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ENERGY RESEARCH

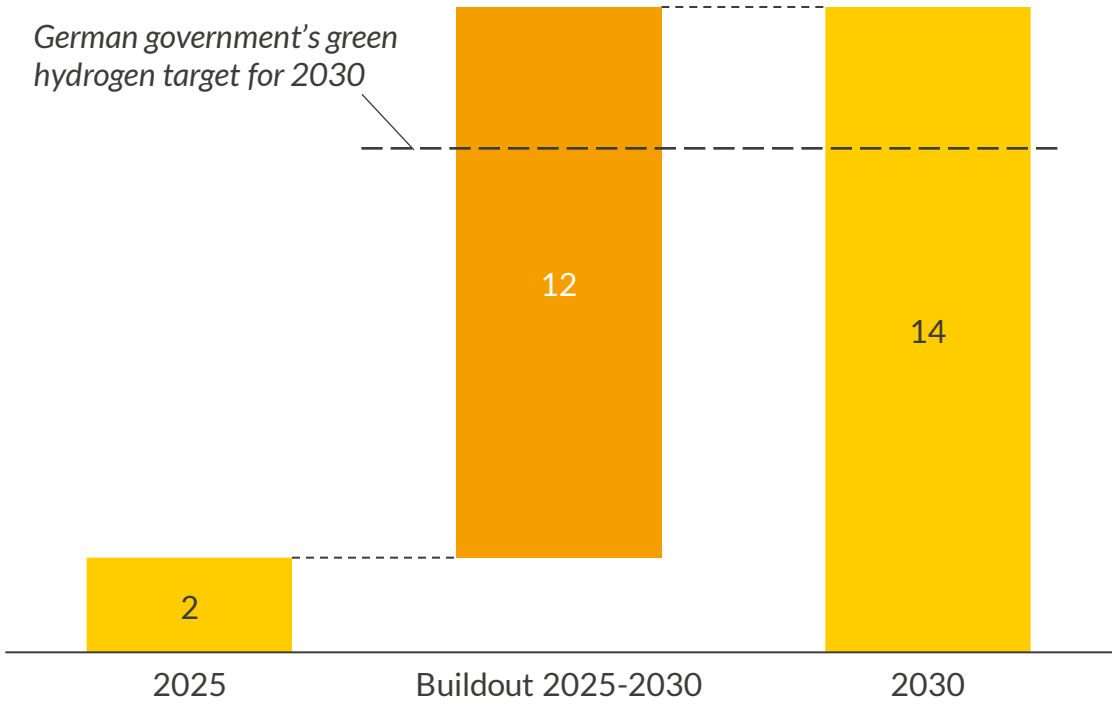
Electrolysers in Germany and their Rocky PPA Path

Public report

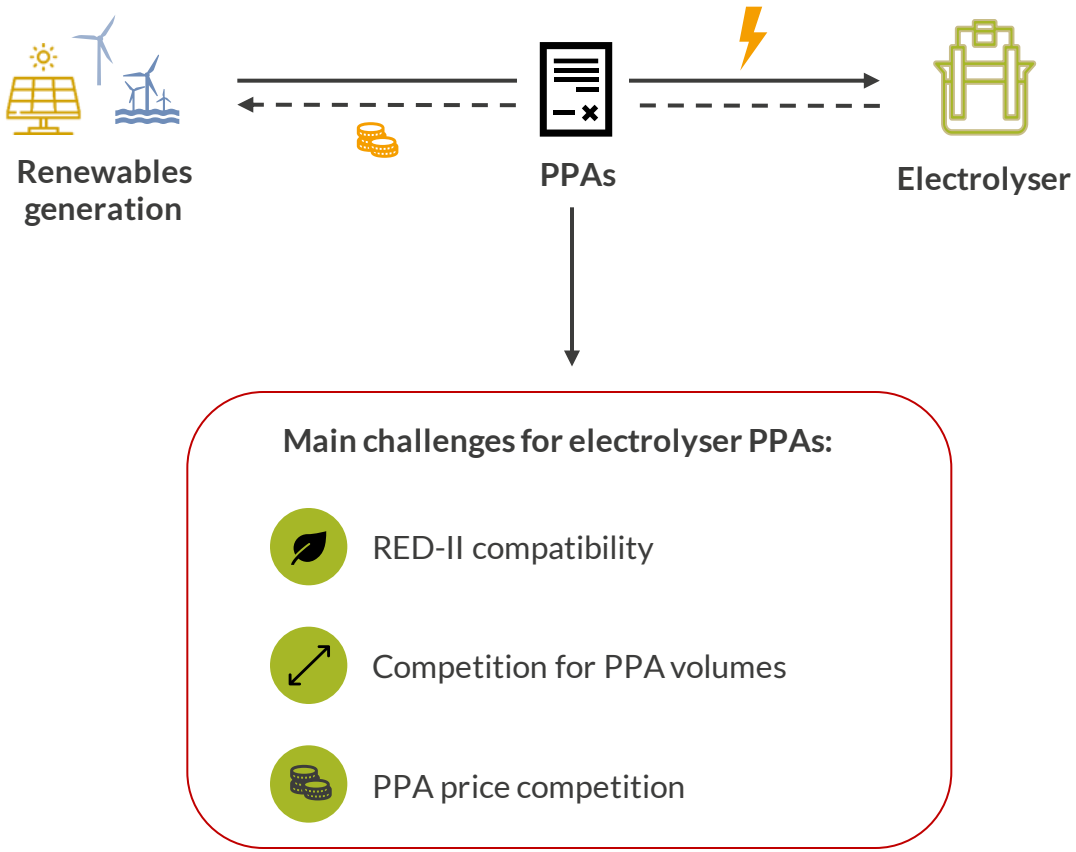
Power Purchase Agreements play a central role in unlocking the ambitious pipeline of electrolyser projects, but regulatory and market challenges exist

As Germany's demand for hydrogen continues to rise, it boasts Europe's largest pipeline of (late-stage) electrolyser projects to be built by 2030.

Cumulative electrolyser pipeline in Germany (late-stage)[1]
GW



A key milestone for electrolyser project development is establishing the power procurement strategy and close PPAs.



1) These project capacities are extracted from Aurora's global electrolyser database, which keeps track of all announced electrolyser projects globally. The timeline and the capacities provided in these charts might not necessarily be achieved fully.

Source: Aurora Energy Research

Agenda

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I. RED-II compatibility

II. Competition for PPA volumes

III. PPA price competition

Electrolyser business models must fulfil three criteria for green H_2 production, which places significant demands on their PPA strategies

Required Renewable Energy Directive II[1] (RED-II) criteria for H_2 to be considered "green":

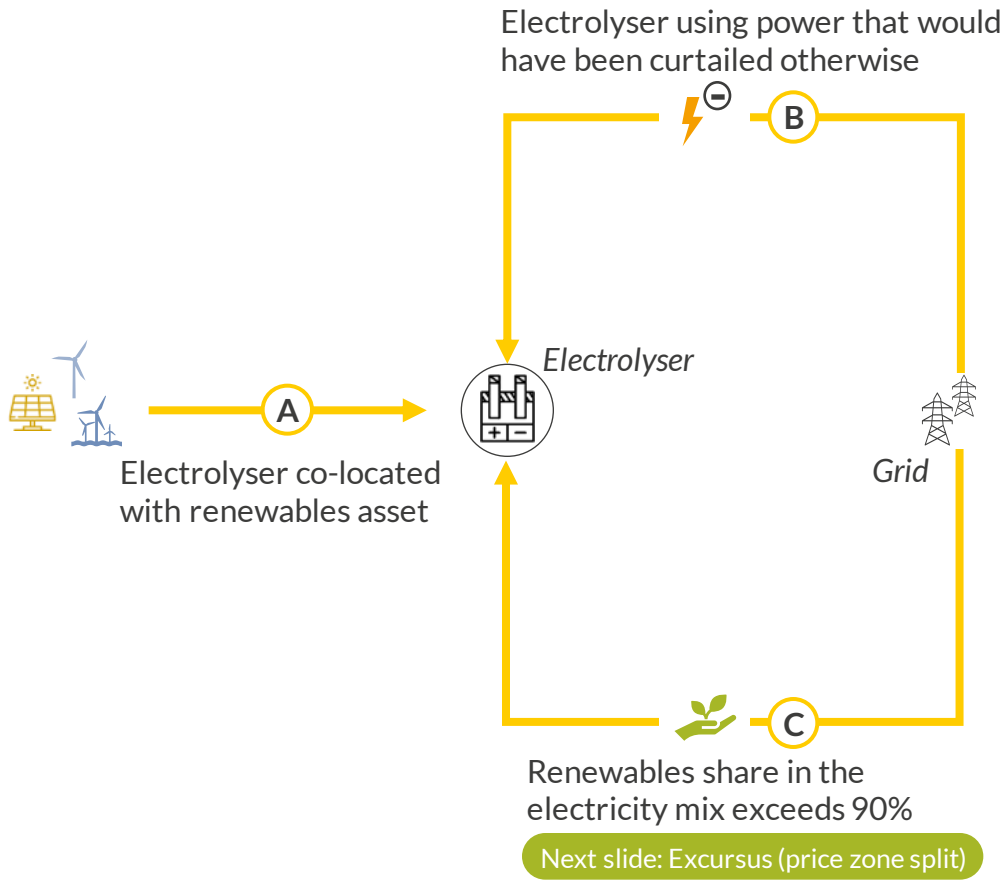
Additionality
Electricity used must come from a newly built renewables asset that came into operation max. 36 months before the electrolyser. The renewables asset must not receive subsidies.

- Assets that start operation before 1 January 2028 are exempted from this requirement until 1 January 2038.

Geographic correlation
The renewables asset and the electrolyser must be located within the same bidding zone or neighbouring ones.

Temporal correlation
The power generation and hydrogen production must match in a certain timeframe: This is monthly until 1st January 2030, and hourly afterwards.

There are several cases when electrolysers do not need to have a PPA in place, and can procure green power directly from the grid:



Next slide: Excursus (price zone split)

1) The Renewable Energy Directive sets renewable energy targets across all sectors within the EU. RED-II entered into force in December 2018.

Sources: Aurora Energy Research, European Commission

A split of the German bidding zone would mean that grid-based electrolysers in the Northern zone would not require a PPA to procure green power

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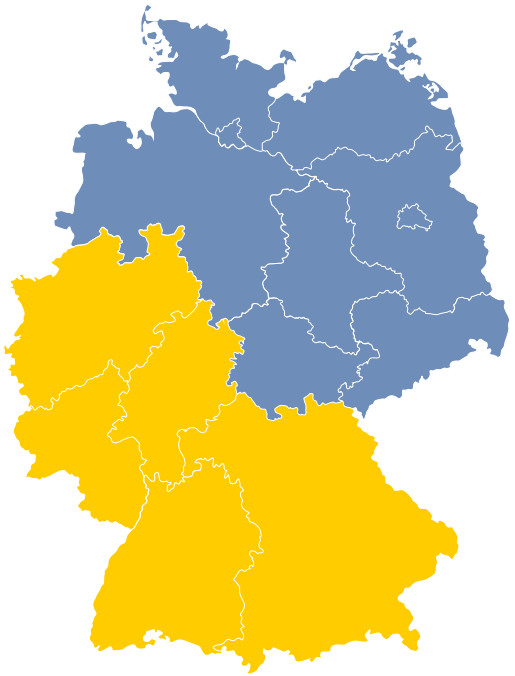
Excursus

Effect on electrolyser projects in Germany



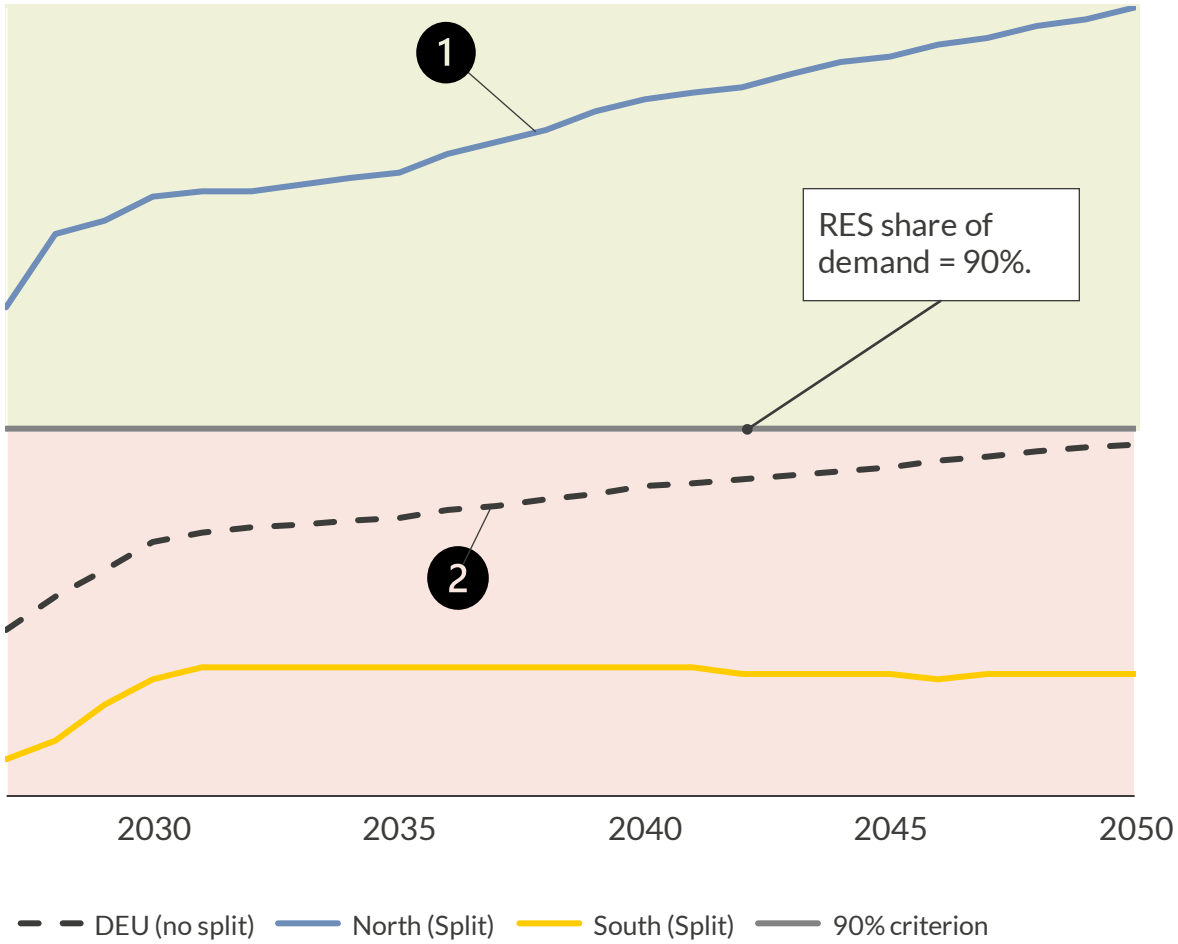
1 **With a price zone split, the northern zone would have a RES share of demand > 90%.**

As a result, the production of green H_2 from grid-based electrolysers would be permissible without a PPA.

2 **If the price zone split is not enacted, the German grid is not expected to reach 90% renewables as a percentage of demand until after 2050.**

Electrolysers would continue to require PPAs under RED-II.

Renewable generation relative to power demand[1] ("RES share")



1) Analysis based on the July 2023 publication of Aurora Central. RES share of demand is higher than 100% as Northern Germany is a net exporter of electricity.

Source: Aurora Energy Research, European Commission

The tightening of RED-II green power requirements poses added challenges for securing PPAs for electrolysers with operations starting after 2028

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Electrolyser (operations starting *before 2028*)

Electrolyser PPA have to satisfy the following criteria:

- **Additionality**: Waived until 31 December 2037, allowing for the flexibility to sign a PPA with both EEG-eligible or post-EEG assets.
- **Geographic correlation**: German assets will be contracted.
- **Temporal correlation**: Until 2030, only monthly correlation needs to be considered, allowing for flexibility in structuring power procurement.

These circumstances do **not adversely affect** the PPA strategy:

- ✓ Broad choice of assets to contract (EEG, post-EEG, merchant)
- ✓ Flexible tenor & pricing
- ? Uncertainty regarding bidding zone split might affect the tenor choice

Electrolyser (operations starting *from 2028 onwards*)

Electrolyser PPA will have to satisfy the following criteria:

- **Additionality**: Only new-built assets can be contracted via a PPA; offshore wind zero bids, merchant solar or onshore wind
- **Geographic correlation**: German assets will be contracted.
- **Temporal correlation**: By 2030, the hourly requirement is in place, allowing less flexibility in structuring power procurement.

These circumstances **present additional hurdles** for PPA strategies:

- Limited choice of assets to contract (only zero bids/merchant assets)
- Inflexible tenor & pricing (fixed price, 10–15-year tenor required for the debt financing of new-build assets)
- ! Certainty regarding bidding zone split and potential upside

Next slide: Resulting power procurement challenges

2024 — 2028

Start date of electrolyser operations

Source: Aurora Energy Research

An electrolyser starting operations from 2028 onwards will have to consider competition from other offtakers for limited RED-II-compatible PPA volumes

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Further challenges

Electrolyser operations start *from 2028 onwards*

Competition for PPA volumes

New-built electrolysers face challenges in a competitive PPA market:

- Lack of proof of concept
- No creditworthiness
- Risk of offtake delays

Section II: Volume competition

Is there a sufficient supply of RED-II-compliant PPAs available to cover the power demand of electrolyser projects and the remaining industry?

PPA price competition

- New-built electrolysers are highly price-sensitive as the cost of electricity is a significant component of the production cost of green hydrogen.
- Competitive pressures arise as other industry sectors also contend with strong stakeholder demands, intensifying the competition.

Section III: Price competition

Can electrolyser projects compete effectively with other industry sectors when negotiating PPA prices?

Source: Aurora Energy Research

Agenda

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I. RED-II compatibility

II. Competition for PPA volumes

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Aurora's PPA supply and demand forecasts are developed based on our fundamental forecasts and market intelligence

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PPA demand

- Direct corporate demand
- \+
- Utility demand
- \+
- Electrolyser demand
- \+
- EV demand

PPA supply

- Current assets under PPAs
- \+
- Lifetime extensions
- \+
- PPAs under subsidised buildout
- \+
- Merchant buildout

Model outputs

- On the demand side, we model the annual per-sector PPA volume demand, incorporating sector-specific assumptions on creditworthiness and forecasts for the evolution of each sector's appetite for PPAs.
- On the supply side, we build on our fundamental forecasts and categorize assets based on their capacity to secure a PPA.

Source: Aurora Energy Research

Germany electrolysers will be facing competition for RED-II-compliant PPA supply amid strong demand from other industry sectors

When only considering electrolyser PPA demand, there will be sufficient RED-II-compatible renewables assets to meet PPA supply.

However, considering the remaining PPA demand from industry, the German PPA market will be highly undersupplied.

Questions about RED-II? Contact Alex to get in touch with our team:

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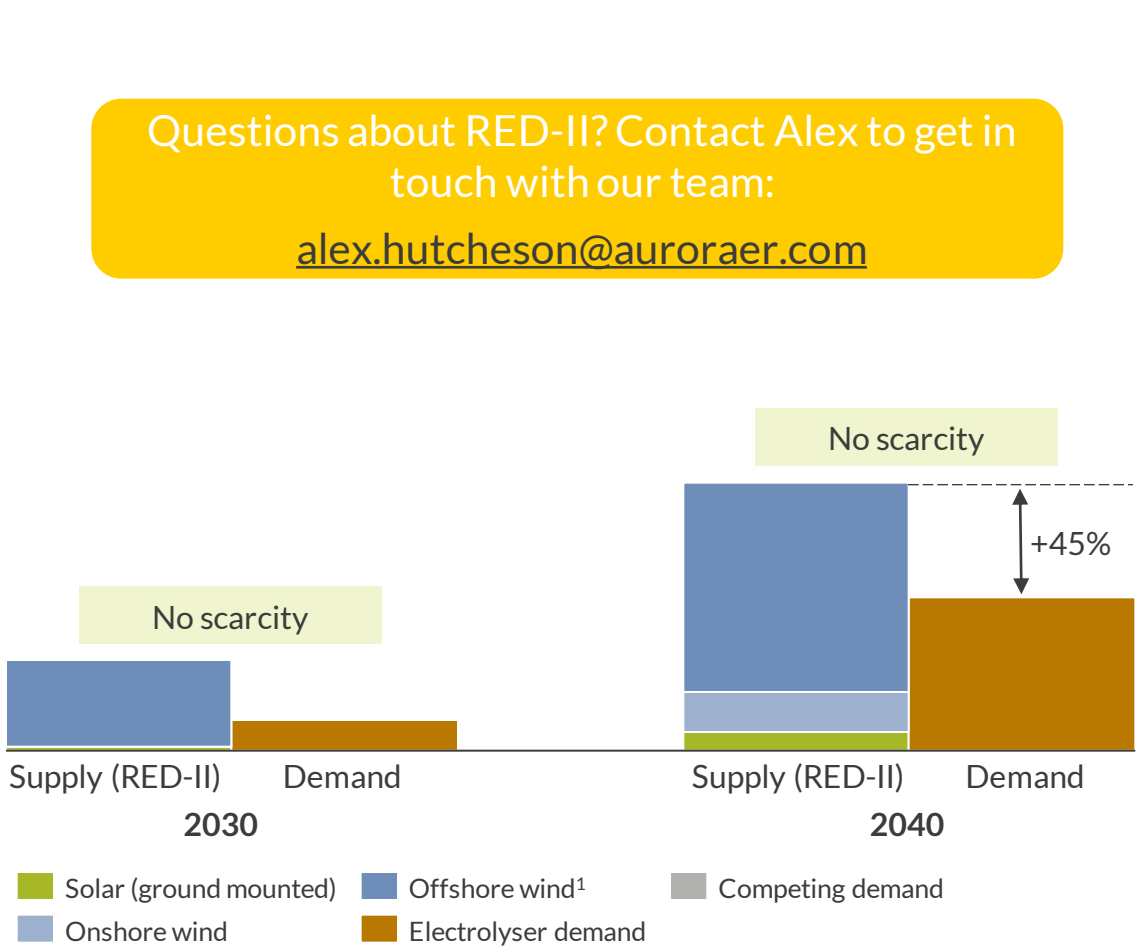

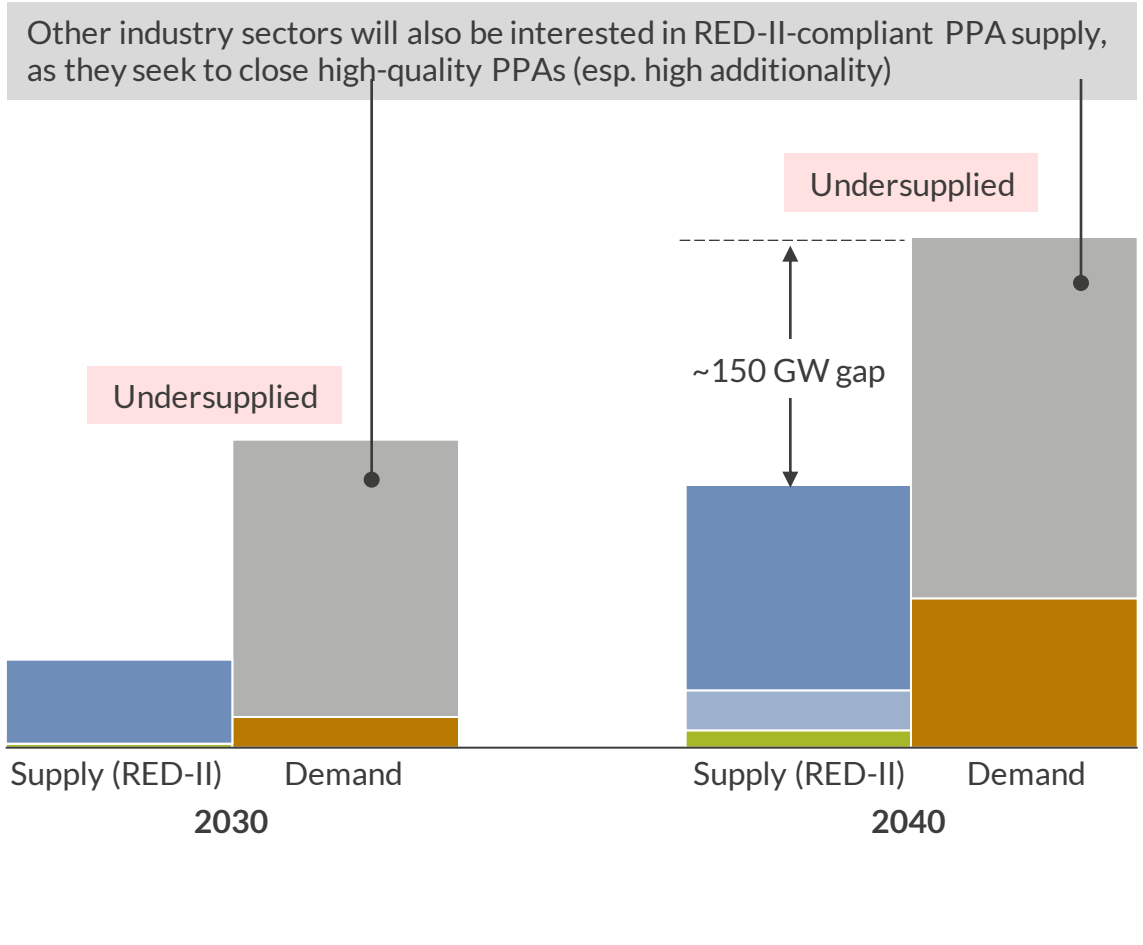

Solar (ground mounted) | Offshore wind[1] | Competing demand
Onshore wind | Electrolyser demand

1) In the case a subsidy scheme with a two-sided CfD will be introduced, most merchant newbuild offshore wind assets will need to be considered as subsidised, strongly impacting the available PPA supply from offshore wind.

Source: Aurora Energy Research

Agenda

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We assess various sectors' willingness to pay for PPAs via a qualitative ranking based on the evaluation of three key components

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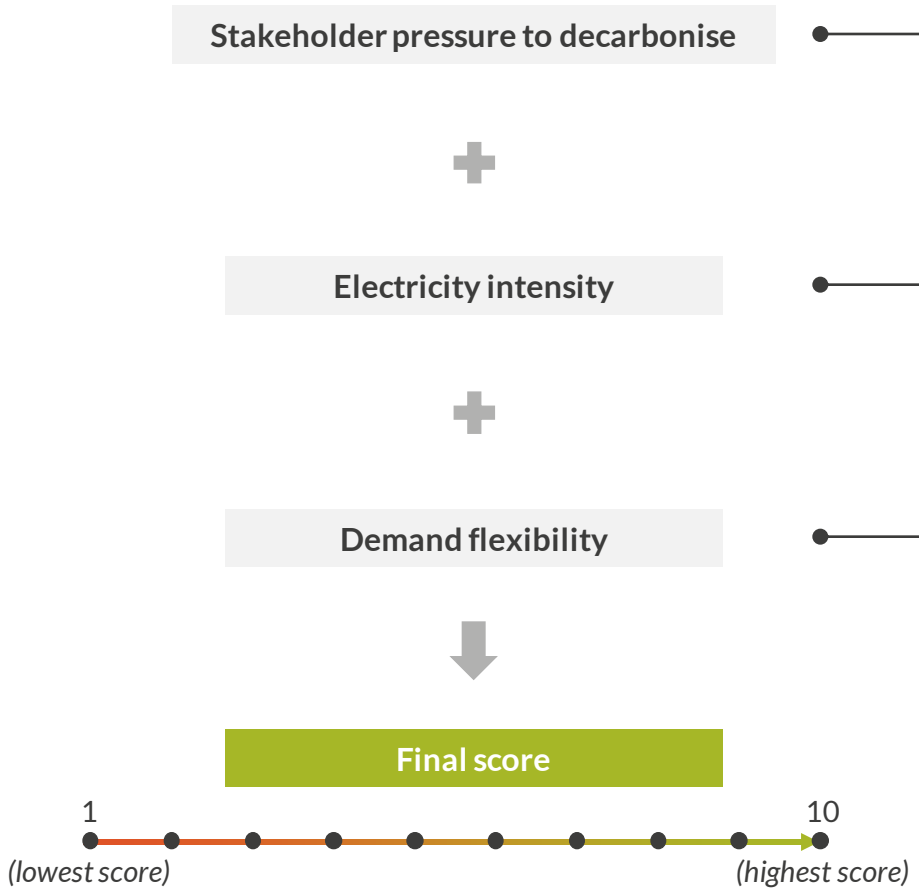
Components of the willingness-to-pay analysis

Explanation and context



- Includes expectations of customers and shareholders, including financial markets and, therefore, regulatory and policy considerations.

\+ Positively correlated with willingness to pay.

- Sectors that are electricity intensive will be highly sensitive to electricity prices.

\- Negatively correlated with willingness to pay.

- Sectors with technically flexible demand can charge from the grid and potentially shift part of the load to hours with lower power prices.

\- Negatively correlated with willingness to pay.

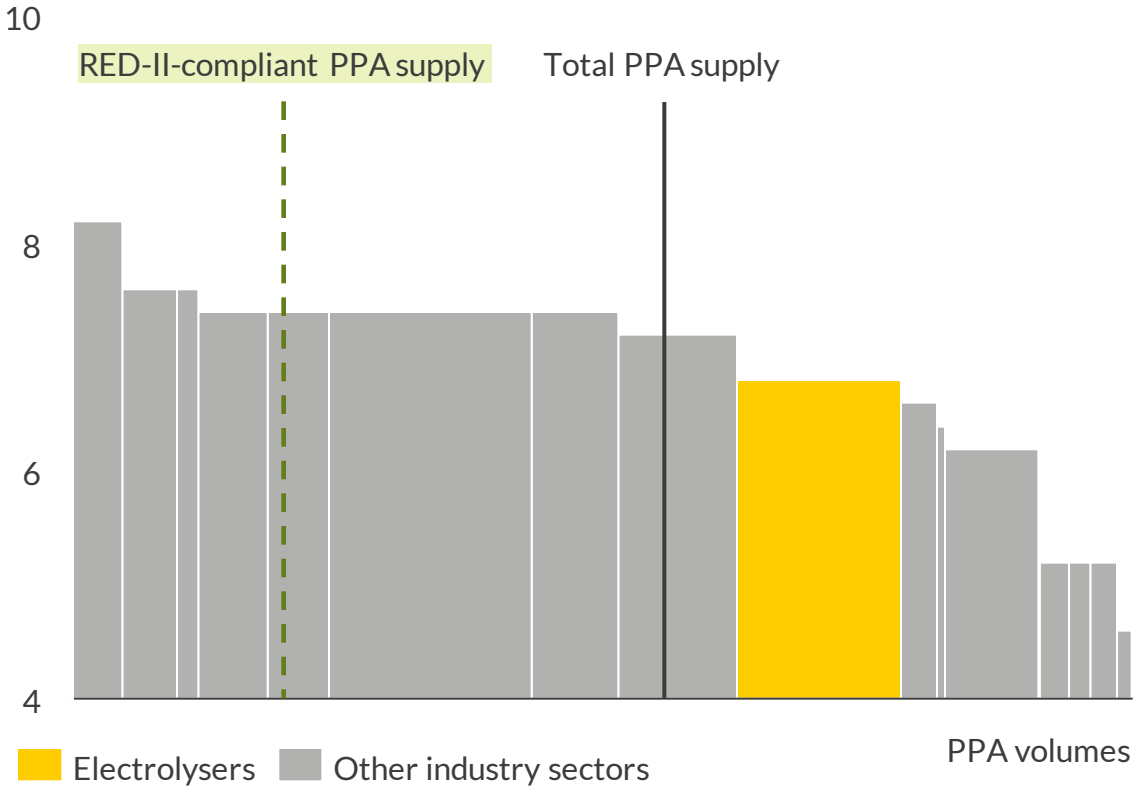
Source: Aurora Energy Research

Electrolysers face tough competition for RED-II-compatible PPA supply from sectors possessing a higher willingness to pay

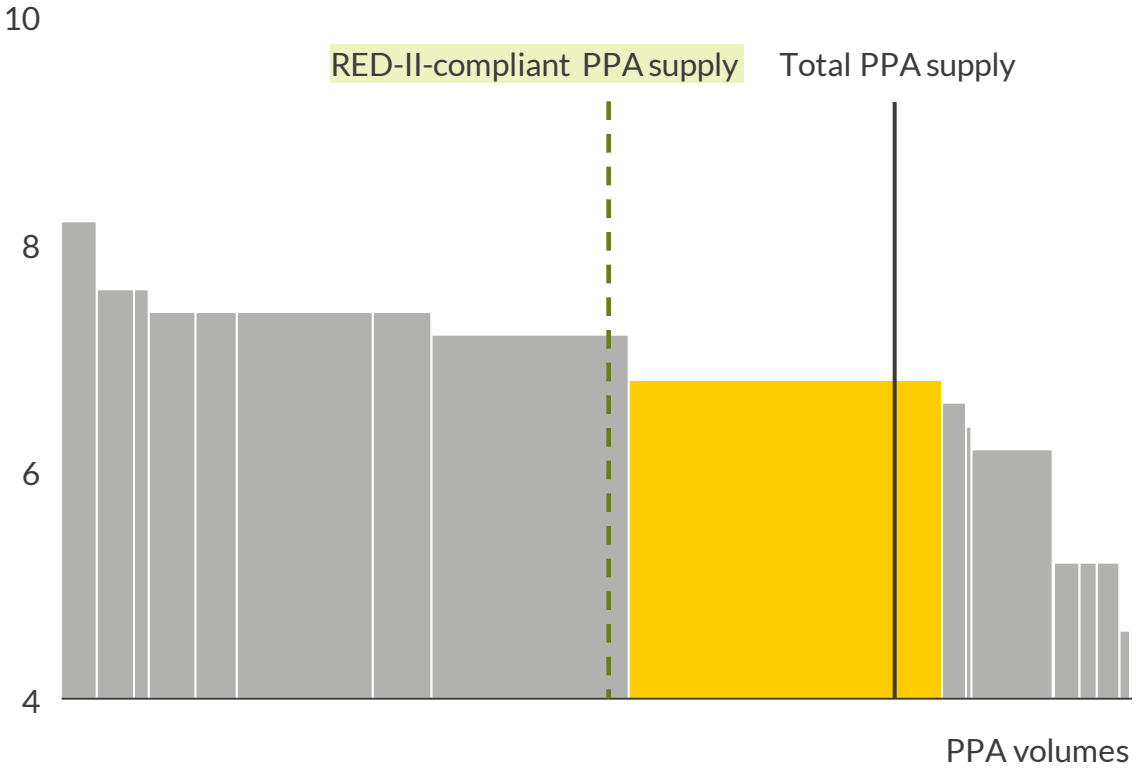
In 2030, industries with a higher willingness to pay will potentially capture all available PPA supply volumes, threatening electrolysers' power procurement.

In 2040, industries with a higher willingness to pay might outcompete electrolysers for all RED-II eligible PPA supply.

Willingness to pay v. PPA demand – 2030
Score out of 10 (sectors ranked from most to least willing to pay)



Willingness to pay v. PPA demand – 2040
Score out of 10 (sectors ranked from most to least willing to pay)



1) A score of 10 corresponds with the highest possible willingness to pay.

Source: Aurora Energy Research

Strategies we support our clients on to accelerate green hydrogen production in Germany?

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De-risk the electrolyser along the H_2 value chain

Align power procurement and hydrogen production incentives:

- **Joint venture with RED-II compatible power provider upstream**: Enables accessing of RED-II-compatible supply and offset creditworthiness issues.
- **Joint venture with hydrogen offtaker downstream**: Enables allocation of power price risk to the hydrogen offtake agreement.

Incentivise merchant RES buildout in Germany

Help create viable business cases for renewables:

- **Incentivise buildout in RED-II compatible supply:** Create opportunities for onsite co-location with renewables assets.

To learn more about how our team can support you, contact Alex:

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Transfer price risk to hydrogen offtake agreements

Roll over price risk to H_2 offtake agreements to increase PPA willingness to pay:

- **Pricing strategies**: Secure H_2 offtake prices above break-even or align them with power procurement indexation (in the case of indexed PPA pricing).
- **Offtaker selection**: Specifically target green hydrogen offtakers with a high willingness to pay.

Policy and regulatory changes

Policy changes could affect the regulatory landscape for electrolyser projects:

- **Price zone split**: If implemented, it would exempt Northern German electrolysers from mandatory PPA requirements.
- **RED-II criteria**: Alterations in the RED-II criteria could reduce obstacles for electrolyser projects seeking to secure green power from 2028 onwards.

Source: Aurora Energy Research

Despite future challenges ahead, German electrolyser projects can take steps to navigate them

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The outset

A robust power procurement strategy is a critical milestone in the development of electrolyser projects. With the introduction of strict requirements for the production of green hydrogen, Power Purchase Agreements (PPAs) have become indispensable components of this strategy.

The challenges

Increasingly stringent RED-II green power standards create hurdles in obtaining PPAs for electrolyser projects commencing from 2028 onwards.

- **Before 2028**: A wide range of options available for power procurement, with no foreseen bottlenecks.
- **From 2028**: A considerably less flexible power procurement landscape due to the requirement for "additionality", raising concerns about feasibility.
- ? **A significant unknown** is the potential implementation of a price zone split, which would allow electrolysers to access green power from Northern Germany's grid.

› **The key obstacle to crafting an effective power procurement strategy and obtaining RED-II-compliant supply**: German electrolysers will encounter strong competition for RED-II-compatible renewables supplies from sectors with greater willingness to pay.

The strategies

Operators of electrolyser projects can pursue different strategies to mitigate the above-mentioned risks to create an effective power procurement strategy.

De-risk the electrolyser along the H_2 value chain
Align H_2 offtake and power procurement strategies via joint ventures.

Transfer price risk to hydrogen offtake agreements
Close hydrogen offtake agreement based on the structure of the PPA.

Incentivise merchant RES buildout in Germany
Create opportunities for onsite co-location with renewables assets.

Policy and regulatory changes
Advocate for policies facilitating stronger electrolyser buildout.

Source: Aurora Energy Research

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