AURORA ENERGY RESEARCH

"THG Quoten" & electrolyser profitability in Germany – more than hot air?

Public Webinar, 17 May 2023

Aurora provides market leading forecasts & data-driven intelligence for the global energy transition

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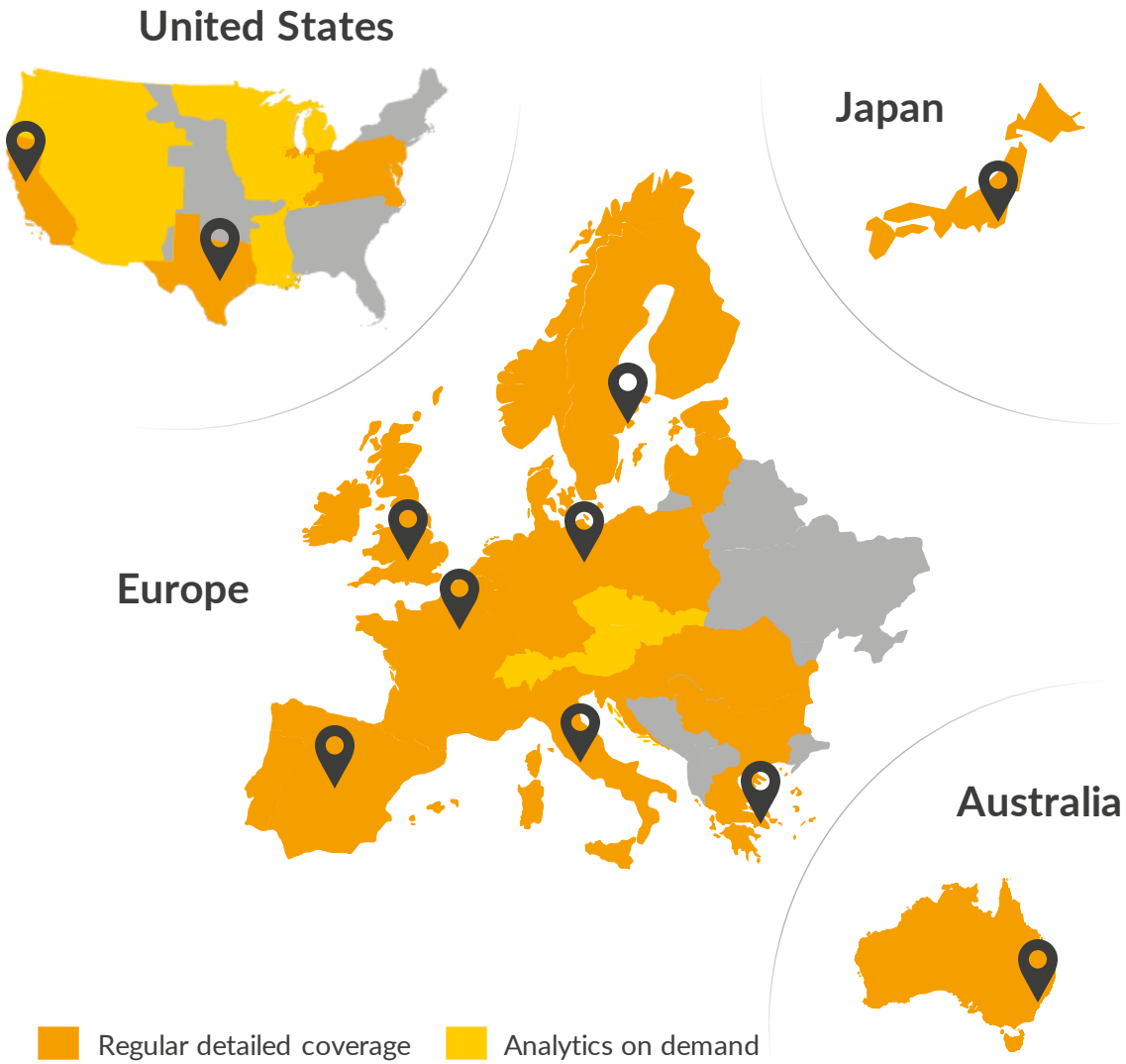
- Power markets
- Renewables
- Storage
- Electric vehicles
- Hydrogen H_2
- Carbon CO_2
- Natural gas



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Source: Aurora Energy Research

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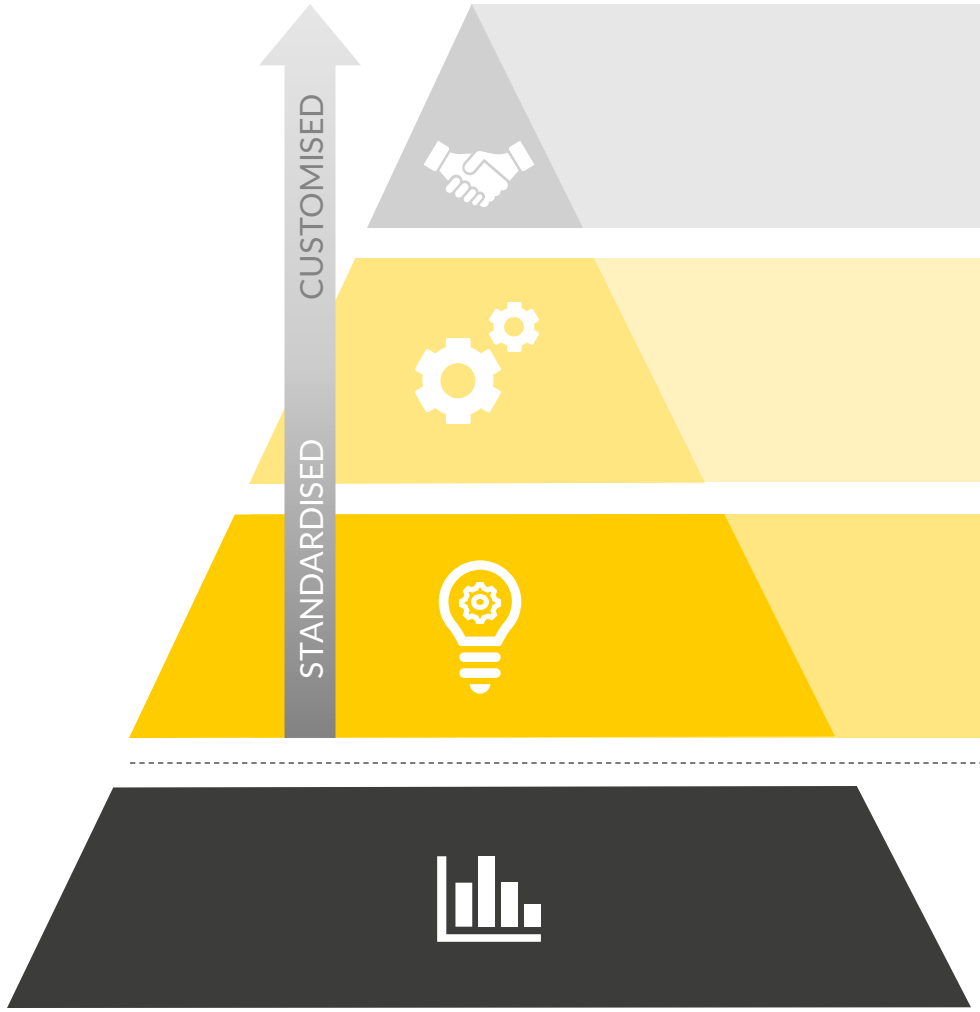

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Developed over 10 years, 40+ dedicated modellers

Source: Aurora Energy Research

Our European Hydrogen Market Service keeps you up-to-date with regular insights, policy & market updates, and roundtable discussions

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Full European Hydrogen Market Subscription Analytics Service

Forecast Reports & Data

Hydrogen Market Attractiveness Report (HyMAR)

- Summary of policy developments and incentives across Europe
- Global electrolyser project database
- Hydrogen market sizing: demand scenarios by country and sector
- Analysis of demand and supply drivers

Investment case analysis

- Hydrogen production economics based on Aurora's in-house power, gas and carbon price forecasts
- Forecasted Hydrogen prices out to 2060

Interactive Online Database and Scenario Explorer

Explore scenarios through EOS, our dynamic online platform featuring a full library of reports and datasets.

Strategic Insights

Strategic Insight Reports

Regular insight reports on topical issues in the evolving European hydrogen market covering country, policy, and technology deep dives

Policy Updates

- Regular updates on European Hydrogen policies and incentives across power, heat, transport, and industry
- Thought leadership on required policies and incentives to grow hydrogen sector

Group Meetings

- Presentation of Market Attractiveness reports and Strategic Insight reports
- Networking opportunity with developers, investors, and Governments—the 'go-to' roundtable to discuss hydrogen developments in Europe

Analyst Support

Bi-annual workshops and support from our bank of analysts, including native speakers and on-the-ground experts

Discover the major players across the value chain subscribing to our European Hydrogen Market Service

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Department for Business, Energy & Industrial Strategy
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Committee on Climate Change
Department for Transport
National Infrastructure Commission

Upstream gas & networks

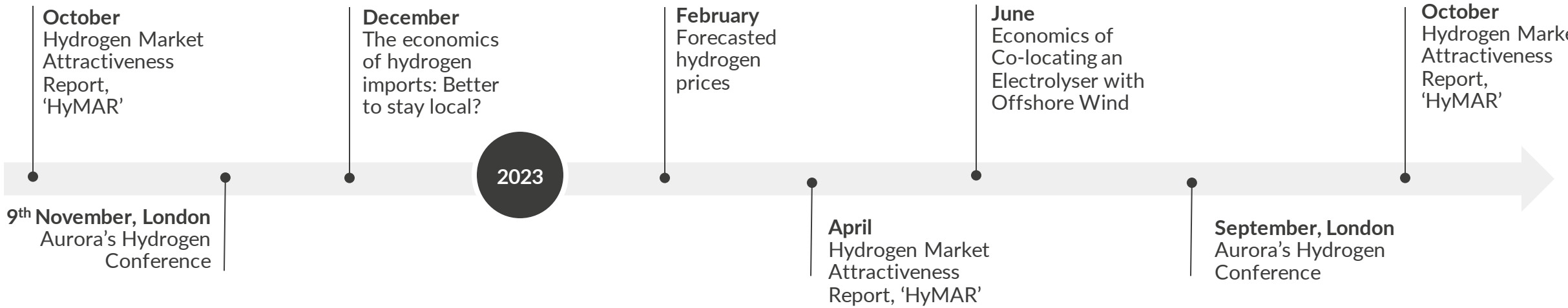
REPSOL
equinor
Naturgy
OGE
nationalgrid
Thyssengas
Vitol
fluxys

Source: Aurora Energy Research

What's coming up in the European Hydrogen Market Service?

Timeline of Strategic Insight Reports and Policy Updates

Upcoming reports of European Hydrogen Service



Existing reports[1]

Policy notes

- RePowerEU Plan: May 22
- UK hydrogen policy updates
- Poland H_2 strategy policy note
- Scotland H_2 strategy policy note
- Canada H_2 strategy policy note
- Preliminary Italian National Hydrogen Strategy

Country deep-dives

- Green hydrogen in Germany- Could co-location become a new business model for renewables?
- The role of green hydrogen in Iberia
- Hydrogen for a Net Zero Great Britain
- Low carbon hydrogen in the Nordics
- Italian Net Zero Strategy and Aurora's Net Zero modelling for hydrogen
- Hydrogen in France

Strategic Insights

- Hydrogen in mobility: understanding the economics and incentives
- Shades of green (hydrogen) – part 2: in pursuit of 2 EUR/kg
- Shades of green (hydrogen): optimising electrolyser business models
- From near and far: the economics of hydrogen imports
- Financing electrolysers: Overview of market trends in Europe

1) All reports are available to subscribers of Aurora's European Hydrogen Service

Source: Aurora Energy Research

Agenda

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I. Regulatory framework

II. GHG quota price – forecast methodology

III. Implications for hydrogen

To reduce GHG emissions in the transport sector a regularity framework evolved that is based on mandatory reduction quotas

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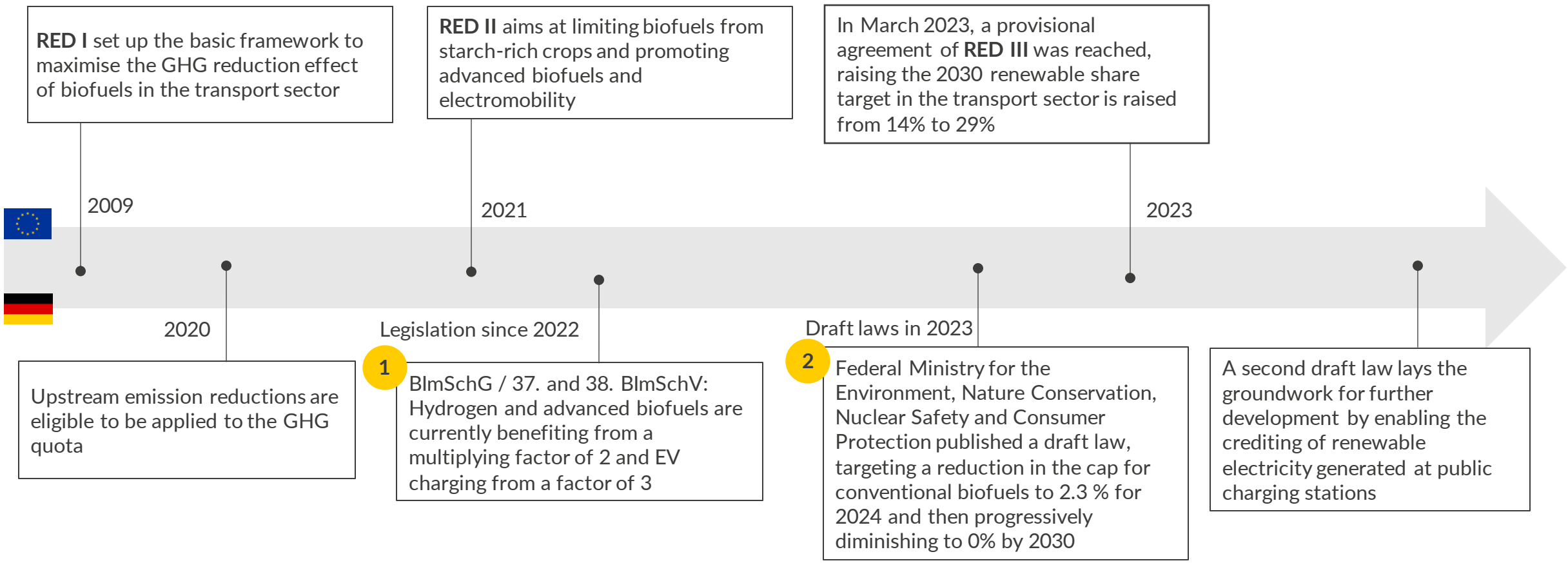

Sources: Aurora Energy Research

Hydrogen and advanced biofuels currently benefit from a multiplying factor of 2 and EV charging from a factor of 3

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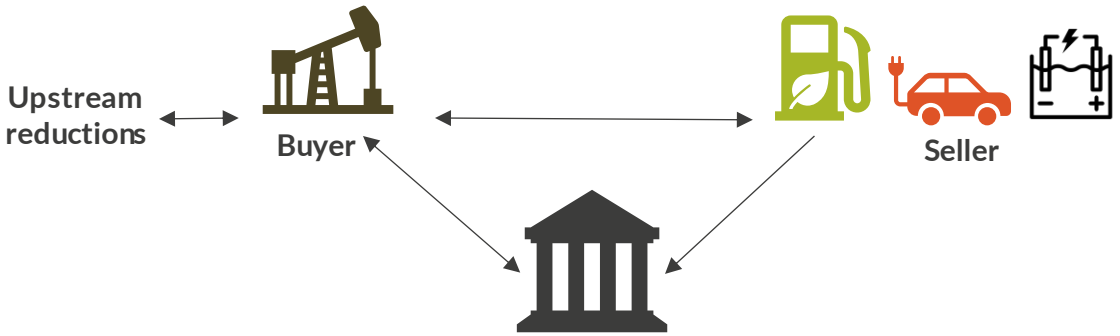
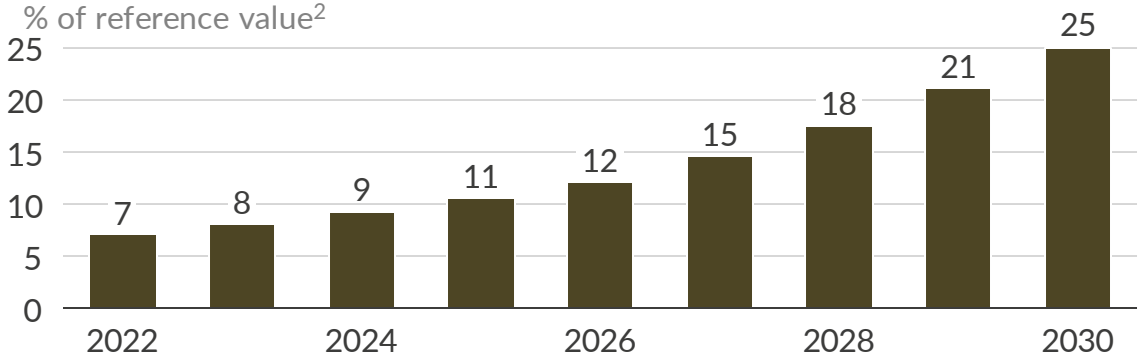
1 BImSchG §37a



- The amount of GHG emissions the companies are obliged to reduce is calculated by multiplying the base value by the amount of fuels used in transport. If GHG-quotas are not fulfilled, a penalty price of 0.6 EUR/kg CO_{2eq} needs to be paid.

Regulation for GHG reduction determines the demand for "GHG Quotas"

% of reference value[2]



37. and 38. BImSchV

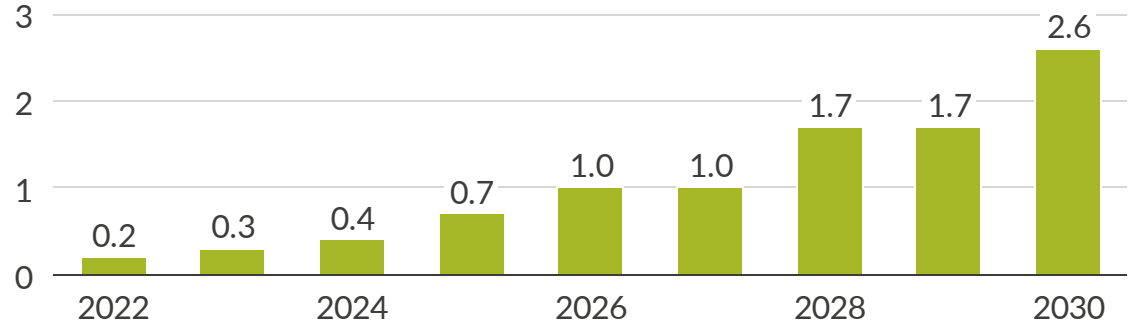
- The quota obligation can be supplied by three main types:

	Advanced Biofuels	Electromobility	Electricity-based fuels
Multipliers	x2	x3	x2

- For biofuels an upper limit for conventional fuels and lower limit for advanced biofuels is applied
  - Since 2023, biofuel produced from palm oil is no longer eligible

Lower-bound for advanced biofuels

% of energetic amount of fossil fuels used in transport sector



1) The electricity used to produce the fuels needs to be produced from non-biofuel renewables 2) The reference value is defined as the base value (94.1 kgCO2eq/GJ) multiplied by the energy content of fuel used in the transport sector.

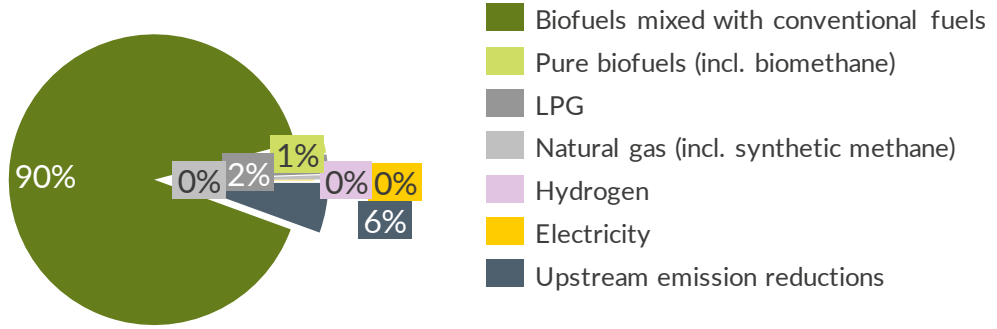
Sources: BImSchG, BImSchV

A coalition of ministers from green party and social democrats plans to reduce crop-based biofuels to 0% in 2030, liberals oppose

2 Current discussions around crop-based biofuels in Germany

- In light of the war in Ukraine and the emerging food crisis, a draft law was published beginning of 2023, aiming at reducing the upper limit of crop-based biofuels to 2.3% in 2024 and 0% until 2030
  - 1.9 mio ha land are occupied to produce the crop-based biofuels consumed in Germany
  - By reducing the amount of crop-based biofuels used in the transport sector, the ministries hope to increase the supply of crops and thereby reduce the price pressure
- To compensate for the missing biofuels, the draft law proposes the following changes:
  - **Increase the multiplier for hydrogen from 2 to 3** and for EVs from 3 to 4
  - Increase the maximum share for biofuels from waste
  - To extend upstream emissions as a fulfilment option from 2026 to 2028
  - Slight downward adjustment of quota in 2024-2026 (around 1 p.p.)
- Advocates of crop-based biofuels are sceptical:
  - Biofuels made up 92% of the quota in 2020; reducing the eligible amount of crop-based biofuels to 0% by 2030 can endanger the emission targets in the transport sector

Quota fulfilment – 2020
% of achieved emission reductions



Implications for the GHG market

- The supply of GHG quotas could be significantly reduced:
  - In 2020, crop-based biofuels made up 72% of the biofuels providing quotas
  - Until capacities for advanced biofuels are increased, a decrease in supply exercising an upwards price pressure is expected
- Increasing multiplying factors could, by contrast, increase the supply of GHG quotas:
  - EVs and hydrogen are expected to provide cheaper quotas than crop-based biofuels until 2030
  - If hydrogen becomes price-setting in the quota market, this could also lead to a decrease in expected quota prices

Sources: Handelsblatt, Zoll, BLE

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We model the GHG quota market based on a demand-supply balance and the short-run marginal costs of different supply options

Illustrative merit-order for forecasting the GHG quota

Two scenarios are forecasted:

- Central scenario
- High-supply scenario

Source: Aurora Energy Research

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Forecast methodology

1 Demand

- Starting point is historic consumption of Diesel & Gasoline; Forecast based on assumptions about vehicle stock

2 Supply

- Biofuels:
  - based on feedstock prices, input intensity, specific emission reductions and min./ max. shares of biofuels
- EVs:
  - Based on EV stock assumptions and Aurora's forecast on emission intensity of power
- Hydrogen/SynFuels:
  - Based on refinery demand and Aurora's expectation of H_2 production and SRMC

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By 2030, German refineries could have an offtake potential of 13 TWh for hydrogen

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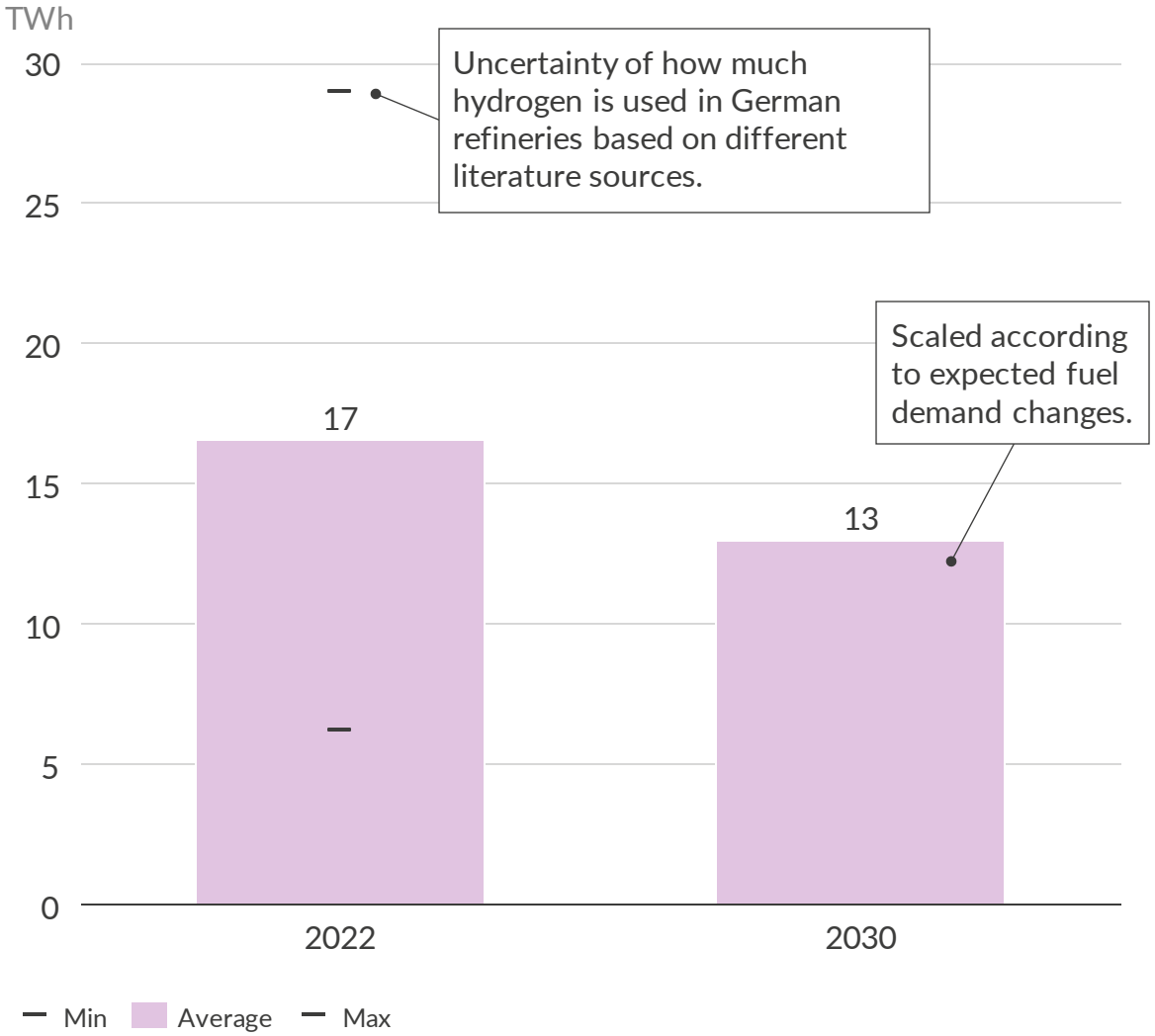
German hydrogen demand in refineries



Status of the regulation

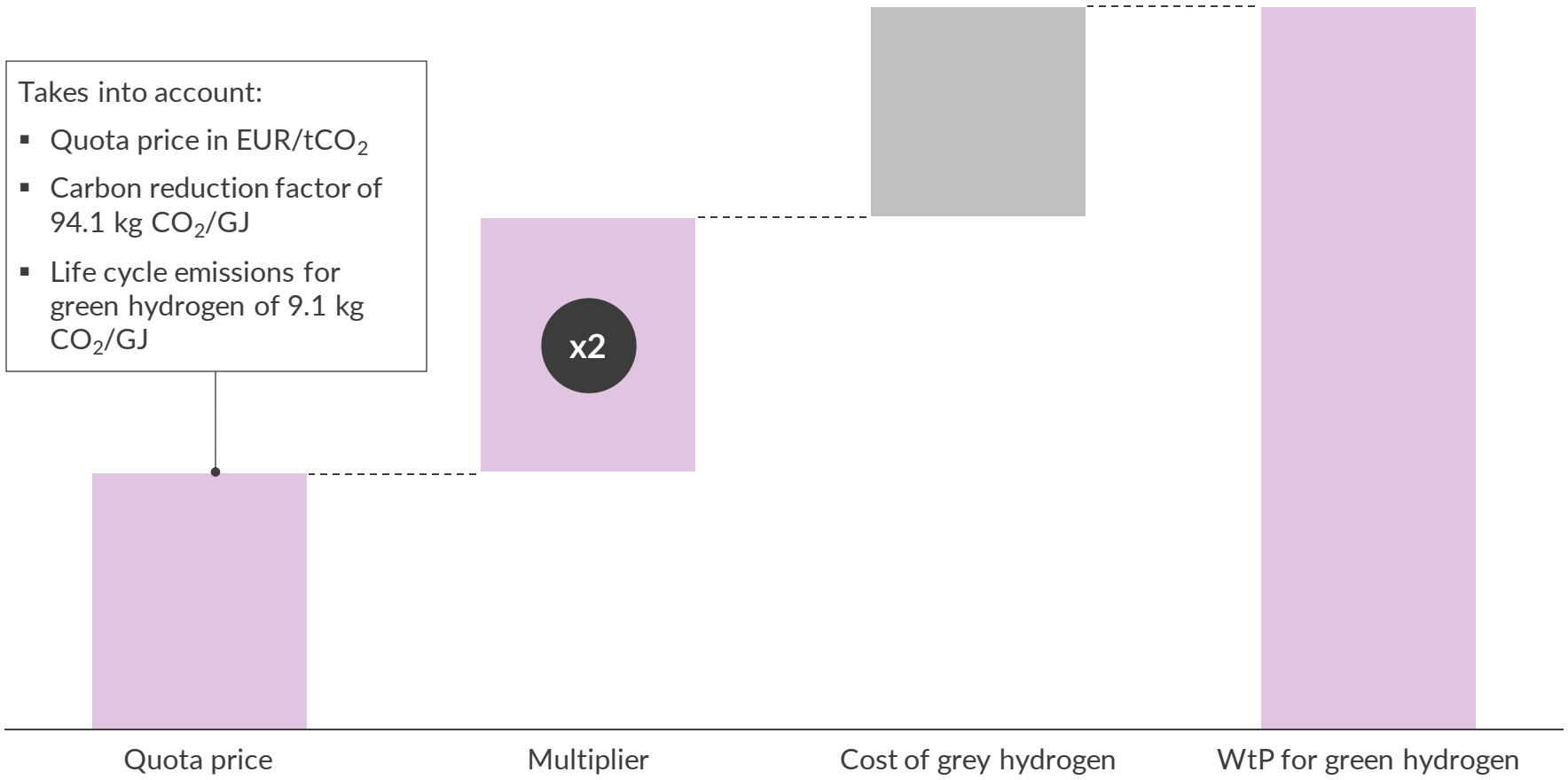
- The current status of regulation allows green hydrogen to sell quotas, if it is used in fuel cell cars:
  - We expect that this provides for only a limited use case in the next years
- In contrast, refineries already have big off-take of grey hydrogen of 17 TWh
  - This could be substituted by green hydrogen in the coming years
- The eligibility of green hydrogen to sell quotas, if it is used in refineries, is already defined in current law
  - **BUT**: it only comes into action, if a respective ordinance is published – this ordinance is missing so far
- The German government announced last year, that hydrogen used in refineries will benefit from the same multiplier as hydrogen used in fuel cells

  → Therefore, it is likely only a matter of time until hydrogen used in refineries becomes eligible for the GHG quota market

Sources: Aurora Energy Research, FCHO, BMWK

The willingness to pay for hydrogen is based on the Quota price, the emission reduction factor, the multiplier and cost of grey hydrogen

WtP for green hydrogen as stimulated by GHG-Quota[1]
EUR/kg H_2



Source: Aurora Energy Research

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Comments

- We derive the willingness to pay (WtP) of refineries for green hydrogen based on refineries' alternative options:
  - Purchasing grey hydrogen and
  - Purchasing Quotas
- The quota price, which is defined as EUR/tCO_2, is translated into EUR/kg H_2 taking the legally defined carbon reduction factors and life cycle emissions for green hydrogen into account
- Additionally, the multiplier of 2 is applied

As the price for GHG-Quotas is much higher than for producing hydrogen, refineries have an incentive to produce hydrogen themselves

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The GHG-Quota will boost the demand for green hydrogen in refineries

- Hydrogen is an attractive option for refineries to fulfil their GHG-Quota
  - It has a large multiplier
  - It is relatively cheap in comparison to advanced biofuels
  - Refineries have the know-how to produce it hydrogen, broadening their value chain

Regulatory uncertainty prevents investments

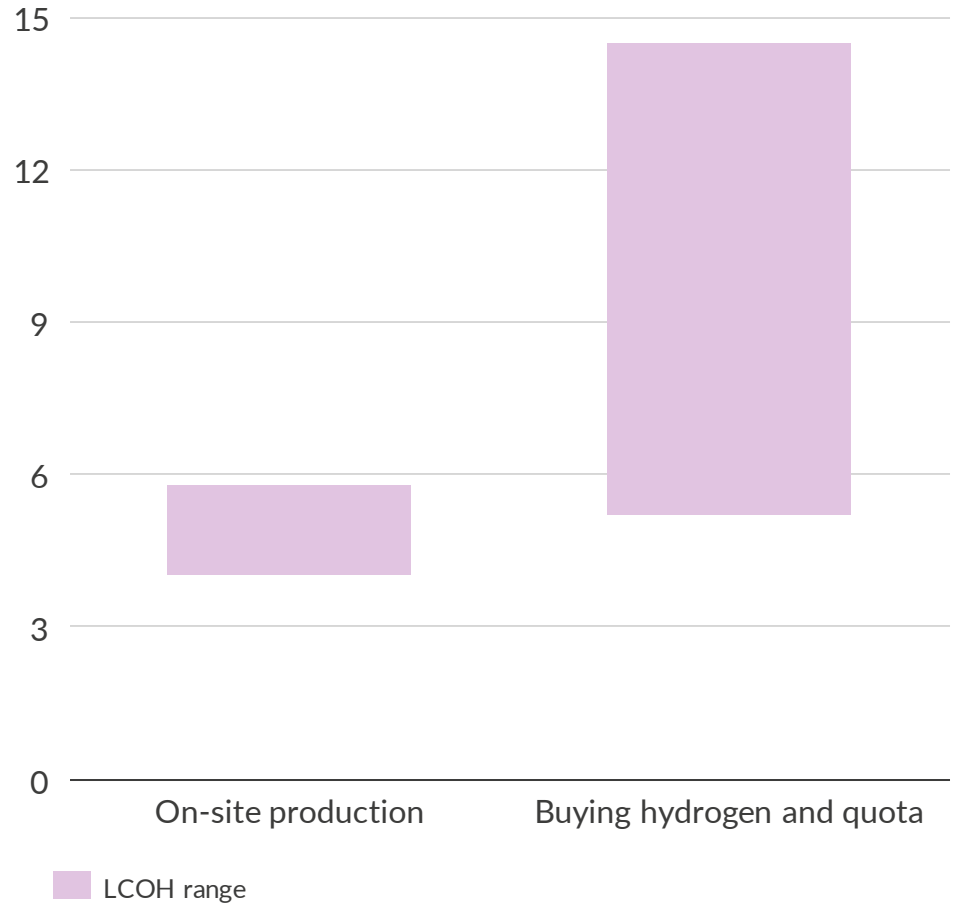
- Currently, there are only few investments from refineries in electrolysers
- There is now a definition of green hydrogen, but still a lot of uncertainties with respect to the usage of hydrogen for the GHG quota market

The uncertainty around hydrogen offtaker prices is transferred to the electrolyser developer

- If refineries invest in their own electrolysers, their willingness to pay will be reduced to the production costs of green hydrogen

Hydrogen price based on LCOH and based on GHG-Quota prices

EUR/kg H_2



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