AURORA
ENERGY RESEARCH

Role of PPAs in the GB Power Market

December 2022

This is a redacted sample of the report. For the full report, contact Pablo Mayo, (pablo.mayo@auroraer.com).

Agenda

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Overview of the PPA market

- What are the advantages of a PPA contract compared to a CfD contract?
- What are the key trends in the PPA market in GB?
- What are some typical setups of PPA contracts?

Introduction to Aurora's methodology for pricing PPAs

- What are the considerations in valuing PPAs?
- How are PPAs valued? How does length of tenor influence the valuation?
- What additional factors are considered for baseload PPAs?

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- What is the Electricity Generator Levy?
- How does the demand and supply for PPAs evolve in Aurora's Central scenario?
- What are the valuations of PPAs?
- How does the demand and supply balance change in Aurora's Net Zero scenario?

Considerations for PPAs

- How can developers optimise their returns by splitting the asset between PPAs and CfDs?
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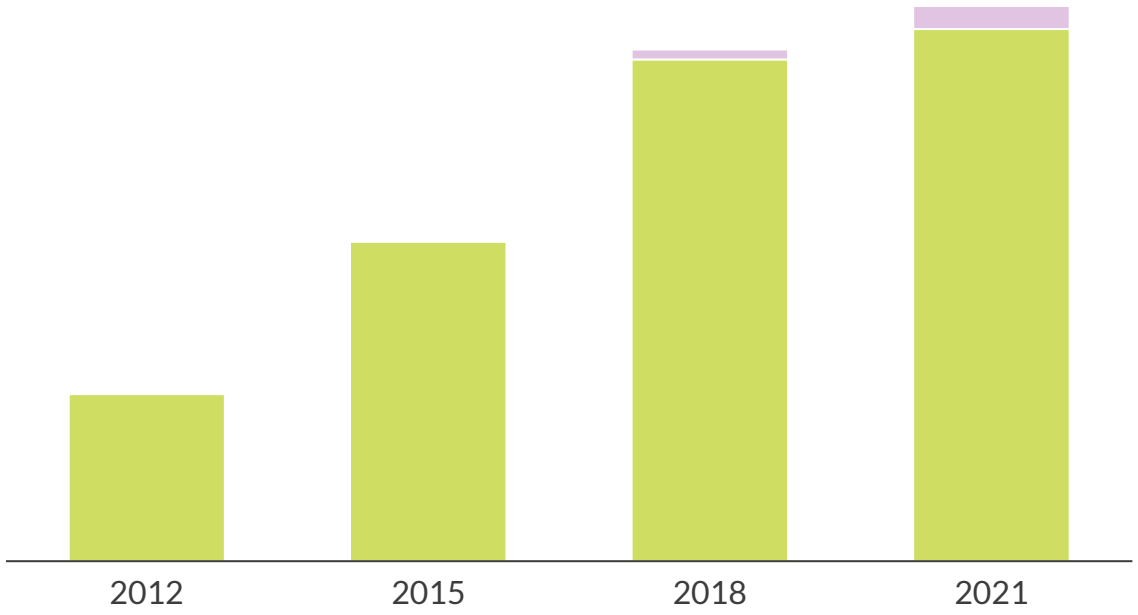
Route to market Power Purchase Agreements (PPAs) are playing an increasingly important role in making renewable projects bankable

1 Renewables projects backed by PPAs have grown by 2 GW since 2018 as Government support has shifted its focus from solar PV and onshore wind

Operational renewable capacity[1] by financing model

GW



- Subsidies have brought over 20GW of renewables capacity to market since 2012
- Financing renewables projects through PPAs has become increasingly lucrative due to the greater flexibility in contract terms compared to CfDs

PPA-backed Subsidised[2]

2 PPAs offer developers the option to trade off the lower cost of capital that CfDs offer for increased flexibility in tenor and volume delivery

	CfD	PPA
Length of contract	15 years	Highly flexible, under 3 years to over 20 years
Volume delivery	As produced	Flexible
Strike price	Fixed, consistently declining since FIDER[3], expected to reach LCOE[4]	Negotiated on a project-specific basis, can be at a premium to LCOE
Cost of capital	Under 6% due to revenue streams guaranteed by the Government	6-9% depending on creditworthiness of the offtaker
Hedge against risk	Very strong for the duration of the CfD, guaranteed by the Government	Subject to a range of risks relating to the offtaker

1) Includes solar PV, onshore wind and offshore wind; 2) Financed through the FiT, RO or CfD schemes, may still have an offtake agreement for the production volumes; 3) Final Investment Decision Enabling for Renewables was a pre-cursor to the CfD scheme without a competitive auction; 4) Levelised Cost Of Energy

Sources: Aurora Energy Research, BEIS

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In addition to hedging risk, PPAs offer a range of benefits to both developers and offtakers

1 While the energy transition brings unique challenges to asset developers, financers and offtakers, PPAs provide certainty to better manage them

Area	Challenges	Solutions from PPAs
Cost of capital	Energy transition will lead to extensive deployment of renewables and lower capture prices	Predictable, constant revenue streams allow developers to unlock lower cost of capital
Compliance	Fuel Mix Disclosure requirements and stakeholder pressure for corporates to decarbonise	Access to high quality green power
Risk	Utilities and heavy industry require hedges against high power prices	Hedge against short and long term risk

2 Route to market alternatives mainly differ on the level and type of risk management opportunities they offer

Risk Category	CfD	CfD + PPA	PPA	PPA + Merchant	Merchant
Price Risk[1]	Low	Medium	Medium	Medium	High
Profile Risk[2]	Low	Medium	Medium	High	High
Credit Risk[3]	Low	High	High	High	High
Cost of Capital[4]	Low	Medium	Medium	Medium	High

- An asset's risk profile varies based on its financing model, with CfD contracts offsetting most risks while a merchant-risk profile is largely unhedged
- Hybrid financing options allows developers to optimise risk profiles and maintain some upside potential

Low Risk Medium Risk High Risk

1)) Risk of the price of power changing (captures extent of exposure to wholesale prices); 2) Risk of generated power volumes deviating from a contracted level; 3) Risk of counterparty not meeting debt obligations; 4) Minimum rate of revenue to be earned before being profitable;

Sources: Aurora Energy Research

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GB has a more mature PPA market than most of continental Europe with 14 GW of contracted capacity

1 GB is one of three mature markets for PPAs in Europe, second only to Spain in terms of capacity contracted

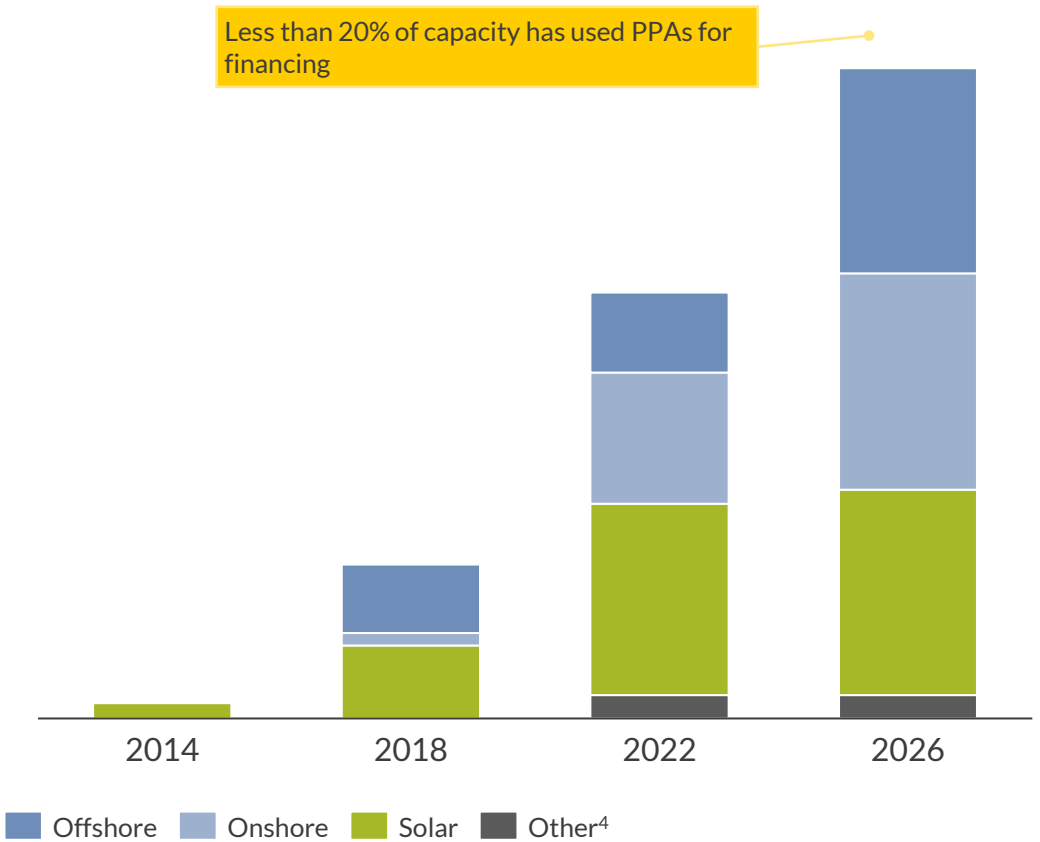
Operational capacity in 2026 that presently hold PPA contracts[1]
GW

Country	Contracted PPA capacity (GW)	Share of installed RES capacity (GW)	Market Maturity Stage
		24%	
		24%	
[2]		12%	
		10%	
		2%	
		5%	
		2%	
		10%	
		1%	
		6%	
		7%	

Mature Medium Immature

2 While route-to-market PPAs in GB initially facilitated the deployment of solar capacity, they are increasingly being used to finance wind projects

Operational capacity by technology in GB that presently hold RtM[3] PPA contracts, GW



1) Includes both offtake and route-to-market agreements which will be operational by 2026; 2) Nordic countries: Denmark, Finland, Sweden and Norway; 3) Route-to-market; 4) Energy from Waste and battery storage.

Sources: Aurora Energy Research

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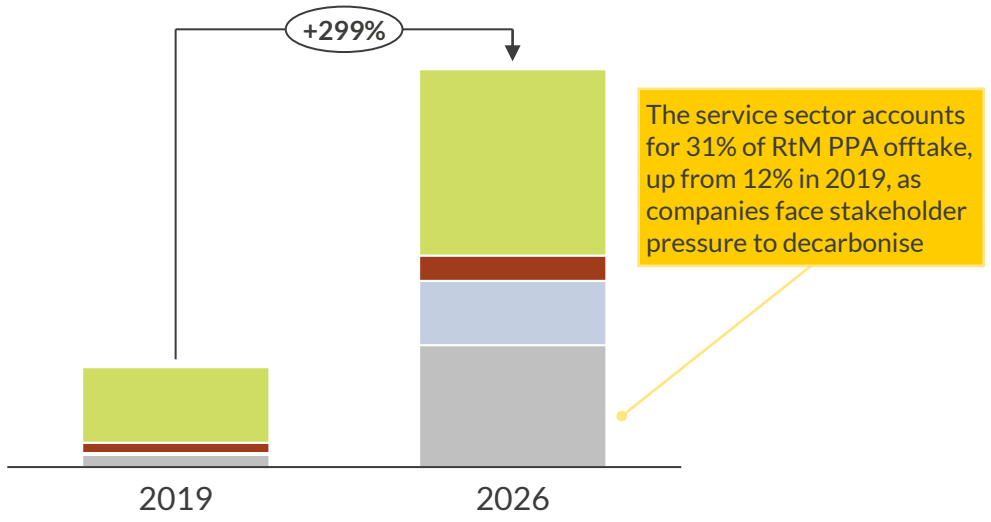
Utility firms dominate both the demand and supply side of route-to-market PPAs, but corporate demand is increasing

PPAs are commonly classified based on the type of offtaker. A corporate PPA involves a businesses directly agreeing to purchase power from a generator, while the offtaker in the case of utility PPAs is a commercial energy provider

1 Utility RtM PPAs are dominant in GB, while corporate agreements will grow 8-fold by 2026

RtM[1] PPA offtake capacity in GB by industry

GW



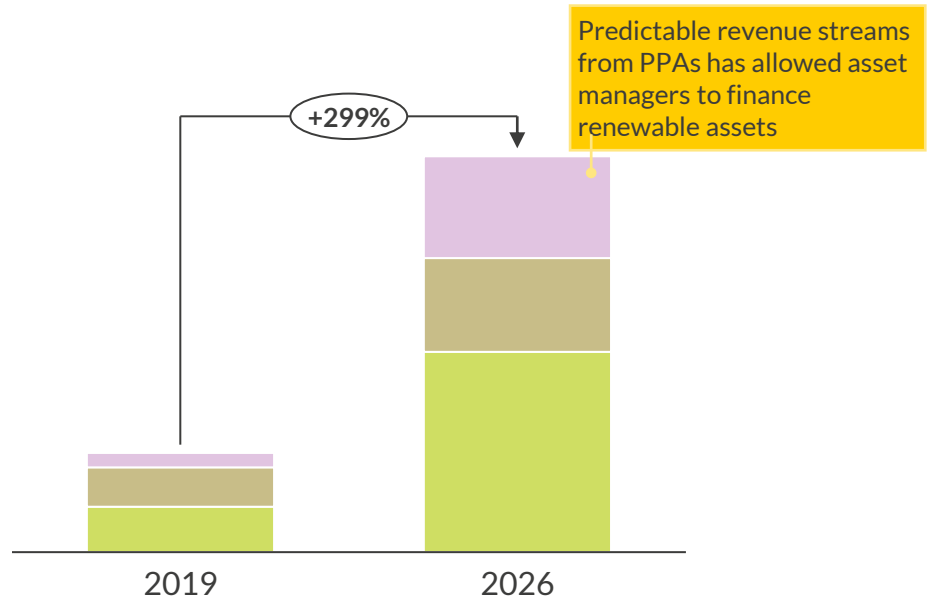
- Utility offtakers make up 47% of RtM PPA volumes to meet Fuel Mix Disclosure requirements and lower exposure to market prices

Utility | Heavy Industry[2] | Light Industry[3] | Services[4] → Corporate

2 Utilities also supply 51% of RtM[1] PPAs in GB, while asset managers account for a further 26%

RtM[1] PPA supply capacity in GB by type of asset owner

GW



- Vertically integrated utilities leverage route-to-market PPAs as an alternative financial route to expand their generation fleets

Asset Manager | Renewable Developer | Utility

1) Route-to-market 2) High capex industries focused on raw material production, e.g. Iron-steel, chemicals 3) Agriculture and low CAPEX industries focused on producing consumer goods, e.g. Automotive, food/beverages 4) Industries not directly concerned with the production of physical goods

Sources: Aurora Energy Research

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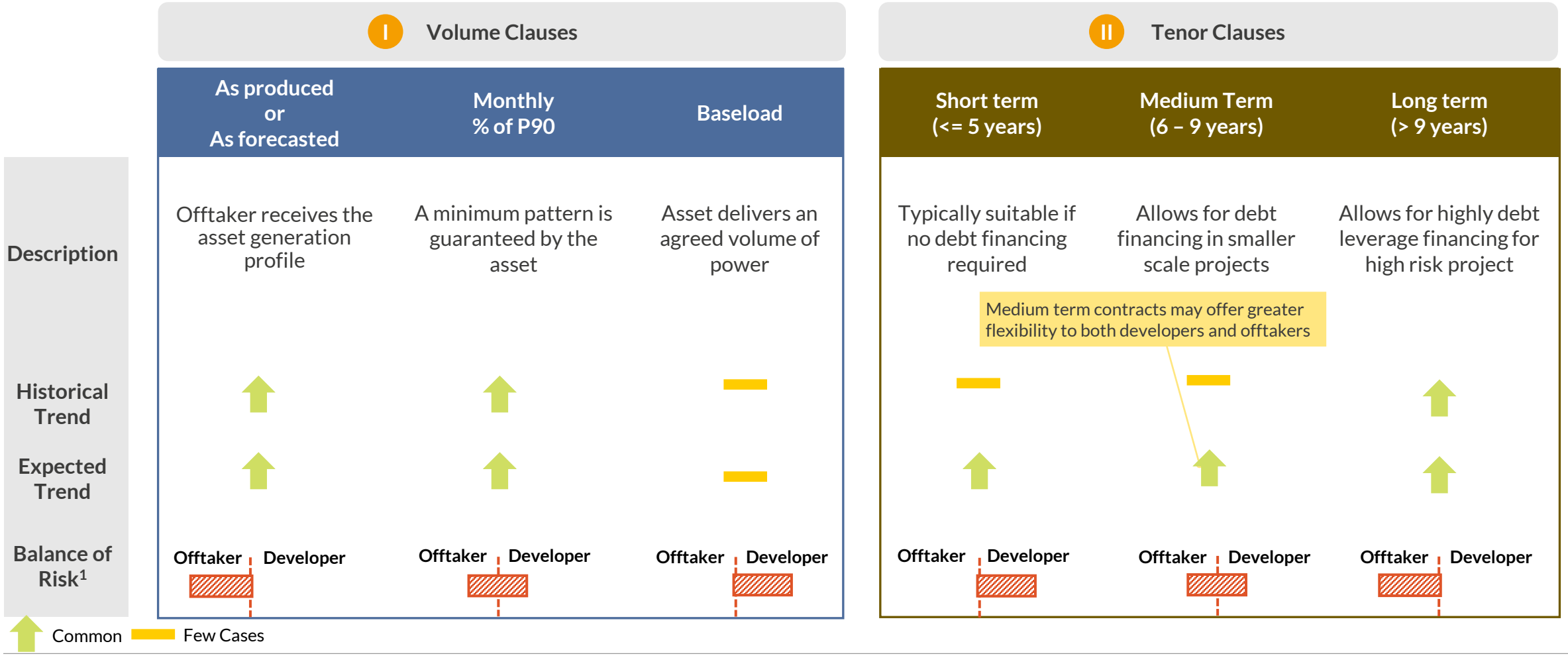
PPAs can be set up in a variety of arrangements with differing commercial clauses to meet the needs of both parties

Offtake volumes and contract durations in PPAs can be customised to best suit the needs and risk tolerance of the counterparties involved. This flexibility can make them more attractive than CfDs to developers



1) Balance on risk assessed based on expected weightage of volume risk in the case of volume clauses and ease of financing in the case of tenor clauses

Sources: Aurora Energy Research

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Aurora has modelled two pricing methodologies and considered three different types of PPA arrangements

1 The fair value of PPAs can be derived either from futures prices or a bottom-up pricing of individual cost components

	Futures based pricing models	Fundamentals based pricing models
Description	PPA value is derived from futures settlement price curves indicating the current market value of power	PPA value is linked to renewable capture prices, with an asset's LCOE representing the lower price limit
Baseline	Extrapolated futures settlement prices	Forecasted baseload or capture price
Additional Factors	Expected renewable and offtaker discounts Expected risk of stack and roll strategy	Expected renewable discount to baseload price Expected risk and value of hedge
Challenges	Poor liquidity in backend tenors reduces price confidence and increases volatility	Less suited for near-term PPAs as capture price forecasts might differ significantly from prompt derivative prices

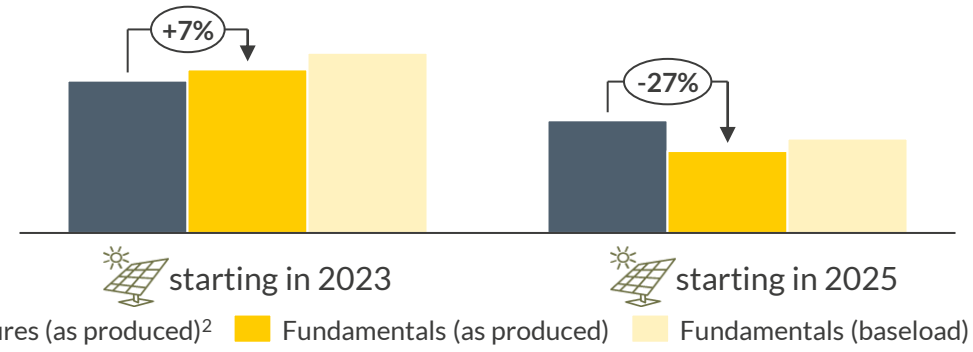
2 Aurora has considered three types of PPA arrangements, as produced, baseload and 24/7 clean

	As produced	Baseload	24/7 clean
Description	The asset is required to produce a fixed volume over the year without any profile requirements	The asset is required to deliver a fixed "baseload" volume, either by generating or by procuring from the market	The half-hourly demand of the off-taker is matched by generation from the asset or a time-stamped REGO

3 Valuations derived using these approaches diverge and a blended approach can be used to incorporate near-term futures with fundamentals

As-produced 5-year PPA prices for solar PV[1]

£/MWh (real 2021)



1) We use a 9% WACC; 2) Futures taken 12th September 2022, or same date as commodity futures for Aurora October 2022 Central forecast which the fundamental PPA approach uses.

Sources: Aurora Energy Research

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Developer and offtakers need to consider additional risks beyond valuations based on fundamentals and futures

While fundamental models price in key risk categories, stakeholders need to consider additional factors which can alter the attractiveness of securing a PPA. These additional risks are typically managed using specialised contract clauses

	Description of Risk		Impact on developers	Impact on offtakers
	**Credit Risk**	▪ Since PPAs are bilaterally agreed, both sides hold significant counterparty risk which needs to be evaluated based on contract length		
	**Policy and Regulatory Risk**	▪ Changes to subsidy schemes, taxation and changes to market structure can alter the value of a PPA for both parties		
	**Development and consent risk**	▪ While PPAs are usually agreed during the project financing phase, PPA contracts are usually set up such that developers bear the risk for development and consenting		
	**Delivery Risk**	▪ Risk of outages, and failures affect both parties and are managed using tailored clauses in the contract		

Sources: Aurora Energy Research

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Sources: Aurora Energy Research

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Aurora has studied the evolution of demand and supply for PPAs, and evaluated the business case for PPAs with the fundamental methodology

X Deep-dive on subsequent slides

1 The demand for PPAs will outstrip supply in 2030 as offtakers seek to reduce their carbon emissions A

Offtakers consider PPAs for a variety of reasons:

- **Reducing emissions** by procuring power from renewable generators
- **Additionality** is often an objective in many Corporate Social Responsibility charters
- **Hedging against price risk** is a consideration for heavy industrial demand
- H_2 **The Low Carbon Hydrogen Standard** requires electrolysers to produce hydrogen at an intensity of up to 2.4 $kgCO_2/kgH_2$

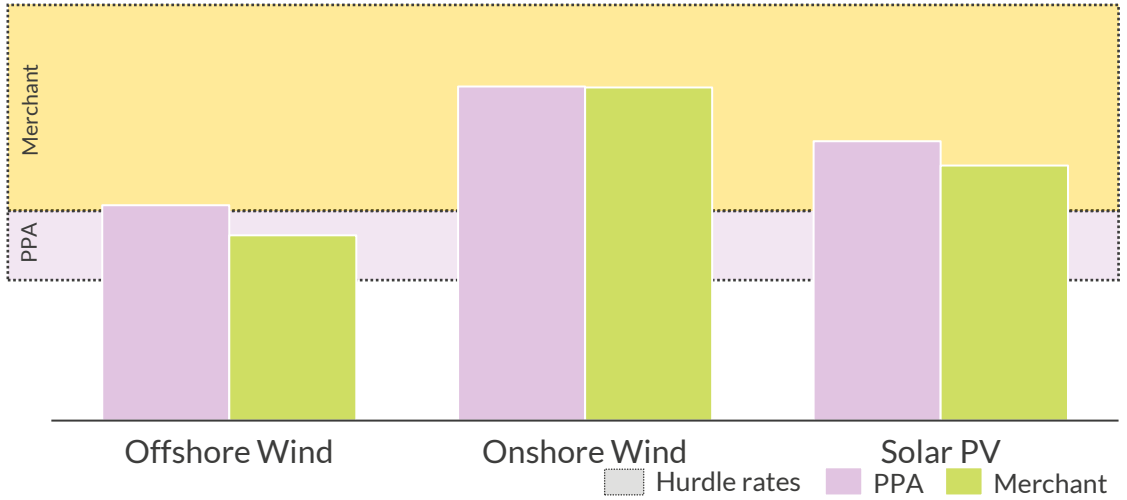
Greater interest from offtakers could exert an upwards pressure on the demand for PPAs, while:

- **CfD** is an alternative to PPAs for developers
- **Logistical and regulatory constraints** limit the deployment of renewables in the mid-term

2 PPAs are a lucrative option for developers due to the lower cost of capital compared to merchant projects B

As produced 10-year PPA projects starting in 2025[1]

IRR %, pre-tax (real 2021)



3 PPAs can serve as a hedge against declining capture prices due to rapid deployment of renewables in Net Zero C

- The rapid deployment of renewables in the 2030s leads to capture prices decreasing below LCOEs
- The supply for PPAs decreases faster than demand in the Net Zero scenario, consequently the imbalance increases

1) The Electricity Generation Levy is included in the IRRs.

Sources: Aurora Energy Research

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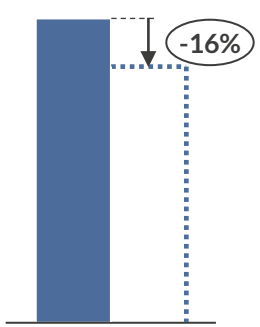
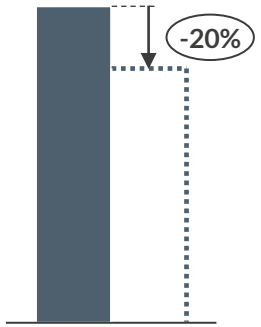
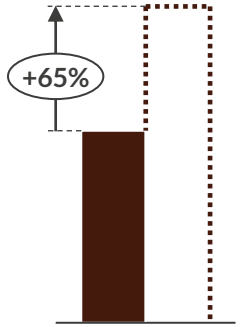
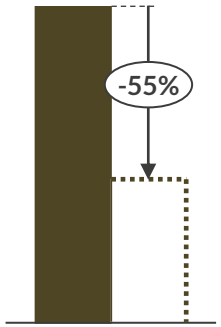
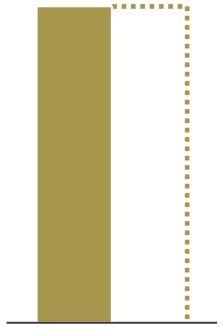
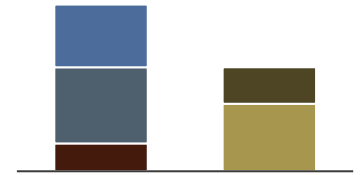
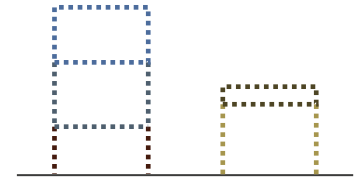
Aurora Central sees the GB PPA market undersupplied in 2030, with the deficit widening in Aurora Net Zero

	A PPA Demand Potential			B PPA Supply Potential		C Market Balance
	Direct corporate demand	Utility demand	Electrolyser demand	Unsubsidised generation	Contracted PPA generation	
Description	Demand from credit-worthy[1] businesses	Sleeving agreements[2] and demand from businesses with low credit ratings	Demand for green H_2 production	Assets with full merchant business plans or expired subsidies	Assets with generation currently contracted under PPAs	
Volume in 2030 (TWh)						Aurora Central  Undersupplied Aurora Net Zero  Undersupplied
Driver of change	Lower grid carbon intensity reduces demand for PPA backed renewable power		Demand for green H_2 increases	Lower capture prices reduces unsubsidised generation	Remains unchanged	

Aurora Central Aurora Net Zero

1) Minimum rating of BBB- (S&P) or Baa3 (Moody's); 2) Agreements where an intermediary utility handles transfer of power between counterparties

Sources: Aurora Energy Research, BEIS, S&P Global

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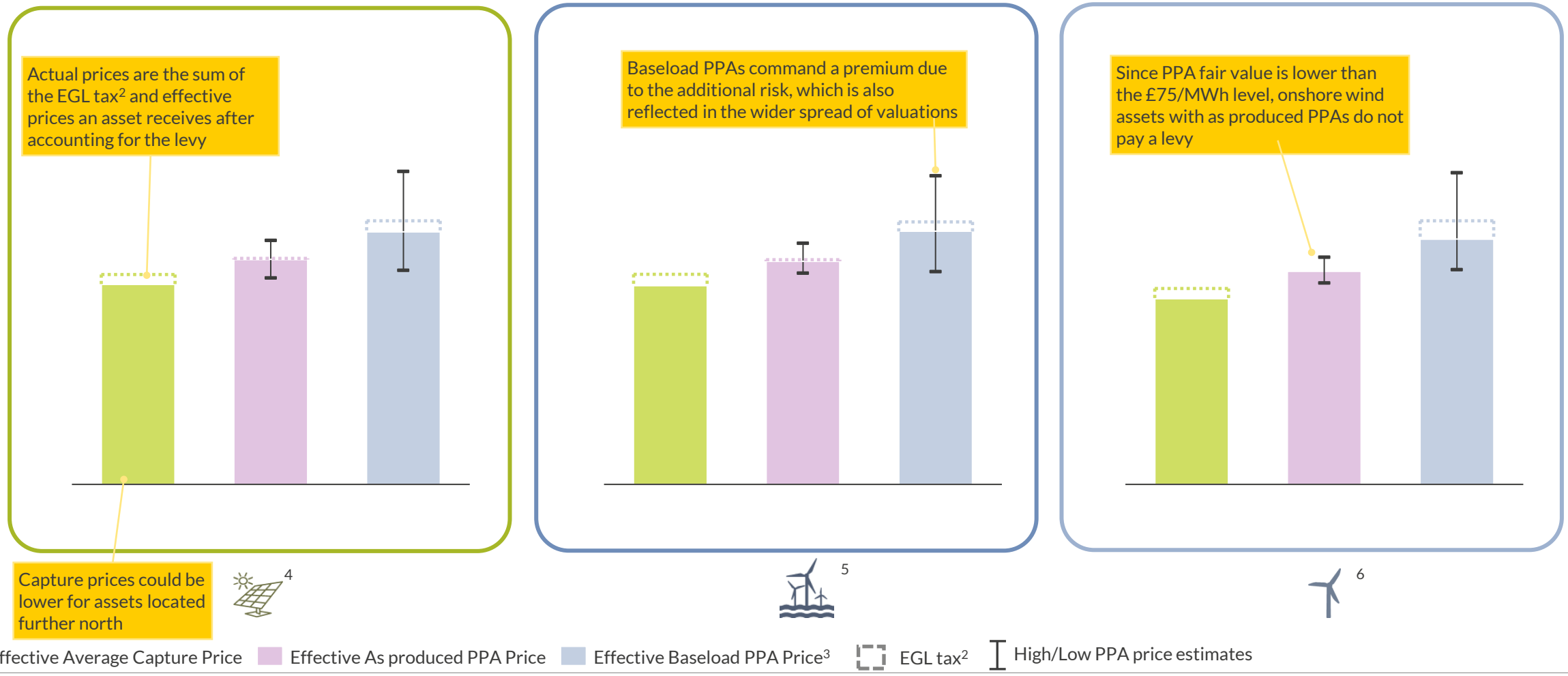
As demand outstrips supply, PPAs offer attractive returns due to the lower cost of capital, and solar PV assets command a premium to capture prices

PPA prices by technology for 10-year contracts starting in 2025[1]

£/MWh (real 2021)



1) Fully indexed PPAs with investment grade offtaker, WACC of 9% assumed; 2) Electricity Generator Levy 3) Central price estimate assumer developer price and profile risk/hedge to be zero in cases where value of hedge greater than risk, as we assume that developers would not accept a discount on the basis of power price forecasts alone; 4) Distribution connected solar PV in South England, assumed load factor of 12.5%; 5) Transmission connected offshore wind in North Sea, assumed load factor of 52.5%; 6) Distribution connected onshore wind in Scotland, assumed load factor of 37.6%. Sources: Aurora Energy Research

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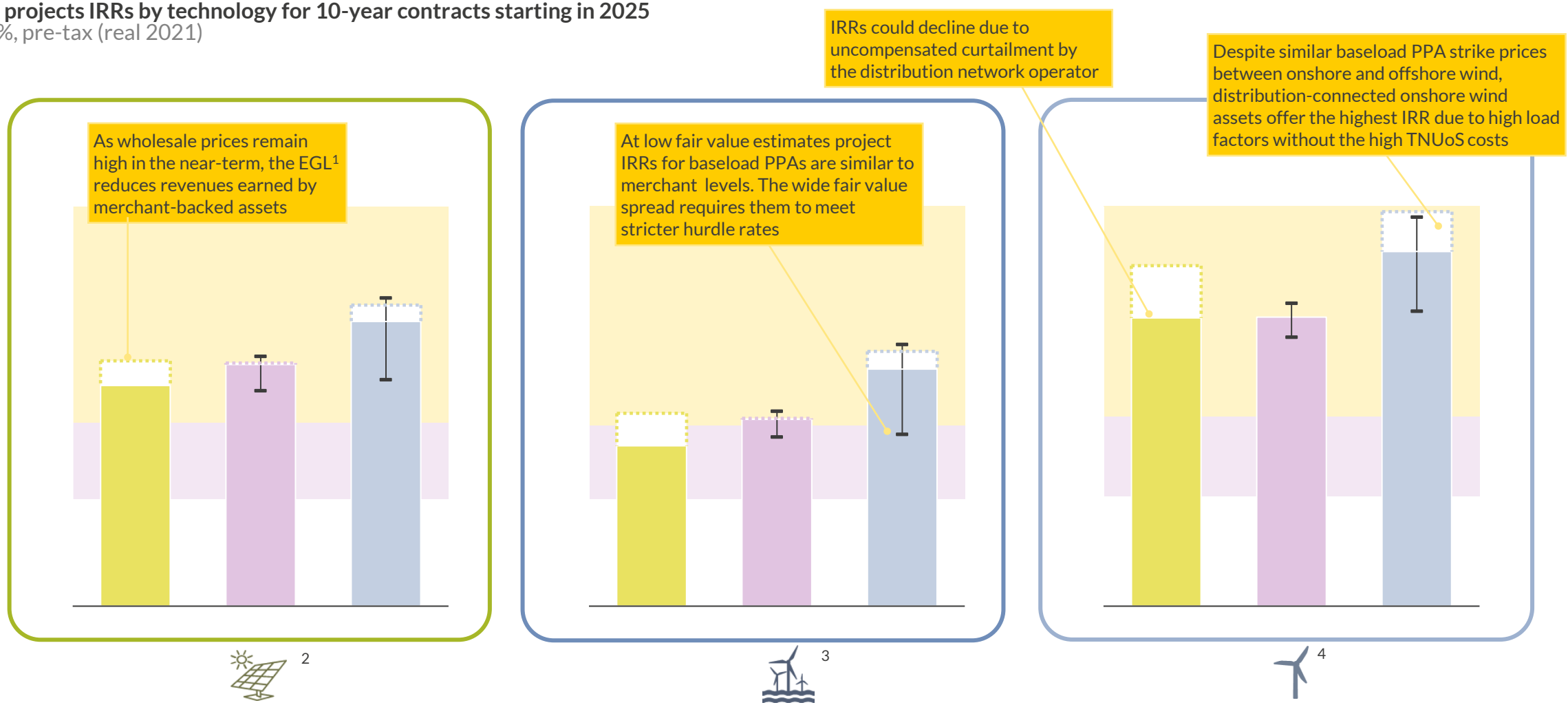
Solar PV can benefit from higher IRRs by entering 10-year baseload PPA contracts compared to a pure merchant route to market…

PPA projects IRRs by technology for 10-year contracts starting in 2025
IRR %, pre-tax (real 2021)



1) Electricity Generator Levy; 2) Distribution connected solar PV in South England, assumed load factor of 12.5%; 3) Transmission connected offshore wind in North Sea, assumed load factor of 52.5%; 4) Distribution connected onshore wind in Scotland, assumed load factor of 37.6%, assuming no curtailment

Sources: Aurora Energy Research

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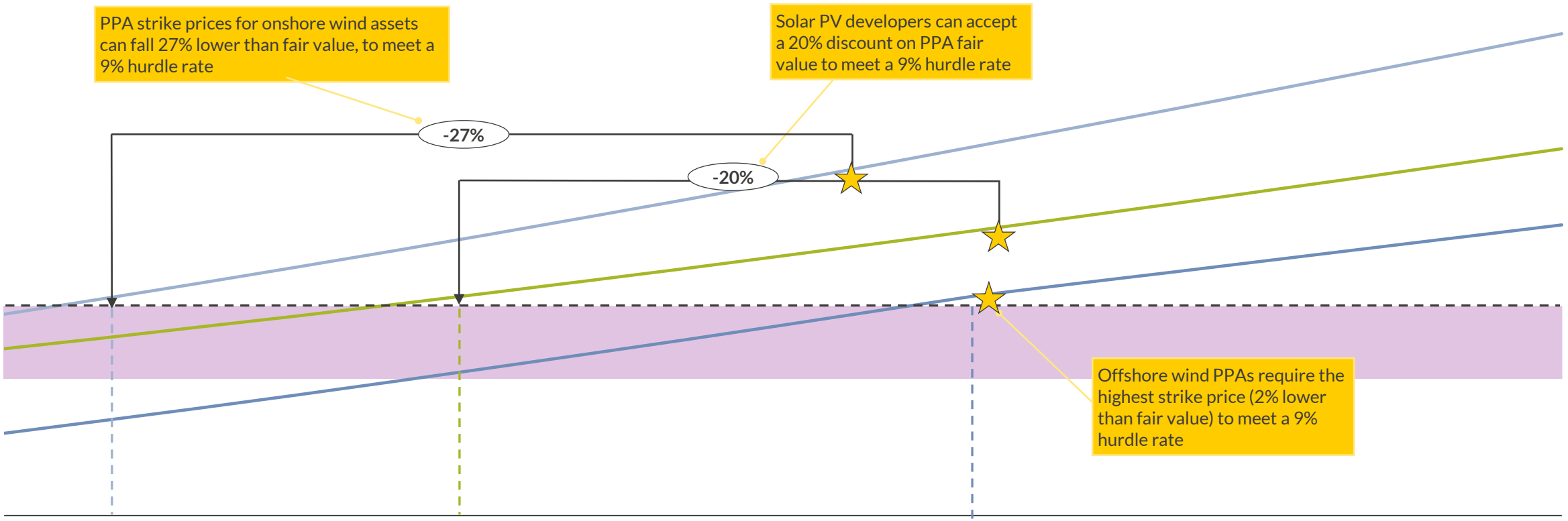
… however, developers might accept PPA prices closer to their hurdle rate to close projects and secure financing if competition is stiff

PPA projects IRRs by technology for 10-year, as-produced contracts starting in 2025
IRR %, pre-tax (real 2021)



PPA prices by technology for 10-year, as-produced contracts starting in 2025[1]
£/MWh (real 2021)

Solar PV[2] — Offshore wind[3] — Onshore wind[4] — PPA Hurdle rate — - - - Minimum PPA strike price to achieve 9% hurdle rate — ★ Fair value PPA price

1) WACC of 9% was used; 2) Distribution connected solar PV in South England, assumed load factor of 12.5%; 3) Transmission connected offshore wind in North Sea, assumed load factor of 52.5% ;4) Distribution connected onshore wind in Scotland, assumed load factor of 37.6%.

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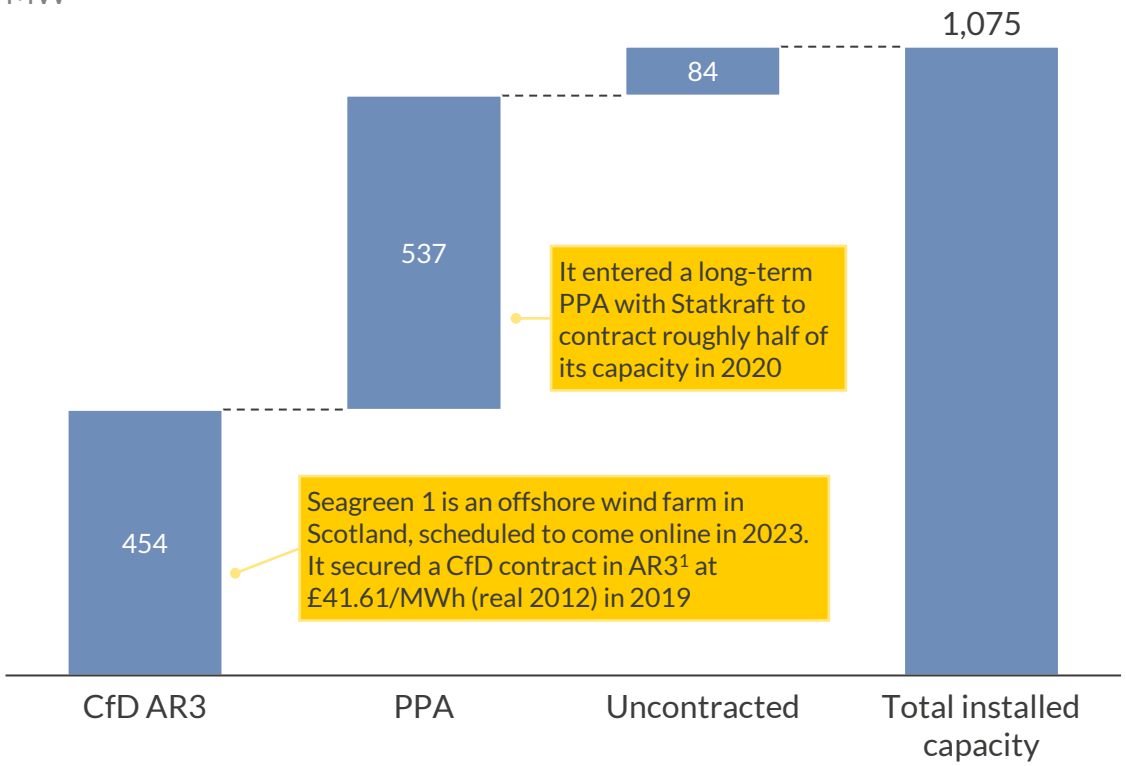
Further considerations include a blend of multiple financing models, the level of emissions abatement achieved and the Electricity Generator Levy

X Deep-dive on subsequent slides

1 Developers use PPAs in conjunction with subsidies and merchant financing models to manage risk and increase their returns A

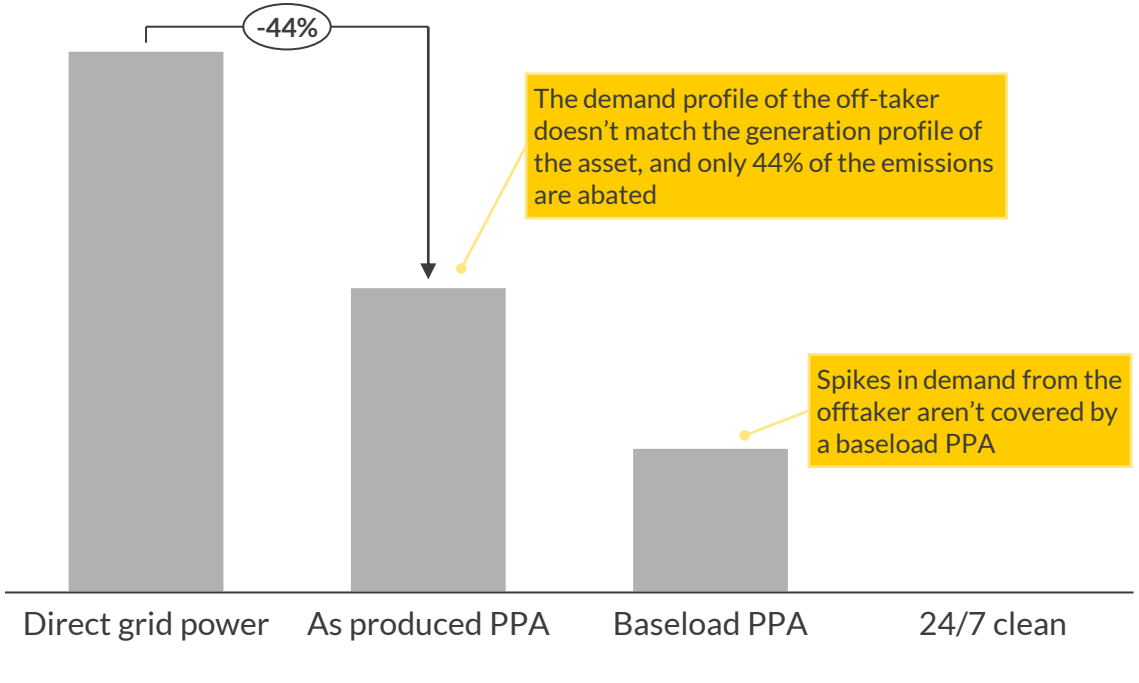
Capacity of Seagreen 1 by financing model

MW



2 The emissions reduction offered by PPAs depends on the type of PPA and the demand profile of the offtaker B

Emissions intensity in 2025 for a corporate offtaker with direct grid power and PPAs[2], gCO_2e/kWh



The Autumn Statement (17th November 2022) announced an Electricity Generator Levy (EGL). It applies to non-fired generators that benefit from the high-price environment with limited or no exposure to the underlying high costs, and is intended as one of the measures to cover the UK's fiscal deficit. This policy could impact investor sentiment, but the impact on business cases for PPA-backed projects is lower than merchant risk projects C

1) Allocation Round 3; 2) As-produced PPA to cover 100% of annual demand with a solar PV asset; baseload PPA covering up to 90th percentile of the offtaker's demand.

Sources: Aurora Energy Research, Open Power System Data

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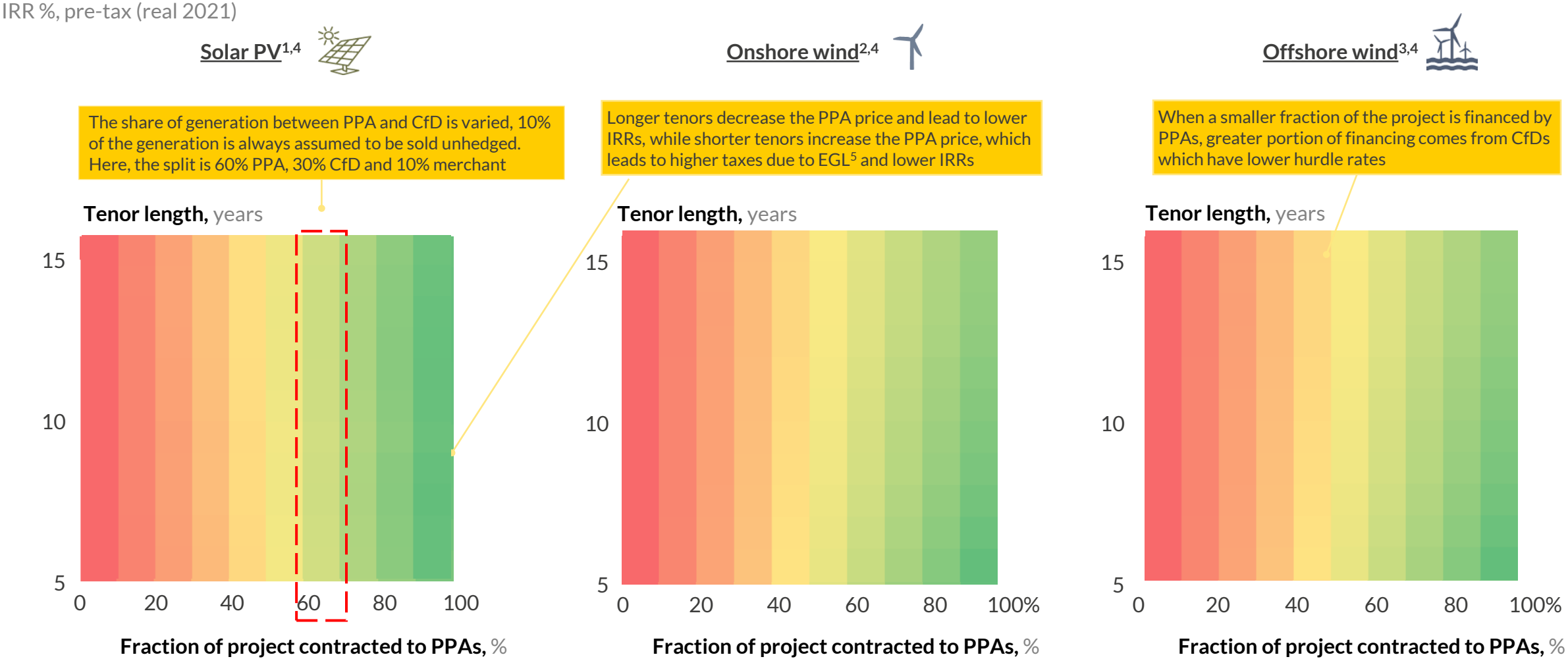
Both CfD-backed and merchant projects can increase profitability and mitigate risk by incorporating PPAs into their strategies

Project IRR by technology assuming 2025 entry

IRR %, pre-tax (real 2021)



1) Distribution connected in South England, assumed load factor of 12.5%; 2) Distribution connected in Scotland, assumed load factor of 37.6%; 3) Transmission connected in the North Sea, assumed load factor of 52.5%; 4) Assuming 2025 entry, CfD strike price for each technology assumed to be the LCOE at 6% WACC in 2025; 5) Electricity Generator Levy

Sources: Aurora Energy Research

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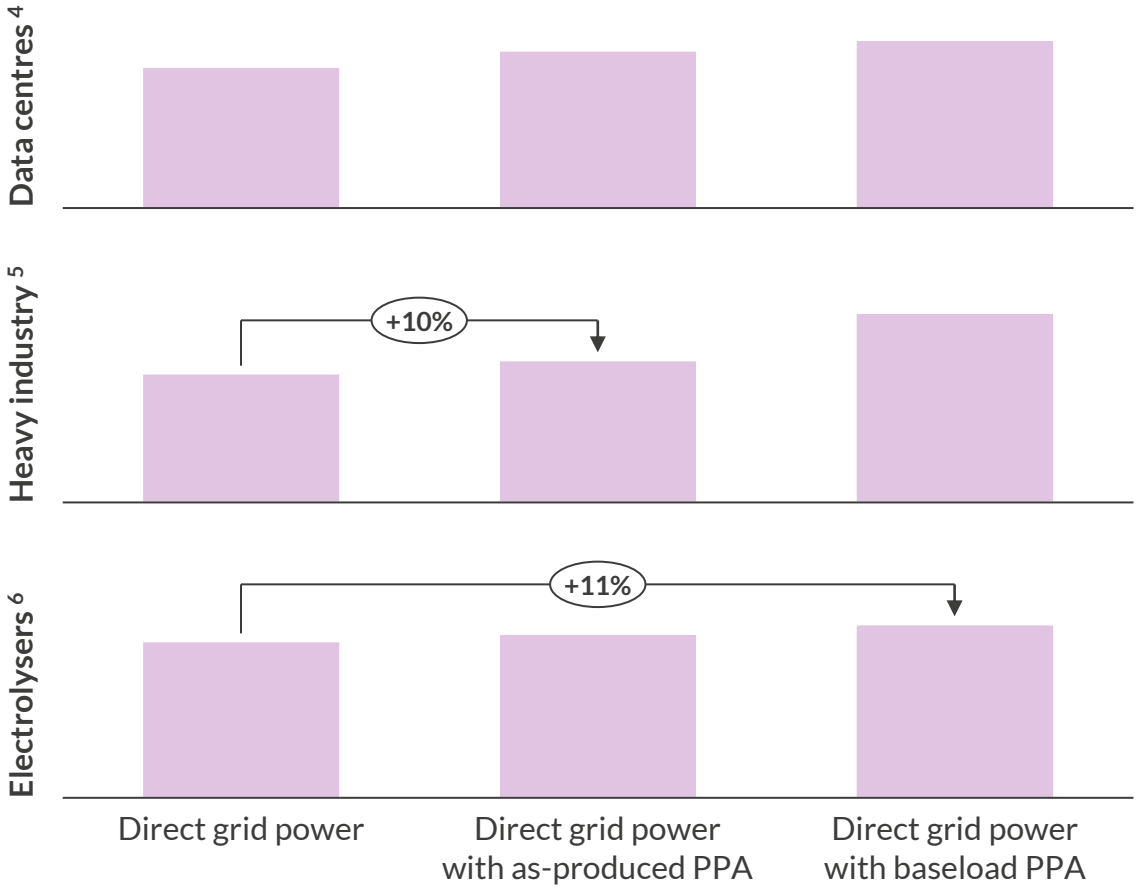
Offtakers can achieve significant emissions reductions by entering PPAs, with electrolysers able to abate all emissions at 11% higher than wholesale prices

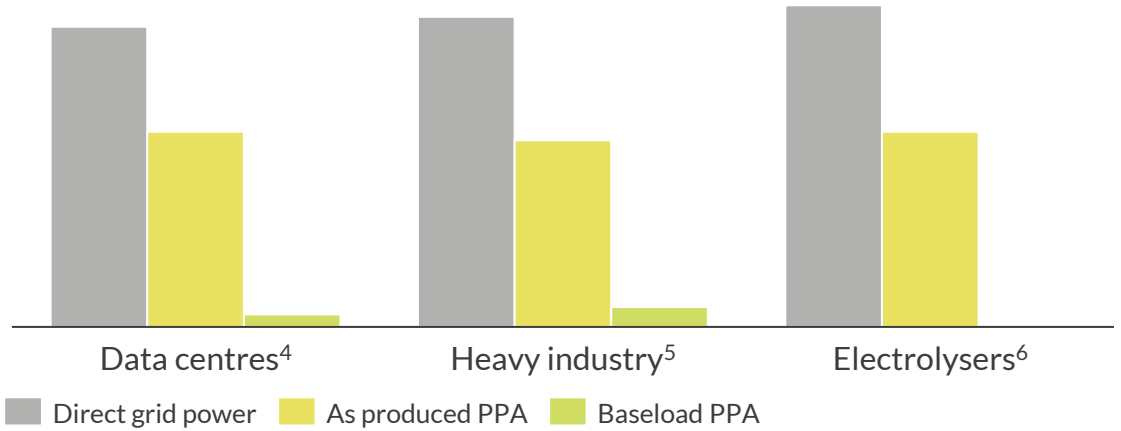
1 Compared to wholesale prices, as produced PPAs cost up to 10% more and baseload PPAs cost 47% more depending on the offtaker

Average wholesale cost of PPAs by offtaker type between 2025-34[2,3]
£/MWh (real 2021)

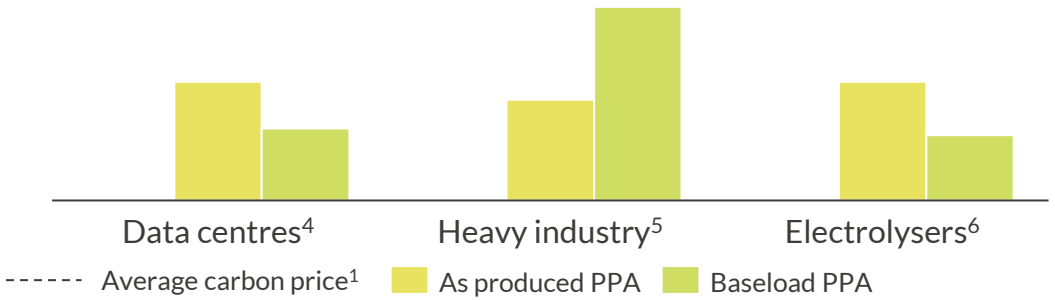


2 The optimal emissions reductions depend on the cost of the PPA and the magnitude of emissions reduction it offers

Average emission intensity between 2025-34 by sector for different offtake options, gCO_2e/kWh



Average cost of emissions reduction and UK carbon price from 2025-34
£/tCO_2 (real 2021)



1) Average UK carbon price from 2025-34; 2) Solar PV asset in the south of England with an assumed load factor of 12.5%; 3) Baseload PPA volume set to covers the 90th percentile of offtaker's demand 4) Demand profile for a flat load data centre located in the USA considered, assumed load factor of 85% 5) Demand profile for an Iron and Steel plant in Korea considered, assumed load factor of 20% 6) Demand profile for a GB PEM electrolyser consider, assumed load factor of 90%

Sources: Aurora Energy Research, Open Power System Data, Berkeley National Laboratory

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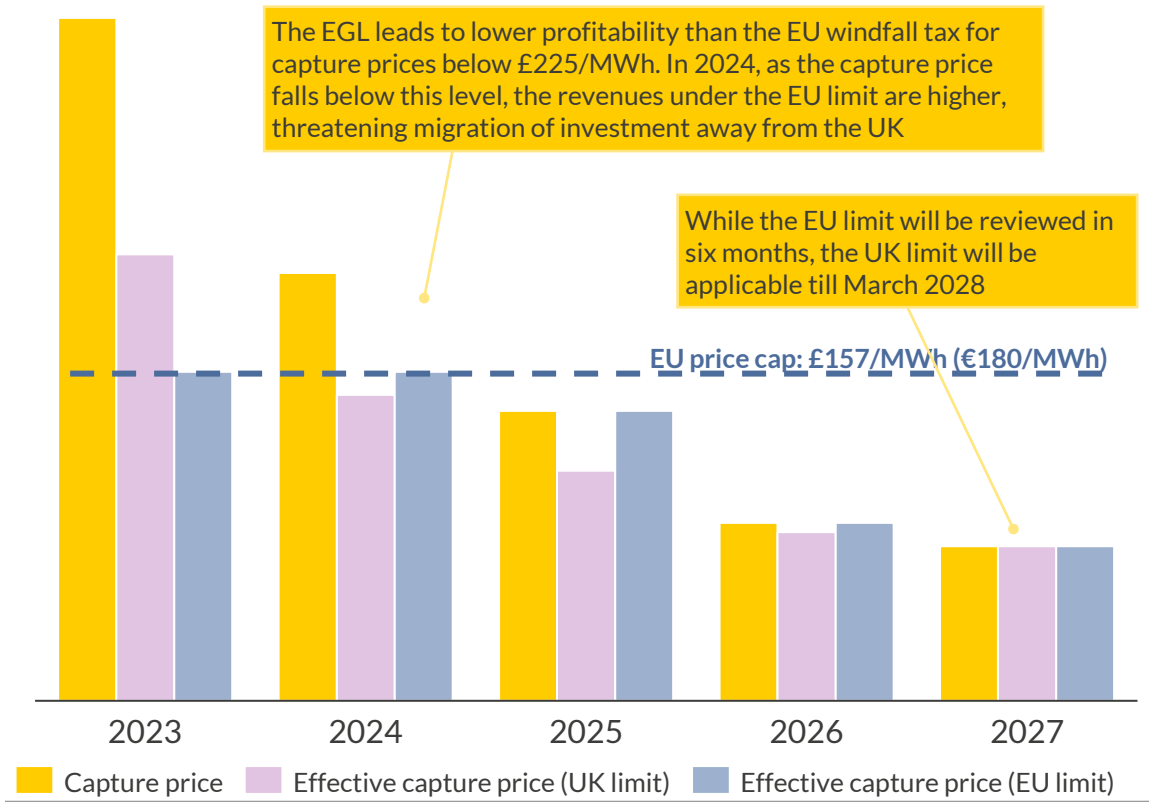
The EGL risks diverting investment in renewables to EU countries, but the impact on PPA-backed projects is lower than merchant projects

The EGL mandates a 45% tax on profits from capture prices over £75/MWh made by low-carbon generators between January 2023 and March 2028. It applies to nuclear, renewable and biomass generators that are not backed by CfD contracts. The EU has a similar scheme that taxes all profits from prices over €180/MWh

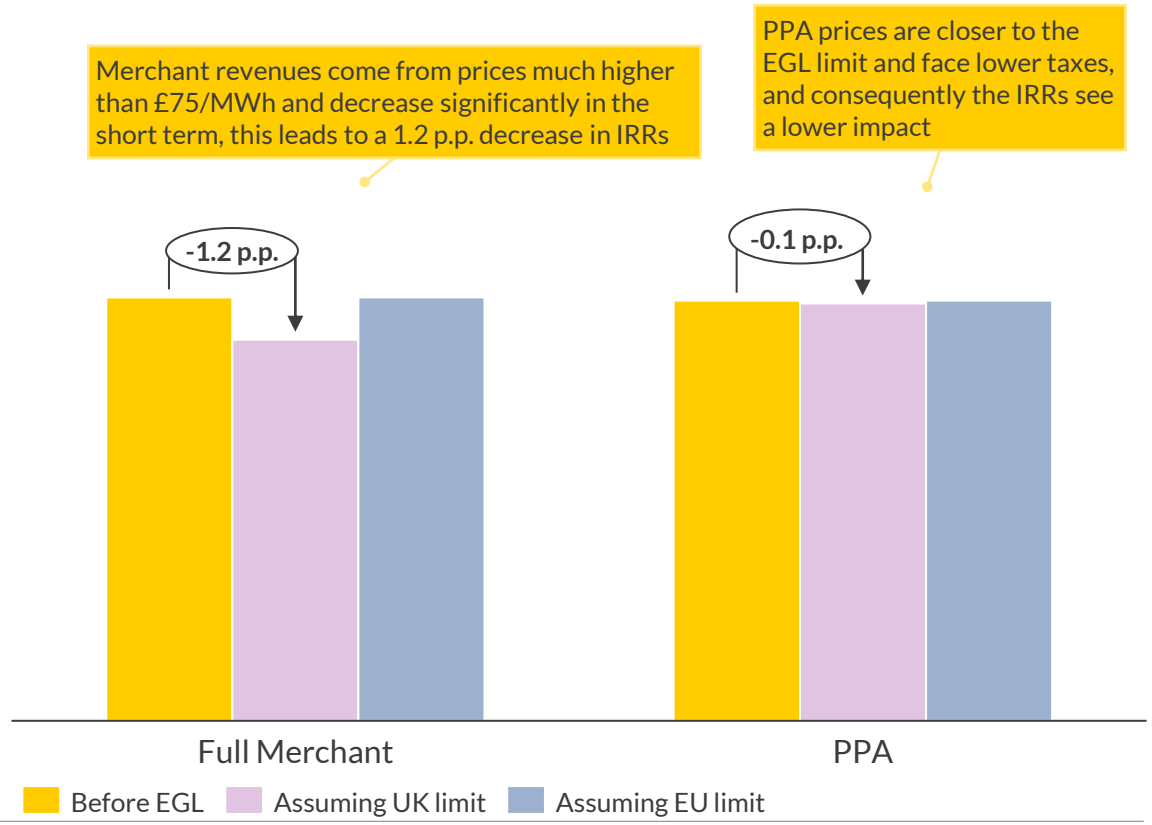
1 The EGL risks an investment hiatus in the UK as the EU price cap of €180/MWh leads to greater profitability for assets between 2024 and 2026

Solar PV[1] capture price and effective capture prices due to windfall taxes assuming the UK and EU limit, £/MWh (real 2021)



2 PPAs lock in lower prices for 10- or 15-year tenors, and are less impacted by the EGL compared to merchant-risk projects

Full merchant and 10-year as produced PPA-backed solar PV[1] project starting 2025, IRR %, pre-tax, (real 2021)



1) Solar PV asset in the south of England with an assumed load factor of 12.5%

Sources: Aurora Energy Research

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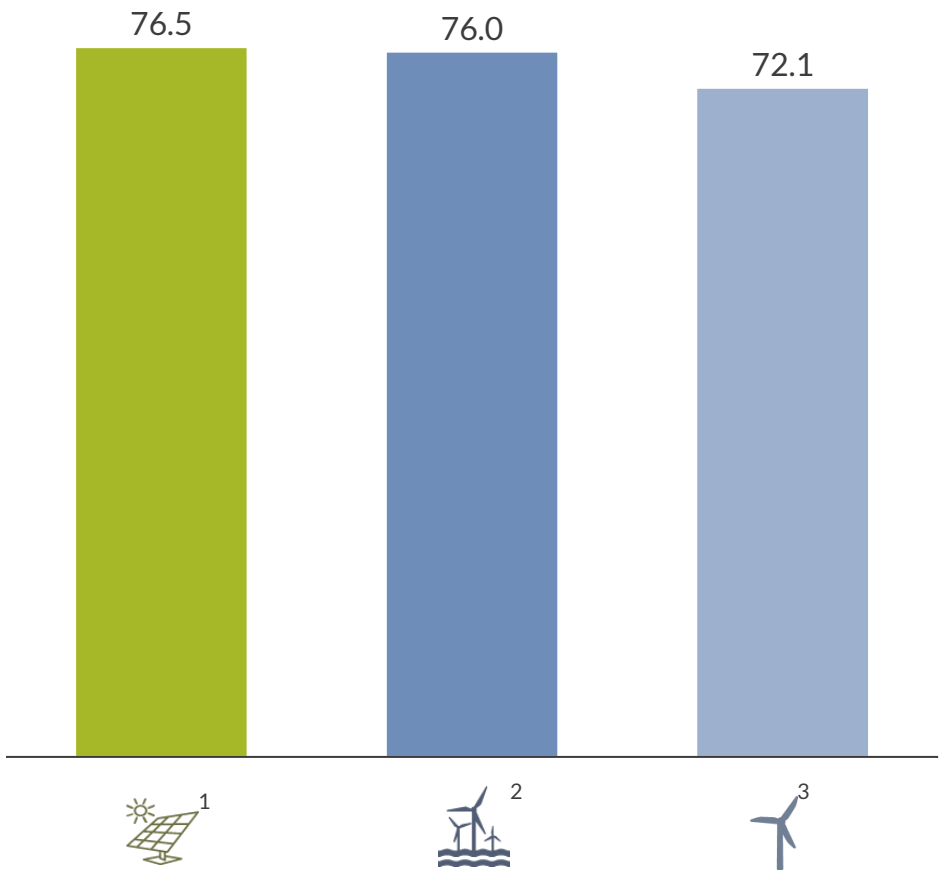
Key takeaways: PPAs can make renewables projects bankable as Government subsidies wane while helping offtakers decarbonise faster than the grid

PPA prices for a 10-year contract starting in 2025
£/MWh (real 2021)



1. Route-to-market PPAs have become an increasingly prevalent financing model for renewables due to lower availability of subsidies and the lower flexibility that the dominant subsidy scheme, Contract-for-Difference offers
2. PPA can be set up in a range of contract arrangements like as produced, baseload or 24/7 clean PPAs to meet the needs of both offtakers and developers
3. Aurora forecasts the GB PPA market to be undersupplied in 2030, with the demand rising to 101 TWh as offtakers seek to decarbonise, with supply only rising to 63 TWh due to logistical constraints
4. 10-year as produced PPAs starting in 2025 can offer IRRs of 14.5% for onshore wind, 12.1% for solar PV and 9.3% for offshore wind according to Aurora's fair value analysis, however developers would likely accept lower IRRs of up to 9% to close projects
5. Offtakers can achieve significant emissions reductions by entering PPAs, with a moderate reduction from as produced PPAs and a significant reduction from baseload PPAs
6. Developers can manage risk and increase their returns by choosing to blend the CfD, PPA and merchant-risk financing models, however due to the introduction of the Electricity Generator Levy, the attractiveness of the merchant-risk model has decreased

1) Distribution connected solar PV in South England, assumed load factor of 12.5%; 2) Transmission connected offshore wind in North Sea, assumed load factor of 52.5%; 3) Distribution connected onshore wind in Scotland, assumed load factor of 37.6%.

Sources: Aurora Energy Research

Dive into key market analysis and forecasts for the GB Power and Renewables market

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- Sub-regional investment case by business models with costs and revenue streams under different business models
- PPA benchmarking—fair value & contract terms

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Details and disclaimer

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