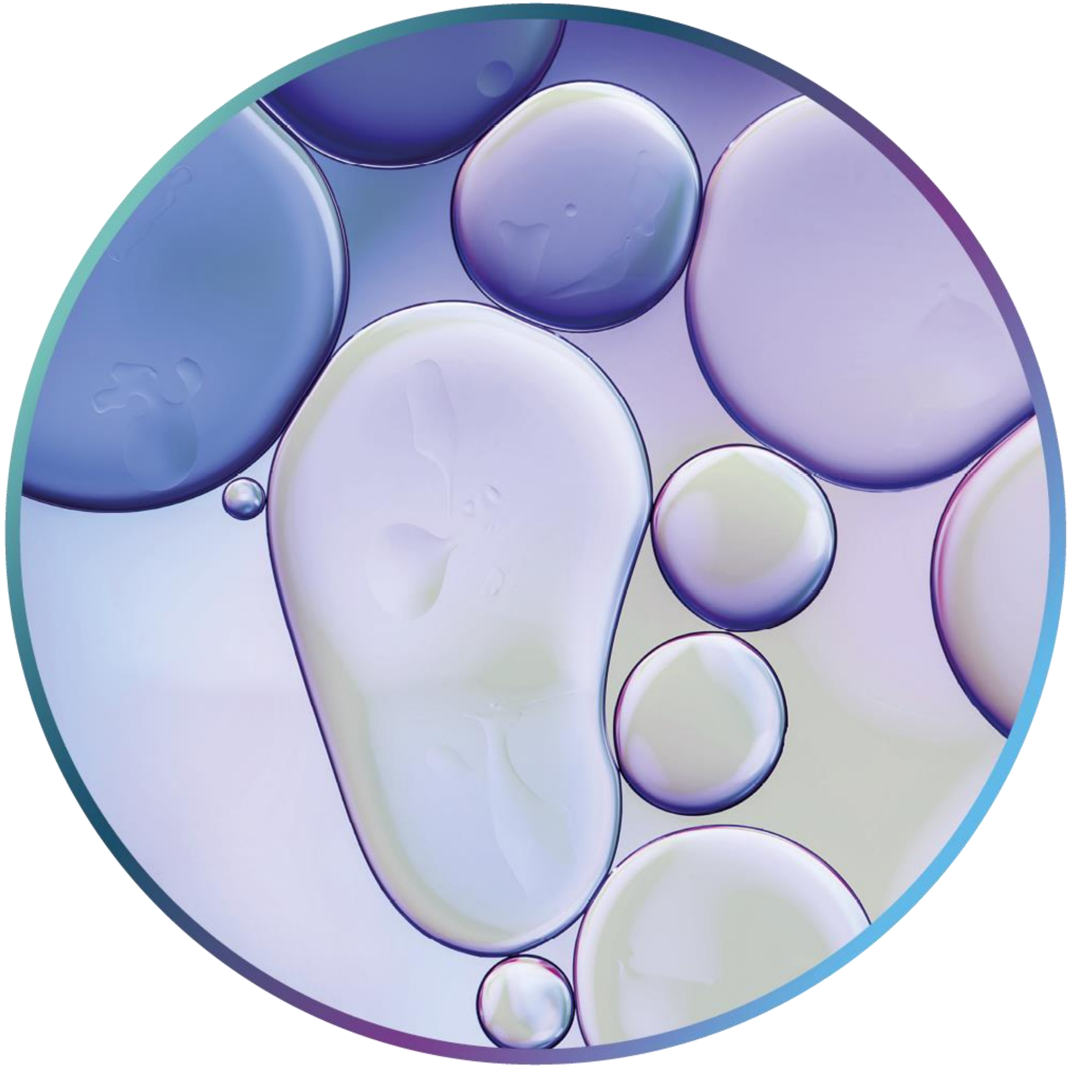

The Future Cost of Electricity-Based Synthetic Fuels:

Conclusions Drawn by Agora Verkehrswende and Agora Energiewende

Matthias Deutsch, Agora Energiewende

Strommarkttreffen, Berlin

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Agora Verkehrswende and Agora Energiewende

Who we are

- **Two think tanks** with 40 Experts, independent and non-partisan
- **Financed by** Mercator Foundation & European Climate Foundation
- **Project duration**: 2012-2021 (Energiewende) and 2016-2023 (Verkehrswende)
- **Mission**: Develop strategies to decarbonize the energy system in Germany and beyond.
- **Focus**: Power, heating and transport
- **Methods**: Analyzing, discussing, putting forward proposals, Councils of Agoras

Study on the future cost of electricity-based synthetic fuels

Commissioned by: Agora Verkehrswende and Agora Energiewende

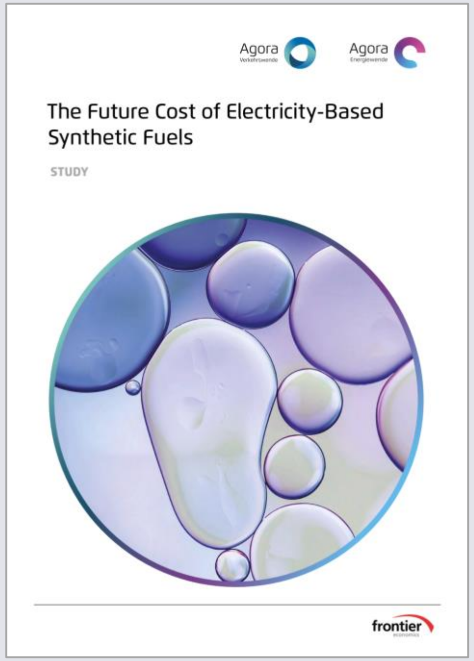
Study by: Frontier Economics

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:

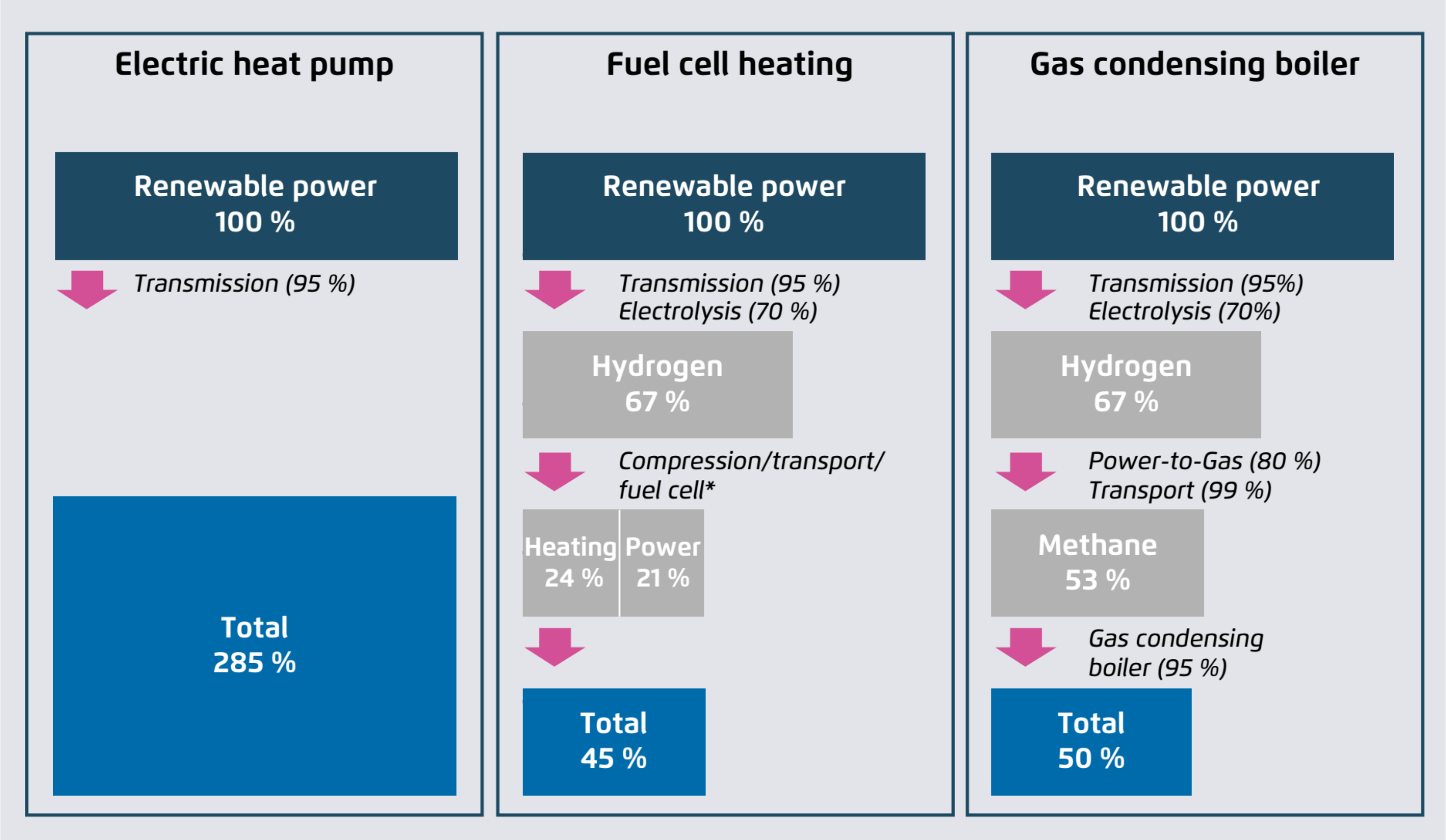
- Study
- PtG/PtL-Excel-Tool
- Presentation (long)
- Webinar

1

Synthetic fuels will play an important role in decarbonising the chemicals sector, the industrial sector, and parts of the transport sector.

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

Individual and overall efficiencies for different heating systems



→ 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 %.

→ **Open question:** Can the indisputable, physics-based disadvantages of synthetic fuels be more than offset by avoidance of infrastructure costs?

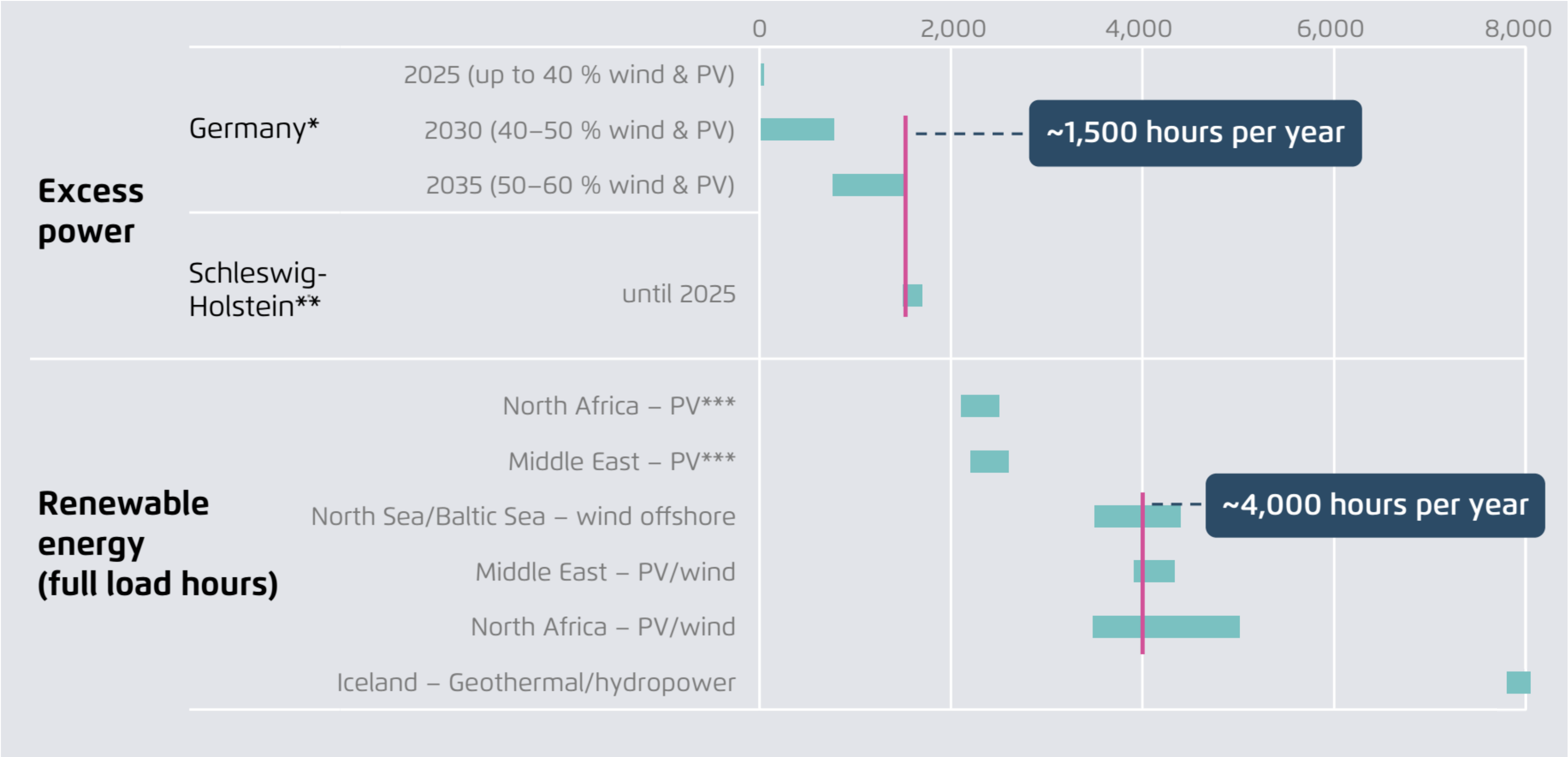
Own calculations based on acatech et al. (2017 a,b), Köppel (2015), FENES et al. (2015)

2

To be economically efficient, power-to-gas and power-to-liquid facilities require inexpensive renewable electricity and high full load hours. Excess renewable power will not be enough to cover the power demands of synthetic fuel production.

PtG/PtL facilities require high full load hours and inexpensive renewable electricity.

Hours per year



→ **Capacity utilisation of** at least 3,000-4,000 hours/year needed due to high fixed cost.

→ **„Excess power“** with < 2,000 hours/year at low prices is insufficient.

→ **Additional renewable energy plants** needed for PtG-/PtL production: offshore wind, PV & onshore wind ~ 4,000 hrs/year.

→ **Full cost** of renewable energy facilities are relevant.

Own illustration based on acatech et al. (2015), ecofys/IWES (2014), Frontier Economics (2018)

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3

In the beginning, synthetic methane and oil will cost between 20 and 30 cents per kilowatt hour in Europe. Costs can fall to 10 cents per kilowatt hour by 2050 if global Power-to-Gas (PtG) and Power-to-Liquid (PtL) capacity reaches around 100 gigawatts.

The cost of synthetic methane and oil can fall from initially 20 to 30 ct/kWh to about 10 ct/kWh by 2050.

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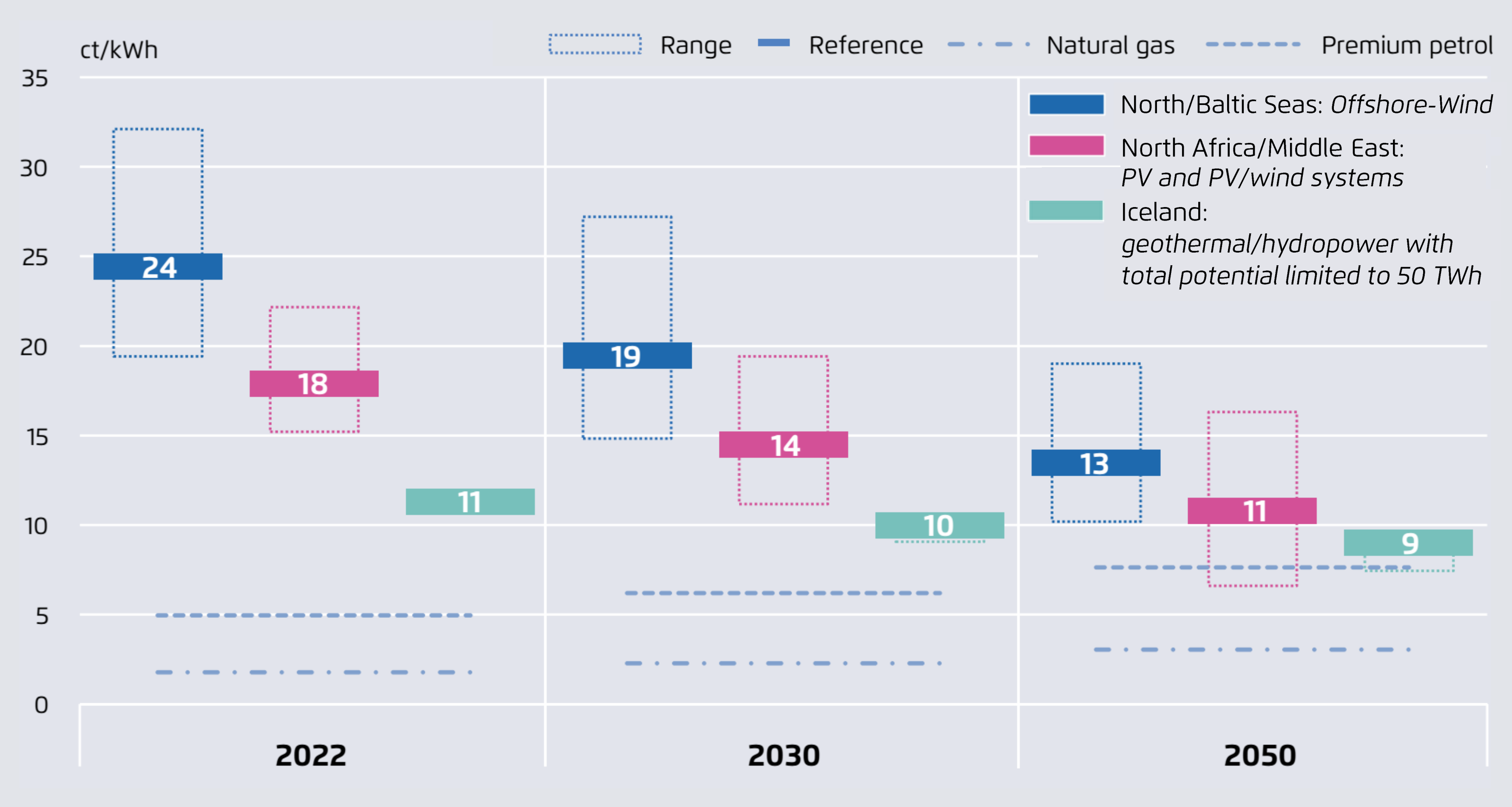
Cost of synthetic methane and liquid fuels in ct_{2017}/kWh *



→ **Prerequisite:** Increase in global electrolysis capacity to 100 GW.

→ **Imports are cheaper**.

→ Further **cost reductions** due to PV, batteries, very large facilities.

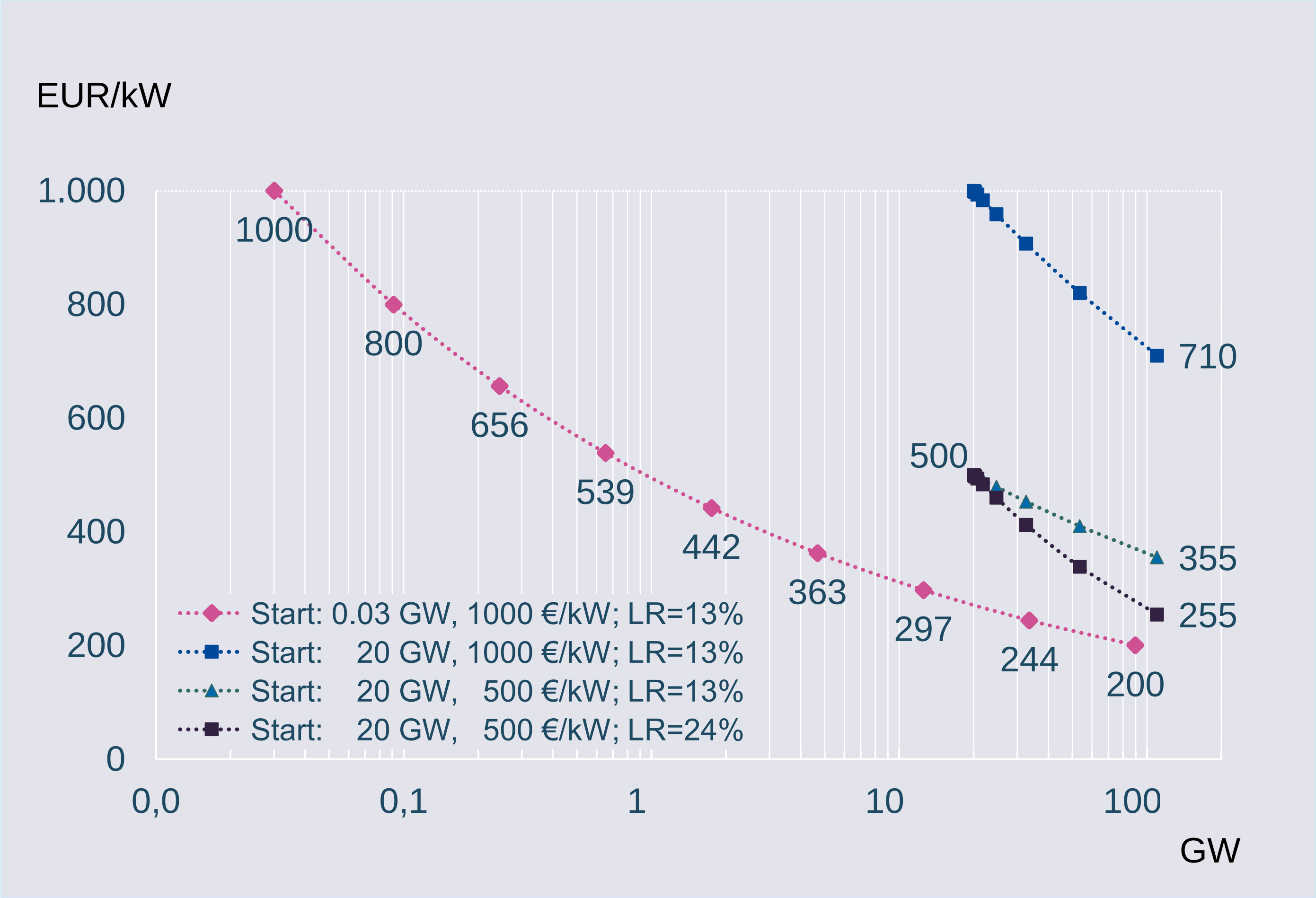
→ **Cost increase** due to higher cost of capital in countries with elevated risks; may inverse situation of imports versus domestic production.

→ **Prices**: royalties and global PtG/PtL market.

* without network charges and distribution cost; own calculation based on Frontier Economics (2018) with cost of capital of 6% and CO_2 from *Direct Air Capture*

Deriving a global capacity of ~100 GW electrolysers through learning curves comes with uncertainty.

Electrolysis investment cost over cumulative installed capacity



- → There is **uncertainty** in starting values for investment cost, cumulative installed capacity, learning rate, technology assumed (AEC, PEMEC).
- → **The cost of electrolysers** >100 MW may only be around 500 €/kW today.
- → As to **cumulative installed capacity**, discussions in Germany often start with PtG facilities in Germany (~30 MW), but learning will be global.
- → When starting from the ~20 GW global installed capacity (mostly AEC), the learning rate must be high to reach the optimistic cost path determined by Frontier Economics (2018).

Agora Energiewende and Agora Verkehrswende (2018): footnotes 39 and 46, drawing on Frontier Economics (2018), FENES et al. (2014), Schmidt et al. (2017), DLR et al. (2014), IEA (2017)

4

We need a political consensus on the future of oil and gas that commits to the phase-out of fossil fuels, prioritises efficient replacement technologies, introduces sustainability regulations, and creates incentives for synthetic fuel production.

Building blocks for an oil and gas consensus

Greenhouse gas emission reduction goals

Agreement on an oil and gas consensus

between politics, economy and civil society

Phase out of fossil oil and gas

Gradual decrease in the total use and associated emissions

Priority for effi-cient replacement technologies

for example with battery-electric mobility and electric heat pumps

Incentives for synthetic fuel production

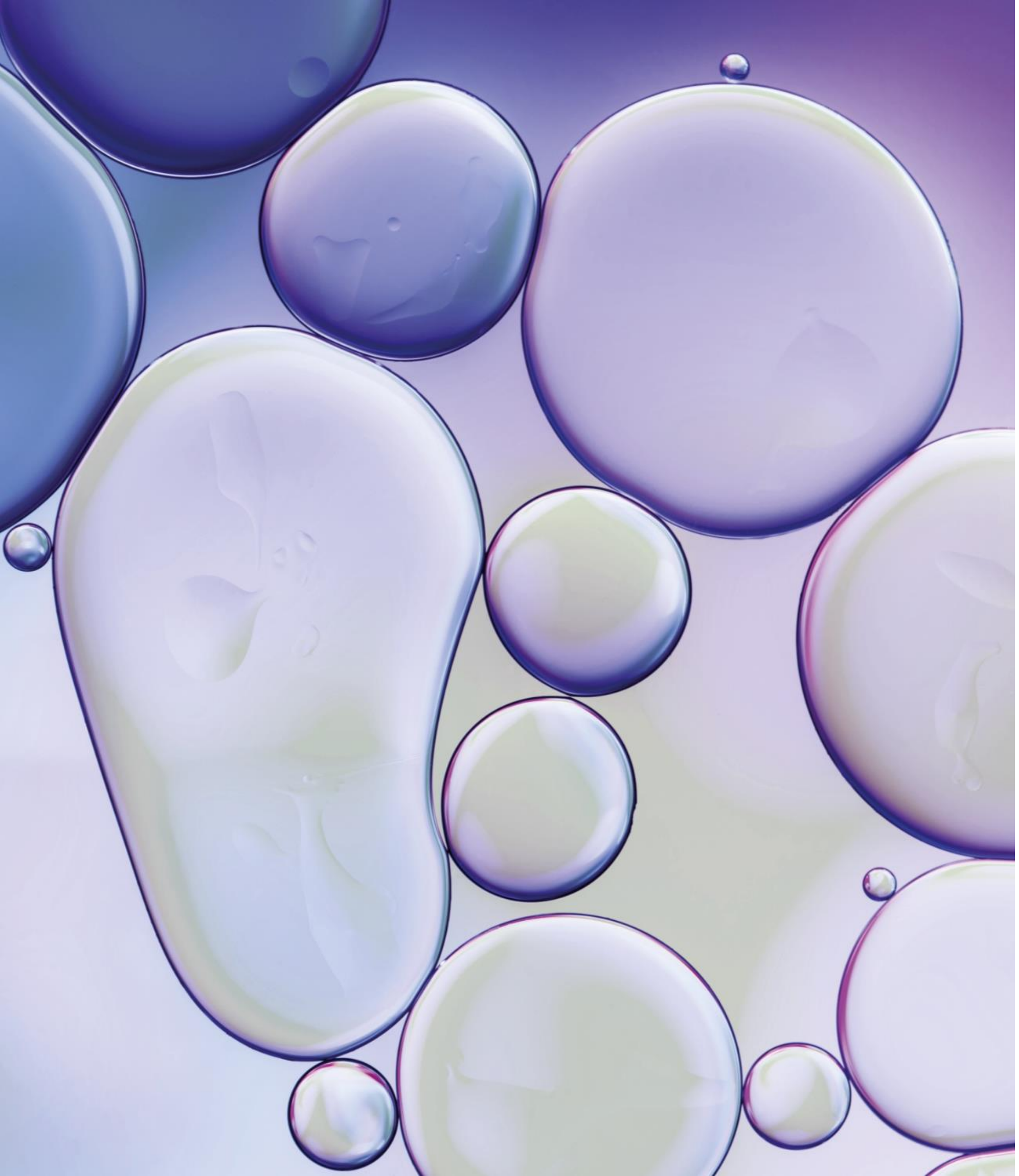
on the basis of sustainability standards for PtG/PtL and application-specific targets*

* (1.) Minimum greenhouse gas reduction by 70% relative to fossil reference fuels; (2.) Additionality of renewable electricity generation; (3.) CO_2 from the air or from sustainable biogenic sources; (4.) Sustainable use of water and land; (5.) Social sustainability of fuel production

Sustainability standards also need to be established for the raw materials and production of electric batteries.

Conclusions drawn at a glance

1	Synthetic fuels will play an important role in decarbonising the chemicals sector, the industrial sector, and parts of the transport sector.
2	To be economically efficient, power-to-gas and power-to-liquid facilities require inexpensive renewable electricity and high full load hours. Excess renewable power will not be enough to cover the power demands of synthetic fuel production.
3	In the beginning, synthetic methane and oil will cost between 20 and 30 cents per kilowatt hour in Europe. Costs can fall to 10 cents per kilowatt hour by 2050 if global Power-to-Gas (PtG) and Power-to-Liquid (PtL) capacity reaches around 100 gigawatts.
4	We need a political consensus on the future of oil and gas that commits to the phase-out of fossil fuels, prioritises efficient replacement technologies, introduces sustainability regulations, and creates incentives for synthetic fuel production.



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