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Chancen und Potenziale alternativer Kraftstoffe

Results from the FVV scenario study «Renewables in Transport 2050»

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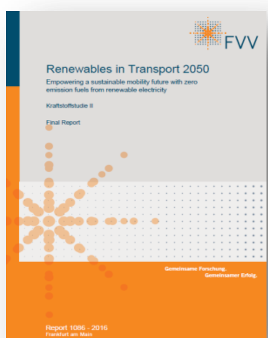
- Independent expert for sustainable energy and mobility for over 30 years
- Bridging technology, markets, and policy
- Renewable energies, fuels, infrastructure
- Technology-based strategy consulting, System and technology studies, Sustainability assessment
- Global and long term perspective
- Rigorous system approach – thinking outside the box
- Serving international clients in industry, finance, politics, and NGOs



Latest projects:

- FVV Renewables in Transport 2050
- BMVI German Mobility & Fuels Strategy (MKS)
- JRC/EUCAR/CONCAWE (JEC) Well-to-Tank Analyses

Agenda

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1. Motivation and approach
2. Scenarios
3. Results
   - Greenhouse gas emissions
   - Energy demand
   - Costs
4. Conclusions

Study motivation

- Greenhouse gas reduction targets of 80-95% by 2050 will require substantial contributions from the transport sector
- 100% renewables in transport by 2050 – pie in the sky?

  → 2 archetype scenarios + 1 mix scenario
- What are the consequences in terms of energy and costs?
- What are determinants for future use of internal combustion engines?

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Two distinct transportation demand scenarios (HIGH, LOW)

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Transportation demand scenario	Sector	Change from 2010 to 2050	
		DE	EU
HIGH	Passenger	+30%	+50%
	Freight	+60%	+80%
LOW	Passenger	-25%	+10%
	Freight	+20%	+50%

Sources:
DE-HIGH: Verkehrsprognose 2030, extrapolated to 2050, DE-LOW: eMobil 2050, scenario „Regional"
EU: AEA (2012), EU Transport GHG – Routes to 2050 II

Renewable share in the fuels (per MJ fuel)

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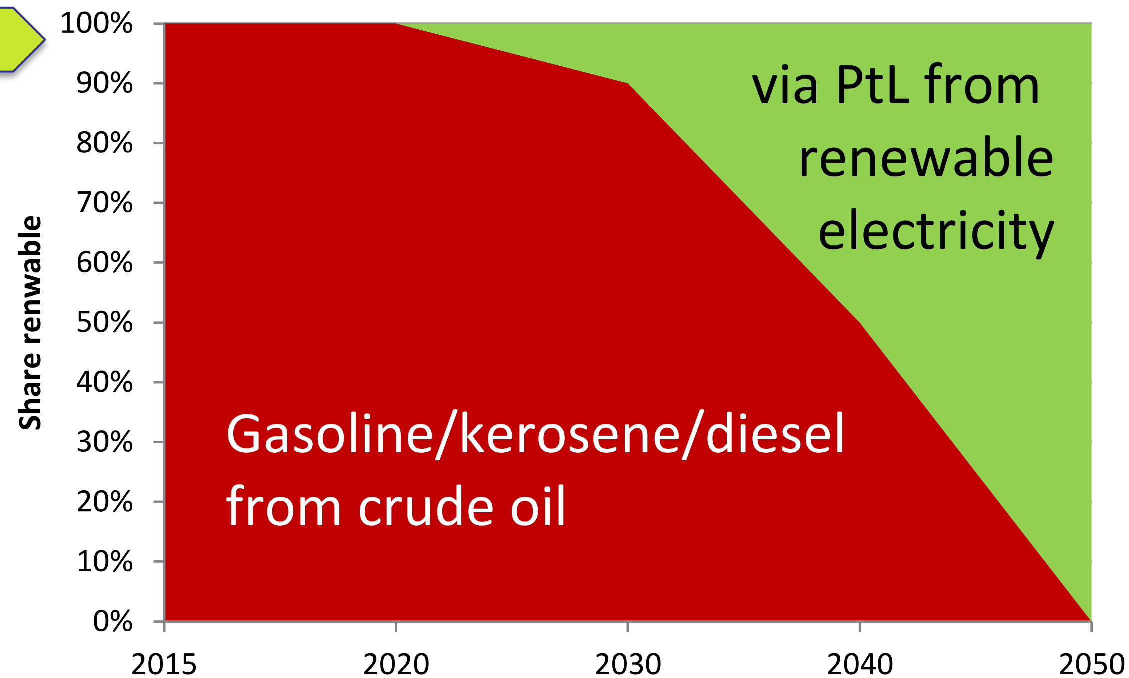
Target scenario – gradual shift from today to 100% renewable PtX by 2050

- Gasoline/kerosene/diesel
- Methanol
- Methane
- Hydrogen



PtL · Power-to-Liquids
PtX · Power-to-Anything

Definition of three distinct fuel/powertrain scenarios

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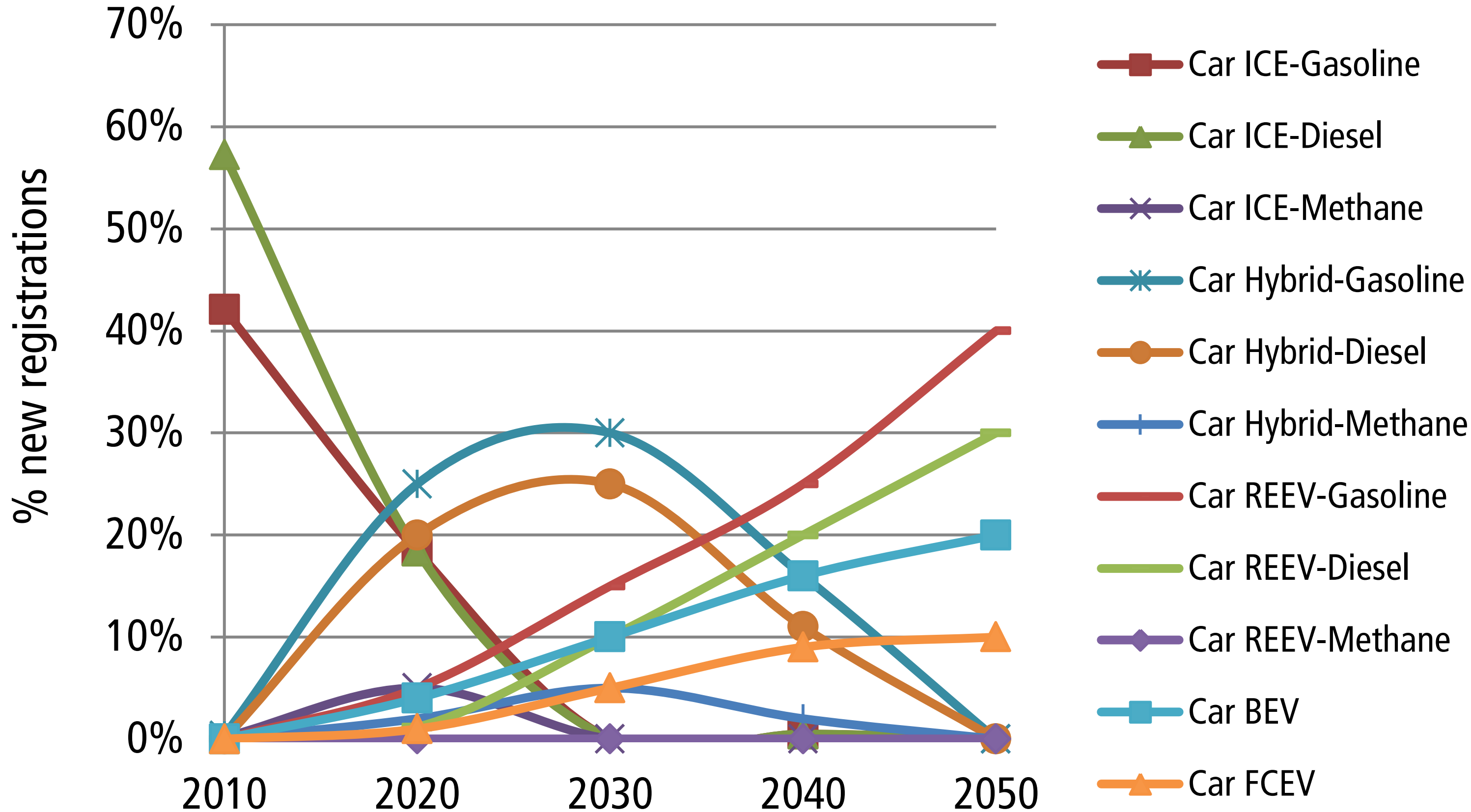
- **PTL** | Conservative scenario based on well established fuels/powertrains/infrastructures, incl. ICE mild hybrids with power-to-liquids dominating all transportation modes
- **FVV** | A mix of currently discussed options, comprising ambitious ICE development progress, incl. ICE hybrids, REEV, BEV, FCEV
- **eMob** | Derived from the study "eMobil 2050" [Öko-Institut 2015], with a dominance of electrified drivetrains

BEV · Battery-electric vehicle
eMob · Electric mobility
FCEV · Fuel cell-electric vehicle
FVV · Research association
PHEV · Plug-in hybrid vehicle
PTL · Power-to-liquids
REEV · Range-extender vehicle

Fuel/powertrain scenario | Example: FVV | Cars

	ICE-Gasoline	ICE-Diesel	ICE-Methane	Hybrid-Gasoline	Hybrid-Diesel	Hybrid-Methane	REEV-Gasoline	REEV-Diesel	REEV-Methane	BEV	FCEV
2010	42	57	0	0	0	0	0	0	0	0	0
2020	18	18	5	25	20	2	5	1	0	4	1
2030	0	0	0	30	25	5	15	10	0	10	5
2040	0	0	0	16	11	2	25	20	0	16	9
2050	0	0	0	0	0	0	40	30	0	20	10



LBST, 2015-07-30

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Greenhouse gas emissions (example FVV scenario)

Greenhouse gas emissions | EU | All transport | «FVV»

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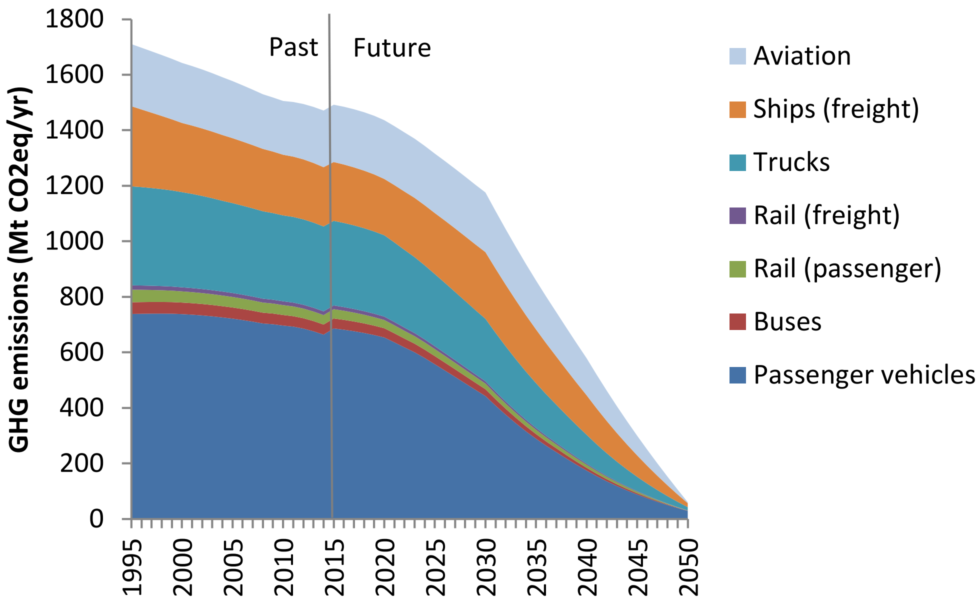
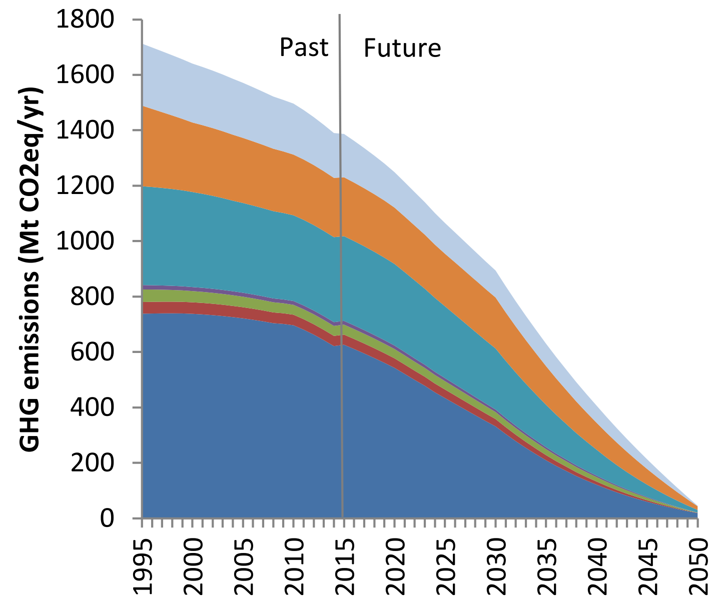
FVV + HIGH



FVV + LOW



- Recall: Fuel target scenario => 100 % renewable by 2050
- Climate impacts from high-altitude emissions (aviation) not included

Final fuel demand, electricity demand

Fuel demand (TWh/a) | EU | All transport | «FVV»

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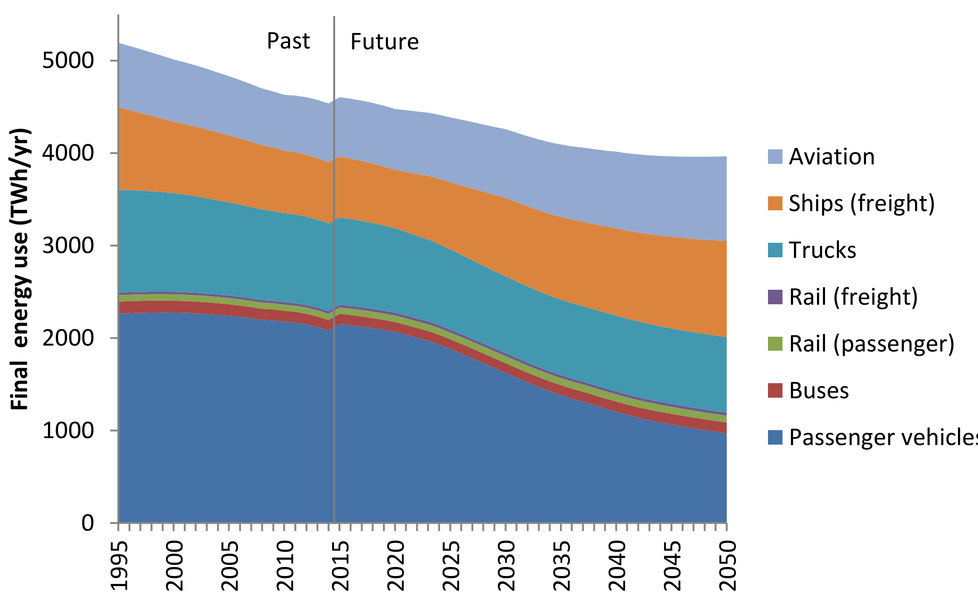
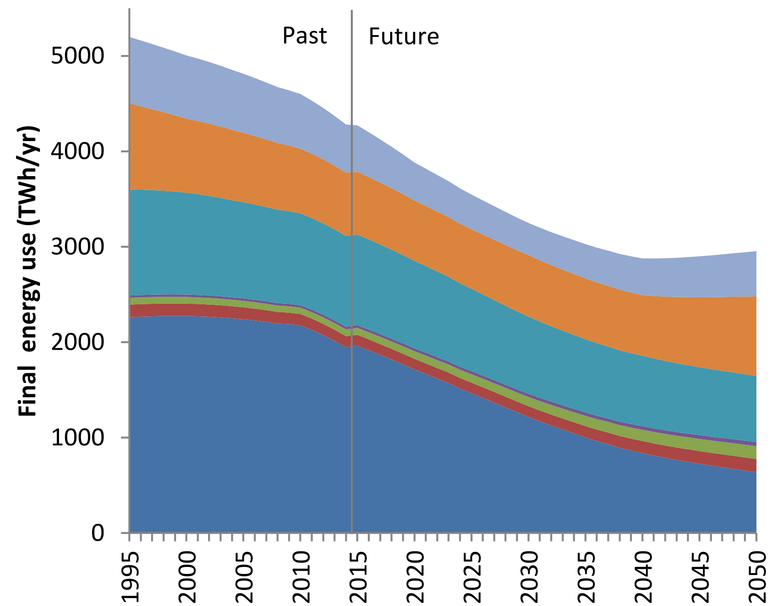
FVV + HIGH

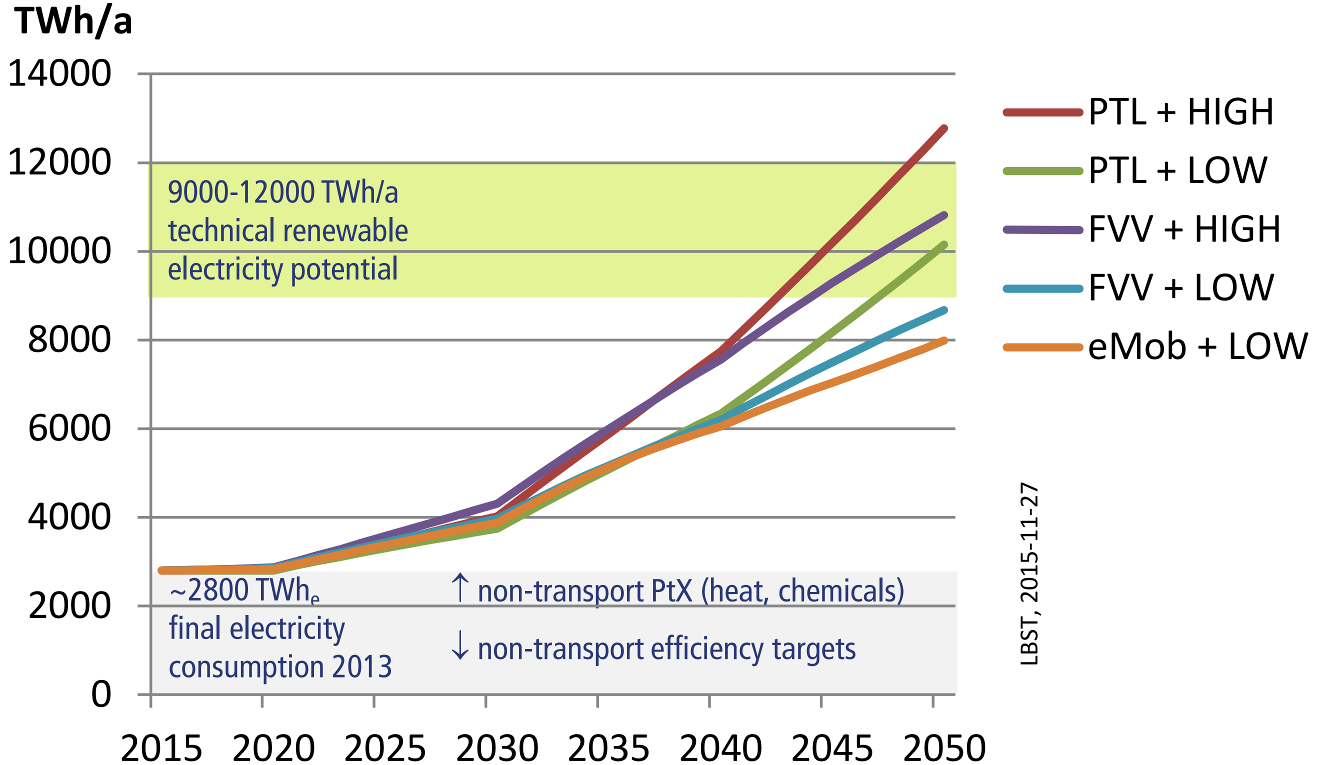


FVV + LOW



- Relative importance of trucks, ships and aviation increases
- Ships and aviation predominantly international destinations

Electricity demand (TWh_e/a) | EU | Today + transportation



- Transportation demand is the key driver for energy use across all scenarios.
- Truck freight and aviation push transportation demand in the HIGH scenarios.
- Total electricity demand in 2050 is a factor 3 to 4.5 of today's electricity demand.
- Most scenarios could be feasible with domestic renewable electricity production.

Cumulated investments energy transition in transportation

Cumulated investments until 2050 | Methodology

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- The cumulated investments consist of the following elements:
  - Renewable power plants
  - PtX production plants
  - Infrastructure for fuel transport & distribution
- Investments for end-of-life replacements are included in the cost model with a PtX plant lifetime of 25 years.
- Learning curves for electrolysers assumed, i.e. the 1st PtX production plant is more expensive than the nth one.
- BEV home-charging assumed for passenger cars.
- Vehicle costs not included.

Cumulated investments fuel supply until 2050 | EU

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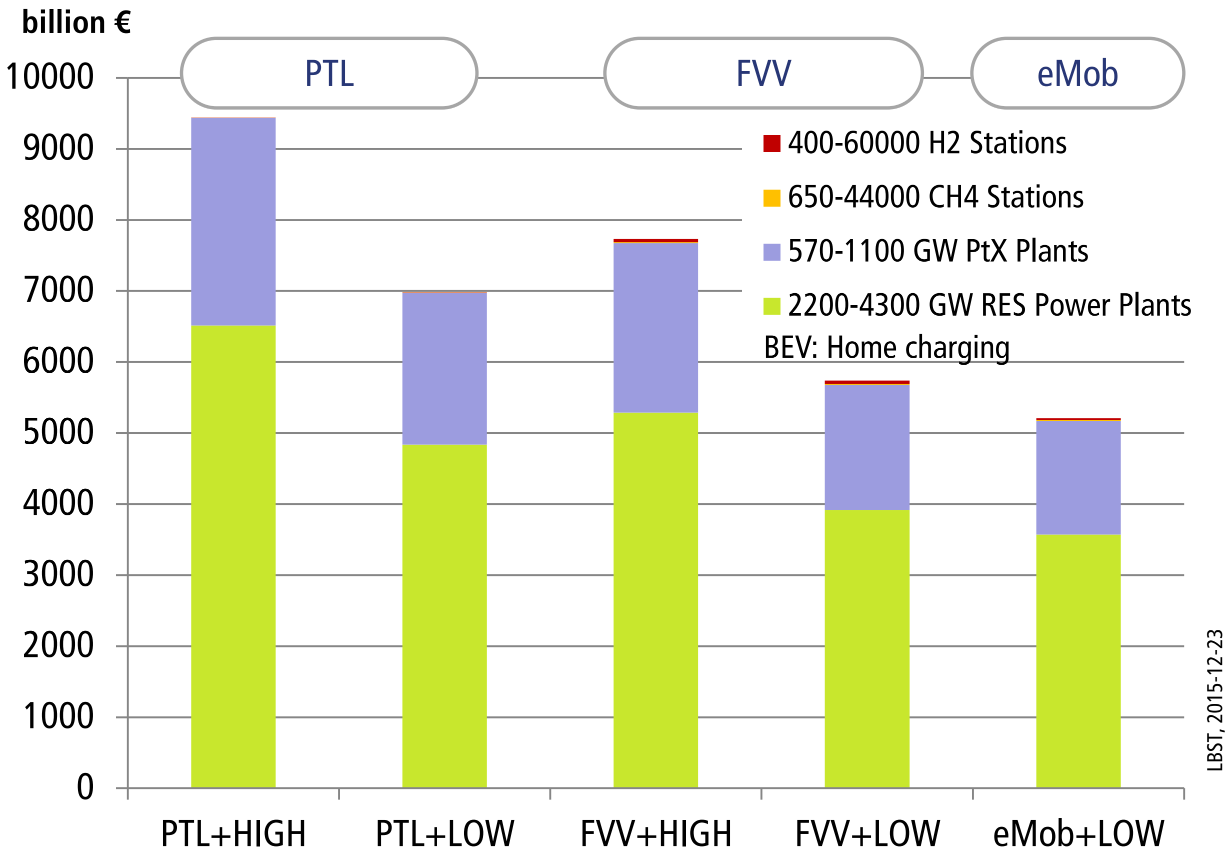


For comparison 2014 in EU:

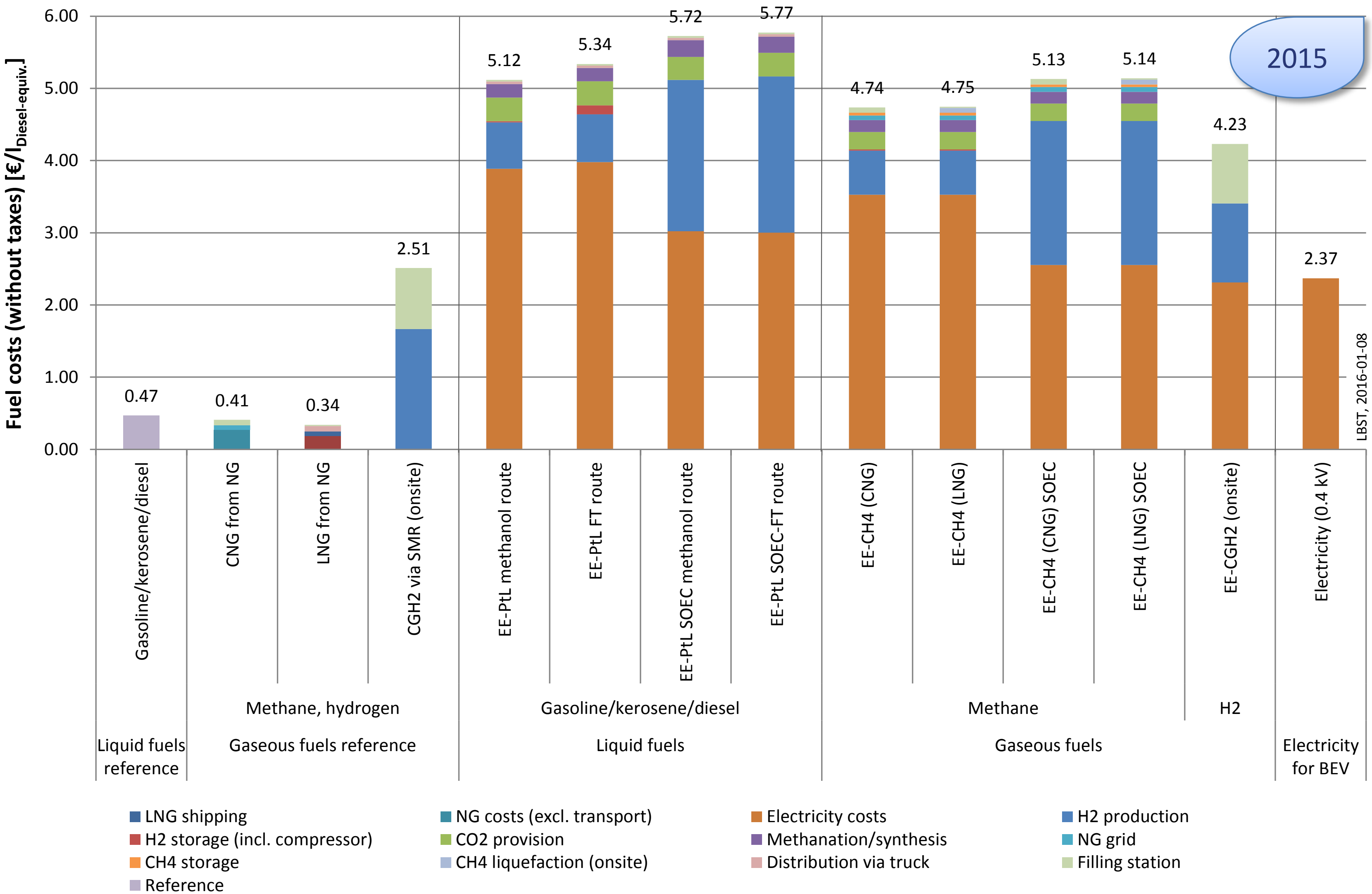
Gross domestic product (GDP) = 13920 billion €/a

Fossil oil spendings = ~290 billion €/a

>364 GW renewable power (150 GW hydro, 121 GW wind onshore, 8 GW wind offshore, 85 GW PV)

Fuel costs

Fuel costs – EU – 2015 (well-to-tank)



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13.4 ct/kWh electricity costs (incl. transport)

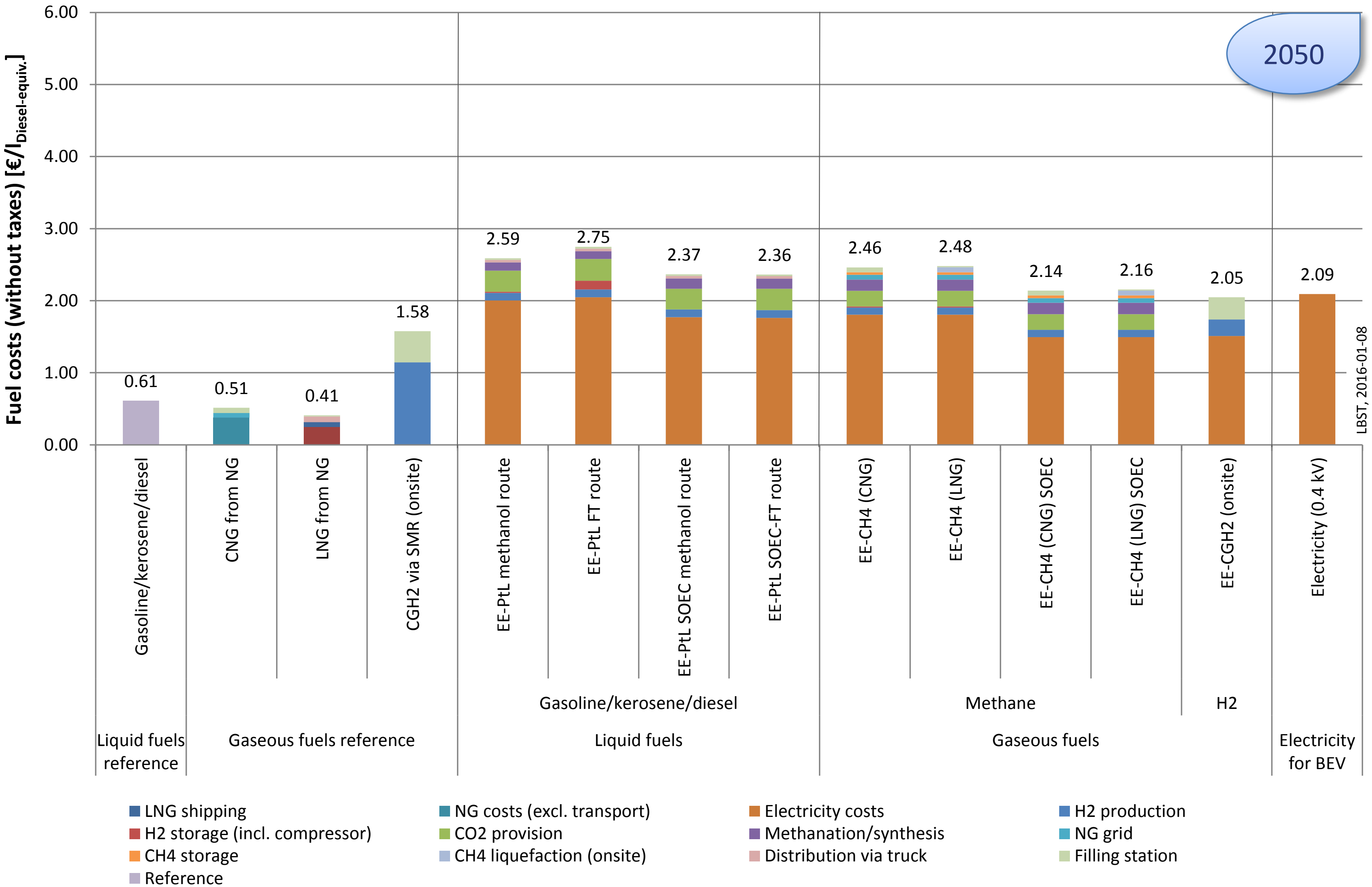
4000 h/a equivalent full load period

CO_2 from air

60 US$/bbl fossil liquids (today)

0 €/t CO_2

Fuel costs – EU – 2050 (well-to-tank)



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8.0 ct/kWh electricity costs (incl. transport)

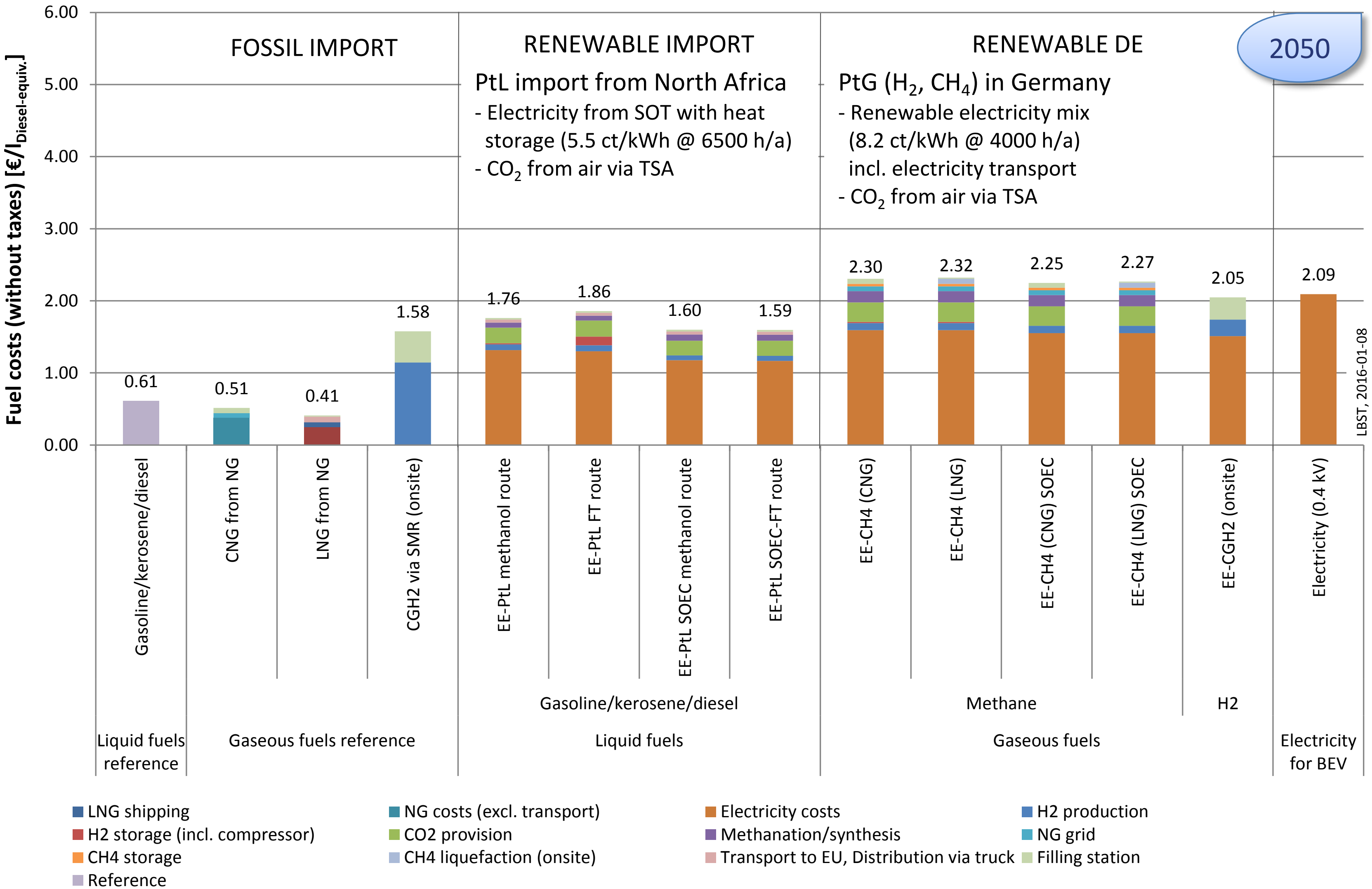
4000 h/a equivalent full load period

CO_2 from air

100 US$/bbl fossil liquids (IEA)

0 €/t CO_2

Fuel costs – PtL Import vs. PtG EU – 2050 (well-to-tank)



100 US$/bbl fossil liquids (IEA)

0 €/t CO_2

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Conclusions from the FVV Future Fuel study (EU) in a nutshell

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- Transportation demand development (pkm, tkm) is strongest driver for fuel/electricity demand.
- All scenarios but PTL+HIGH could technically be satisfied with domestic renewable electricity in the EU.
- Depending on the scenario, total electricity demand in 2050 is a factor 3 to 4.5 of the electricity demand today.
- PtX fuel costs could half between 2015 and 2050; PtL imports ~20% lower in cost.
  → Further cost reductions are subject to project-specific business cases
- PtX costs are dominated by electricity costs, which strongly depends on the fuel choice (H_2, CH_4, PTL) and associated plant efficiencies.
- Fuel distribution infrastructure costs are negligible compared to the upstream investments required for any of the scenarios analysed.
- Cumulated investments for Energiewende (energy transition) in the transportation sector seem manageable for any of the scenarios analysed.
- Transport must get more electric, with regard to the fuel and the propulsion system.

pkm · person kilometre
tkm · tonne kilometre
PtX · Power-to-anything
PtL · Power-to-liquids

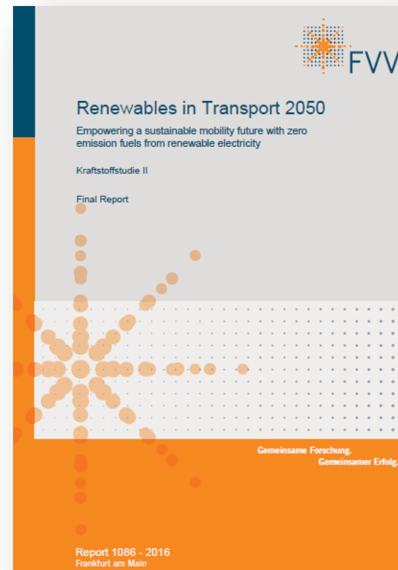
Literature

P. Schmidt, W. Zittel, W. Weindorf, T. Raksha (LBST)

Renewables in Transport 2050 – Empowering a sustainable mobility future with zero emission fuels from renewable electricity – Europe and Germany

Research Association for Combustion Engines e.V. (ed.)

FVV-Report 1086 / 2016



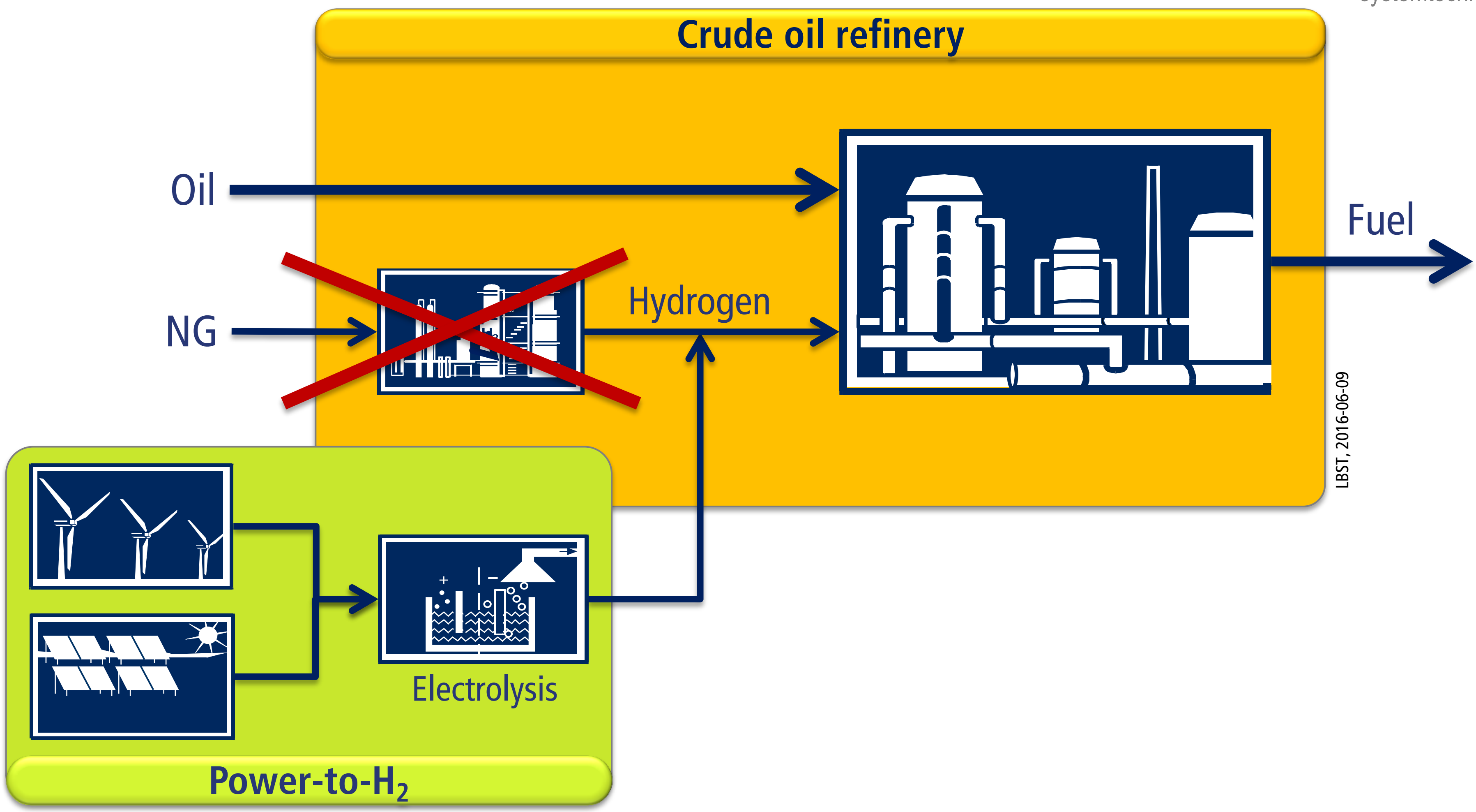
→ Download

http://www.fvv-net.de/en/download/renewables-in-transport-2050/renewables-in-transport-2050.html ludwig bölkow systemtechnik

Spotlight on short-term, no-regret option

Renewable power-to-hydrogen for use in oil refineries

Substituting natural gas with renewable power-to-H_2



Refinery GHG emission reduction (gate-to-gate) France and Germany

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	France	Germany
GHG mitigation of refinery emissions	1.33 Mt CO_{2eq}/a	1.50 Mt CO_{2eq}/a
	14.1 $\%_{gate\text{-}to\text{-}gate}$	7.2 $\%_{gate\text{-}to\text{-}gate}$
	331 €/t CO_{2eq}	339 €/t CO_{2eq}

→ Economic option for German refineries against 470 €/t CO_{2eq} penalty

To give an impression about the quantities, this is equivalent to annual GHG emission in the order of 650,000 C segment cars in France and Germany each.

Gasoline car @ 7.0l/100km	575,000	648,000
Diesel car @ 5.5l/100km	658,000	740,000

→ Tangible action for refinery corporate social responsibility (CSR)

Literature

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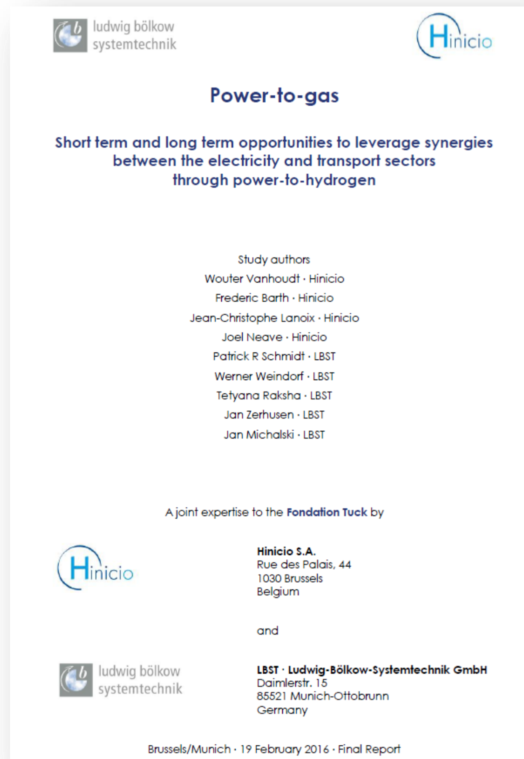
Vanhoudt, W., Barth, F. (Hinicio), Schmidt, P., Weindorf, W. (LBST), et al.: Power-to-gas – Short term and long term opportunities to leverage synergies between the electricity and transport sectors through power-to-hydrogen; Brussels/Munich, 19 February 2016

- Application A: Hydrogen from power-to-gas for use in refineries
- Application B: Semi-centralised power-to-hydrogen business cases

→ Download

http://www.fondation-tuck.fr/jcms/r_16975/fr/hinicio-lbst



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Hinicio

Power-to-gas

Short term and long term opportunities to leverage synergies between the electricity and transport sectors through power-to-hydrogen

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