



Post-Fossil Carbon Neutral Transport: Options by Transport Segments

**Christian Hochfeld, Senior Advisor
Sustainable Transport**
Deutsche Gesellschaft für Internationale
Zusammenarbeit (GIZ) GmbH

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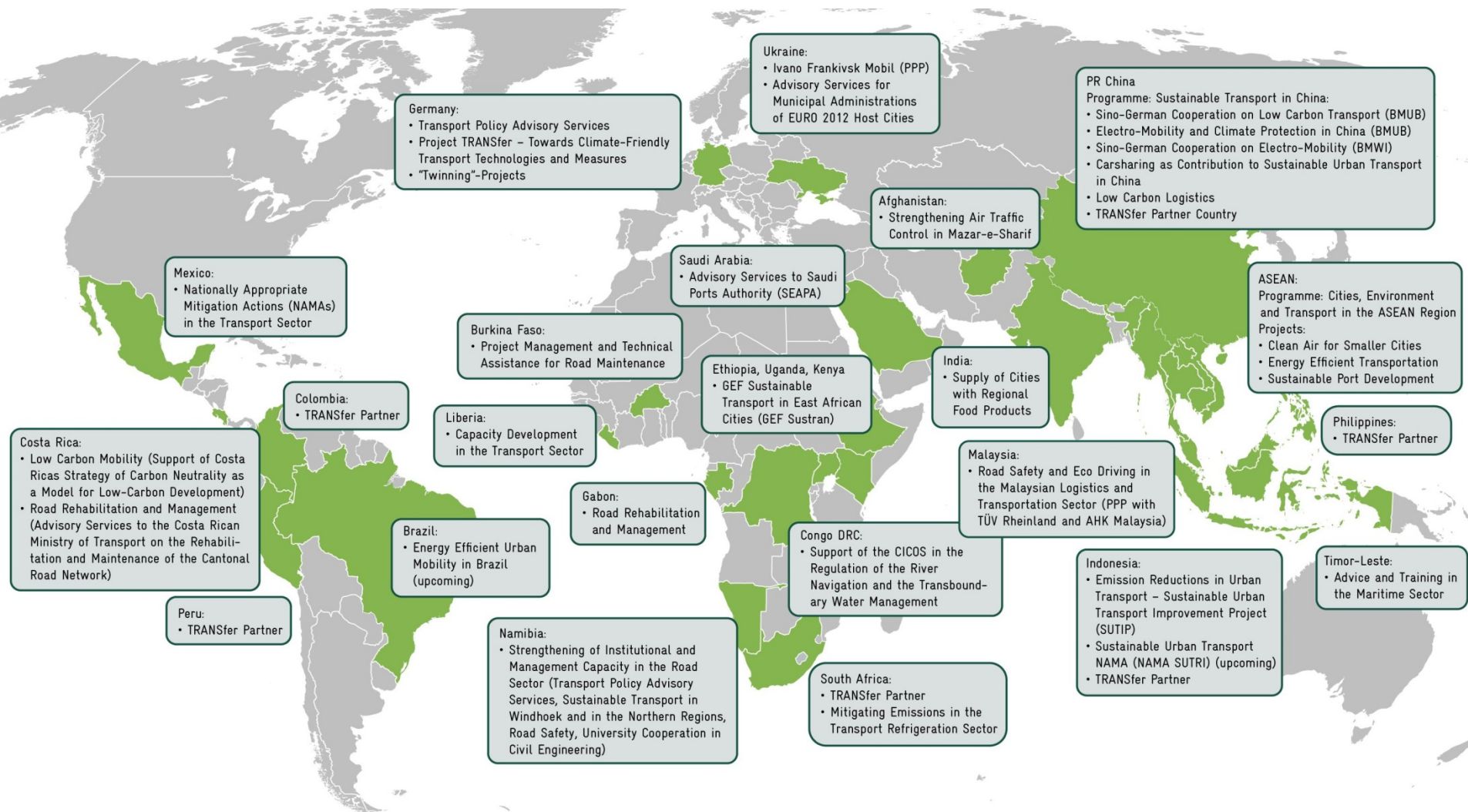
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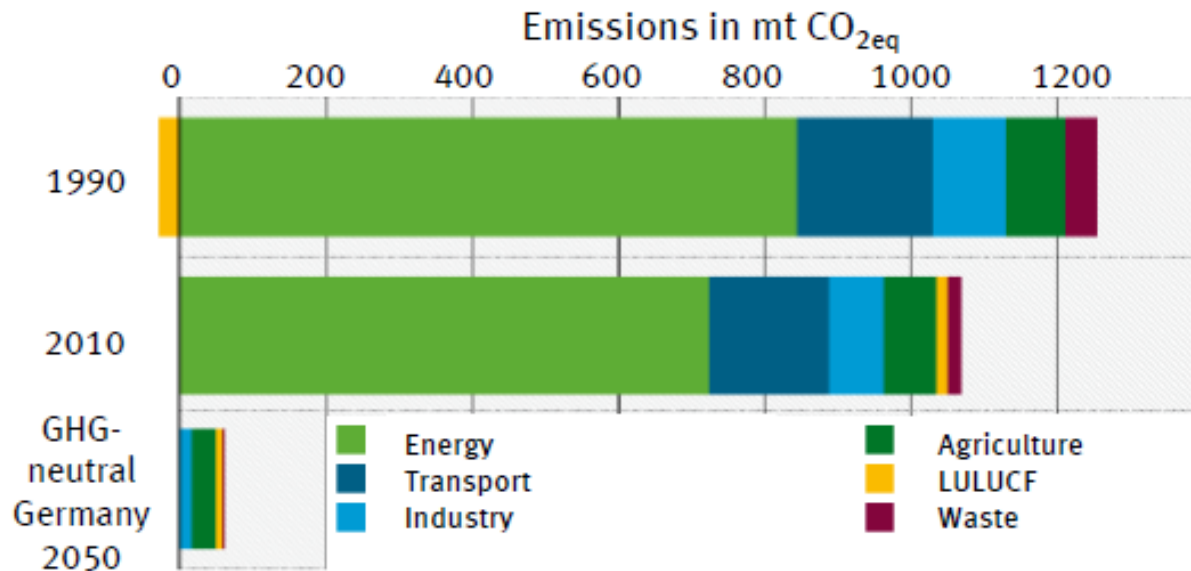
Is there light in the darkness?





Motivation: Germany in 2050 – a greenhouse gas-neutral country

- **Goal:** Reducing GHG emissions across all sectors by 95 % until 2050 compared to 1990



Source: UBA 2014





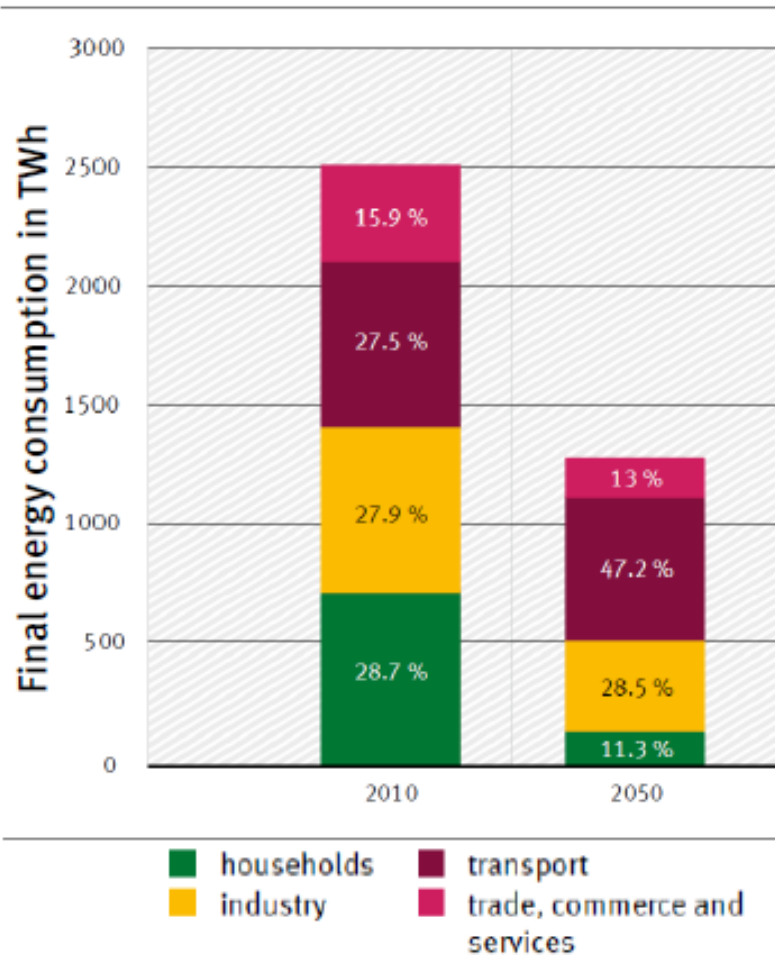
Outline

- 1 A FURTHER INSIDE INTO A GHG-NEUTRAL GERMANY IN 2050**
- 2 Technical measures in transport**
- 3 Evaluation of the long-term perspective of a GHG-neutral transport**
- 4 Scenarios for a post-fossil energy supply until 2050**





Comparison of final energy consumption 2010 and 2050

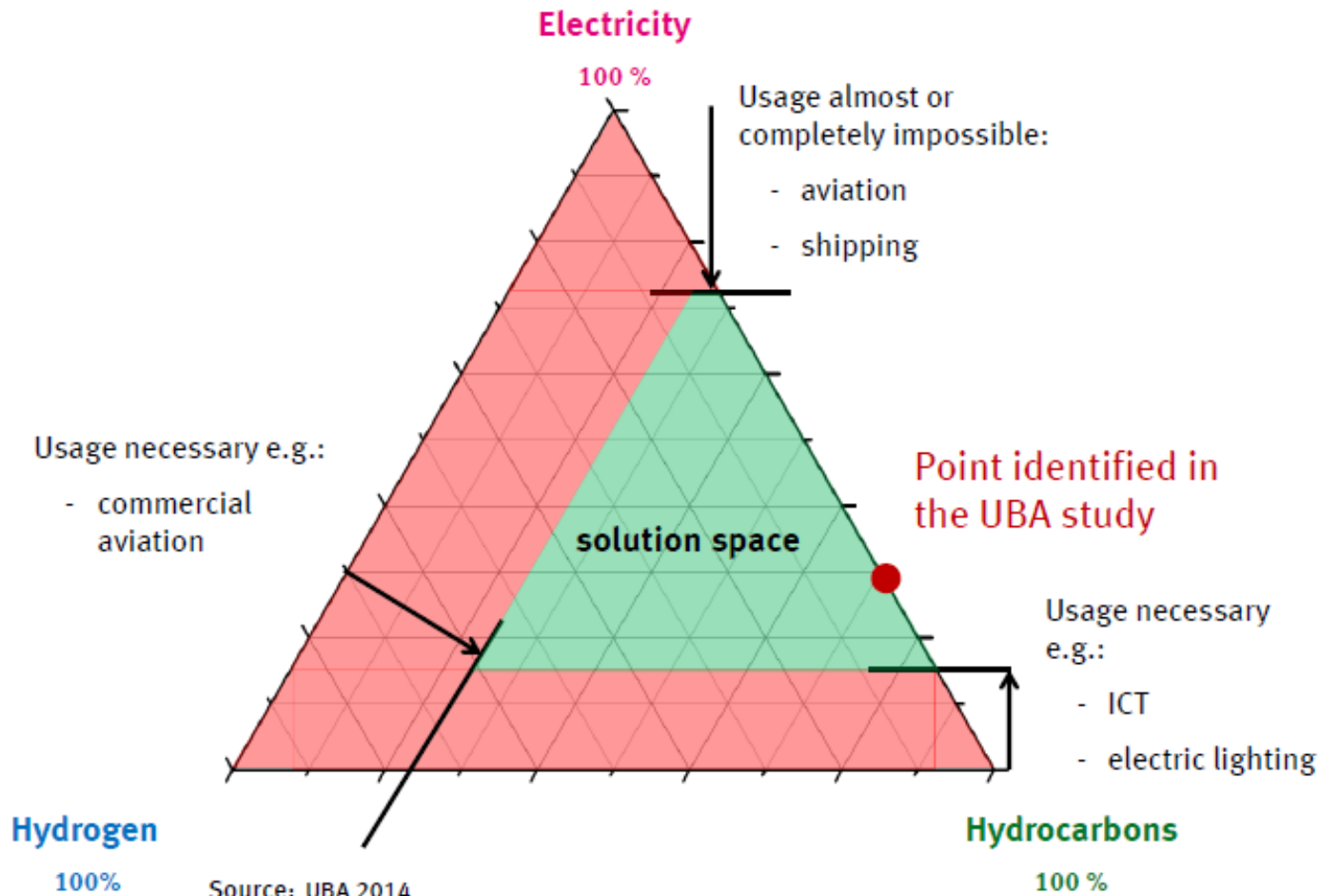


- Final energy demand reduced by 50% by 2050 relative to 2010
- Considerable reductions in households and the heat demand
- Industry and trade, commerce and services can reduce their emissions by at least 50%
- In transport the reduction is small, as Germany's share of international aviation and shipping regarding the final energy demand is included

Source: UBA 2014



GHG-neutral final energy carriers – a qualitative assessment





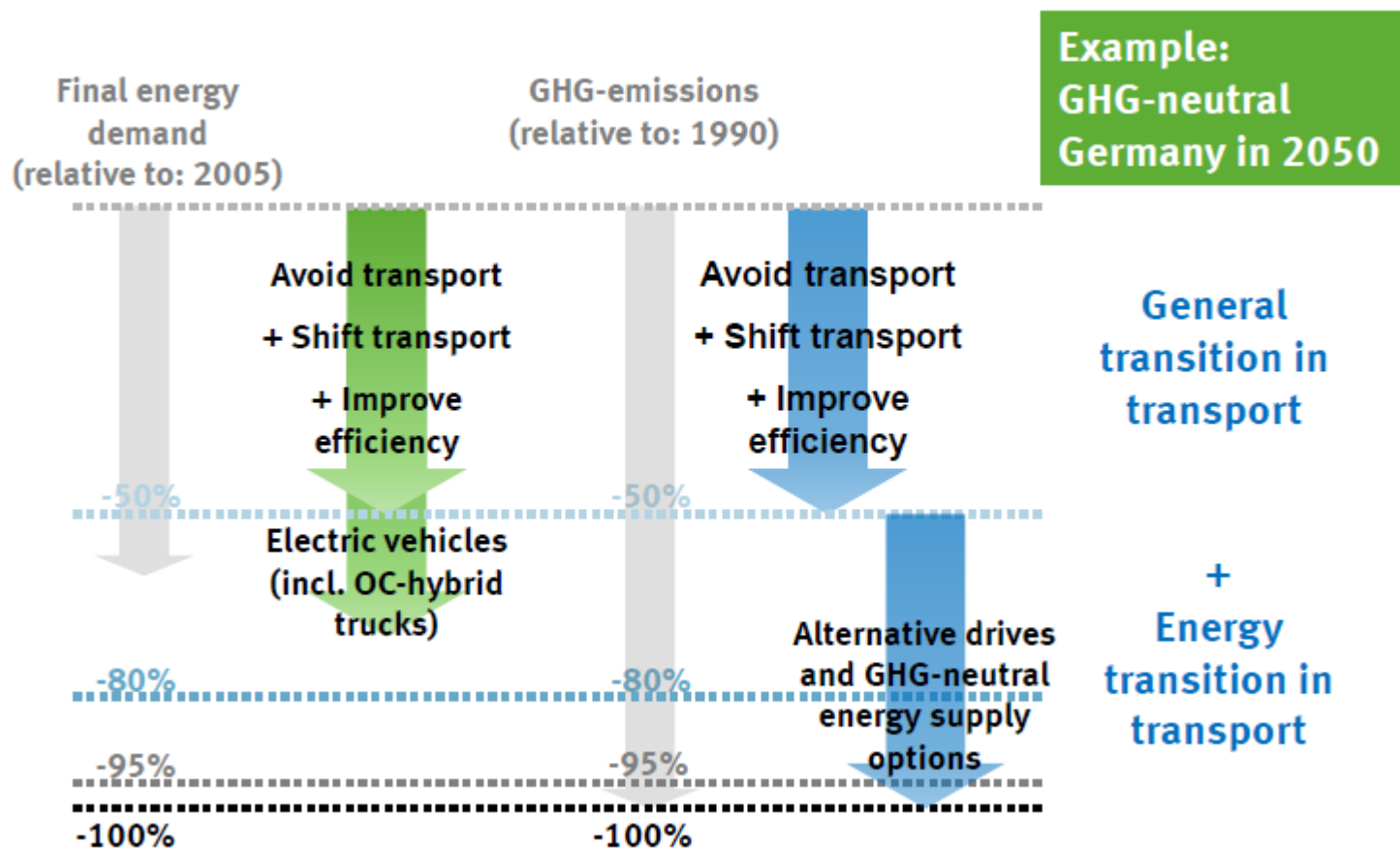
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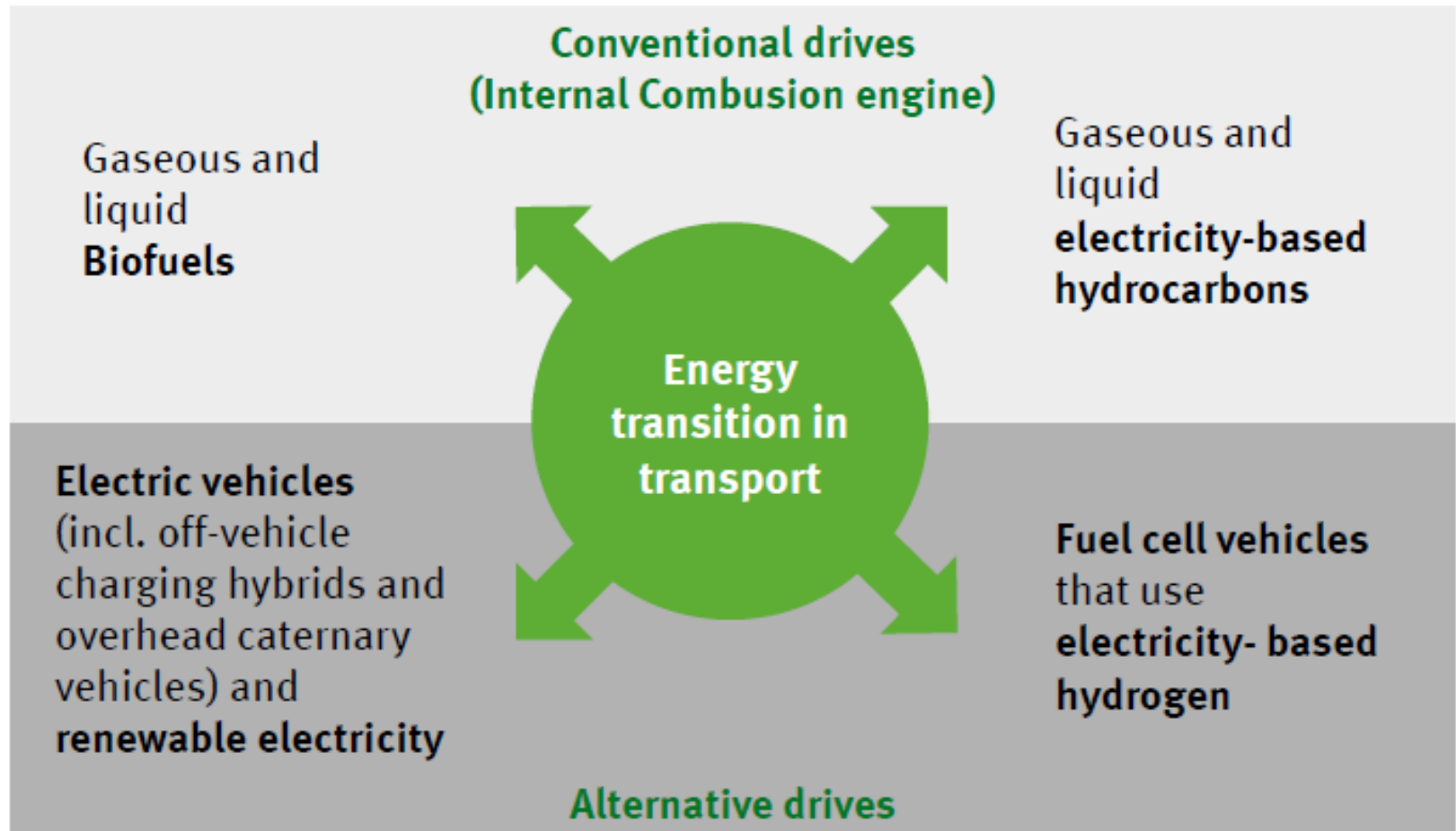


Ambitious climate protection targets in the transport sector require a fundamental transition





Postfossil energy supply options for transport

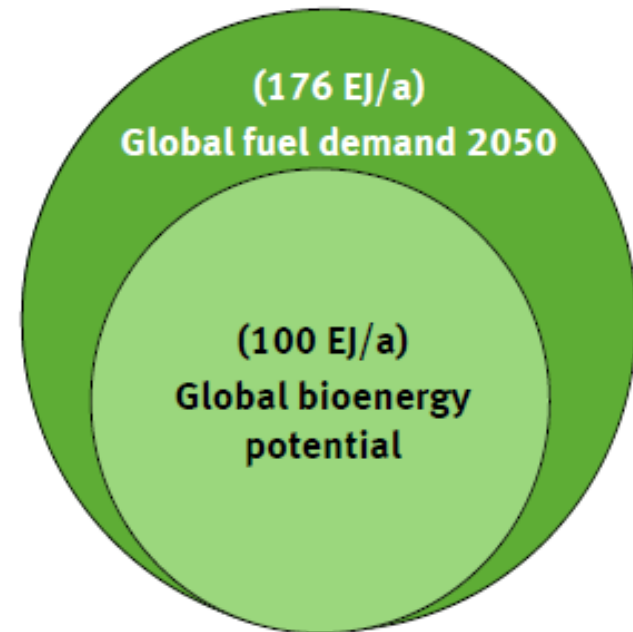




Energy supply options under discussion - Bioenergy

BIOMASS – A “MAGIC BULLET”?

- is suitable for different uses, e.g. heat, transport, electricity, material utilization
- but comes with various problems
- is in **competition with food products**
- **Problem of quantity:** the predicted global fuel demand is much bigger than the predicted global bioenergy potential
- Additional **environmental problems**, e.g. acidification, over-fertilization, GHG emissions due to direct and indirect land use changes



Source: WBCSD 2004; UBA 2013



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Energy supply options for different transport carriers

Post-fossil, GHG-neutral supply options for transport in 2050

Transport carrier	Electricity (incl. Plug-in-Hybrid cars)	PtG-H ₂	PtG-CH ₄ / Power-to-Liquids
Passenger car	✓		
Trucks short haul	✓		
Trucks long haul	? Overhead catenary	?	?
Urban buses	✓		
Rail traffic	✓		
Aviation			✓ (PtL)
Sea transport		Short haul	✓

(Source: INFRAS/Quantis 2013)



Long haul transport with HDV: 4 possible solutions

Trucks long haul

Diesel hybrid

+

PtL

**Overhead catenary
hybrid trucks**



Gasoline hybrid

+

PtG-CH₄

Fuel cell

+

PtG-H₂

Overhead catenary trucks:

- Electrification of about 4.000 motorway-km of 12.850 km (≈60% of the vehicle miles)
- OC-trucks are in general hybrids with ICE to be able to drive without overhead wire

Pros:

- Costs, energy efficiency

Cons:

- Chicken or the egg dilemma
- International (e.g. EU-wide) system necessary



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4 Energy supply scenarios for transport

Partial electrification of LDV and short haul trucks*

E+

+ further electrification (LDV, trucks)
+ el. busses + OC-hybrid trucks

Liq+

+ further use of liquid hydrocarbons

CH₄+

+ change to gaseous hydrocarbons when possible

H₂+

+ change to hydrogen when possible

+ substitution of fossil fuels
by electricity-based ones

Studied items:

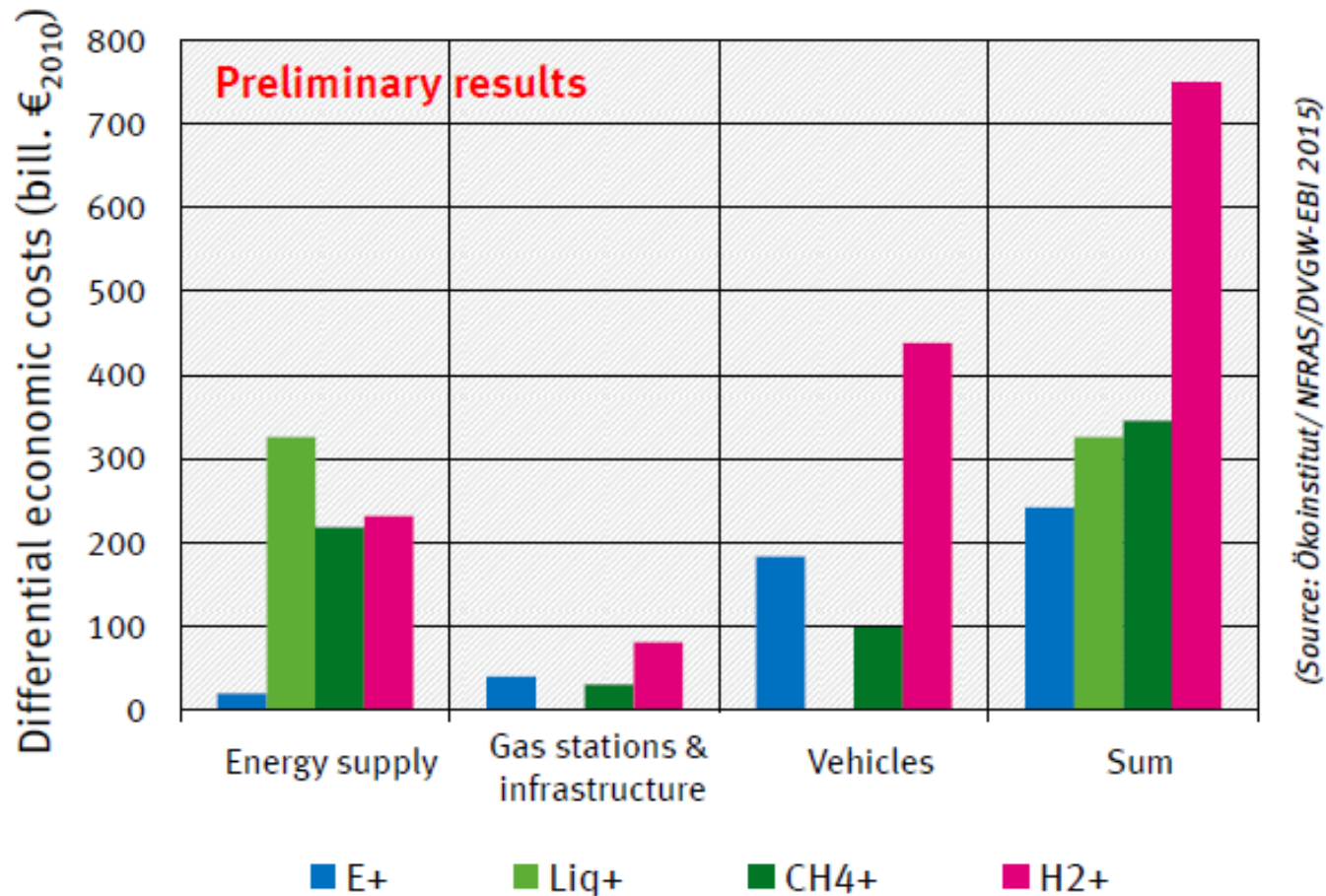
- Need for adaptation for vehicles and infrastructure
- Final energy demands for transition to 2050
- Costs of adaptation until 2050
- Energy carrier costs roughly approximated

* LNG/PtG-CH₄ partially substitutes heavy oil in shipping

(Source: Ökoinstitut/
NFRAS/DVGW-EBI 2015)

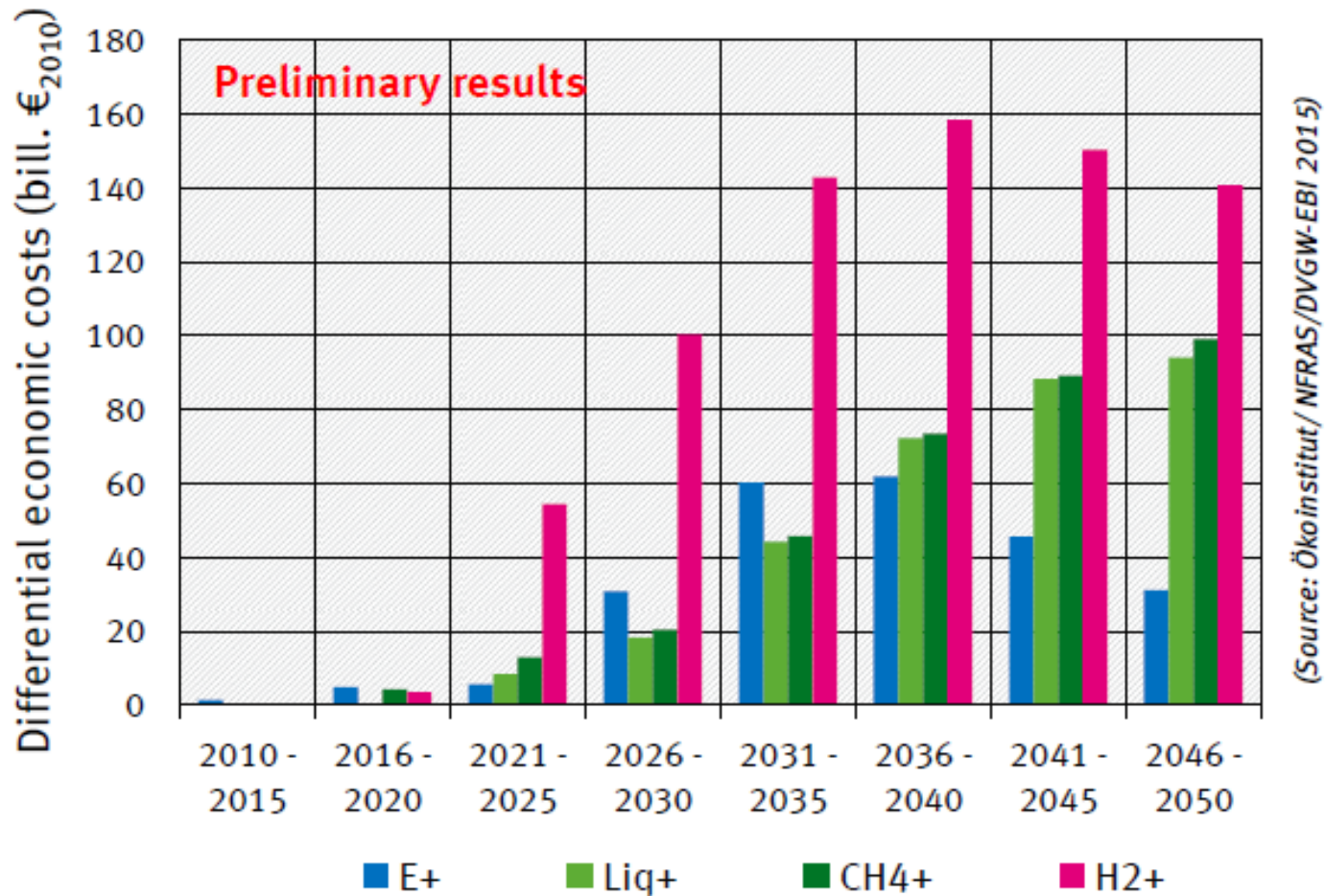


Road: Short haul transport (LDV, short haul trucks)



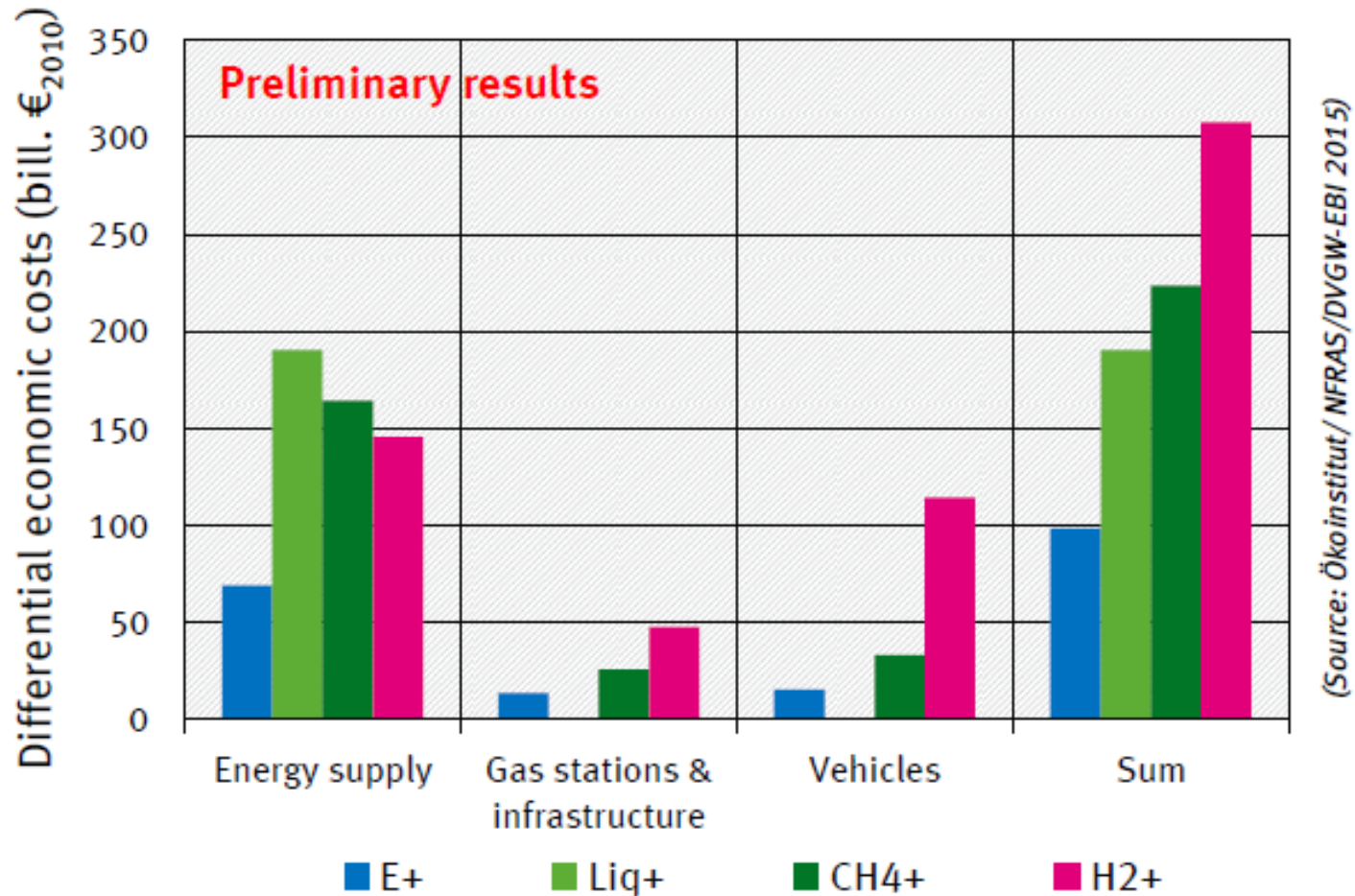


Road: Short haul transport (LDV, short haul trucks)



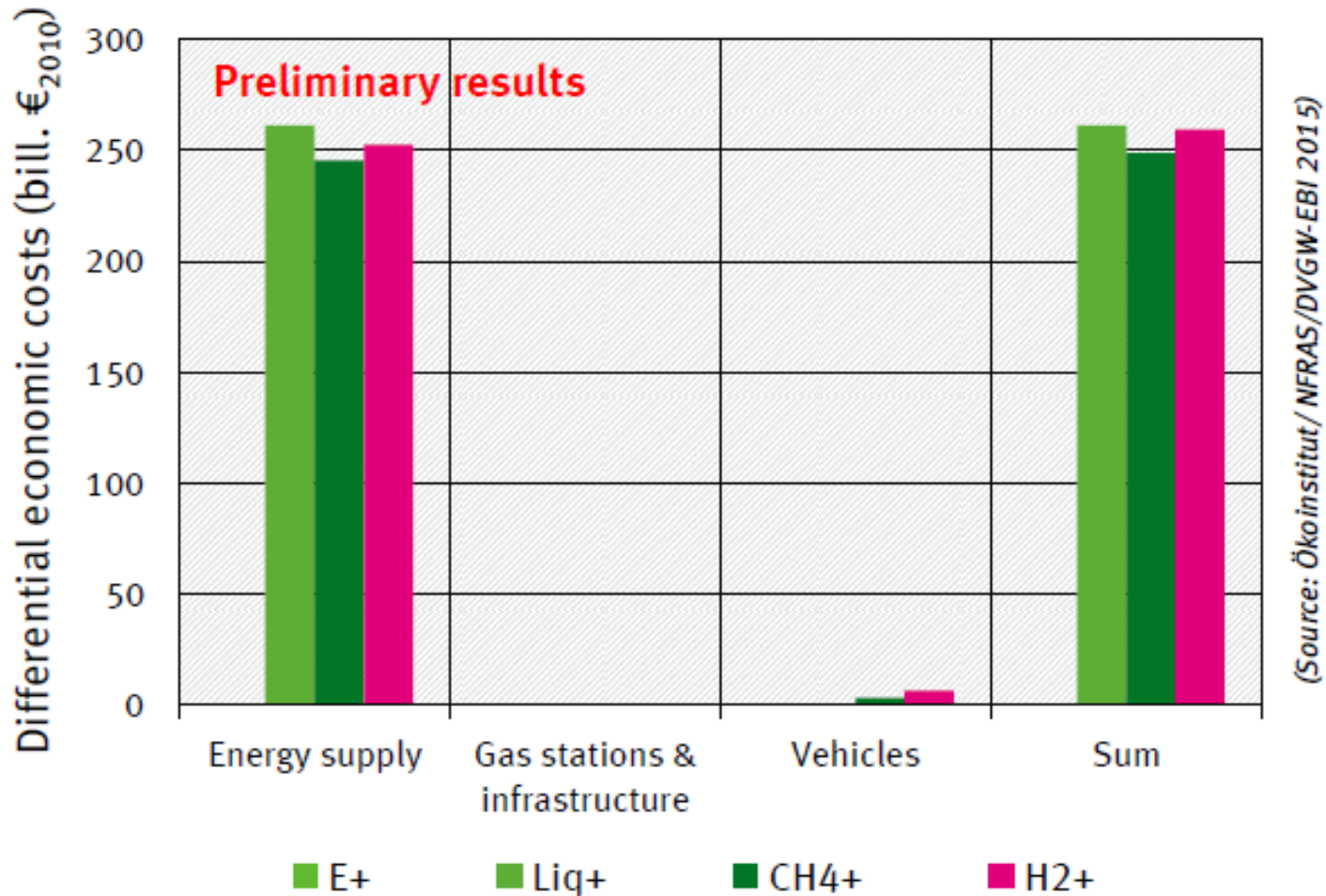


Road: Long haul transport (HDV)



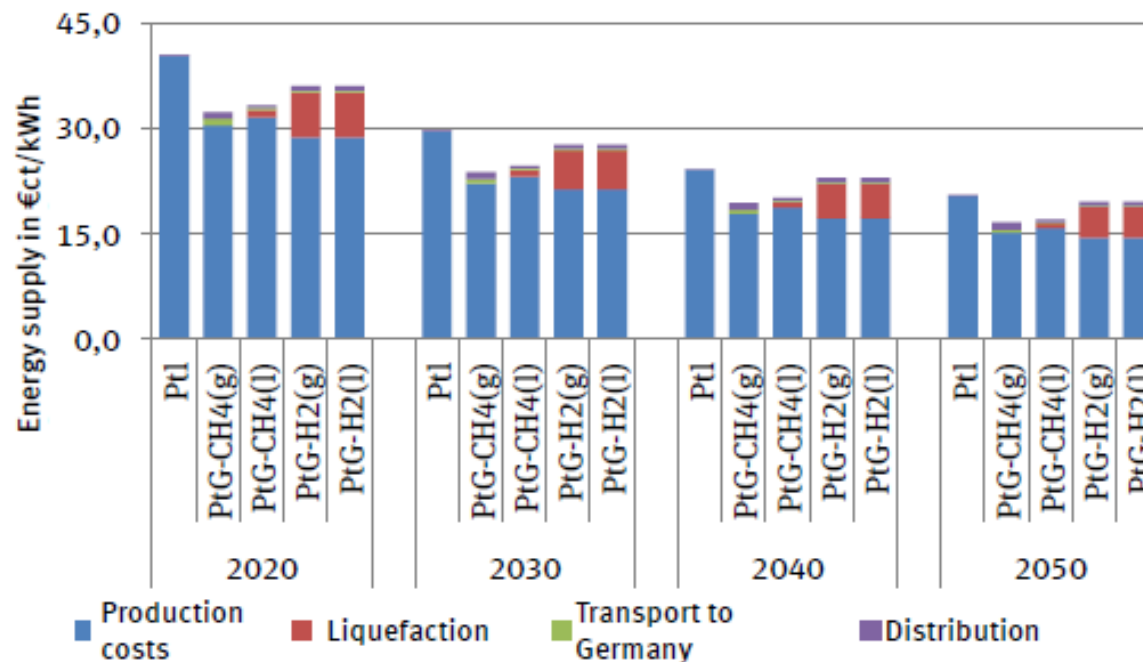


Shipping (including int. shipping)





Production costs of PtG/PtL-fuels up to the filling station



(Source: Ökoinstitut/ NFRAS/DVGW-EBI 2015)

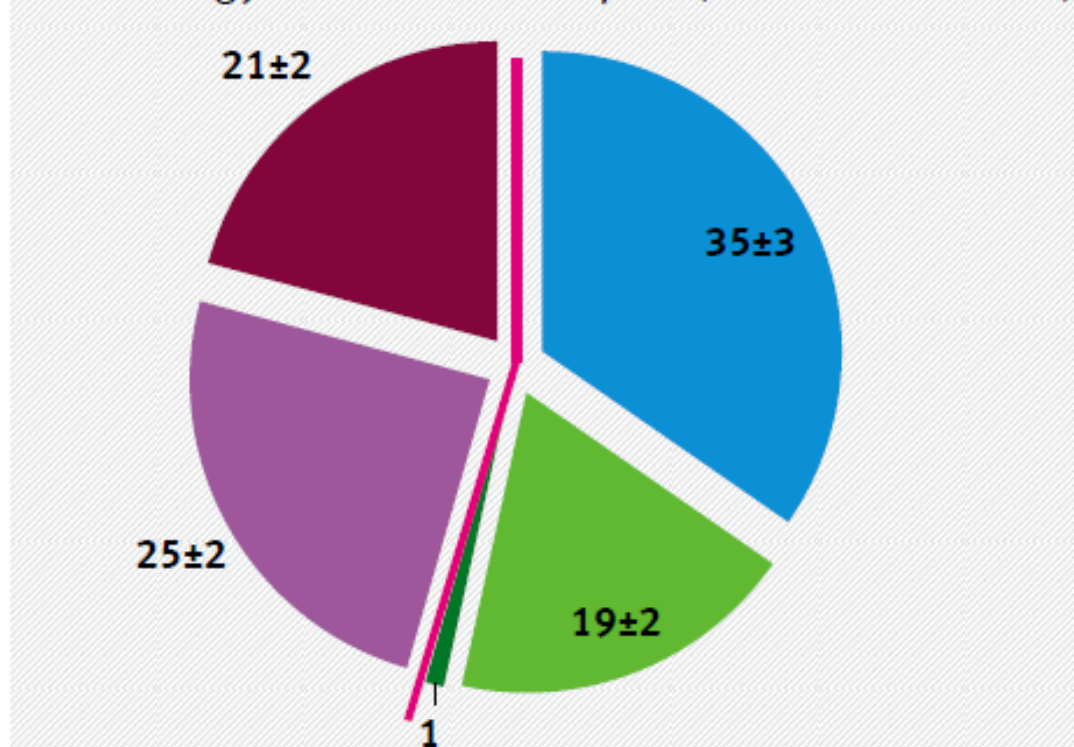
Assumptions:

- Representative Renewable electricity (RE) production sites
- Decreasing investment costs and costs of operation for RE techniques and the PtG- and PtL-pathways
- Full load hours determined by RE techniques
- Transport to Germany in a liquefied state



Post-fossil, electricity based fuels are needed for int. transport

Final energy demand in transport (incl. international)



■ Road: short haul ■ Road: long haul ■ Bus
■ Shipping ■ Aviation

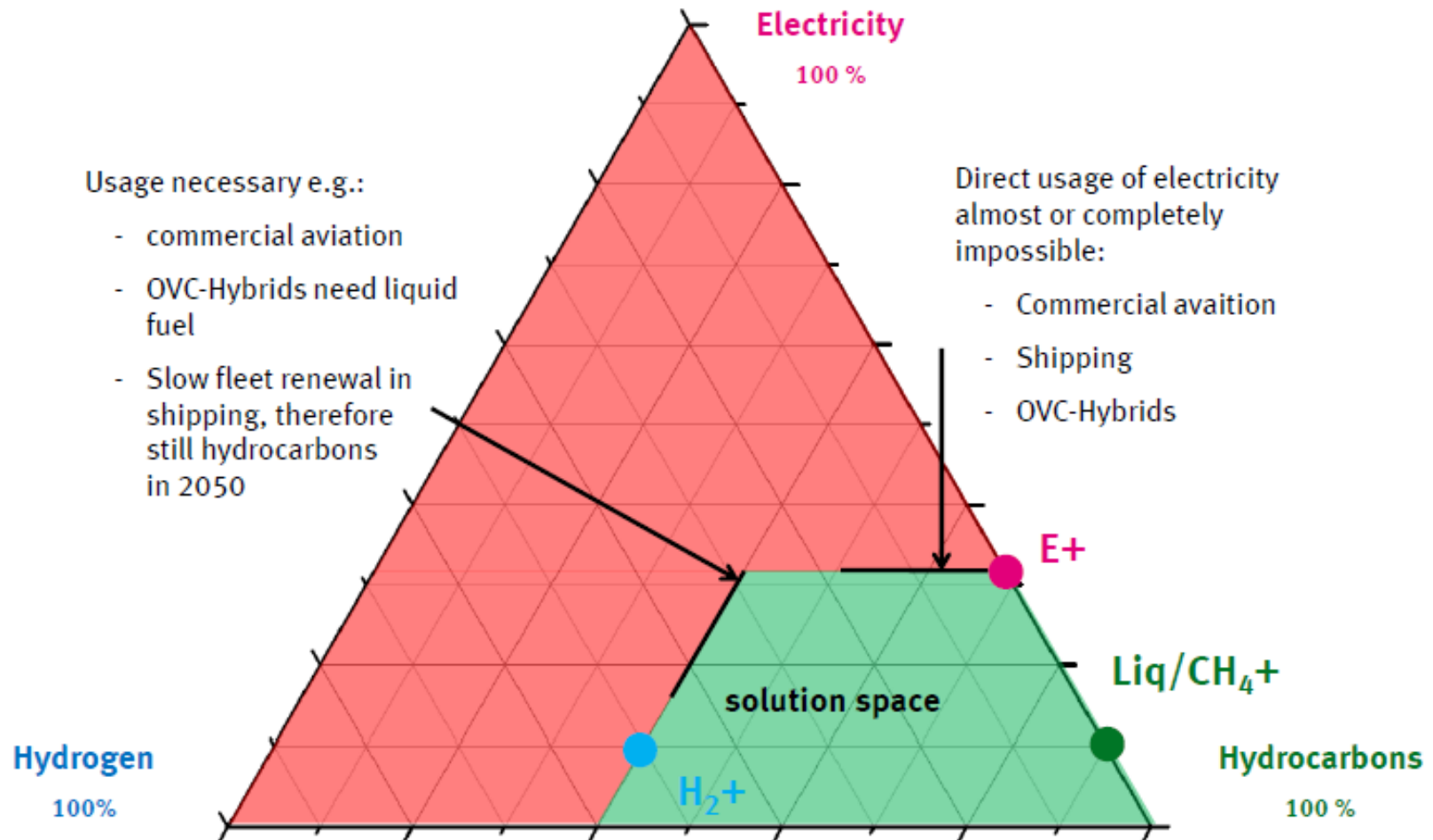
(Source: Ökoinstitut/ NFRAS/DVGW-EBI 2015)

⇒ Shipping and aviation cause almost half of transport's final energy demand in 2050

⇒ Electricity-based fuels are the only possible GHG-neutral solution



GHG-neutral final energy carriers – studied options, promising solutions





Summary

- A comprehensive strategy for energy supply of transport contains a general transition and an energy transition
- Electric vehicles are crucial for an transports energy transition, at least for LDV and buses (long haul trucks?)
- Various solutions for a GHG-neutral transport possible; however, some at the moment show disadvantages (H₂?)
- All “extreme” solutions studied, ultimately require a huge demand of PtG and PtL fuels
- CO₂ uptake from atmosphere and efficiency of processes to separate it from air play a major role



“Confidence is what you have, before you understand the problem.”

Woody Allen

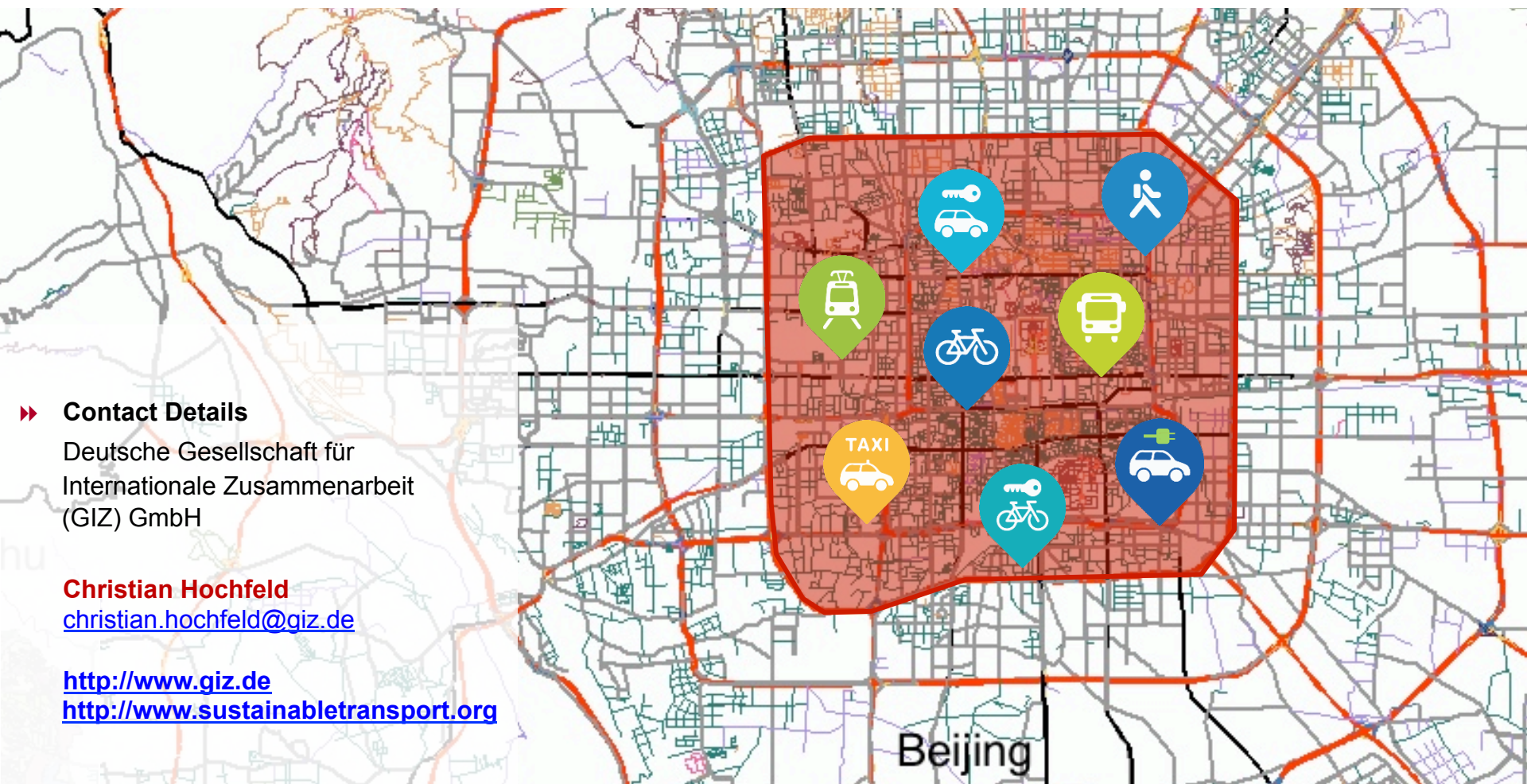


“Confidence is what you have, **because you understand the problem.”**

Woody Allen



Thank you very much for your attention!



» Contact Details

Deutsche Gesellschaft für
Internationale Zusammenarbeit
(GIZ) GmbH

Christian Hochfeld
christian.hochfeld@giz.de

<http://www.giz.de>
<http://www.sustainabletransport.org>