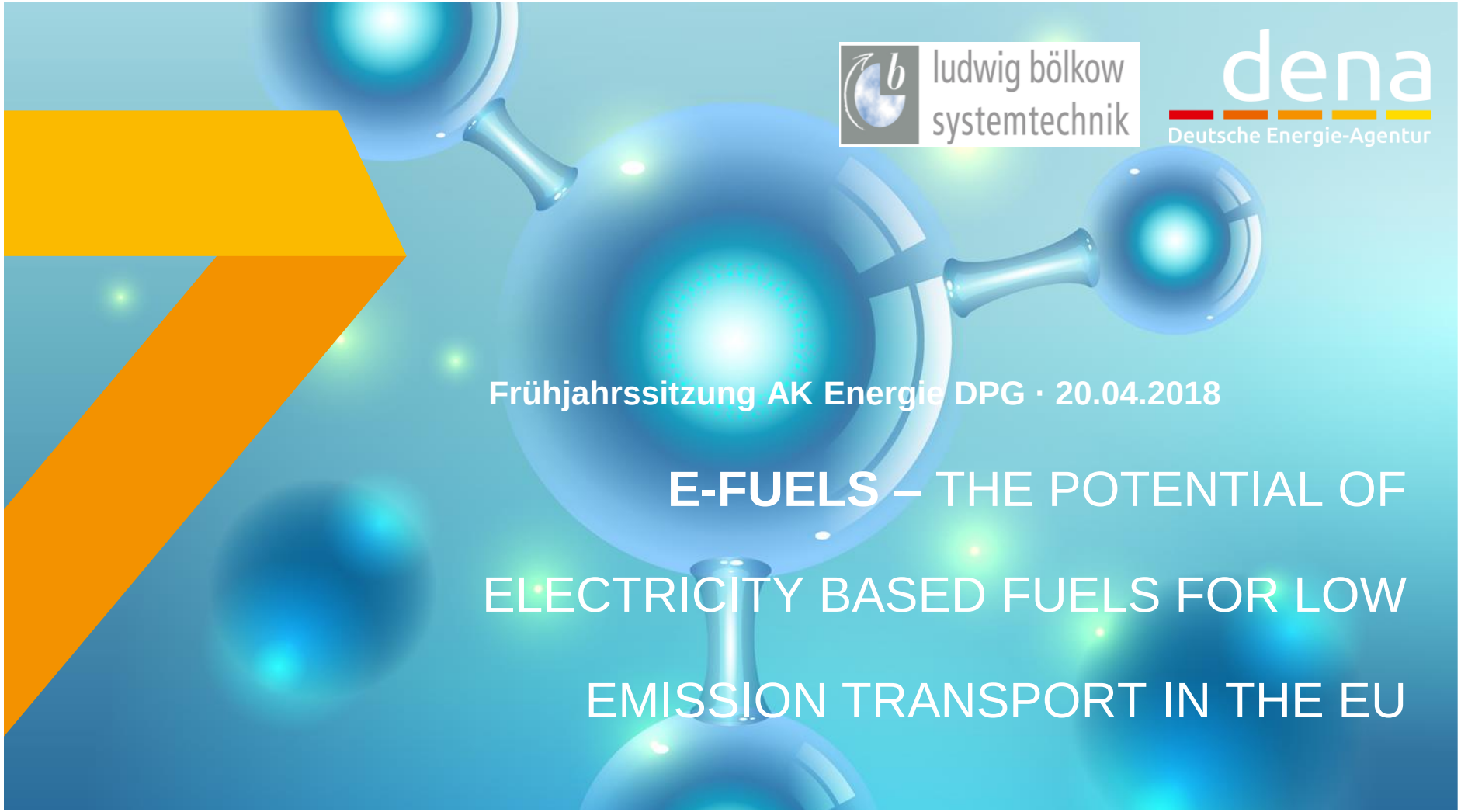


Frühjahrssitzung AK Energie DPG · 20.04.2018

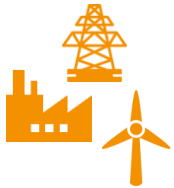
E-FUELS – THE POTENTIAL OF ELECTRICITY BASED FUELS FOR LOW EMISSION TRANSPORT IN THE EU

DENA - OUR FOUR PILLARS

ENERGY EFFICIENCY

Think tank and moderator for the establishment of the energy transition

INTELLIGENT ENERGY SYSTEMS



Integration, optimisation and think tank

STAKEHOLDER PROCESSES

Moderator at the interface between politics, commerce and society

INTERNATIONAL ACTIVITIES

Marketing the energy transition abroad

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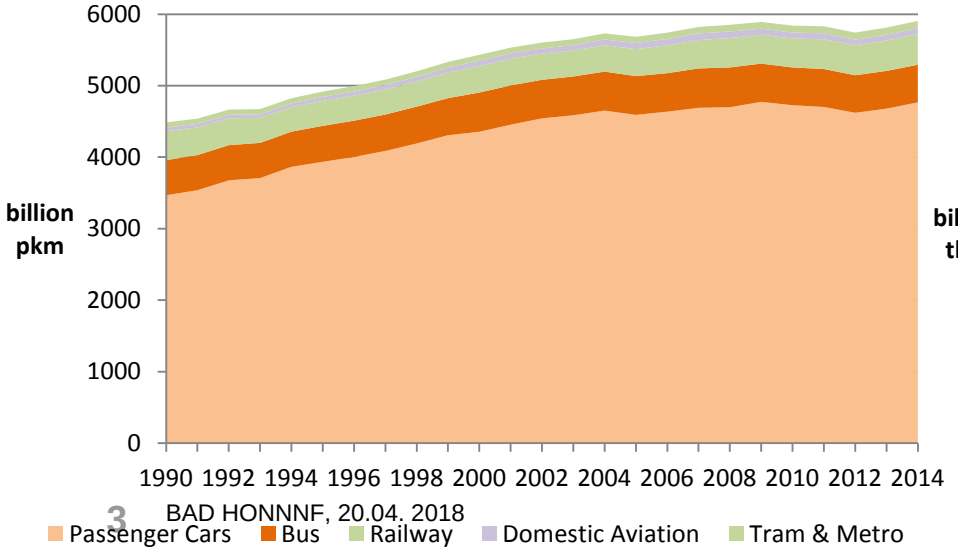
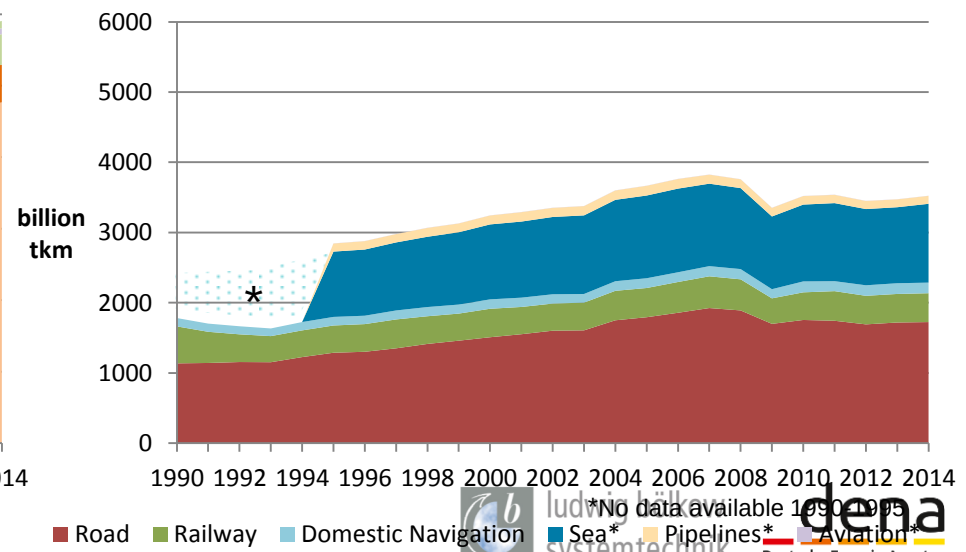
DEVELOPMENT OF TRANSPORT CAPACITY AND MODAL SPLIT

- **Passenger transport 1990-2014:** **All transport modes +32 %, Passenger cars +37 %**
- **Share of Passenger cars:** **81 %**
- **Freight transport 1995*-2014 :** **All transport modes +24 %, Road Transport +34 %, Navigation +21 %**

Share of Road Transport: **49 %**
Share of Navigation: **36 %**





Sources: Statistical Pocketbook 2016. EU Transport in figures, Odyssee Database

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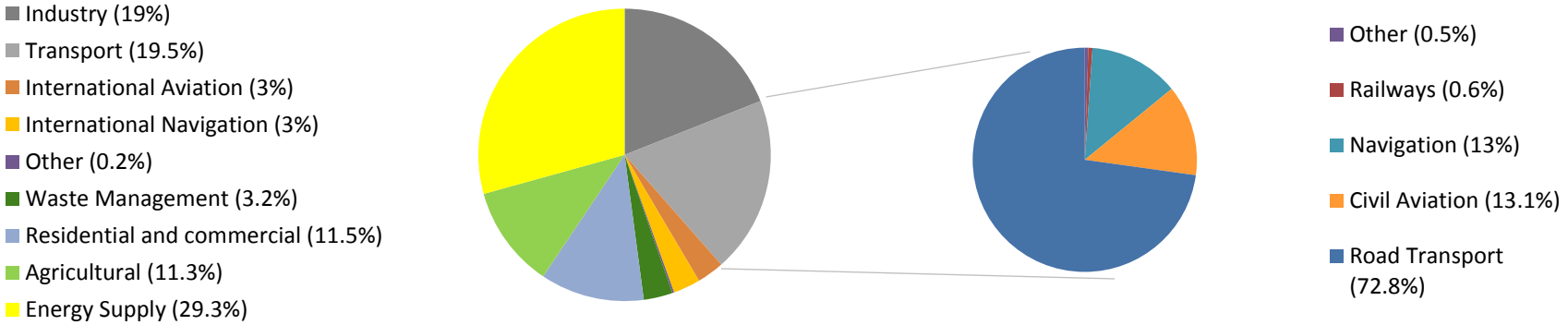
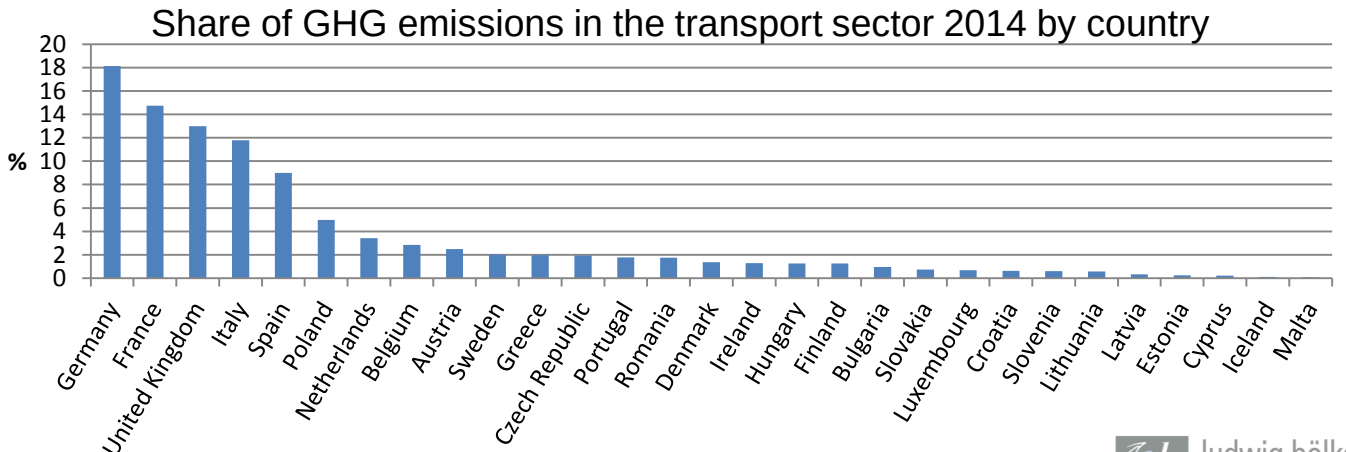
EU GHG EMISSIONS





Source: EEA (2016)

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STUDIENMOTIVATION

AUSGANSPUNKT

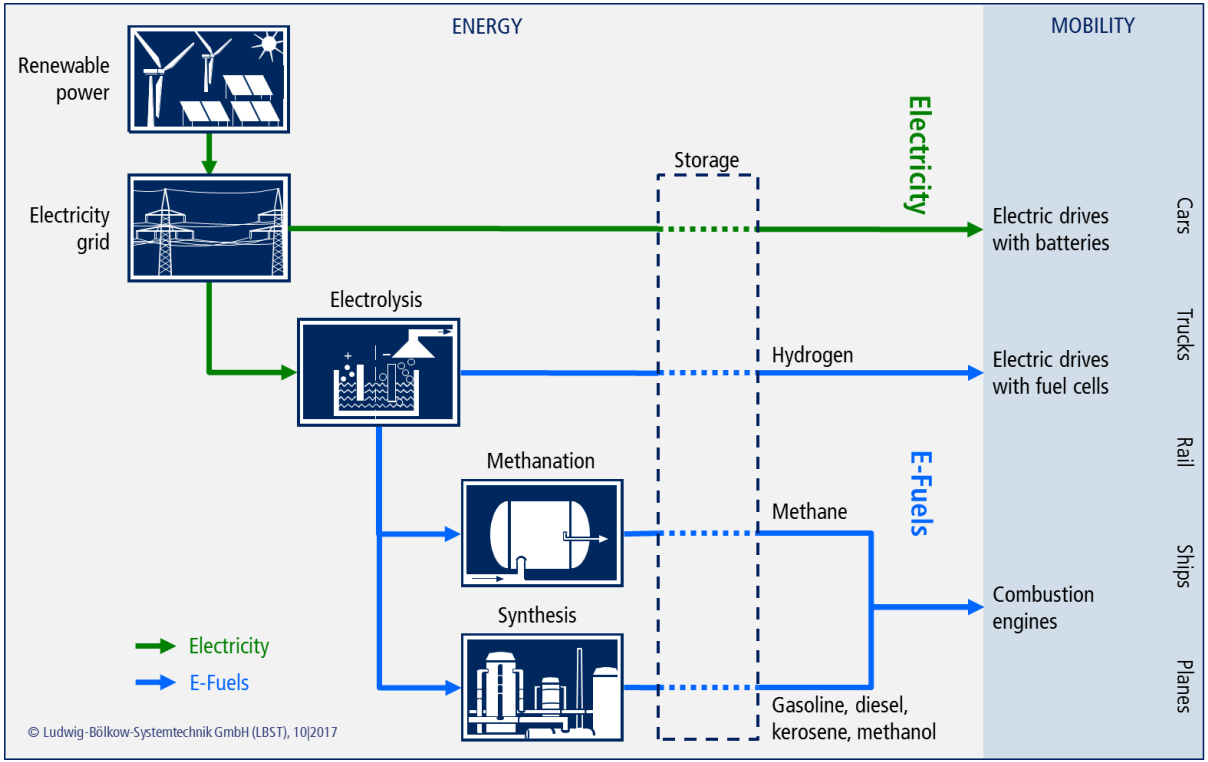
- Die THG-Reduktionsziele von 80-95% im Jahr 2050 erfordern einen wesentlichen Beitrag seitens des Verkehrssektors (Das Paris 2°C Ziel erfordert ein Ausphasen nahezu aller fossiler Energieträger vor 2050)
- Die Steigerung der Energieeffizienz aller Verkehrsmittel ist wichtig, muss jedoch durch den Einsatz von erneuerbaren Energien begleitet werden, um die THG-Emissionen in dem erforderlichen Maße zu senken
- Die Gestehungskosten für erneuerbaren Strom sind in den letzten Jahren deutlich gesunken, was die Betrachtung der Potenziale und Kosten von E-Fuels als erneuerbare Kraftstoffe lohnenswert macht

STUDIENMOTIVATION

FRAGESTELLUNGEN

- Welchen Beitrag können E-Fuels zum Erreichen der EU-Klimaschutzziele des Verkehrs leisten?
- Wie groß ist der Ausbaubedarf an erneuerbaren Energien für die Bereitstellung der für den Verkehrssektor notwendigen Energiemengen?
- Welche kumulierten Investitionen wären für die Energie- und Kraftstoffbereitstellung bis zum Jahr 2050 notwendig?

DEFINITION E-FUELS



E-Fuels sind auf Basis von erneuerbarem Strom hergestellte gasförmige und flüssige Kraftstoffe wie Wasserstoff, Methan, synthetische Otto- und Dieselkraftstoffe inklusive Kerosin.

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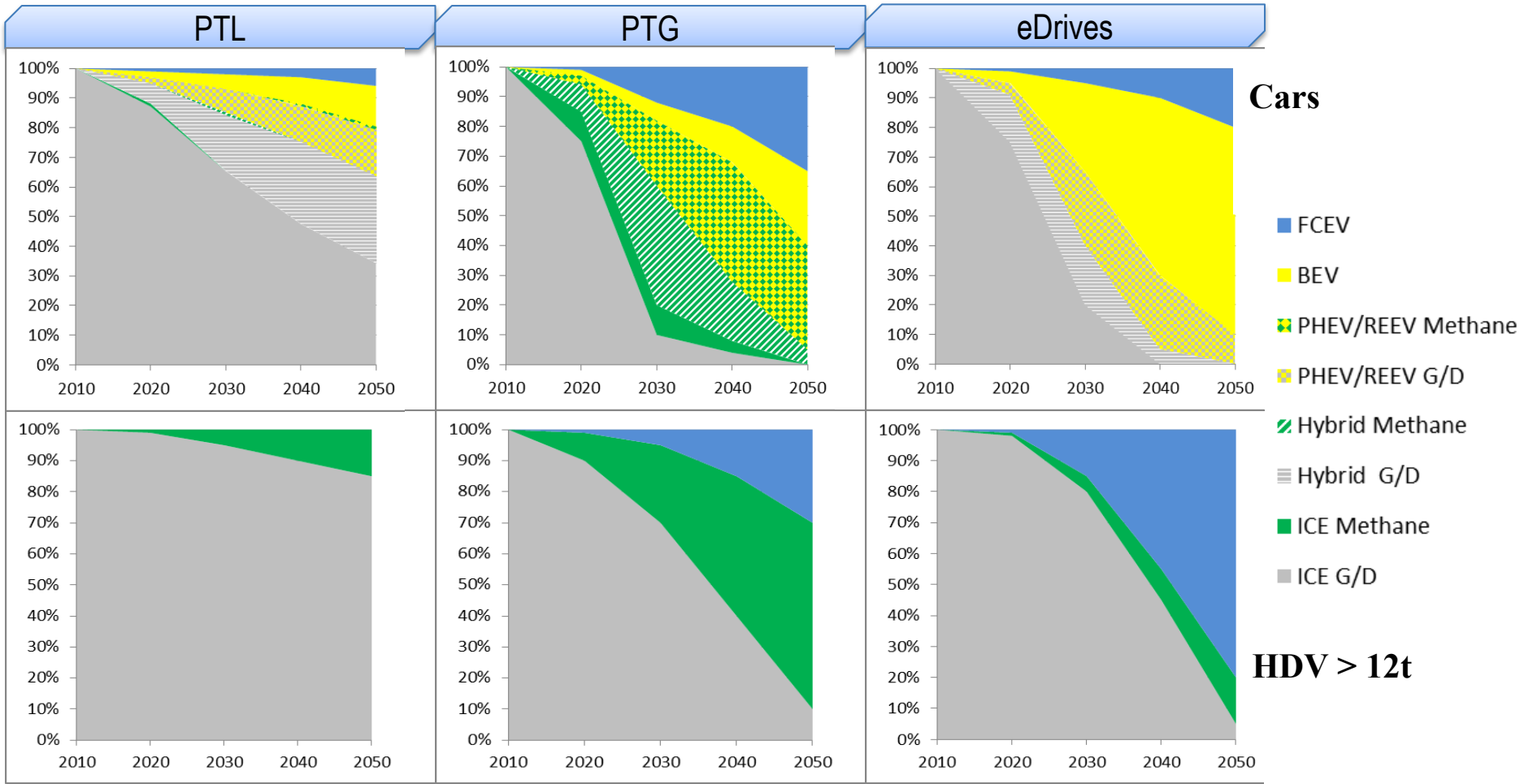
METHODIK

- Analyse 4 verschiedener Szenariorouten + 1 Importsensitivität auf Basis von 3 Antriebs/Kraftstoffszenarien, 2 Verkehrsentwicklungsszenarien und 2 THG-Reduktionszielen.

Development routes	Transportation demand scenario		Fuel/powertrain scenario			Climate mitigation ambition 2050 (base-year 1990)		Import ($PtCH_4$, PtL) variant
	HIGH	LOW	PTL	PTG	eDrives	-80%$_{GHG}$	-95%$_{GHG}$	
1.a BAU-moderate	■		■			■		■
1.b BAU-ambition		■	■				■	■
2. Progressed-mix		■		■			■	■
3. More-electric		■			■		■	■

ZULASSUNGSZAHLEN PKW & SNFZ



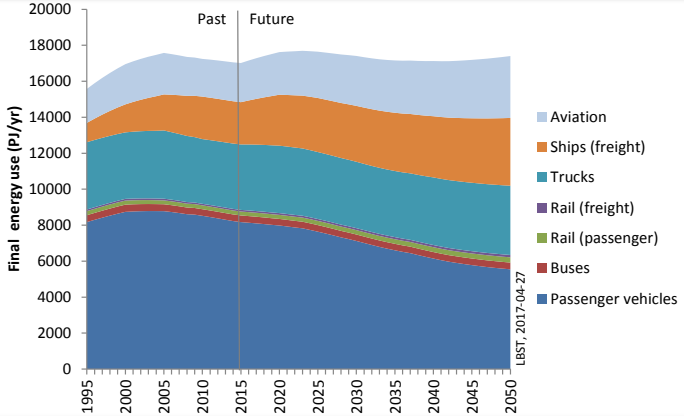
VERKEHRSNACHFRAGE (HIGH, LOW)

Transport sector	Demand 2015	Demand 2050 (change %$_{2015}$)	
		HIGH	LOW
Passenger (billion pkm)	**7,271**	**10,242 (+41%)**	**7,998 (+10%)**
Car	4,871	6,149 (+26%)	4,080 (-16%)
Train	546	878 (+61%)	1,285 (+135%)
Aviation	1,308	2,465 (+88%)	1,274 (-3%)
Freight (billion tkm)	**13,681**	**23,265 (+70%)**	**20,065 (+47%)**
Truck	1,915	2,835 (+48%)	2,116 (+11%)
Train	428	724 (+69%)	893 (+109%)
Sea ship	11,187	19,500 (+74%)	16,792 (+50%)

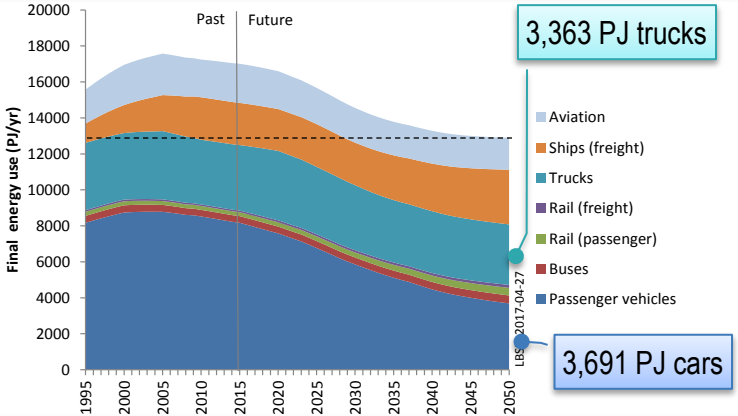
- 2015 data: EU Transport Pocket Book 2016
- EC (2016): EU Reference Scenario
- AEA (2012): EU Transport GHG – Routes to 2050 II
  - **HIGH**: AEA scenario “BAU-a”
  - **LOW**: AEA scenario “C5-b”

ENTWICKLUNG DER ENERGIENACHFRAGE

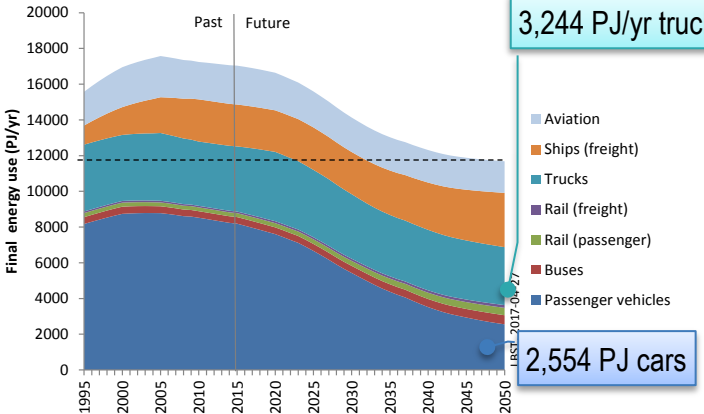
BAU-moderate · PTL / HIGH / -80%$_{GHG}$



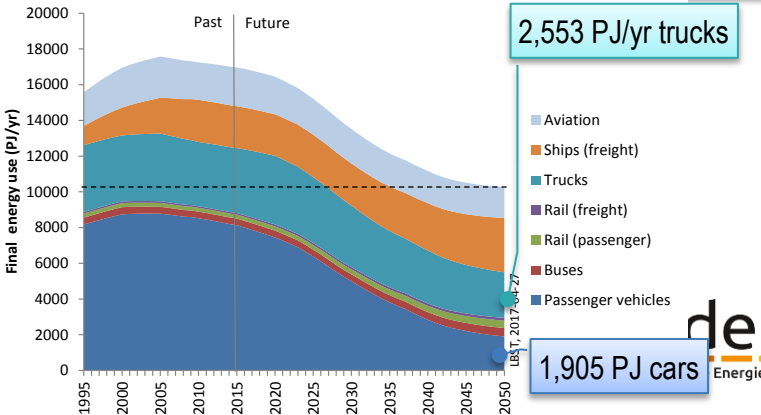
BAU-ambition · PTL / LOW / -95%$_{GHG}$



Progressed-mix · PTG / LOW / -95%$_{GHG}$



eDrives / LOW / -95%$_{GHG}$



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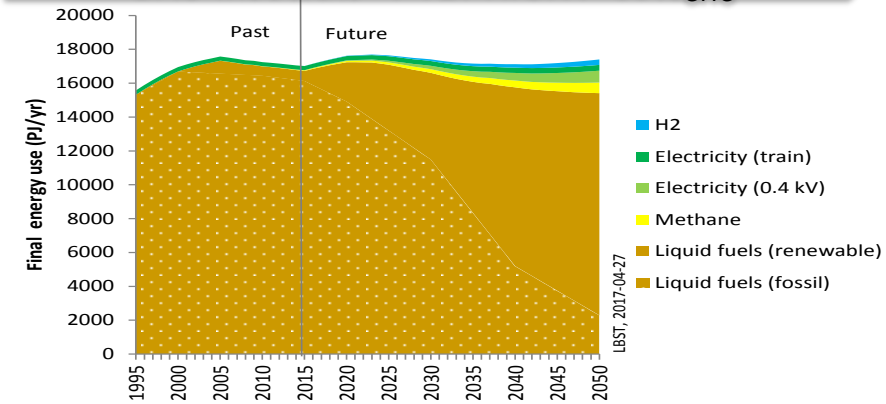
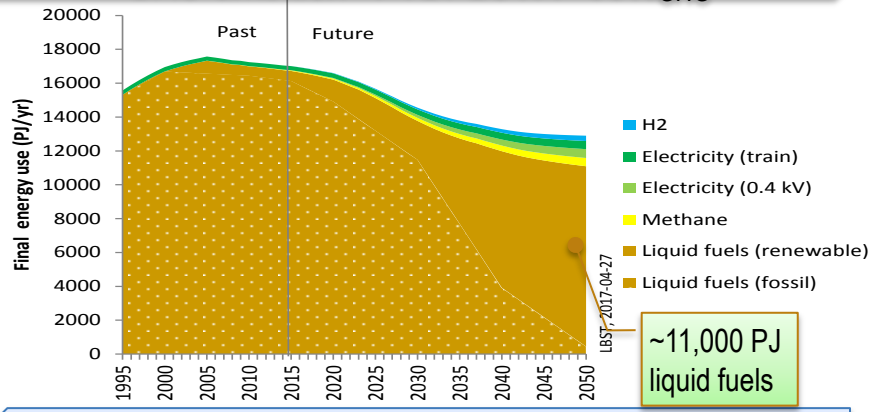
ENTWICKLUNG DER NERGIENACHFRAGE (BY FUEL)

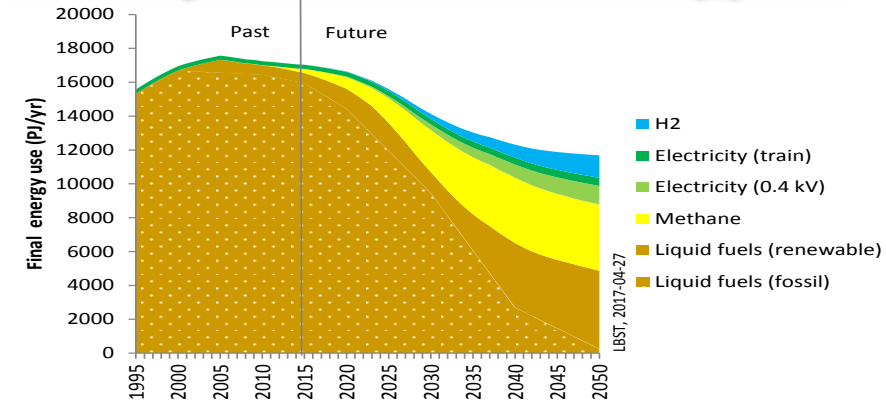
BAU-moderate · PTL / HIGH / -80%$_{GHG}$



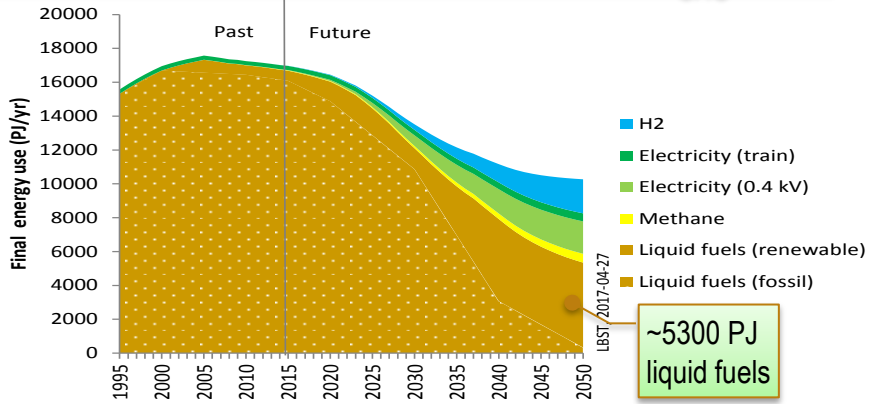
BAU-ambition · PTL / LOW / -95%$_{GHG}$



Progressed-mix · PTG / LOW / -95%$_{GHG}$



More-electric · eDrives / LOW / -95%$_{GHG}$



ENERGIEVERBRAUCH UND STROMBEDARF VERKEHRSSEKTOR 2050

BAU-moderate · PTL / HIGH / -80%$_{GHG}$

- **Fuel demand*: 17,402 PJ/a**
  (about as much as today, despite increasing transportation demand)
- **Total electricity demand**: 8,459 TWh/a**
  thereof 4 % for BEV cars and trucks

BAU-ambition · PTL / LOW / -95%$_{GHG}$

- **Fuel demand*: 12,897 PJ/a**
  (transportation demand is the most sensitive parameter to fuel demand)
- **Total electricity demand**: 6,899 TWh/a**
  thereof 5 % for BEV cars and trucks

Progressed-mix · PTG / LOW / -95%$_{GHG}$

- **Fuel demand*: 11,683 PJ/a**
- **Total electricity demand**: 5,582 TWh/a**
  thereof 10 % for BEV cars and trucks

More-electric · eDrives / LOW / -95%$_{GHG}$

- **Fuel demand*: 10,268 PJ/a**
- **Total electricity demand**: 4,666 TWh/a**
  thereof 18 % for BEV cars and trucks

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NOTWENDIGER EE AUSBAUPFAD

| RE ELECTRICITY PLANT BUILT-UP

Development route	Annual new installations in average 2030-2050 (GW/yr)			Installations end 2050 (GW)		
	Wind onshore	Wind offshore	PV	Wind onshore	Wind offshore	PV
PTL / HIGH / -80	30	28	46	1266	739	1625
PTL / LOW / -95	39	27	53	1032	603	1325
PTG / LOW / -95	34	22	45	835	488	1072
eDrives / LOW / -95	29	19	38	698	408	896

LBST, 2017-04-27

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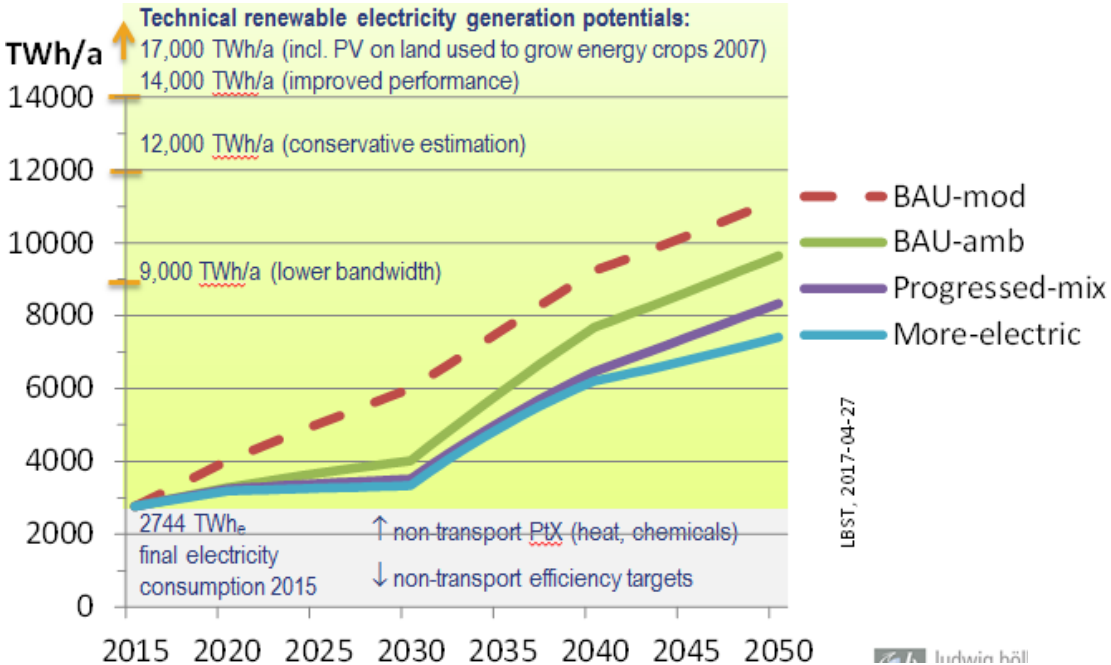
EE POTENZIAL EU28
STROMNACHFRAGE |EU HEUTE + VERKEHR



- Der erneuerbare Strombedarf des Verkehrssektor liegt im Jahr 2050 1.7 bis 3 Mal über dem heutigen Nettostromverbrauch aller Verbraucher in der EU
- Das technische erneuerbaren Energien Potenzial der EU28 könnte diesen Strombedarf decken

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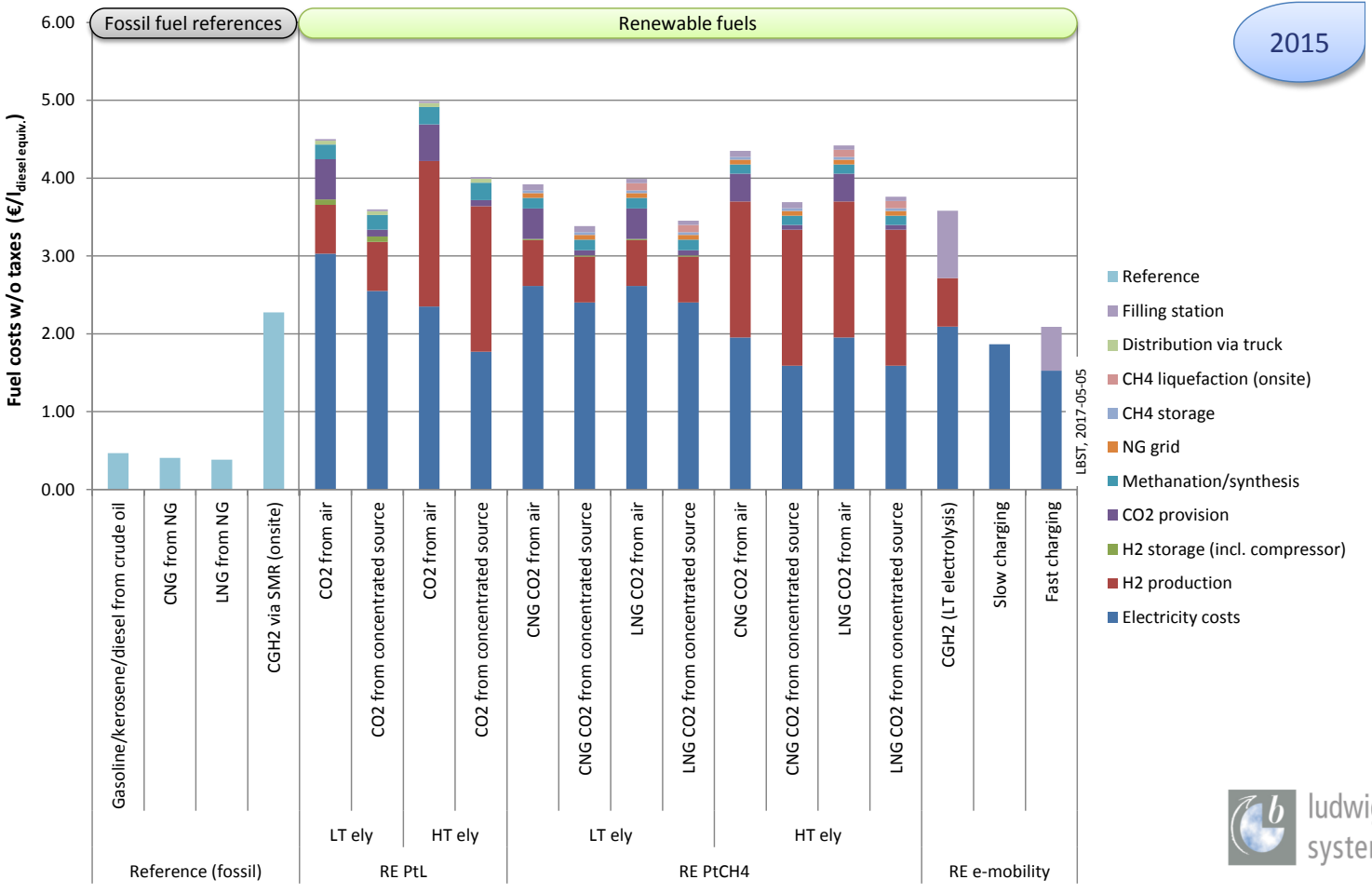
* Comprising both power-to-fuels and the direct use of electricity in transport. Base-case EU domestic energy.

FUEL COSTS PER LITER | EU-28 | 2015



8.8 ct/kWh electricity costs without grid for PtX plants

4000 h/a equivalent full load period for PtX plants

60 US$/bbl fossil liquids (IEA)

0 €/t CO_2

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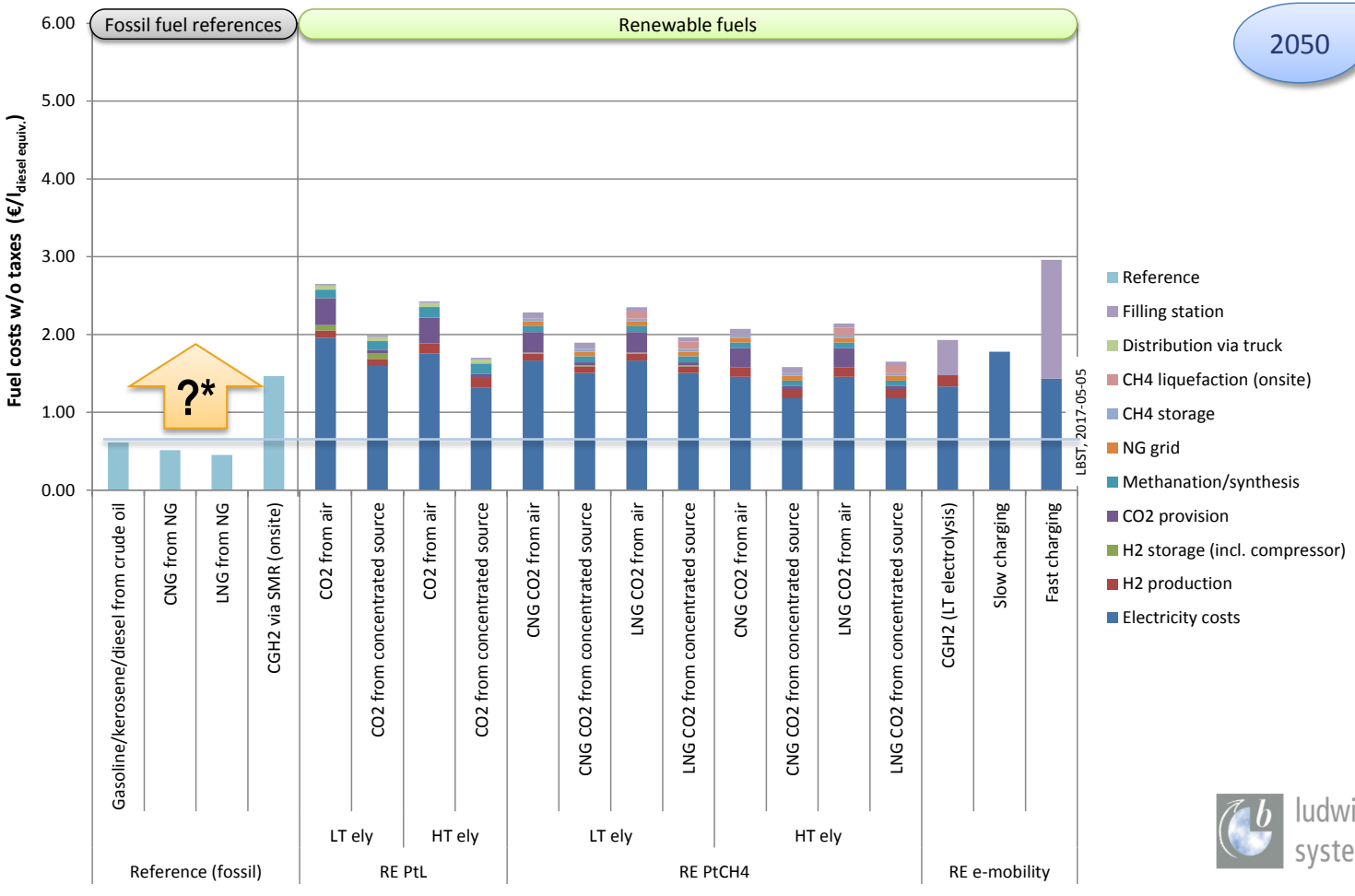
FUEL COSTS PER LITER | EU-28 | 2050



2050

6.3 ct/kWh electricity costs without grid for PtX plants

4000 h/a equivalent full load period for PtX plants

100 US$/bbl fossil liquids (IEA)

*Fuel costs, taxes/levies, other measures.

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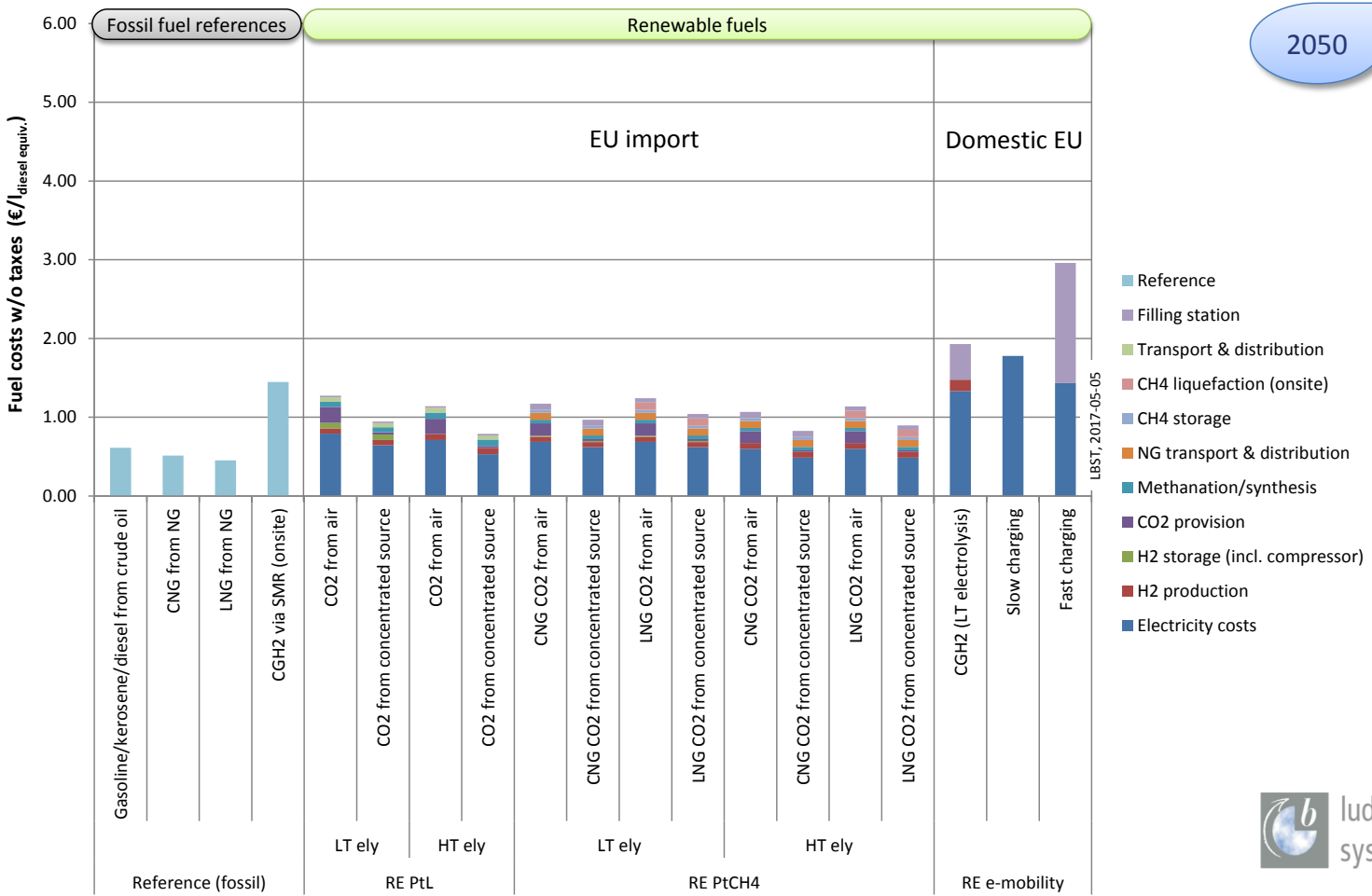
FUEL COSTS PER LITER | IMPORTS | 2050



2050

RE mix North Afr.:
3.4 ct/kWh w/ grid
6800 h_{eq}/a PtX

RE mix EU-28:
6.3 ct/kWh + grid
4000 h_{eq}/a PtX

100 US$/bbl
fossil liquids
(IEA)

*Fuel costs,
taxes/levies,
other measures.

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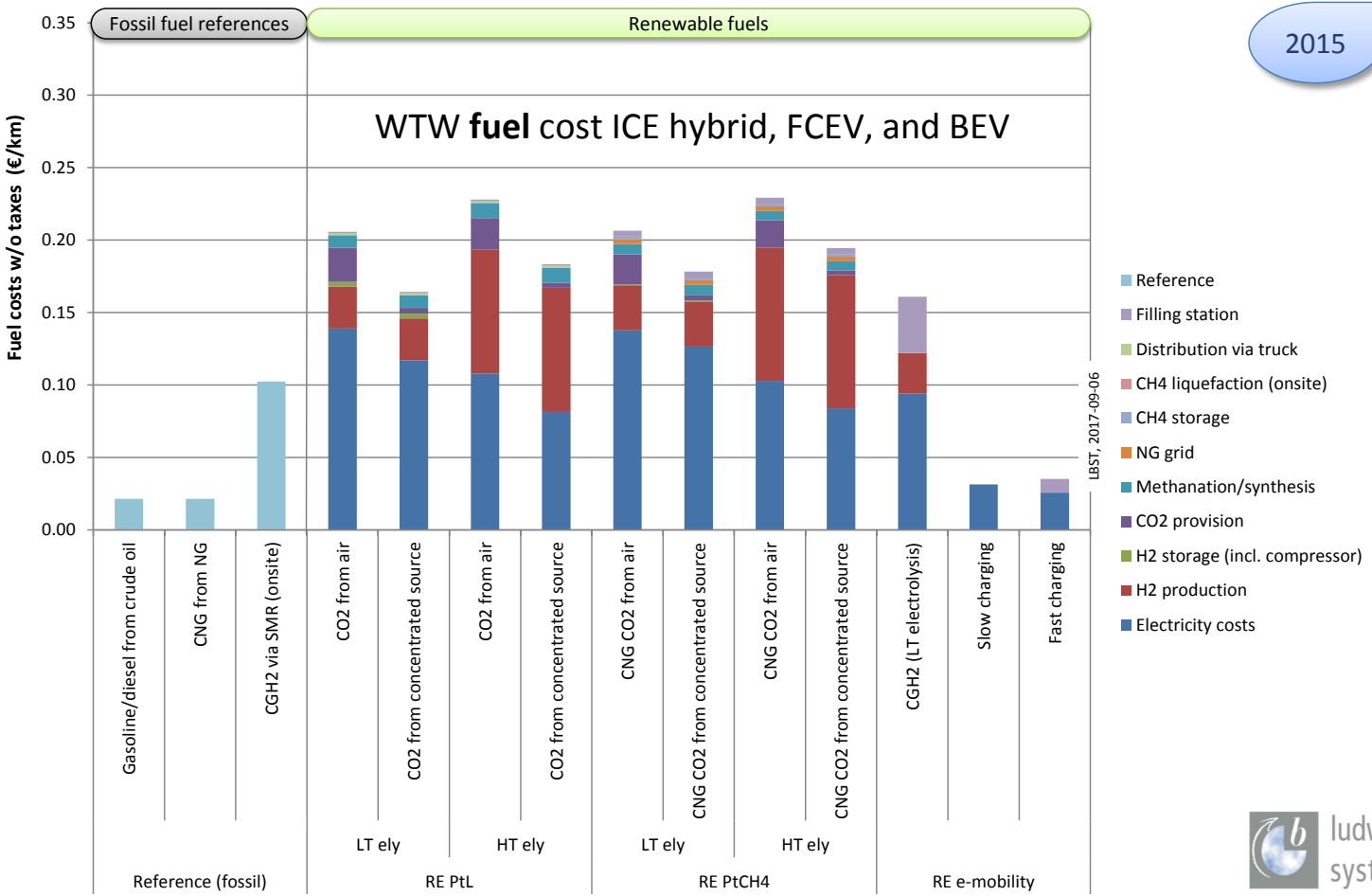
FUEL COSTS PER KILOMETER | EU 28 | 2015



2015

8.8 ct/kWh electricity costs without grid for PtX plants

4000 h/a equivalent full load period for PtX plants

60 US$/bbl fossil liquids (IEA)

0 €/t CO_2

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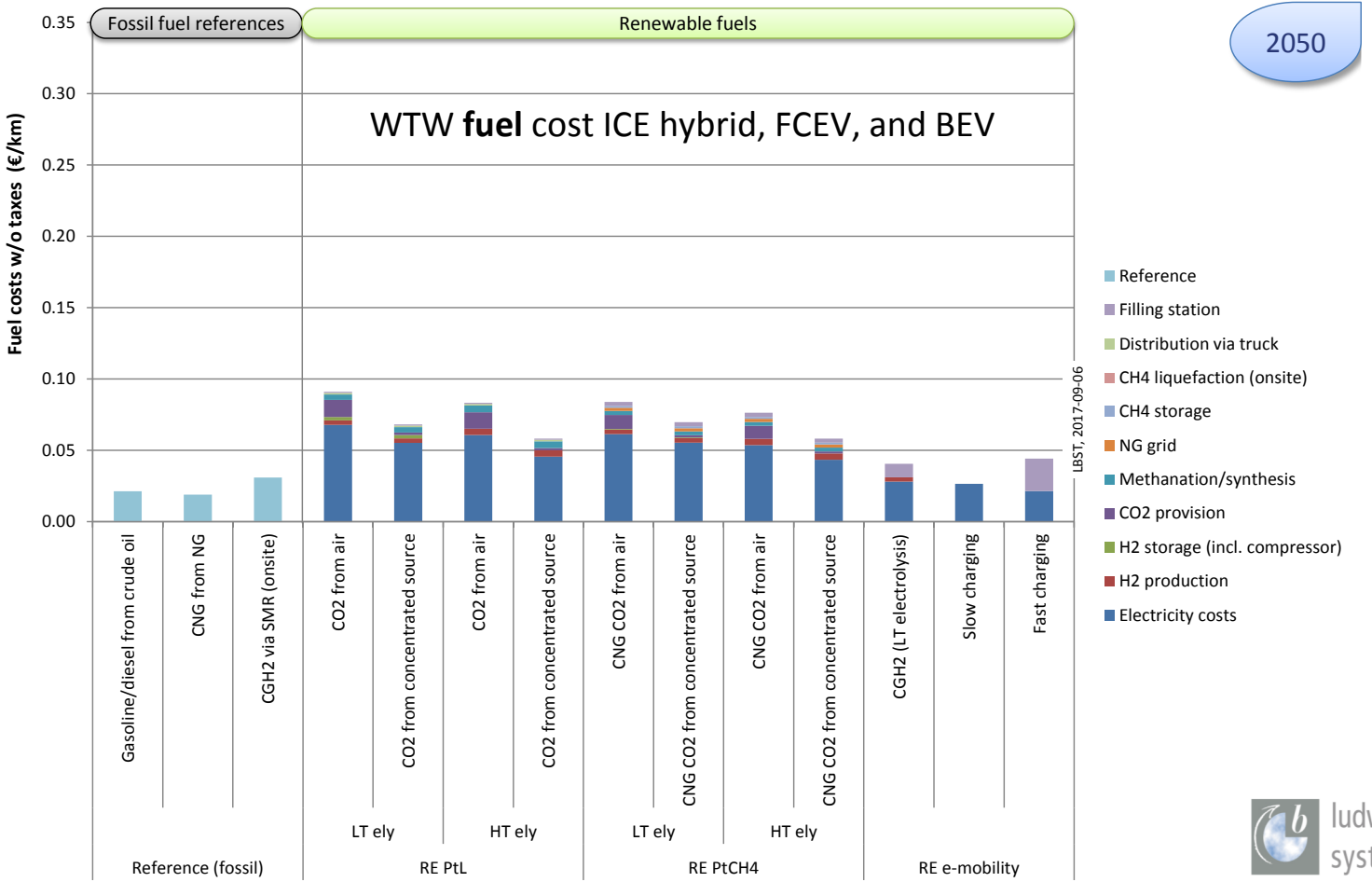
FUEL COSTS PER KILOMETER | EU 28 | 2050



6.3 ct/kWh electricity costs without grid for PtX plants

4000 h/a equivalent full load period for PtX plants

100 US$/bbl fossil liquids (IEA)

*Fuel costs, taxes/levies, other measures.

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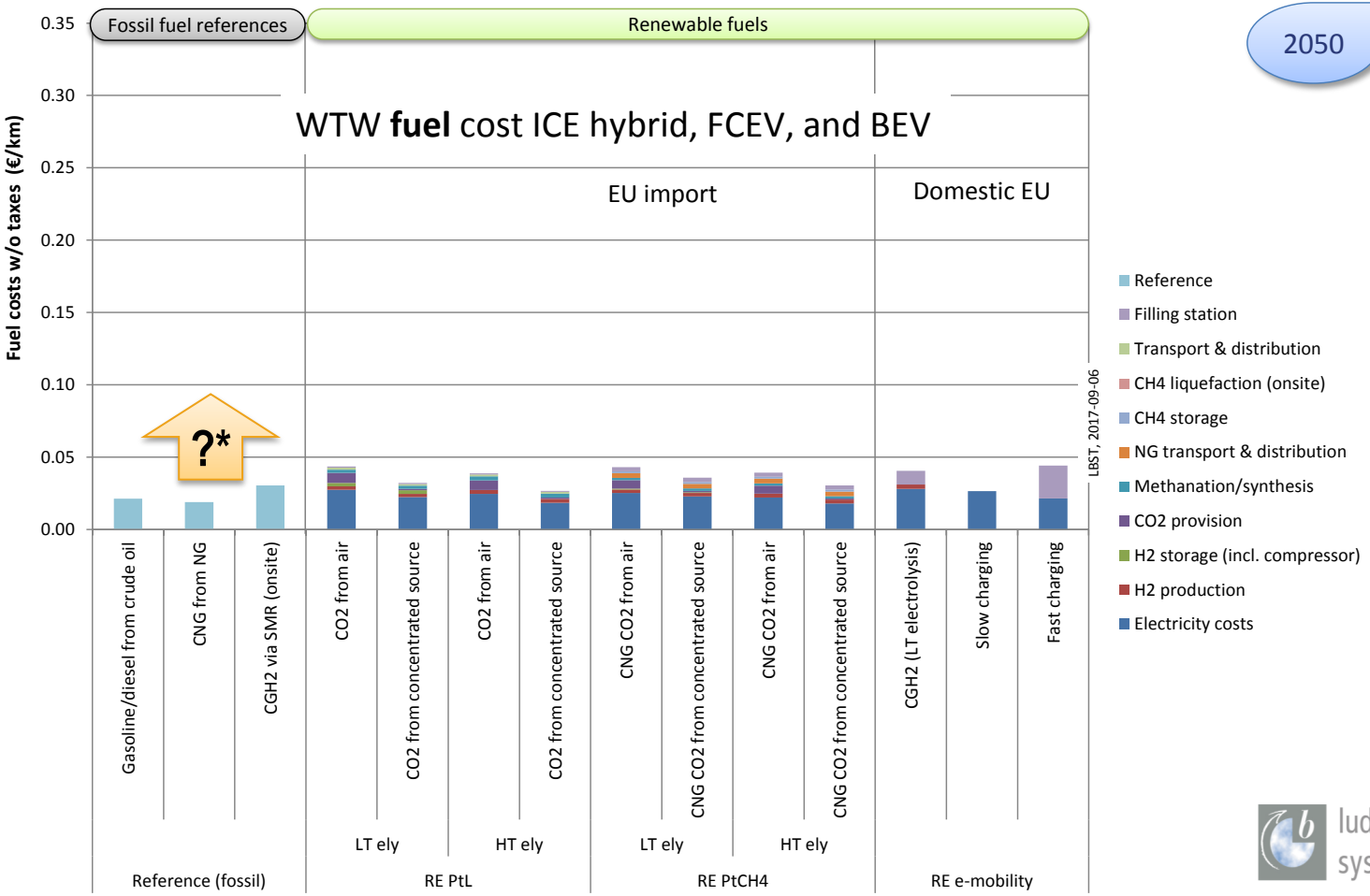
FUEL COSTS PER KILOMETER | IMPORTS | 2050



RE mix North Afr.:
3.4 ct/kWh w/ grid
6800 h_{eq}/a PtX

RE mix EU-28:
6.3 ct/kWh + grid
4000 h_{eq}/a PtX

100 US$/bbl
fossil liquids
(IEA)

*Fuel costs,
taxes/levies,
other measures.

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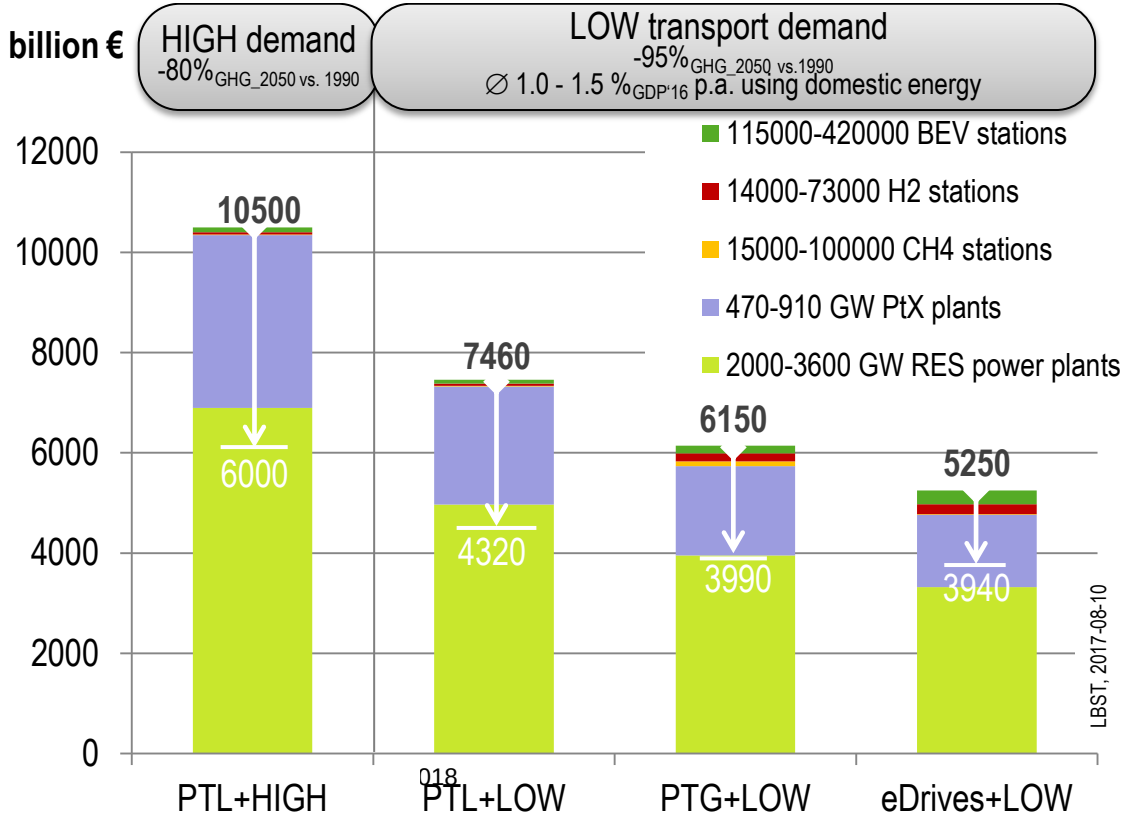
KUMULIERTE INVESTITIONEN BIS 2050

| EU DOMESTIC ENERGY (SENSITIVITY: PTCH4 & PTL IMPORTS)



- Die kumulierten Investitionskosten bis 2050 sind im eDrive Szenario 15 bis 30% geringer
- E-Fuels Importe aus sehr guten Standorten außerhalb der EU können die Kosten deutlich senken (weißer Pfeil).

EU domestic energy supply

↓

Full import of $PtCH_4$ & PtL

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VORAUSSETZUNGEN ZUM ERREICHEN DER KLIMAZIELE

To reach 2030/2050 greenhouse gas emission targets in transport it is necessary to address different policy areas

Renewable Energy

Are the basis to defossilise all transport modes

Necessary to a large extent in order to achieve post 2030 GHG targets independently of powertrain scenarios.

EU RE potential and the one abroad have to be exploited much quicker

It needs more ambitious EU RE goals until 2030 and thereafter as well

Energy Efficiency

Is the basis to compensate transport growth

Necessary to reduce RE-expansion and RE-costs

Important to limit energy dependency from abroad

Has a competitive advantage in times of high fuel costs

Clear and ambitious efficiency goals for road transport would provide all market players the same level of investment security

Transport Demand

Makes the difference of how fast GHG emission targets can be achieved

Is the major factor besides energy efficiency to limit costs for RE-expansion

Lower transport demand offers potential to strengthen regional value chains and new businesses

An integrated sustainable mobility strategy should accompany the energy transition in transport

Grid Stability

Energy security is an EU competitive factor

An energy system based on a high share of fluctuating RE needs besides DSM- incentives long-term storage capacities

Transport sector could benefit from an e-fuels strategy which aims to deploy (large scale) e-fuels capacities and to gain technology leadership. But as a co-benefit RE-use and grid stability could be optimized as well.

2030
-30% GHG
vs. 2005
(~-8% vs. 1990)

2050
80-95% GHG
vs. 1990

ZUSAMMENFASSUNG – E-FUELS STUDIE

- Selbst in einer BEV-dominierten Szenario, wird 70 % der Energienachfrage des Verkehrs der EU durch E-Fuels gedeckt werden. Der Großteil der E-Fuels Nachfrage wird aus der Luftfahrt, der Schifffahrt und dem Straßengüterverkehr kommen.

- Wesentlicher Treiber für Energieverbrauch und THG-Emissionen ist die weiterhin steigende Verkehrsleistung.

- Der Strombedarf aus erneuerbaren Quellen für den Verkehr ist 2050 ca. 10 Mal höher als die aktuelle erneuerbare Stromproduktion der EU. Über 80% dieser Stromnachfrage wird für die Produktion von E-fuels benötigt.

- Die Kosten von E-Fuels sind derzeit sehr hoch (bis ca. 4,50 € pro Liter Diesel Äquivalent). Die Kosten könnten sich jedoch auf etwa 1€ bei Importen aus Regionen mit sehr guten Sonnen- und Windbedingungen reduzieren.

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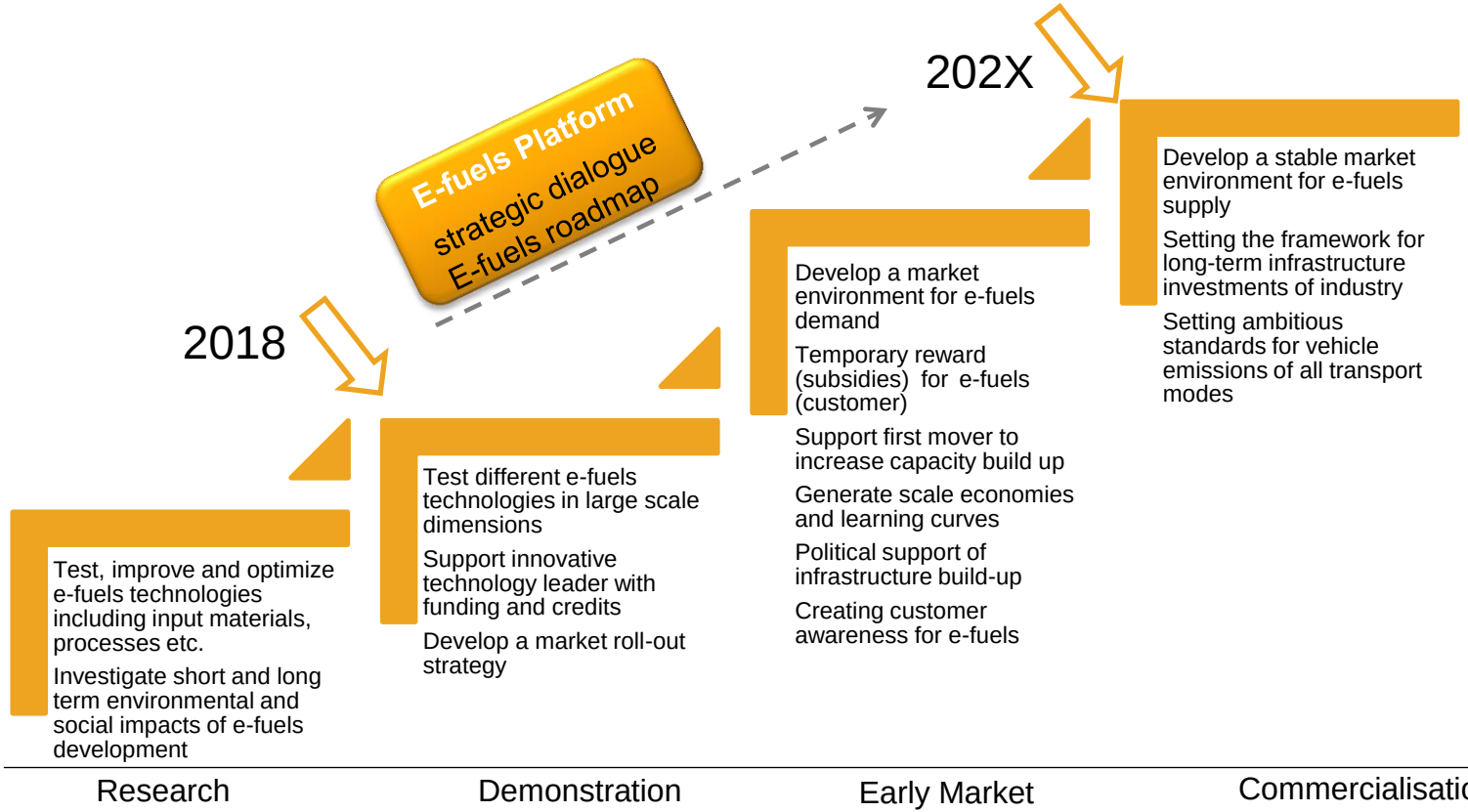
SCHRITTE ZUR E-FUELS MARKTREIFE



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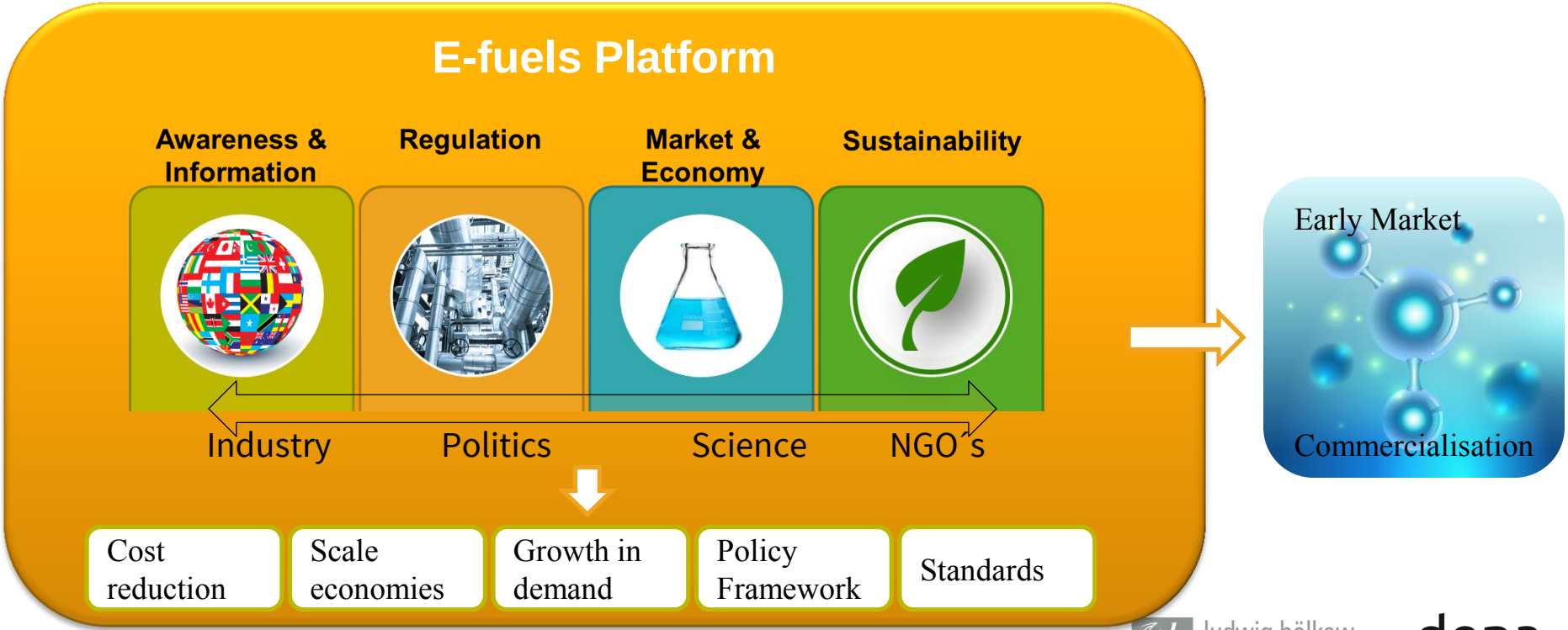
INTERNATIONALE E-FUELS PLATTFORM ALS NUKLEUS DER MARKTENTWICKLUNG



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VIELEN DANK FÜR IHRE AUFMERKSAMKEIT

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