SHELL WASSERSTOFF-STUDIE

ENERGIE DER ZUKUNFT?

Nachhaltige Mobilität durch Brennstoffzelle und H_2

Erstellt durch Shell in Zusammenarbeit
mit dem Wuppertal Institut

Wuppertal Institut

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This presentation contains forward-looking statements concerning the financial condition, results of operations and businesses of Royal Dutch Shell. All statements other than statements of historical fact are, or may be deemed to be, forward-looking statements. Forward-looking statements are statements of future expectations that are based on management's current expectations and assumptions and involve known and unknown risks and uncertainties that could cause actual results, performance or events to differ materially from those expressed or implied in these statements. Forward-looking statements include, among other things, statements concerning the potential exposure of Royal Dutch Shell to market risks and statements expressing management's expectations, beliefs, estimates, forecasts, projections and assumptions. These forward-looking statements are identified by their use of terms and phrases such as ''anticipate'', ''believe'', ''could'', ''estimate'', ''expect'', ''goals'', ''intend'', ''may'', ''objectives'', ''outlook'', ''plan'', ''probably'', ''project'', ''risks'', "schedule", ''seek'', ''should'', ''target'', ''will'' and similar terms and phrases. There are a number of factors that could affect the future operations of Royal Dutch Shell and could cause those results to differ materially from those expressed in the forward-looking statements included in this presentation, including (without limitation): (a) price fluctuations in crude oil and natural gas; (b) changes in demand for Shell's products; (c) currency fluctuations; (d) drilling and production results; (e) reserves estimates; (f) loss of market share and industry competition; (g) environmental and physical risks; (h) risks associated with the identification of suitable potential acquisition properties and targets, and successful negotiation and completion of such transactions; (i) the risk of doing business in developing countries and countries subject to international sanctions; (j) legislative, fiscal and regulatory developments including regulatory measures addressing climate change; (k) economic and financial market conditions in various countries and regions; (l) political risks, including the risks of expropriation and renegotiation of the terms of contracts with governmental entities, delays or advancements in the approval of projects and delays in the reimbursement for shared costs; and (m) changes in trading conditions. All forward-looking statements contained in this presentation are expressly qualified in their entirety by the cautionary statements contained or referred to in this section. Readers should not place undue reliance on forward-looking statements. Additional risk factors that may affect future results are contained in Royal Dutch Shell's 20-F for the year ended December 31, 2015 (available at www.shell.com/investor and www.sec.gov). These risk factors also expressly qualify all forward looking statements contained in this presentation and should be considered by the reader. Each forward-looking statement speaks only as of the date of this presentation, March 9th 2017. Neither Royal Dutch Shell plc nor any of its subsidiaries undertake any obligation to publicly update or revise any forward-looking statement as a result of new information, future events or other information. In light of these risks, results could differ materially from those stated, implied or inferred from the forward-looking statements contained in this presentation.

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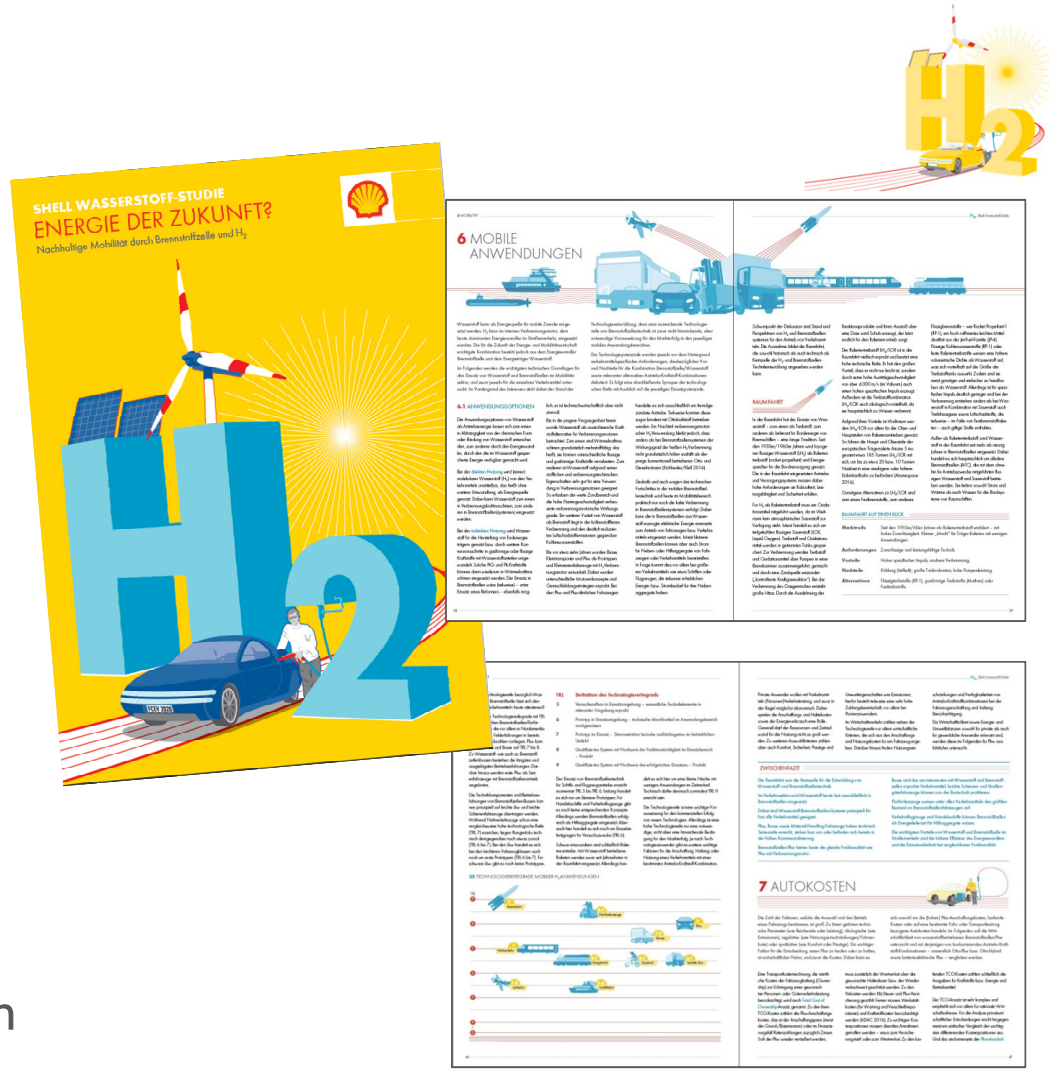
Shell Wasserstoff-Studie

- Shell Szenariostudien (seit 1958)
- Shell schon lange in H_2 FuE, Erzeugung/Anwendung
- eigene Business Unit Shell Hydrogen
- Wassersstoff-Studie → welche Ziele?
  - Zukunftspotenziale abschätzen
  - Business Opportunities analysieren
  - Schwerpunkt (Auto)Mobilität
  - Geschäftspartner/Kunden/Stakeholder informieren
- Kooperation mit Wuppertal Institut

Studien-Inhalte

1) H_2-Eigenschaften
2) Erzeugungs-/Bereitstellungspfade
3) Speicherung/Transport
4) Nutzungspfade → stofflich/energetisch
5) Stationäre Nutzung
6) Mobile Nutzung (Technologiereife)
7) Autokosten (Wirtschaftlichkeit)
8) Tankstellen-Infrastrukturaufbau
9) FCEV-Flotten, Energie-/Umweltbilanzen

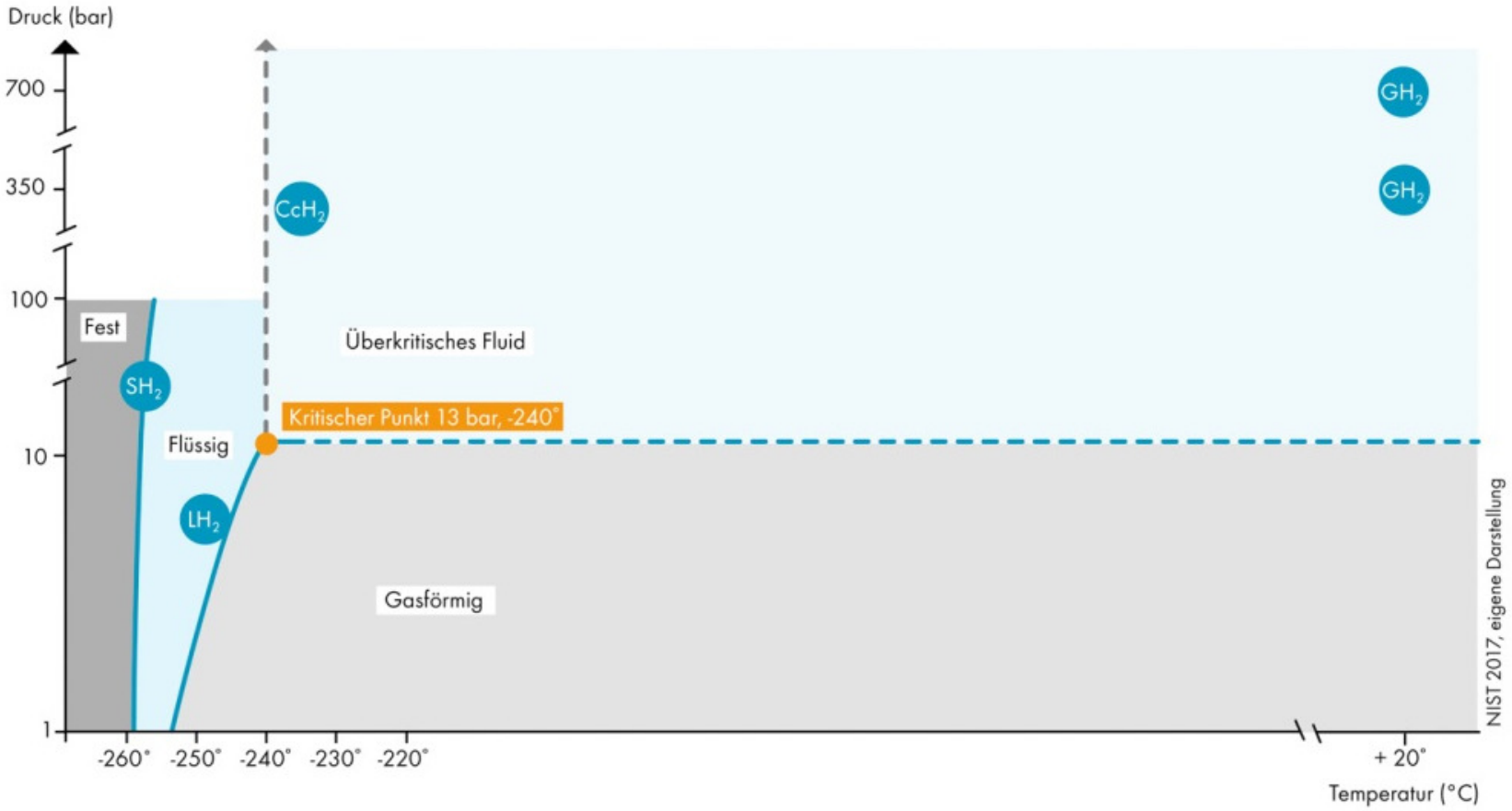


Jules Verne: Wasser - die neue Kohle?

Dieter Zetsche: Wasserstoff - das bessere Öl?

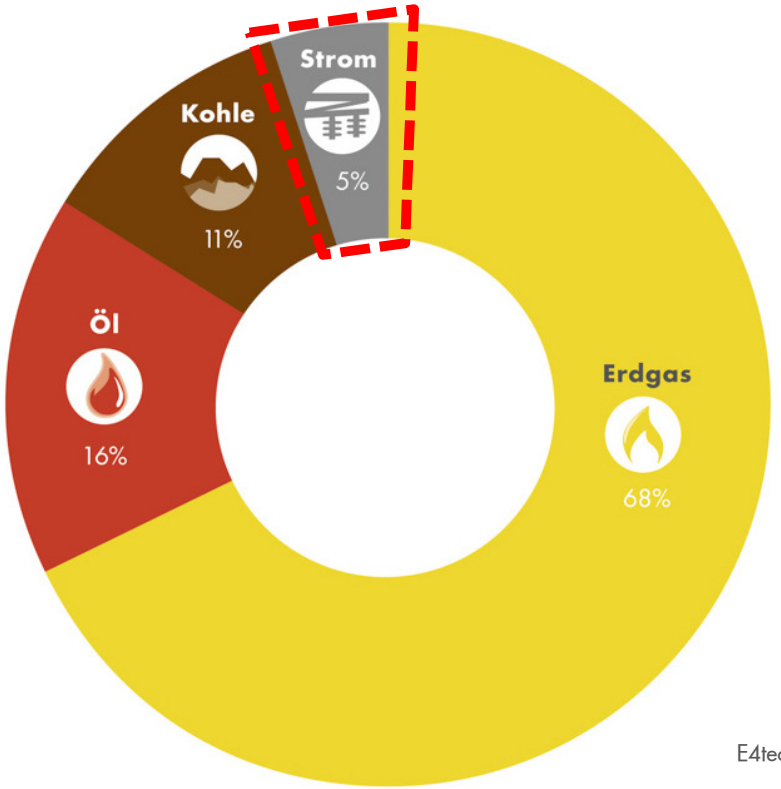
Welche Rolle wird Wasserstoff künftig als Energieträger spielen?

Phasen-Diagramm Wasserstoff



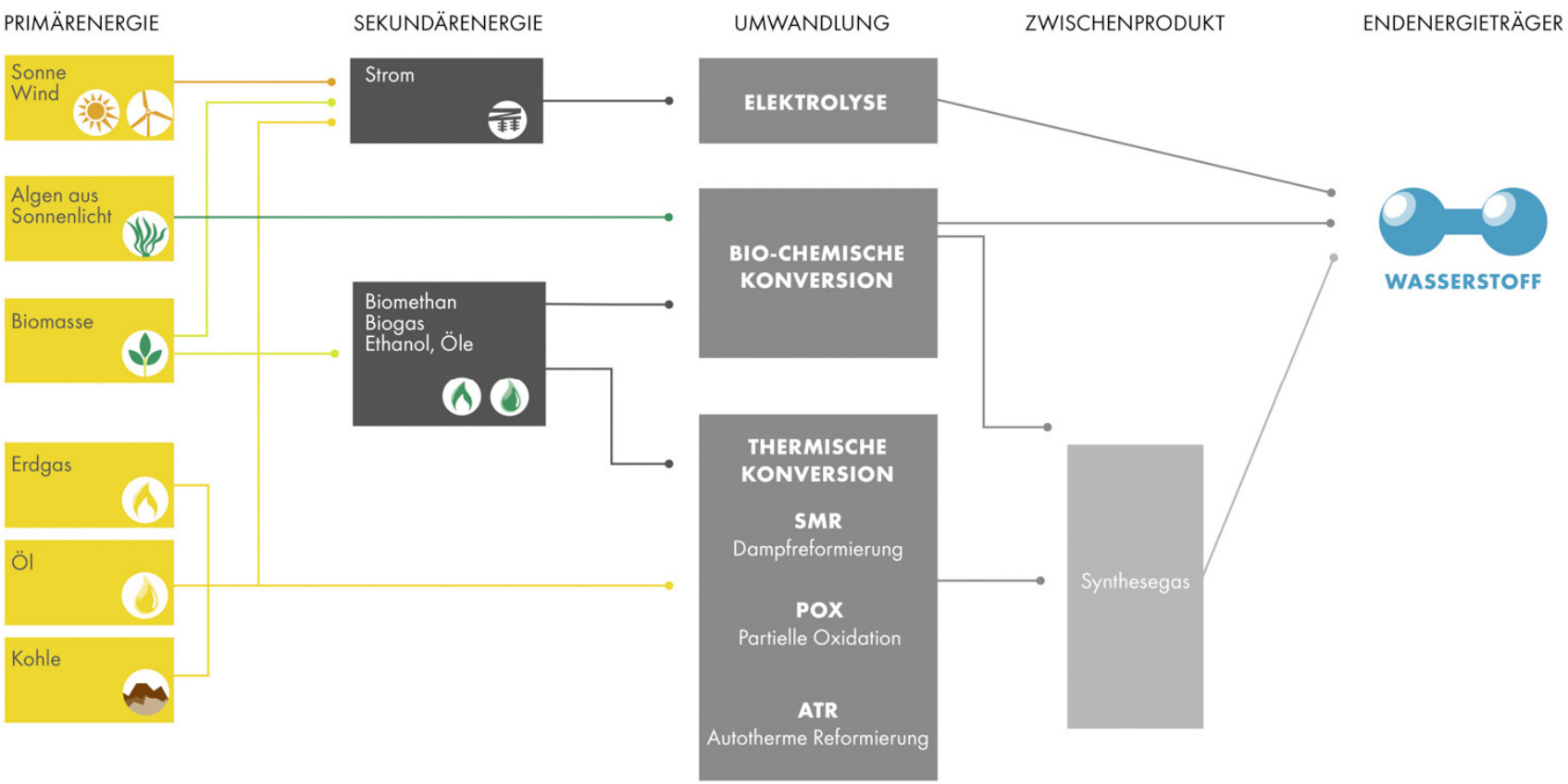
Primärenergien → Wasserstoff

- Wasserstoff (H_2) kommt in der Natur nur in gebundener Form vor
- unterschiedliche Primärenergien für Wasserstoffherstellung möglich
- wichtigste Primärenergie = Erdgas
- Strom = Sekundärenergie
  - Strommix aus Stromnetz
  - Strom aus erneuerbaren Energien

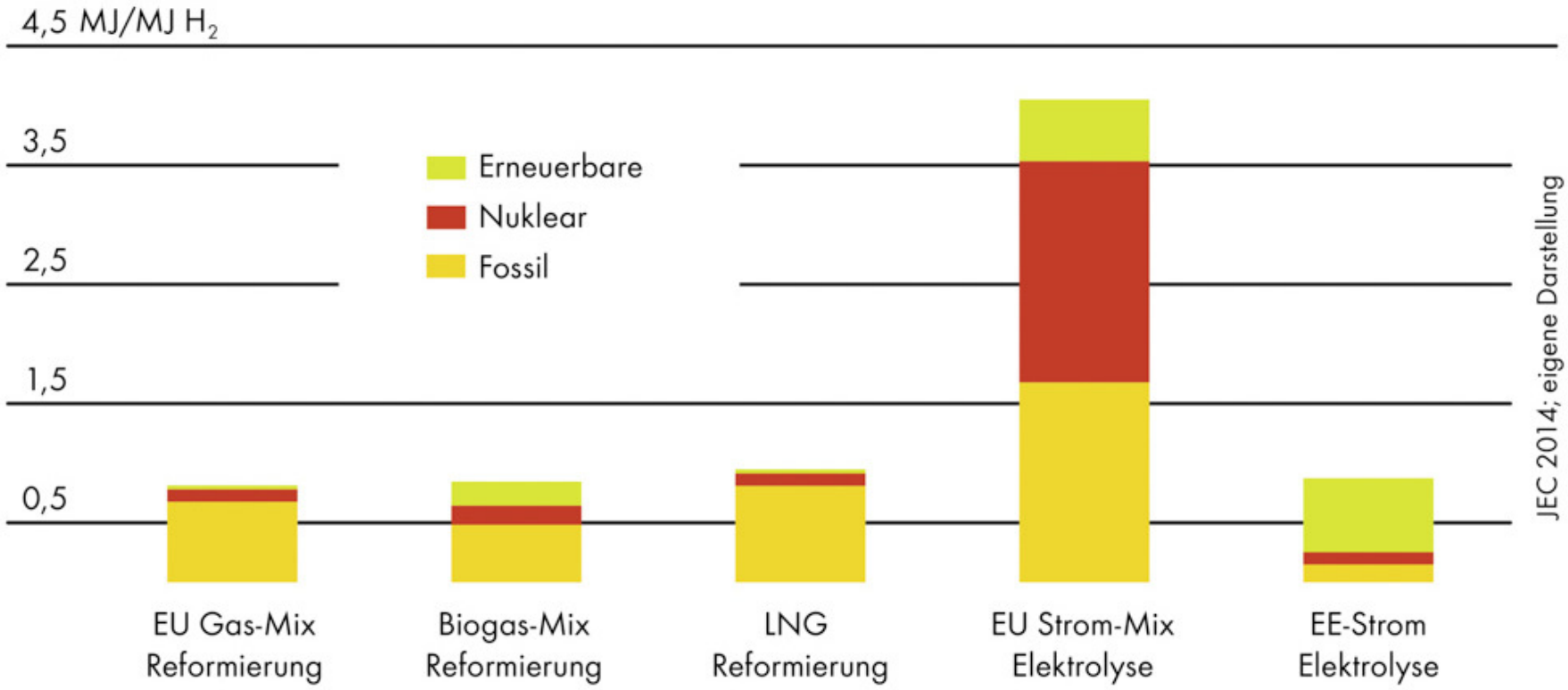


E4tech 2014

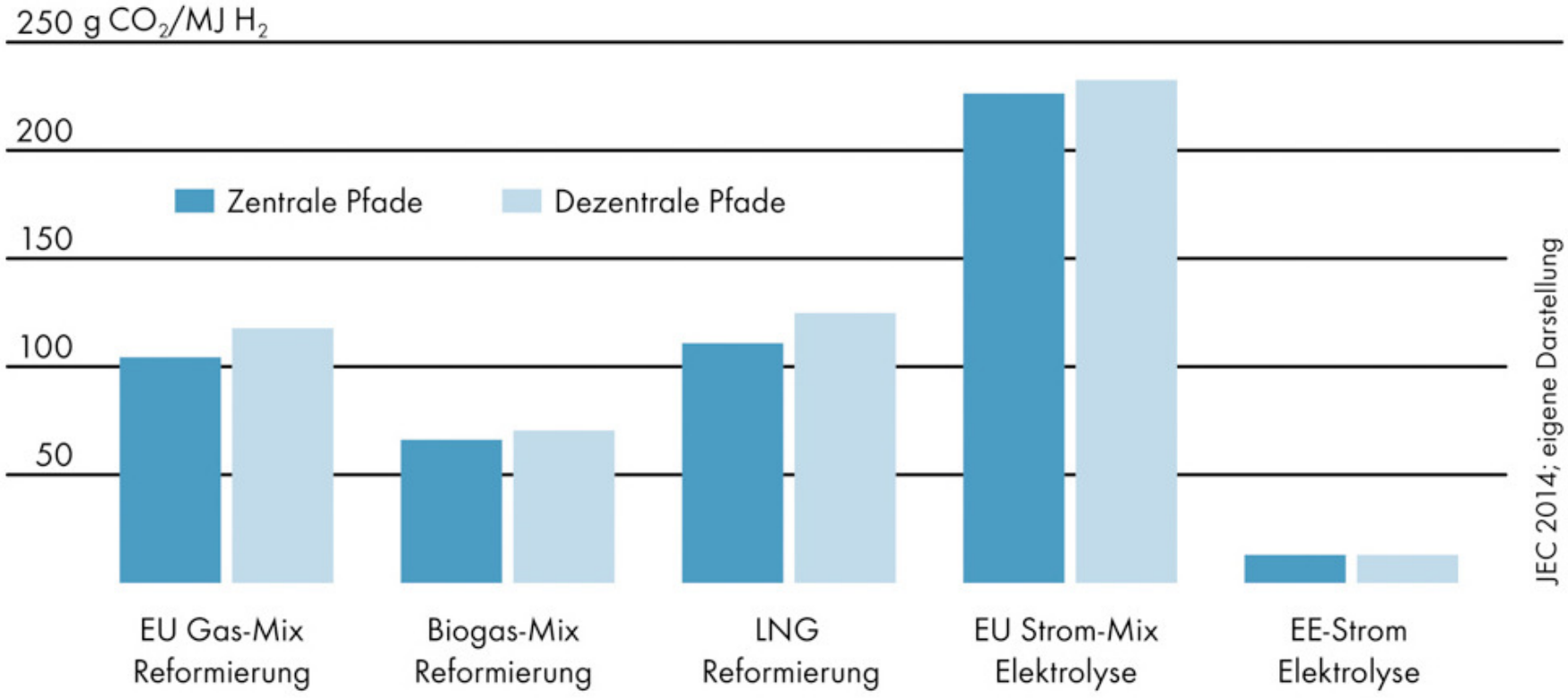
Bereitstellungspfade für Wasserstoff



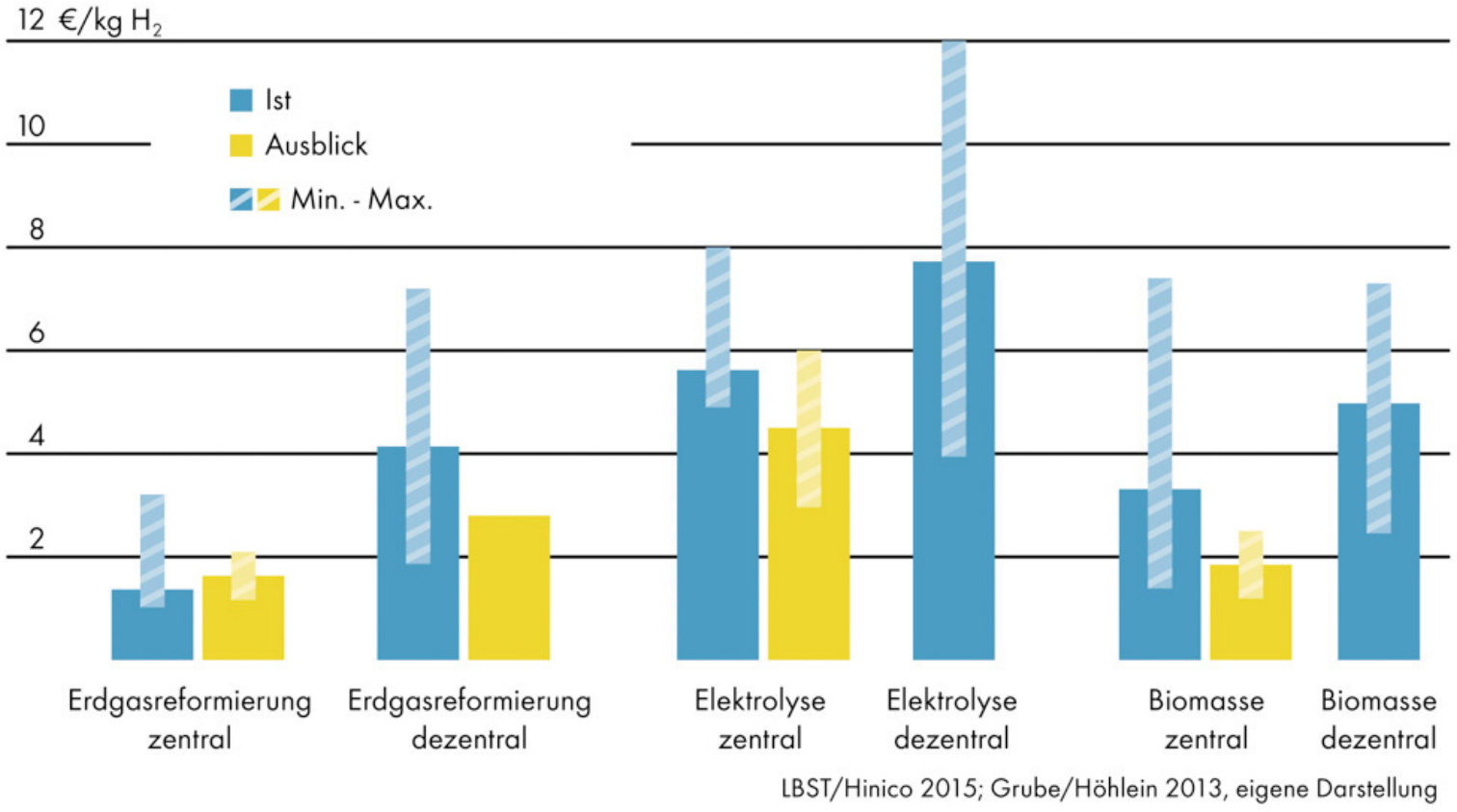
Primärenergie-Aufwand Wasserstoff-Bereitstellung



Treibhausgasemissionen Wasserstoff-Bereitstellung

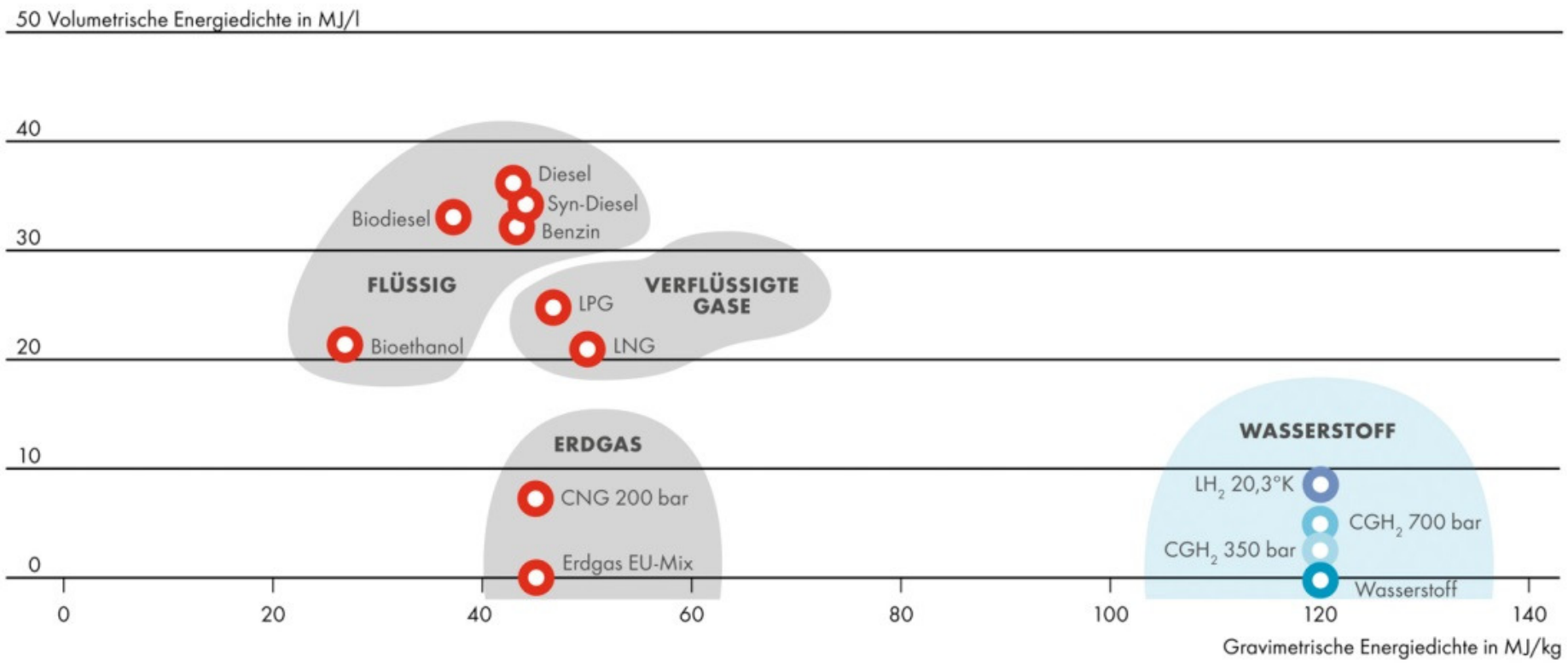


Kosten Wasserstoff-Herstellung



LBST/Hinico 2015; Grube/Höhlein 2013, eigene Darstellung

Energiedichte Kraftstoffe



Wasserstoff-Speichermethoden

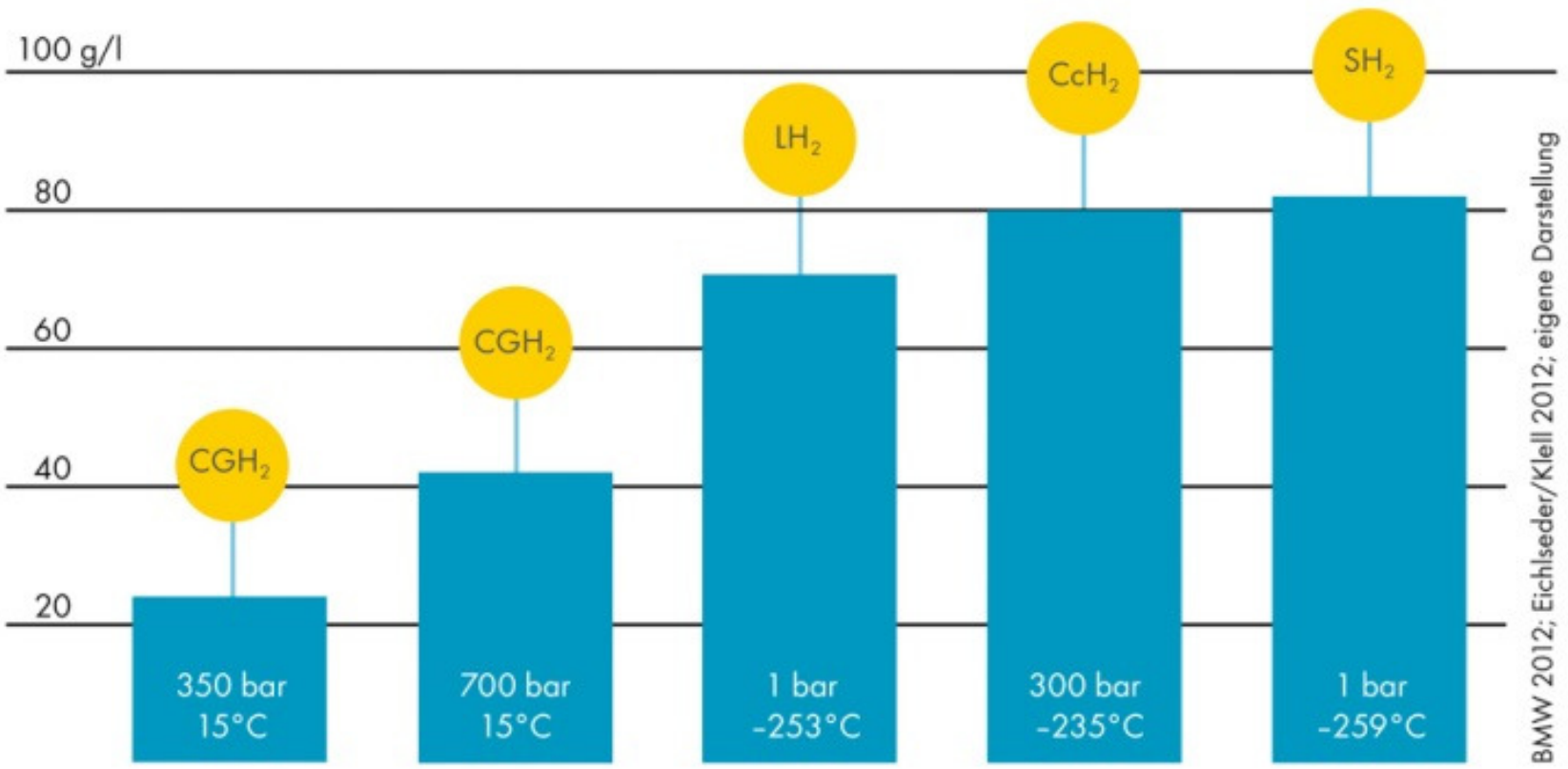
PHYSIKALISCH

- Compression CGH_2 (350, 700 bar)
- Verflüssigung LH_2
- Cryo-compressed Hydrogen $CcGH_2$
- Slush Hydrogen SH_2

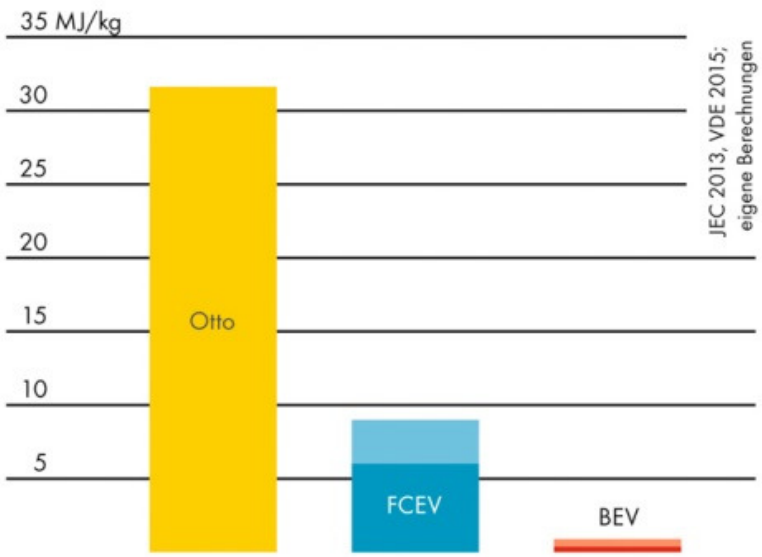
STOFFLICH

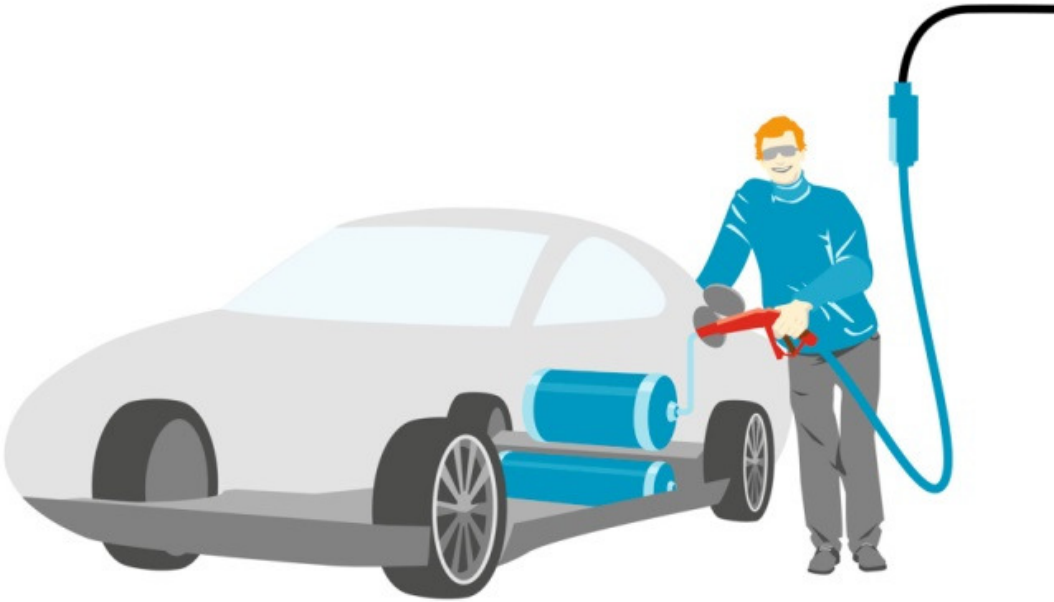
- Metall-Hydride
- Liquid Organic Hydrogen Carriers LOHCs
- Sorbente (MOFs, Zeolithe, Nanotubes)

Energiedichte Wasserstoff



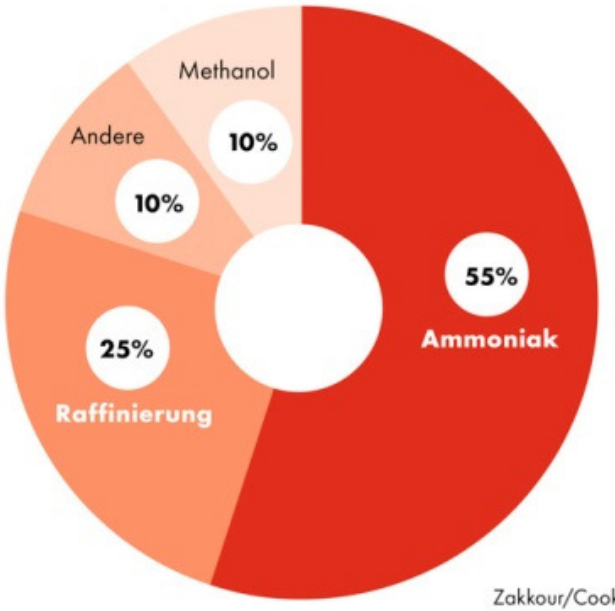
Energiedichte Pkw-Tanksysteme





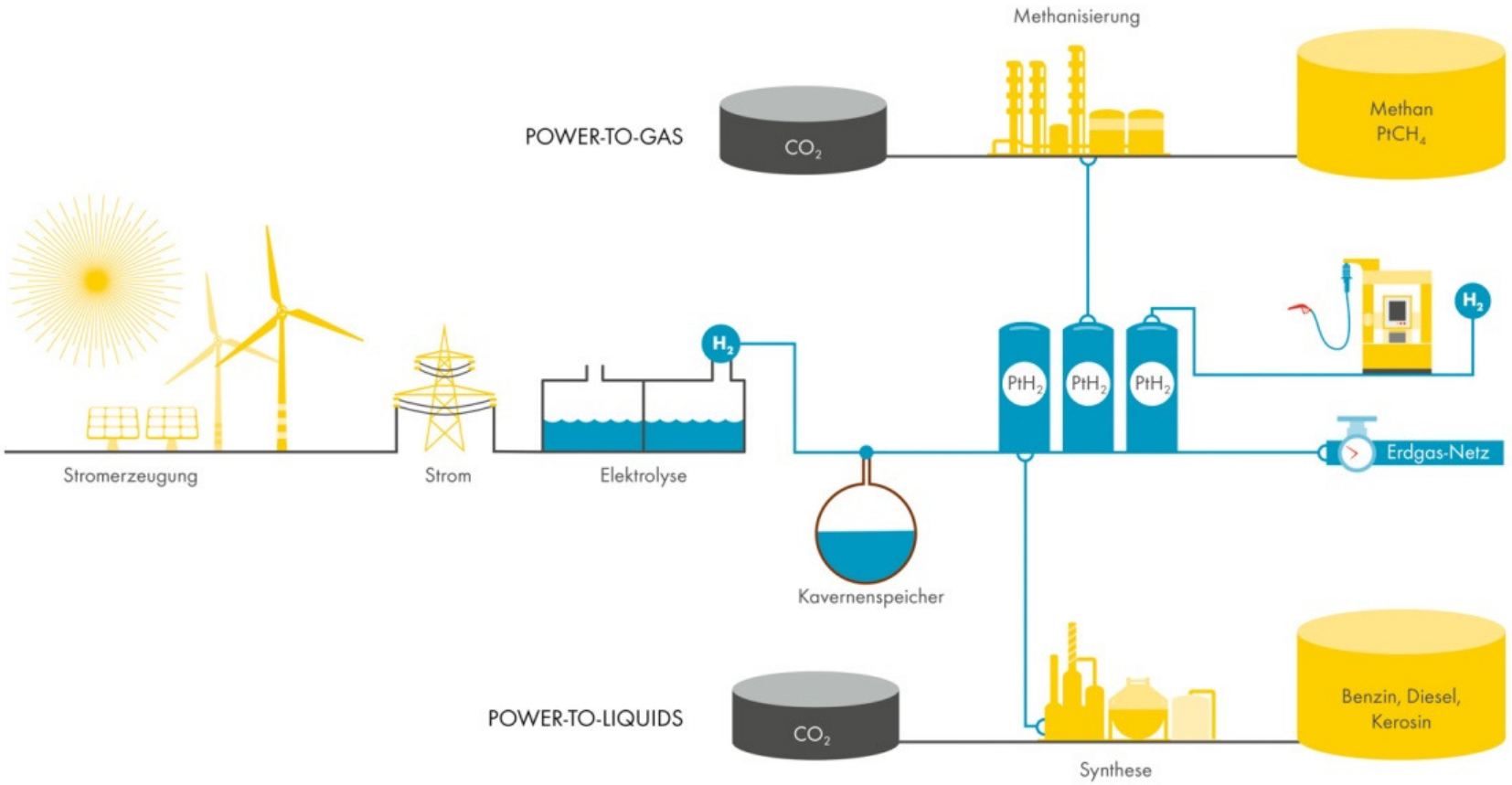
Wasserstoff-Nutzung

- globale H_2-Erzeugung: 45-50 Mio. T/a
- Einsatz als chemischer Ausgangsstoff und als technisches Industriegas
  - Ammoniak-Synthese
  - Methanol-Synthese
  - Veredelung von Ölprodukten
  - andere

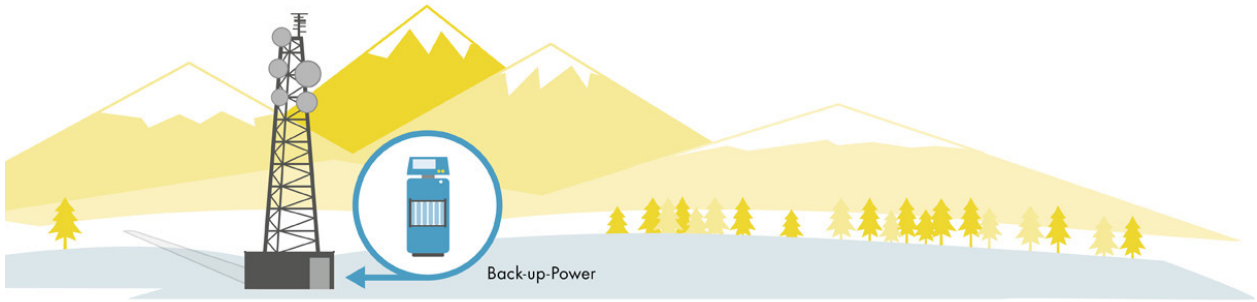


Zakkour/Cook 2010; eigene Darstellung

Wasserstoff im künftigen Energiesystem

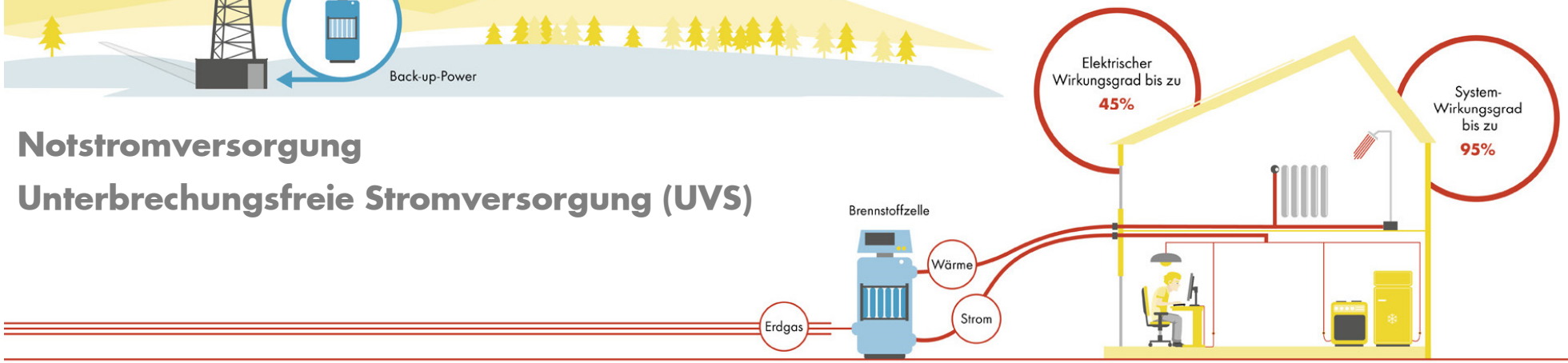


Stationäre Energie-Anwendungen



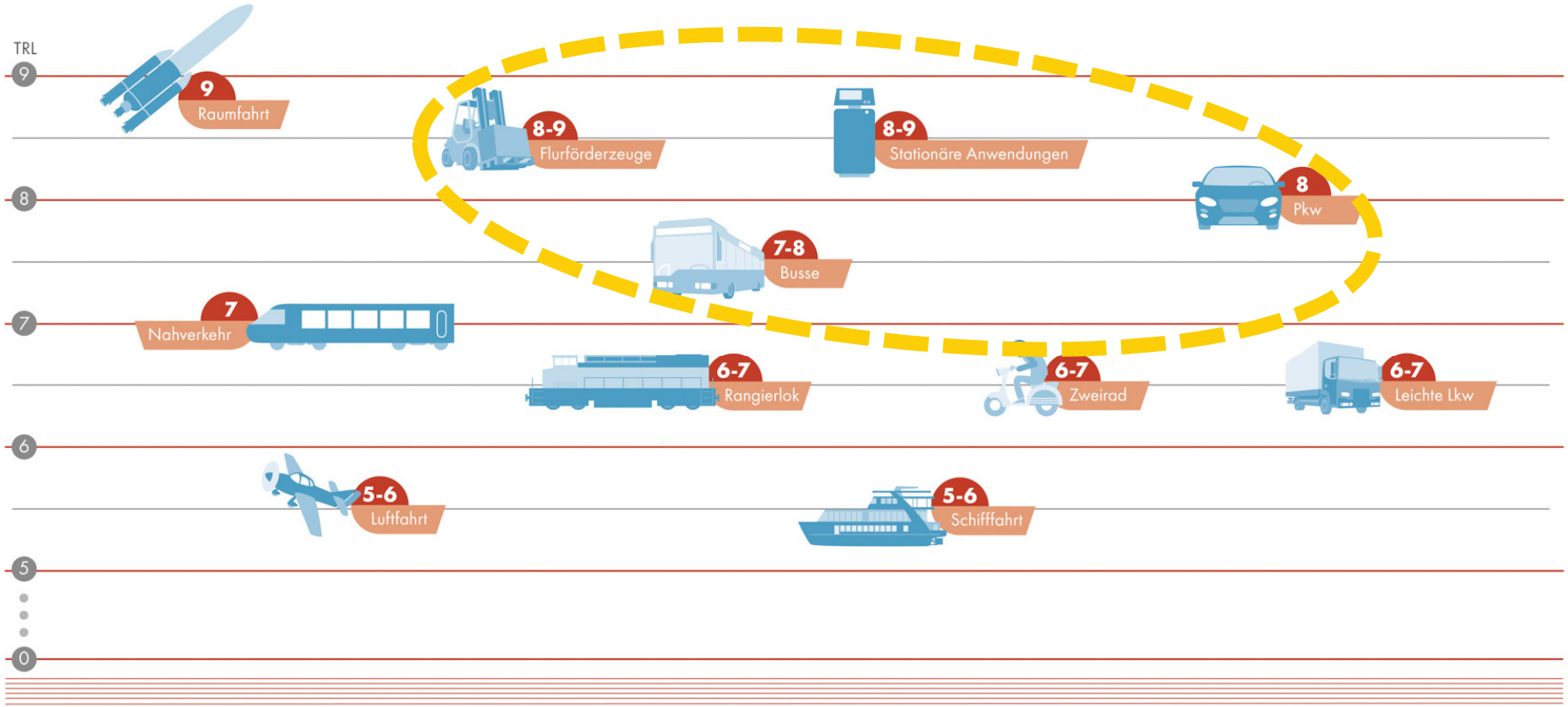
Notstromversorgung

Unterbrechungsfreie Stromversorgung (UVS)

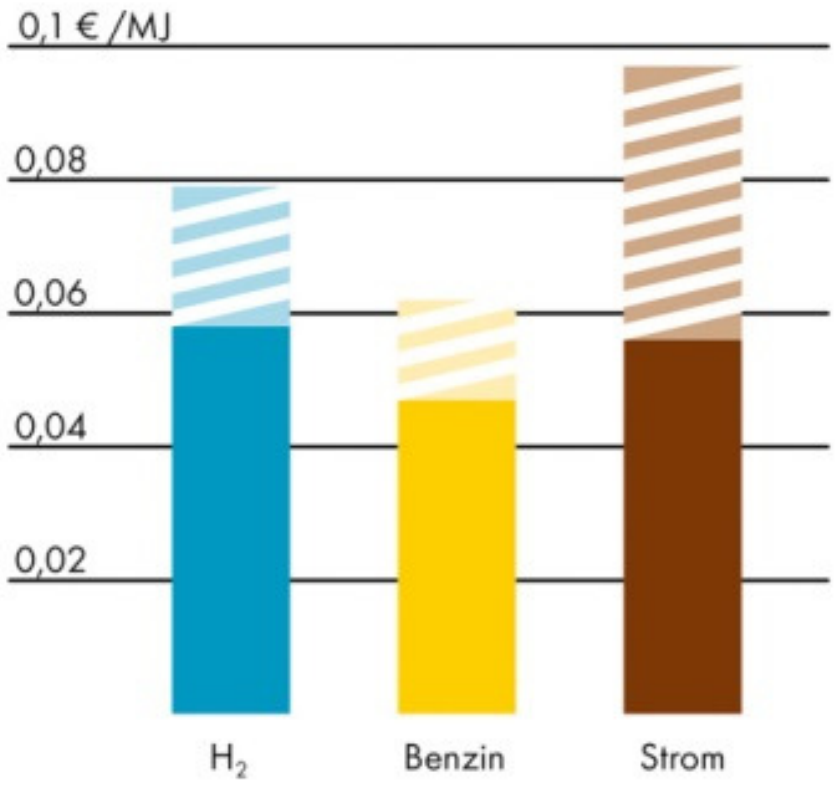


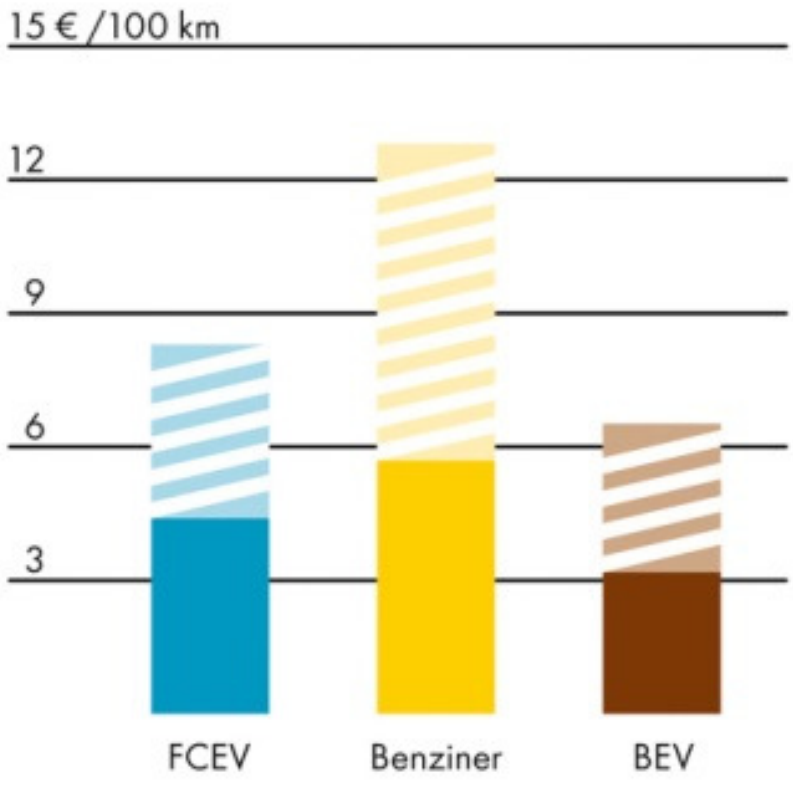
Mikro-KWK-Brennstoffzellen

Technologie-Reife (TRL) Wasserstoff-Anwendungen



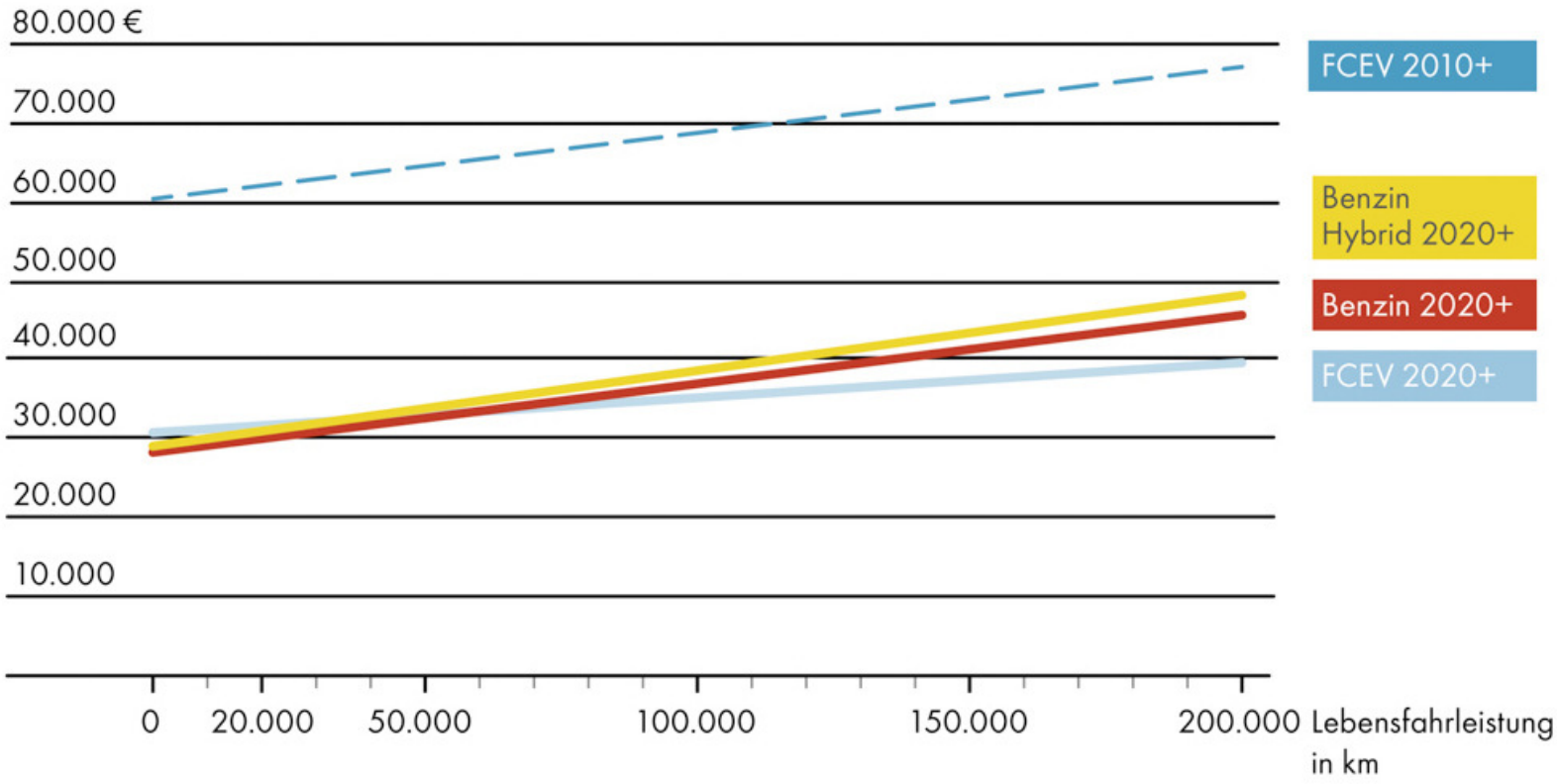
Kraftstoffkosten im Vergleich*





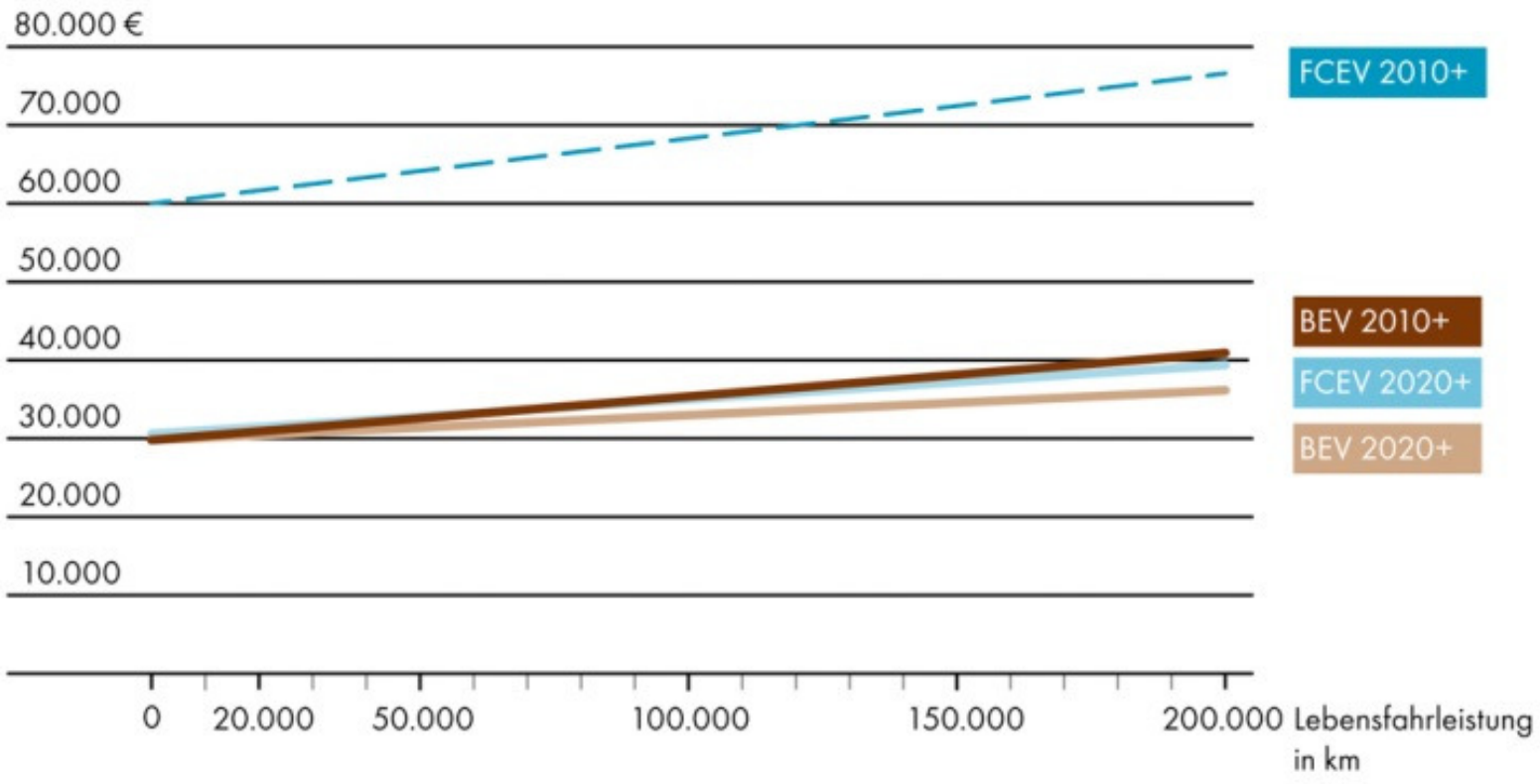
*europäische Kraftstoffpreise

Autokosten: Brennstoffzelle vs. Benziner*



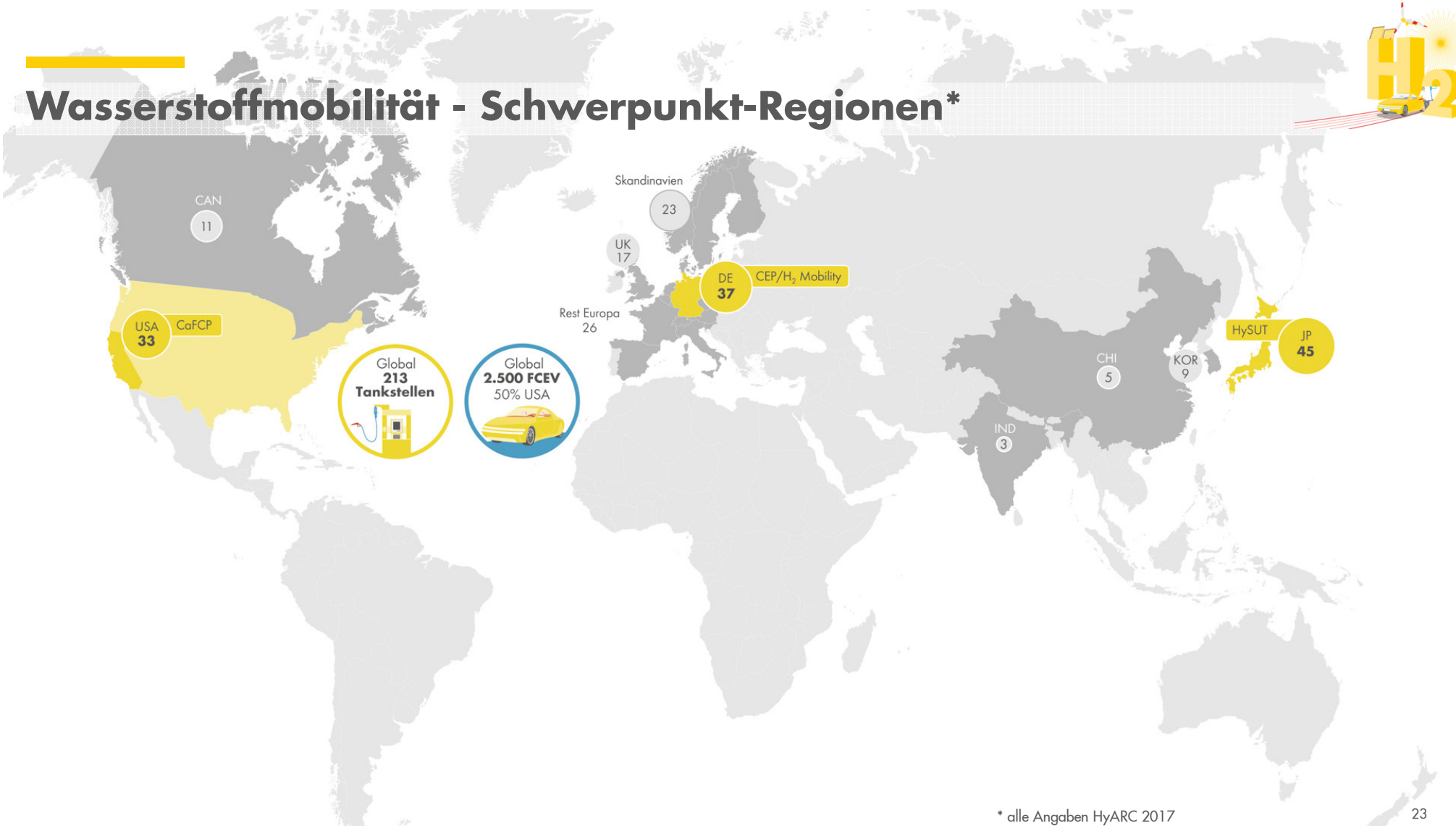
*vereinfachte Autokostenrechnung: Anschaffungs- und Kraftstoff/Energiekosten

Autokosten: Brennstoffzelle vs. BEV*



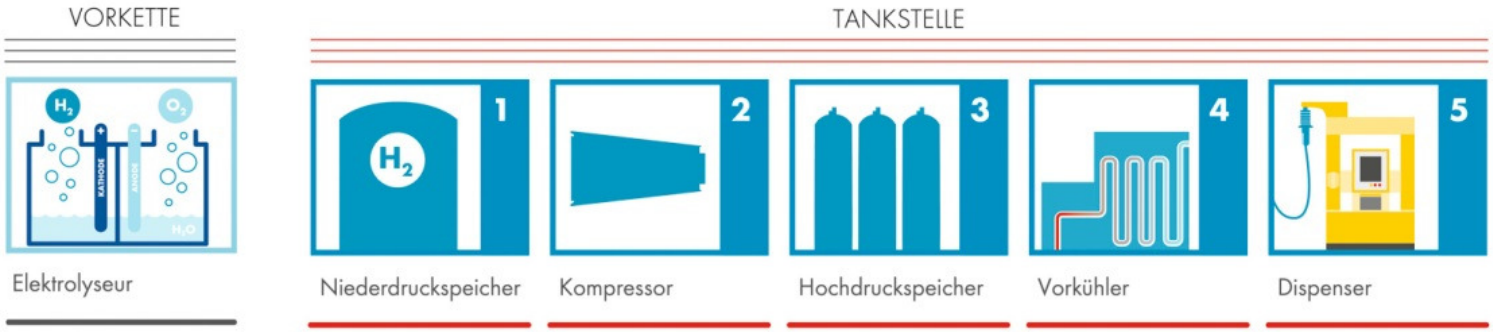
*vereintachte Autokostenrechnung: Anschattungs- und Krattstott/Energiekosten

Wasserstoffmobilität - Schwerpunkt-Regionen*

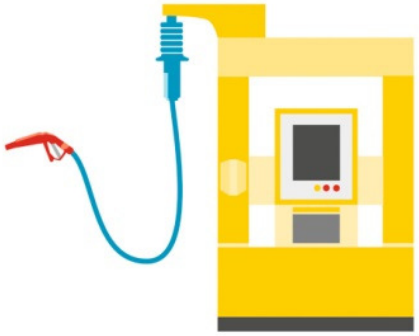


* alle Angaben HyARC 2017

Wasserstofftankstellen – Module/Grössen

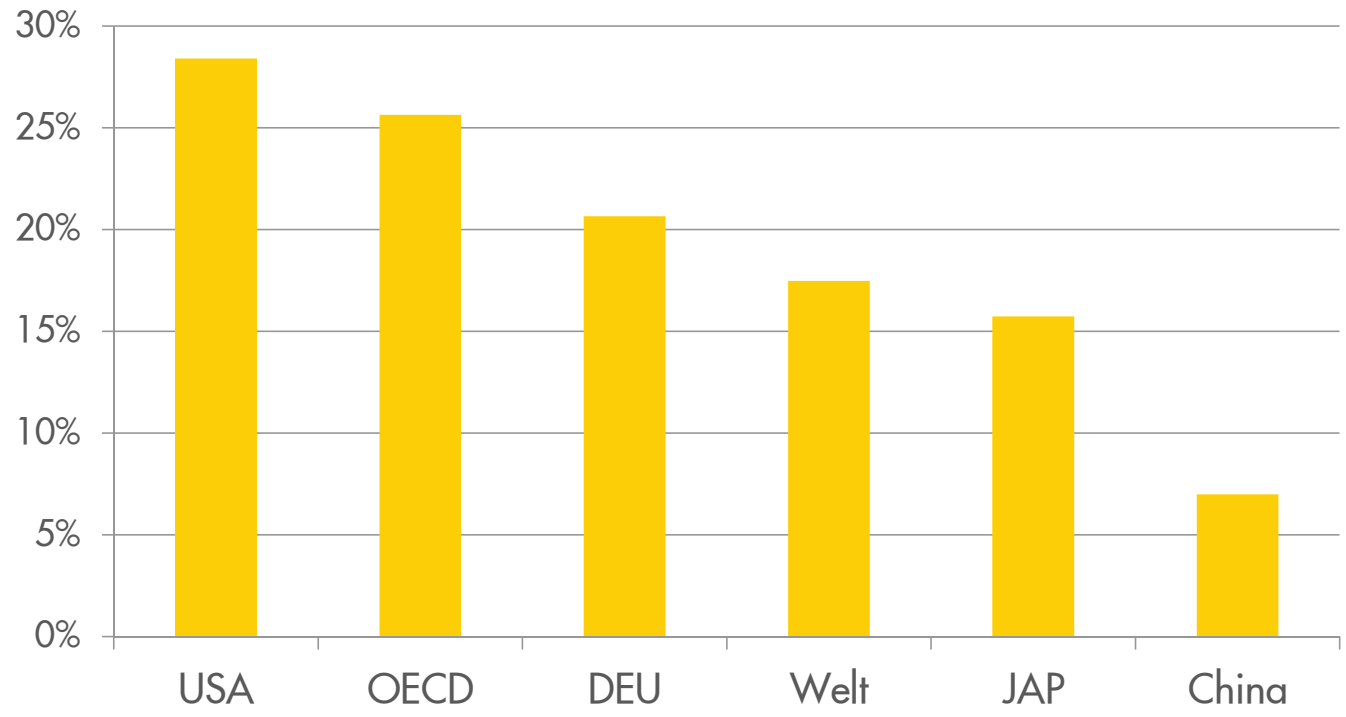


	Sehr klein XS	Klein S	Mittelgroß M	Groß L
Zapfpunkte	1	1	2	4
Maximaler Durchsatz pro Tag	80 kg	212 kg	420 kg	1000 kg
Maximale Betankungen pro Tag	20	38	75	180
Versorgte Fahrzeuge pro Station	100	400	800	1600



H_2M 2010

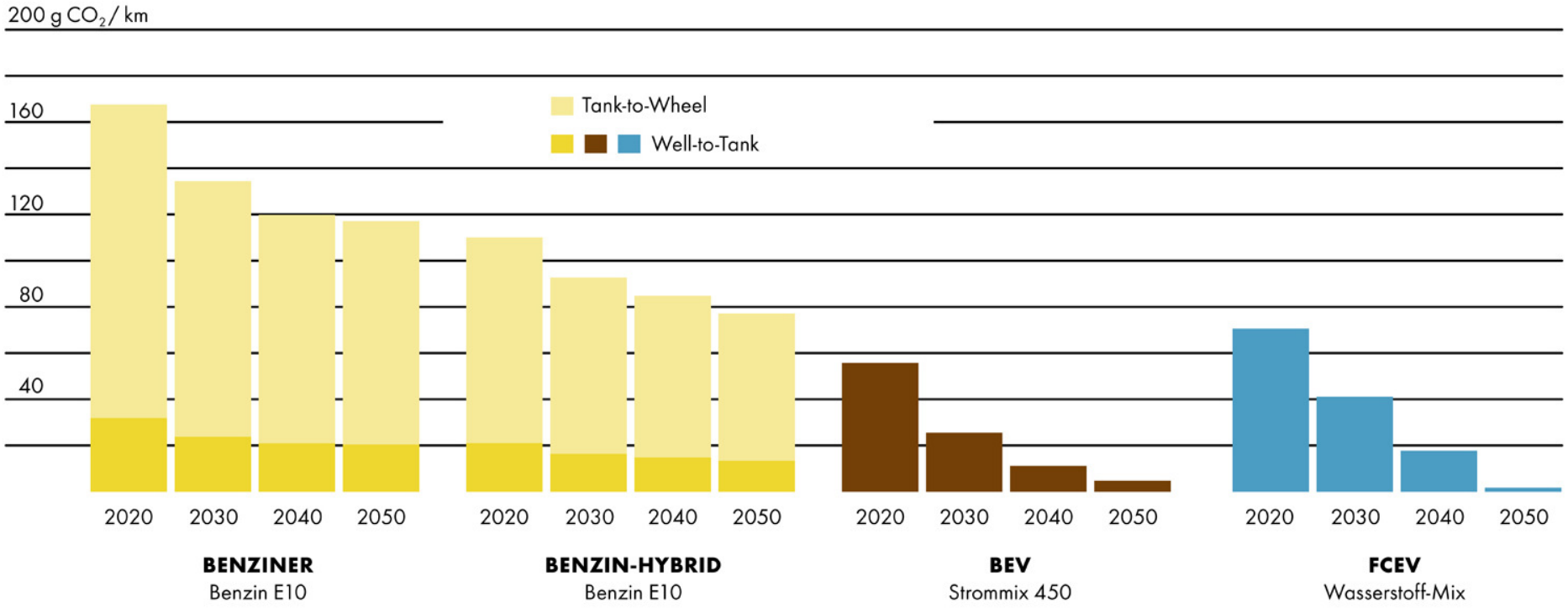
Signifikanter Beitrag Verkehr zur Erreichung des 2°C gefordert



Straßenverkehr
Δ1990-2014:
Welt: + 70%
OECD: + 30%

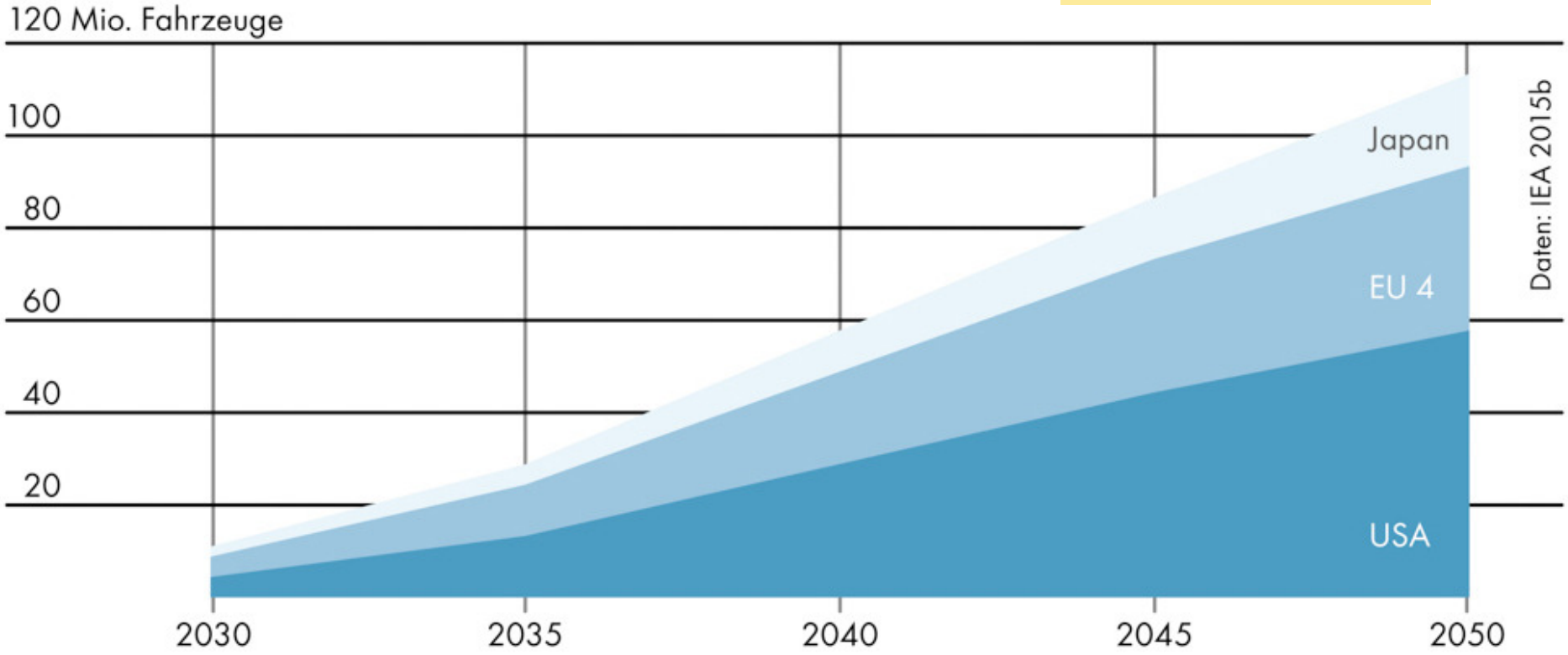
nur verbrennungsbedingte CO_2-Emsissionen; IEA 2016

Wasserstoff und Klimaschutz – spezifische Pkw-Treibhausgasemissionen



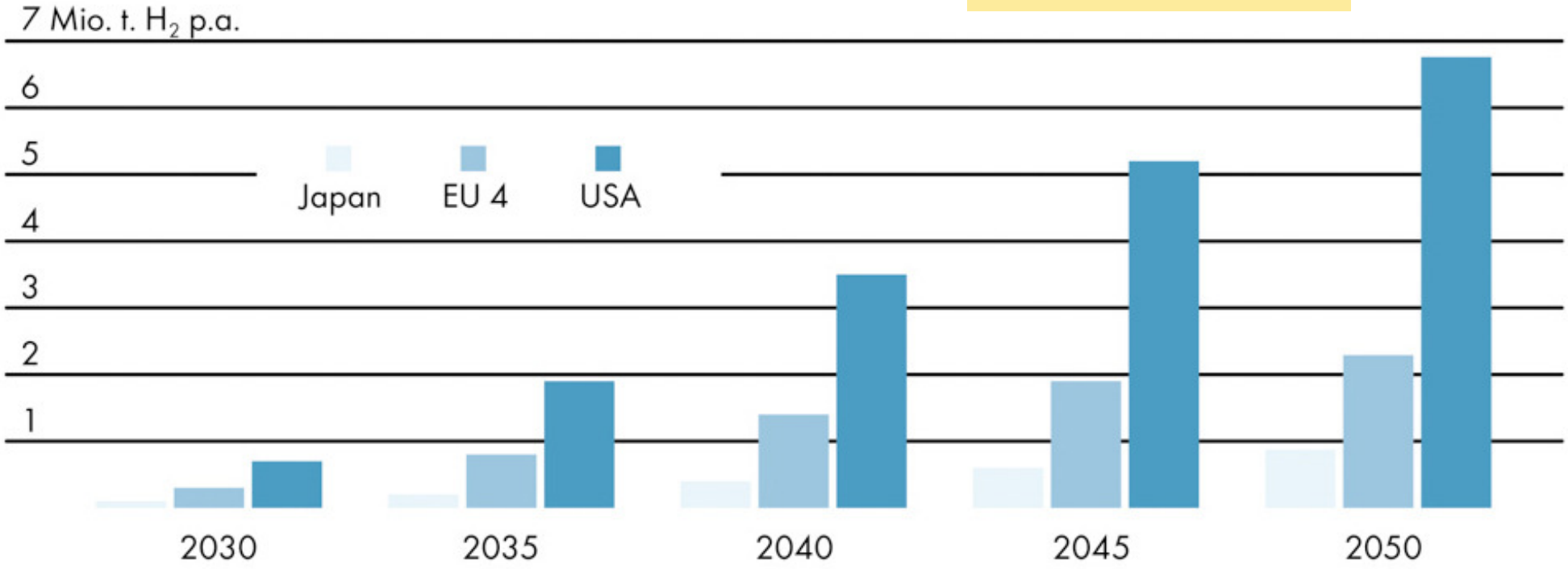
Brennstoffzellen-Pkw-Flotte (IEA 2015)

ca. 1 Mrd. Pkw heute
ca. 2 Mrd. Pkw 2050



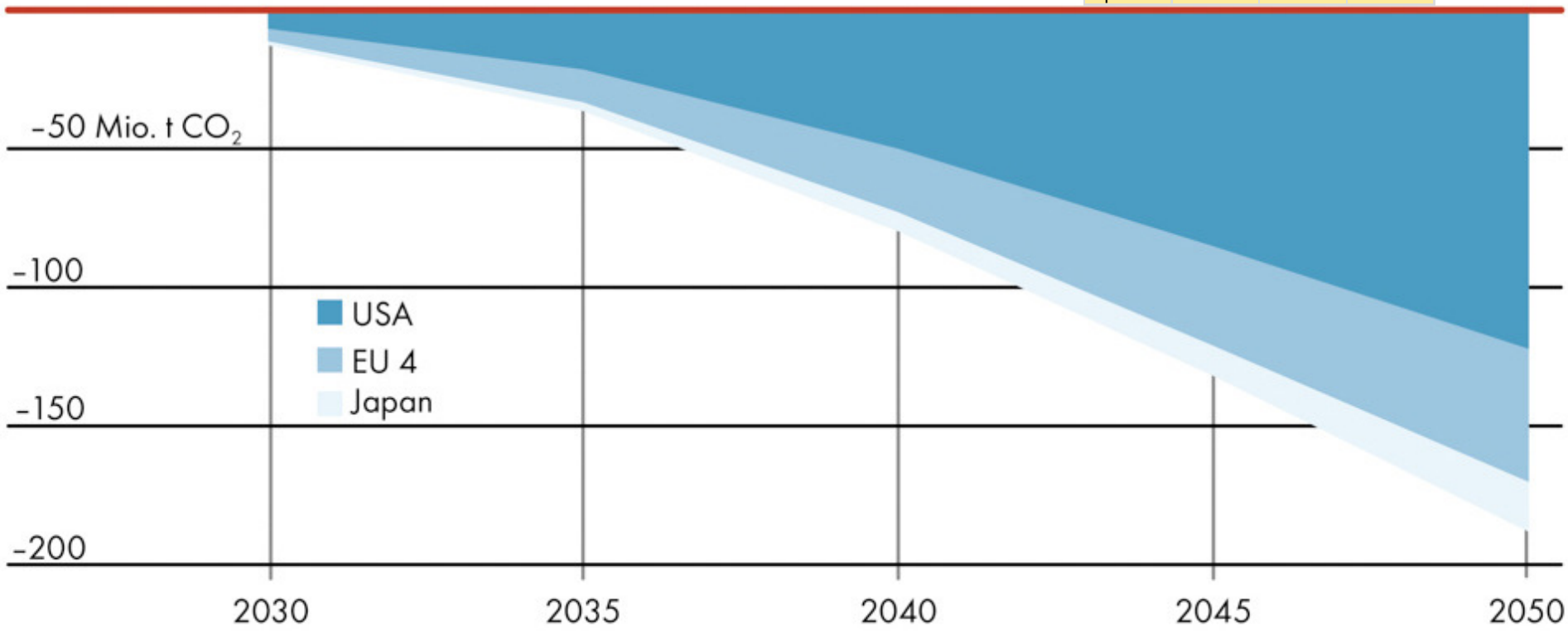
Wasserstoff-Pkw-Flottenverbrauch

globale H_2-Erzeugung
heute: 45-50 Mio. T/a



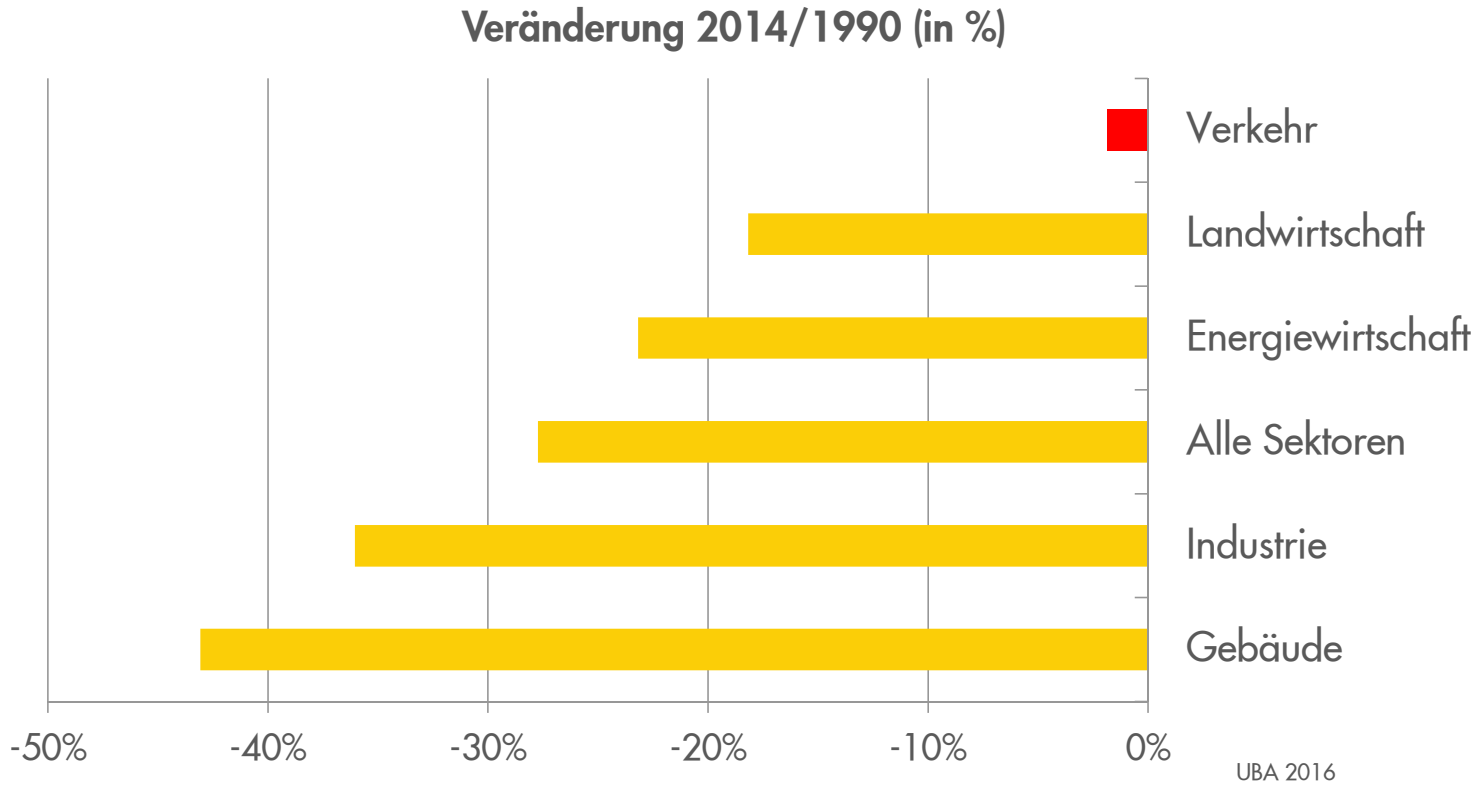
Treibhausgaseinsparungen Brennstoffzellen-Pkw-Flotte

	CO_2 Emissions (in Mio. T)		
	2014	NPS '40	450 '40
World	7306	8802	5298
USA	1681	1132	594
EU 28	864	572	303
Japan	208	120	88



Dies entspricht rund 8% der gesamten verkehrsbedingten Emissionen der drei Regionen im Vergleich zur Baseline (New Policy Scenario IEA 2014).

Handlungsbedarf Klimaschutz im Verkehrssektor in Deutschland



UBA 2016

Welche Aktionen/Maßnahmen?

- Herstellverfahren: Kosten, Effizienz, Flexibilität
- Brennstoffzellen: Kosten, Effizienz, Stabilität
- Großspeicher; FuE in Stoffspeicher
- Markteinführung BUP/KWK-Systeme + Kraftfahrzeuge
- Ausbau Wasserstoff-(Tankstellen)Infrastruktur
- "level playing field" + Sektorkopplung
- Verbraucher-Akzeptanz schaffen

Questions and Answers

www.shell.de/h2studie
www.shell.de/wasserstoffstudie