

PPAs in the Greek energy transition - Overrated or underrated?

Dec 1st 2021



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Aurora provides data-driven intelligence for the global energy transformation

Power markets



Renewables



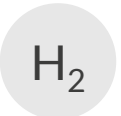
Storage



Electric vehicles



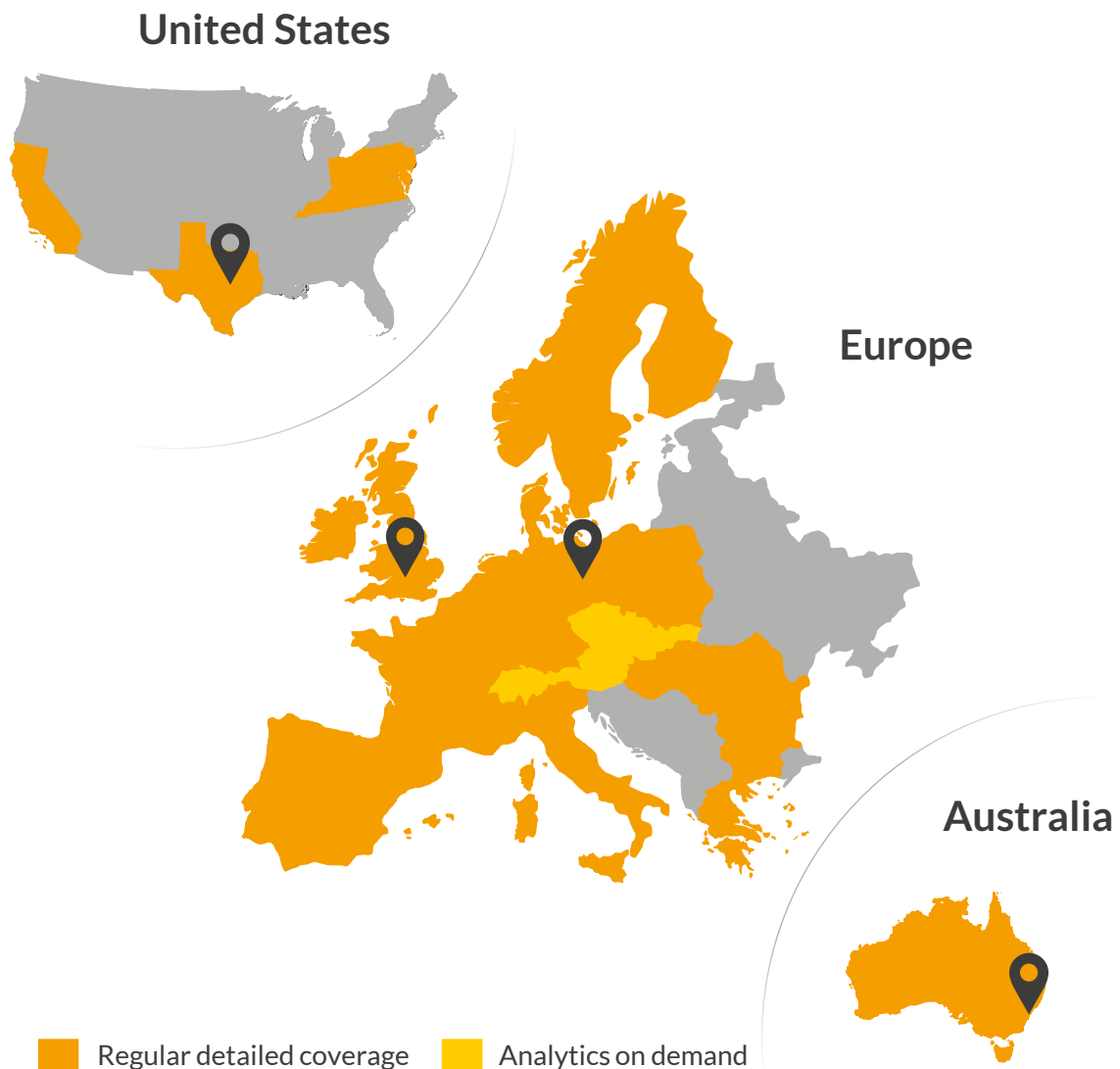
Hydrogen



Carbon



Natural gas



4 Offices

Oxford | Berlin | Sydney | Austin



200+

market experts



350+

subscribing companies



100+

transactions supported in 2020

Aurora brings a sophisticated approach to the provision of analysis and insight to the energy industry

Research & Publications

- Industry-standard market outlook reports and bankable price forecasts for power, gas, carbon and hydrogen markets
- Strategic insights into major policy questions and new business models
- Read and constantly challenged by 350+ subscribers from all industry sectors

Commissioned Projects

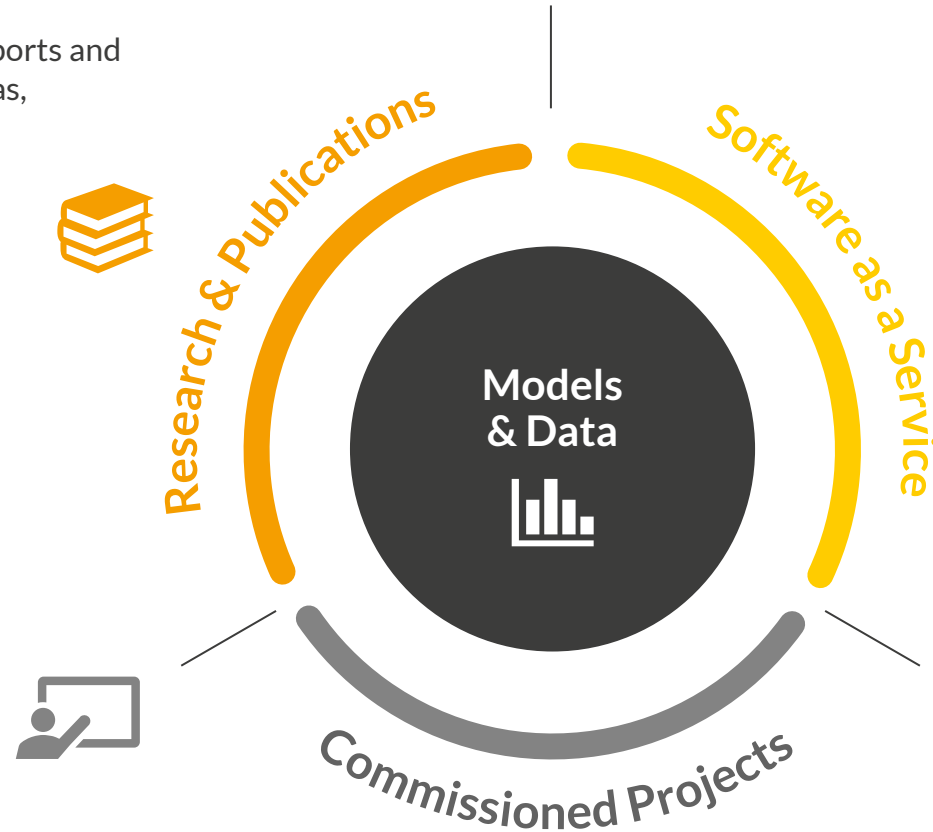
- Bespoke analysis, drawing upon our models and data
- Trusted advice for all major market participants proven in 500+ projects: transaction support, valuations, strategy & policy engagement

Software as a Service

- Out-of-the-box SaaS solutions, combining cutting-edge sophistication with unparalleled ease of use
- **Origin** provides cloud-based access to Aurora's market model, pre-populated with our data
- **Amun** automates asset-specific wind farm valuations for over 30 leading funds, developers and utilities

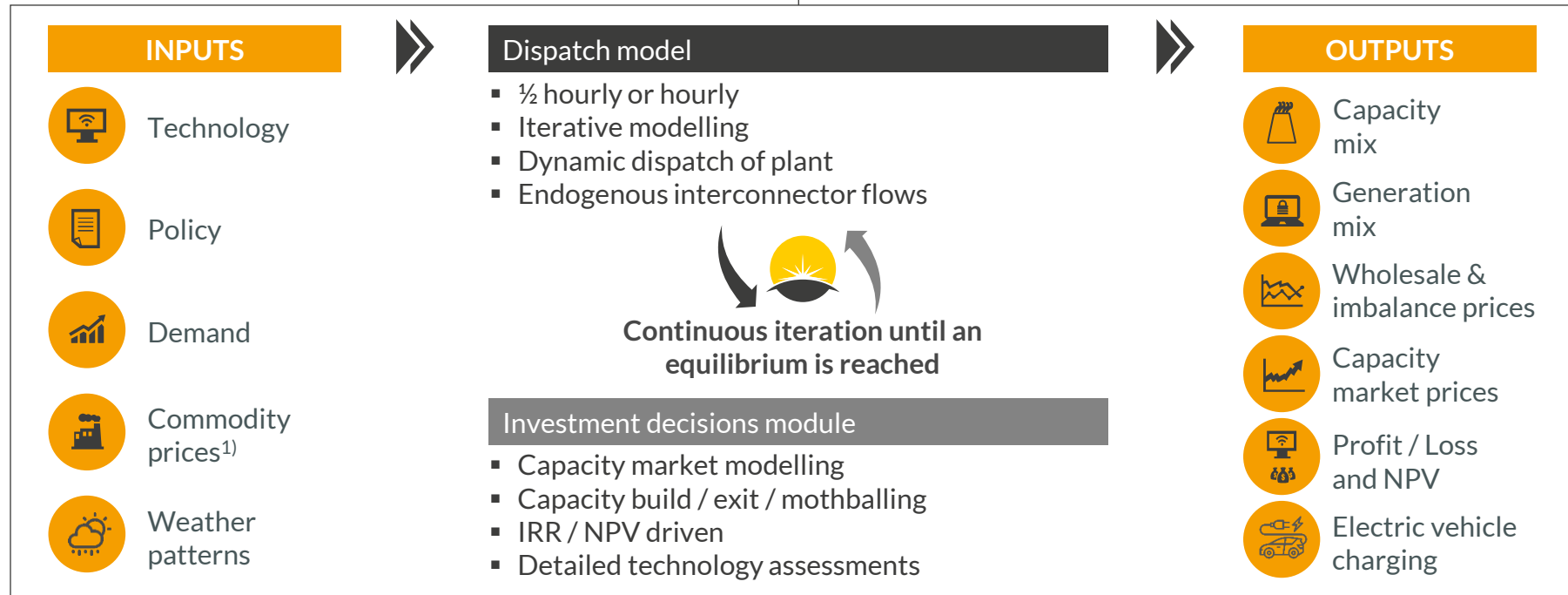
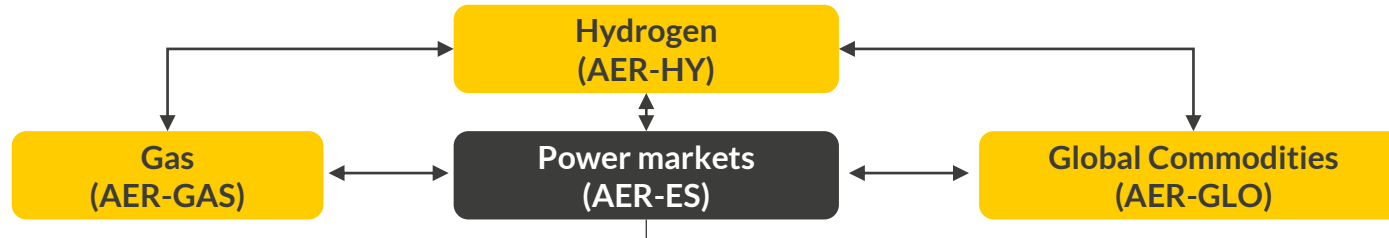
Models & Data

- Market-leading long-term models for power, gas, hydrogen carbon, oil and coal markets
- Continuous model improvements to reflect policy and market developments



Unique, proprietary, in-house modelling capabilities underpin Aurora's superior analysis

4 Integrated Models



Up to 70
specifications modelled for each plant

c. 85k
investment hours on modelling capabilities

~15k
model runs per week

30+
strength of modelling team globally

Advantages of Aurora approach

- Aurora have invested heavily in developing our dispatch models since 2013 and believe they are the most sophisticated available
- Our models have been rigorously tested and refined in a wide range of client contexts
- Flexible and nimble because we own the code
- Transparent results
- State-of-the-art infrastructure
- Zero dependence on black-box third-party software (e.g. Plexos)
- Constantly up to date through subscription research
- Ability to model complex policy changes quickly

1) Gas, coal, oil and carbon prices fundamentally modelled in-house with fully integrated commodities and gas market model

PPAs in the Greek Energy Transition: Overrated or Underrated?

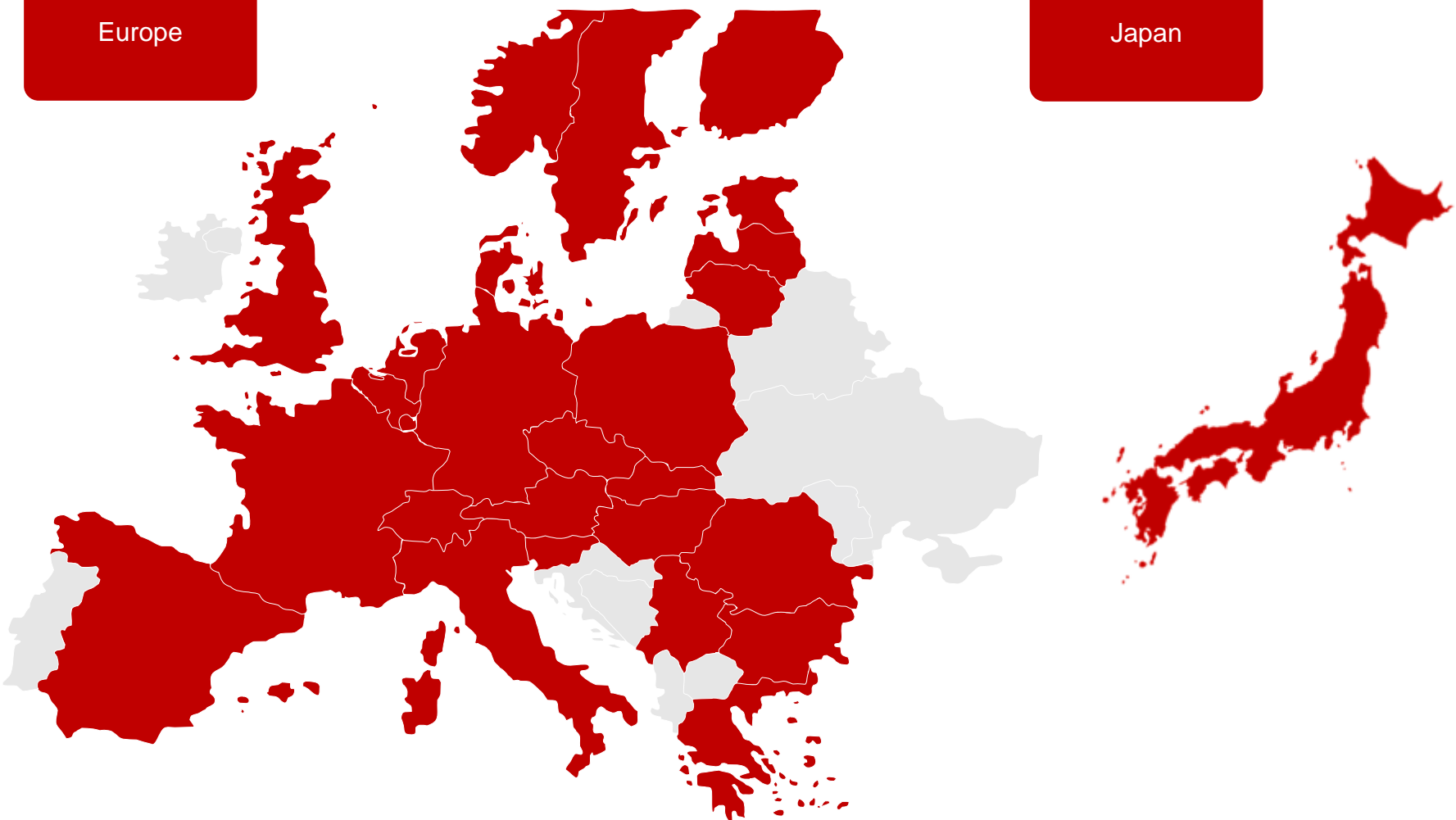
Hedging with EEX Power Futures

December 1st 2021

Market Coverage – EEX Power Derivatives

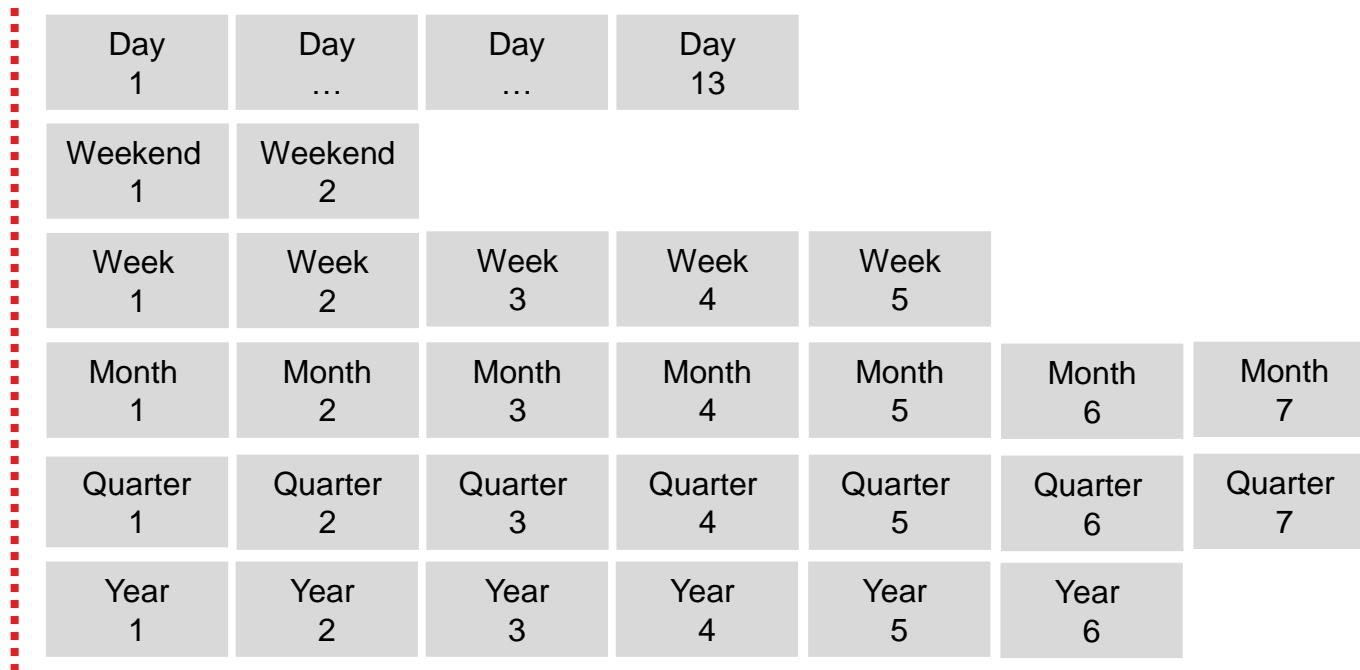
Europe

Japan



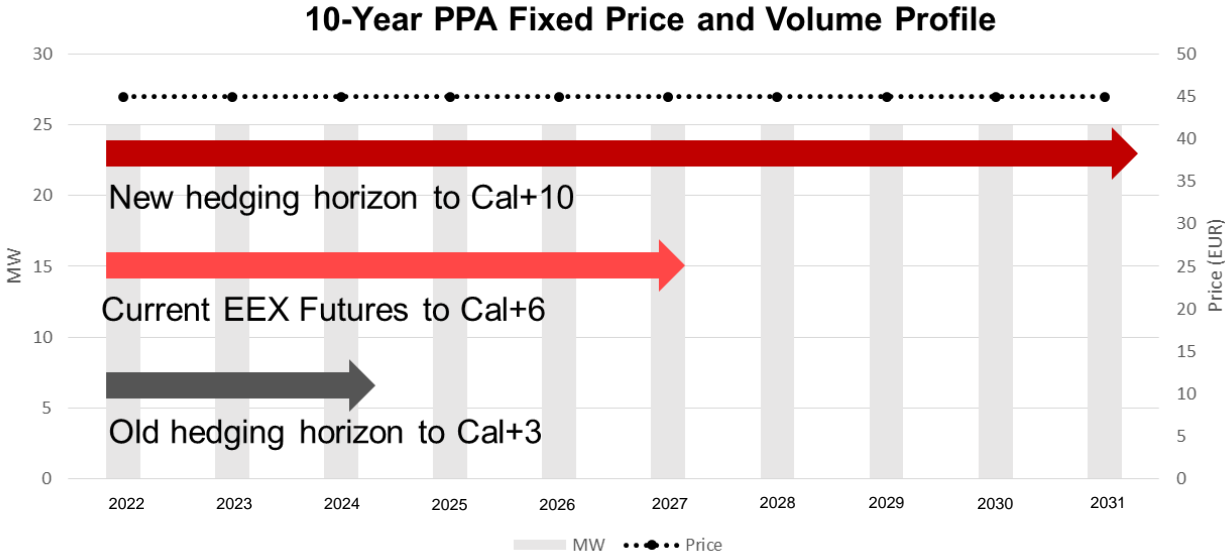
EEX Power Derivatives Markets

- The standard Power product setup of EEX comprises financially settled Futures with the following maturities for Base and Peak Load.*
- Each product has as its underlying the Spot index for the respective market (ie. for German power, the day-ahead price for the AMPRION control zone).
- EEX lists Power Futures for **20 European markets**.



New Renewables investments are driving demand for long-term risk management

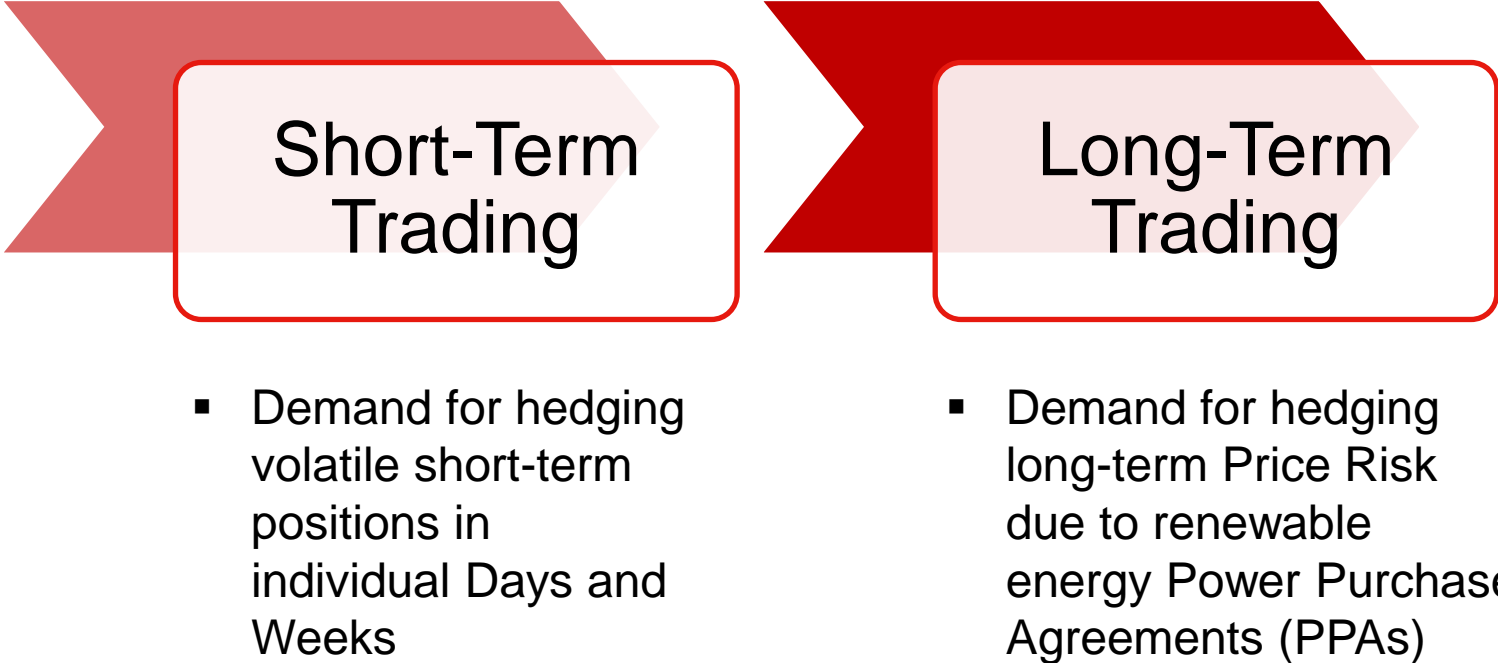
- EEX members have been increasingly demanding long-term hedging capability in order to manage risk from long-term contracts such as PPAs, primarily used to fund the construction of new Renewable Energy assets
- EEX extended its Base Year Futures to **Cal+10** in markets with high potential of PPA activity: **Spain, Germany and Italy**, to facilitate long-term hedging and more PPA development
- PPAs, combined with hedging price risk on exchange, provides a **market-based solution to achieving EU renewable energy targets** instead of Member States relying on onerous subsidies (e.g. CfDs)



Other EEX Power Derivatives Markets

Product	EEX Volume Jan 2021 - Oct 2021	EEX Volume Jan 2020 - Oct 2020	EEX Volume YTY Comparison
Greek Power Futures	14.5 TWh	2.5 TWh	↑ 488%
Nordic Power Futures	15.9 TWh	3.7 TWh	↑ 327%
UK Power Futures	4 TWh	2.8 TWh	↑ 41%
PXE Polish Power Futures	0.5 TWh	0 TWh	↑ 1579%
PXE Bulgarian Power Futures	1.7 TWh	1.1 TWh	↑ 52%
PXE Serbian Power Futures	0.2 TWh	0.2 TWh	↓ -23%

Renewables are driving two major trends in Power Derivatives markets



Short-Term Trading

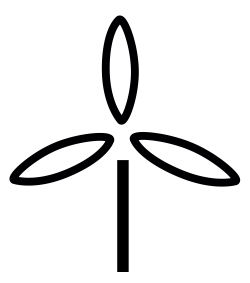
- Demand for hedging volatile short-term positions in individual Days and Weeks

Long-Term Trading

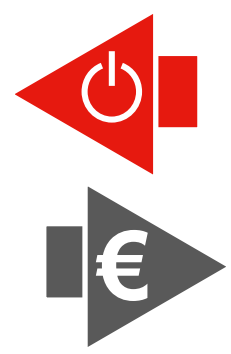
- Demand for hedging long-term Price Risk due to renewable energy Power Purchase Agreements (PPAs)

How are EEX Members active in PPAs?

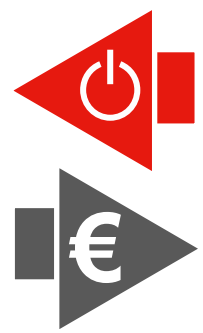
RE Developers sell Power via Long-Term PPAs



EEX Members buy Power via Long-Term PPAs and build RE assets



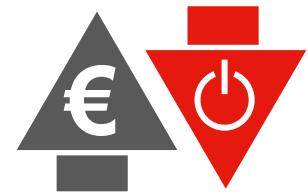
EEX Members provide balancing services on Spot & hedge via Futures



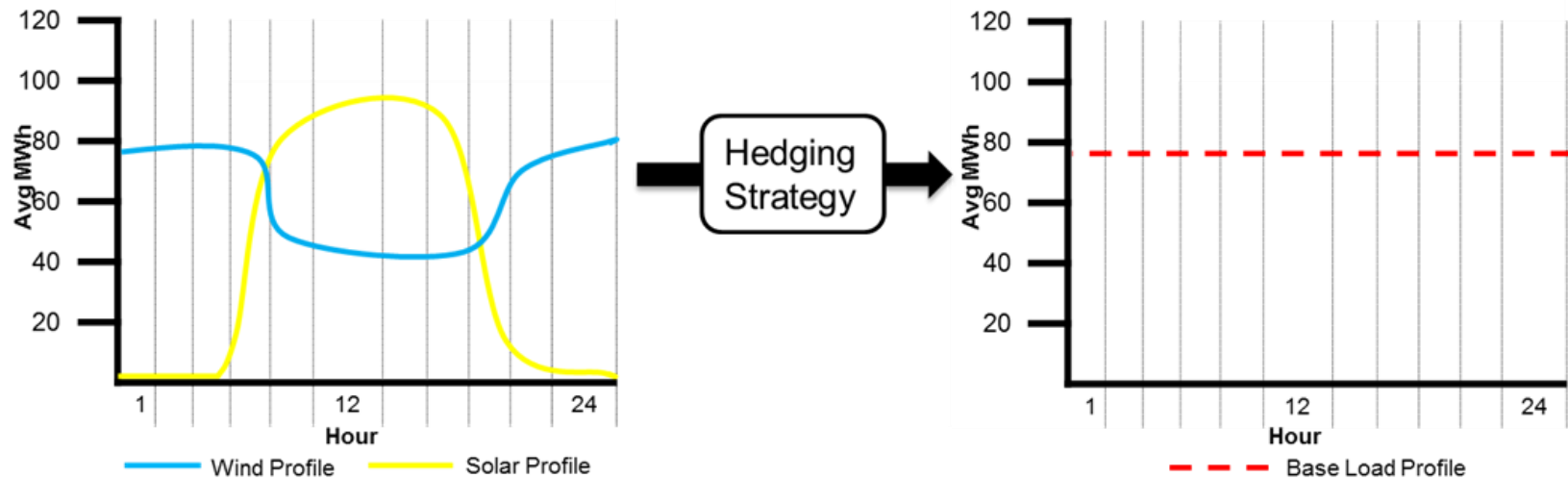
Banks provide financing once PPA is in place



EEX Members sell Power via LT Corporate PPAs



Managing Renewable Energy Price Risk with Base Futures requires a Hedging Strategy

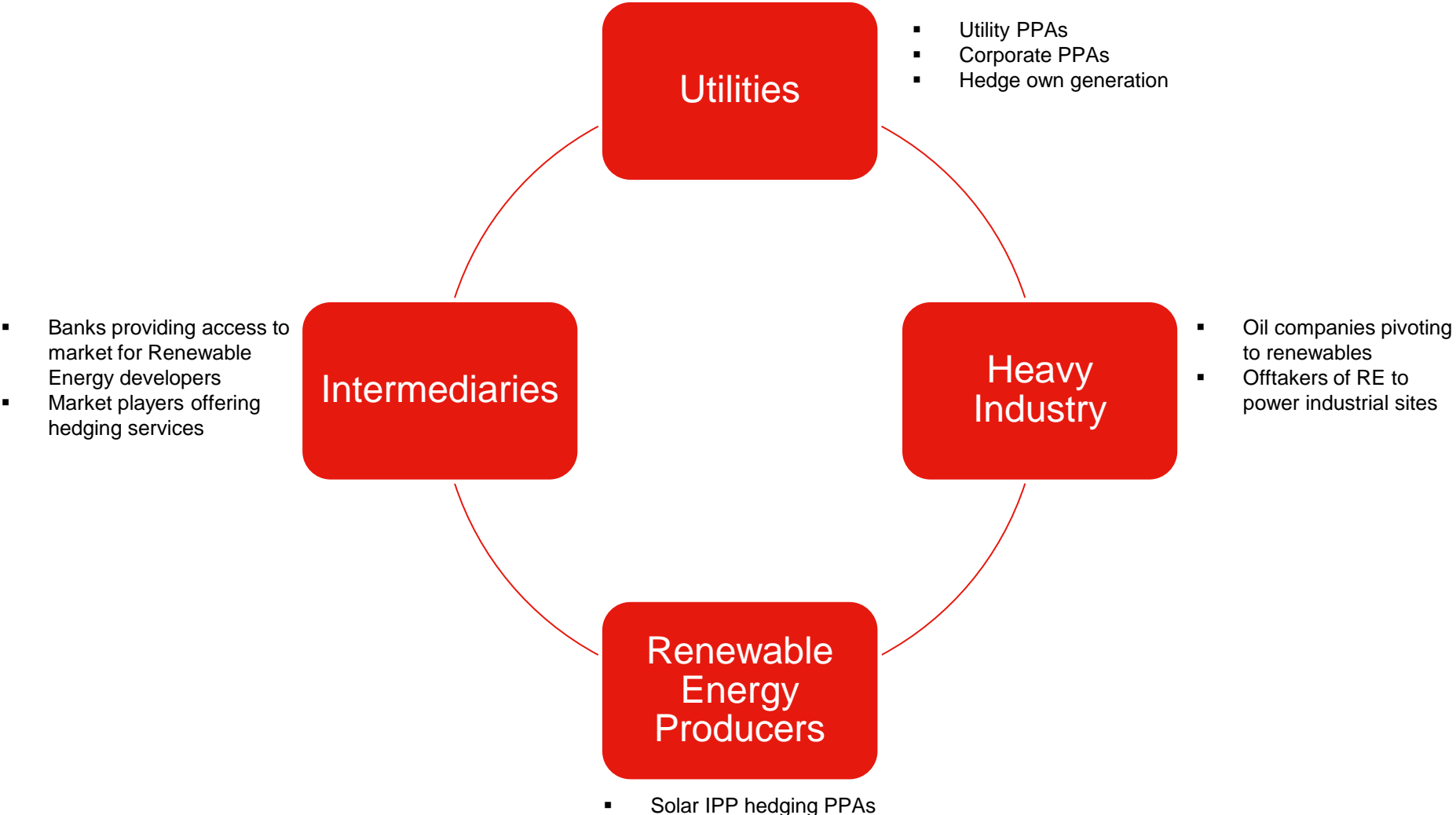


- Base Futures are a **best-fit product** and attract the most liquidity, creating a **strong price signal** and opportunities for trading at fair market prices
- To use the Base Futures to manage the risk of a wind or solar profile, a **Hedging Strategy needs to be designed** to translate the variable generation profile into a constant Base load profile
- Different Hedging Strategies can be employed, such as a **value-neutral hedge**

Long-Term Hedging of PPAs with EEX

- Since 29th May 2018, **33** long-term hedges of have been registered OTC in **Spanish Power**, with a total volume of **15.8 TWh**
- The first **5 MW** long-term hedge was cleared in Polish Power on 18 December 2019. The execution price of each trade was **52,19 EUR**.
- The Polish deal proves the value for **multinational utilities with Renewable Energy assets across the EU** to hedge long-term on EEX Power Futures and offload their PPA risk onto ECC, even in relatively **illiquid markets**.
- EEX will offer the possibility for **long-term hedging** by extending Calendar Year Future expiries in the Spanish, Italian and German power markets to 10 years ahead.
- Therefore the purchase or sale of electricity derivatives provides **long-term price risk hedging** together with **counterparty risk mitigation** through the ECC clearing house.

Who are the PPA Hedgers on EEX?



Example: 36th Long-Term Hedge on Spanish Power

Trade Date	Product	Expiry Year	Expiry Month	Trade Price	Initial Margin per Contract	Lots (MW)	Initial Margin (in EUR)	Trade Volume (in MWh)	Notional Value
04/15/2021	Spanish Power Base Year	2023	12	41.70 €	11,563 €	2	23,126 €	17,520	730,584 €
	Spanish Power Base Year	2024	12	41.70 €	11,507 €	2	23,014 €	17,568	732,586 €
	Spanish Power Base Year	2025	12	41.70 €	14,454 €	2	28,908 €	17,520	730,584 €
	Spanish Power Base Year	2026	12	41.70 €	15,855 €	2	31,710 €	17,520	730,584 €
								106,758 €	70,128
Initial Margin in % of Notional Value									3.65%

- Long-term hedges are primarily bilaterally negotiated then registered for clearing at a flat price and flat volume.
- Initial margin requirements for long-term hedges have been on average **2.15% to 5%** of the notional value of the deal.

Role of the Exchange in the PPA Market

Price Transparency

- EEX's market prices provide reliable price references.
- Project developers and buyers of PPAs can assess their valuations against EEX wholesale prices.

Price Risk Management

- Manage power price risk for renewable energy assets.
- Reduce the overall risk exposure for the largest risk element in RE portfolios.

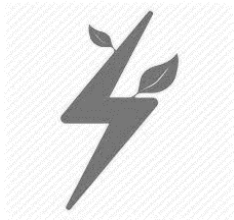
Counterparty Risk Management

- Trading and hedging on EEX alleviates counterparty risk for trading participants.
- This is especially important for long-term risk management.

Enabler of Renewable Energy Growth

- Price and counterparty risk is offloaded onto the clearing house, freeing internal risk capacity within trading participants.
- This enables them to take on more PPAs and facilitate growth of renewable energy capacity in Europe.

Merchant Renewables are the Next Phase in the Energy Transition



PPAs are one enabler of new Renewable Energy investments....



...but the market is in need of more standardisation and better risk management products in order to grow and meet the EU's ambitious targets.



Major energy players are already starting to hedge their long-term price risk with standard EEX products.



EEX will ensure we remain part of our Members' long-term hedging strategy, and explore opportunities to build new products for risk management of Renewable Energy.

Thank you!

Alex Papageorgiou

Senior Sales Manager

Sales Power Derivatives Southern Europe

Milan office

Phone +39 02 8633 7215

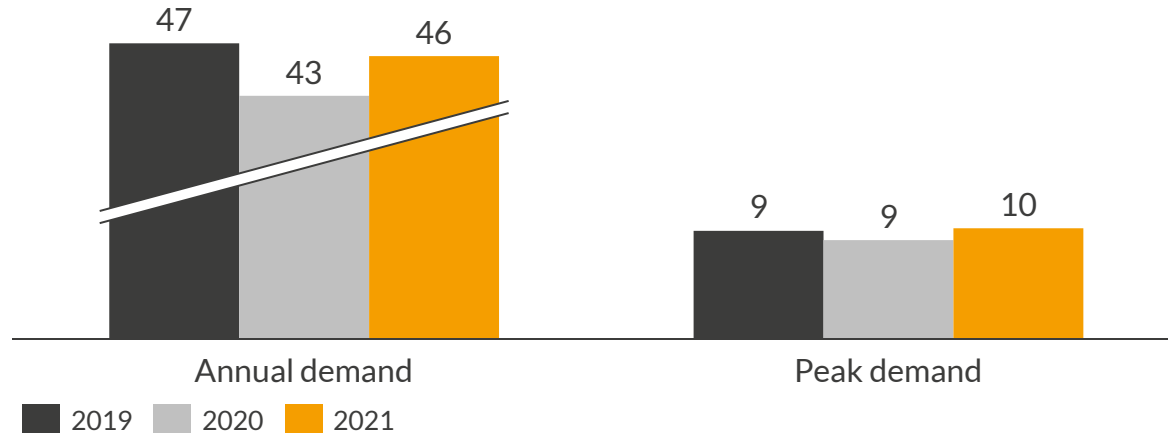
Mobile +39 347 3946996

E-Mail | Eikon ID: alex.papageorgiou@eex.com

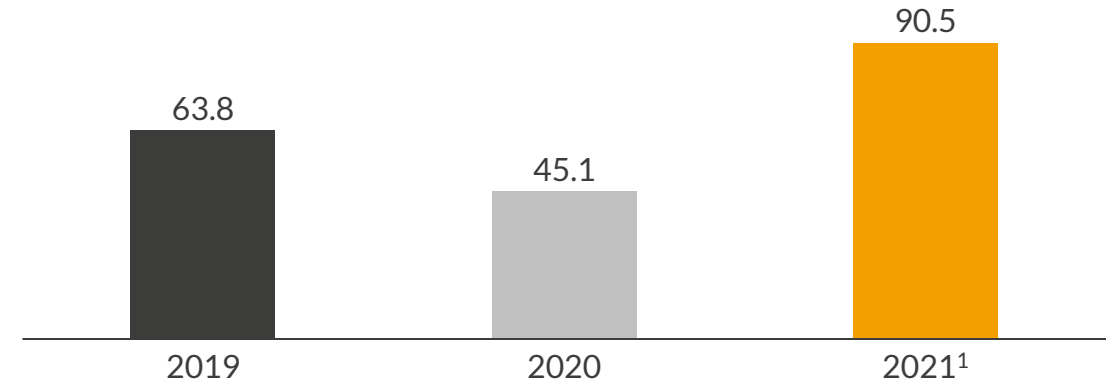
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2020 was dominated by the COVID-19 pandemic, but 2021 sees a recovery in demand and a massive increase of baseload prices

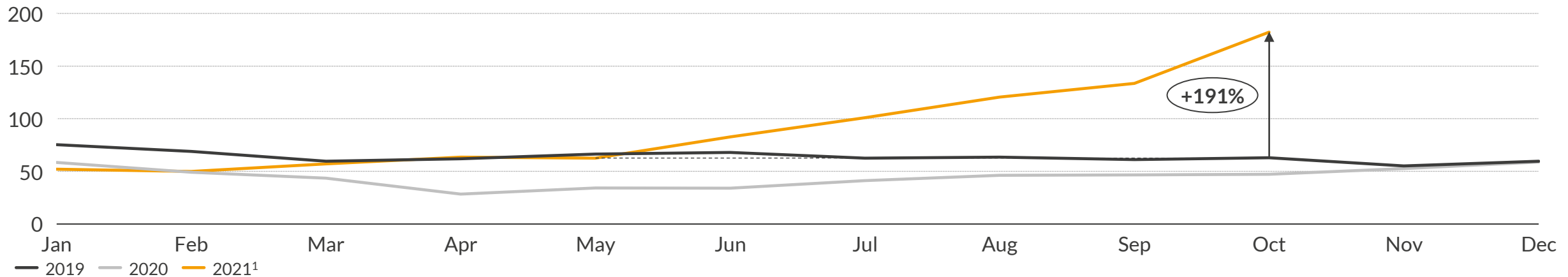
Annual demand and peak demand in 2020 and 2021¹
TWh/GW



Annual average day-ahead prices
EUR/MWh (real 2020)



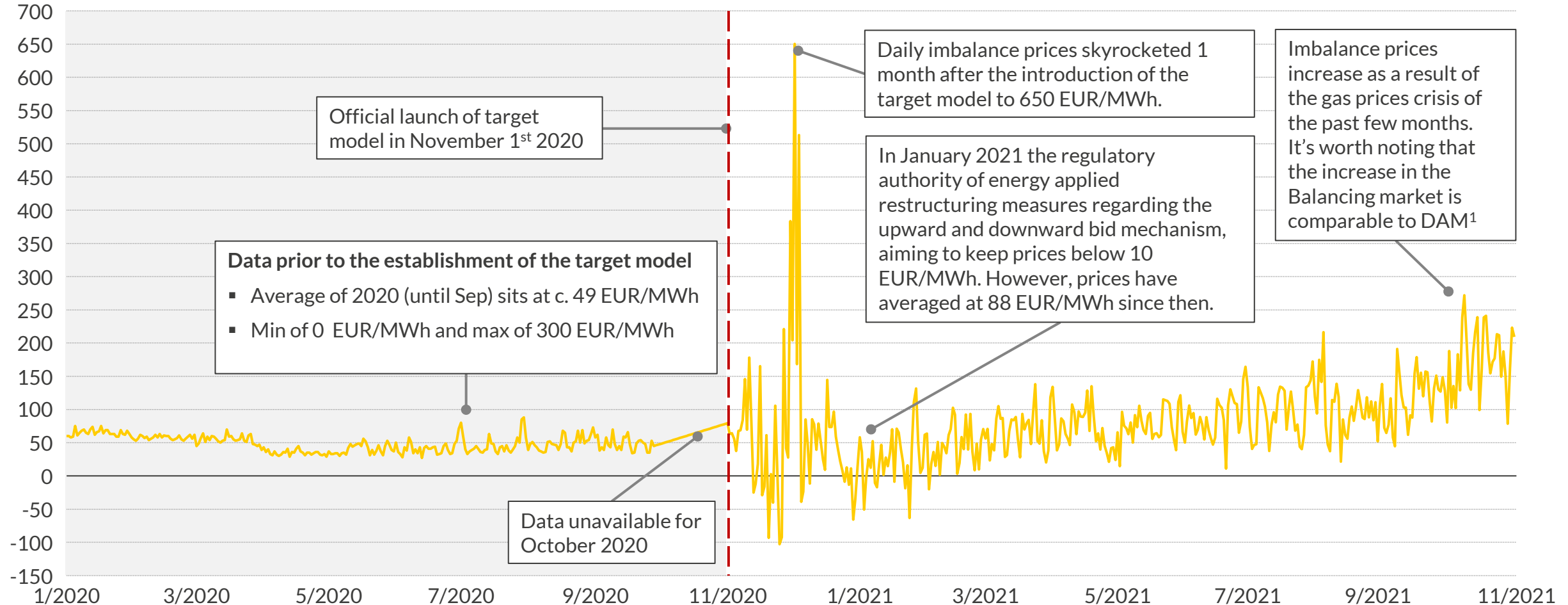
Monthly average day-ahead prices
EUR/MWh (real 2020)



1) Data until October 2021.

The introduction of the target model had a significant impact on imbalance price but prices head towards a stabilisation

Daily imbalance price in EUR/MWh since January 2020 in Greece



1) Day Ahead Market.

The market reform plan sets a set of actions for improving processes, transparency and liquidity and ultimately increase competition

The market reform plan sets an action plan along timelines and covers the following categories: wholesale market, interconnections and grid enforcement, retail market competition, liquidity of forward market, investment support and capacity adequacy and finally price limits

Key actions for wholesale market

- Compensation in the balancing market based on **re-dispatching volumes**
- Participation of Demand Side Response (**DSR**) and **storage** in the wholesale markets
- Participation of dispatchable RES units and RES portfolios as Balancing Service Providers (BSP)
- Participation of traders in the Intraday market and launch of continuous intraday coupling
- Participation in the EU balancing reforms

Key actions for interconnections and grid enforcement

- Achieving the completion of the following **interconnection projects**:
 - New interconnection with Bulgaria by end of 2022
 - Additional interconnection with Italy, Turkey, Albania
 - Upgrade of interconnection with North Macedonia
- Continue the **island interconnection program**:
 - Crete Phase II
 - Skiathos
 - Cyclades Phase D
 - Dodecanese
 - North east Aegean islands
- **Re-enforcement of the transmission system**

Market competition

- **RES PPA and support of energy intensive industry** (see in next pages)
- Increasing the liquidity of the forward market
- **Confirming the new RES auction scheme** – Already confirmed with 3 GW of capacity to be awarded by 2025
- **Strategic reserve and launch of full Capacity Remuneration Mechanism**

A storage subsidy support scheme is under development with 450 million EUR to be deployed in pumped hydro and battery projects

Time to delivery

Storage subsidy support scheme

Final consultation and proposal by **June 20th 2021**

Submission of plan with legal and organisational rules expected by **October 31st 2021**

First auction for storage system expected in **Q2 2022 for 700 MW of battery storage**

Plant categories and licensing

- The Ministry of Energy is said to have agreed on a common definition for storage projects and has formulated final proposals in terms of licensing, market participation and ancillary services
- It is expected that the scheme will have a category for standalone plants and one for storage plants co-located with RES
- Standalone storage plants are expected to be licensed with the same rules as any electricity generation plant
- Co-located storage plants are likely to be licensed according to the rules that RES projects face
- Storage plants are expected to be able to participate in the day-ahead, intra-day and balancing markets

Behind the meter batteries

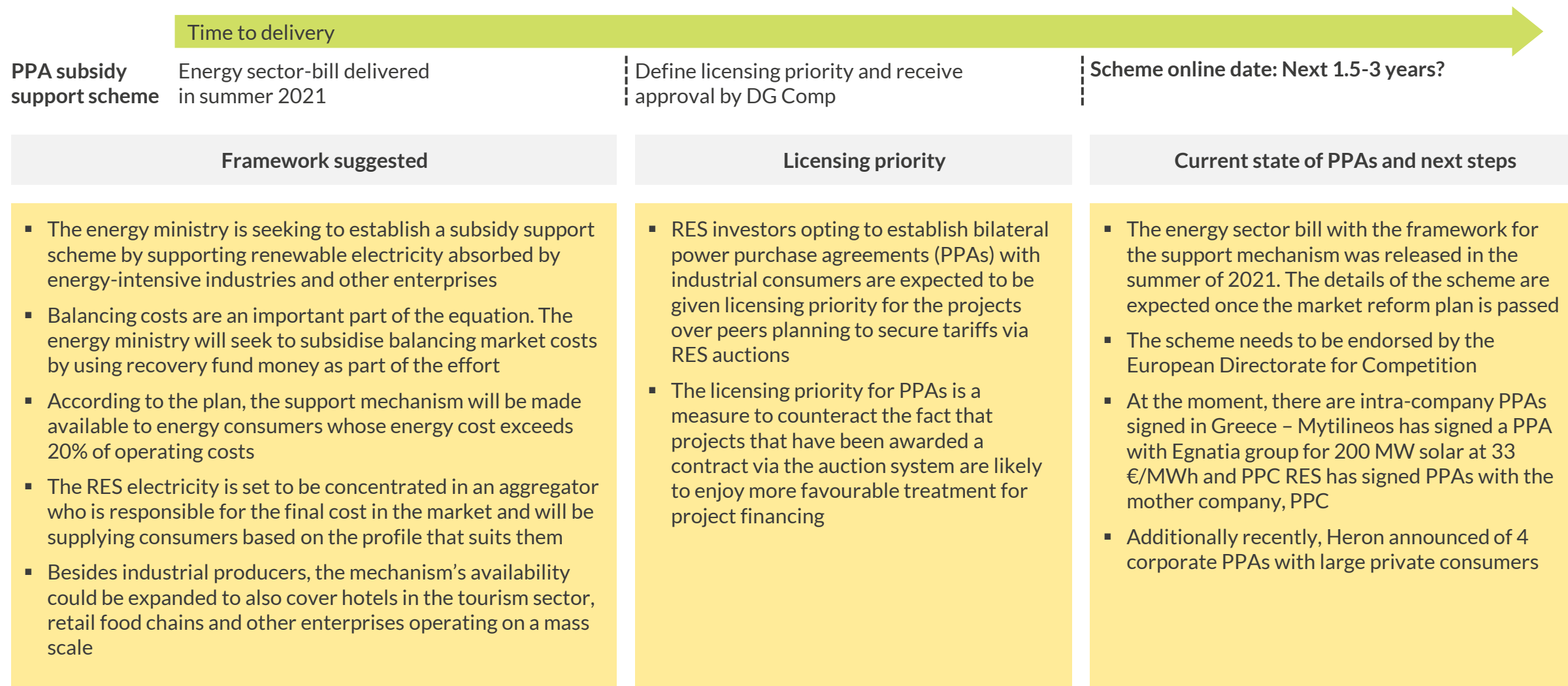
- Currently, behind the meter batteries for storage with a maximum power of 30 kW are allowed only if they are co-located with a rooftop PV for self-consumption
- The Ministry of Energy currently proposes the removal of all the limitations related to behind the meter batteries
- The latest proposal by the Ministry of Energy suggests allowing the installation of any size of behind the meter batteries without the need of co-location with solar, which implies that the battery can be charged and discharged from the grid

Why is there such a big interest in storage?

- €450 million of grants are planned for the development of storage systems (batteries as well as pumped hydro projects). There are a few very mature pumped storage projects that will likely receive state aid, however for batteries we expect the support to be awarded via auctions
- The upcoming CRM¹ mechanism could further support storage projects which are expected to compete
- According to the new subsidy support scheme for RES in Greece (3 GW by 2025), there could be an auction for co-located projects (batteries with RES)
- A capex based subsidy support auction that is reported to cover up to 40% of a project's capital cost is said to take place in the first half of 2022
- The large growth of wind and solar by 2030 creates a systemic need for higher storage capacity

1) Capacity Remuneration Mechanism.

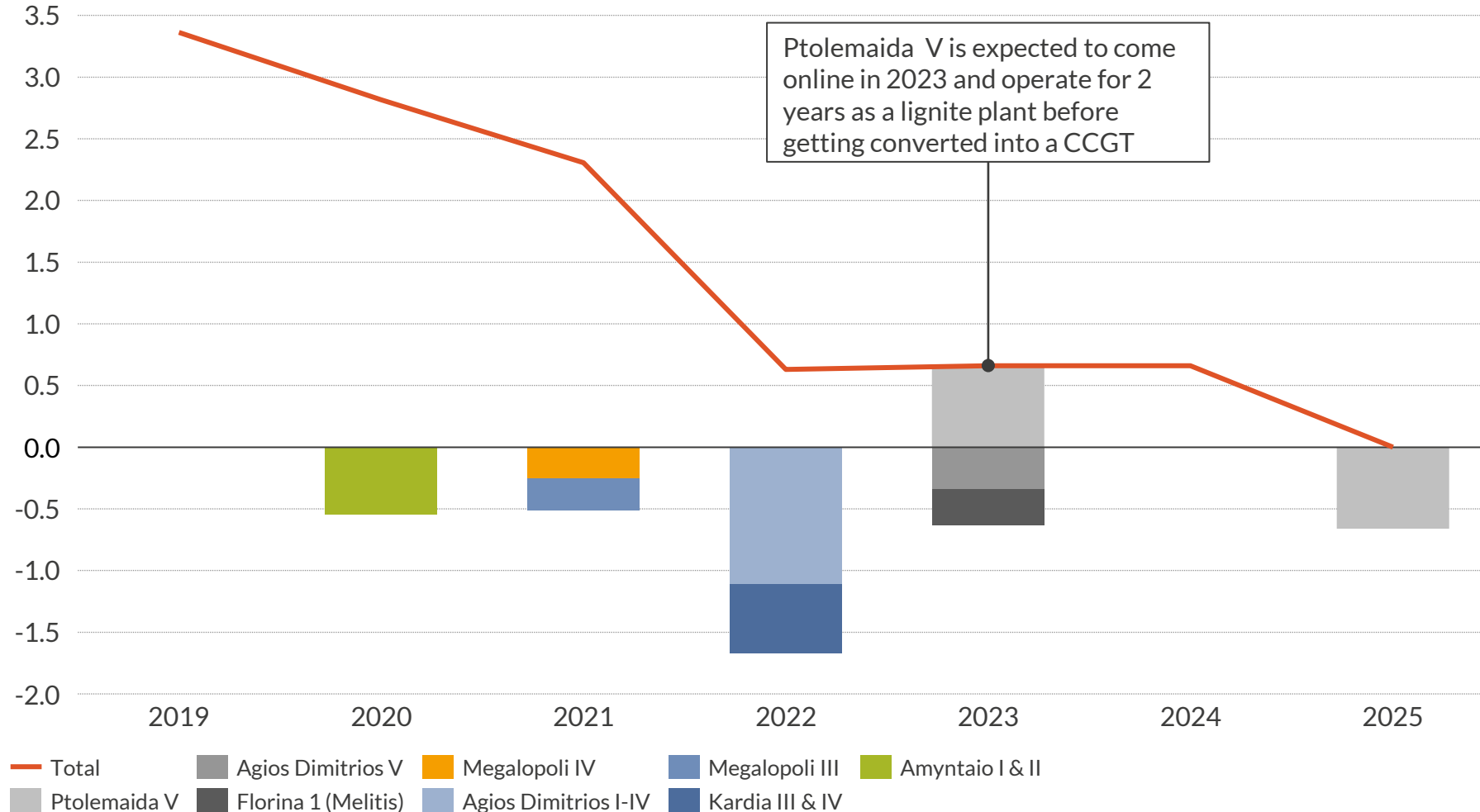
Several GWs of merchant driven projects are expected to come online by 2030; A framework for PPAs is key for their deployment



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The Greek lignite fleet is expected to undergo major phase-outs in the next 3 years, retiring 3.4 GW of capacity from 2019 to 2023

Installed capacity¹
GW



Ptolemaida V is expected to come online in 2023 and operate for 2 years as a lignite plant before getting converted into a CCGT

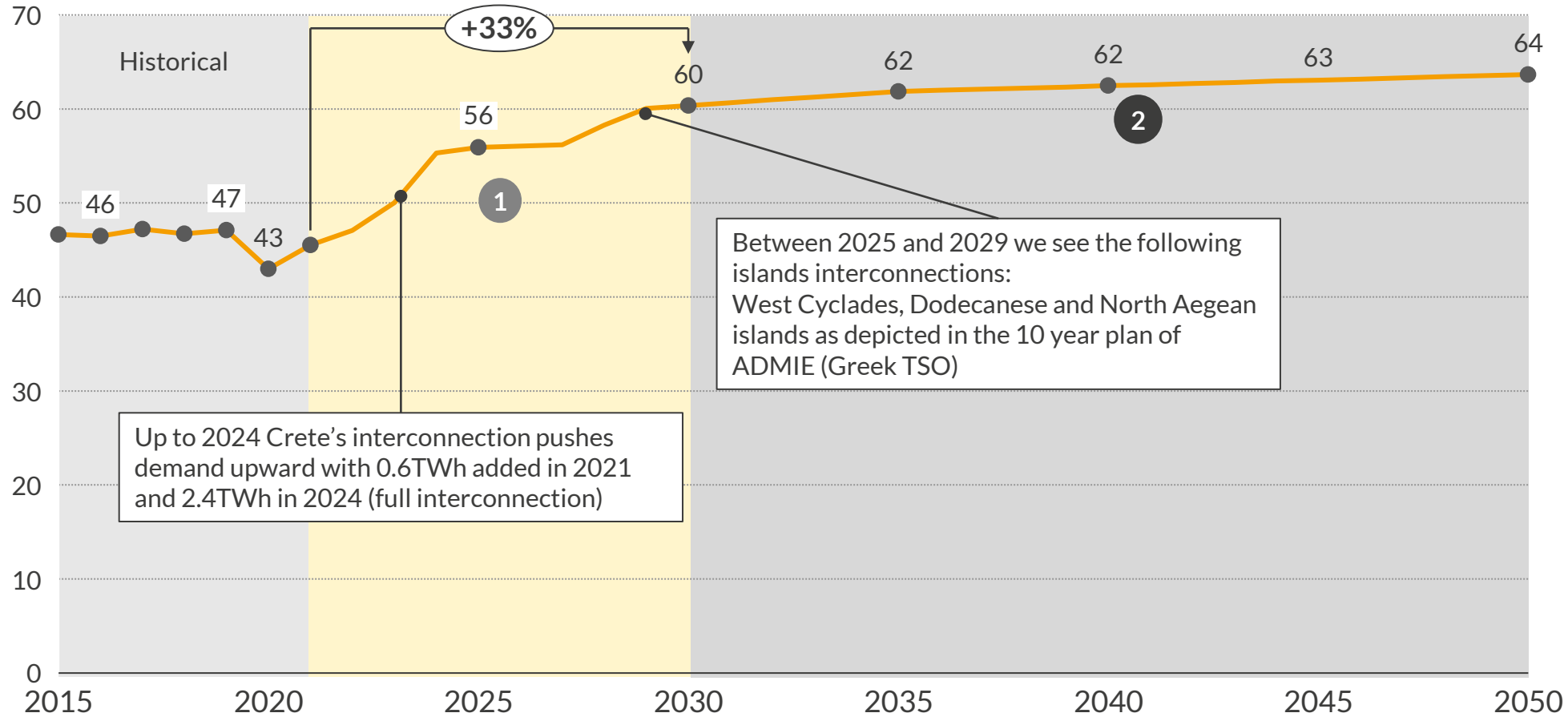
Comments

- In 2019, the Public Power Corporation (PPC) announced a rapid lignite exit with 3.4 GW of planned retirements by as early as 2023
- PPC's ambition to reduce operational costs while increasing profit margins together with EU pressure has accelerated lignite exit in Greece
- Beyond 2023, Ptolemaida V is expected to be the only lignite plant online until 2025 after which it will be converted to a CCGT
- From 2025 onwards Greece is not expected to have any lignite left on the grid

1) As announced by the Public Power Corporation on 16 December 2019 for the retirement up to 2023 and on 31 March 2021 for Ptolemaida's V conversion.

Post COVID-19, Aurora projects a 33% demand increase driven by island interconnection and economic growth

Net electricity demand
TWh/a



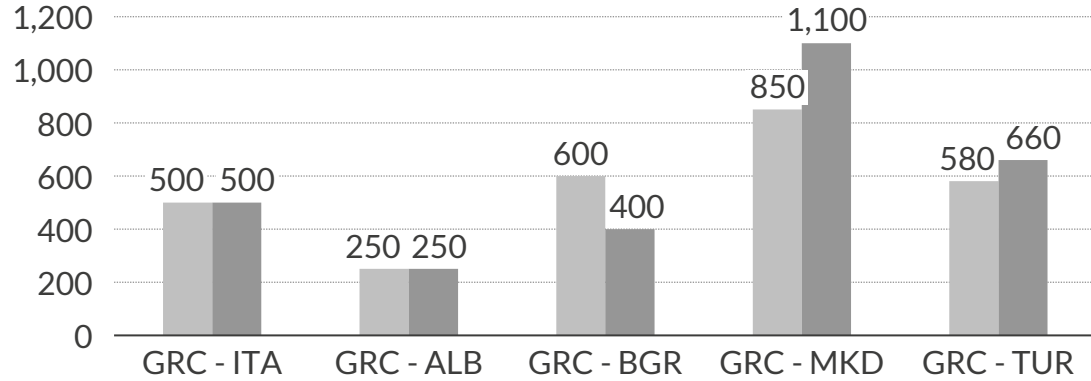
— Aurora Forecast

1
Following recovery from COVID-19 crisis in 2022, demand increases until 2030 as almost all Greek islands get interconnected

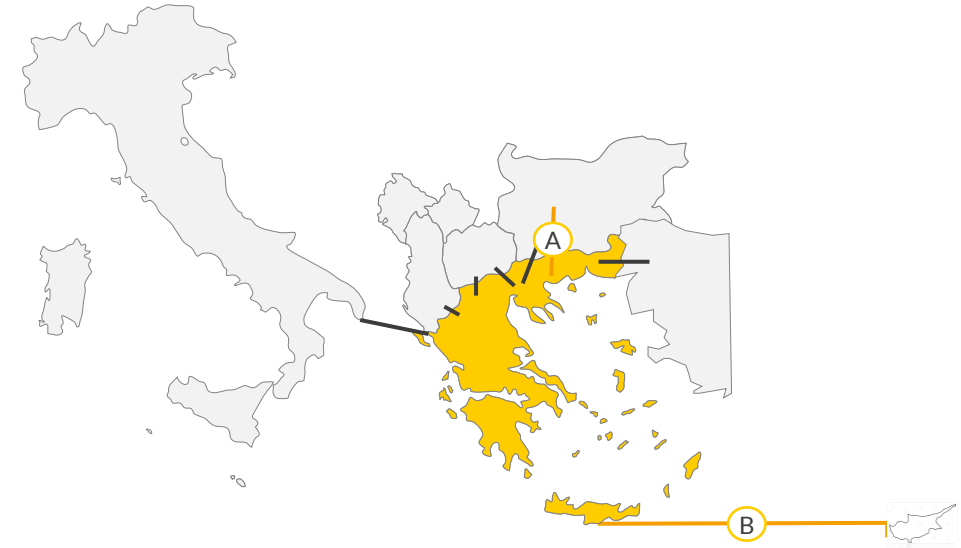
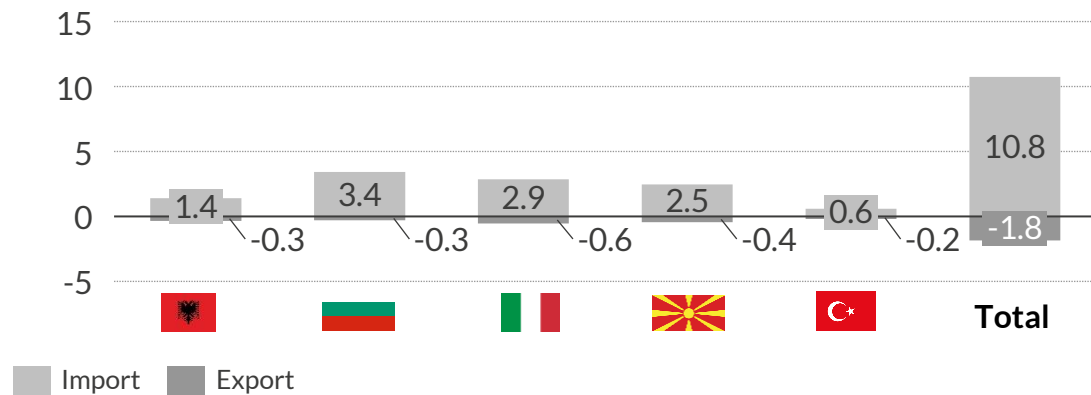
2
Sector-coupling, i.e. electrification of transport and heating, increases demand

Greece is a net electricity importer and is interconnected with all its land-neighbouring countries and Italy

Interconnection capacity¹
MW



Import/export flows in 2020
TWh

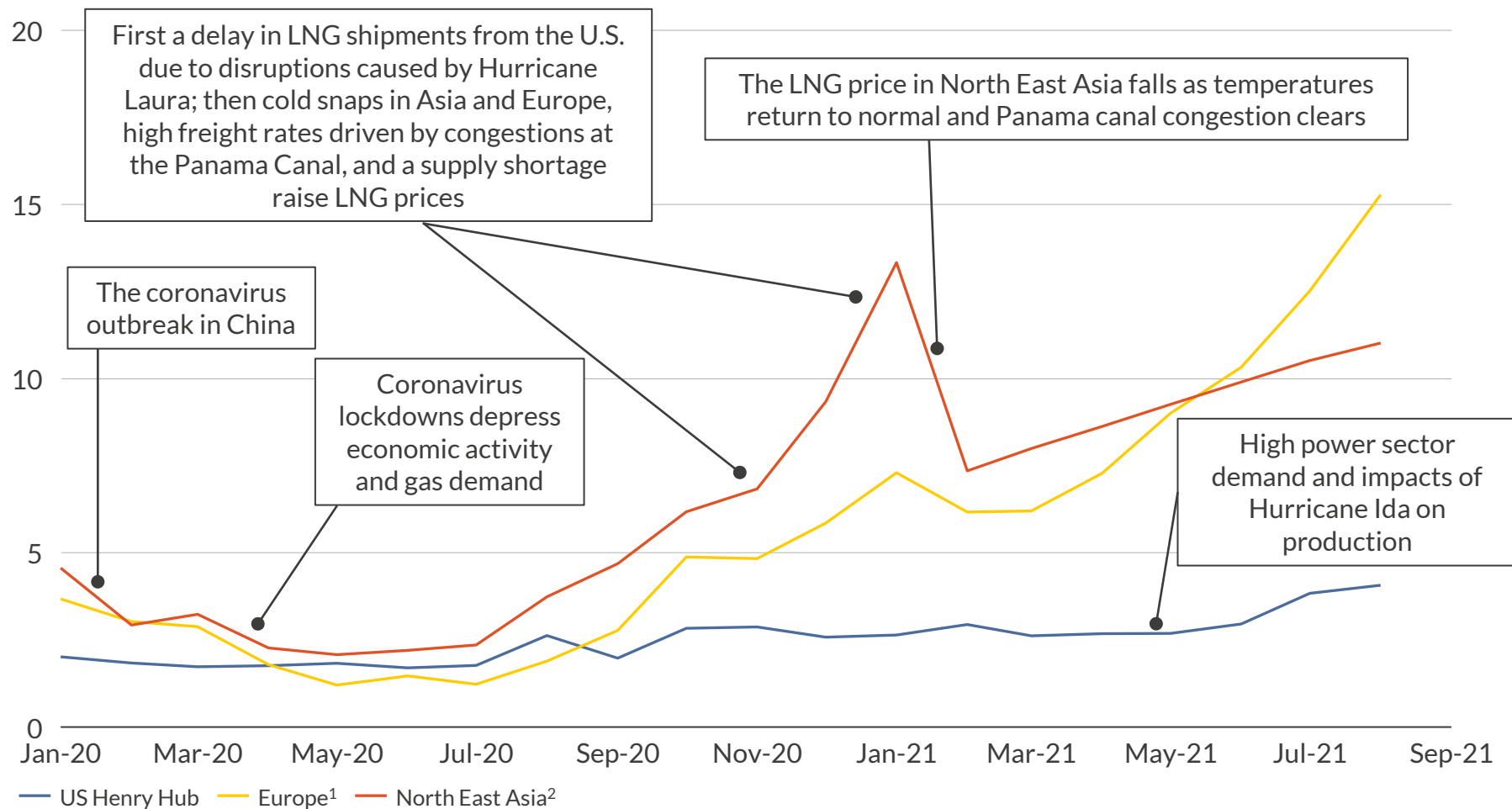


Interconnectors	Import/export capacity MW	Status	Planned until
Aurora Central			
A GRC - BGR	1350/800	Under construction	2023
B GRC - CYP - ISR	700 ¹	Late development	2024
Total additions	3350/2800		

1) Net Transfer Capacity as per ADMIE data in 2019. 2) The proposed capacity of the project is 2000 MW however it is discounted to 700 MW due to the low probability of materialising as a result of the current project stage.

Gas prices in Europe and Asia have increased significantly since Feb-21 due to economic recovery amid tight pipeline and LNG supply

Traded average monthly gas prices
\$/MMBtu

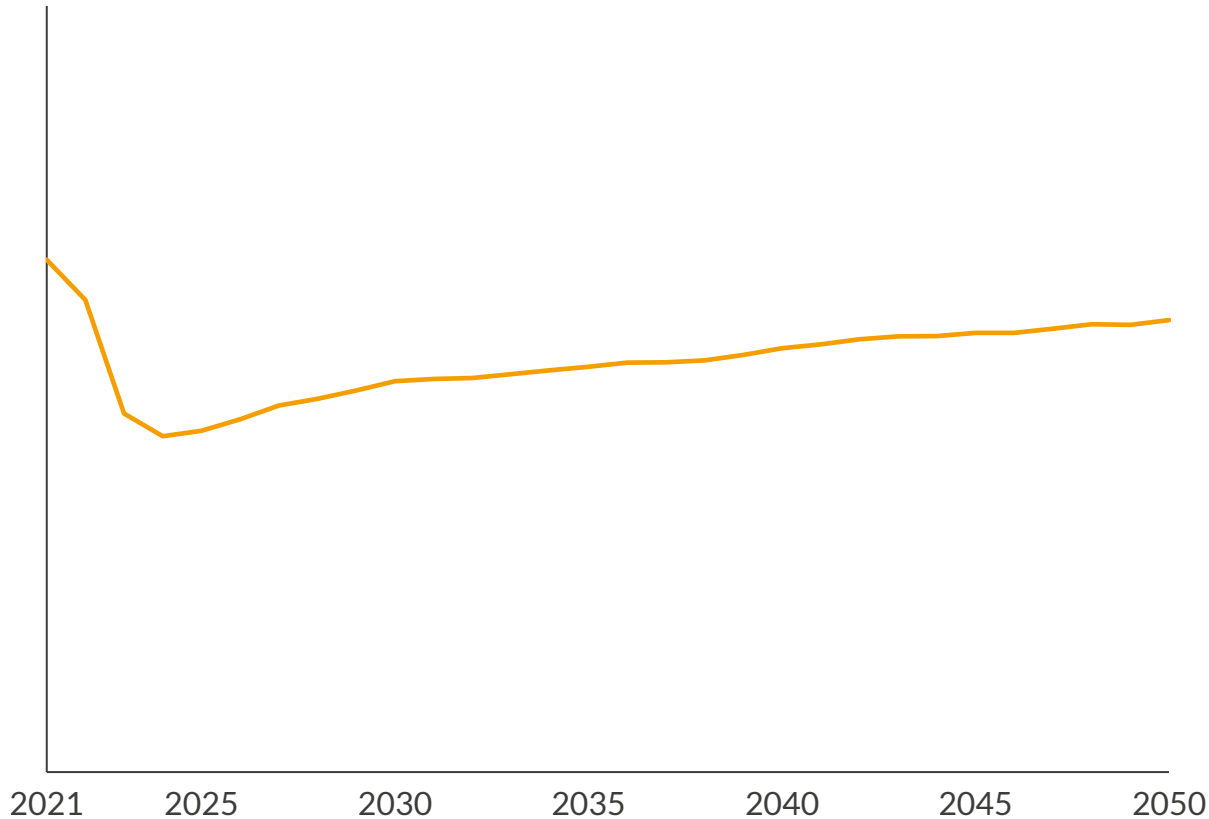


1) The reference hub is TTF in the Netherlands. 2) The reference country is Japan.

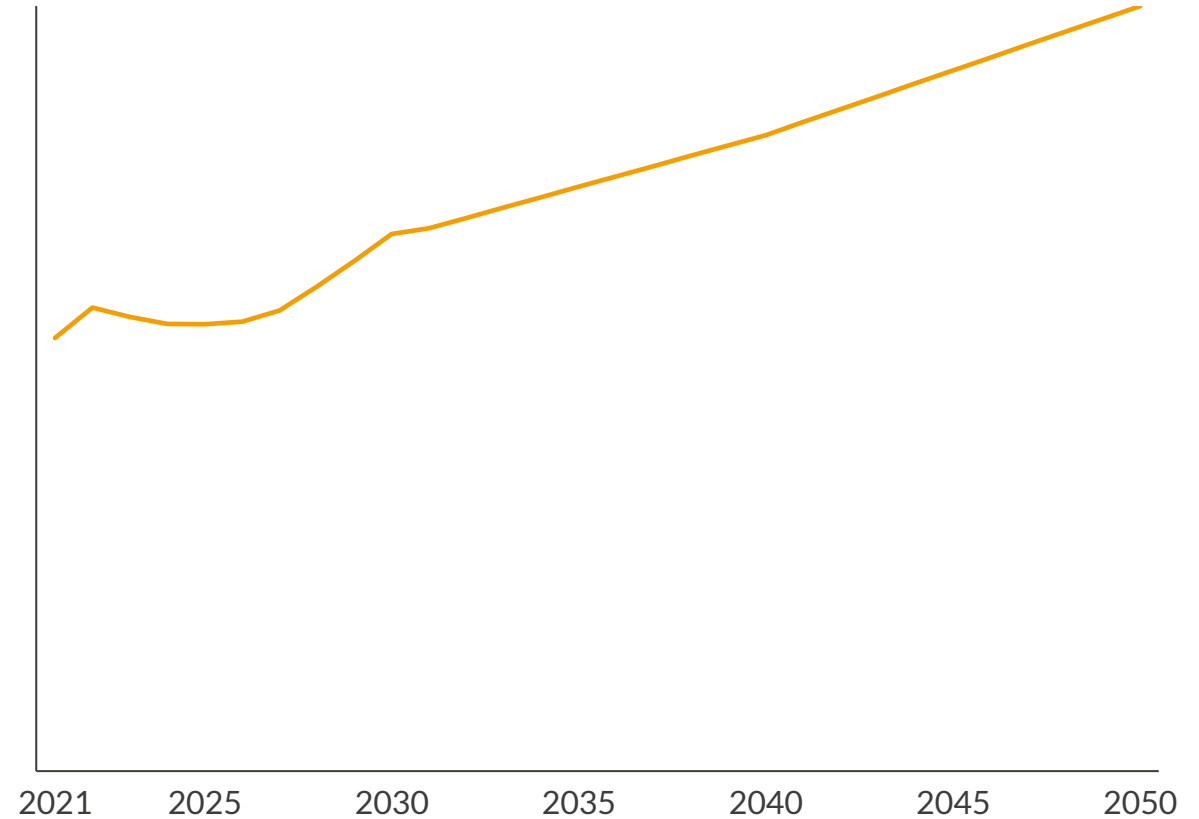
- European and Asia gas prices have been on the rise since Feb-21. North East Asia gas price reached \$11/MMBtu in Aug-21, growing by 49.8% in six months. TTF averaged \$15.3/MMBtu in Aug-21, increasing 19.8% m-o-m on average since Mar-21, surpassing Asian price levels in May-21
- The surge in European gas prices was driven by a combination of
 - 1 High demand as Europe emerges from lockdown
 - 2 Asian demand driving a tight LNG market
 - 3 Fall in indigenous production
 - 4 Flat Russian pipeline supply
 - 5 Low inventories following colder-than-normal weather

Uncertainty about long-term prices is driven largely by underlying commodity price risks

Natural gas prices
EUR/MWh (real 2020)



Carbon prices
EUR/tonne CO₂ (real 2020)



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The Greek power sector is expected to add 7 GW of solar and wind by 2030 with auctions but mainly merchant routes to market

Installed capacity
GW



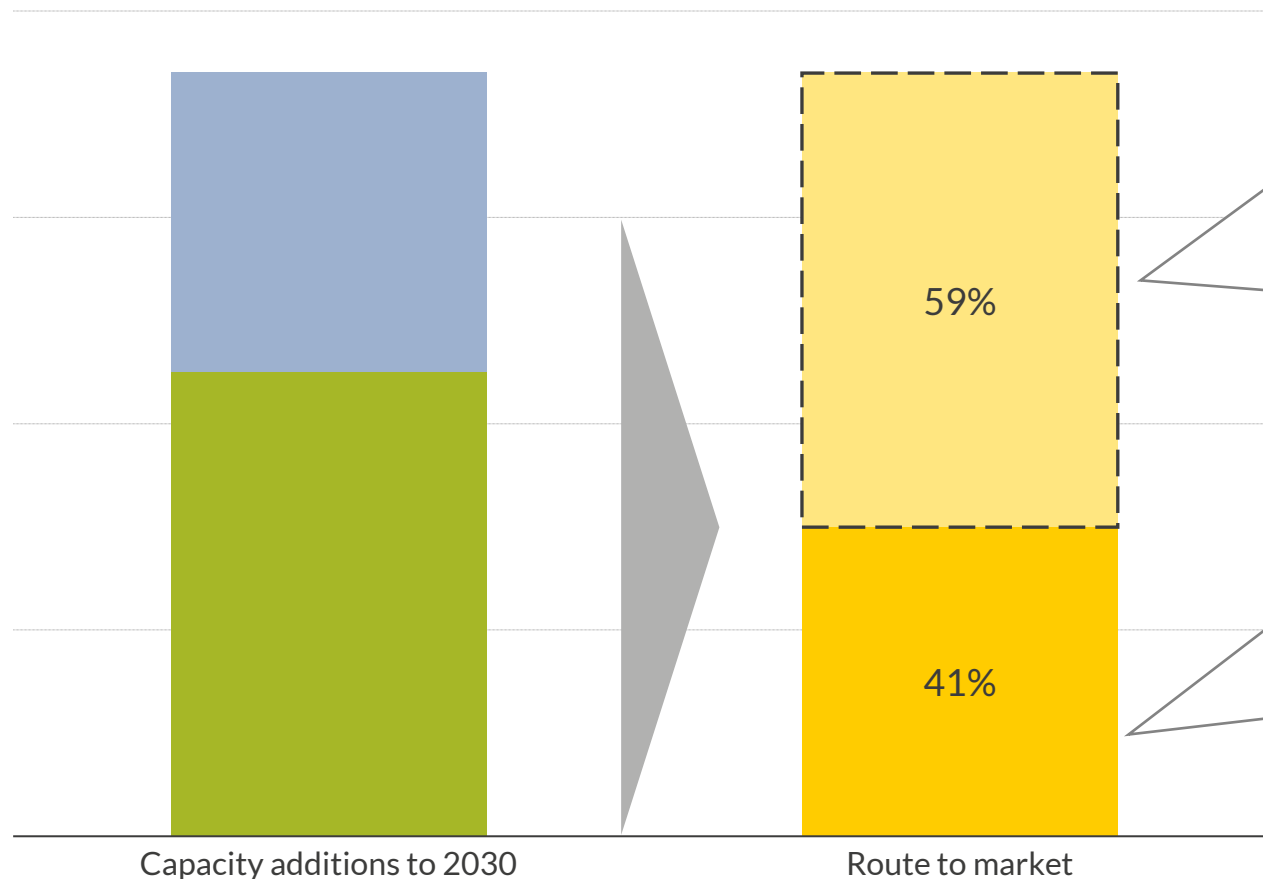
Comments

- RES buildout in line with NECP targets until 2030 with solar overpassing the target by 0.4 GW and wind missing it by only 200 MW
- Out of the 7 GW expected by 2030, 3 GW will come online via the recently announced auction scheme and the rest 4 GW via merchant projects that either participate in the market freely or sign long-term PPAs
- By 2025, gas is clearly the dominant baseload source as more than 2 GW of lignite exits the system in the next 4 years
- Greece could have over 20 GW of wind and solar by 2050

A strong RES deployment is expected in Greece by 2030; Aurora provides intelligence for both merchant and subsidised assets

Wind and solar capacity additions from 2021 to 2030

GW



■ Solar
 ■ Wind
 ■ Subsidised
 Merchant



How can these merchant projects be financed and brought to market?

- What are the expected revenues/returns of merchant-based RES projects?
- What are the key risks and considerations for investors and financing banks?
- Are PPAs a viable alternative route to market, how attractive are they and what are key risks?
- **Aurora's analysis can provide crucial intelligence to understand and assess all different types of merchant risk**

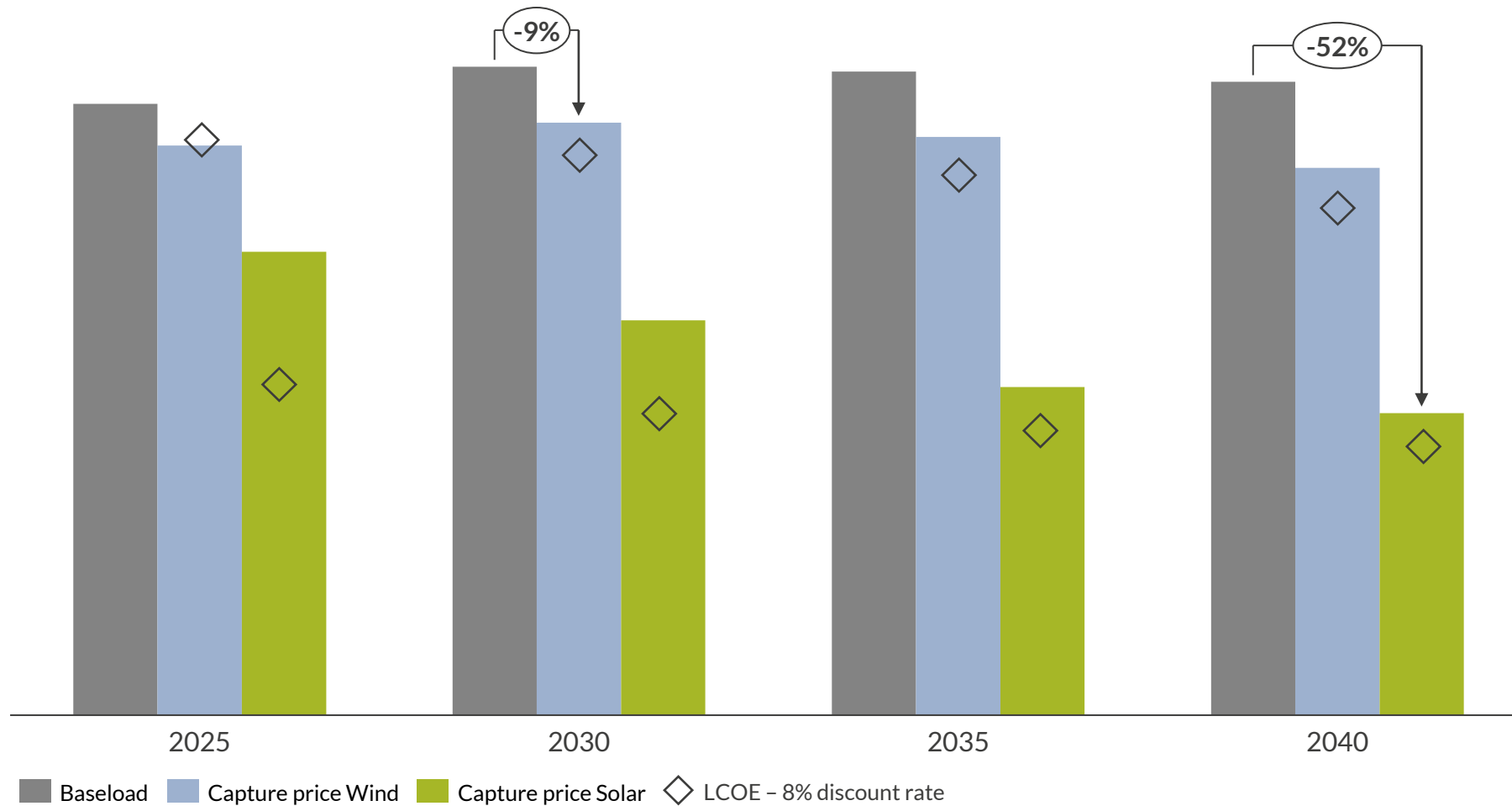


Auctions increase competition and push prices downward. How can a project be successful in an auction?

- How are auction prices expected to develop?
- How important is the merchant tail of subsidised projects?
- **Aurora's insights can be used to inform a bidding strategy which reflects the true value of RES assets**

On top of subsidized renewables, capture prices for wind and solar appear attractive in comparison with the LCOE of each technology

Baseload and uncurtailed capture prices¹
EUR/MWh (real 2020)



1) Average capture price for each MWh produced of theoretical generation.

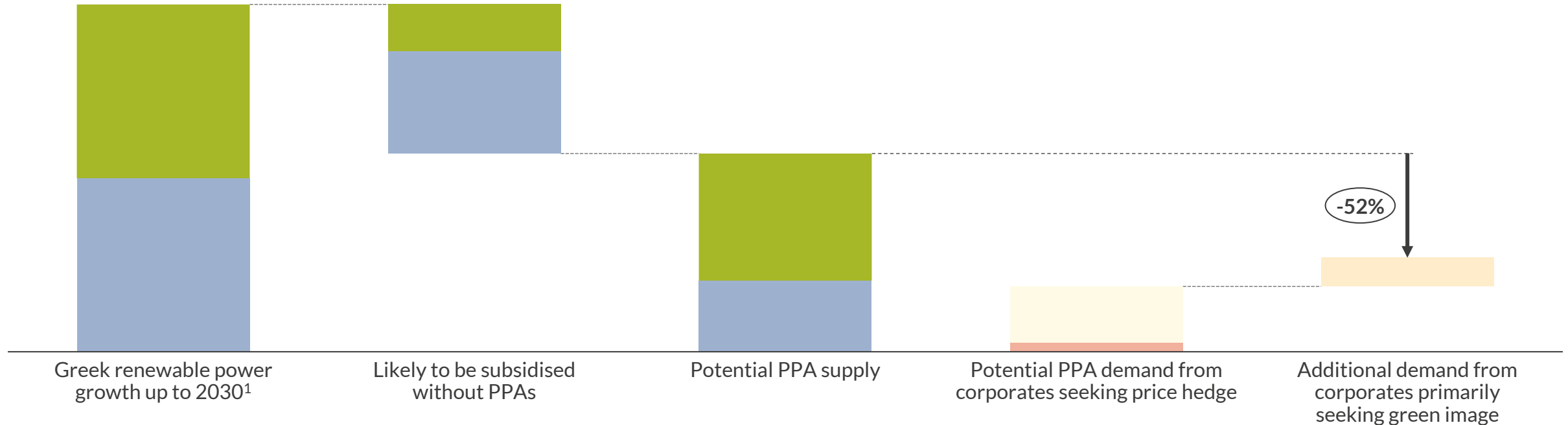
Comments

- The largest difference between capture prices and the LCOE for both wind and solar appears in 2021 due to te extremely high baseload prices
- In the future, the difference between capture prices and LCOE reduces over time, and especially for solar, due to the increased cannibalisation observed more capacity comes online

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We expect the potential PPA supply in 2030 to be double the corporate PPA demand

Cumulative total PPA potential supply and corporate demand up to 2030
TWh












Key takeaways

- Attractive RES economics lead to buildout on top of already extensive amounts of subsidised capacity
- Market will be a strong buyer’s market - Corporate demand for long-term price hedges less than half of PPA supply potential, putting downside pressure on PPA prices. Additional demand creates an opportunity for utilities to act as risk aggregators

■ Solar
 ■ Onshore
 ■ Green Image seekers
 ■ Green giants
 ■ Price Hedgers
 ■ Intermediates

1) Under Aurora Central, lists only renewable power generation added between 2021 and 2030. Subsidised generation is based on 3 GW of subsidies planned by the Greek government from 2021 to 2025.

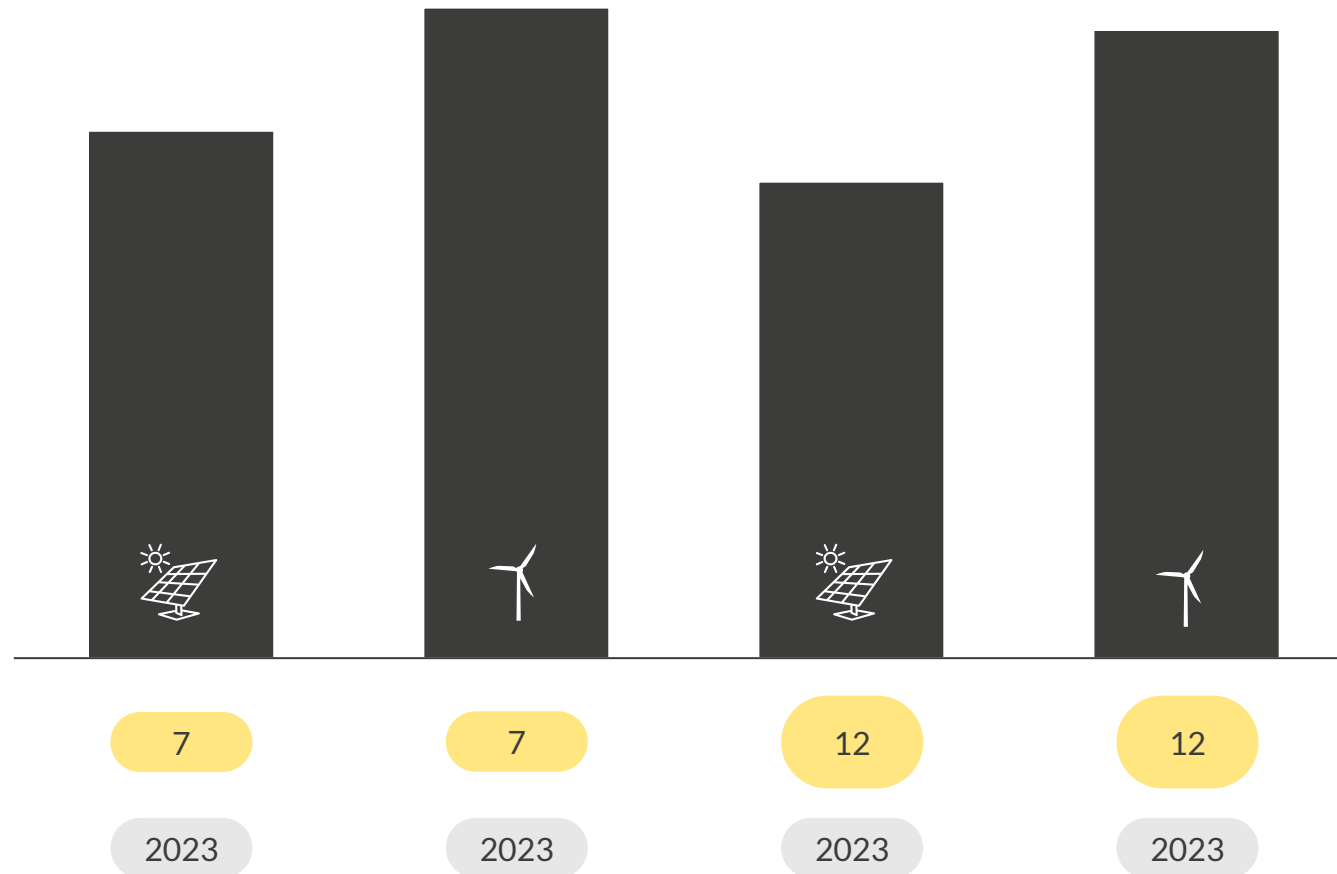
Commercial contract clauses determine the risk distribution and the fair value of the PPA

Commercial clause	Description	Who holds the risk?	
		Offtaker	Developer
Price clauses			
Fixed price	Fixed long-term price, offtaker takes on full price risk		
Collared	Price follows capture price, contract guarantees a max/min price		
Floating/Indexed price	Price linked to baseload index, offtaker only takes on capture price cannibalisation risk		
Tenor clauses			
Short term (<=5 years)	Not suitable for price hedging as futures liquid, suitable if no debt financing required. E.g. Onshore / solar > 20 yrs COD (out of EEG)		
Medium term (6 - 9 years)	Allows debt financing for smaller new build projects. E.g. solar and onshore merchant		
Long term (>9 years)	Allows for highly debt-leveraged finance required for high risk projects, e.g. offshore wind (zero bids)		
Volume clauses			
As produced	Offtaker receives asset generation profile		
Monthly % of P90	Asset(s) guarantees minimum pattern		
Fixed pattern/ baseload	Asset delivers power at a pre-agreed fixed pattern		

● Common
 ● Few cases
 ● Uncommon

The fair value of typical fixed price PPA contracts range between the low 40s and the low 60s EUR/MWh for volume as forecasted

Fair value of PPAs¹
EUR/MWh (real 2020)



Fair value of PPAs

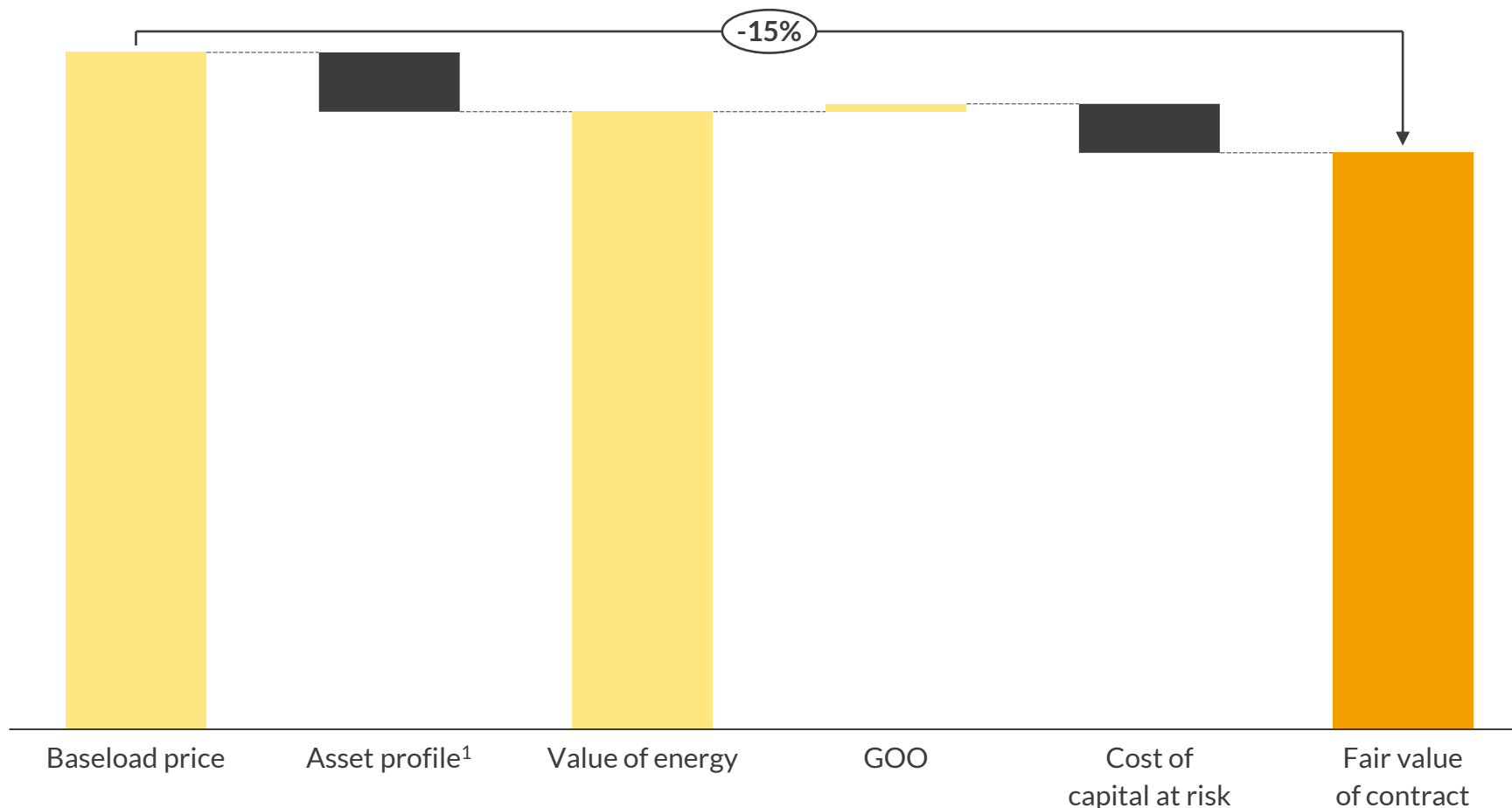
- The fair value of PPA contracts differs, with the most important factors being:
 - Renewable technology
 - Price clause
 - Volume clause
 - Tenor
 - Starting date of contract
- A fair value for a 7-year PPA starting in 2023 is in the low 50s for solar and low 60s EUR/MWh for onshore wind
- For a 12-year contract, a fair PPA value for delivery starting in 2023 is in the mid 40s EUR/MWh for solar and high 50s EUR/MWh for wind

1) The fair value is calculated assuming as forecasted volume and fixed price clause.



The fair market value of an onshore wind fixed price 7-year PPA starting in 2023 is in the low 60s EUR/MWh for volume as forecasted

Decomposition of price components for a 7-year onshore wind PPA with as forecasted volume clause and fixed price clause
EUR/MWh (real 2020)



Fair value of a 7-year onshore wind PPA

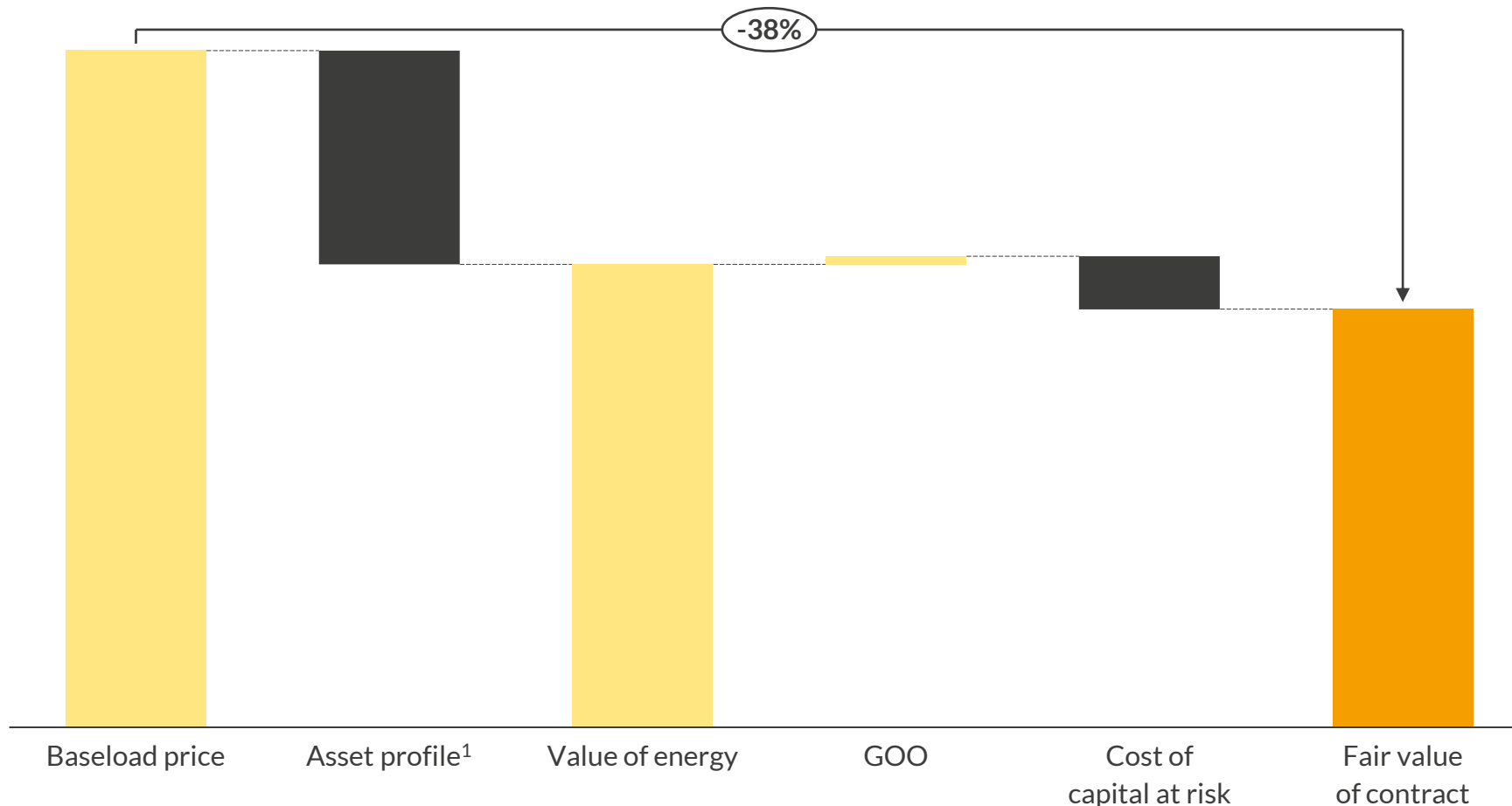
- Between 2023 and 2028, the average value of energy from onshore wind generation is in the mid 60s EUR/MWh, given the price projections in our Central scenario

1) Asset profile is calculated based on the technology-specific capture price and includes interannual variability.



The fair market value of a solar PV fixed price 12-year PPA starting in 2023 is in the low 40s EUR/MWh for volume as forecasted

Decomposition of price components for a 12-year solar PV PPA with as forecasted volume clause and fixed price clause
EUR/MWh (real 2020)



Fair value of a 12-year solar PV PPA

- Between 2023 and 2035, the average value of energy from solar PV generation is in the high 50s EUR/MWh, given the price projections in our Central scenario
- The delta between our Central and Low scenario increases over the years. Consequently, the longer contract period of 12 years leads to an increased cost of capital at risk
- Thus, the fair value of a 12-year solar PV PPA in 2023 is in the low 40s EUR/MWh driven by higher discount to baseload as a result of increased cannibalisation

1) Asset profile is calculated based on the technology-specific capture price and includes interannual variability.

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Greek Power Market Service: Key market analyses and forecasts for all participants in the Greek power market



Key information on Aurora's new Greek subscription service

- Up-to-date report available (November 2021)
- Next update in May 2022
- Regular updates thereafter (Biannually)
- **Introductory workshop**, with insights on market and policy status quo, policy and market outlook, price curves, market scenarios and PPA analysis
- **Subscriber webinar**, Aurora's experts will be organising a webinar for each bi-annual update where we highlight key market developments as well as their impact on our modelling

Biannual data and market reports to assess business models

- **Yearly forecasts of wholesale market prices along three scenarios** (High, Low, Central) until 2050
- **All the latest trends and forecasts**, recent market and policy developments
- **Price distributions**, capture spark spreads, peak prices
- **Capacity development**, generation mix, interconnector capacity, capacity buildout, exports
- **Capture prices** of key technologies (onshore, solar), load factors
- **Corporate PPA market analysis and valuation**, example of fair price valuation
- **Data in Excel**, all forecast data easily downloadable in Excel format
- **EU ETS carbon price & gas price forecasts**

Interaction through workshops and ongoing support

- **Bilateral workshops** at your offices to discuss specific issues on the Greek market
- **Ongoing availability** (calls, access to market experts, modellers) to address any questions across European power markets
- Discounted invitations to Aurora's annual **Spring Forum**



All intelligence for a successful business, based on bankable price forecasts



Our bi-annual report and accompanying data book provide in-depth RES market intelligence

Greek Power & Renewables Market Forecast report

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Discussion - Q&A

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