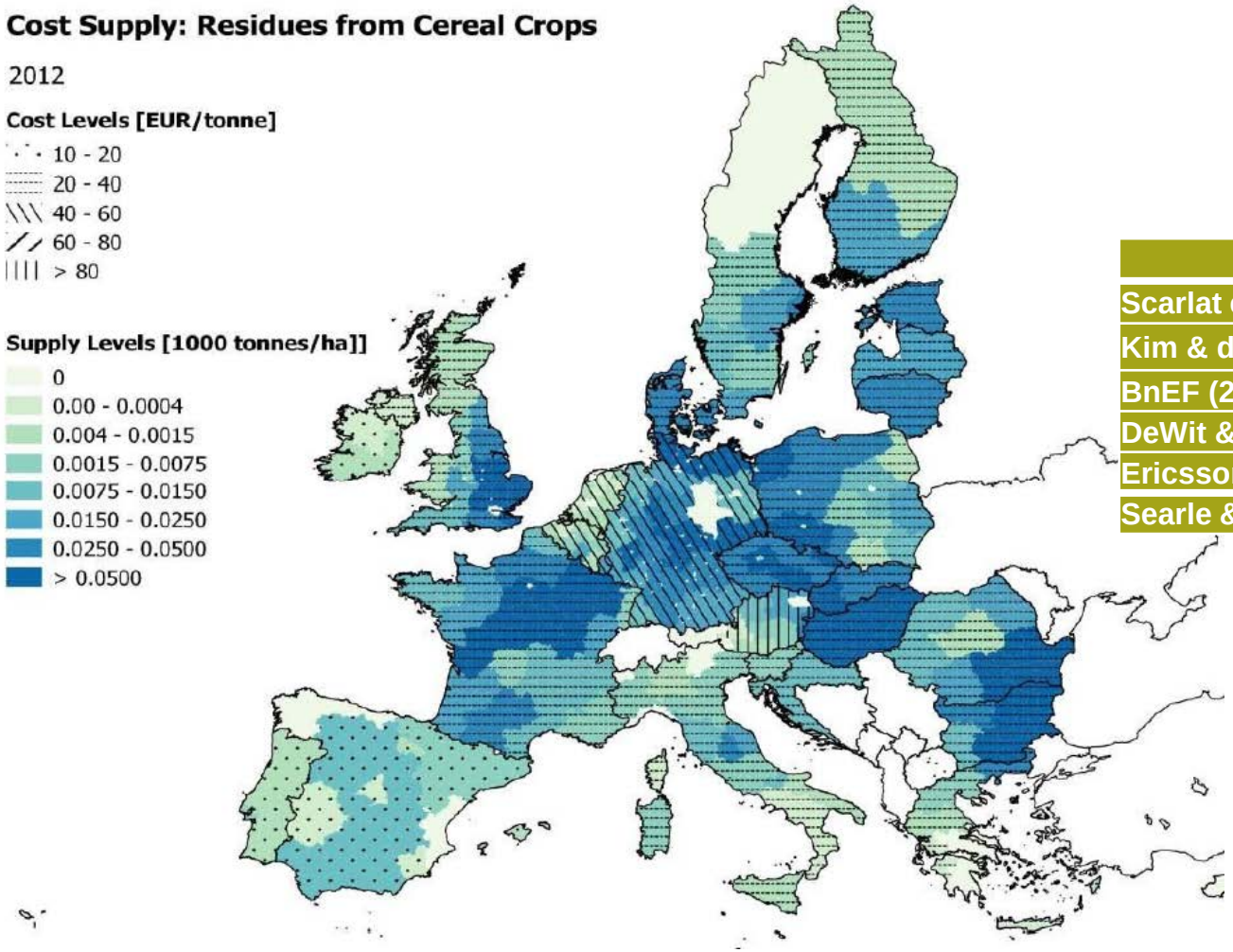
- **Theoretical** straw potential
- **Technical** straw potential
- **Sustainable** straw potential
  - strongly dependent on **regional conditions** (soil type, climate, soil, rainfall,…)
  - **agricultural practice** (crop rotation, tillage practice, yield level of main crops, cover crops, manure management, …)



Source: IPPC Working Group 3 Report

difficult to determine!
available models show high variety in results
methodological advancement & long-term in-situ monitoring is necessary

own work applying soil organic carbon balancing
Lindorfer, J. et al. Sustainable Energy Technologies and Assessments Volume 5, March 2014, pp. 95–105



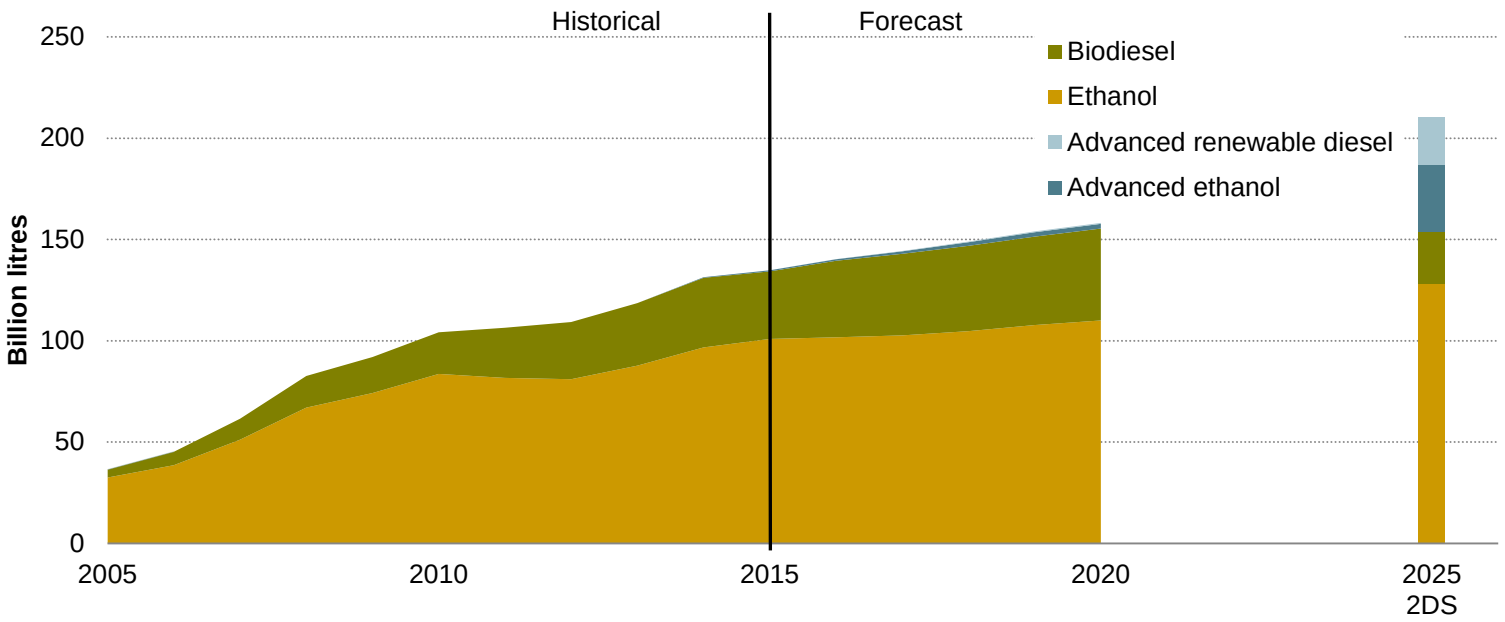
exemplary literature estimates for residue availability in the EU

million tonnes yr^{-1}	
Scarlat et al. (2010)	62-109
Kim & dale (2004)	225
BnEF (2012)	151
DeWit & Faaij (2010)	182-229
Ericsson & Nilsson (2006)	35-53
Searle & Malins C. (2013)	139

Source: http://www.s2biom.eu/en/, Delivery of sustainable supply of non-food biomass to support a "resource-efficient" Bioeconomy in Europe, EU-7th Frame Programme. Grant Agreement no. 608622

S2Biom

Global biofuels production

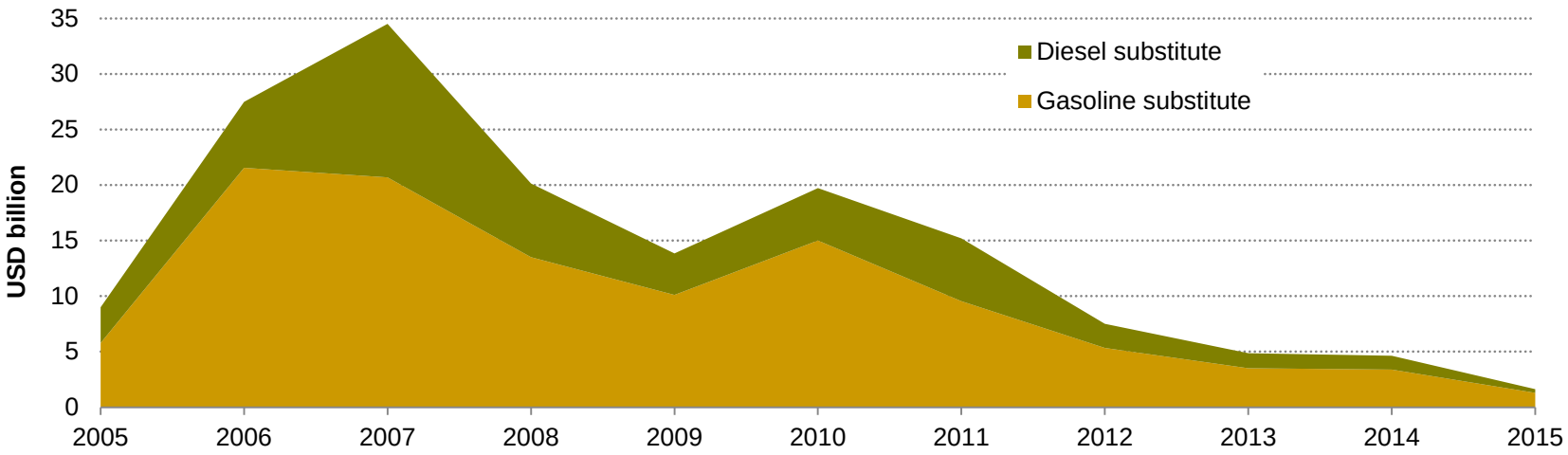


Source: own representation based on International Energy Agency (2016), Tracking Clean Energy Progress 2016, OECD/IEA, Paris

the urgency for drastic disproportional emission reductions in the transport sector is growing…

decarbonisation by 2050 requires:
+ traffic efficiency
+ alternative drives
+ alternative fuels

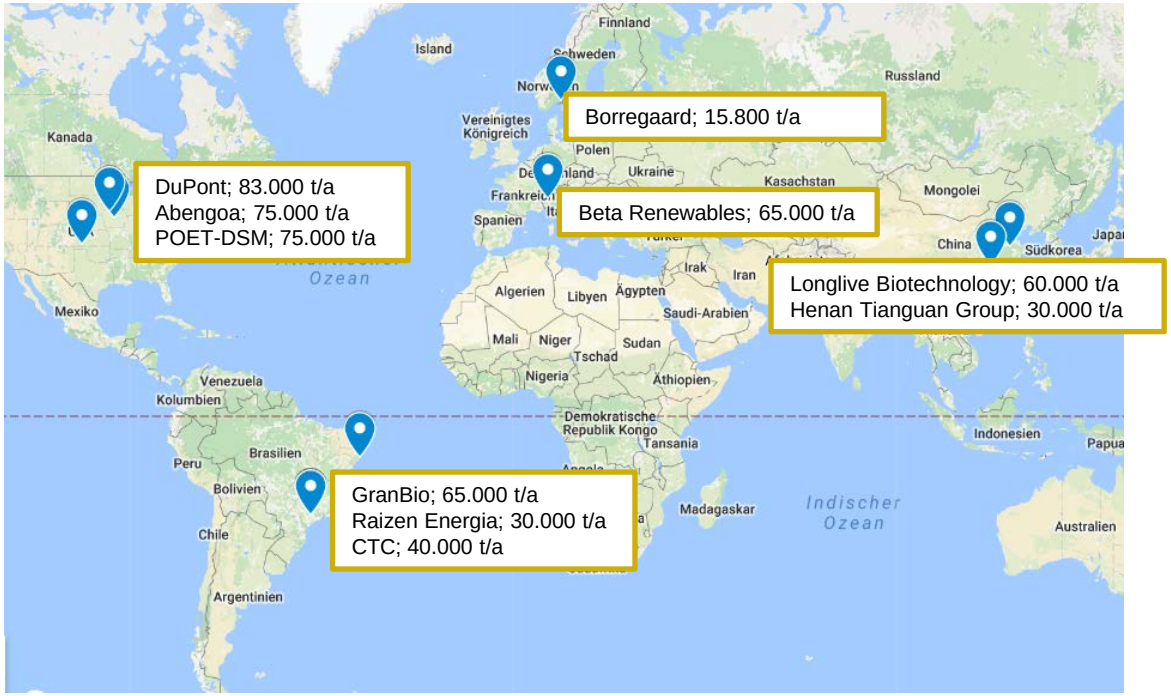
Global Biofuels Industry Investments



Source: own representation based on Bloomberg New Energy Finance (BNEF) (2015), Funds Committed (database), www.bnef.com/FundsCommitted/search.

- 7 commercial-scale advanced biofuel plants commissioned in 2014-15, adding over 650 Mio. Liters of new production capacity
- **In all relevant European energy scenarios biofuels play a significant role**
- 95 % of new registrations in Brazil in 2015 were for flexible-fuel vehicles

The commercial uptake of advanced biofuels - slower than predicted



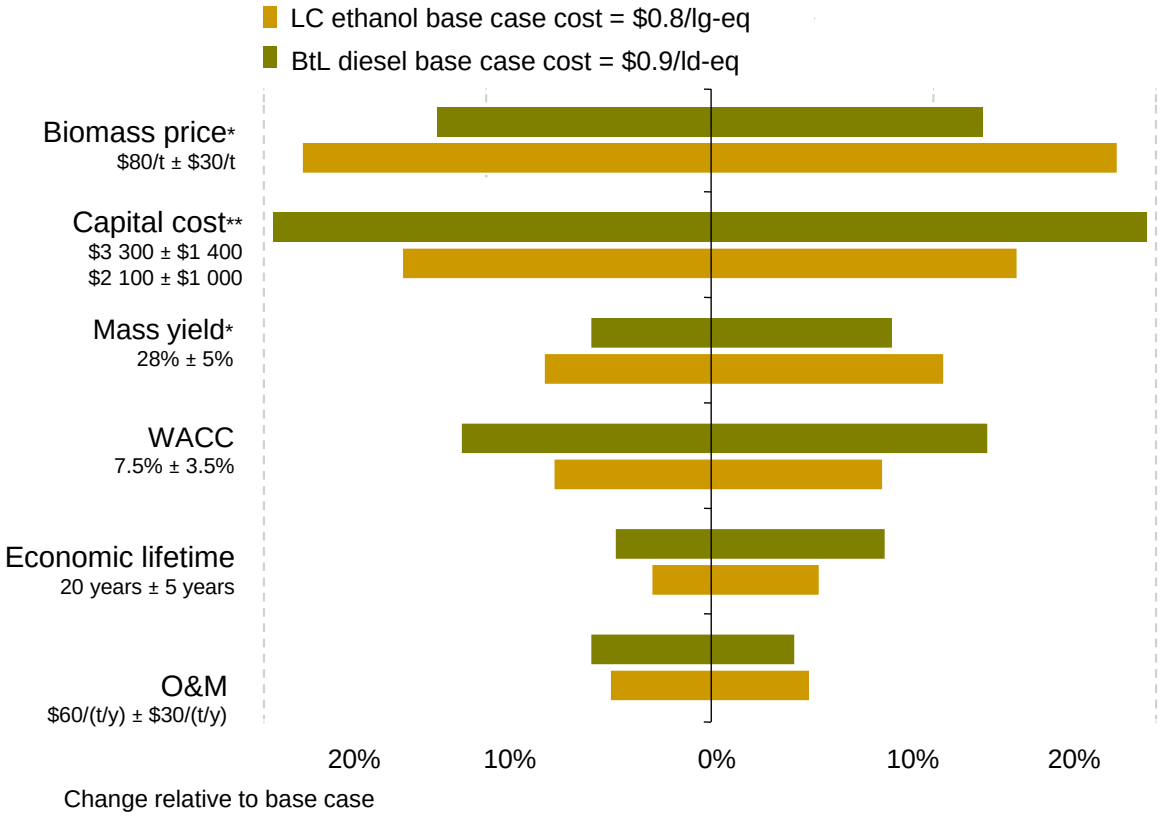
Source: own representation based on company presse releases and http://demoplants.bioenergy2020.eu/

A high number of projects with pending investment decisions, freezed or cancelled

(Woodspirit-NL, UPM Stracel BTL – FR, Ajos BTL – FIN, CEG Plant – PL, Gobigas 2 & Pyrogrot – SE, Maabjerg Energy Concept - DK…)

A lot more…

Sensitivity analysis of levelised cost of advanced biofuels production



Notes: * On a dry matter basis. ** Capital cost is expressed in dollars per tonne per year of production capacity. LC = lignocellulosic; lg-eq = litres of gasoline equivalent; BtL = biomass-to-liquid; ld-eq = litres of diesel equivalent; WACC = weighted average cost of capital; O&M = operation and maintenance; t/y = tonnes per year.

Source: International Energy Agency (2016) World Energy Outlook 2016, OECD//IEA

The main levers for cost reduction of advanced biofuel processes are **supplying cheap biomass and decreasing capital costs**

Revenue from by-products has a detrimental effect on competitiveness

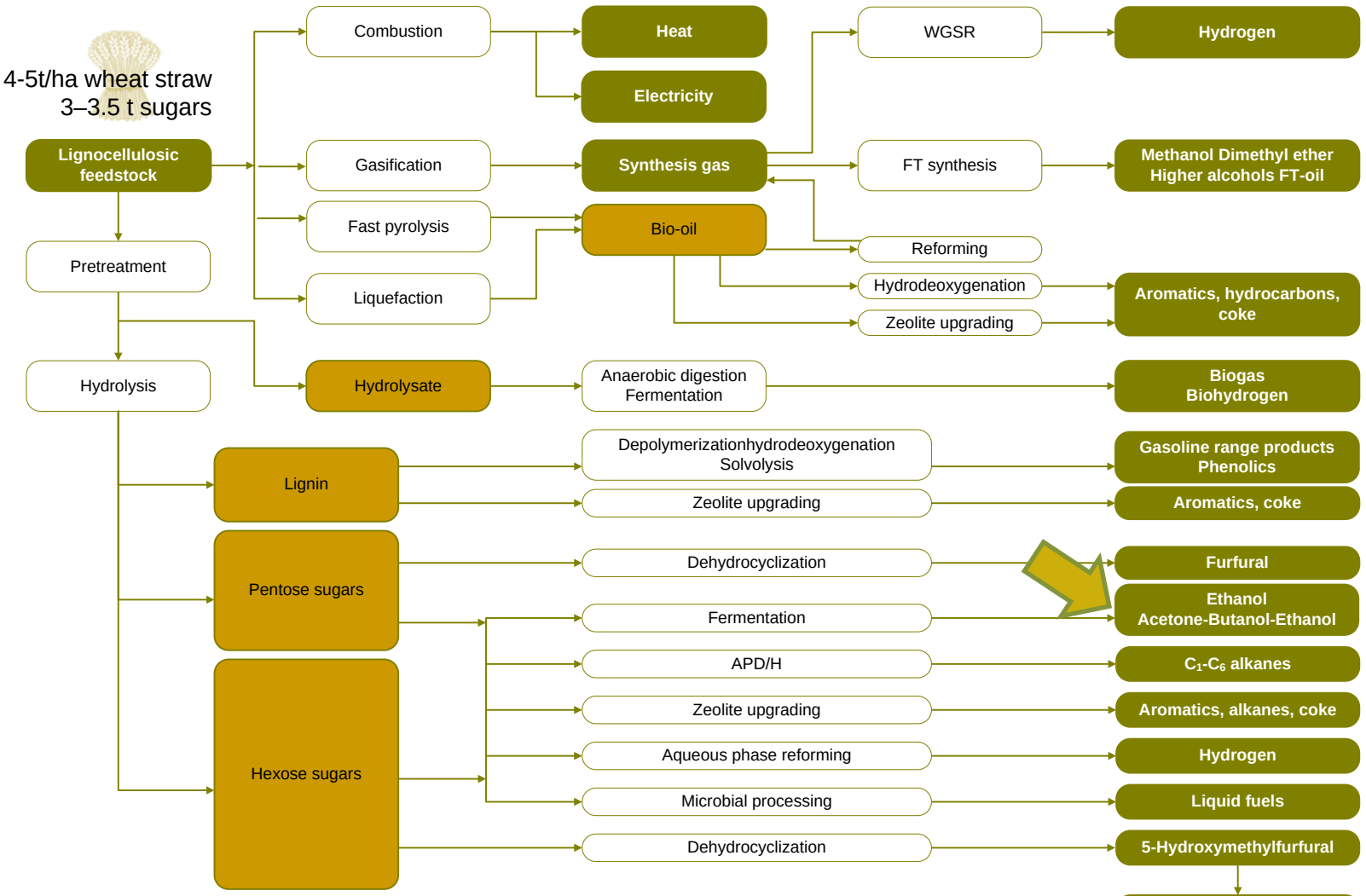
Risk assessment: financing, policies, market regulations

Building blocks for policy

- Most of the Member States consider a **fuel-mix strategy**: Cellulosic ethanol offers a fast track to decarbonisation as advanced biofuel
- **Performance based standards** that set an overall emission reduction target for transport options are best suited to regulating fairly comparable fuel alternatives
- **Life Cycle Assessment (LCA)** is a valuable tool for policy making: The parameters should be 'sense-checked' to ensure relevance to real world conditions
- **Driving behavioural and technological change** is the ultimate goal of policies discussed

Coherent sustainability requirements for all pathways!
Policy in this sector leverages innovation
in biotechnologies and bio-based chemistry.
Sugar is the natural substrate to biotechnologies and a bridge to biobased products

Cellulosic biomass and the biorefinery approach



Source: own representation based on Sunil K. Maity (2015) Renewable and Sustainable Energy Reviews 43:1427-1445

environmental, economic & societal research

If you have any questions or please contact us!

For more information please visit:

http://sunliquid-project-fp7.eu/

http://www.energieinstitut-linz.at/v2/portfolio-item/sunliquid/

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