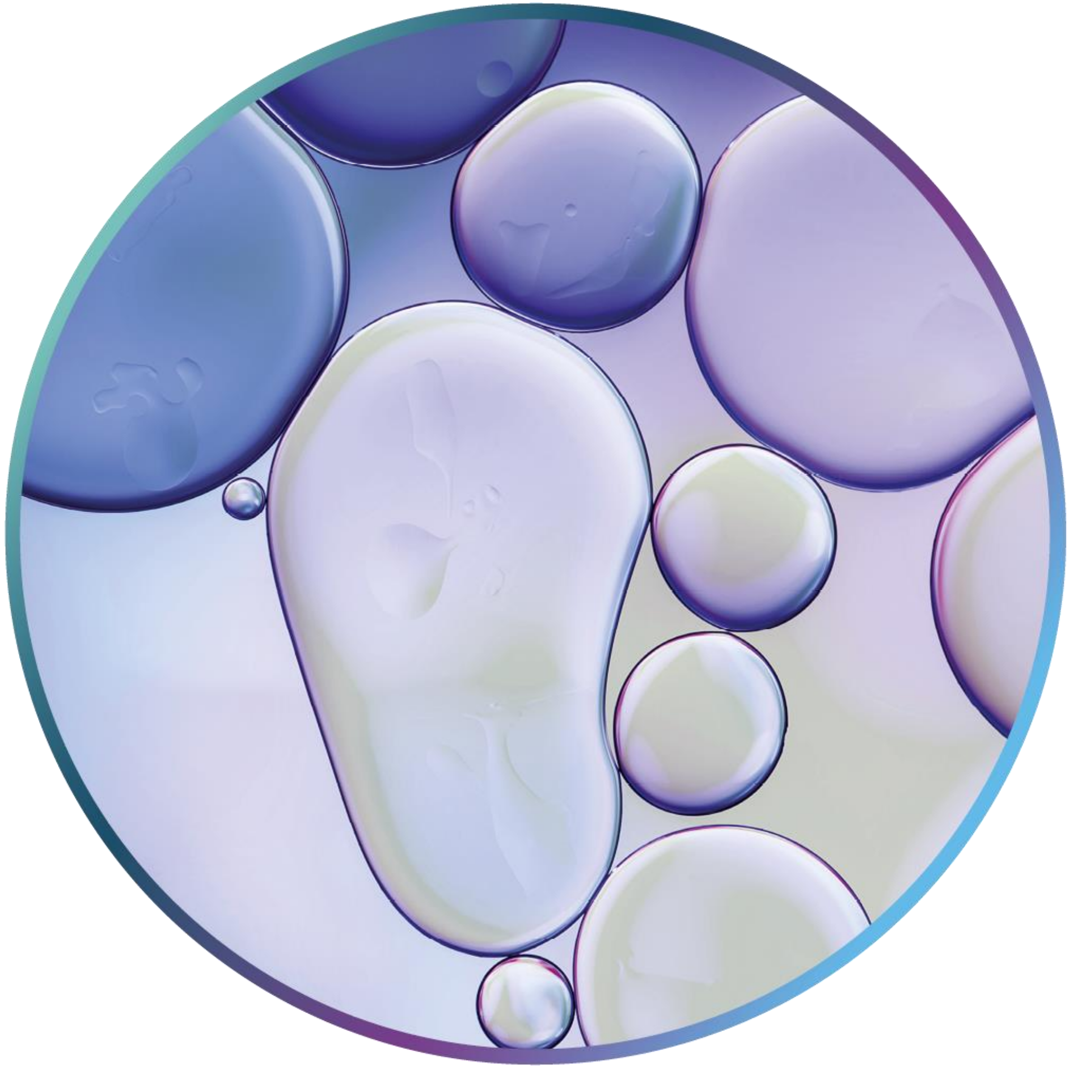


Making the Most of Power-to-X

Matthias Deutsch, Agora Energiewende

Next steps for energy systems integration: Linking policy and practice for clean energy transitions across sectors
2 April 2020, Webinar

Agora Energiewende – Who we are

Think Tank with more than 40 Experts

Independent and non-partisan

Project duration 2012 – 2021

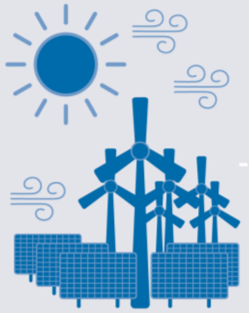
Financed by Mercator Foundation & European Climate Foundation

Mission: How do we make the energy transition in Germany a success story?

Methods: Analyzing, assessing, understanding, discussing, putting forward proposals, Council of Agora

Power-to-X encompasses both direct and indirect electrification

Renewable electricity



	Common terms	Power-to-X	
Direct electrifi-cation	• Green electrons	• **M**obility • **H**eat: heat pumps, resistance heating, inductive, infrared, plasma heating, …	
Indirect electrifi-cation	• Green molecules • Electrofuels (e-fuels) • Powerfuels • Synthetic fuels (synfuels)	• **A**mmonia • **C**hemicals • **F**uel • **G**as	• **H**ydrogen • **L**iquid • **M**ethane • **S**yngas

Own illustration, VDE/ETG (2015): Potenziale für Strom im Wärmemarkt bis 2050

Indirect electrification:
Renewable hydrogen as the basis for a range of e-fuels

Electrofuels with and without carbon

E-fuels	Without carbon	Containing carbon
Gaseous	Hydrogen gas (H_2)	Methane (CH_4)
Liquids	Ammonia (NH_3)*	Alcohols (C_xH_yOH) Hydrocarbons (C_xH_y)

**Carbon-containing molecules*

Pros:

→ High energy density

→ Existing infrastructure for natural gas and liquids can be used

Cons:

→ Higher conversion losses in production, need for sustainable carbon source (air or biomass)

→ Methane:
Risk of leakage (prominent example: gas motors in CHP plants)

Philibert, IEA (2018)

Indirect electrification is particularly relevant for the harder-to-abate segments in industry and the transport sector

		Role of direct electrification	Role of electricity-based fuels: Hydrogen	Role of electricity-based fuels: Ammonia	Role of electricity-based fuels: Synfuels
Industry	Cement	Electrification of kiln heat (process emissions remain)	As heat source		
Industry	Steel	Electrification of furnace heat Direct iron electrolysis	As reduction agent and heat source		
Industry	Plastics	Electrification of furnace heat	As heat source		Potential role as plastics feedstock
Transport	Heavy-road transport	Battery electric vehicle (BEV) Catenary overhead wiring	Fuel cell electric vehicle (FCEV)		
Transport	Shipping	Battery electric for short distance Cruise and RoPax ships	Burnt in ICE or used in fuel cells	Burnt in ICE or used in fuel cells	
Transport	Aviation	Battery electric for short distance	Fuel cell electric for medium distance		In conventional jet engine
Building heating		Through heat pumps or induction	As substitute for natural gas		
Electricity system			Energy storage	Energy storage Transportation of H_2	

Relevant criteria:

→ Energy density

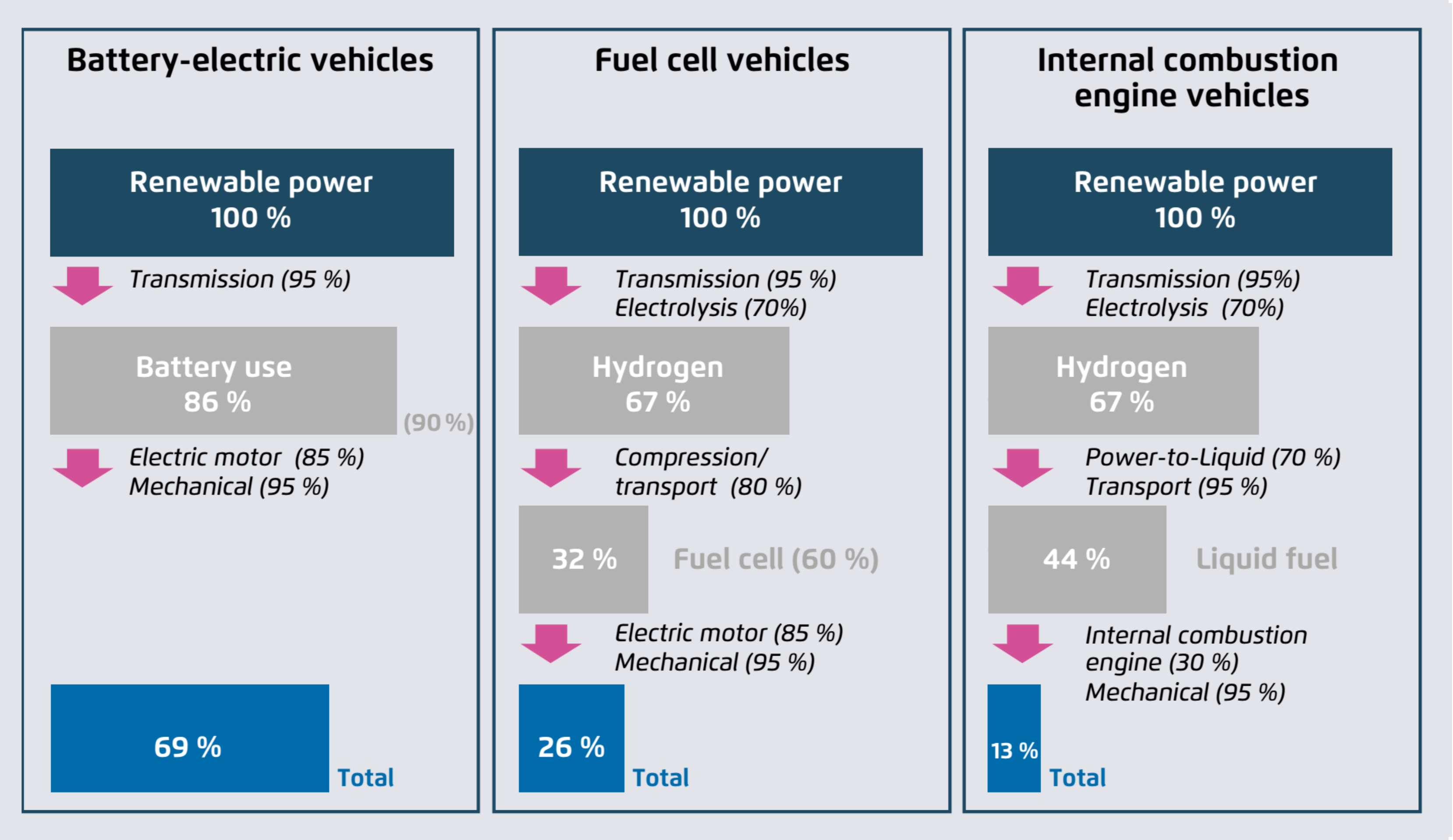
→ High-temperature heat

→ Carbon for feedstock

Direct vs. indirect electrification: Conversion losses for passenger cars and building heating

For passenger cars, battery-driven electric vehicles are the energy efficiency benchmarks.

Individual and overall efficiencies for cars with different vehicle drive technologies



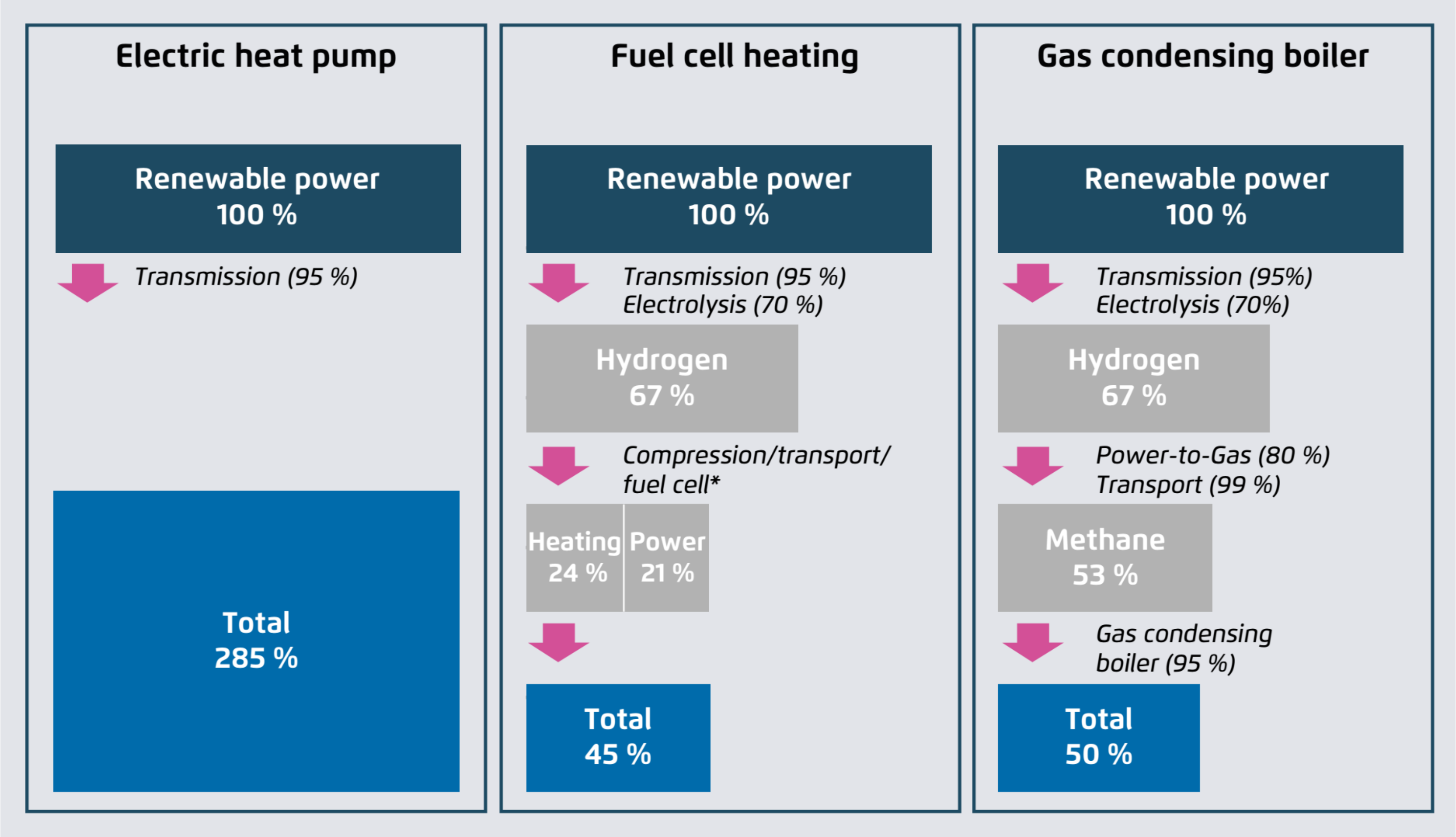
→ To travel the same distance, a **combustion-engine vehicle** would need about **five times** as much renewable electricity as a battery-driven vehicle.

→ A **fuel cell vehicle** needs about **two and a half times** as much electricity.

Own illustration, based on acatech et al. (2017a), Figure 5

Heat pumps have a particular leverage and use renewable electricity especially efficiently.

Individual and overall efficiencies for different building heating systems



→ **Boilers with renewable hydrogen** (instead of fuel cells) yield a total efficiency of about 50 to 60 %.

→ The electric **heat pump** withdraws more energy from the environment (air, soil or water) than required in terms of operational power, which is why it can have an efficiency rating over 100%. It can also be used for cooling.

Own calculations based on acatech et al. (2017 a,b), Köppel (2015), FENES et al. (2015), Committee on Climate Change (2018)

Conclusions

Power-to-X encompasses both direct and indirect electrification.

Direct electrification:

→ For **passenger cars**, battery-driven electric vehicles are the energy efficiency benchmarks.

→ For **buildings**, heat pumps have a particular leverage and use renewable electricity especially efficiently. They can also be used for cooling.

Indirect Electrification:

→ **Electrofuels** will play an important role in decarbonising the chemicals sector, the industrial sector, and parts of the transport sector.

→ **Open question** for some applications: Can the indisputable, physics-based disadvantages of electrofuels be more than offset by avoidance of infrastructure costs?

Study on the future cost of electricity-based synthetic fuels

Commissioned by: Agora Verkehrswende and Agora Energiewende

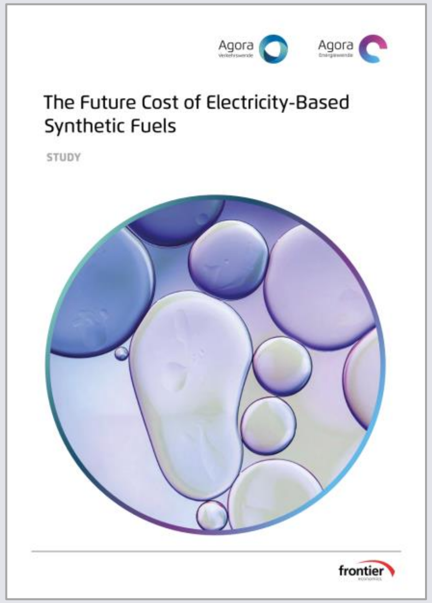
Study by: Frontier Economics **Conclusions by**: the Agoras

Guiding questions:

- How can the **cost of importing** synthetic fuels – i.e. **methane and liquid fuels** – develop until 2050? (exemplary analysis for North Africa, Middle East and Iceland)
- What are the cost of producing those fuels on the basis of offshore wind energy in the **North Sea and Baltic Sea**?

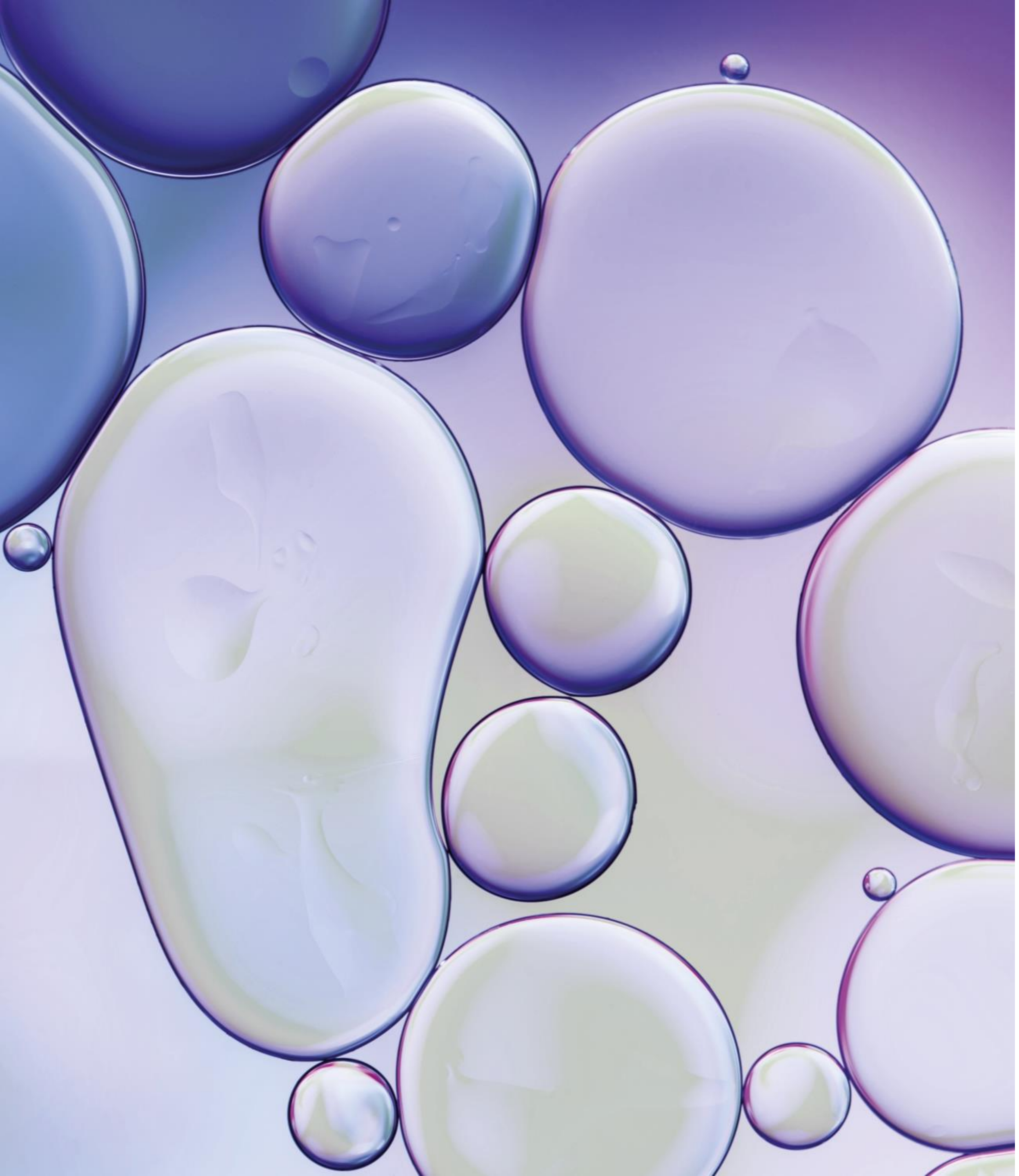
Approach:

- Cost estimation along the value chain:
  Power generation, conversion, transport, blending/distribution
- Cost ranges from the literature, expert workshop
- CO_2 neutrality by assuming CO_2 from the air (*Direct Air Capture)*



Download:

- Study
- PtG/PtL-Excel-Tool
- Presentation
- Webinar



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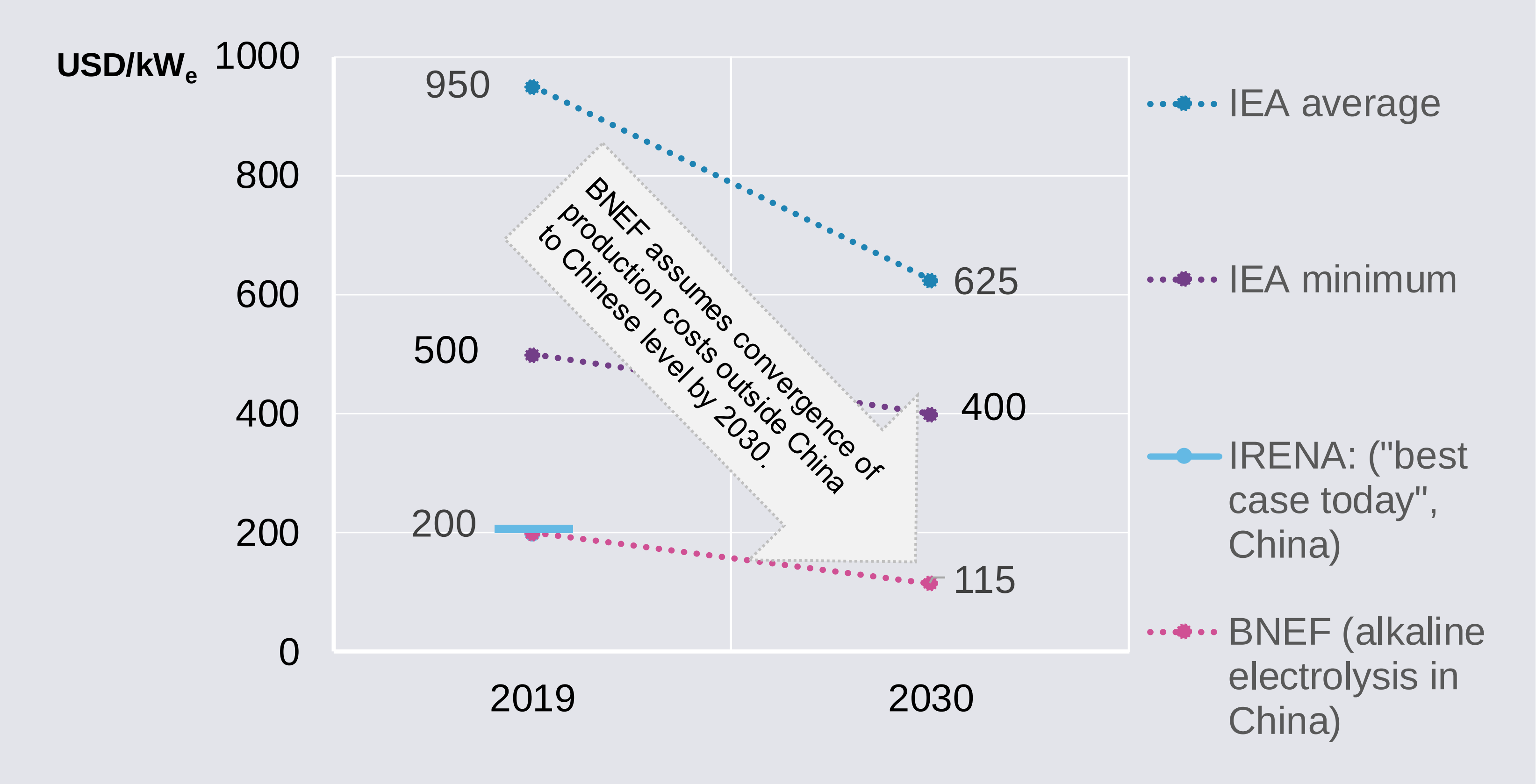
Agora Verkehrswende and Agora Energiewende are joint initiatives of the Mercator Foundation and the European Climate Foundation.

More on the capital expenditure of alkaline electrolysis

CAPEX of alkaline electrolysers 2019 and projection for 2030



Own elaboration, based on IEA (2019), IRENA (2019), BNEF (2019)

> download background paper

Further publications by Agora Energiewende

EU-wide innovation support is key to the success of electrolysis manufacturing in Europe	Building sector Efficiency: A crucial Component of the Energy Transition	European Energy Transition 2030: The Big Picture	Making the Most of Offshore Wind: Re-Evaluating the Potential of Offshore Wind in the German North Sea	Heat Transition 2030
				
> full study	> full study (EN)	> full study	> full study	> summary (EN) > full study (DE)
	> slide deck (DE)	> slide deck	> Feed-in time series > KEBA model	> slide deck