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Session 4CO.2: Market implementation and financing

Economic and environmental prospects of biofuels in the European transport sector

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Research Area Alternative Fuels
Institute of Engineering Thermodynamics

DLR e.V.
16. May 2018
Copenhagen, Denmark

DLR

Agenda

1. Motivation for Biofuels
- Need for GHG emission reduction
- Actual GHG emissions in Europe
- Biofuels options in European transport
- Options to reduce GHG emissions

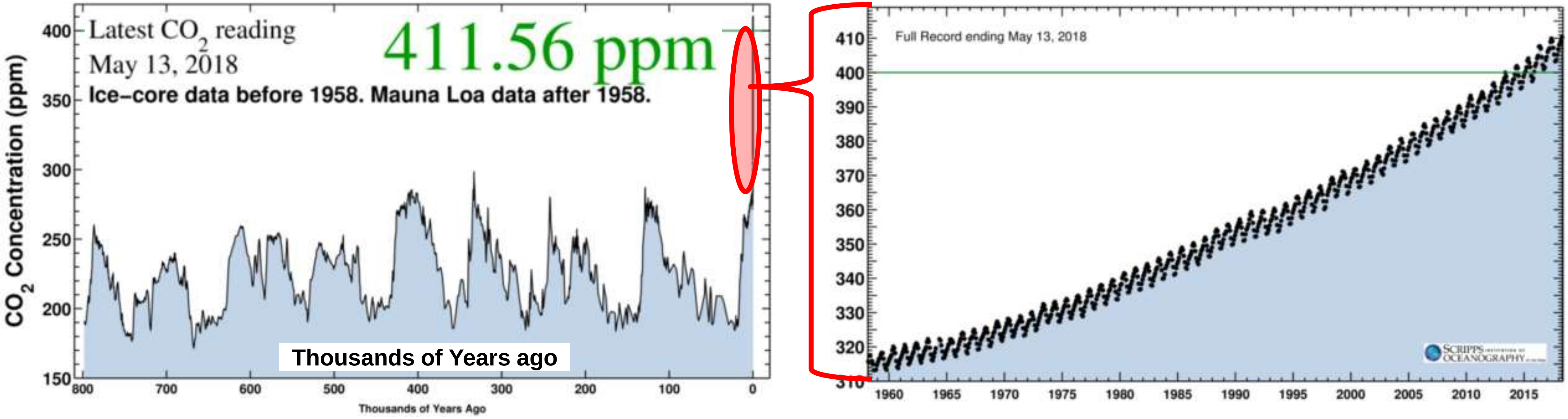
2. Options for renewable transport
- Biofuels Options
- Evaluation criteria of Biofuels Concepts

3. Process evaluation of aviation biofuels
- Introduction to DLR methodology
- Example: PBtL – Jet fuel by Fischer-Tropsch

4. Summary and Outlook

Climate Change – Driver for bioenergy?

- Historic natural fluctuation between 180 and 280 ppm CO_2 concentration
- undeniable break-out since 1960’s
- No visible impact of renewables introduction since 2000’s



Source: https://www.co2.earth/daily-co2

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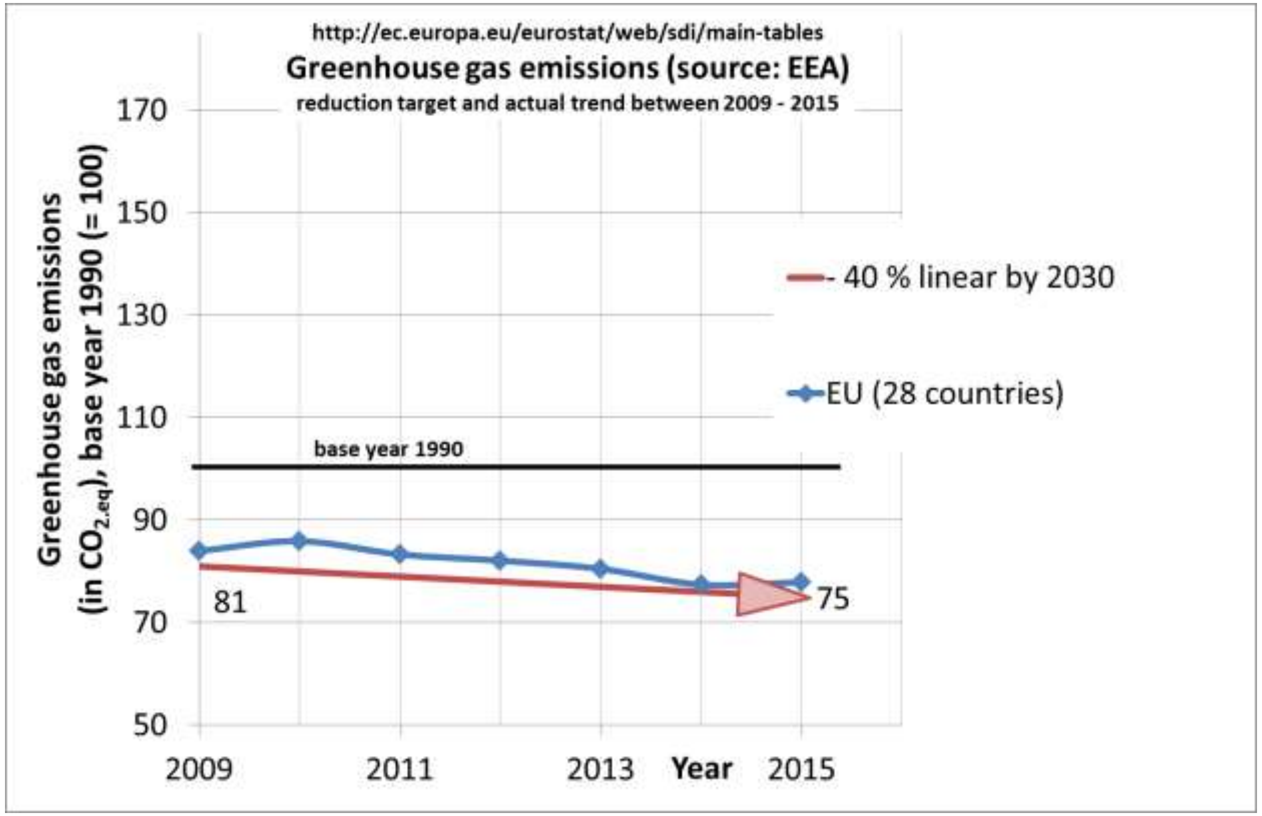
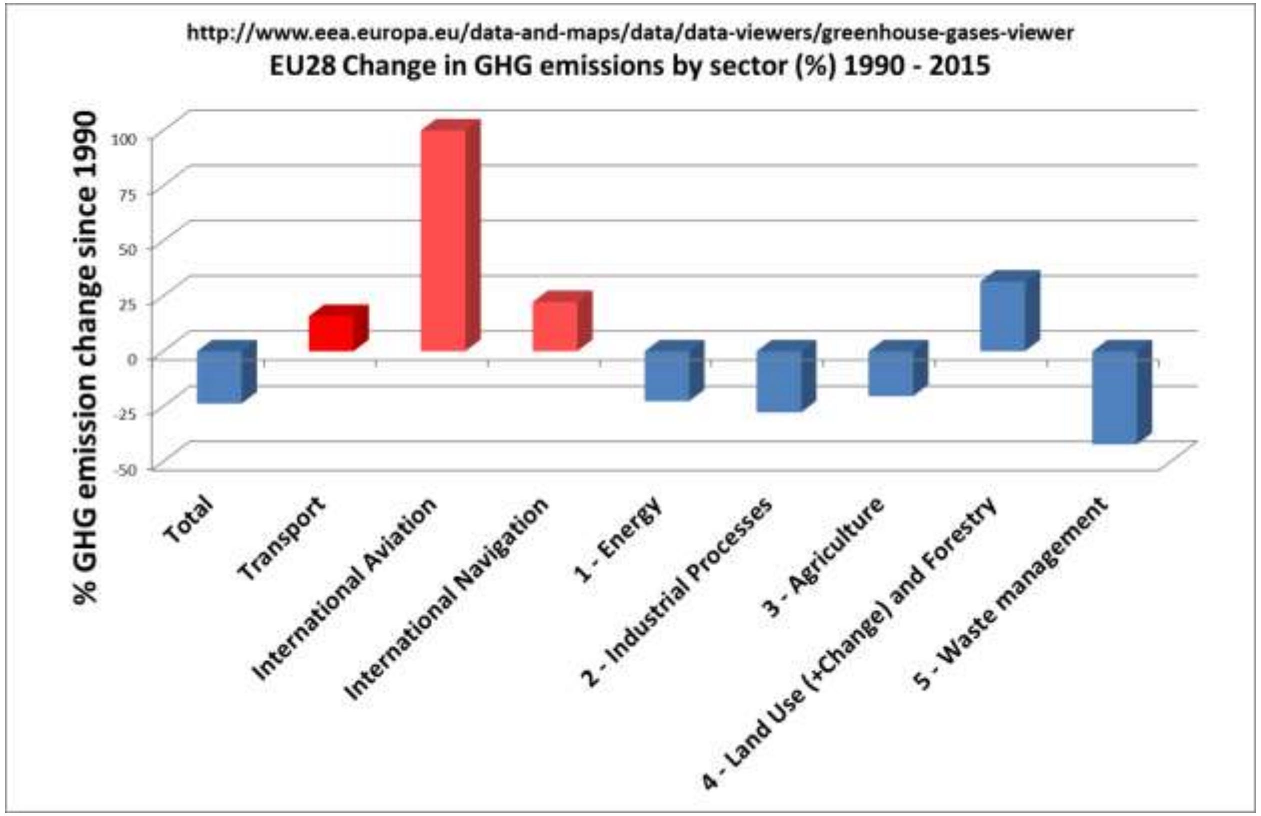
GHG emission trend in Europe

- European GHG reduction behind target
- Transport GHG emissions grow considerable





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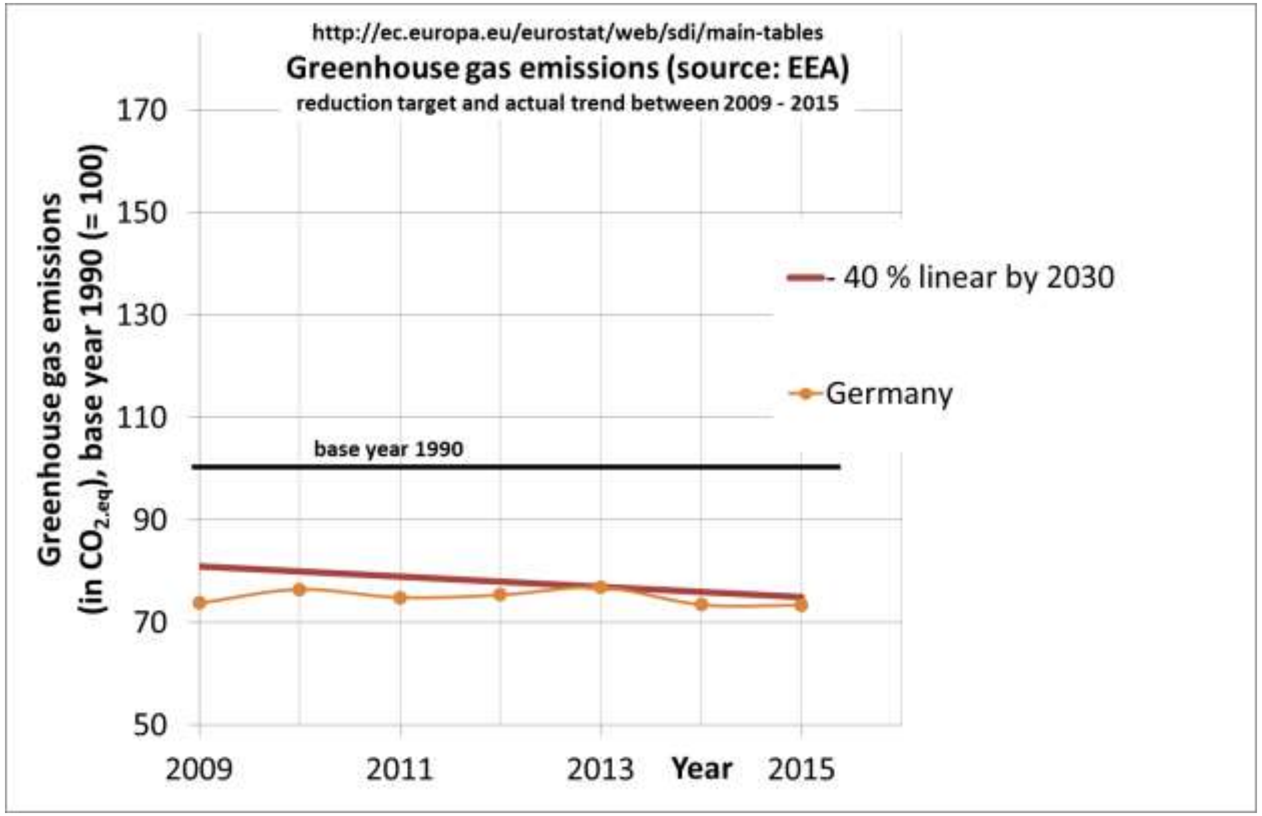
GHG emission trend in Europe

- Germany lost momentum



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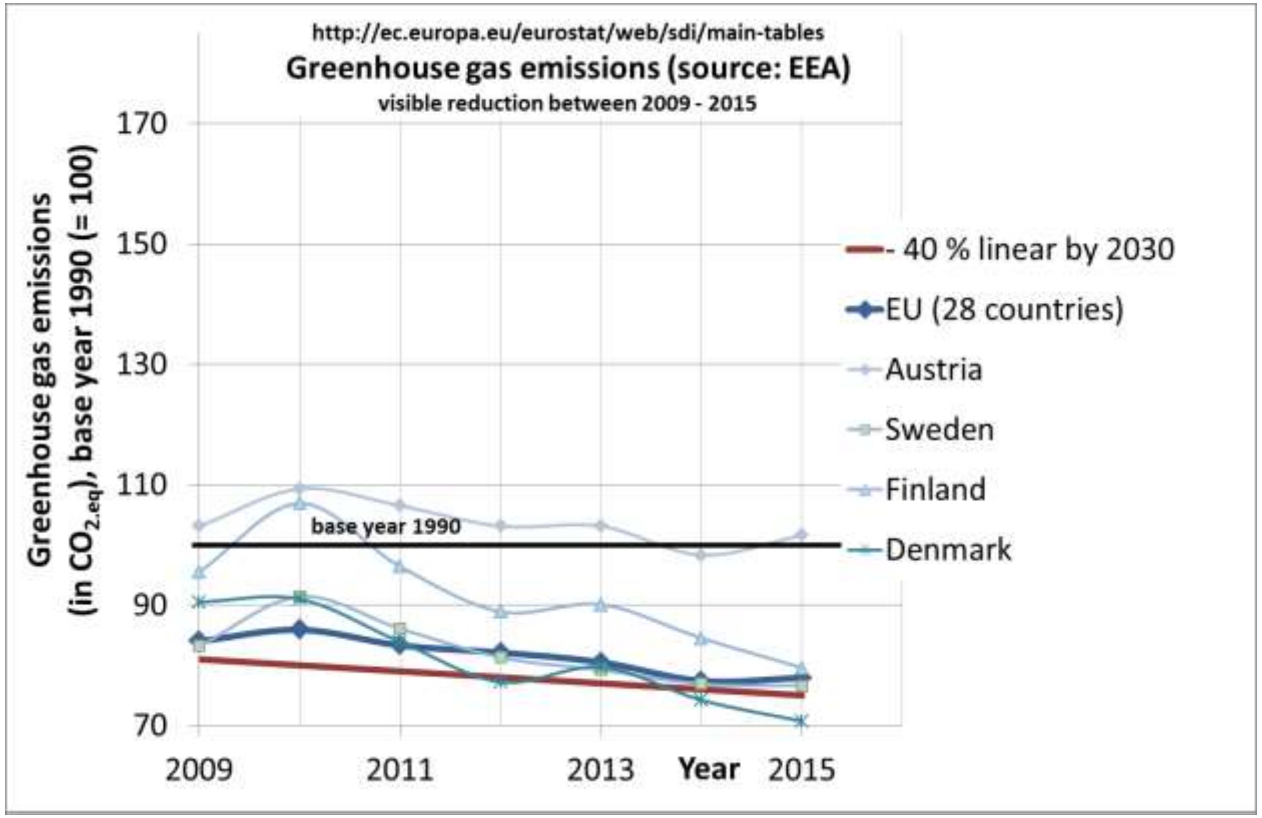
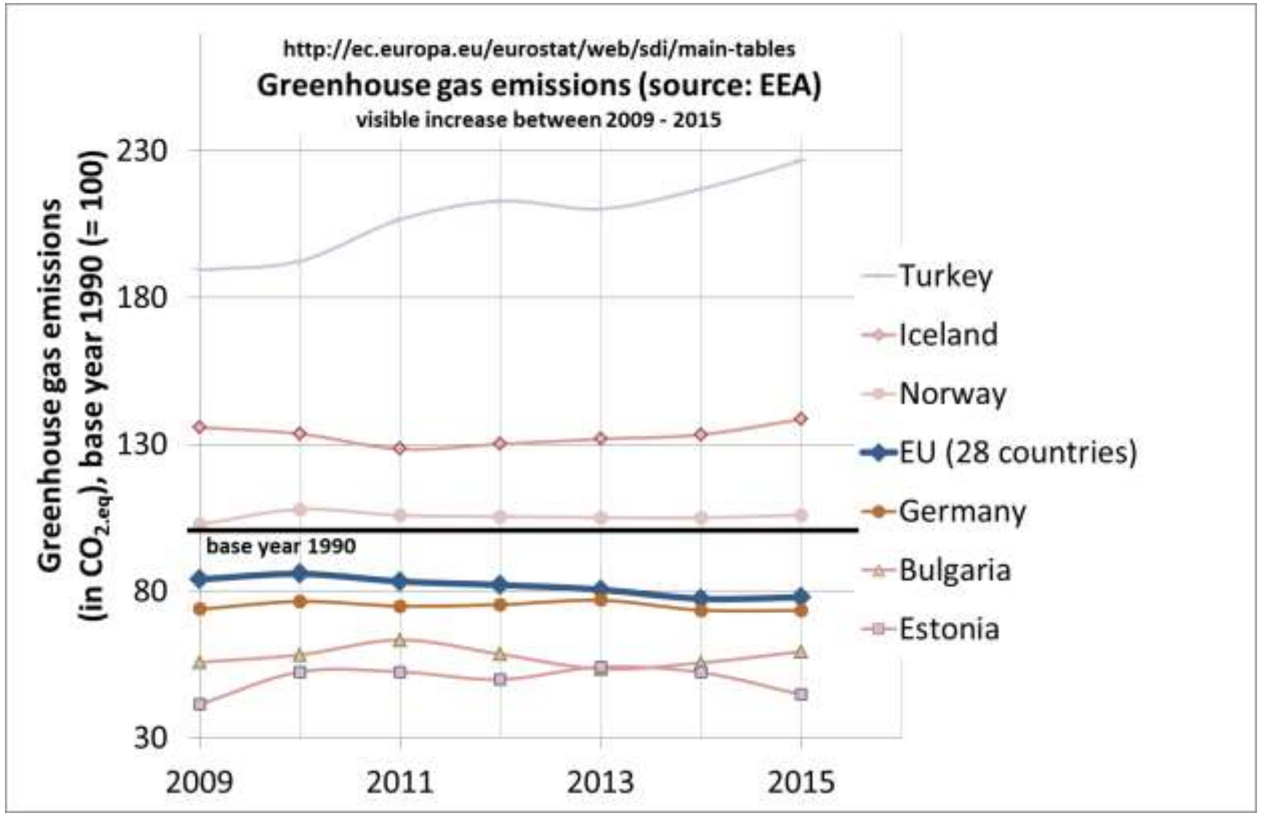
GHG emission trend in Europe

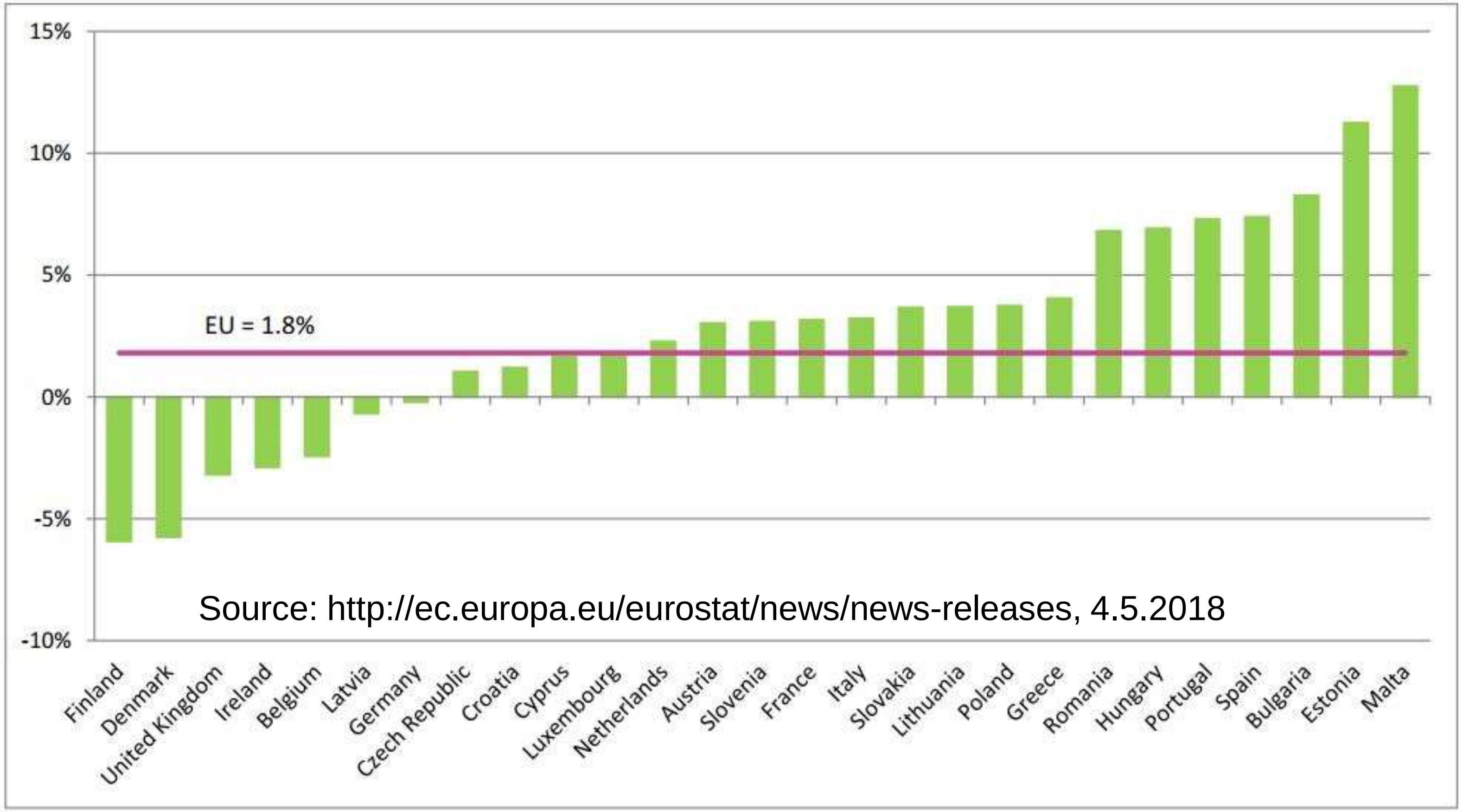
- no common European approach for GHG emission reduction
- Austria, Denmark, Finland and Sweden demonstrate GHG emission reduction without affecting GDP growth





CO_2 emissions change 2017/2016

- Eurostat estimates that in 2017 carbon dioxide emissions from fossil fuel combustion **increased by 1.8 %** in the European Union (EU), compared with the previous year.



Source: http://ec.europa.eu/eurostat/news/news-releases, 4.5.2018

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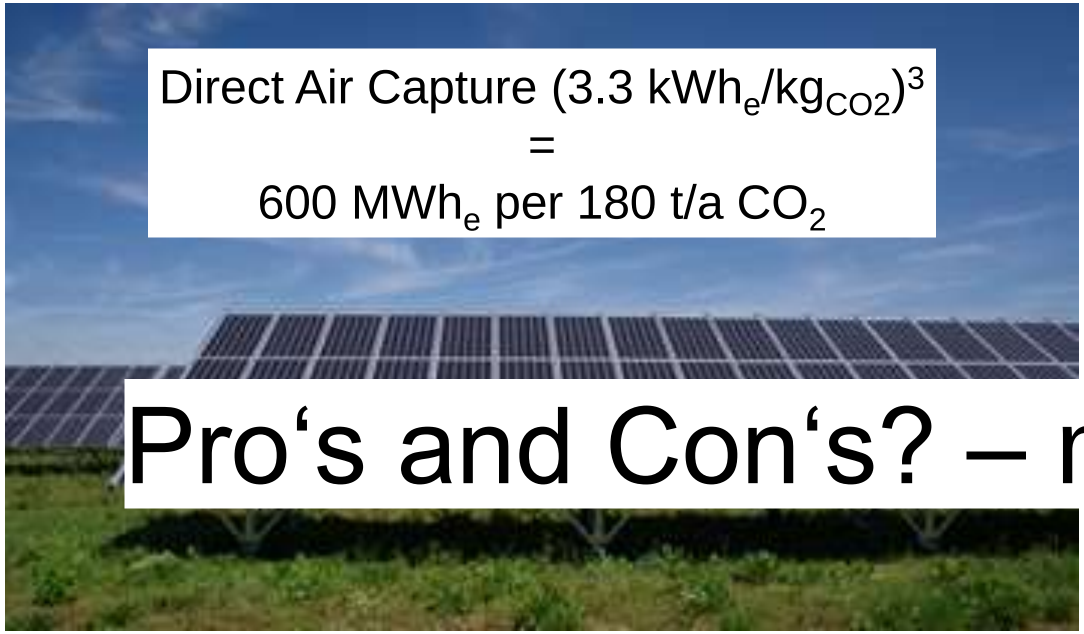
Compare renewable energy options

Example[1]: Solar power plant Seefeld, Bavaria
- 3 GWh_e/a from 8.2 ha PV field
- available on meadows and grassland

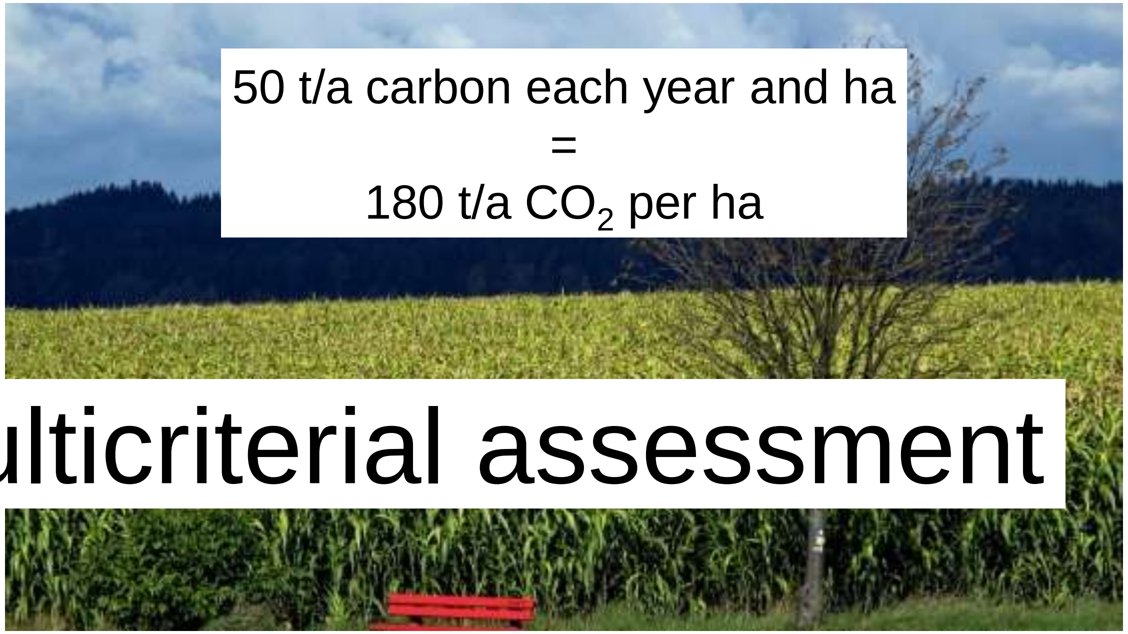
➔ 366 TWh_e/a per ha (@ sunshine hours)

Example[2]: Silage maize for biogas in Germany
- 40 - 60 t/a per ha ≙ 4 – 6 TNm^3 Methane (+ CO_2)
- ILUC, fertilizer + pest control, GHG: CH_4 leakage, N_2O

➔ 15 – 22 TWh_e/a per ha as needed + usefuel heat



Direct Air Capture (3.3 kWh_e/kg_{CO2})[3]
=
600 MWh_e per 180 t/a CO_2



50 t/a carbon each year and ha
=
180 t/a CO_2 per ha

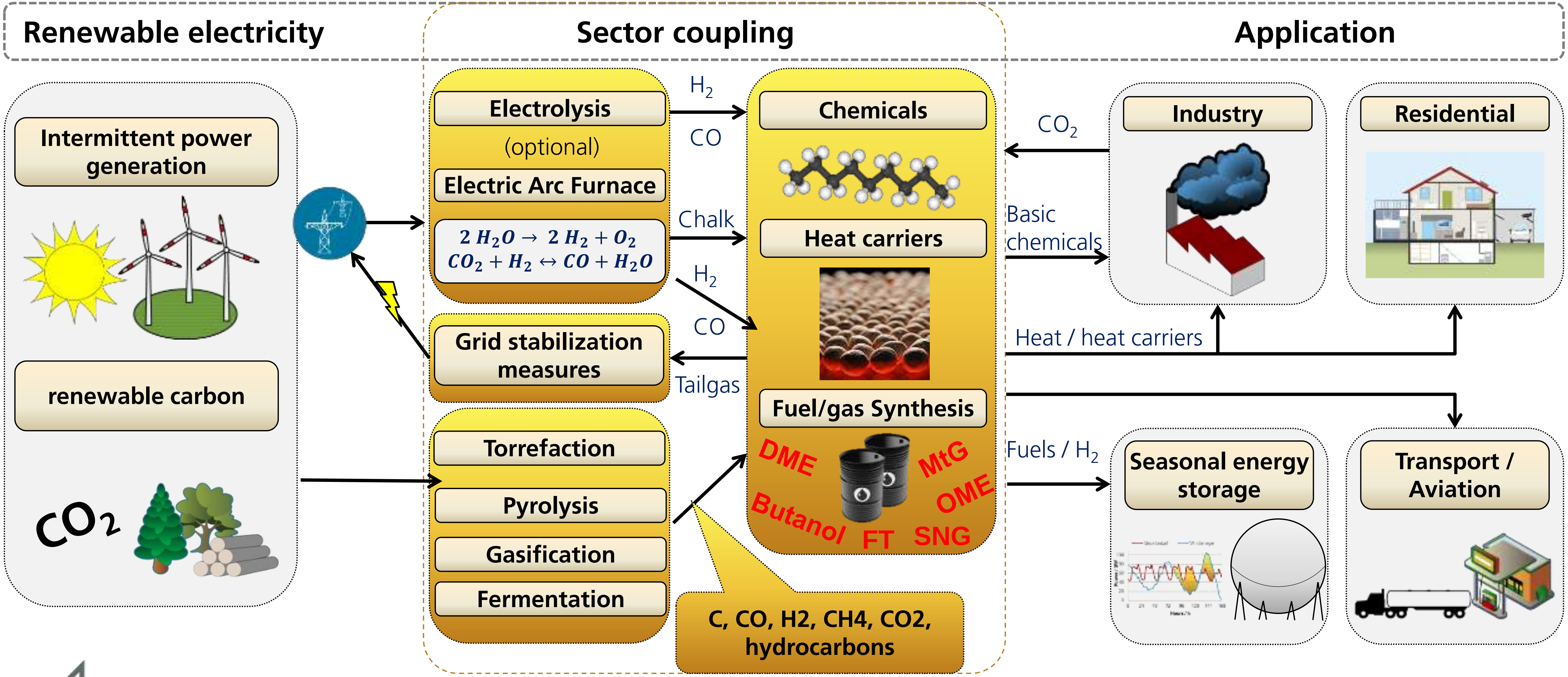
Pro‘s and Con‘s? – multicriterial assessment

[1]Source: www.bayerische-solar.com

[2]Source: www.fnr.de

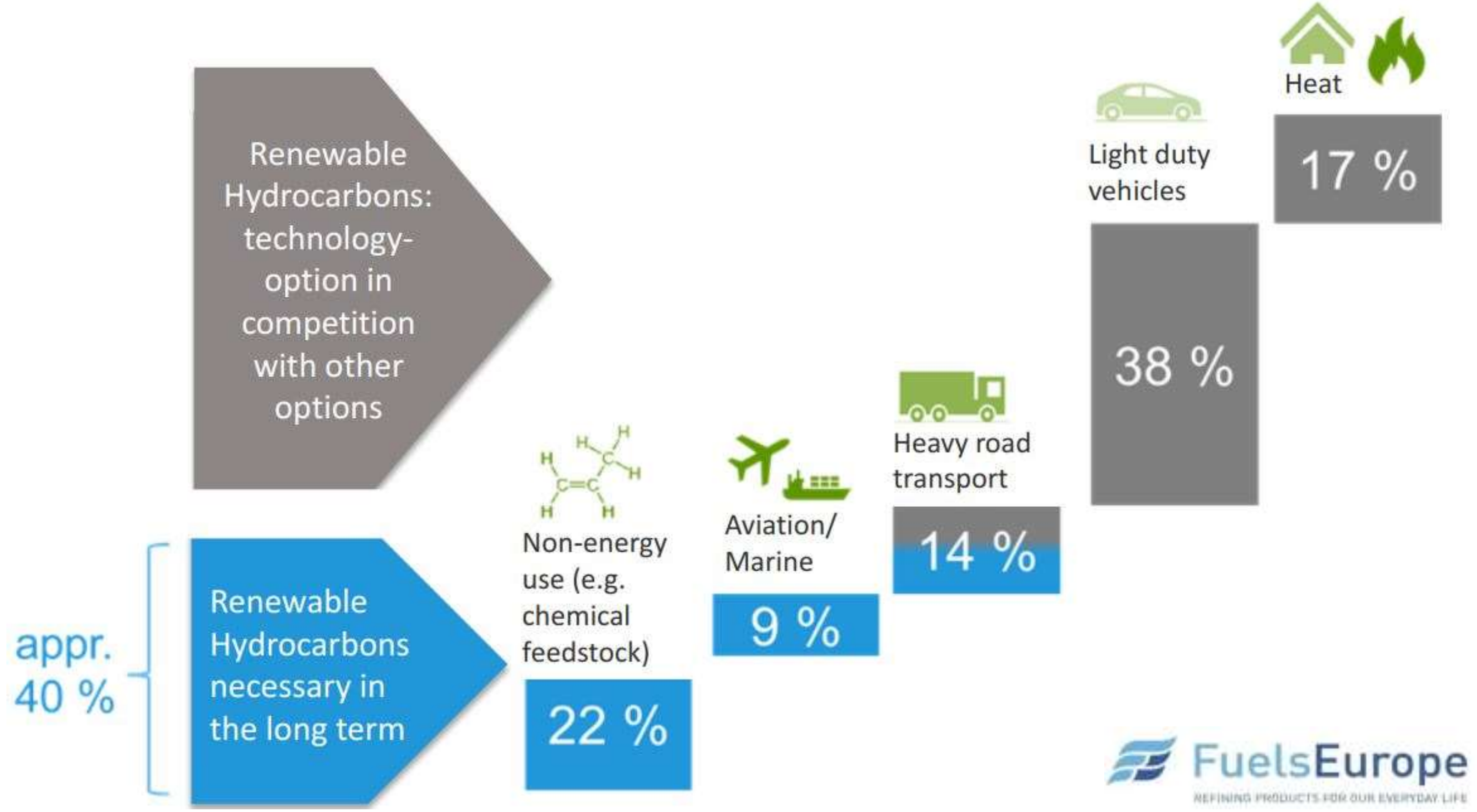
[3]Source: www.neocarbonenergy.fi (Climeworks)

A new integrated energy system



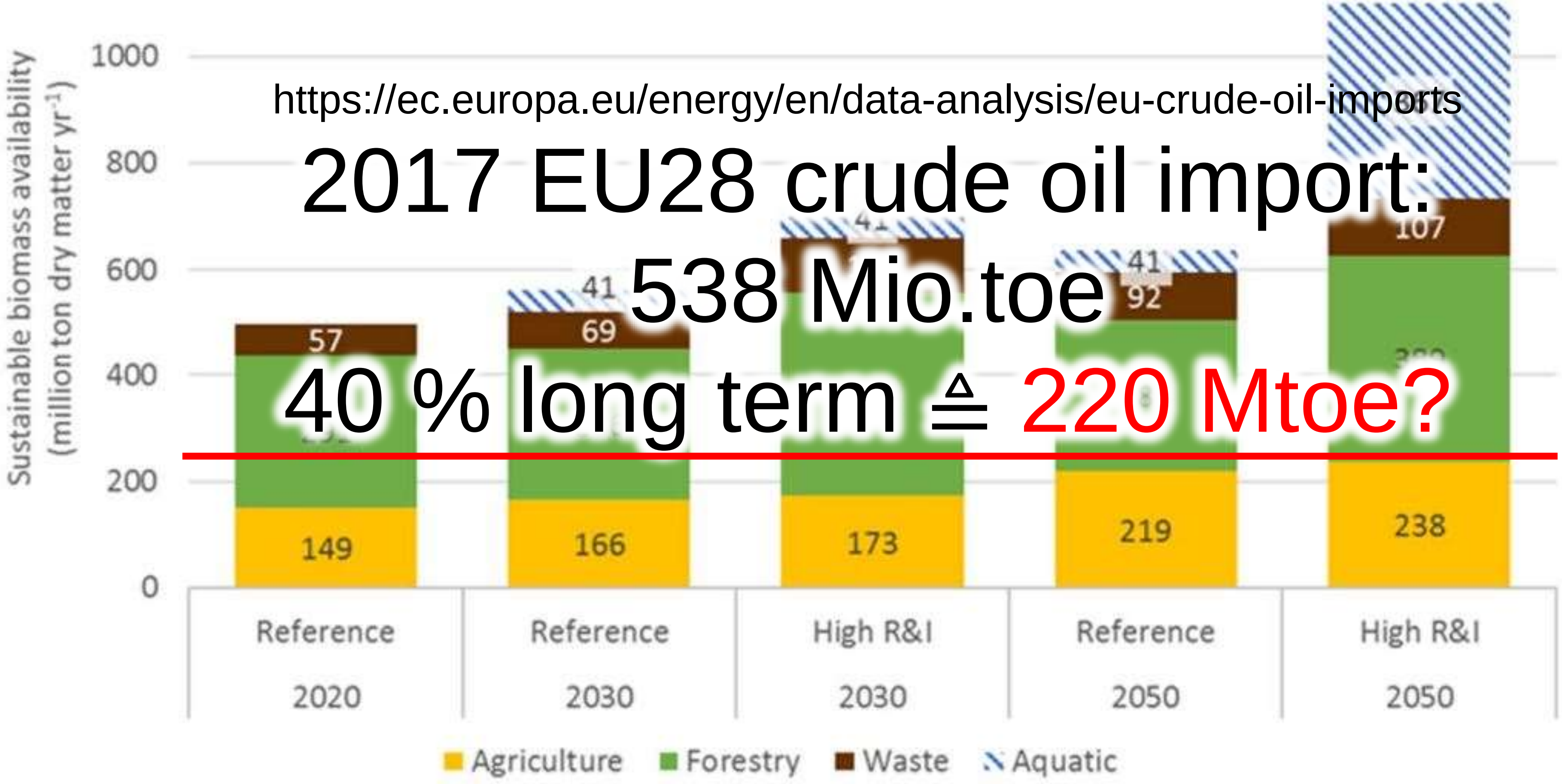
Beyond electricity – Oil Replacement will become much more challenging

- From current use of oil products (Germany, 2016) – minimum 40 % will be long-term required



European biomass potential

- source: EU Directorate-General for Research and Innovation / Ecorys B.V., November 2017
- Research and Innovation perspective of the mid – and long-term Potential for Advanced Biofuels in Europe



https://ec.europa.eu/energy/en/data-analysis/eu-crude-oil-imports

2017 EU28 crude oil import:
538 Mio.toe

40 % long term ≙ 220 Mtoe?

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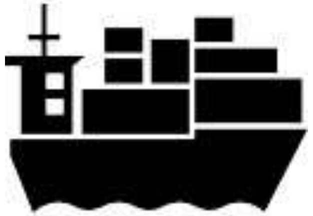
Options for Transport GHG reduction

- e-mobility + ren. Power
- Green-H_2 and Fuel cells
- ~~(Bio-)Methane~~
- Methanol, ~~Ethanol~~, Butanol
- DME, OME, …

- ~~(Bio-)Methane, -LNG, -CNG~~
- Green-H_2 and Fuel cells
- synthetic fuels (Fischer-Tropsch)



- ~~(Bio-)Methane, -LNG, -CNG~~
- synthetic fuels (Fischer-Tropsch)

- Synthetic paraffinic kerosene (SPK) from Fischer-Tropsch
- ~~HEFA kerosene~~
- ~~Farnesane~~
- ~~Alcohol-to-Jet~~

ban on RED II?

Pro‘s and Con‘s? – multicriterial assessment

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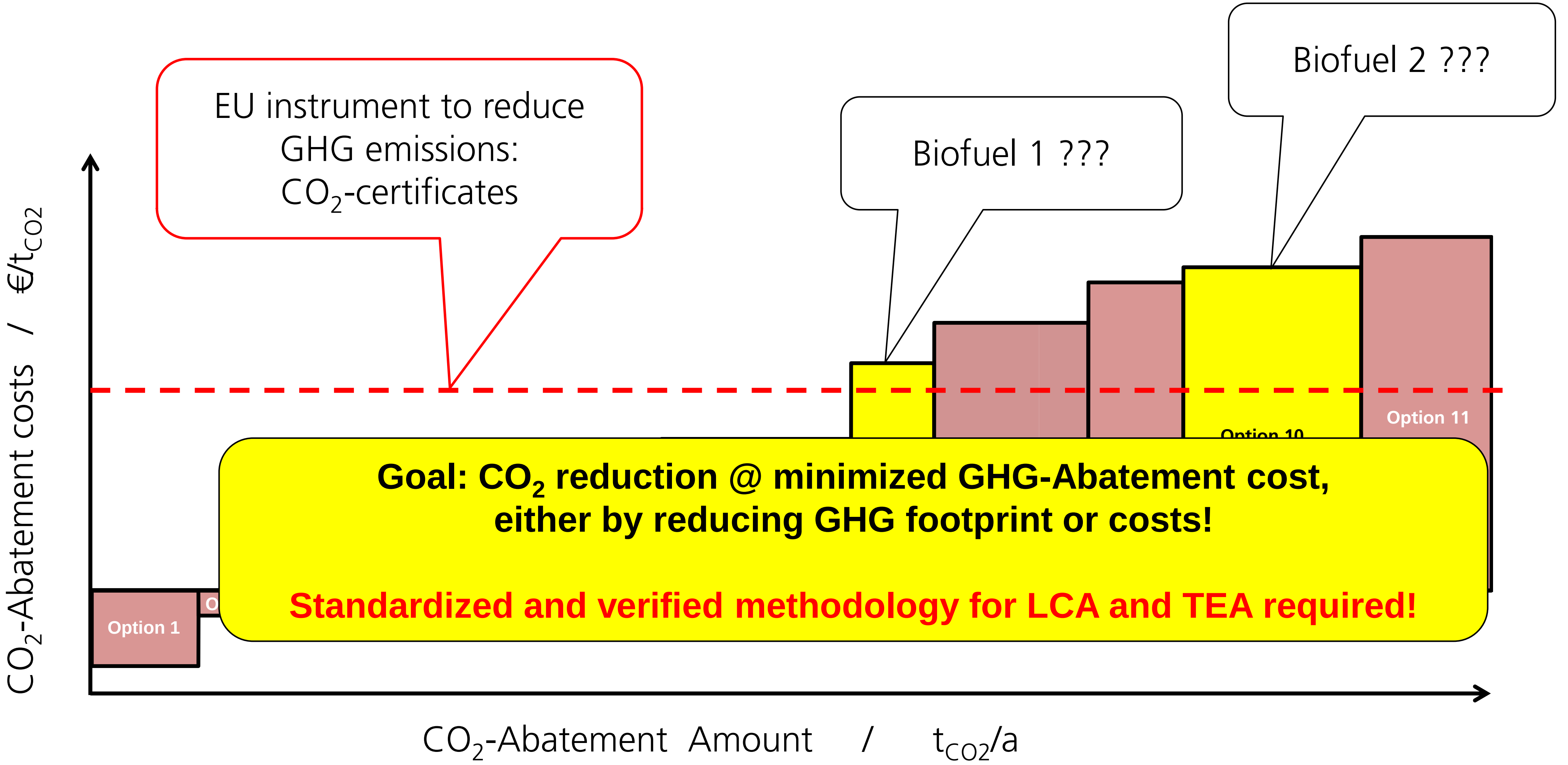
Evaluation of Biofuels concepts

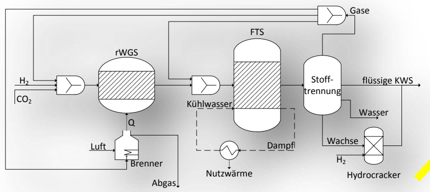
Merit-Order of carbon reduction technologies

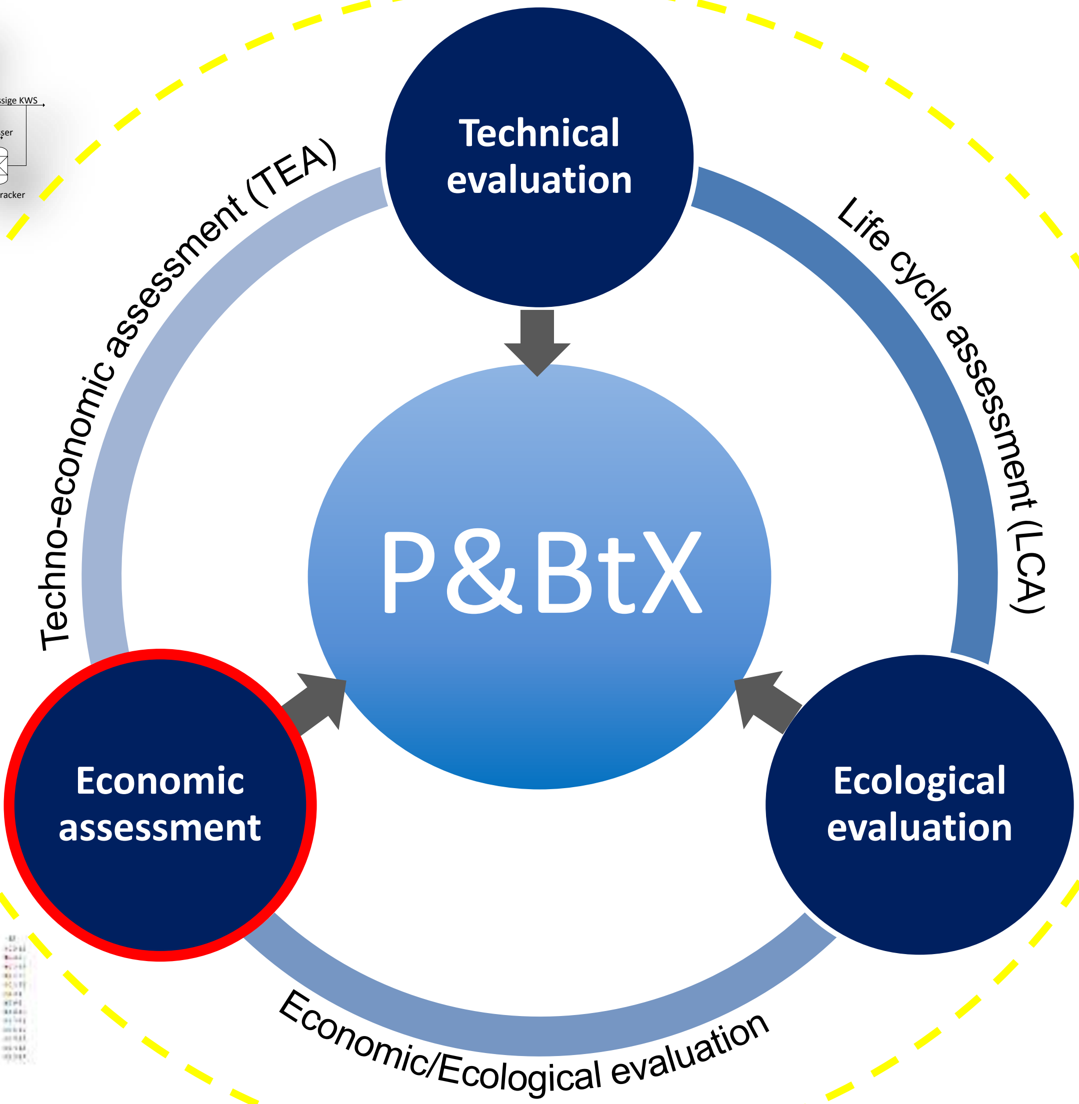


Goal: CO_2 reduction @ minimized GHG-Abatement cost, either by reducing GHG footprint or costs!

Standardized and verified methodology for LCA and TEA required!

3. Process evaluation @ DLR

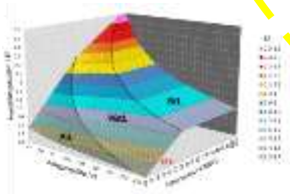




DLR-evaluation and optimization tool*

TEPET
Powered by DLR
Standardizing economic process evaluations

*see: Albrecht et. al, **Technical and Economic Optimization of Biomass-to-Liquid Processes Using Exergo-economic Analysis**
17.05.2018, 11:25, session: 3DO.6.3



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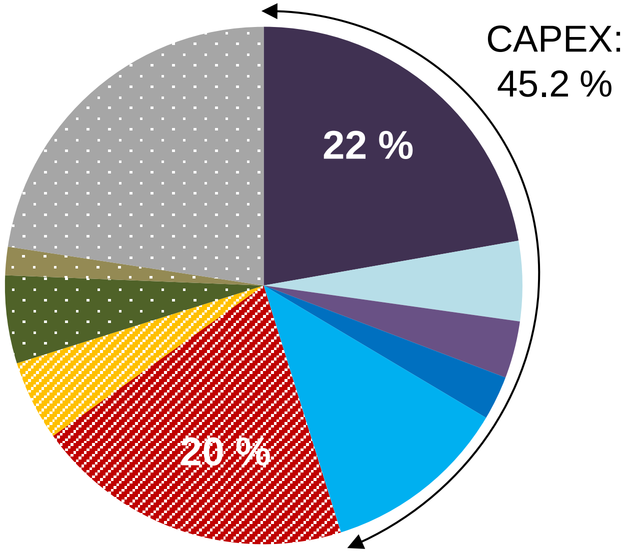
TEA results*: 100 MW_{LHV} biomass ➔ Jetfuel

- Electrolyzer
- Entrained flow gasification
- Pyrolysis
- Fischer-Tropsch
- Selexol
- Remaining (CAPEX)
- Power[3]
- Biomass[4]
- Remaining (Utilities)
- Maintenance
- Labor costs
- Remaining (OPEX)

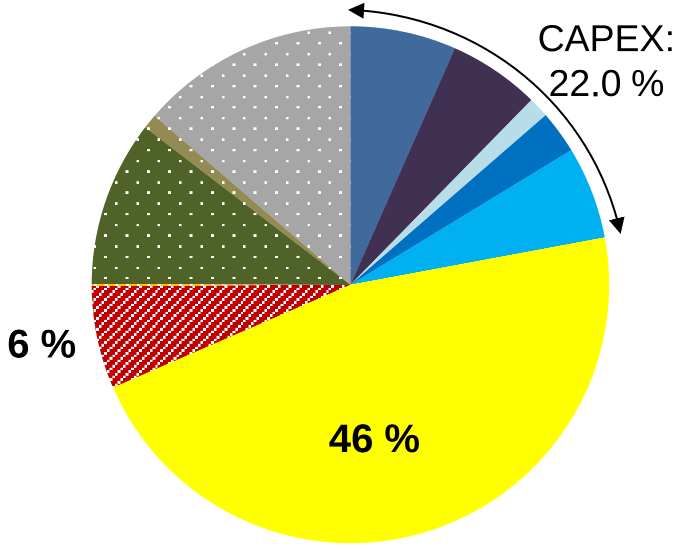
Biomass-to-Liquid (BTL)

Investment: ca. 395.2 mio. €
Fuel production: 24.2 kt/a
Fuel costs: ca. **2.37 €/l**



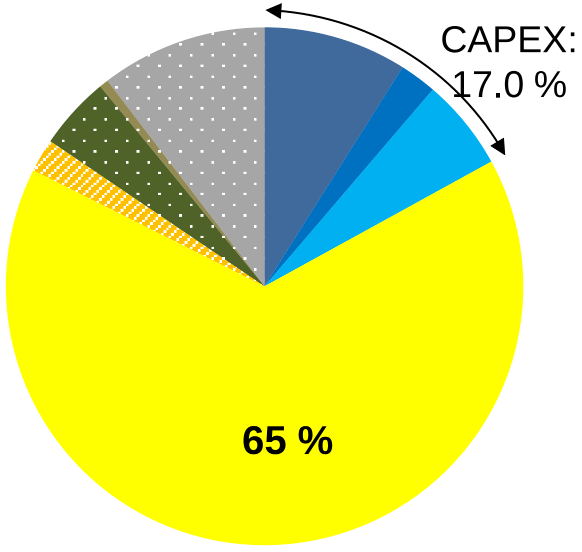
Power&Biomass-to-Liquid (PBTL)

Investment: ca. 751 mio. €
Fuel production: 91.3 kt/a
Fuel costs : ca. **1.95 €/l**



Power-to-Liquid (PTL)

Investment: ca. 672.5 mio. €
Fuel production: 91.3 kt/a
Fuel costs : ca. **2.26 €/l**



*see: Dietrich et. al, **Cost calculations for three different approaches of biofuel production using biomass, electricity and CO_2,** 17.05.2018, Biomass and Bioenergy, Volume 111, April 2018, Pages 165-173, https://doi.org/10.1016/j.biombioe.2017.07.006

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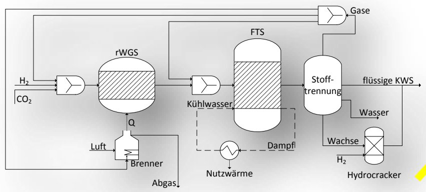
3. Process evaluation @ DLR



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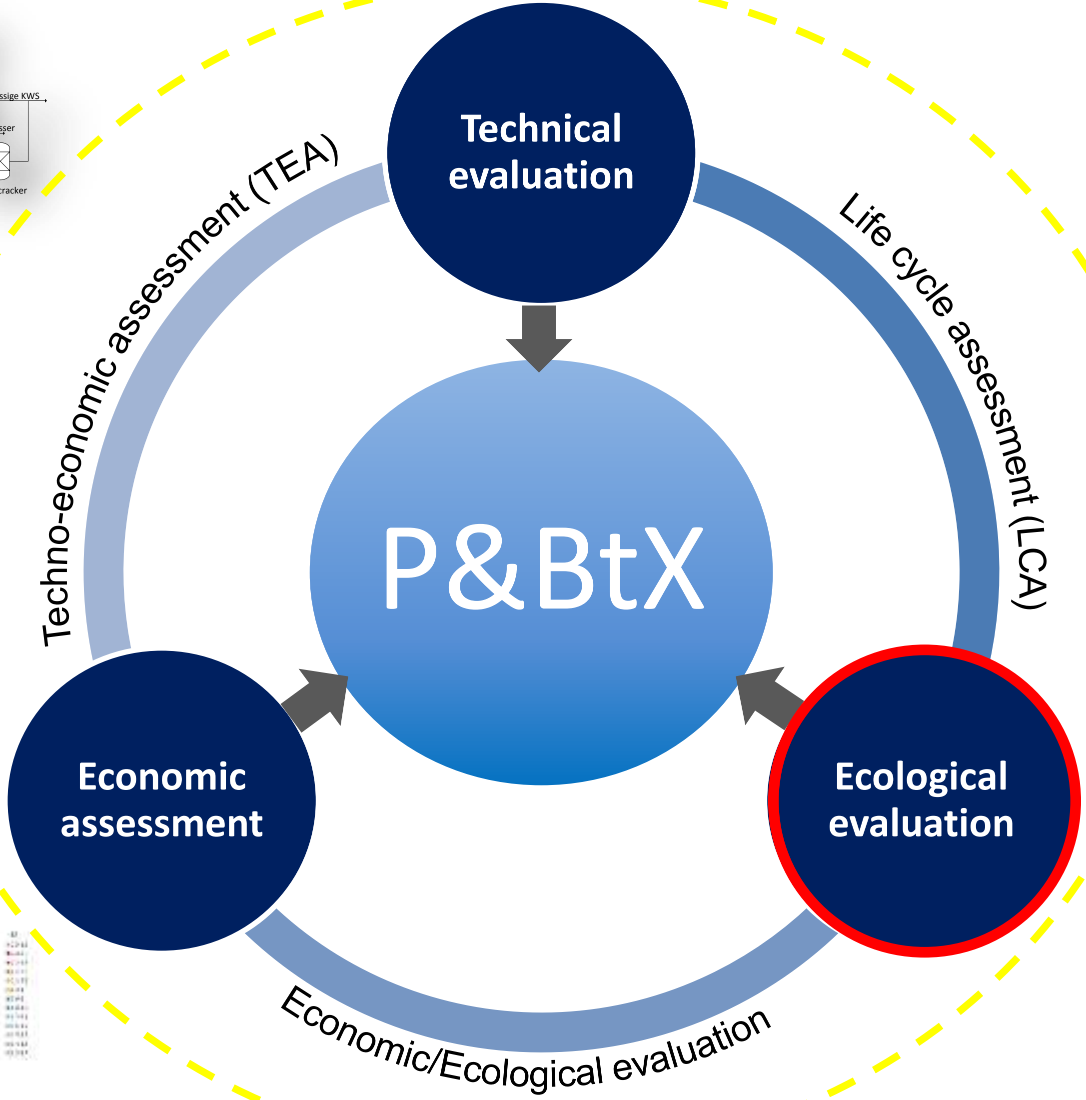

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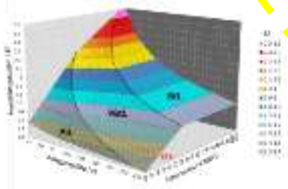

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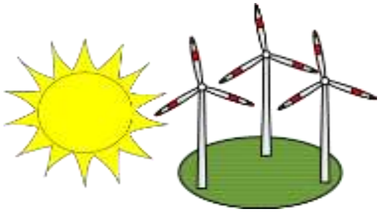
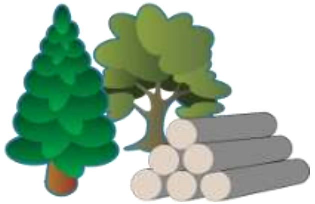
Example: PtL – GHG-Footprint Calculation

Carbon footprint of used raw materials and energy sources defines product carbon footprint!

Carbon dioxide footprint



Power footprint



Biomass footprint

efficiency losses

System integration

Plant efficiency

P&BtX - Concept

Plant emissions

Accounting for by-products

Footprint of products: Fuel/heat/H_2 etc.

H_2

O_2

Fuel efficiency of usage

$$CO_2 - Abatement\ costs \left[\frac{€}{t_{CO_2}}\right] = \frac{Difference\ in\ tranport/heat/H_2\ costs}{CO_2 - emission\ reduction}$$

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Ongoing economic and environmental evaluation of biofuels @ DLR

DLR project: Future Fuels[1]	H2020: COMSYN[2] www. comsynproject.eu	H2020: FlexCHX[3] www.flexchx.eu	H2020: ABC-Salt[4] TBD	National Project: Energy transition in transport[4]

1. see: Friedemann Georg Albrecht et al.: Technical and Economic Optimization of Biomass-to-Liquid Processes Using Exergoeconomic Analysis, EUBCE Subtopic 3.2 Pyrolysis, session 3DO.6.3
2. see: Johanna Kihlman et al.: Compact Gasification and Synthesis process for Transport Fuels EUBCE Subtopic 6.2 Thermochemical conversion processes, session ICO.8.1
2. see: ~~Zoé Béalu~~, Simon Maier et al.: Techno-Economic Evaluation of a New Biomass-to-Liquid Process Concept for Reduced Biofuel Production Cost, EUBCE Subtopic 6.2 Biorefineries: assessments and innovative technologies, session 3BV.5
3. Just started: 1.3.2018 ➔ next EUBCE?
4. Just started: 1.4.2018 ➔ next EUBCE?
5. To be started: 1.6.2018 ➔ next EUBCE?

4. Summary & Outlook

- European GHG emission reduction by 1 % p.a. required until 2030 – only 5 EU28 countries on track
- Renewable hydrocarbons will be long-term required for transport and chemicals – 40 % of current crude oil?
- European bioenergy has large potential to contribute to GHG emission reduction in transport
  - vital part of a new integrated energy system (full usage of European biomass potential)
  - shall serve mainly as renewable carbon source
- Multicriterial assessment of biofuel / e-fuel production and usage required:
  Transparent and reliable DLR methodology for cost estimation and GHG-footprint calculation offers a starting point for future unified technology assessment
- **R&D, demo and market introduction of sustainable 2G transport/chemicals applications need to speed up even though R&D&D alone will never achieve (energy price) competitiveness**

THANK YOU FOR YOUR ATTENTION!

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