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International Conference “Elements of a Greenhouse Gas Neutral Society”

# **DIVERSIFIED CHALLENGES FOR THE ENERGY TRANSITION IN THE TRANSPORT SECTOR**

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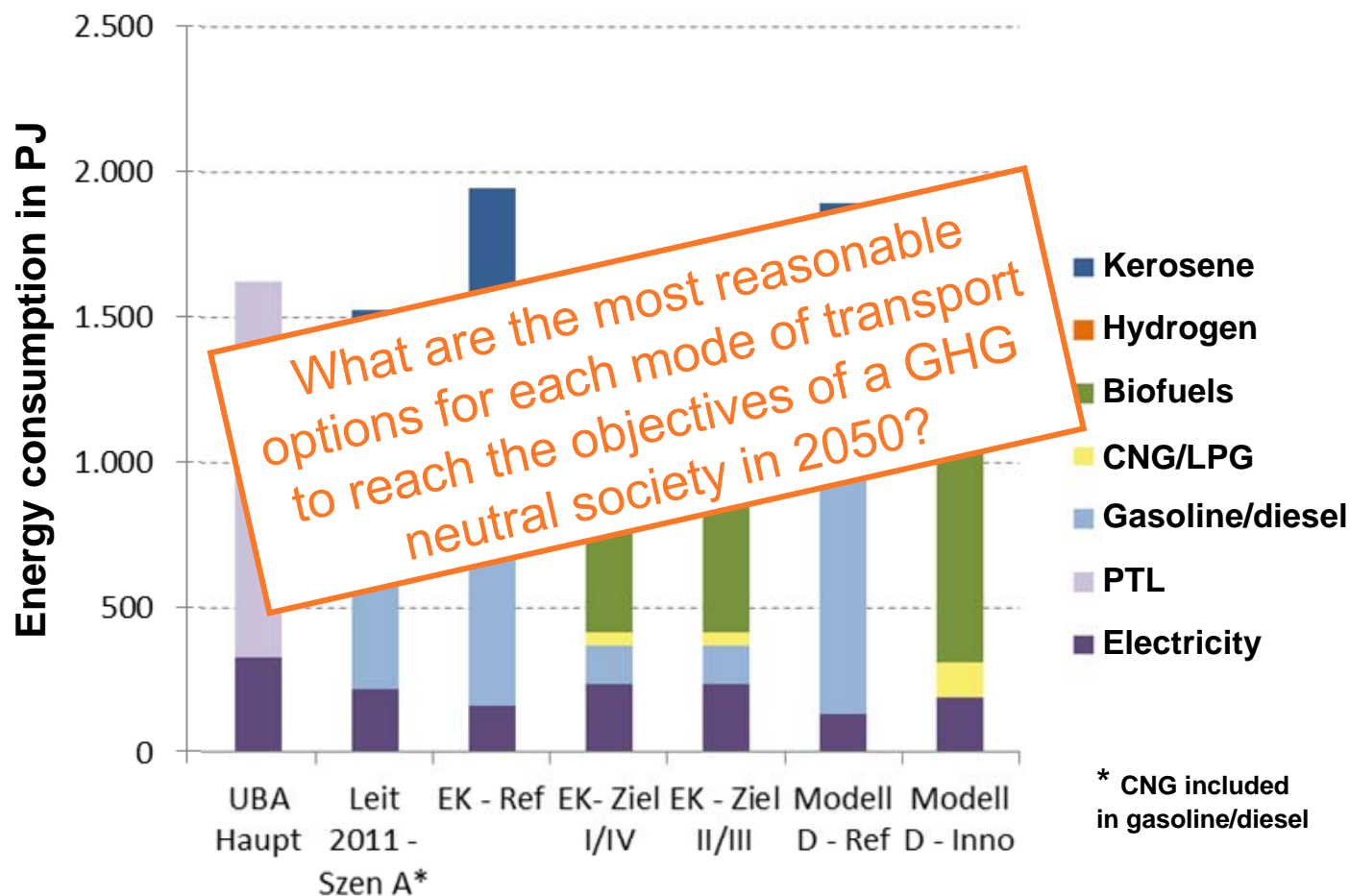


# Content

1. **Starting point of discussion**
2. **Pre-selection of possible energy supply options**
3. **Assessment of pre-selected options**
4. **Conclusions and next steps**

Starting point of discussion

# Öko-Institut: Energy consumption of the transport sector in Germany 2050 within different scenarios



On behalf of:

## UBA project “Ecological requirements for the energy transition in the transport sector ”

- ☐ Systematic and comprehensive overview of energy supply options for the transport sector beyond fossil fuels (using only renewable energy sources)
- ☐ Considering all transport modes (passenger cars, trucks, trains, airplanes, and ships) as well as national, European and worldwide level
- ☐ Assessment of the different energy supply options including ecological, economical, technological, infrastructural and systemic aspects ⇒ identification of the most advantageous option for each transport mode
- ☐ Time horizon of the study is the year 2050
- ☐ The analyses are based on recently published studies, reports and analyses combined with own investigations
- ☐ Project will be finished at the end of November 2013



On behalf of:



# Ecological requirements on the transformation of the traffic-related energy supply: Approach

**Step 1:**

**Pre-selection**

- Pre-selection of the most reasonable renewable energy supply options for the transport sector
- Considering of options beyond fossil fuels
- Identification of “must” criteria

**Step 2:**

**Assessment**

- Assessment of energy supply options based on ecological, economical, technological, infrastructural and systemic aspects
- Firstly: focusing on GHG reduction and costs
- Secondly: considering the other aspects

**Step 3:**

**Recommendation**

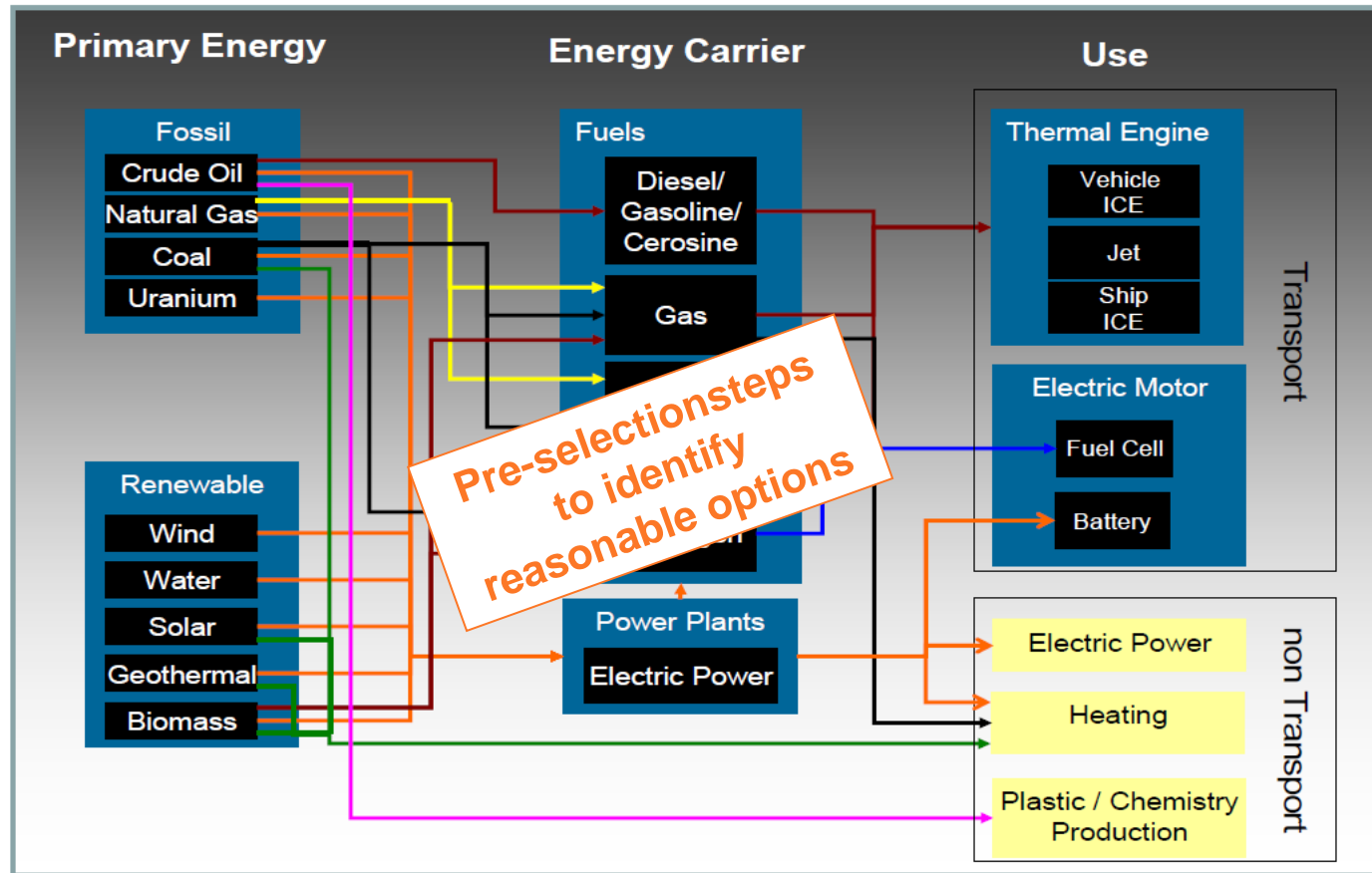
- Identification of the most advantageous energy supply option(s) for each of the transport modes considered
- Final recommendations

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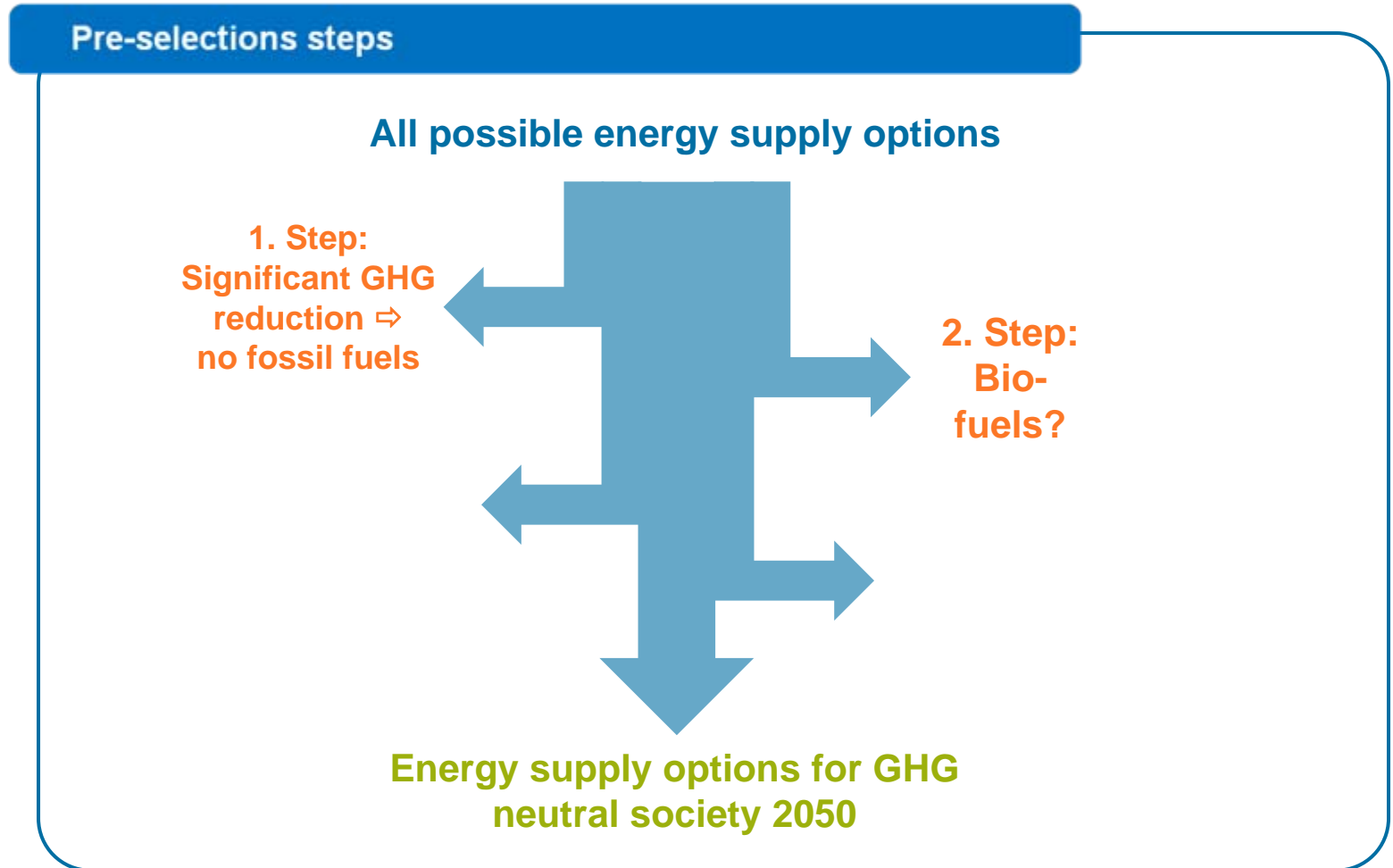
Pre-selection of possible energy supply options

# A wide range of possible alternative ways to supply the transport sector with energy



Source: ERTRAC, cited in the report of the European Expert Group on Future Transport Fuels 2011.

# Pre-selection steps of the most reasonable renewable energy supply options for transport (1)

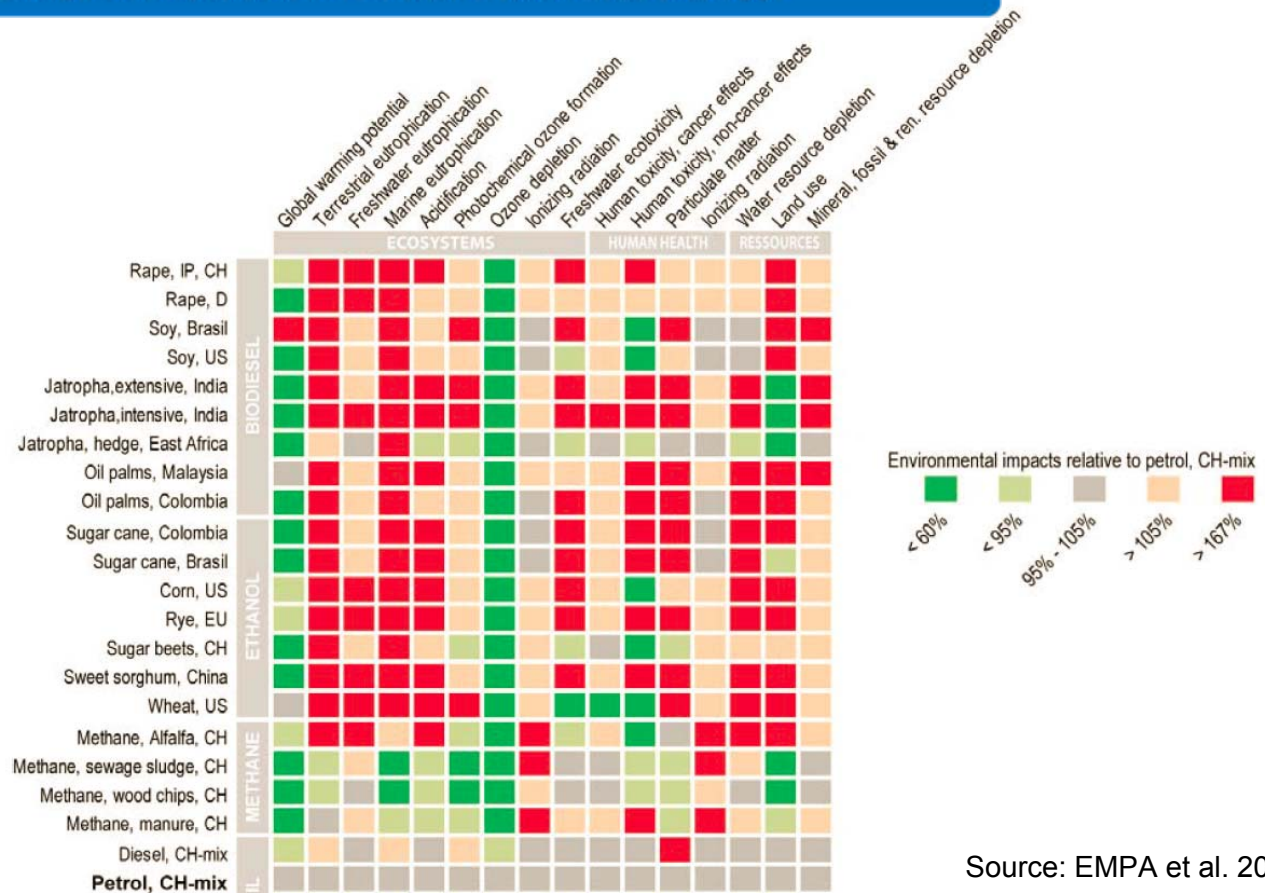




Pre-selection of possible energy supply options

# Environmental and climate impact of biofuels based on detailed life cycle assessment (1)

## EMPA study for the Swiss Federal Office for Energy

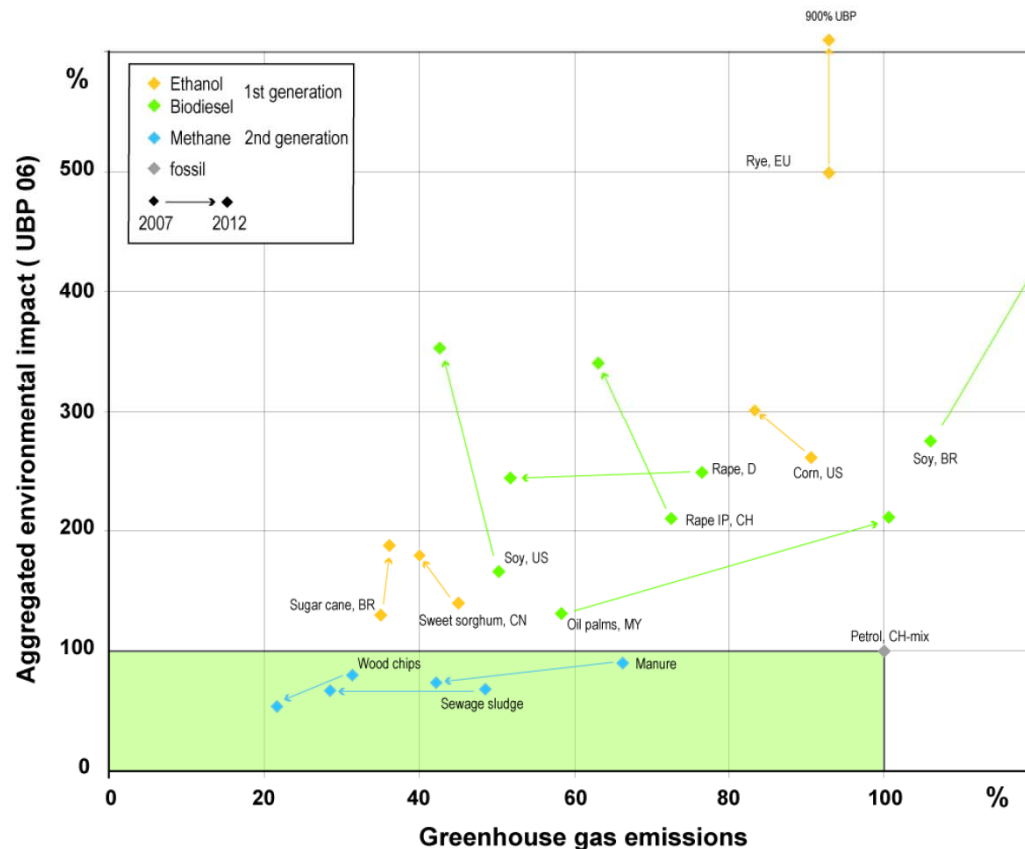


Source: EMPA et al. 2012.

Pre-selection of possible energy supply options

# Environmental and climate impact of biofuels based on detailed life cycle assessment (2)

## EMPA study for the Swiss Federal Office for Energy

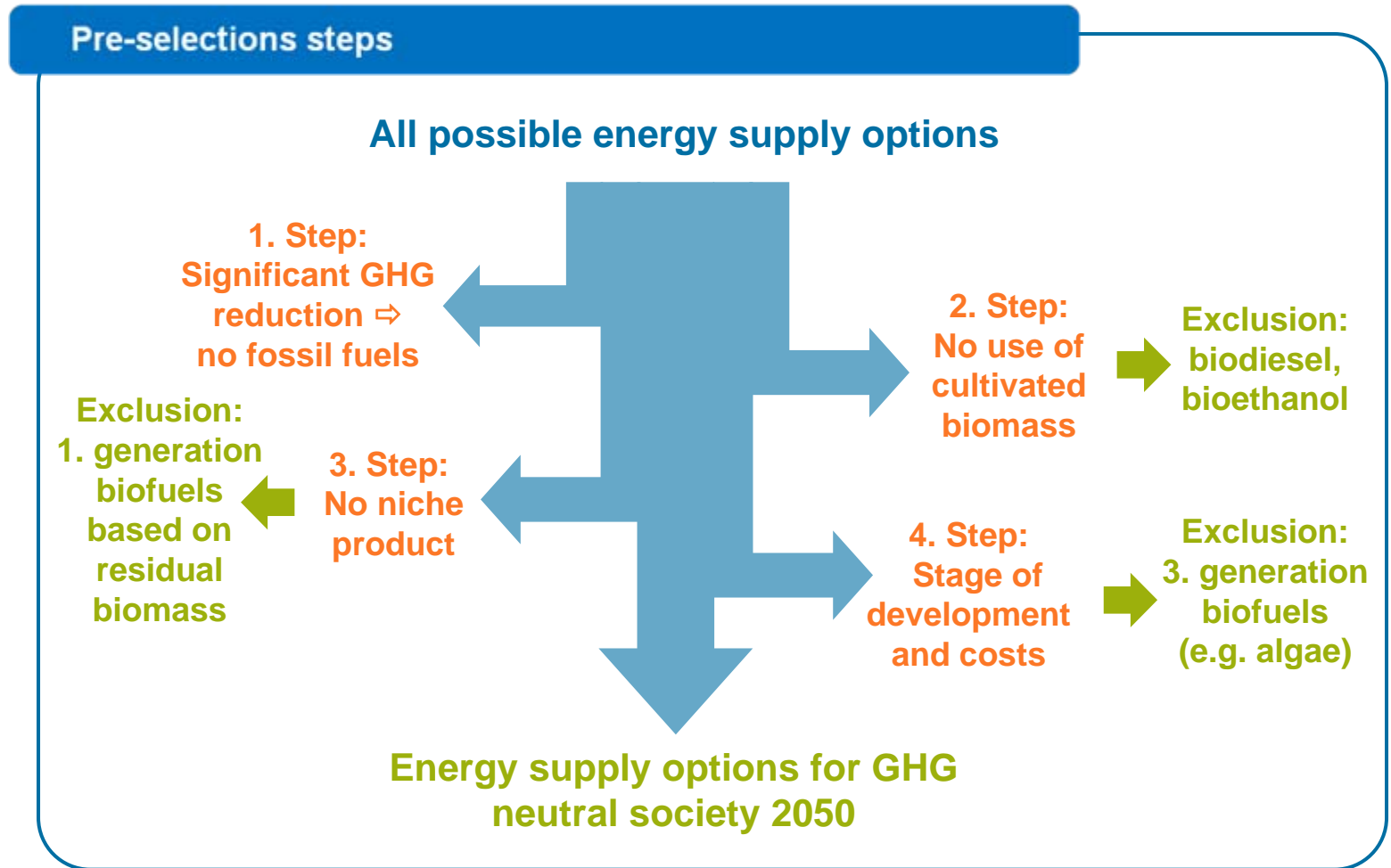


**1<sup>st</sup> generation biofuels based on cultivated biomass have higher impacts on the environment than conventional fuels**

Source: EMPA et al. 2012.



## Pre-selection steps of the most reasonable renewable energy supply options for transport (2)



Pre-selection of possible energy supply options

## Pre-selected energy supply options for each transport mode in 2050 used for detailed assessment

	Renewable electricity					2nd generation biofuels	
	Battery electric vehicle/ Plug-in hybrid electric Vehicle	Overhead catenary wire	Hydrogen: compressed/ liquid (renewable)	Power-to-Gas (renewable)	Power-to-Liquid (renewable)	Biomass-to-Liquid/ Ethanol: wood/straw	SNG: wood/straw
Passenger car	x		x	x	x	(x)	(x)
Trucks - collection and distribution	x		x	x	x	(x)	(x)
Trucks - long haul		x	x	x	x	(x)	(x)
Air traffic - short haul			x		x	(x)	
Air traffic - medium and long haul					x	(x)	
Sea transport			x	x	x	(x)	(x)
Rail traffic		x			x	(x)	
Urban buses	x	x	x	x	x	(x)	(x)

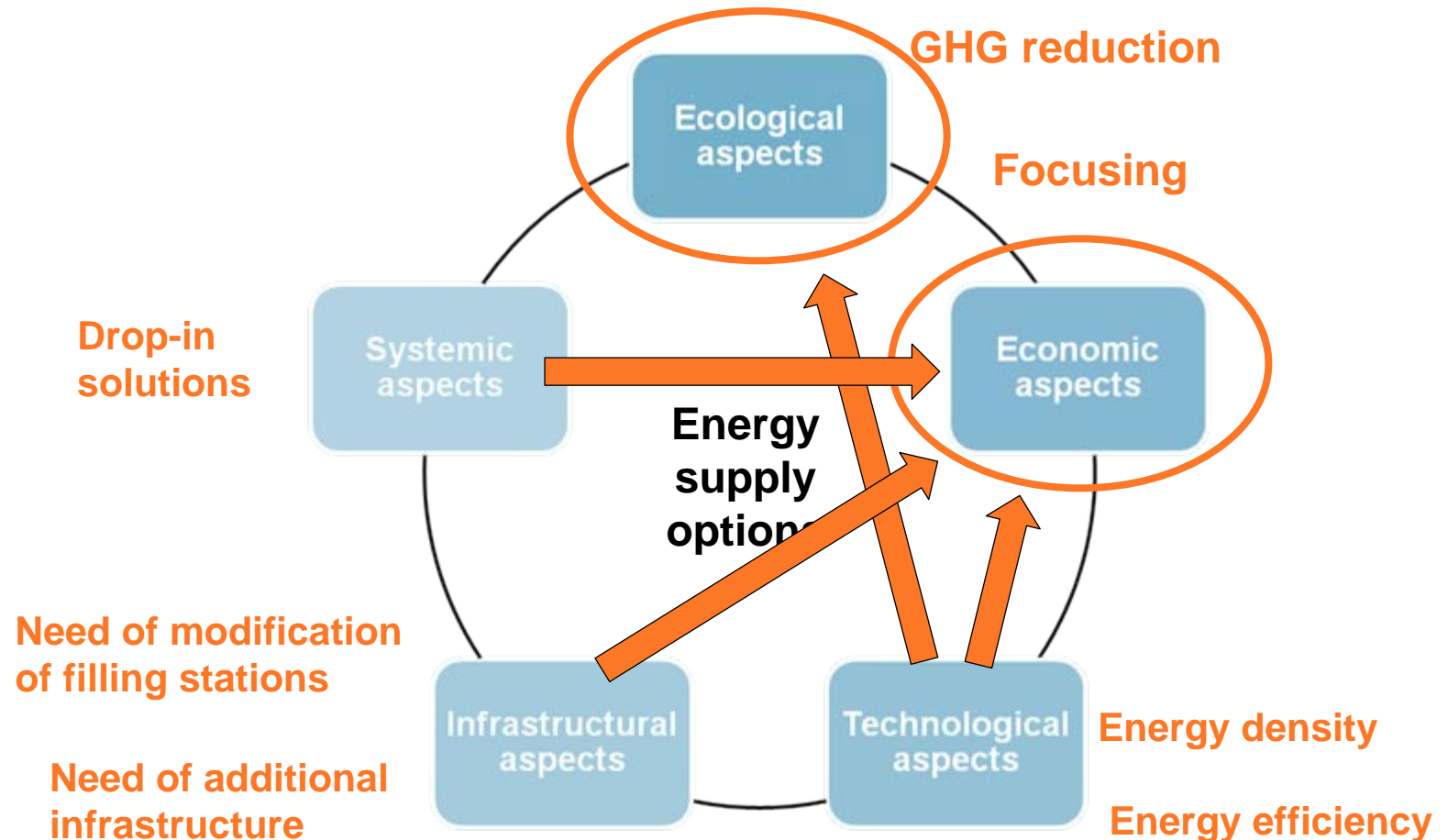
⇒ 2050: without fossil fuels and 1st/3rd generation biofuels

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# Ecological requirements on the transformation of the traffic-related energy supply: First assessment



# Pre-selected energy supply options for collection and distribution trucks (<12 t GVW)

	Renewable electricity					2nd generation biofuels	
	Battery electric vehicle/ Plug-in hybrid electric Vehicle	Overhead catenary wire	Hydrogen: compressed/ liquid (renewable)	Power-to-Gas (renewable)	Power-to-Liquid (renewable)	Biomass-to-Liquid/ Ethanol: wood/straw	SNG: wood/straw
Passenger car	x		x	x	x	(x)	(x)
Trucks - collection and distribution	x		x	x	x	(x)	(x)
Trucks - long haul		x	x	x	x	(x)	(x)
Air traffic - short haul			x		x	(x)	
Air traffic - medium and long haul					x	(x)	
Sea transport			x	x	x	(x)	(x)
Rail traffic		x			x	(x)	
Urban buses	x	x	x	x	x	(x)	(x)

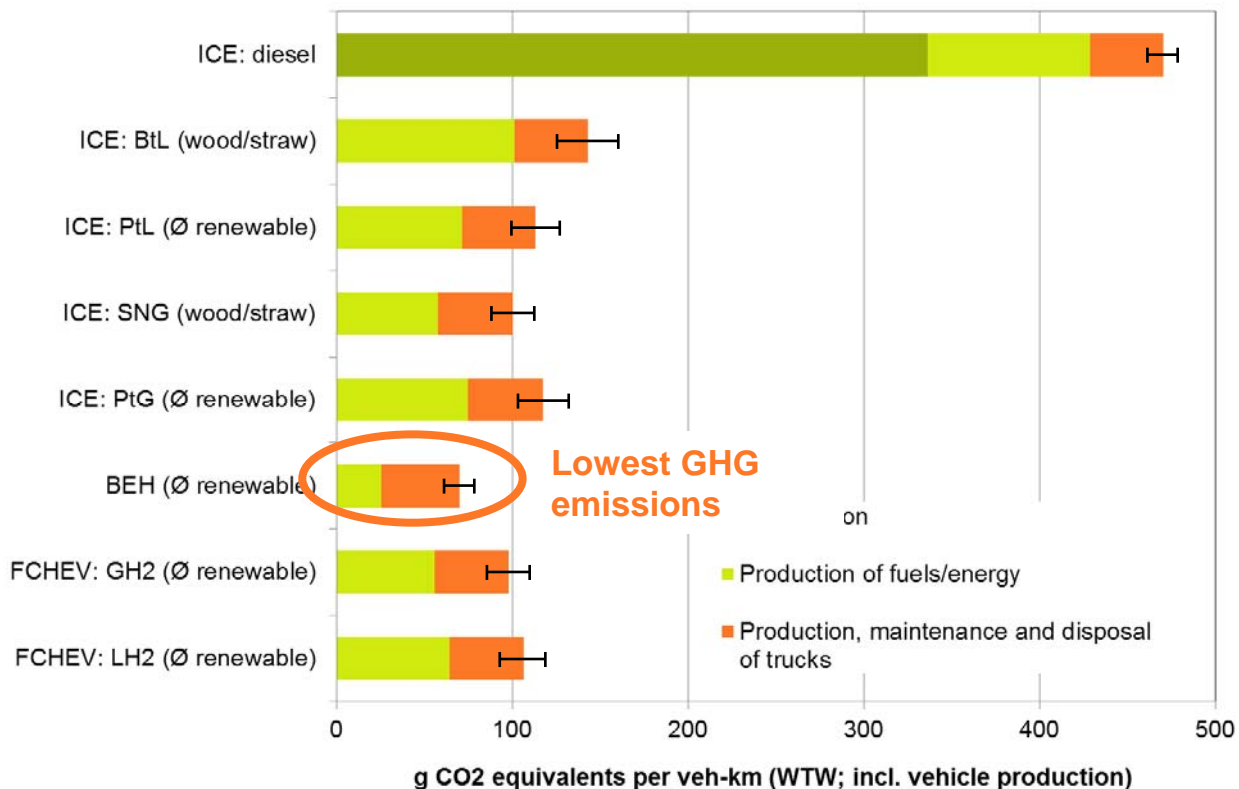


Assessment of pre-selected options

# 10 t truck: WTW GHG emissions per vehicle kilometre in 2050 for different fuel types

CE-Delft/DLR: «Zero emission trucks»; own calculations

Preliminary results

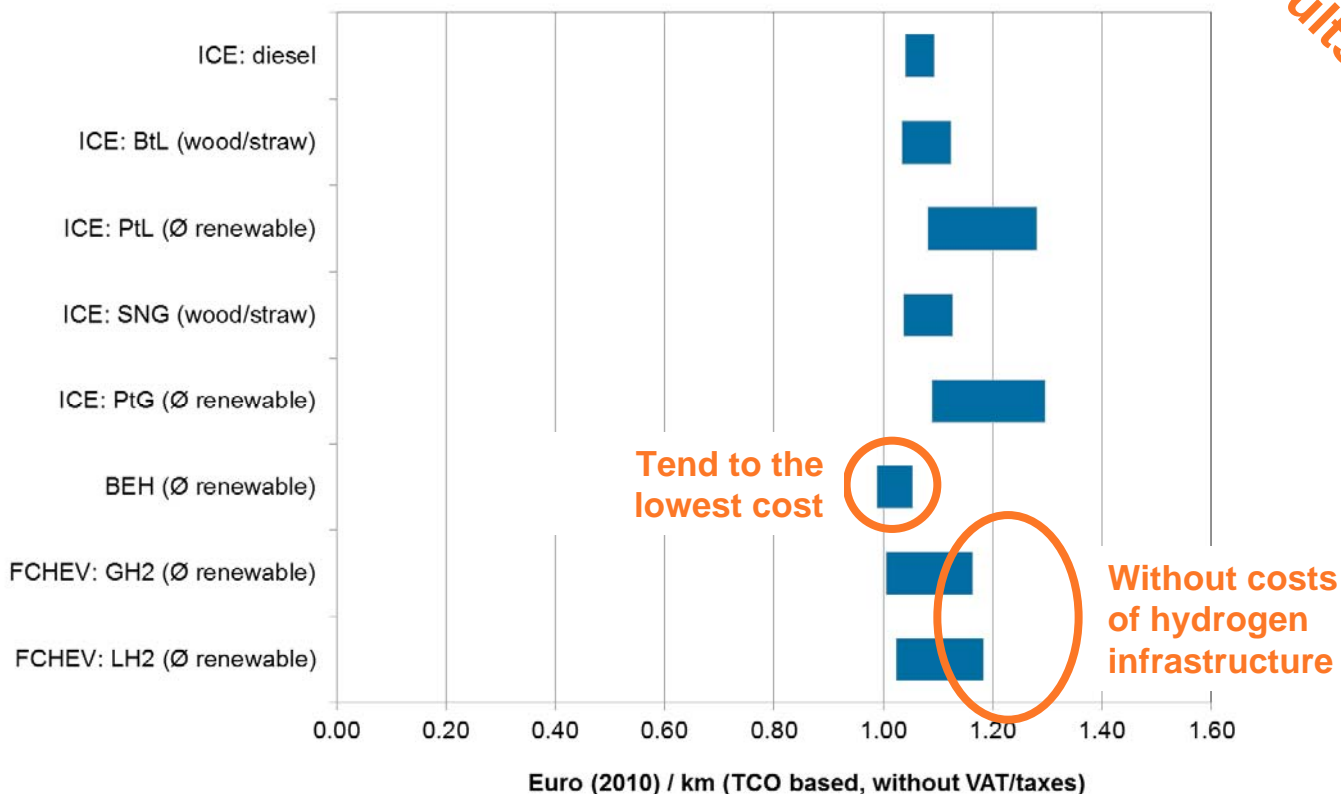




# 10 t truck: Total costs of ownership (TCO) per vehicle kilometre in 2050 for different fuel types

CE-Delft/DLR: «Zero emission trucks»; own calculations

Preliminary results



# Pre-selected energy supply options for the air traffic without fossil fuels / 1<sup>st</sup> generation biofuels

	Renewable electricity					2nd generation biofuels	
	Battery electric vehicle/ Plug-in hybrid electric Vehicle	Overhead catenary wire	Hydrogen: compressed/ liquid (renewable)	Power-to-Gas (renewable)	Power-to-Liquid (renewable)	Biomass-to-Liquid/ Ethanol: wood/straw	SNG: wood/straw
Passenger car	x		x	x	x	(x)	(x)
Trucks - collection and distribution	x		x	x	x	(x)	(x)
Trucks - long haul		x	x	x	x	(x)	(x)
Air traffic - short haul			x		x	(x)	
Air traffic - medium and long haul					x	(x)	
Sea transport			x	x	x	(x)	(x)
Rail traffic		x			x	(x)	
Urban buses	x	x	x	x	x	(x)	(x)

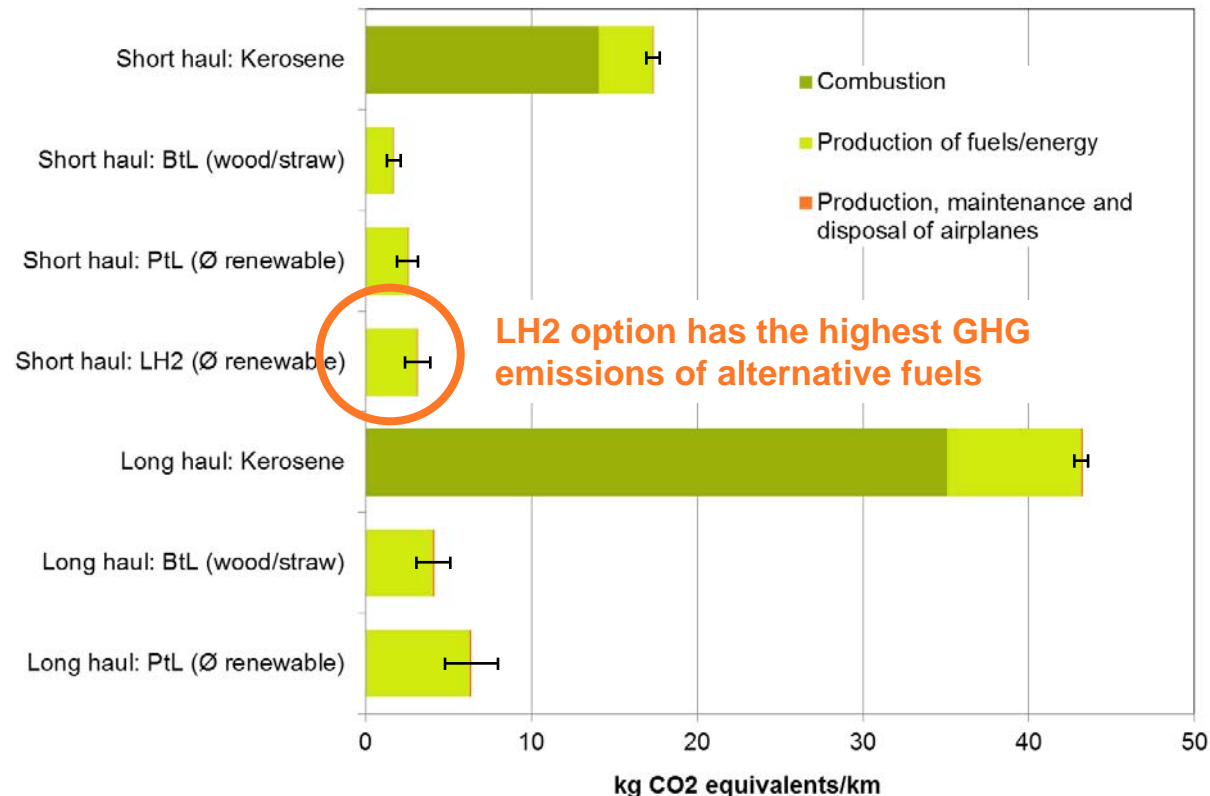


Assessment of pre-selected options

# WTW GHG emissions of short and long haul passenger airplane 2050 by different fuel types

Own calculations

Preliminary results



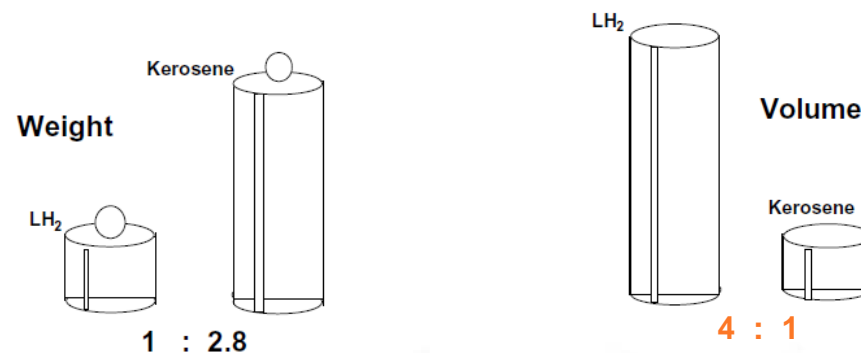
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# For similar energy content the volume of liquid hydrogen is four times higher than for kerosene

## Volumetric and gravimetric energy density

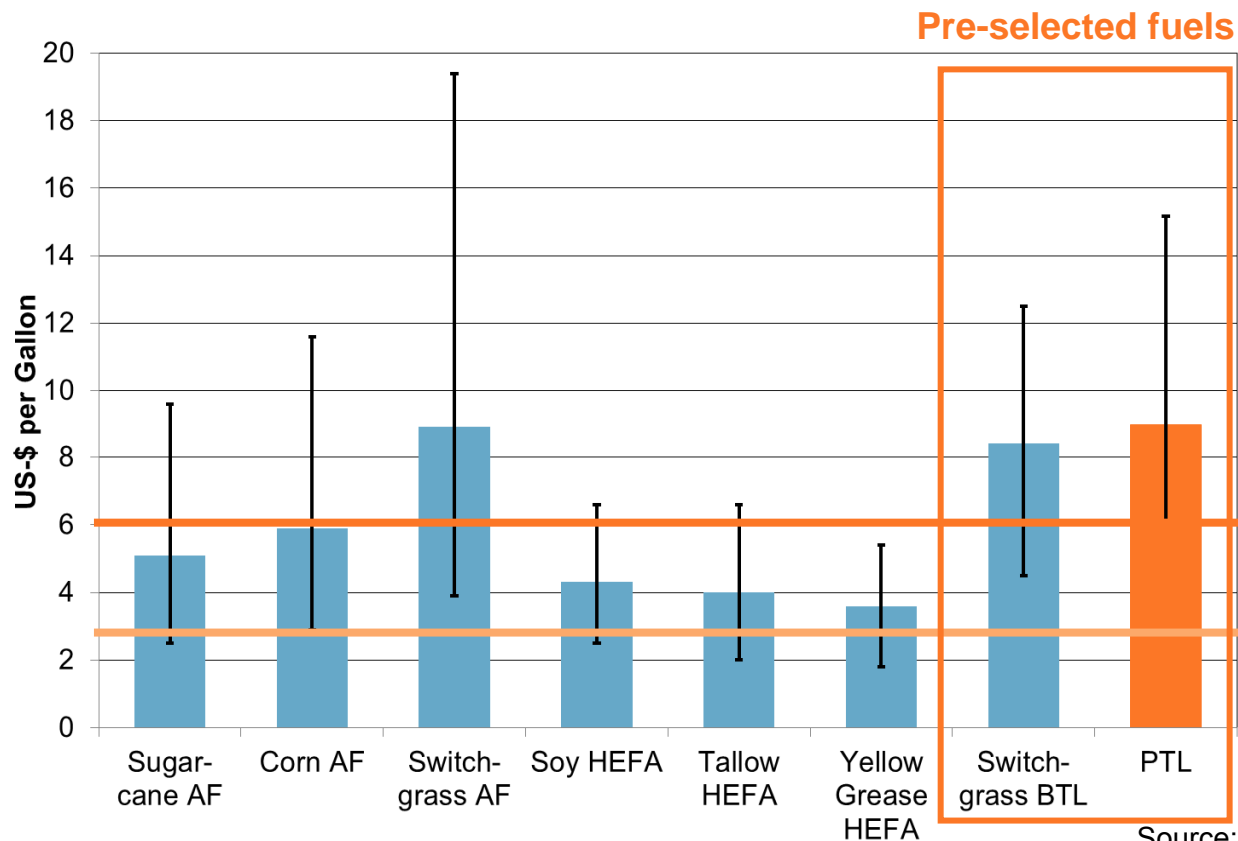
### Compariosn of LH2 and kersone – similar energy content:



- ⇒ **New design of airplanes**
- ⇒ **No realistic option for 2050**

# Comparison of costs for different types of fuels for air traffic

Malina 2013 «Economics of alternative fuels»; own calculation



Preliminary results

AEO 2012: High price 2040

May 2013: 2.81 US-\$ per gal.



On behalf of:



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## **Diversified challenges for the energy transition in the transport sector: Conclusions (1)**

- ☐ Fossil fuels and first generation biofuels don't fulfill the ecological requirements of a GHG neutral mobility in 2050
- ☐ Therefore only electricity, electricity-based fuels (e.g. PtG: H<sub>2</sub> and Methane, PtL) and second generation biofuels (but with very limited potential) are available for the energy supply of the transport sector in 2050
- ☐ Considering costs and GHG emission reduction potentials the direct use of electricity is the most advantageous option  
⇒ if possible battery-electric vehicles and plug-in-hybrid vehicles should be preferred
- ☐ If electricity can't be used directly (e.g. airplanes, ships, 40 t trucks) electricity-based fuels are the first choice due to limited potential of second generation biofuels

## Diversified challenges for the energy transition in the transport sector: Conclusions (2)

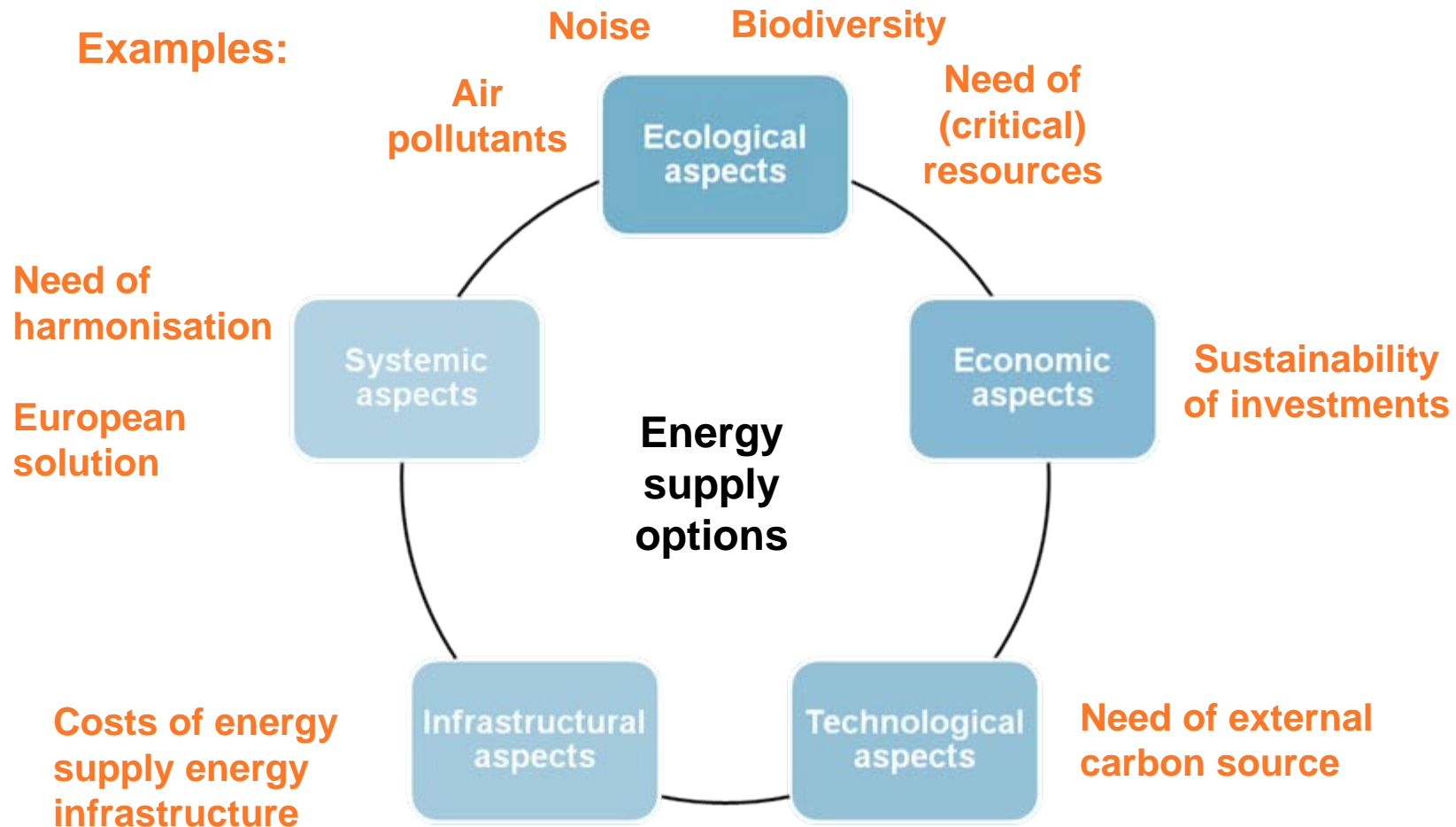
- ☐ Which electricity-based fuel is preferable depends on the transport mode and vehicle size considered
  - ☐ Airplanes  $\Rightarrow$  PTL
  - ☐ Sea ship  $\Rightarrow$  PTG
  - ☐ 40 t trucks  $\Rightarrow$  different options (*catenary*, H2, PTL) which has to be investigated in more details
- ☐ *But:* A challenge is that electricity-based fuels won't be available with appreciable potentials before 2040  $\Rightarrow$  it has to be avoided installing of infrastructures for fuels which aren't purposeful for a GHG neutral future
- ☐ Independent of the energy supply option chosen the reduction of the traffic-related energy demand by avoiding, shifting and improving is needed  $\Rightarrow$  a energy transition in the transport sector requires a transition of the transport sector



Next steps

## Diversified challenges for the energy transition in the transport sector: Next steps

Examples:



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# Thank you for your attention

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The logo for INFRAS, featuring the word "iNFRAS" in white lowercase letters on a black rectangular background, which is followed by a solid yellow rectangle.The logo for INFRAS, featuring the word "iNFRAS" in white lowercase letters on a black rectangular background, which is followed by a solid yellow rectangle.The logo for Quantis, featuring a stylized blue and green arrow pointing right, followed by the word "Quantis" in a blue sans-serif font.

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On behalf of:

The logo for the Umwelt Bundes Amt, featuring the text "Umwelt Bundes Amt" in green, with "For our Environment" in smaller text below, and a small circular emblem to the right.