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Energy

The Role of PPAs in Decarbonising the UK Power Grid

Executive summary

The UK Government has legally committed to reaching Net Zero by 2050 and has set a further target to decarbonise the power sector by 2035. The Government's independent advisor on climate change, the Climate Change Committee (CCC), estimates that £500bn[1] of additional private sector investment is needed in electricity generation and networks between now and 2050 to meet these targets.

The UK has already made considerable progress in decarbonising the electricity system, with the share of renewables already exceeding 40%.[2] Support schemes such as the Renewables Obligation (RO), Contracts for Difference (CfDs) and Feed-in-Tariffs (FiT) have contributed significantly to renewables buildout and cost reductions in renewable energy technology to date. However, reaching the UK's decarbonisation target would require for this effort to accelerate not only through subsidies but also, and increasingly, through market-based instruments.

A higher proportion of renewables financing underpinned by market-based instruments is increasingly feasible and necessary. Given the cost reductions achieved in renewable energy technology over the past decade and the impact of carbon prices, many wind and solar projects are now competitive and can be delivered without government support. This can be done through debt or equity financing underpinned by commercial renewable power purchase agreements (PPAs) and by market revenues, where possible. Market-based renewables growth would ensure that new renewables volumes are developed cost-efficiently. It would also help to reduce the pressure of the energy transition on consumers, who are bearing not only the costs of subsidies, but also the costs of market distortions caused by subsidies.

Renewable PPAs are an important instrument for de-risking renewable energy investment. They ensure long-term revenue stability, which enables producers to access capital at better rates. They also allow buyers to lock-in electricity costs over the long term, providing an important hedge against price volatility. In addition, PPAs give buyers greater control over procurement decisions, helping them to take action to reduce their carbon footprint in line with voluntary sustainability commitments and targets.

CfDs – currently the primary vehicle for low-carbon development – are a barrier to PPAs growth. This restricts access to long-term arrangements for corporate, industrial, and other consumers who want to hedge their energy costs. In addition, generators supported through CfDs do not have incentives to sell volumes in the traded forward market either. This reduces forward market liquidity and makes it more difficult and expensive for suppliers to hedge the consumption of their domestic and business customers, a cost that is ultimately borne by consumers and increases their exposure to short-term price volatility.

In contrast, PPAs offer a forward hedge to corporate, industrial and other business consumers, while allowing generators to manage their price risk exposure from a couple of months to over a decade ahead. Intermediaries can also pool renewable energy supply through PPAs, warehouse and manage risks through their portfolio and trading activities, and sell renewable energy volumes to businesses (e.g., including by aggregating demand) to help them meet their specific hedging needs. In certain cases, intermediaries can also hedge PPA volumes on the traded forward market, thereby adding to its liquidity.

Furthermore, the failure of the CfD Allocation Round 5 auction to meet the needs of offshore wind developers, which resulted in no bids from such projects, also suggests that the current structure of CfDs may not provide the right dynamic incentives for developers and the broader supply chain to support the efficient growth of the sector. The Government is already reviewing the role and structure of CfDs as part of its Review of Electricity Market Arrangements (REMA), and we welcome this initiative. The review should ensure that the reformed CfD mechanism leaves enough room for the market-based growth of renewables by deploying subsidies only where the market is unable to deliver the policy outcome alone. It should also reduce the negative impact of CfDs on forward market liquidity – an impact that would become unsustainable if increasing volumes are withheld from the forward timeframe.

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[1] Energy UK Report (2023), *Storms Approaching: How to Prevent an Investment Hiatus in UK Low-Carbon Generation*, https://www.energy-uk.org.uk/wp-content/uploads/2023/03/EnergyUKReport-230216.pdf

[2] Department of Energy Security and Net Zero (2024), *Statistical Release: Energy Trends UK, October to December 2023*, https://assets.publishing.service.gov.uk/media/660433dff9ab41001aeea3e0/Energy_Trends_March_2024.pdf

Over the past decade, demand for renewable PPAs has risen considerably among businesses and industry across Europe, tripling between 2019 and 2023.[3] With the surge in corporate net zero action, growing interest of corporate and industrial buyers in hedging against price volatility, expected development of green hydrogen production and increasing interest in 24/7 green energy purchasing, demand for PPAs is expected to continue to grow. The UK Government must leverage this ambition and demand in support of its legally binding net zero target.

While there is significant potential for PPAs in the UK, several barriers are currently limiting developers and offtakers in unlocking their full potential. To address these challenges, we would urge policymakers to:

- Ensure a stable regulatory and policy environment – i.e., avoid market interventions, such as inframarginal revenue caps, and uphold political commitments to legally binding decarbonisation targets
- Formally recognise and support privately negotiated PPAs as an important instrument to bring forward renewable energy generation
- Reform the CfD scheme to facilitate PPAs growth and reduce negative impact on forward market liquidity
- Develop a credit guarantees framework for smaller offtakers to enable their access to PPAs
- Simplify accounting for virtual PPAs to facilitate their use
- Facilitate sleeving services by third-party suppliers

Addressing these challenges would enable the private sector to contribute to the accelerated growth of renewable energy, which is essential for reaching the UK's carbon neutrality target.

[3] Re-Source Platform (2024), *PPA Deal Tracker*, https://resource-platform.eu/buyers-toolkit2/ppa-deal-tracker/ ; Pexapark (2024), *European PPA Market Outlook 2024*, go.pexapark.com/l/891233/2024-02-06/hd4y8/891233/1707212342jlEFslZb/European_PPA_Market_Outlook_2024_HighR.pdf

How do PPAs support decarbonisation and consumers?

Renewables, such as solar PV and onshore wind, are now the lowest-cost electricity generation technologies and will be the bedrock of the future low-carbon electricity system. As mature technologies, they no longer need financial support measures and can be fully exposed to the market. Their output can be sold either in the spot or forward market in a fully merchant setup, or, if required for obtaining capital or reducing the cost of capital, through longer-term renewable PPAs.

Ensuring bankability of new renewable energy generation

As part of the necessary evolution of the sector to more merchant-based arrangements, PPAs are an important tool facilitating investment in new renewable energy generation.

- Most renewable electricity generators have high up-front investment costs and revenues only materialise in the longer term. PPAs are often concluded before the installations are commissioned and allow renewable electricity project developers to secure funds years in advance.
- PPAs are an effective way to reduce electricity price risk. With payment for the electricity already secured in advance,[4] plant operators de-risk their investment and increase their creditworthiness. This enables them to secure capital and reduce financing costs.
- PPAs allow investors to calculate cash flows with a higher degree of certainty. This allows them to determine present value more accurately, which lowers risk premiums. In this way, using PPAs to underwrite financing needs can free up funds for investment in additional renewable energy capacity.
- In contrast to CfDs, which currently have an as-produced profile and an agreed fixed strike price, PPAs offer generators flexibility in the agreed contract terms, including tenor, delivery profile and pricing. PPAs can be customised to suit the needs of counterparties based on their project financing structures, risk tolerance, view of the market, and trading expertise.
- PPAs usually include Renewable Energy Guarantees of Origin (REGOs) that act as a transparency tool relating to the renewable nature of the electricity produced and more recently, as a meaningful source of additional revenues for renewable energy producers.[5] The additional income earned from the sale of certificates increases the profitability of existing and new renewable production capacity when compared to fossil-based sources.

In addition to their benefits for new renewable energy assets, PPAs can also be an effective way to manage price risk for existing assets, including those that have reached the end of their subsidy.

Offering green electricity hedges for corporates and industrials

PPAs are also a helpful instrument for corporate and industrial buyers, as they enable them to manage their energy consumption costs and reduce their carbon footprint.

- Just as developers are looking for revenue certainty to de-risk their assets, so do businesses try to actively manage price risks related to their energy consumption. This is particularly relevant for corporate and industrial consumers for whom electricity costs make up a large percentage of their overall costs (but it is also relevant for any other business that wants to have greater visibility on future energy costs and protect itself from price volatility). As a result, demand for renewable PPAs has tripled across Europe over the past five years.
- PPAs can help corporate and industrial consumers to meet their sustainability commitments and contribute to the green transition through their energy procurement decisions. The growing interest in voluntary carbon accounting initiatives and the increasing scrutiny of green claims are creating additional demand for renewable PPAs and the REGOs bundled with them.

Several more recent regulatory developments and market trends are likely to add to the demand for renewable PPAs. Those include:

- Green hydrogen: The Government's ambition for up to 10GW of low carbon hydrogen production capacity by 2030 is expected to create strong demand for PPAs. Green hydrogen developers will look for long-term, cost-

[4] There are different types of PPAs. Some structures – e.g., fixed-price pay-as-produced PPAs – would secure fixed revenues for the entire output of an asset for the duration of the contract. Other structures may involve a higher degree of exposure for generators to price, profile, and other risks.

[5] While the price of REGOs was traditionally quite low and guarantees of origin served mostly a transparency function (noting that this is still a very important function), more recently, prices have increased considerably, making them a meaningful and helpful revenue source for renewable energy producers. For more information, see the analysis carried out by Veyt, https://www.veyt.com/articles/rego-market-stabilises-but-undersupply-persists

competitive renewable energy agreements that meet the requirements of the Low Carbon Hydrogen Standard. Aurora Energy Research estimates demand from green hydrogen production to amount to 17TWh in 2030 (and 28TWh in the Aurora Net Zero scenario).[6]

- Hybrid PPAs: There is growing interest in combining renewable energy production with storage through the so-called hybrid PPAs.[7] Hybrid PPAs offer a better match for the usually stable consumption profile of buyers compared to output from intermittent renewable energy assets alone, reducing market exposure for the counterparties. Hybrid PPAs also have benefits for grid stability, alleviating the pressure on the network operator to match supply and demand at a system level.
- 24/7 green energy purchasing: Companies are starting to show an interest in more granular temporal matching of their energy consumption with renewable energy production. While this is still a niche area, studies show that in addition to improving carbon accounting, such PPAs can also provide hedging benefits.[8]

Contributing to efficient market functioning

PPAs are commercial contracts between a generator and an offtaker, which address a number of risks characteristic of electricity markets (e.g., price, volume, profile, balancing, etc. [9]). These risks are allocated between the counterparties according to who is best placed to manage them. The wholesale market is then used to trade the volumes contracted under the PPA and manage the associated risk. Effective reduction of commercial risks requires active management of contracted volumes in the market and for this, a functioning, liquid forward market is essential. Well-functioning spot markets, on the other hand, are critical for short-term optimisation.

Liquid forward markets

Forward markets are used to lock in prices and mitigate future price risks. Liquidity is a function of the number of buyers and sellers available in the market for a specific traded product, and it is also related to the depth of the market, i.e., the ability of the market to absorb relatively large bids and offers without significant impact on prices. Generally, the larger the number of potential buyers and sellers, the easier it is to find a counterparty and the lower the costs and complexity of hedging.

CfDs and PPAs differ in their impact on liquidity in the forward timeframe and on the possibilities for hedging.

- CfDs for solar and wind generation, as currently designed, do not incentivise generators to sell output in the forward market. As the difference with the strike price offered by the contract is settled against Day-Ahead (DA) prices (the Intermittent Market Reference Price (IMRP) based on DA data from EPEX and N2EX), generators are likely to sell all of their output DA (to manage basis risk exposure), and since their price risk is covered by the strike price, they have no need to hedge by selling any part of their output forward. This removes significant volumes (supply) from the forward market. As a result, hedging becomes more difficult and costly for the demand side, i.e., for businesses and suppliers (with costs ultimately borne by consumers). If more volumes of renewable energy are developed under these conditions, the negative impact on the costs of and prospects for hedging may become unsustainable. Support schemes, therefore, should focus on technologies that are not yet cost-competitive and should be reformed to mitigate this negative effect.
- In contrast, PPAs contribute to the availability of volumes for hedging in the forward timeframe. They can be used by corporate, industrial and other businesses to lock in prices longer-term, enabling effective risk management, improving competitiveness and adding to the achievement of sustainability objectives. In these cases, while removing volumes from the traded forward market, PPAs also removes demand, as that demand is now hedged through the PPA. Intermediaries can, at times, also hedge PPA volumes on the traded forward market, thereby adding to its liquidity.

Thus, in terms of forward market liquidity and overall volume of hedged production and consumption (which is important from a system risk management and mitigation perspective), PPAs lead to better outcomes compared to CfDs.

[6] Aurora Energy Research (2022), *Role of PPAs in the GB Power Market.*
[7] Pexapark (2024), *European PPA Market Outlook 2024*, go.pexapark.com/l/891233/2024-02-06/hd4y8/891233/1707212342jlEFslZb/European_PPA_Market_Outlook_2024_HighR.pdf
[8] Eurelectric (2024), *Improve your Energy Procurement Contracts with 24/7 Carbon Free Energy Matching*, https://www.eurelectric.org/in-detail/energyprocurement; Pexapark (2023), *24/7 CFE Hedging Analysis*, https://www.eurelectric.org/media/6764/eurelectric_pexapark_247-hedging-analysis.pdf
[9] The different types of risks in a PPA are discussed in more detail in the Appendix.

Efficient spot markets

Spot markets are an essential tool to manage the short-term needs of the electricity system and ensure a balance between supply and demand. This role becomes even more important in a system with growing share of intermittent renewables where forecasts can change significantly within day and flexibility to adjust positions closer to delivery is key. Liquid spot markets are therefore also essential for optimising volumes contracted under PPAs and managing effectively related exposures.

Under a physical PPAs,[10] volume excesses or shortfalls need to be managed by selling or buying those volumes on spot markets. Generators (via their offtaker) are incentivised to optimise trading to reduce market risk in response to market signals and system needs. When it comes to CfDs, however, the design of the scheme can distort incentives for efficient market behaviour. The negative price rule according to which generators do not receive a subsidy payment in hours when DA electricity prices are negative removed an important distortion that had incentivised generators to maximise output regardless of system needs. However, distortions remain in the intraday and balancing timeframes. For instance, when the outcome of DA clearing indicates that a generator will be topped up to the strike price (the reference price is below the strike price; it is low but not negative), the generator is still incentivised to maximise production even if subsequent Intraday prices go negative (and below short-run marginal costs). Such distortions could have a considerable impact in the future if growing volumes of renewable generation lack incentives to respond efficiently to market signals and system needs.

Furthermore, as currently designed, CfDs – which largely remove market risks from generators – do not create incentives for innovation, e.g., adding technical equipment to provide system balancing services, such as on-site equipment for system inertia. In contrast, the need for PPA producers and offtakers to actively manage market risks incentivises innovation, and the flexibility of PPA contracts facilitates it. Once such example is combining renewables with storage to offer a portfolio of assets with more complementary production profiles to reduce the discrepancy between the seller's generation output and the buyer's needs. Besides the benefits for the parties to the contract, such innovative solutions also have advantages for grid management as they reduce the need to match supply and demand at a system level.

Well-functioning spot markets able to deliver clear signals for flexibility are also key for incentivising growth in battery storage technologies and demand response. Developing flexibility in the system in the form of low-carbon assets capable of responding to system needs at short notice is key for delivering a decarbonised electricity system. The intermittency of renewable energy, combined with growing volumes of renewables, have already and will continue to increase the need for short-term flexibility to address changes in forecast renewables close to real time, or in the balancing timeframe, to ensure system balance and stability. Undistorted price signals, combined with efficient dispatch, are therefore essential for creating favourable conditions for investment in battery storage and other types of low-carbon flexibility.

How can government help unlock the potential of PPAs?

The cost-competitiveness of renewable energy technologies continues to improve. Hence, PPAs (and merchant investment to a limited extent) are becoming increasingly attractive to investors and developers. Analysts estimate 101 TWh demand potential in the GB PPA market in 2030, seeing the market undersupplied by 38 TWh.[11] Several challenges, however, stand in the way of unlocking the full potential of the PPA market. We elaborate on them in the following sections.

Ensuring a stable regulatory and policy environment

Market interventions and the implementation of stop-and-go policies reduce confidence in the political and regulatory environment. This increases risk premiums and, by extension, the cost of renewables. Giving investors confidence that the UK is an attractive and reliable market for renewables requires long-term stability of the market environment and the policy and regulatory framework. It is important that investors receive clear long-term signals about the overall vision for the development of the sector and the design of the wholesale market. Ad hoc and/or retroactive interventions should therefore be avoided.

[10] The features of key types of PPA structures are discussed in more detail in the Appendix.
[11] Aurora Energy Research (2022), *Role of PPAs in the GB Power Market.*

As part of this overall vision, the Government should shift focus away from offering direct policy support for mature and lower capex technologies. Instead, it should work to further develop an overall enabling environment, including through PPAs, that supports bankability and the continued scale-up of renewable assets over the coming decades. In the case of variable renewables such as solar or wind, solutions to efficiently integrate their output into the grid and support overall system flexibility must be accelerated.

Formally recognising and supporting PPAs growth

The Government should formally acknowledge privately negotiated PPAs alongside CfDs as an instrument to bring new investment in renewable energy. This will provide a boost to the PPA market and give confidence about its future. And this, in turn, as discussed throughout the paper, will have important benefits for hedging, market functioning, and innovation, as well as for the cost-efficient built-out of renewables in support of the net zero target.

Reforming the design of CfDs

The current focus on CfDs as the primary vehicle for mass low-carbon development and the design of the mechanism limit the scope for growth of otherwise feasible and sought after market-based instruments for renewables development and create inefficiencies in the wholesale market. CfDs can have a dampening effect on the supply side of PPAs (interest from developers and lenders). As PPAs can offer comparable benefits in terms of reduced price risk and competitive prices, we think this is largely due to lower perceived counterparty risk, predictable legal terms and considerable risk re-allocation from developers to electricity consumers. Therefore, the use of CfDs should be limited to what is needed to bridge the gap between market-based investment and policy targets (e.g., support for nascent technologies and capital-intensive projects). The REMA process should also be used to reform the design of CfDs with a view to reducing their negative impact on forward market liquidity and improving incentives for generators to respond to market signals and system needs.

Developing a framework for credit guarantees

Small and Medium-Sized Enterprises (SMEs) often have limited access to PPAs as they encounter difficulties in demonstrating their bankability and ability to honour obligations. The availability of credit guarantees – public or private – for small and medium-sized offtakers without public credit rating, but with robust financial standing, would therefore remove a significant barrier to PPAs growth in this segment. Examples of such measures already exist in Spain[12] and Norway.[13]

SMEs can typically not achieve attractive contract volumes for PPAs and are also not able to hedge long-term (more than several years in advance). Intermediaries can help to aggregating volumes from several smaller offtakers, balance fluctuations in demand amongst the group of offtakers and provide increased comfort to enter into longer-term price commitments. However, even in those cases counterparty credit risk could be an issue and effective mechanisms to address it are necessary.

Simplifying accounting for virtual PPAs

Virtual PPAs are relatively simple to implement, and this structure is increasingly favoured throughout Europe. The accounting treatment of virtual PPAs, however, is typically far less favourable under International Financial Reporting Standards (IFRS), where they are treated as derivative contracts and must be recognised at fair value (FV) on the balance sheet.[14] Allowing companies to recognise the link between virtual offtake of green power and the underlying power consumption of a corporate to simplify their financial statements would therefore be helpful and would facilitate the uptake of virtual PPAs.

Facilitating sleeving services by third-party suppliers

Under a renewable PPA, energy delivery from the generator's site to the corporate offtaker must be facilitated by a third-party energy supplier, who integrates the power volumes into the corporate's existing energy contract. The corporate or industrial offtaker is therefore heavily reliant on suppliers to provide sleeving services to conclude a PPA. Suppliers are not always able or willing to facilitate this, creating a need for alternatives to be explored.

[12] RDL 24/2020 BOE-A-2020-6838 Real Decreto-ley 24/2020, de 26 de junio, de medidas sociales de reactivación del empleo y protección del trabajo autónomo y de competitividad del sector industrial, https://www.boe.es/buscar/act.php?id=BOE-A-2020-6838

[13] Eksfin - Export Finance Norway, *Helping Norwegian Export Companies*, https://www.eksfin.no/en/

[14] FV movements can create Profit and Loss (P&L) volatility if there is not an effective hedge and if the company does not elect to use hedge accounting. For more information on the treatment of virtual PPAs under IFRS, see WBCSD (2018), *IFRS Accounting Outline for Power Purchase Agreements Report*, https://www.wbcsd.org/Programs/Climate-and-Energy/Energy/REscale/Resources/IFRS-accounting-outline-for-Power-Purchase-Agreements.

In cooperation with PPA offtakers, energy suppliers, and intermediaries facilitating PPAs, the Government should explore the challenges and barriers to the provision of sleeving services. To facilitate the sleeving of PPAs, it should be possible for third-party suppliers, not only the offtaker's supplier, to trade in markets on behalf of smaller customers. Trade volume allocation and indemnification of other market parties such as the supplier should be arranged by a central party and should not be offloaded onto specific market participants.

Conceptualising the future of renewable energy policy

Cost-competitiveness for rapidly scalable renewable energy technologies (such as solar photovoltaics and wind power) continues to improve, signalling a new phase of renewable energy policy. Solar PV and onshore wind are now the cheapest source of new electricity generation across a range of jurisdictions, particularly those with strong wind and solar resources. In some countries, wind and solar power are beginning to be financed on fully merchant terms, indicating that these technologies are reaching full cost-competitiveness in regions with strong resource potential and the right institutional environment.

Government support schemes have helped close the gap

Prior to achieving cost-competitiveness, the rationale for renewables receiving government support was clear – helping to bridge the gap between the cost of renewable energy technologies and that of conventional generation. During the period from 2012 to 2021, government support schemes played an important role in bringing forward approximately 29.4GW[15] of new renewable generation, and competitive Contract for Difference (CfD) tenders have contributed to significant cost reductions for renewables as seen in the Levelised Cost of Electricity (LCOE) trend data in Figure 1.

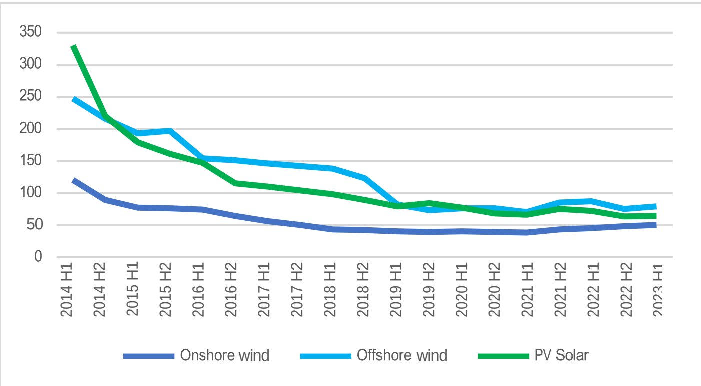

Figure 1: Historic LCOE data – UK, prices in USD/MWh. Based on data from Bloomberg New Energy Finance (BNEF), 2023.

We are entering a new phase of renewable energy policy development

With renewable technologies becoming competitive or even cheaper than conventional generation forms and becoming the dominant generation technology, the debate has begun to shift, highlighting the need for policymakers to reconceptualise the future of renewable energy policy. The International Energy Agency[16] distinguishes between three main phases of renewable energy policy development, based on a technology's cost-competitiveness:

Phase 1: Early Commercialisation

The stage of market development in which a given technology is starting to be deployed. Typically, the objective for renewable energy policies at this stage is to demonstrate the technology's viability and assess its performance. This phase is characterised by the use of direct subsidies or support in the form of targeted research funding, cash grants, and other direct financial support to support a particular renewable energy technology's introduction to the market.

[15] *LCCC (2024)* https://www.lowcarboncontracts.uk/our-schemes/contracts-for-difference/

[16] IEA-RETD (2016), *Transitioning to Policy Frameworks for Cost-competitive Renewables*, https://www.e3analytics.eu/wp-content/uploads/2019/11/IEA-RETD_RE-TRANSITION.pdf

Phase 2: Policy Support
The stage of market development in which a given renewable energy technology begins to scale-up and become more established in the marketplace. The Policy Support Phase sees the emergence of a range of support mechanisms such as a feed-in tariffs, feed-in premiums, auctions, and net metering. The primary objective during this phase is to bridge the cost gap between renewables and fossil-based generation.

Phase 3: Policy Framework
This is the phase in which a renewable energy technology has become cheaper than the LCOE of conventional new-build generation. In the Policy Framework Phase, the focus shifts away from offering direct public financial support and toward a more merchant-based model. A priority becomes establishing (or maintaining) an overall enabling environment that supports bankability and continued scale-up of renewables in the coming decades. In the case of variable renewables like solar PV and wind power, the focus increasingly shifts to how output can be appropriately integrated into the grid, and how overall system flexibility can be increased. Finally, the Policy Framework Phase involves sending clear long-term signals to investors about the overall vision for the development of the sector.

The UK Government assessed LCOE of projects commissioning in 2025 at £114/MWh for CCGT H Class, £44/MWh for Offshore Wind, £38/MWh for Onshore Wind and £41/MWh for Large-Scale Solar (Figure 2).[17] The cost differences between fossil fuel generation and renewable generation are expected to increase over the coming years, due to carbon prices and lower renewable generation LCOE.

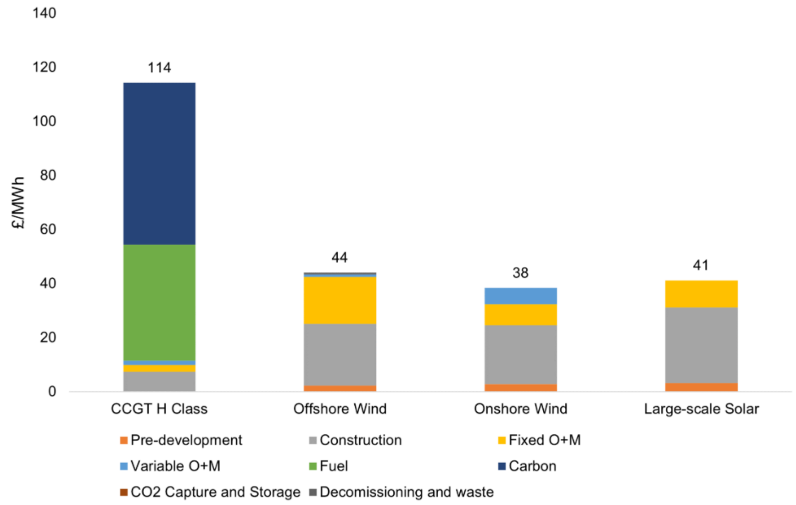

Figure 2: LCOE estimates for projects commissioning in 2025, in real 2021 prices. Source: DESNZ, 2023.[18]

Building a robust policy framework that creates an enabling environment

Renewable generation in the UK has reached cost-competitiveness, enabling financing and development without reliance on government subsidies. Having entered Phase 3 of the IEA framework described above, the Government should now focus on building out a robust policy framework that creates an enabling environment to support long-term growth in renewable energy projects and investments that deliver net zero at the lowest cost to consumers.

This policy framework should aim to establish open market access, reduce soft costs, and ensure project-specific investments can happen in a timely manner. This includes aspects such as grid access, project permitting, planning, as well as continuous government support for technology research, development, demonstration, and deployment activities. Such activities need not be limited to spurring technological innovation, but also innovation across policy, regulation, operation, planning, business models, and finance.

[17] We note that since the publication of these figures by the Government, high interest rates and increased costs of materials have put upward pressure on some renewable energy technologies, as discussed in Pexapark (2024), *European PPA Market Outlook 2024*, go.pexapark.com/l/891233/2024-02-06/hd4y8/891233/1707212342jlEFslZb/European_PPA_Market_Outlook_2024_HighR.pdf
[18] Department for Energy Security and Net Zero (DESNZ) (2023), *Electricity Generation Costs 2023*, https://assets.publishing.service.gov.uk/media/6556027d046ed400148b99fe/electricity-generation-costs-2023.pdf

PPAs as a critical tool in Phase 3 of policy development

As the sector enters Phase 3, PPAs can play a critical role in enabling market-based financing for renewables growth. Banks and lenders have now become familiar with the renewable energy sector and are better able to assess the risks without necessarily requiring a state-backed counterparty to underwrite financing contracts for renewable projects. In some regions, offshore wind tenders have also resulted in zero-subsidy bids, meaning that developers did not require financial support from the government to make a project bankable.[19]

PPAs are becoming increasingly important, even if they are unable to entirely replace the CfD scheme in the short- to medium-term. In this sense, PPAs and CfDs are competing frameworks: the faster PPAs become established, the less government subsidies are required. On the other hand, if CfD schemes are very attractive, the demand for PPAs falls. Expanding the use of PPAs will not only reduce consumers' exposure to price risk, but also improve market functioning.

An efficient market is based on supply and demand creating a signal for market participants to utilise assets and optimise costs. Markets will also adequately price any risks and thus reflect the true value of electricity. On the other hand, government subsidies always come with unintended distorting effects for markets, leading to less efficient market operation and overall higher costs to consumers in the long term.

[19] www.offshorewind.biz (2021), https://www.offshorewind.biz/2021/09/09/zero-subsidy-bids-rule-offshore-germany-rwe-and-edf-named-winners/ | www.offshorewind.biz (2022), https://www.offshorewind.biz/2022/09/07/rwe-wins-german-offshore-wind-tender-with-zero-subsidy-bid-vattenfall-expected-to-step-in/

Appendix

A Power Purchase Agreement (PPA) is a contract between an electricity generator (producer) and a party purchasing power (offtaker), which includes the commercial terms for the sale and purchase of electricity from a renewable asset. The value of a green PPA is composed of the value of the contracted electricity volume and the value of the proven green attribute via Renewable Energy Guarantees of Origin (REGOs).[20] PPAs can either include physical power supply or be purely financial (synthetic or virtual) contracts.

Types of risks

Risk allocation is agreed during the contract negotiation based on who is best placed to manage the different risks. Some[21] of the key risks covered in a commercial PPA contract include the following:

- **Price risk:** Price risk is the probability of an adverse movement in the market price. It reflects the uncertainty and potential volatility of future prices in the wholesale market. Price risk is unavoidable but can be mitigated through hedging instruments such as a PPA or forward/ futures contracts. Hedging instruments give more visibility and certainty to producers and consumers about the prices that would be paid in the future for the produced / consumed electricity.
- **Volume risk:** This is the risk of deviations from the annual energy production forecast of an asset. Annual energy production is typically estimated on the basis of long-term meteorological data. If a renewable asset is hedging a fixed volume at a fixed price, there is a risk that certain volumes are not produced (due to variations in wind speed or solar radiation) and need to be procured from the market. If this is the case, the producer may have to purchase the missing volume at market prices that may be worse than the original fixed price. Volume risk is similar to profile risk, but while the latter has more to do with the requirements of the technology (e.g., solar panels cannot produce electricity at night), volume risk is a function of variations in environmental factors. Like profile risk, managing volume risk is crucial.
- **Profile risk:** Profile risk relates to the ability of different renewable energy technologies to generate only according to certain profiles - e.g., solar panels cannot produce electricity at night. Its magnitude depends on the actual profile of the generating asset, forecast errors, and market prices, and the technology mix where the asset is located. In markets with significant renewable energy capacity, times of high production (e.g., sunny or windy days) can lead to oversupply, reducing revenues for producers (where same-type renewables produce at the same time, this could have a dampening effect on prices and therefore, revenues; this is referred to as a "cannibalisation" effect and forms part of the profile cost).
- **Balancing risk:** A plant has production commitments not only to the seller but also to the system operator. When the plant deviates from what the grid expects production volume to be, there are imbalance costs for the project charged by the system operator. The magnitude of the imbalance cost is driven by the actual deviations between scheduled production and real production (forecast error), the regulatory design of the balancing market (i.e., punitive design with penalties) and finally, whether portfolio effects may exist. The seller usually has a balancing agreement with a third party for a fee as a mitigation tool.
- **Credit risk:** The credit ratings of generators and offtakers reflect their respective financial strength. Credit rating agencies such as Standard & Poor's (S&P) and Moody's assess credit risk based on various qualitative and quantitative factors. These agencies rank the credit quality of debtors by assigning them to different rating classes, based on their financials.
- **Legal risk:** PPA contracts are complex. Commercial risks, Force Majeure, Change of Control, Termination, and Conditions Precedent are amongst the key clauses that need to be negotiated. Legal risk is the risk of a change in the law that affects the balance of revenue or risk between the parties, for example, tax change.
- **Regulatory risk:** Regulatory risk stems from regulatory changes impacting a business model. For renewable assets, a regulatory change can take many forms such as instances of a regulator making generators liable for all transmission losses, retroactively cutting down pre-agreed feed-in tariffs, market design changes, or a government introducing an additional levy on renewable generators' revenues or profits.

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[21] The list is not exhaustive. It covers only some of the key risks involved. For more information, visit Pexapark, *What is a PPA? The Guide to Power Purchase Agreement*, https://pexapark.com/solar-power-purchase-agreement-ppa/#:~:text=Profile%20Risk%3A,price%2C%20that%20is%2C%20revenue

Elements of a PPA contract

There are various types of PPAs, depending on who the counterparties are, whether the contract includes physical delivery of power, what the pricing agreement is, etc. The following section explores some of the typical characteristics of a PPA contract.

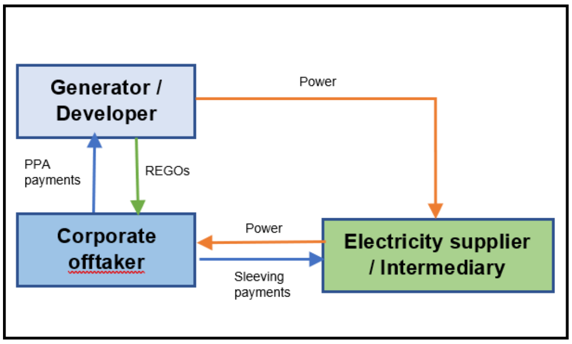
- **Contracting parties:** Different parties can be involved in the conclusion of a PPA: generators, investors, and consumers (e.g., corporate or industrial end users), but also utilities and trading houses as intermediaries. Intermediaries often take the role of structurers, risk takers and aggregators. They are important in bringing different risk and tenor preferences together, can assume the management of the balancing group, deliver a certain profile shape and deliver energy system-supporting services in the balancing timeframe.

  Intermediaries can pool and re-structure terms and quantities to bring supply and demand together. In this way, they hedge some of the risks, e.g., by separating a long-term PPA into different sub-products with short maturities and lot sizes to different customers. Corresponding secondary PPA markets offer consumers the possibility to adjust their green power purchases over time in the event of changes in demand. Shorter tenors are also possible, since not all end consumers have the same interest in long-term contract and/or price commitments.

- **Price:** A PPA does not have a mandatory predetermined pricing structure. It can be based on a fixed price, an indexed price or another structure. A fixed price helps to remove price risk from the producer. Instead, by indexing to the wholesale price and agreeing on the upper and lower limits, the market price risk can be balanced between the counterparties. The PPA contract price does not only incorporate the price for the delivered or hedged electricity, but will also consider the price of REGOs, embedded benefits (Triad, BSUoS, GDUoS), balancing management, ancillary services etc. The concrete elements of the price will depend on the agreed content of the PPA contract.

- **Physical delivery vs virtual PPAs:** A physical PPA includes the delivery of electricity volumes and, if applicable, REGOs, and the financial settlement takes place directly between the contracting parties. Residual electricity quantities or quantities complementary to the PPA can be procured or sold on the wholesale market. A physical PPA includes the management of the actual physical energy production - including balancing responsibility capabilities. Ancillary services to the power grid can also form part of a PPA and offer additional revenue streams.

  Under a virtual PPA, the price for a certain volume of electricity, and potentially the delivery of REGOs, is agreed. However, this PPA type does not include physical delivery of electricity– it is rather a financial swap. The generator sells its electricity directly into the DA market and receives the prevailing market price. However, if the agreed DA market price is lower than the PPA price, the offtaker pays the difference to the generator. If the market price is higher than the PPA price, the generator pays the difference to the offtaker. Physical settlement takes place entirely outside the PPA via the wholesale market by a third party. A virtual PPAs is therefore very similar to the CfD but negotiated privately between a generator and a consumer without the involvement of a government-backed agency.



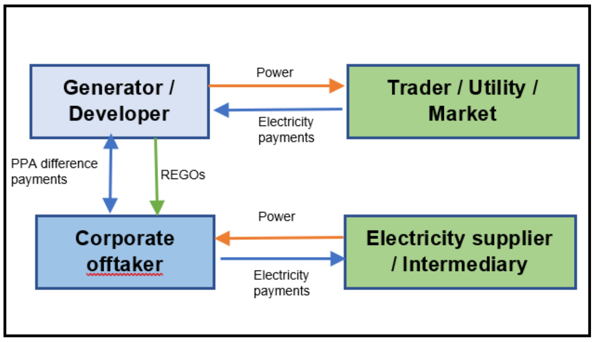


Figure 3: Simplified diagram - physical PPA (left) and virtual PPA (right)

Another difference between a physical and a virtual PPA is how they are treated from an accounting perspective. Virtual PPAs are typically treated less favourably under International Financial Reporting Standards (IFRS), where they are classified as derivative contracts and must be recognised at fair value on the balance sheet. This requires the virtual PPA to be re-valued using mark-to-market accounting, based on forward energy prices, leading to volatility risk on the balance sheet and Profit & Loss (P&L) statement.

- **Delivery profile**
  Typical delivery profiles include baseload, as-produced, as-forecasted and pre-defined volume.

Baseload: Under a baseload profile, the electricity offtaker (e.g., a corporate) receives an agreed in advance electricity volume every day for the duration of the contract. The generator or intermediary needs to buy any missing volume or sell any excess volume on the wholesale market. Due to the intermittency of renewable energy generation, the production output profile will never match exactly a baseload profile. Therefore, additional risk is put on the generator or intermediary to manage the volume risk.

As-produced or as-forecasted: A PPA with an as-produced or as-forecasted delivery profile reflects the output profile of the renewable energy generator. The electricity offtaker received the electricity as it is produced or forecasted and needs to manage any residual demand or excess delivery separately. Any demand-side flexibility on the offtakers side, e.g., shifting demand to hours with high renewables output or on-site energy storage (battery, electrolyser), would minimise the need to buy or sell any volume that does not match the demand profile.

Pre-defined profile: The contracting parties can agree any profile between baseload and as-produced and determine who will be responsible for selling and buying any excess and missing volumes.

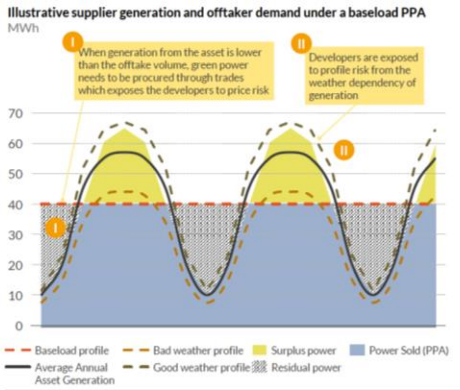


Figure 4: Illustrative generation and offtake under a baseload PPA. Source: Aurora Energy Research, *Role of PPAs in the GB Power Market*, 2022.

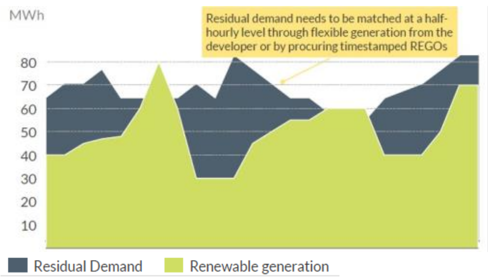


Figure 5: Illustrative generation and offtake under an as-produced PPA. Source: Aurora Energy Research, *Role of PPAs in the GB Power Market*, 2022.

- **Tenor**

  PPA durations can range from typically 6 months through to 20 years. PPAs can thus be adapted to suit the needs of generators based on their project financing structures and electricity offtakers based on their willingness to lock in an electricity supply contract for a certain amount of time.

  Short-term PPAs, typically 5 years and less, are usually used if the generator does not require debt financing or if a generator wants to market their generation output after a government subsidy ends. Medium-term PPAs, typically between 6-9 years, allow for debt financing of smaller scale projects. Long-term PPAs, typically over 9 years, enable the financing of large-scale new renewable energy projects with debt.

- **Operational obligations**

  A physical PPA contract will contain clauses that govern the responsibilities and terms regarding forecasting, scheduled maintenance, outages, commissioning and construction milestones, metering and others.