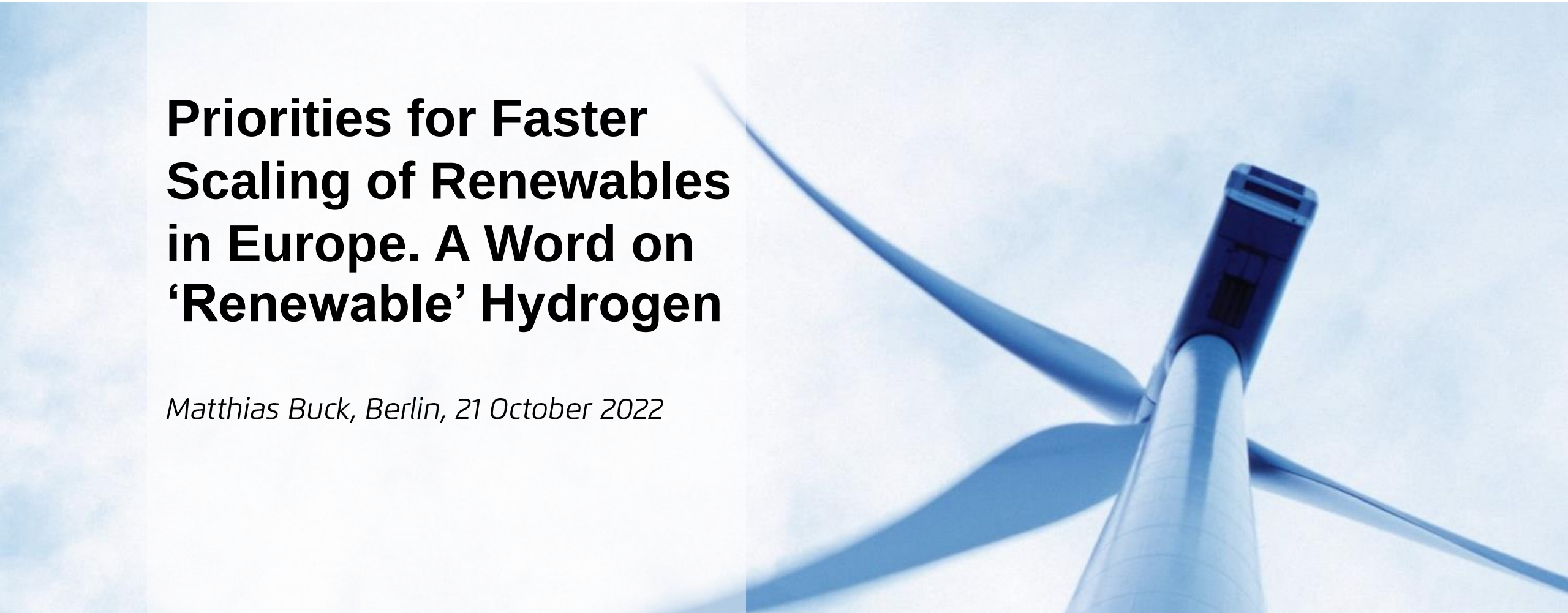
Agora Energiewende

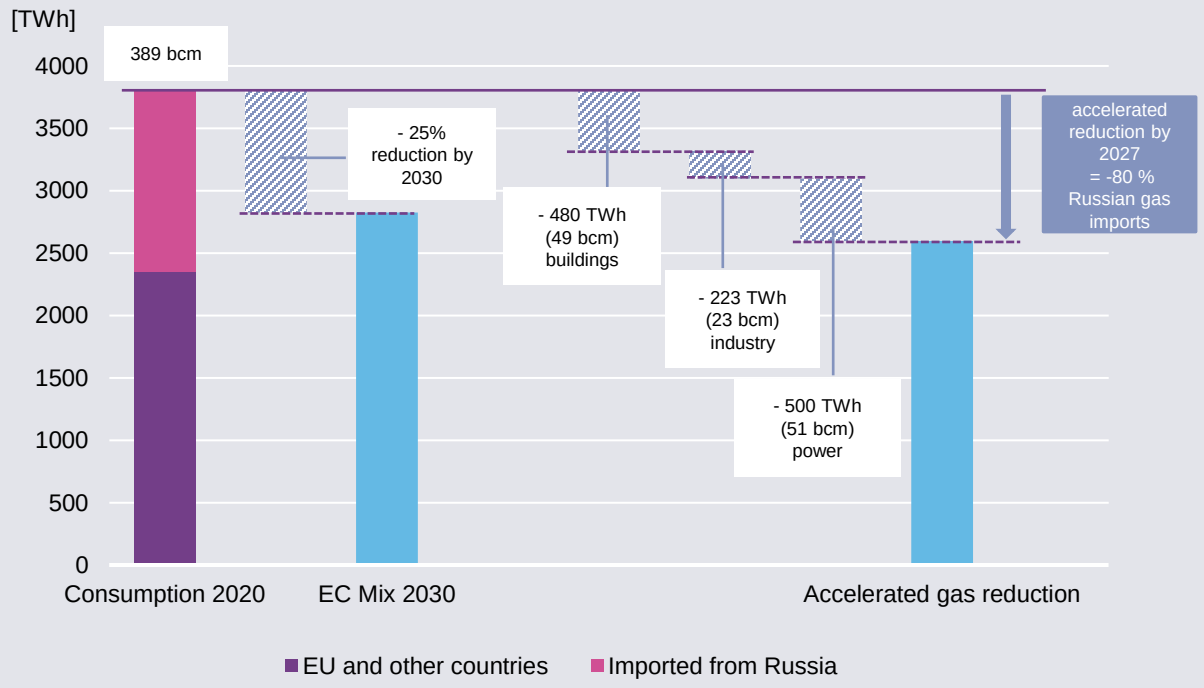
Priorities for Faster Scaling of Renewables in Europe. A Word on ‘Renewable’ Hydrogen

Matthias Buck, Berlin, 21 October 2022



Energy efficiency measures and fast renewables ramp up must be at the core of regaining Europe's energy sovereignty

EU-27 fossil gas consumption and reduction potentials

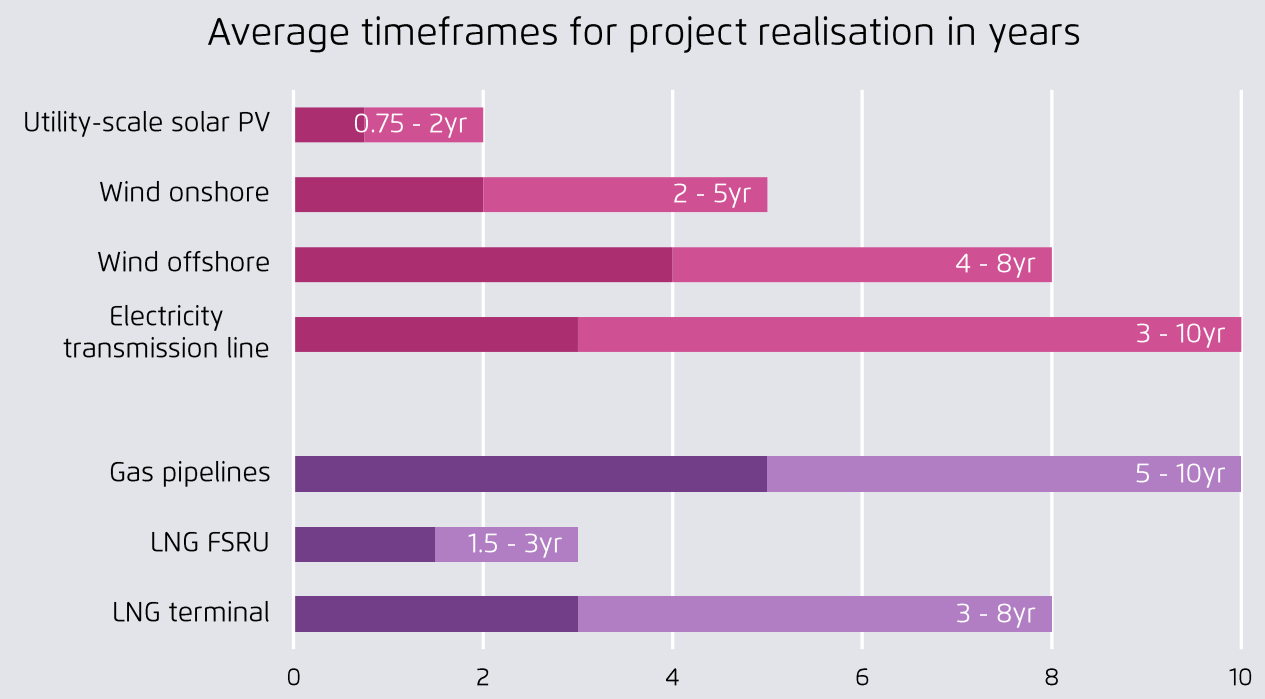


Agora based on modelling from Artelys, Wuppertal Institute and TEP Energy

- Focus of RePowerEU must be on ramping up energy efficiency and faster scaling of renewables. This will **permanently reduce** fossil gas consumption and go hand in hand with Europe's pathway to climate neutrality.
- **Substituting gas** from Russia with gas from other sources is necessary to some extent, but costly, risky and will create stranded assets.
- The buildings sector can save 480 TWh through **energy efficiency**, **district heating** and a **heat pump** revolution.
- The industry sector can reduce at least 223 TWh through **heat pumps**, fuel switch and reduction of fossil gas as a feedstock.
- Pulling all stops to **scaling renewables**, investing into flexible assets and into enhanced power system flexibility will displace around 500 TWh fossil gas in the power sector.

Prioritising gas reduction over gas substitution does not compromise energy security! It is often faster to *permanently reduce gas consumption* than to build new gas infrastructure.

Average timeframes for RES vs gas project realisation



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- Permanently reducing gas consumption avoids need for new gas infrastructure & reduces risk of gas assets becoming stranded.
- Only a sub-set of today's fossil gas infrastructure will be needed in the future to transport (green) hydrogen. LNG terminals cannot be built "hydrogen ready" (only ammonia receiving stations can temporarily be used for importing LNG)
- The bottleneck in expanding LNG capacities lies in sufficient additional liquefaction infrastructure and LNG supply from *outside of Europe*, rather than in insufficient regasification infrastructure within Europe.
- Using RRF & CEF for LNG investments takes away resources required for strengthening power grids to cope with rapidly growing RES-e shares (0.9 to 3 bn EUR per addtl GW).

„Renewable“ Hydrogen is widely characterised as key element in Europe‘s response to the fossil energy crisis. – But it remains an inefficient and costly use of renewable electricity.

Use of renewable electricity for producing renewable hydrogen via electrolysis is several times less efficient (and thus more costly) to reduce carbon emissions in industry, transport or buildings than direct use of renewable electricity.

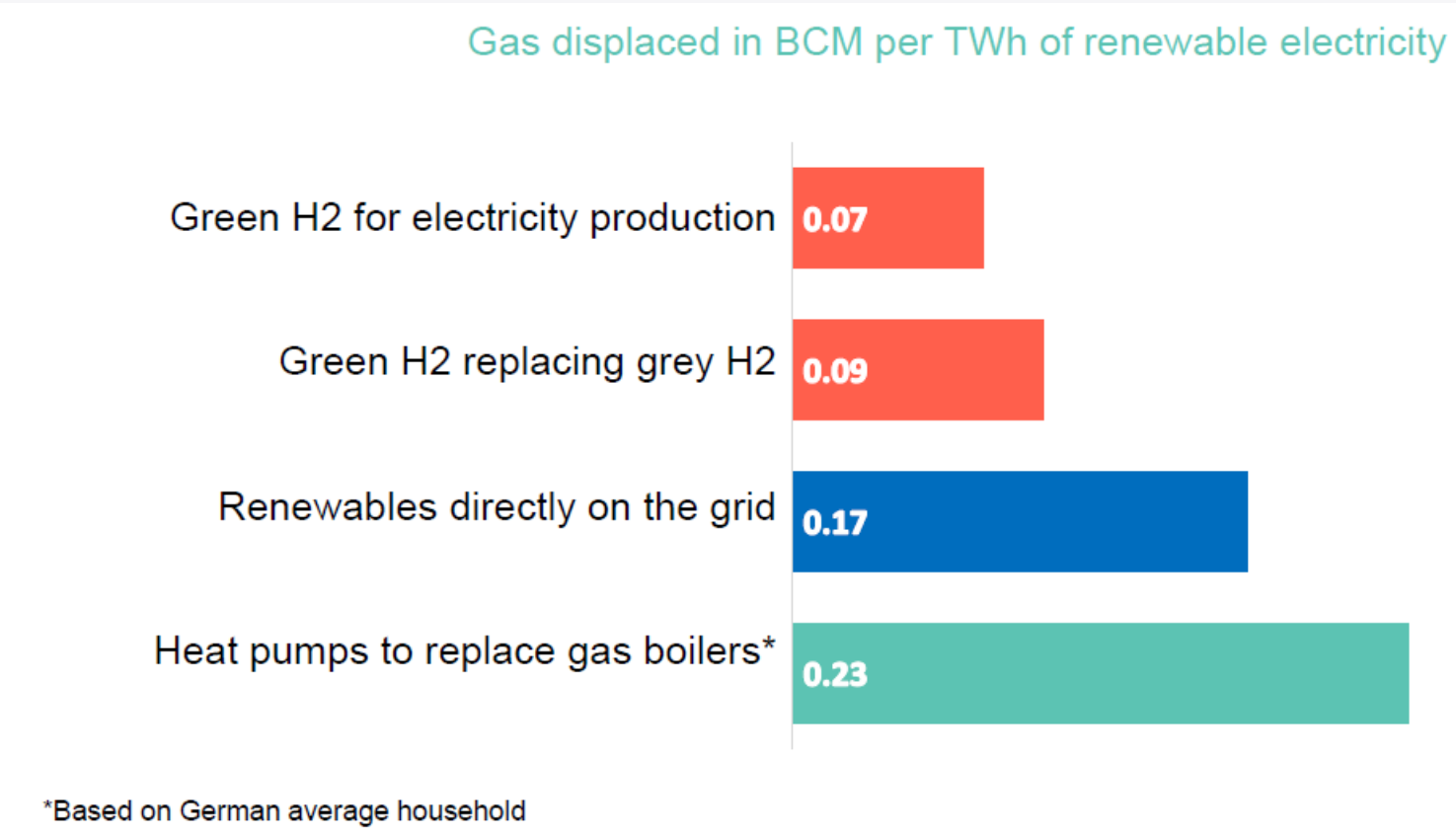
REPowerEU doubles the EU‘s renewable hydrogen target for 2030 to **10 million tons of domestic** renewable hydrogen production and **10 million tons of imports**.

10 million tons of domestic hydrogen production will require around **120 GW of electrolyser capacity within Europe** and create about **250 TWh additional electricity demand.**

In comparison:

- 250 TWh of electricity corresponds to **half of the renewable electricity generated by wind power installed in Europe in 2021** (onshore and offshore, EU27+UK).
- 250 TWh of electricity corresponds to **half of the annual electricity demand of France**.

How much freedom for 1 Twh of renewable electricity?

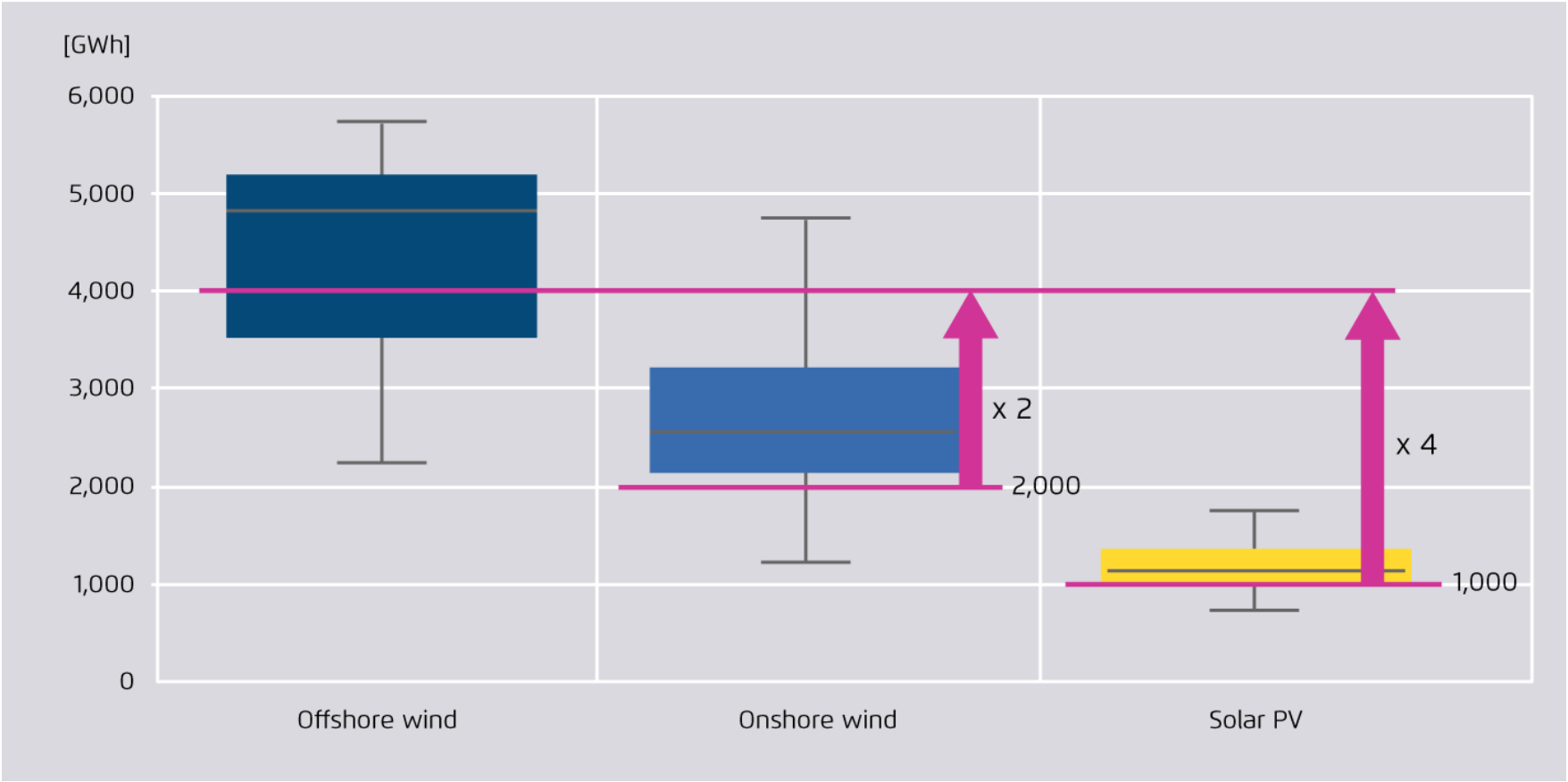


Source: Bellona 2022

Each GW electrolysis must come with up to 4 GW of additional renewables

GWh electricity produced by 1 GW of renewable technology per year

Figure 19



Agora Energiewende based on AFRY Management Consulting (2021) Note: The underlying box plots represent key statistics of average full-load hours, multiplied by 1 GW at the level of hexagons in Europe with an approximate size of 50,000km². They do not represent the total potential volume of renewable electricity that can be generated.

„Renewable“ Hydrogen will only be part of the solution to the fossil energy crisis if there is an EU-wide, robust definition of the term „renewable“ hydrogen.

Governments in Europe offer large scale subsidies for ramping up investments into a „renewable“ hydrogen economy (electrolysers, hydrogen infrastructure, conversion of industrial processes).

However, there is currently no EU-wide definition of what qualifies as „renewable“ hydrogen.

Informal negotiations take place between Czech Presidency, MEP Pieper and Commission as part of the trilogues on the Renewable Energy Directive update (RED III)

Main issue is „renewable“ hydrogen produced with **electricity drawn from the grid**.

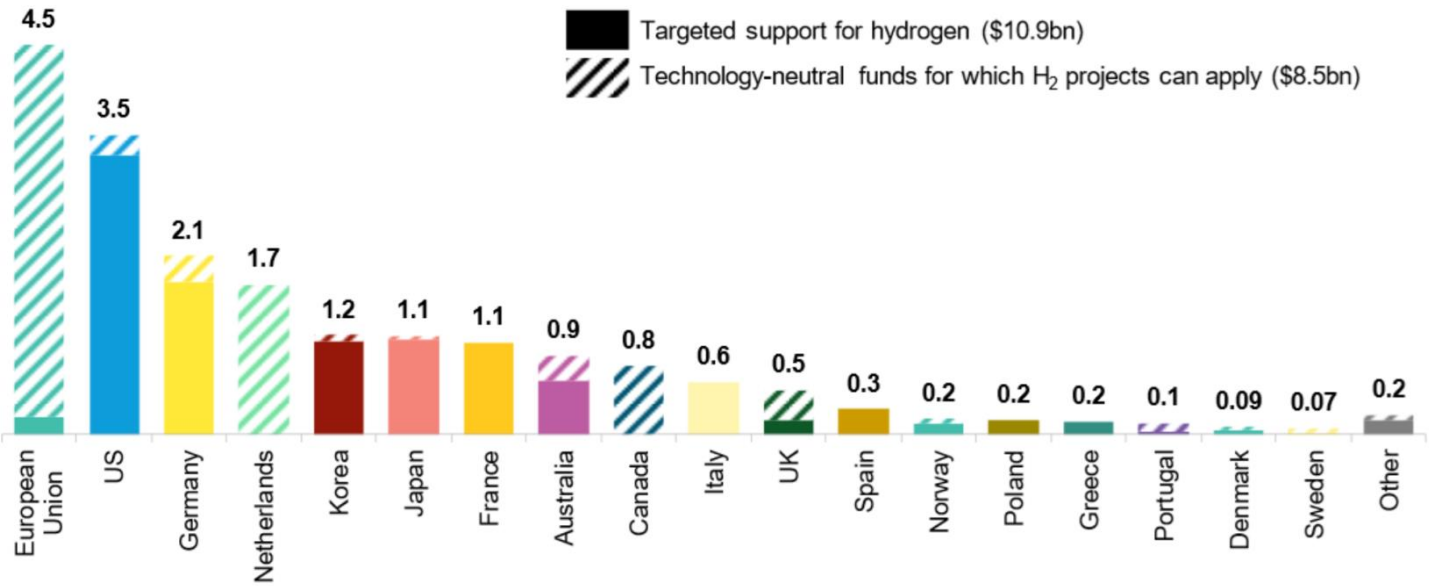
Three concerns:

- Greenhouse gas emissions related to the „renewable“ hydrogen produced
- Power system integration of the electrolysers
- Subsidised use of renewable electricity for hydrogen production delays renewable electricity-led decarbonisation of other sectors

SOLUTION: meaningful temporal and geographical correlation btw renewable power production and hydrogen production plus additionality requirement for renewables capacity used for H2 production

The EU and governments in Europe offer around 10 bn EUR subsidies p.a. for electrolyser manufacturing & renewable hydrogen production. The definition of ‘renewable’ hydrogen will determine what is supported.

Figure 4: Average annual budget for national subsidies open to low-carbon hydrogen projects

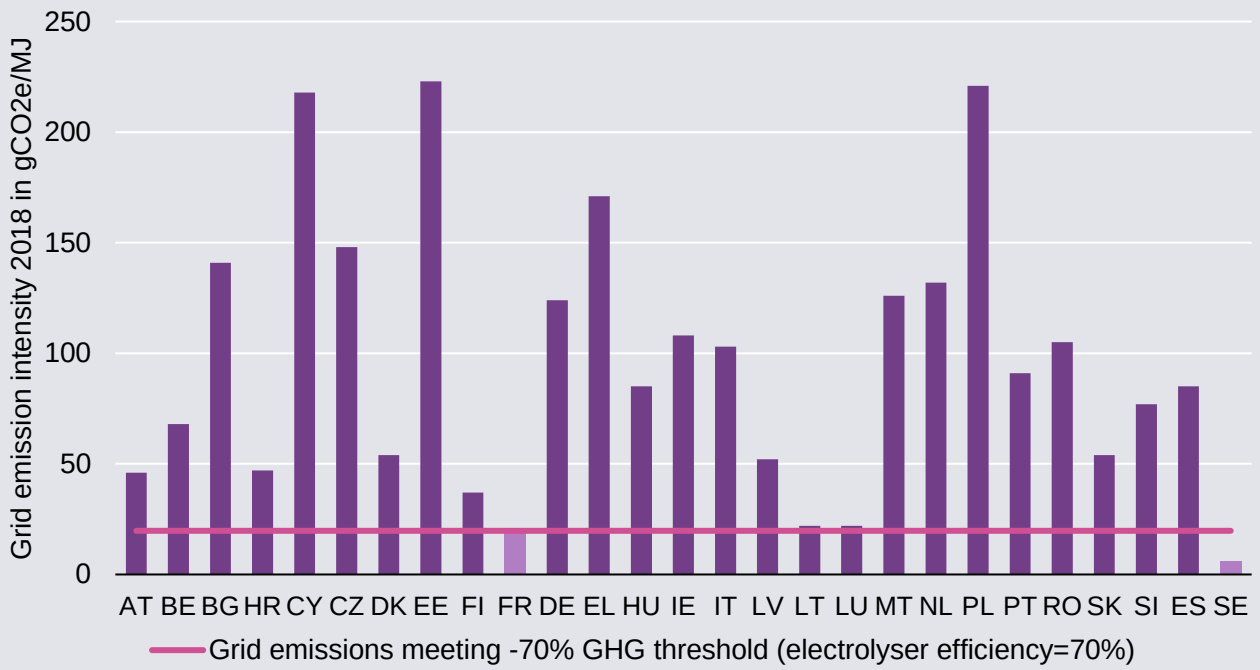


Source: Government and EU agencies, BloombergNEF. Note: ‘Other’ includes Belgium, China, Estonia, Finland and Romania. Includes subsidies announced and in force until 2030. Excludes sub-national funds and loan guarantees. Includes fuel cell funds. Funding amounts are annualized: for example, a $100 million fund delivered over 2021-30 is tracked as $10 million/year. Uses average 2017-22 FX rate for conversions to USD. H_2 is assumed to access 15% of technology-neutral funds (such as the

Source: BNEF (2022)

Hydrogen produced with grid-drawn electricity will be dirtier than fossil-based hydrogen in many Member States if produced with average carbon intensity of the current mix

Grid emission intensity and hydrogen production thresholds in the EU

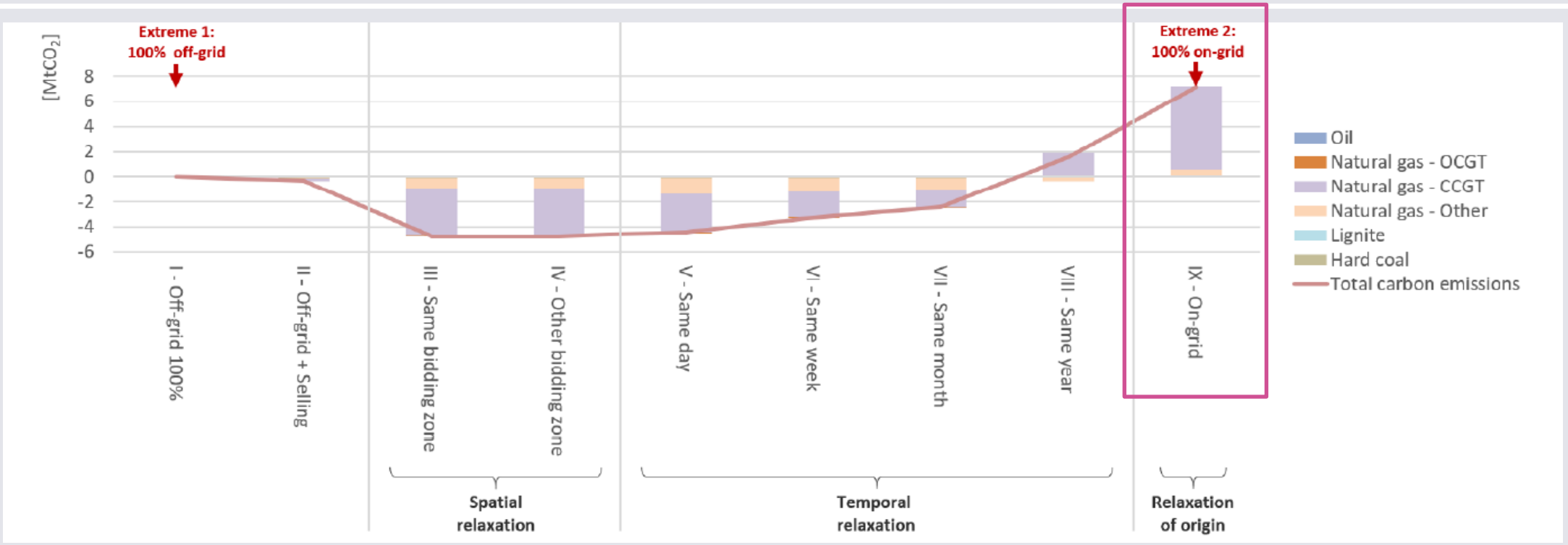


Source: Agora Energiewende, EC Data (2022)

- Electrolytic hydrogen will be dirtier than fossil-based hydrogen in many MS if produced with avg. carbon intensity of the current power mix.
- Defining grid-based hydrogen as “renewable” when it comes with specific GHG-emissions higher than fossil-based hydrogen creates problems for industrial value chains and vis a vis imports in context of the planned CBAM.

The European Parliament proposal for “renewable” hydrogen production criteria would significantly increase carbon emissions at system level

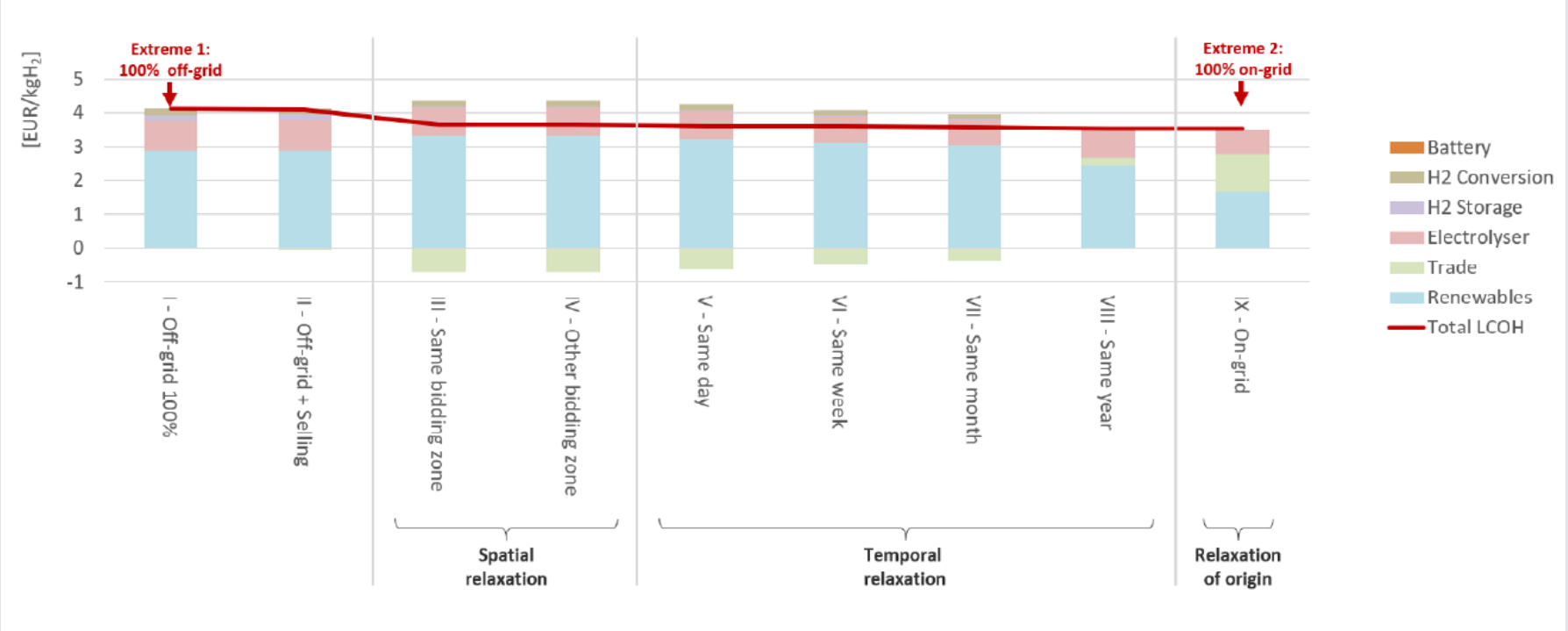
Effects of hydrogen production regulation on carbon emission at the system level for Germany 2030 (assuming additional renewables)



Brauer et al. (2022), Green hydrogen – how grey can it be? FSR Working Paper

The EP proposal will only achieve minimal gains in hydrogen production costs (~10 percent)

Effect of regulations on hydrogen production costs



Brauer et al. (2022), Green hydrogen – how grey can it be? FSR Working Paper

Currently, there is a serious risk, that Europe will define „renewable“ hydrogen in a way that does systemic damage

Loosely defining „renewable hydrogen“ as is proposed by the European Parliament means pouring 10 bn EUR subsidies per year into an industrial ecosytem that adds significant electricity demand to the system and maximises full load hours of electrolysers for hydrogen production without attention to the specific power mix.

This will do systemic damage. It would mean:

- Subsidising an increase in power sector greenhouse gas emissions;
- Subsiding an increase in electricity demand with upward pressure on power prices;
- „Renewable“ hydrogen made in Europe would not be carbon free, but come with (significant) specific greenhouse gas emissions, that may be higher than what is defined as „low carbon“ gas;
- Europe would be obliged under international trade law to recognise as „renewable“ all hydrogen imports that come with a carbon ruck-sack comparable to „renewable“ hydrogen made in Europe.
- Downstream industrial value chains (e.g. cars, chemicals) relying on the zero-carbon content for green claims in future product markets may see such claims challenged.

How a meaningful definition of „renewable“ hydrogen made in Europe should look-like

Contracting of sufficient renewable capacities through power purchase agreements **+**

→ **<u>Correlation</u>**

- Hourly correlation in same bidding zone (as of now)
- Hourly correlation across bidding zones if there is no congestion (as of now)

→ **<u>Additionality</u>** of renewables used for producing “renewable hydrogen”

- No additionality requirement for electrolysers entering into operation before 31.12.2026 for a limited duration.
- Additional renewables required for all electrolysers built as of 1.1.2027

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Questions or comments? Feel free to contact us:
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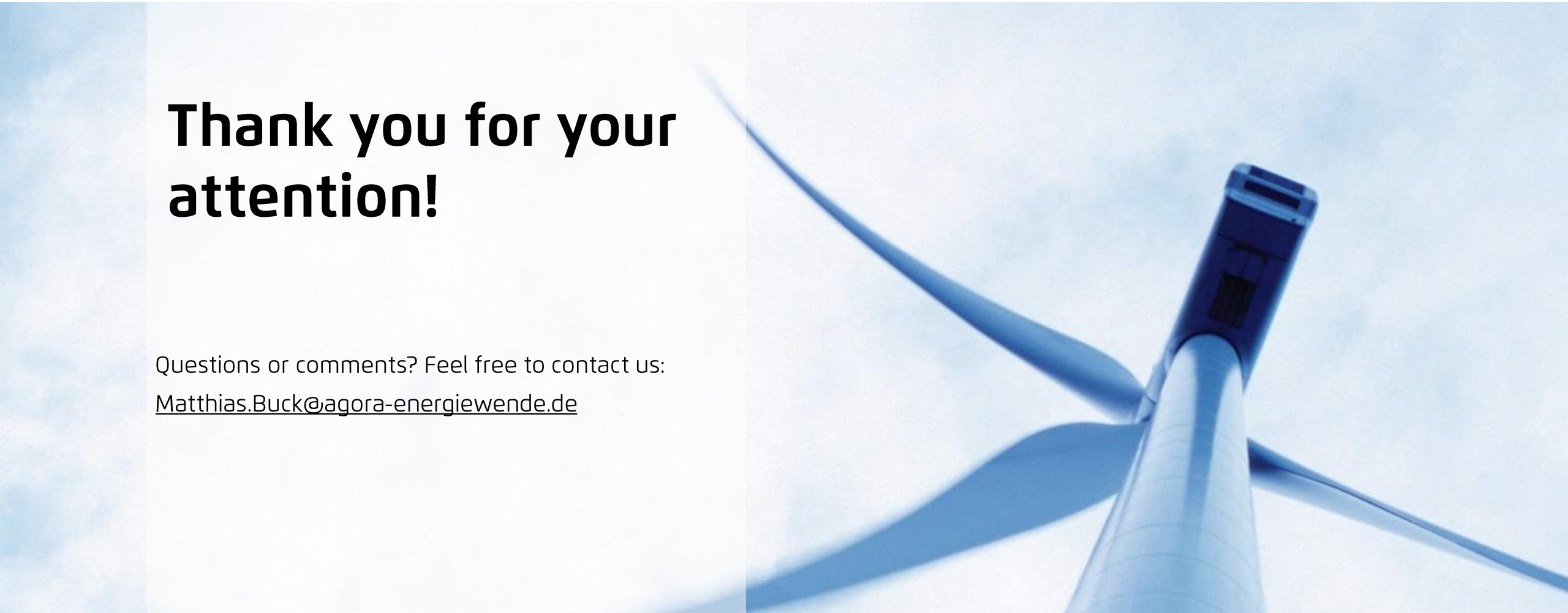
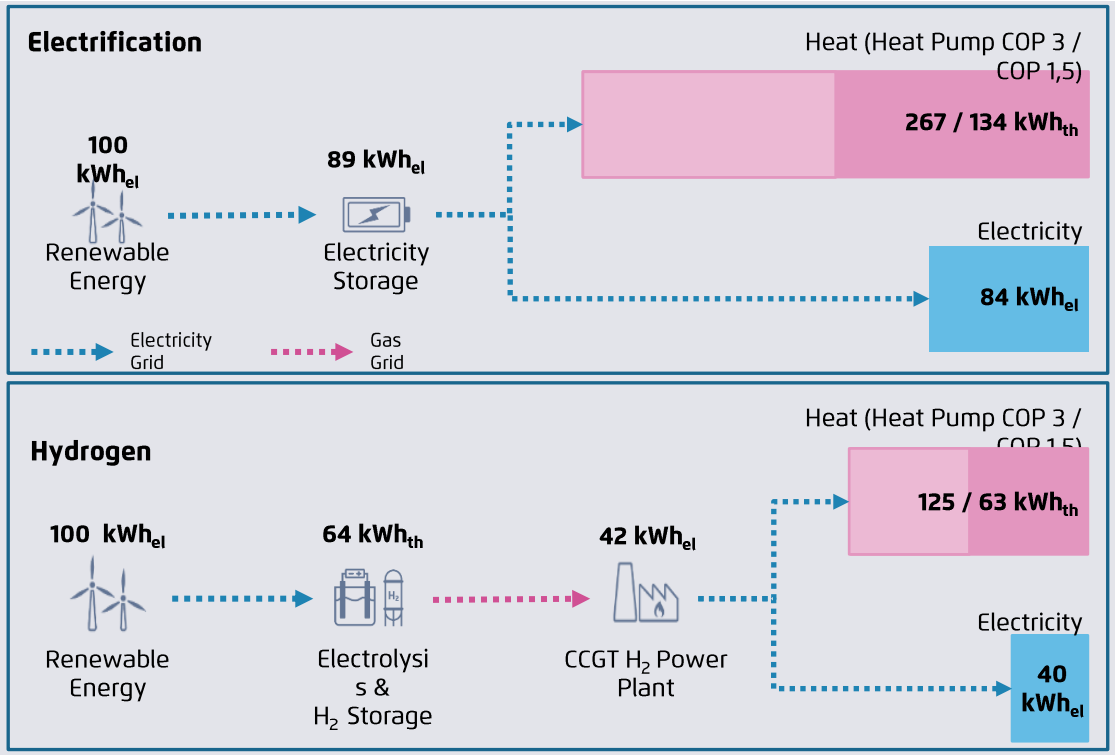


Back-Up

Keeping costs low requires that direct electrification is prioritised over H2 and low-carbon gases wherever possible

Efficiency of electrification vs. green H2 for heat & electricity

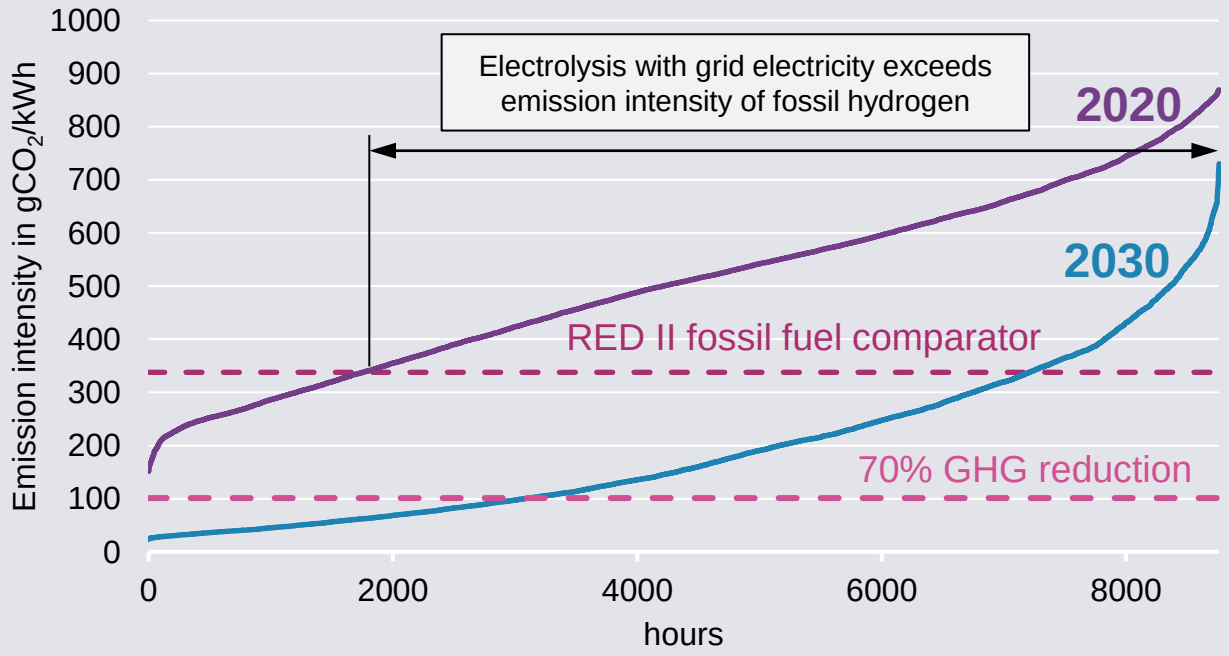


Source: Agora Energiewende

- Direct use of renewable electricity is several times more efficient than using renewable electricity to produce green hydrogen as energy carrier for heating or power generation.
- The majority of today's molecules will be replaced by electricity.
- An over-reliance on the need to replace today's fossil molecules by non-fossil molecules is risky and costly (risks include insufficient availability of green hydrogen, insufficient availability and costs of CCS, unsustainable biogas demand).

Hydrogen production using grid-drawn electricity in Germany results in higher emissions than unabated fossil hydrogen production in 75% of the hours of the year

Emission intensity of hydrogen production with German grid mix

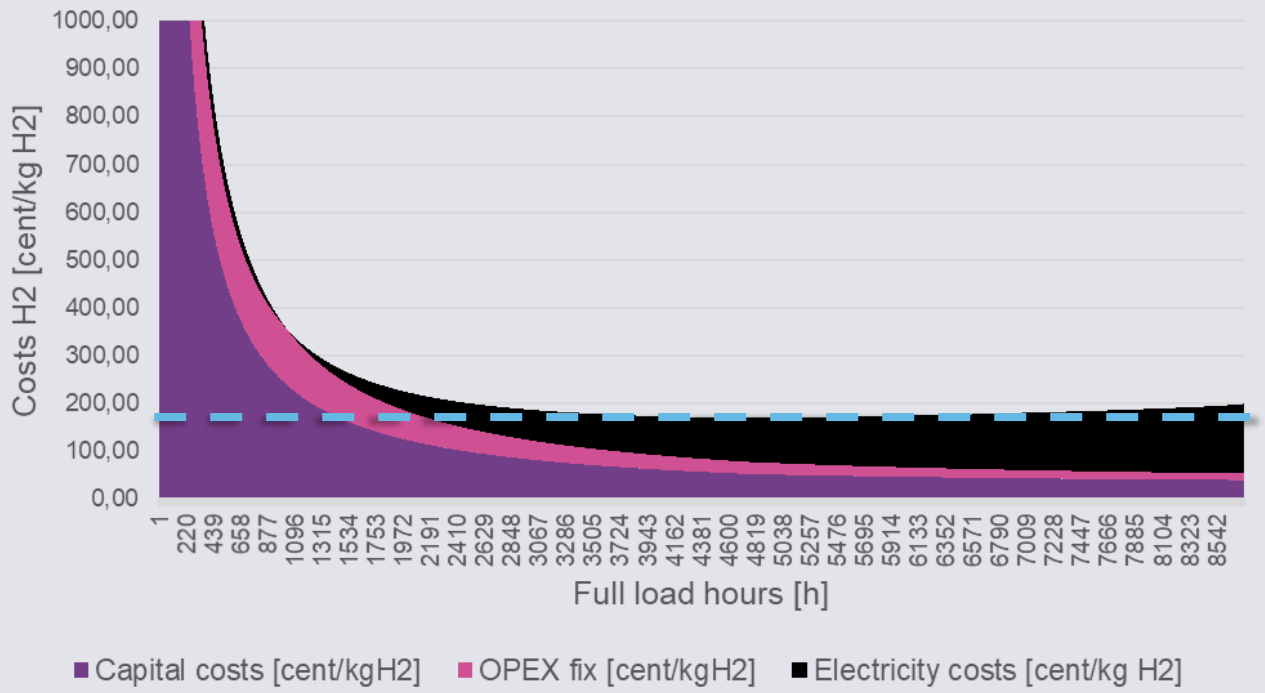


Agora Energiewende (2022)

- Loose temporal correlation allows grid-drawn electricity to fill gaps of contracted renewable PPAs
- In the case of Germany, in 75% of hours this would result in higher direct CO2 emissions than unabated fossil hydrogen production
- Subsidised hydrogen production that is declared renewable must comply with the minimum 70% GHG reduction criteria

Electrolysers operating on grid electricity based on market prices achieve optimal costs at around 5000 FLH

Hydrogen production costs based on full load hours on German grid 2020



Agora Energiewende, Guidehouse (2021)

- → Hydrogen production costs are dominated by electricity costs at high operating hours
- → Restrictions on full load operating hours are justified to limit operation at peak demand hours with emission intensity

Assumptions	
CAPEX	500 €/kW
OPEX (fixed)	5% of CAPEX
Interest rate	8%
Efficiency	69%
Electricity prices based on hourly prices Germany 2020	

Policy should focus on no-regret applications

Green molecules needed?	Industry	Transport	Power sector	Buildings
No-regret	· Reaction agents (DRI steel) · Feedstock (ammonia, chemicals)	· Long-haul aviation · Maritime shipping	· Renewable energy back-up depending on wind and solar share and seasonal demand structure	· Heating grids (residual heat load *)
Controversial	· High-temperature heat	· Trucks and buses ** · Short-haul aviation and shipping · Trains ***	· Absolute size of need given other flexibility and storage options	
Bad idea	· Low-temperature heat	· Cars · Light-duty vehicles		· Building-level heating

* After using renewable energy, ambient and waste heat as much as possible. Especially relevant for large existing district heating systems with high flow temperatures. Note that according to the UNFCCC Common Reporting Format, district heating is classified as being part of the power sector.

** Series production currently more advanced on electric than on hydrogen for heavy duty vehicles and buses. Hydrogen heavy duty to be deployed at this point in time only in locations with synergies (ports, industry clusters).

*** Depending on distance, frequency and energy supply options