



United Kingdom

MAKING SOLAR PAY

THE FUTURE OF THE SOLAR PPA MARKET IN THE UK NATIONAL IMPLEMENTATION GUIDELINES

**PV FINANCING PROJECT
DELIVERABLE 4.1 – PUBLIC
PUBLISHED IN OCTOBER 2016**

Written by the Solar Trade Association



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 646554

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Executive Summary

This paper examines the future of solar financing and investment in the UK by breaking down the various business models into their constituent parts and then considers the implications on existing business models from recent market changes. It also looks at some of the innovative PPA model structures that are being developed for large consumers.

Financing solar PV projects in the UK has changed significantly over the past 10 years. Starting with self-funded pioneers willing to invest in an innovative technology, it has widened to incorporate, amongst others, major banks, financiers, energy consultants, lawyers, risk analysts and energy modellers. As the market has grown, project sizes have also grown from less than 10kW to 50MW or greater. The additional sophistication that large-scale developers and EPCs have brought to the market has also seen a continual reduction in costs, without compromising on quality. The increase in the overall market size and the availability of longer-term reference data has also attracted lower cost capital into the maturing market.

The development of the UK solar market has been primarily policy-driven, with subsidy schemes enabling profitable projects and encouraging investors into a market with highly credible and reliable revenues. Incorporated within the policy frameworks were pre-determined subsidy reductions to take into consideration reductions in capital expenditure, operational expenditure and financing costs over time. Faster than expected reductions in these costs resulted in the government triggering rapid changes in law to reduce subsidy levels.

Over the last 24 months, rather than there being a phased reduction in subsidy levels, the government has embarked on a more significant overhaul of the underpinning policies that formed the basis of the business models over the past 5 years. These changes have made the development of new projects more challenging. The industry as a whole is endeavouring to produce different business models that

incorporate these challenges while still allowing sufficient profit to be generated. However, to date, no long-term sustainable replicable business models have emerged.

The Self-consumption Project Investment Model, favoured for smaller scale domestic and commercial projects, will continue to be deployed in a low-subsidy world albeit at a much reduced level. There are a number of participants in this segment who are driven by both economic and non-economic drivers. Therefore, pure profitability, while still critical, does not play the only role in determining overall viability. Behavioural (non-economic) drivers such as energy independence, smart home concepts, publicly declared targets and reputation also play an influential role in determining whether the participant decides to make an investment. As the development of a low-subsidy market in this small-scale segment will depend on non-economic factors, which are outside the scope of this report, no specific profitability analysis has been undertaken on this model.

The Power Purchase Agreement (PPA) model has underpinned the growth of large-scale commercial rooftop, private wire and ground-mounted installations over the last 5 years. Three PPA model structures have been successful in the market: Wholesale PPA (typically from a utility), and Sleeved and Private Wire PPAs (directly with large consumers). Since about 2013 the latter two forms of PPA have become increasingly popular, however with no/minimal future government subsidies these PPA models are challenging in the post-ROC policy environment unless costs fall significantly. It must be noted that the analysis contained within

this report contains commonly accepted assumptions and does not capture specific project details, so there could be cases where projects are profitable (e.g. private wire PPAs that benefit from avoiding non-commodity pass-through charges). However, the bulk market is the relevant section to analyse, rather than one-off cases that may not be replicable. There are more innovative models such as the 'Mini Utility' or 'Synthetic' PPA structures, which may prove to be profitable in the future, but they have not yet been tested widely in the UK market.

The UK solar market has historically been supported by a policy framework that was both secure and profitable. However, over the last two

years in particular, this policy framework has fundamentally changed, leaving the industry with the challenge to develop new profitable models incorporating little or no subsidy revenue.

On a positive note, and to conclude, the reduction in profitability within the current market does not mean that there will not be profitable solar projects within the UK in the future. It will take time for the UK solar industry to evolve, but in the meantime, the global solar industry is continuously working on cost reduction and lowering the cost of capital and an outcome of this will be that the UK will again see profitable solar projects at scale in the future. The question is when this will occur, not if.

Glossary

The following is a list of terms commonly used in the report.

Big Six	Largest UK electricity companies, namely: British Gas, EDF Energy, E.ON UK, npower, Scottish Power and SSE	kW	kilowatt
Capex	Capital expenditure	kWh	kilowatt-hour
CfD	Contract for Difference	MW	megawatt
DNO	Distribution Network Operator	MWh	megawatt hour
DNUoS	Distribution Network Use of System	NPV	Net Present Value
EIS	Enterprise Investment Scheme	O&M	Operations and Maintenance
EPC	Engineering, Procurement and Construction contract/contractor	Opex	Operational expenditure
FAC	Final Acceptance Certificate, a milestone within EPC contracts which governs when the EPC's primary responsibilities terminate	PPA	Power Purchase Agreement
FIT	Feed in Tariff	ROC	Renewable Obligation Certificate
IRR	internal rate of return, a financial measure of evaluating the attractiveness of an investment	SPV	Special Purpose Vehicle
		TNUoS	Transmission Network Use of System
		TSO	Transmission System Operator
		VCT	Venture Capital Trust

1. Introduction

1.1. General Introduction

This report is part of the Horizon2020 PV Financing project, which seeks to understand and shape how PV projects are structured and financed in a low or no subsidy world. It is written at a time of significant change in both the UK solar market as well as within the UK more generally following the recent referendum result for the UK to exit the European Union that unfortunately makes longer-term predictions or forecasts very difficult to make.

Previous reports covering Business Models and Financing Schemes have already been completed, and this report brings together those two aspects of project implementation to evaluate the future of the PV market in the UK post-subsidy for the following five years.

This report looks at the various aspects that would typically be included within any business model and focuses in particular on the revenue and risk allocation aspects and corresponding financing solutions. These aspects are largely picked up within the Power Purchase Agreement and this is where a number of interesting innovations are currently being developed.

1.2. Regulatory Framework Overview

The regulatory environment and policy framework for solar in the UK has changed significantly over the past two years. In 2014, the Renewables Obligation (RO) and the Feed-in Tariff (FIT) frameworks offered routes to market for every market segment. A new government was elected in May 2015 and a number of policy changes were introduced soon after, including the closure of the RO for solar and a ~70% reduction in the FIT. Levy Exemption Certificates (LECs) were also removed affecting not just new installations but those that had been built and have been operating prior to the removal. Alongside this, there has been a lack of clarity and coherence in

energy strategy, as the political rhetoric turned to cutting carbon at the lowest cost but government policy continued to support technologies that were relatively expensive (nuclear, offshore wind) while removing support for technologies (onshore wind, solar) that are able to deliver carbon reductions at a much lower cost to the consumer.

In June 2016, the UK public voted to leave the European Union. There have been economic impacts due to this result including a significant depreciation in the value of the UK currency. It also resulted in the UK Prime Minister, David Cameron, resigning and Theresa May being appointed as the new leader of the conservative party and therefore the new Prime Minister. One of the first actions of her new government was to merge the Department of Energy and Climate Change (DECC) with the Department of Business, Innovation and Skills (BIS) to form a new Department of Business, Energy and Industrial Strategy (BEIS). Both the merge itself and the appointment of new ministers have created additional uncertainty in energy policy within the UK.

As a result of these policy and political changes, investor confidence in the UK market – for solar as well as other investment classes – has been significantly affected. The wider impacts and long-term questions around Britain's changing relationship with the EU (so-called "Brexit") will also have an impact on long-term investment into the UK. The challenge for the government and the industry will be to develop a secure and low-risk policy environment to meet the market's objectives of profitability whilst limiting the cost to consumers through subsidy schemes.

There are potentially reasons to be optimistic about the UK solar market. The (new) government recently agreed to ambitious carbon budgets in the period 2028-2032 and has stated that it will ratify the Paris Climate Agreement by the end of 2016. Additionally, the benefits of a smart,

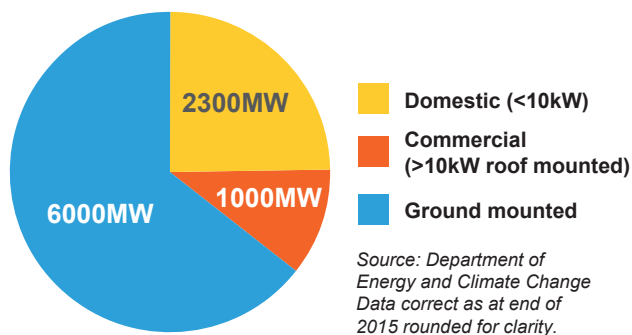


Figure 1: UK solar market segmentation

decentralised and more flexible energy system have been clearly set out, and solar could play a key role.

It is therefore within the context of this complex and uncertain policy landscape that this report is set. In summary:

- Government support (financial and political) for solar is at present very uncertain.
- Over the past two years, there has been a deliberate push towards reducing subsidy.
- The industry has been challenged by government to deliver cost reductions and bankable revenue streams without a direct subsidy.

1.3. Market Segments for PV

The UK solar market is broadly segmented into domestic, commercial and utility scale.

The domestic segment covers projects of sizes up to around 10kW (typically 3-4kW), which are installed on the roofs of homes. In the past the

majority of solar projects have been on homes that are owned by their occupants, although future relationships could develop between landlords and tenants (particularly social landlords) involving the sale of solar electricity behind the meter between landlord and tenant. Previous research undertaken for the PV Financing project demonstrated that owner-occupiers are the principal investors in domestic solar, and that landlord-tenant based projects are rare.

The commercial segment covers projects of many shapes and sizes from 10kW-5MW, installed on the roofs of commercial buildings. The demand profile and roof capacity of commercial buildings varies significantly.

Utility scale solar refers to large-scale ground mounted projects. There has been a significant amount of deployment in this segment over the past 4 years (approximately 6GW). The sizes of these projects range from <1MW to 70MW.

Historically, the solar market has been dominated by the domestic segment, and more recently, the utility segment. The commercial segment has underperformed compared to these other segments due to a variety of factors, but provides interesting potential in a zero-subsidy world.

1.4. Business models studied in this report

There are many different business models that operate within the UK solar industry; however,

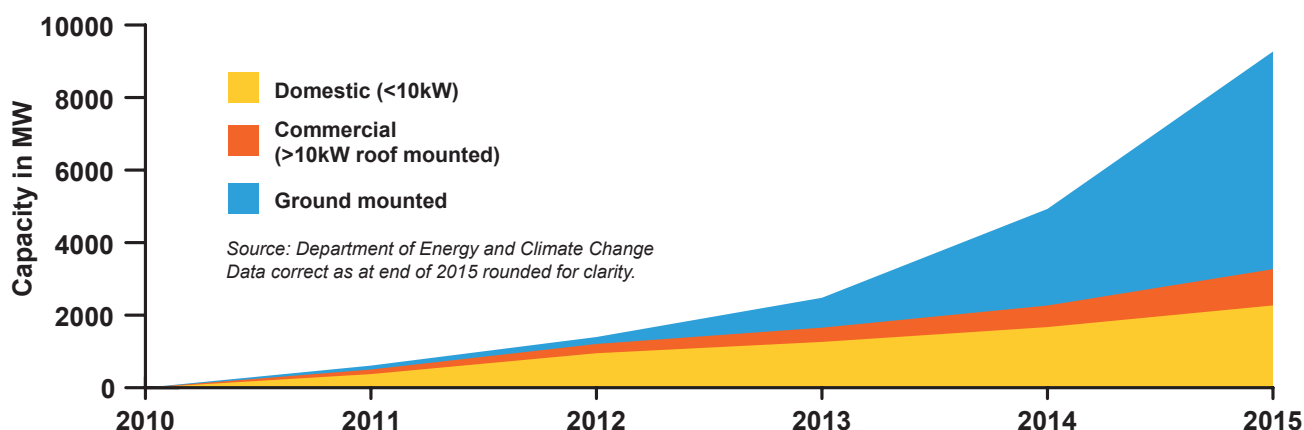


Figure 2: UK solar market development by segment

these are all underpinned by the profitability to the ultimate owner of the solar PV project. Therefore, we only look at the underlying project economics within this report and do not consider business models that build upon the profitability of the underlying project.

We have made a distinction in this report between projects owned by the party that consumes the electricity generated by the project (the Self-consumption Project Investment Model) and those projects that are owned by a different party to that who consumes the electricity generated (the PPA Project Investment Model).

To summarise the difference:

Self-consumption Project Investment

Models are those where the solar PV project is operated and owned by the consumer of the electricity generated. The financial benefits come from the use of that electricity offsetting imported electricity from the grid, as well as from selling any excess electricity to the market.

Power Purchase Agreement (PPA) Project Investment Models are those in which the solar PV project is operated and owned by one entity, and the electricity consumer is a separate body that is sold the electricity generated through a contract called a PPA. The financial return for the Owner comes from the sale of the electricity to the consumer, and the consumer benefits from obtaining ownership of certain zero carbon attributes, and may receive long-term price security for the electricity that they are buying.

The use of these models is delineated clearly between the different segments. As shown in the table below, the smaller scale projects tend to fall within the Self-consumption Project Investment Model, whereas larger scale projects tend to be based on the PPA Project Investment Model. The added complexity and requirement to regulate the relationships between the Owner, the off-taker, and the land/roof owner within the PPA Project Investment Model introduce additional transaction costs into the project. These transactional costs are only able to be absorbed by scale therefore it is rare to see PPA's within smaller scale projects unless the Owner has aggregated a number of these together.

This report considers the Self-consumption Project Investment Model briefly; however, it focusses on the PPA Project Investment Model. This is due to a number of reasons including that profitability within the Self-consumption Project Investment Model is based largely on behind the meter aspects (where the electricity generated is used to offset using electricity from the national grid) where each specific owners individual electricity requirements can vary greatly and it is very difficult to reduce this down to a general view.

	Domestic	Small Commercial	Large Commercial	Ground Mounted (Solar Farms)
Size range	<10kW	10kW-250kW	250kW-5MW	>1MW
Use of Self-consumption models	Almost always	Often	Rarely	Almost never
Use of PPA models	Almost never	Rarely	Often	Almost always

Table 1: Business models applicability to market segments

2. Self-consumption business model

2.1. Overview

The Self-consumption Project Investment Model underpins a significant number of the domestic and smaller commercial projects. The revenue for these projects comes through four revenue streams:

- Using the electricity generated on-site therefore reducing their imported electricity from the grid and reducing their electricity bill (a behind the meter saving);
- Exporting and selling any electricity not used on-site to the grid;
- Any subsidies for generating electricity (called the generation tariff within the UK);
- Reducing the cost of carbon reduction and pricing commitments and taxes ¹.

Operational costs are minimal and broadly take the form of panel cleaning, system monitoring and periodic maintenance, as well as provision for replacement invertors, which are assumed to require replacement once over the lifetime of the project.

¹ For example, electricity that is imported from the grid is subject to a climate change levy (CCL), and self-supply solar electricity is not subject to this tax. In the past, exemption certificates (LECs) were also provided for non-onsite solar generation, but this is no longer the case.

In order to minimise the upfront capital required for the project, some domestic and many commercial investors will use debt financing (i.e. loans) to provide some or all of the initial required capital. At the domestic scale there are a wide range of domestic loans available, although few are focussed directly on solar. In the commercial scale there is also a range of both solar-specific and more general loan facilities.

2.1.1. Self-consumption business model structure

The typical Self-consumption Project Investment Model would have some or all of the following participants:

- Investor/Operator/Consumer: This entity owns the solar PV project. They are also the operator and the electricity consumer.
- EPC (Installer): The entity that is responsible for installing the solar PV Project.
- Electricity provider: This entity provides the electricity consumer with their grid electricity connection, and provides any non-solar generated electricity requirements in exchange for the electricity price.

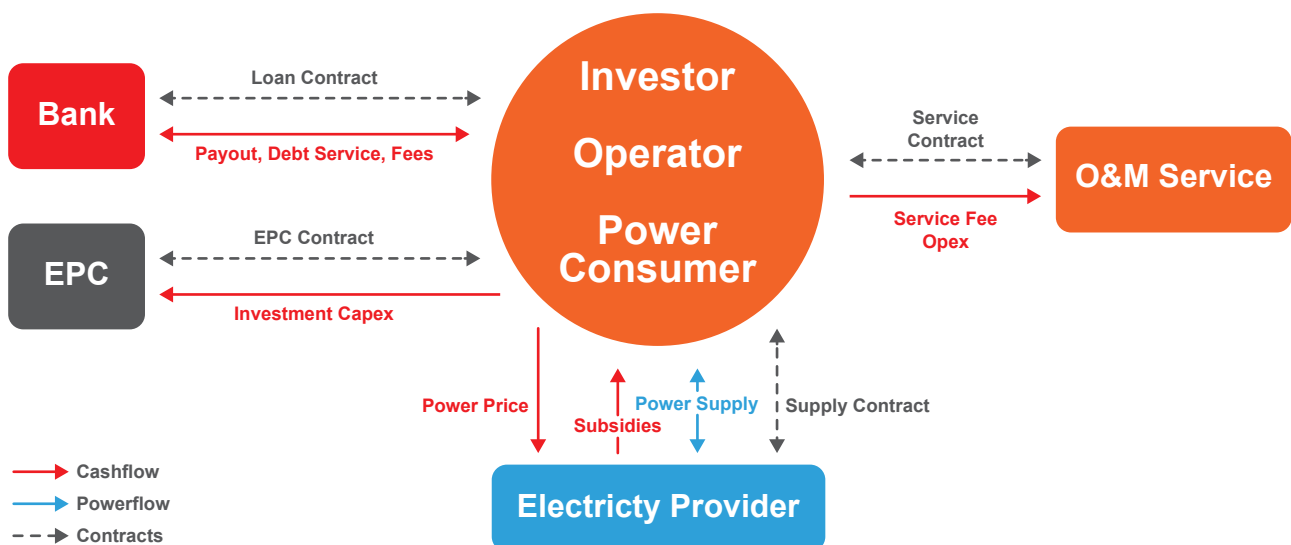
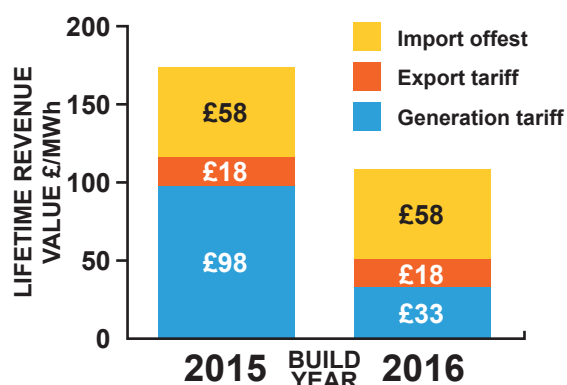


Figure 3: Business structure for commercial and utility Self-Consumption

Split of Revenue Streams

The below graphs demonstrate the change in revenue streams from generation tariff (backed by government and index linked), Import Offset (dependant on long-term electricity forecasts) and export tariff¹ (backed by government and index linked) for a self-consumption domestic system in 2015 compared to 2016. The balance has shifted in the last year such that the import offset (or self-consumption) is now the greatest portion of revenues, and therefore the profitability of domestic solar is highly dependent on future electricity price forecasts. Profitability has also dropped with payback year increasing from 9 years to 15 years.

¹ The lifetime £18/MWh is lower than the roughly 5p/kWh published export tariff rate as the rate is only paid on 50% of the generated power, and only for 20 of the 25 years of the solar project's lifetime.



- O&M service: This entity, which may also be the EPC, provides maintenance and monitoring of the system.
- Finance Provider: A bank or other lending body who may provide the Owner with a loan to purchase the solar PV project.

2.2. Profitability of the Self-consumption Project Investment Model

With the reduction of the tariff schemes available, the profitability of the Self-consumption Project Investment Model has fallen, in most cases, below

levels that make a pure profit driven investment attractive. There are however exceptions to this and they include, amongst others, the Owner:

- Making significant behind the meter savings, and/or
- Placing emphasis on the security of electricity supply embedded within owning the solar PV project, and/or
- Believing that electricity prices will raise significantly in the future therefore effectively hedging their electricity price by owning the solar PV project, and/or
- Valuing the intangible and/or emotional aspects of owning their own solar PV project, and/or
- Not having a better alternative to invest into, and/or
- Valuing the 'green' aspects surrounding ownership of a solar PV project.

All of these aspects are very owner specific and therefore we have not included analysis on these.

These owner specific factors will continue to ensure that there is an ongoing solar PV market particularly for small and commercial scale projects however this also means that it is very difficult to predict the size of this market, which in turn makes it difficult for supply chain businesses to survive. The future of the Self-consumption Project Investment Model is going to be determined by the number of owners that place favourable values on the above aspects. One important aspect surrounding this model that we have not mentioned yet is the continued growth of energy storage, and battery storage in particular. This one aspect is worthy of numerous reports so we have not included any analysis of this within this report other than to say that a combination of PV electricity generation combined with storage is something that a number of market participants are excited about and we are looking forward to seeing how this plays out in the future.

3. Power Purchase Agreement Project Investment Model

3.1. Overview

Variants of a PPA Project Investment Model have operated profitably within the UK solar market over the last 5 years. This is due in part to the maturity of PPAs within the wider UK electricity market and the development of solar as a forecastable, secure and reliable generator of electricity backed by tariff based policy frameworks.

3.2. PPA Project Investment Model Fundamentals

The underlying economics of all PPA Project Investment Model solar project companies, no matter how they are arranged, rest on several inter-dependent and fundamental factors. These include;

- (i) Project revenues, and
- (ii) The project capital expenditure (capex), and
- (iii) The project ongoing operational expenditure (opex), and
- (iv) The cost of capital to finance the project.

Scale also plays a part both at a project and market level as economies of scale apply within a project (the larger the project, the lower the cost / unit) as well as within the market (for example the larger the market, the more efficient the supply chain).

In this section, we provide a general outline of these factors with some background. Further on in the report we look at them in detail in respect of specific business models.

What is a PPA?

At its most basic, a PPA is a contract for sale of electricity between two parties. There is significant variation in contract length, price and structure of these contracts, depending on the market conditions, the types of bodies involved and their credit-worthiness.

3.3. Project revenues (PPA)

Within the PPA Project Investment Model, two aspects of project revenues are critical: the value of the revenue stream and the perceived security of the revenue stream. This means that, to a project, a lower price from a very secure creditor (such as government) may be worth more than a high price from a less creditworthy counterparty.

Projects receive revenue from a number of sources. These sources include;

- i) The payment of tariffs and/or sale of renewable obligation certificates
- ii) The sale of the electricity generated
- iii) Locational revenues such as embedded benefits (revenues and avoided costs determined by the size and location of the project), and
- iv) Tax incentives (although not strictly revenue it acts in a similar nature), and
- v) National Grid auxiliary services.

Three primary tariff mechanisms have been used in the UK to date, namely the FIT, ROC and CfD structures. However, as noted earlier in the report, the ROC scheme is in the process of closing and in the FIT scheme, tariffs have been reduced with only certain projects now eligible to receive these. Solar is eligible for a CfD however at present it appears that no further auctions will be held for solar and other “mature technologies” in the near term at least.

The revenue for (i) & (ii) above is typically contracted through the PPA between the Owner and a counterparty. That counterparty can vary and is outlined in more detail below. More information on (iii) & (iv) is provided below.

3.3.1. PPA – Counterparty

3.3.1.1. Licensed suppliers and balancing parties

In this situation, the Owner will sign an agreement with a ‘traditional’ off-taker, such as: one of the Big Six; a balancing party member who do not have their own supply license but instead intends to trade the electricity; or a smaller licensed supplier. Such an off-taker will sign PPAs of any duration up to around 15 years, but will only agree to fixed prices for the period over which the forward physical traded market contains sufficient liquidity – typically three years in the current UK market. Beyond this fixed price period (or for the entire term of the PPA), pricing is typically set as a percentage of a defined wholesale price index, such as the clearing price on one or more of the UK electricity exchanges. Once these PPAs are signed, the off-taker will typically seek to hedge the generation they are procuring in the forward market, progressively revising their position nearer real-time. These off-takers will take volume risk (i.e. the risk that the actual annual generation volume will differ from the forecast) and profile risk (i.e. the risk that the expected profile of that generation volume over individual days and seasons will differ from the forecast). An element of profile risk can be shared with the Owner during the fixed-price period if the off-taker provides a pricing matrix that provides differentiated prices for certain periods e.g. winter vs. summer, weekday vs. weekend, day vs. night, peak vs. non-peak. This will be part of an Owner’s negotiation with the PPA off-taker.

As well as selling electricity through this contract, ROCs (and historically LECs until July 2015) have typically also been sold through the same PPA, with pricing being a percentage of the regulated value. These PPAs typically also provide for payment of embedded benefits to the Owner. Electricity suppliers are incentivised to procure sufficient ROCs to meet their Renewable Obligation (which is proportional to the volume of electricity they supply to end users) and to contract with embedded generators within areas where they supply end users.

Big Six utilities are deemed to have a higher creditworthiness, relative to smaller licensed suppliers and balancing parties who do not have their own end-customers. This is relevant to both equity owners and lenders. Lenders to larger projects typically require a floor on revenues (either electricity-only or bundled electricity together with ROCs), and in this case, only a limited number of potential off-takers will be able to provide credit support for this guarantee. Such a market dynamic means that there is likely to be a trade-off for Owners in securing the highest priced PPA and the most creditworthy contract and counterparty.

The vast majority of renewable projects benefitting from tariffs have used PPAs of this type for a variety of reasons:

- i) The ability to sell all products (electricity, ROCs, LECs and embedded benefits) under a single contract,
- ii) The ability to procure a guaranteed revenue floor (particularly relevant for projects with long-term non-recourse finance),
- iii) Availability of these contracts due to the incentives on suppliers.

3.3.1.2. Corporate PPA providers (private and public sector)

As will be discussed later in this report, Sleeved PPAs and other arrangements allow corporate PPA providers to take the place of traditional off-takers as the primary counterparty to the Owner. Historically, when electricity price forecasts showed continual electricity price rises in both the medium and long term, the prospect of a long term fixed price arrangement was a ‘win-win’ for the Owner and the corporate PPA off-taker. Owners would be able to ‘lock-in’ price certainty for longer than was available through wholesale PPAs, and Corporates were able to hedge themselves against the anticipated price rises in the future. Owners were also attracted to the revenue certainty and creditworthy off-takers. However, in current market conditions of lower prices and weaker forecasts, this ideal scenario

has weakened. Many large electricity users have adopted a least regret model of contracting only for the next season – if electricity prices fall, they will benefit from the lower prices when they re-contract, and if prices rise then they also do so for all their competitors, which will not entail a commercial disadvantage. By comparison, locking in for the long term exposes the user to the risk that electricity prices fall during the term of the contract, leaving them at a commercial disadvantage to their competitors. This risk currently appears to be more pressing than the potential benefit of fixing prices at current low levels and having wholesale prices rise during the term of the contract. Should the forward market pricing rise significantly (perhaps in response to an expected capacity shortage), then this position could quickly change.

However, corporate consumer energy decisions may not be motivated purely by economic considerations. A number of end customers have sustainability and decarbonisation targets to meet, along with wider corporate social responsibility objectives. This incentivises them to contract with renewable electricity generators, but they do have choices. Some corporates are willing to buy “REGO-backed” electricity² via a green tariff from their retail supplier, while other corporates insist on a principle of ‘additionality’ i.e. they require their purchasing to be from new projects constructed as a result of their PPA.

Other project revenues

3.3.1.3. National grid auxiliary services

The National Grid, in its role as System Operator for the UK system, is responsible for maintaining electricity supply and safe operation across the network. In order to do this, it uses a number of financial instruments to incentivise electricity generator and consumer behaviours, such as by ramping up electricity generation to meet peak demand. Solar generation is not well placed to participate in these operations due to its reliance

on the sun and the peaks in demand most often being in the winter evenings. However, the addition of electricity storage technologies may well change this in the future, with the ability to store excess solar for a few hours from earlier in the day until the evening peak demand time. Battery storage can also help to smooth sun/cloud ‘bumps’ during the daytime.

3.3.1.4. Embedded Benefits

In order to pay for the maintenance of the DNO and TSO networks, end users pay fees (through a complicated process) based on a calculation of how much of the physical electricity grid is used to move electrons generated at one location to where they are consumed at another. If generation assets are classed as ‘embedded’ – connected within the distribution rather than the transmission network – generators are treated as negative forms of demand (i.e. supply), which makes them eligible for negative charges (i.e. payments). This effectively means that generators can receive funds for avoiding using the transmission network in situations where end users are located nearby to the generator.

3.3.1.5. Tax relief incentives

Whilst not strictly income, tax relief structures such as Enterprise Investment Scheme (EIS) and Venture Capital Trust (VCT) have played an important part in building the financial justification for investment in solar projects in the UK to date. It is not currently anticipated that these will be available in future.

3.4. Capital expenditure (Capex)

Capital expenditure can be split into three separate components:

- (1) That incurred prior to the commencement of construction (development costs);
- (2) That incurred through and up until the completion of construction, excluding the grid connection costs (EPC costs);
- (3) The costs associated with connecting the project to the transmission or distribution network (grid connection costs); and

² The Renewable Energy Guarantees of Origin (REGO) scheme guarantees that electricity is from a renewable source.

Each of these costs is discussed below.

3.4.1.1. Development Costs

The development costs differ significantly depending on whether the project is ground or roof mounted. A significant proportion of the development costs for both ground and roof mounted projects are also fixed costs and therefore the larger a project, the lower the development cost / MW due to economies of scale.

Before a developer moves too far ahead with the development of a project, they will need to ensure that the land/roof that they wish to use to site the project on is free of any legal rights that may impede the project. This is a reasonably straightforward process for ground mounted projects as title searches will be undertaken and, should the title contain other legal rights, these are quite often utility rights such as gas or power lines in which case the utility will have a specific department within the company to deal with granting the necessary consents. For roof-mounted projects, this process can become more complex as it quite often involves numerous parties. Building owners, occupiers, tenants, sub-tenants, debt providers and others often create a web of legal rights that will need to be worked through, and in most cases, be renegotiated. The legal costs associated with this can sink a project before it has started, particularly where the project is small in size and not able to swallow those large upfront costs.

The commercial and legal relationship between the developer and the land/roof owner will also need to be worked through. For ground-mounted projects, this typically takes the form of an option to lease, and for roof-mounted projects this will take the form of a lease or license. For ground mounted projects, market norms and standardised documentation have largely been established, with negotiation focussing on the pure commercial aspects of the agreement as well as determining security sums and access arrangements for continued use of the land for farming. For roof-mounted projects, standardised documentation

and market norms do not yet exist. This is largely due to the many different circumstances that can be encountered when dealing with numerous different parties, each with their own requirements or objectives. When there is complexity or a lack of standardisation, this will lead to an increase in legal costs in order to work through this.

In most instances, a proposed solar project will need to connect to the distribution network in order to evacuate the electricity generated. In order to do so, the developer will need to ensure that this is possible. The process for this is the same for both ground or roof mounted projects. The developer submits a grid connection application to the DNO and the DNO will respond, free of charge at this point, with the cheapest connection solution available to the developer. The connection solution offered is determined by the size of the project, and the larger the connection voltage required, the more expensive the connection solution. Increasingly, solar projects are also asked to participate in cost sharing of grid upgrade works, which can add substantial cost and time to the implementation of a grid connection. In order to accept the offer, the developer will need to pay a deposit to the DNO. The deposit will be related to the cost of the connection, so ground mounted projects, which are typically larger than roof-mounted projects, will require larger deposits to be paid.

The developer will also need to ensure that they obtain the necessary consents to build the project. For roof-mounted projects, there is generally a presumption to grant consent to the project unless there are extenuating circumstances such as the building being historic in nature, within a national park, or the project being particularly large. Therefore, there are minimal costs associated with obtaining the necessary consents for most roof-mounted projects. These costs increase significantly for ground mounted projects. As well as submitting the project plans to the local planning authority and outlining how the project fits within the overall local authority development plans, the developer

will also need to undertake various studies that assess the impact of the development on the environment. Both central and local government rules determine the specific nature of the studies however they will include, among others, ecology studies, flooding studies, landscape and visual impact studies and construction traffic management plans. As part of the consenting process, the developer will also need to pay application fees to the local planning authority. These are minimal for a small roof mounted project, but can rise significantly for larger ground mounted projects, being based on land area.

The developer will also have a margin. This will vary depending on the market structure, how buoyant the market is (and therefore if they can spread their margin over many or few projects) and the availability and liquidity of capital to purchase projects. This margin is included as a capex item on the basis that it is part of the price a long-term investor will pay for a project, and therefore it is material in considering profitability.

3.4.1.2. EPC Expenditure

EPC expenditure includes the cost of the PV modules, engineering and design, balance of system (BOS) and project operations.

Project size dictates the negotiating power when procuring modules therefore the larger the project, the lower the likely achievable price. The same concept applies to the procurement of BOS components.

Module prices for UK projects are influenced by the minimum import price (MIP) set by the European Commission. The MIP does not apply to modules manufactured outside of China and price reductions are achievable, but only by large volume buyers. This is slowly changing with some Chinese manufacturers setting up plants in other South East Asian countries and/or withdrawing from the MIP undertaking.

Engineering and design includes a large fixed cost element as do project operations therefore a large ground mounted project will benefit from

significant economies of scale over smaller roof-mounted projects, in addition, site access for roof-mounted projects will require, in many instances, scaffolding and edge protection, further increasing the cost for a roof mounted project.

3.4.1.3. Grid Connection

Grid connection costs are determined by the connection voltage rather than the size of the project therefore bigger is not necessarily better. There have been many instances where a small increase in project size has resulted in a quadrupling of the overall grid connection cost. The best grid connection cost / kWp has often been achieved by sizing a project to capture as much of the network capacity available on the grid without having to step up the connection voltage, or participate in substantial upgrade works. Roof mounted projects may be limited, in this regard, by the size of the roof. Ground mounted projects have typically had a lot more flexibility when it comes to project sizing so they have often achieved better value. Of course, both types of projects have also had binary limits applied by tariff regimes so it has always been a case of considering many different factors when determining project size.

The location of the grid connection will also impact on the overall cost of the grid connection. For roof-mounted projects, this is normally not an issue as the grid connection point will be into the existing electrical infrastructure. For ground-mounted projects, there is effectively no limit for additional costs in this regard. If the grid connection point is only able to be reached over third party land, then the developer must obtain the right for the connection cable to cross the land. If that land is privately owned, there are many well-informed agents ready to advise the landowner on how to extract the maximum amount possible from the project. The developers' next best alternative cable route is typically the starting point when it comes to these negotiations. If there is no alternative, the subsequent negotiations will rarely be comfortable or

enjoyable for the developer, and even more so when the developer is paying for the agents and professional fees.

3.5. Operational expenditure (Opex)

Once a project is operating, it will continue to incur costs in order to supply electricity and receive revenues. In comparison to many other forms of electricity generation which require fuel supplies, operating costs for solar projects are very low; however, they do still play a role in driving the economics of PPA Project Investment Model solar projects. Primary amongst operational costs are seven items;

- i) Operations and maintenance costs (O&M)
- ii) Site use payments (land lease costs or rental payments to use the roof)
- iii) DNUoS and/or TNUoS charges
- iv) Insurance
- v) Management fees
- vi) Post construction capital replacement costs e.g. to replace invertors or faulty panels (strictly not an opex item though often treated as such).
- vii) Taxes such as business rates resulting from the new revenue that is generated from the site.

3.5.1. Operations and Maintenance

O&M cost encompasses all aspects associated with the running and maintaining of the project, including the project maintenance, cleaning and pest control, security, performance monitoring, fault reporting, and the administration associated with these activities. Most O&M contracts also include availability and performance warranties, as well as administering any existing warranties from the EPC contractors and main component suppliers providing extended warranties.

The cost of undertaking O&M activities varies particularly between ground and roof mounted projects and also between sites.

A key issue that impacts on the cost of providing O&M services is obtaining access to the site.

A ground-mounted project is generally in a field that is fenced in and access is able to be obtained by simply going through a gate into the site. However, for roof mounted projects there are a number of aspects to be taken into consideration and access is rarely that simple. Most building owners or occupiers will have strict codes of conduct governing work carried out by external contractors on site, particularly where access to rooftops or electrical installations is required. Hours of access may also be an issue, for example on school buildings access is typically limited to outside school hours and can even be limited to outside school term times.

The physical access to a roof-mounted site can also be more difficult. Quite often temporary access equipment, edge protection and scaffolding may be required depending on the specific site. This can increase the cost significantly.

Roof and ground mounted projects also have their own issues with regards to on-going performance. For example, bird droppings can present a significant issue for roof mounted projects whereas ground mounted projects are more affected by burrowing animals which in certain circumstances destabilise structures on site. For smaller projects, it is possible that site inspections can be carried out on the whole project resulting in more effective preventative maintenance regimes compared to large ground mounted projects where it becomes much costlier to perform regular visual checks of the whole project.

3.5.2. Site Use Payments

Commercial arrangements between the developer and the land/roof owner tend to differ by whether the project is ground or roof mounted.

A ground mounted project developer will typically pay the landowner a set amount per acre of land that is being leased for the purposes of the project. Alternatively, the developer may pay the landowner a percentage of the revenue of the project, or combine a mixture of the two. The specific level of rent and/or percentage of

revenue payable has been subject to market forces, however, as the market has matured, the levels have moved from a 'market norm' to being determined by the specifics of the location i.e. connection onsite or offsite, higher solar irradiation etc.

For projects located on a roof, the roof has typically been leased with a 'peppercorn' rent being payable and the landlord effectively being paid either through reduced electricity bills via a direct power purchase agreement at well below market rates of imported electricity, or simply through unmetered offsetting of imported electricity.

3.6. Cost of capital

Any provider of capital, whether debt or equity, will have a cost of capital. This is the rate of return that the provider expects to make in order to participate in the financing of a venture. The level of this cost of capital is a function of the risk and return appetite of the provider of capital and the role that they would play in the capital structure of the venture.

Investors with low return expectations will be prepared to take very little risk. They will likely participate in the debt side of the capital structure, giving them access to contractual revenue streams and a high-level claim to project assets in an event of insolvency (the extreme downside scenario). Depending upon their risk appetite, they may also require a security package, giving them legal rights to take control of specified project assets in an event of default. Debt participants are capped in the 'upside' by their interest rates and arrangement fees, i.e. it is not possible for them to earn any more than that even if the project performs better than expectation. In effect they only face downside and this will shape their approach to carrying out due diligence of a project.

Equity participants on the other hand are able to benefit in an upside scenario, through better than anticipated dividends or capital returns. However, in a downside scenario, they will only recover their investment after secured creditors and normal creditors in an event of insolvency and

may find themselves under pressure from creditors to provide additional funding in a scenario which deviates from the base case assumptions of the project. As they are more exposed to losing their investment in a downside scenario, equity will require a higher rate of return than debt providers who are more insulated from losing their investment.

A solar PV project goes through several phases during its 'life' and these phases are not uniform in the risks they pose to funders.

- A. Development phase – The earliest stages of a project up until it is ready to be constructed.
- B. Construction phase – Constructing a project and commissioning it so that it commences commercial operations.
- C. Operational phase – The longest stage of the project, where the project is operating and generating revenues.
- D. Decommissioning phase – Undertaken when the project comes to the end of its operational life and must be removed from its location and the land/roof returned back to its condition prior to the commencement of construction.

Whilst some funders may have a risk reward appetite which allows them to participate in all phases of the project's life, it is more likely that some will participate in only one or two particular phases. This leads to the phenomenon of 'asset-flipping' whereby project SPVs are sold and/or refinanced at particular points in time throughout the project's life.

Another important difference compared to the wind market is that it has been relatively unusual historically to see debt funding for projects prior to the completion of construction. Rather than being driven purely by risk/reward dynamics, this is more determined by the short timelines for solar construction (less than 6 months for even the largest of utility scale projects), and the relatively lengthy approval processes which banks and other providers of low cost capital tend to go through (typically in excess of two months).

3.6.1. Historic overview of financing landscape for UK solar

Whilst still relatively young, the UK solar financing market has already undergone several distinct phases in its evolution. In 2010, the FIT was introduced to support the development of the UK solar industry. This initially very generous tariff provided clear and stable revenue streams to investors who funded the building of solar assets. This encouraged the entrance to the market of several types of investors and developed knowledge in the market of how to finance solar in a somewhat “protected” environment. Following the strong uptake of the FIT, the rates were cut in 2011 and a control mechanism put in place. This cut initially harmed investor confidence, but business models adapted to take into consideration these changes.

The second key phase of solar deployment in the UK was of larger ground-mounted projects in 2013-2016, using the Renewables Obligation scheme to blend PPA revenues with ROC income. This phase of growth included the emergence of UK-focussed yieldco's, and both mainstream and innovative banks provided financing for the market. The financial institutions behind these became more familiar and comfortable with solar as an asset class through repeated investments over this period, with a resultant lowering in the cost of capital and hurdle rates for projects.

Historically the equity participants in the market have included, amongst others, a combination of

- i) Tax motivated funds
- ii) Publicly listed solar/renewable funds (yieldco's)
- iii) Privately held solar/renewable funds
- iv) Family offices
- v) Utilities
- vi) Institutional direct investors (e.g. pension funds)
- vii) Project participants such as EPC's and panel manufacturers.

Historically the debt offerings have included, amongst others

- i) Non-recourse project finance
- ii) Bridging loans and revolving credit facilities
- iii) Institutional tradable notes
- iv) Project participants who have loaned money to the project rather than taken an equity stake.
- v) OEM working capital

Due to the significant changes that have taken place over the last 24 months, it is difficult to forecast the future equity and/or debt participants other than to suggest that it is difficult to see any participants should the PPA Project Investment Model not be profitable.

3.6.2. Scale – Overview

Two types of scale exist in this context, **market scale** and **project scale**. These are discussed individually below.

Market Scale

The scale of the market – how many projects are installed in any one year – has a significant effect on the economics of PPA Project Investment Model project in a number of ways. Firstly, the component manufacturers and developers will only put effort into a market they think is large enough to warrant the effort of e.g. sales teams and pipeline development. A bigger market will also tend to have a wider and more diverse range of players, who compete on cost and quality to ensure a competitive market. The same is true of other consultants such as lawyers and financial advisors, planning consultants and grid experts.

It is important to note that these skills cannot be developed overnight or shipped in; local knowledge and contacts are key and take time to develop. A long-term vision of the industry is required to ensure that these companies invest in the skills and teams to deliver these benefits.

In summary, market scale can deliver reductions in cost and a long-term vision that allows companies

to invest in people and products to develop healthy competition on delivering projects.

Project Scale

Whilst the fundamental physical principles are the same whether a project is 5kW or 20 MW, the way the project operates commercially is likely to be very different. The economics of very small projects will not be able to support the transaction costs associated with a complicated legal structure. Equally, very low cost of capital funding providers, such as pension funds, will have minimum investment limits which places them beyond the reach of smaller projects unless many separate assets are pooled together. In addition, economies of scale for Capex and Opex costs are often available to larger projects but not available to smaller ones. All of these have an impact on the viability of the PPA Project Investment Model.

4. Observed PPA project structures in the UK and their viability in post subsidy era

4.1. Wholesale PPA – historic standard approach

4.1.1. General description of structure

Over the last 5 years, this PPA structure has been the most frequently used for utility scale projects under both the FIT and ROC regimes. The Generator sells electricity and other services at an agreed price through a PPA with a licensed supplier or balancing party. This PPA provides the Generator with its 'route to market'. The licensed supplier or balancing party in turn then sells the electricity onwards to end consumers (such as the corporate consumer) or through bilateral or exchange based contracts to other balancing parties. From the generator's perspective this structure allows for the greatest level of flexibility, with a high probability of maintaining route to market as, even in situations of PPA counterparty default, the project would be able to access PPAs with other licenced suppliers or balancing parties through the grid connection that would be typically be owned by the generator. The generator is also able to choose from PPAs

with different characteristics (e.g. contract length), to suit their financing requirements. Historically this has also been a structure which suits many different types of generator in physical terms. As long as 1) a grid connection offer from a DNO or TSO can be secured at a financially viable cost, 2) land rights can be secured, and 3) planning permission is gained – little prevents a generator from using this model. This means that in terms of scale it is well suited to widespread adoption as has been evidenced by its success in recent years.

4.1.2. PPA Project Investment Model considerations

4.1.2.1. Revenues (PPA)

In recent years, the UK solar PPA market has been a liquid one for generators, with many licensed suppliers and balancing parties actively seeking to augment their portfolios. This has enabled them to choose their PPA partner to fit their financing requirements (as outlined below). Whilst many participants are active, political uncertainty (on both the upstream and downstream side) has meant that longer-term contracts are costly to the off-taker, impacting the price the

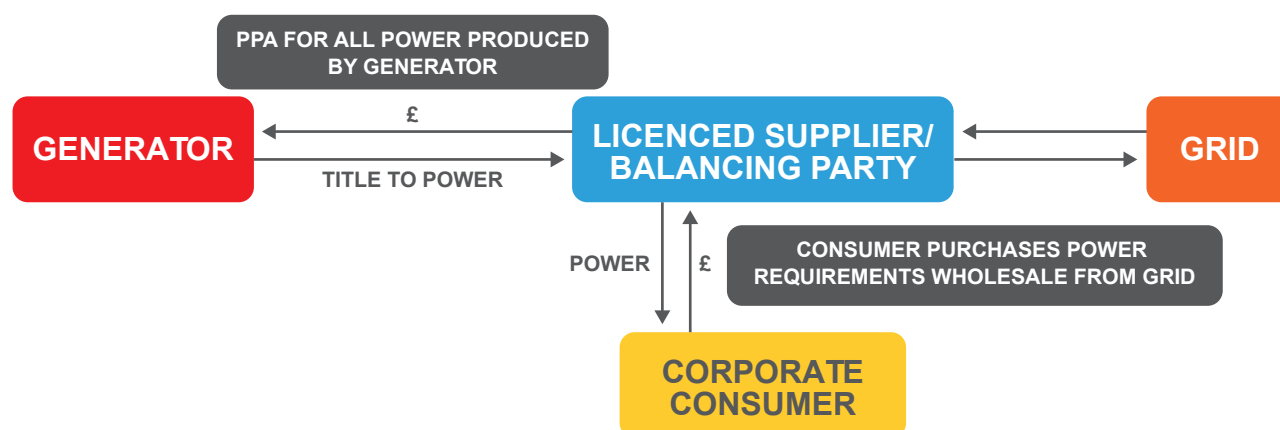


Figure 4: PPA structure (Wholesale PPA)

generator can secure. In many instances, fixed prices longer than three years have simply not been available. PPA prices follow the wholesale market, which is in turn driven by a myriad of factors, and many generators have chosen shorter term PPA's in anticipation of higher value long term PPA's being available in the future. As discussed previously, more creditworthy counterparties (e.g. the Big Six plus other more balance sheet heavy parties) will tend to price lower than off-takers who are perceived as less secure.

4.1.2.2. Capital expenditure (Capex)

The flexibility of the Wholesale PPA model means that it is a suitable structure for many types of electricity generators. Developers have been able to scour the country in order to find cost effective grid connection offers from DNOs and TSOs, only furthering those projects which have economic fundamentals suitable for the project to go ahead. The flexibility also enables the project to be sized appropriately to minimise Capex per kW of generation. Historically the periodic degradation of tariffs has driven the market to surge which has inflated development fees and EPC margins at key periods of the year. It has also resulted in some avoidable costs being incurred (such as those related to wildlife constraints and third party landowners) in the need to meet certain deadlines. Moving away from a subsidy driven market would allow construction times to be better suited to the sites themselves, and we would anticipate that projects well planned for summer commissioning would often be preferable in Capex terms to the Q4 and Q1 rush which has been witnessed in recent years.

4.1.2.3. Operating expenditure (Opex)

The increased volume of solar projects and tightening tariffs have led to market consolidation in the O&M market in recent years and with it, a more professional industry able to offer price competitive services to generators. Larger projects (especially those over 5 MW) tend to be able to secure better prices, with location and the 'clustering' of assets in a certain area also playing a leading role in determining better O&M quotations.

An industry trend is also the insourcing of O&M functions by some of the larger asset owners.

Wholesale PPA solar projects will nearly always be located on land owned by a party separate from either the generator or end corporate customer. This means that the generator will have to pay the landowner rent to secure the exclusive use of the project site. With the reduction or removal of tariffs, the bargaining position of landowners and land agents may fall in relation to project developers. However, as profitable sites will perhaps become more location dependent, for some landowners it may still be possible to demand a high premium above the equivalent agricultural rent.

Capital replacement costs are a function of equipment choice and quality of initial installation. Financiers will often require the project SPV to hold a portion of cash flow in reserve to meet Capex replacement costs when they occur.

4.1.2.4. Cost of capital

To be prepared to lend, debt providers have required PPAs which they deem to be sufficiently creditworthy to be secured. They have often preferred 'Big 6' counterparties and to fix as much income as is possible. Truly fixed prices are likely to only be available for a short number of years, with later year's prices being given at a percentage discount to the wholesale market. Generators will likely be faced with a balancing act of securing visibility for their revenue streams on one hand and giving away potential value on the other.

Historically project finance has relied upon the predictable and 'fixed' nature of tariff revenue streams to enable them to participate in the financing structures of Wholesale PPA projects. Without a government mandated tariff revenue stream all revenues would be perceived as variable (or 'merchant'). In such a situation it is unlikely that low cost of capital finance, such as project finance, will be available to support generators, unless PPAs with long tenors and guaranteed floor prices can be secured with counterparties that are deemed to be of sufficient

creditworthiness. Whilst not impossible, given project cash flows for generators are very tight, it is unlikely that there would be sufficient money available to service debt of any large proportion. This will result in projects having to be all equity financed, raising the effective cost of capital and, hence, preventing the financing of many Wholesale PPA projects.

4.1.2.5. Scale

The Wholesale PPA sector of the UK solar market has undergone very swift market growth in recent years. This is broadly due to the low barriers to entry which the market has exhibited and the value and security of the tariff element of revenue. As long as a connection can be secured to the DNO then a project can secure a 'route to market' via a Wholesale PPA. This means that any plot of land can potentially become a viable site for hosting a solar PV project. With deep liquidity, whilst there will always be market participants who have more or less appetite for broadening their portfolios, in recent years it has typically been possible to find a Wholesale PPA off-taker of some variety. The flexible nature of the structure also means that it is suited to every size of project.

4.1.3. Profitability analysis

This section covers the profitability of this model both previously during the growth phase of 2014/15 and the situation presently (2016/17).

4.1.3.1. Past profitability – 2014/15 project

In 2014/15 there was a supportive framework for larger scale projects, the UK investment environment was seen as stable and safe, and the electricity price was expected to increase ahead of inflation for the foreseeable future. The utility scale segment was relatively nascent, but financiers and lawyers were starting to examine projects in more detail.

Within this context, a Wholesale PPA 10MW project could expect to have an IRR of roughly 8-9%, with the revenues made up of both the RO income and the value of the exported electricity³.

Despite the high initial costs (at over £10m) and relative inexperience within the market, the stable regulatory regime and long-term index linked revenue stream of the RO provided a safe starting point for the industry to develop. In addition, EPCs and contractors from mainland Europe provided high-quality experience to supplement the growing UK supply chain.

4.1.3.2. Current profitability – 2016/17 project

Since the market situation of 2014/15, a number of key changes have taken place:

- The RO was closed for new projects. This took place first for >5MW solar projects in 2015 and then for <5MW projects in 2016, with grace periods allowing commissioning by the end of March 2016 and 2017 respectively.
- A new government was elected in 2015 and made around 15 renewables policy changes, all of which were negative. Some of these (e.g. LECs) affected operational projects as well as short-term changes for new projects.
- The CfD programme, a series of auctions intended to replace the RO, was changed to include only non-established technologies (e.g. offshore wind), and with no auctions for solar PV currently planned.
- Wholesale electricity prices reduced significantly and unexpectedly, and many long-term electricity forecasts were revised downwards. This consequentially meant that electricity price forecasts in general were less trusted.
- The UK electorate voted to leave the European Union, which among other economic impacts resulted in a significant drop in EUR-GBP exchange rate.
- The UK Prime Minister resigned, and the new Prime Minister immediately merged the energy and business departments together and appointed a new ministerial team.

³ This indicative figure is based on long-term ownership, and includes the developer margin within the Capex price.

Table 2: Past Profitability – Wholesale PPA

PV Project			PV Business Model			
PV System Size	kWp	10,000	Category	Share	Unit	Price
Specific System Cost	GBP/kWp	1,050	Renewables Obligation Certificates	100%	GBP/kWh	0.0630
Total System Cost	GBP	10,500,000	Self-consumption Fees	–	GBP/kWh GBP/kWh	– –
Investment Subsidy	GBP	–	Net-metering Fees	–	GBP/kWh GBP/kWh	– –
Total System Cost incl. Subsidy	GBP	10,500,000	Excess Electricity		GBP/kWh	–
Fixed Operation Costs	GBP p.a.	220,500	PPA Tariff	100%	GBP/kWh	0.0600
Variable Operation Costs	GBP/kWh	–	Fees		GBP/kWh	–
PV Generation			Oversupply Price		GBP/kWh	–
Specific Yield	kWh/qm/a	1131	Undersupply Penalty		GBP/kWh	–
Performance Factor	%	84%	Results			
Specific System Performance	kWh/kWp/a	950	Net-Present Value		GBP	1,633,942
Degradation	% p.a.	0.50%	Project IRR		%	8.06%
Investment			Equity IRR		%	9.55%
Project Duration	Years	25	Payback Period		Years	18.35
Equity	GBP	3,744,554	LCOE* (w/o subsidy)		GBP/kWh	0.12
Debt (Gearing) 65%	GBP	6,825,000	LCOE (w subsidy)		GBP/kWh	0.12
Loan Tenor	Years	10	Min DSCR**		x	0.97 x
Interest Rate	%	5.0%	Min LLCR***		x	1.09x
Discount Rate	%	7.0%	* LCOE: Levelized Cost of Electricity			
			** DSCR: Debt Service Coverage Ratio			

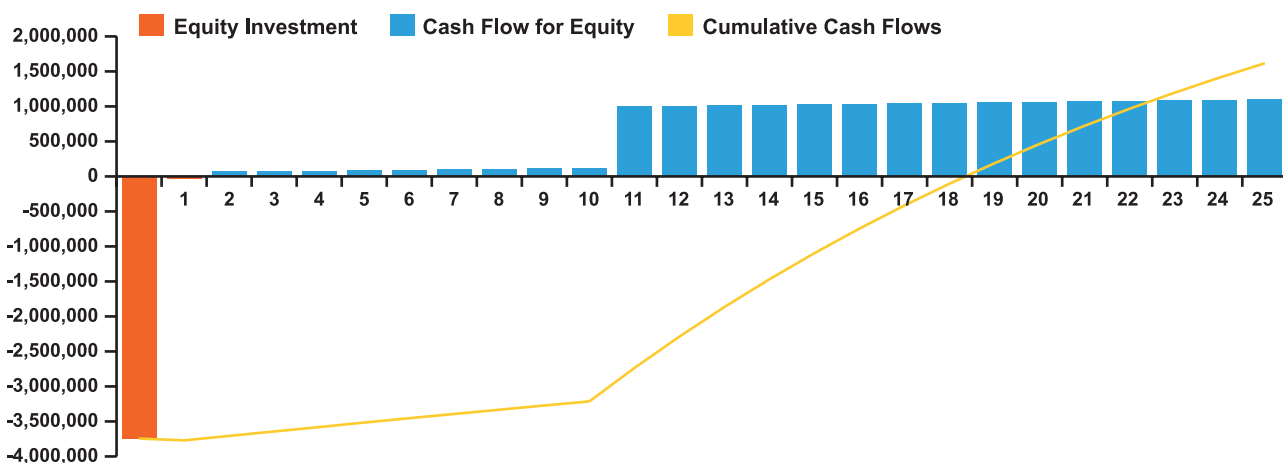


Figure 5: Past Profitability – Wholesale PPA (Cashflow)

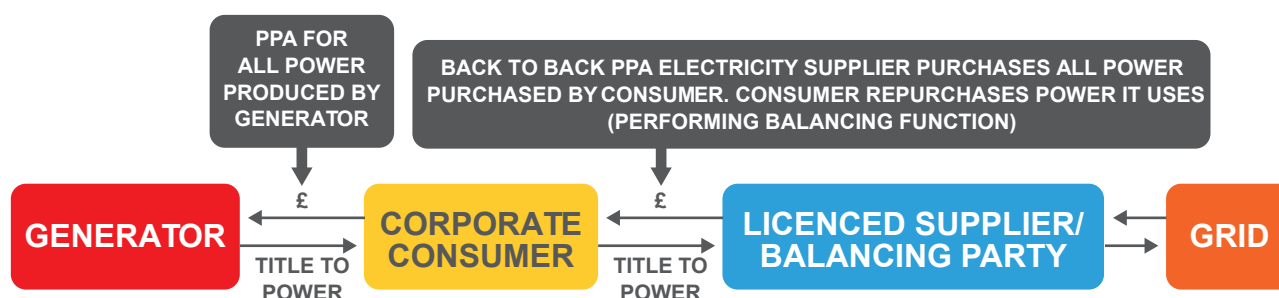


Figure 7: PPA Structure (Sleeved PPA)

The result of all these changes is significant damage to investor confidence in the UK market (both within solar and beyond), and a much changed view of risk. It also means that there is effectively no route to market for larger scale solar projects other than a non-augmented PPA. Within that context, the profitability analysis below demonstrates that new projects are no longer profitable, despite cost reductions over the last 2 years.

4.2. Sleeved PPA (offsite)

4.2.1. General description of structure

A Sleeved PPA structure enables a corporate consumer to buy electricity direct from a generator whilst being neither physically connected to the project, nor a signatory to the balancing code (i.e. a licensed supplier or balancing party). In such a structure, there is a direct PPA between the generator and the corporate, whilst a licensed supplier or balancing party provides a back-to-back or 'Sleeved' PPA with the corporate consumer. The sleeving PPA can vary in the degree of additional services offered by the licensed supplier or balancing party but all enable the corporate consumer to buy electricity from the generator (or more correctly to buy an equivalent volume of electricity as the generator supplied to the electricity grid). From the generator's perspective this structure offers nearly as much flexibility as the Wholesale PPA model outlined above tied with higher PPA prices and longer price certainty, though the contractual complexity means that it may incur higher upfront transaction cost. As with the Wholesale PPA model, the

structure is not location dependent, nor are there limits to scale other than the project being large enough to sustain the higher transaction costs of adopting the contracting structure.

4.2.3. Sleeved PPA Project Investment Model considerations

4.2.3.1. Revenues (PPA)

One primary motivation for corporate customers in choosing to contract directly with a generator is the ability to secure price certainty for a proportion of their electricity needs over a longer period of time (i.e. in excess of 5 years) than would normally be available (or only at a prohibitive cost) through a standard contract with a licensed supplier. In turn this means that from the generator's perspective, they are also able to benefit from the lengthier PPA offtake agreement without having to give discounts at the levels which Wholesale PPA providers (who are not naturally hedged in the same way as corporate consumers) would force upon them. Price levels within this structure are less coupled to market price fluctuations than the Wholesale PPA structure outlined above, but prices will still be influenced by prevailing market alternatives. In normal circumstances, as corporate consumers will still be using the Grid to access their electricity they will still be faced with all the additional charges as per a standard contract direct with a licensed supplier. Whether this structure is preferable to the generator compared to the Wholesale PPA option will likely rest upon the creditworthiness of the corporate consumer and the fixed price achievable with the corporate. For instance, a central government ministry is a

Table 3: Present Profitability – Wholesale PPA

PV Project			PV Business Model			
			Category	Share	Unit	Price
PV System Size	kWp	10,000	Renewables Obligation Certificates	–	GBP/kWh	–
Specific System Cost	GBP/kWp	750	Self-consumption Fees	–	GBP/kWh GBP/kWh	– –
Total System Cost	GBP	7,500,000	Net-metering	–	GBP/kWh	–
Investment Subsidy	GBP	–	Fees Excess Electricity		GBP/kWh GBP/kWh	– –
Total System Cost incl. Subsidy	GBP	7,500,000	PPA Tariff	100%	GBP/kWh	0.0450
Fixed Operation Costs	GBP p.a.	135,000	Fees		GBP/kWh	–
Variable Operation Costs	GBP/kWh	–	Oversupply Price		GBP/kWh	–
			Undersupply Penalty		GBP/kWh	–
PV Generation			Results			
Specific Yield	kWh/qm/a	1131	Net-Present Value		GBP	(3,367,203)
Performance Factor	%	84%	Project IRR		%	1.68%
Specific System Performance	kWh/kWp/a	950	Equity IRR		%	1.68%
Degradation	% p.a.	0.50%	Payback Period		Years	N/A
Investment			LCOE* (w/o subsidy)		GBP/kWh	0.09
Project Duration	Years	25	LCOE (w subsidy)		GBP/kWh	0.09
Equity	GBP	7,500,000	Min DSCR**		x	–
Debt (Gearing) –	GBP	–	Min LLCR***		x	–
Loan Tenor	Years	–				
Interest Rate	%	5.0%				
Discount Rate	%	7.0%				

* LCOE: Levelized Cost of Electricity
** DSCR: Debt Service Coverage Ratio

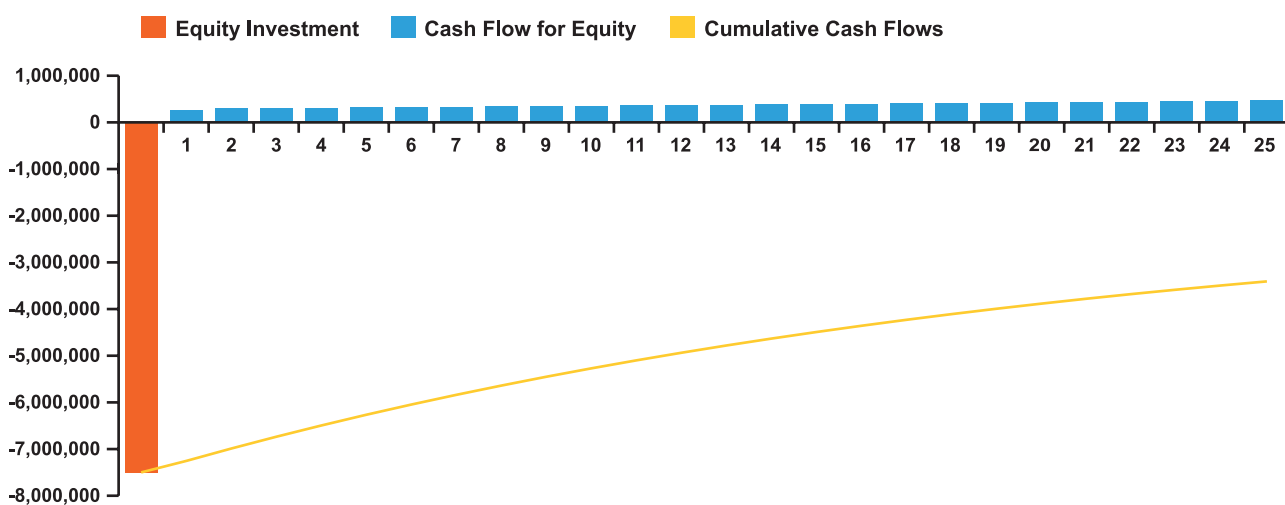


Figure 6: Present Profitability – Wholesale PPA (Cashflow)

very different counterparty proposition to a small private sector firm and a sufficient fixed price is required for an acceptable return. Although in recent years Sleeved PPAs have often offered an overall better balance of price and credit-worthiness than has been available through Wholesale PPAs, recent significant decreases in electricity price forecasts have driven down the level of fixed price that Corporates are willing to accept

4.2.3.2. Capital expenditure (Capex)

The capital expenditure requirements for a Generator to facilitate this contracting structure are almost identical to the Wholesale PPA framework, with the only addition being transaction costs for legal assistance with the corporate PPA. Notably as the project is off site, the Generator may have to pay for the grid connection and associated infrastructure. Lastly, with the Corporate PPA market being younger and more bespoke, most corporates require brokers or financial advisors to be involved in the execution of such a structure together with legal advisors for the PPA contracting. These will add to the Corporate's upfront transaction fees.

4.2.3.3. Operating expenditure (Opex)

O&M contract fees, rent and capital replacement costs will be the same as for the Wholesale PPA structure. The addition of the Sleeved PPA counterparty (the licensed supplier), is unlikely to add to operational costs.

4.2.3.4. Cost of capital

As touched upon above, the creditworthiness of the corporate consumer will play a primary role in defining whether a project is deemed to be 'bankable' and so able to access lower costs of capital. Some consumers, such as certain FTSE100 corporates and central government ministries, in fact offer superior credit risk profiles to Wholesale PPA providers. On the other hand, other corporate consumers are deemed significantly riskier. Historically, as the PPA revenues have only made up a proportion of total project revenues (with tariffs making up the remainder), banks and other low cost of capital finance providers have been prepared to consider Sleeved PPA arrangements.

However, as with the Wholesale PPA market, in a post subsidy landscape, only the very highest quality Sleeved PPAs are likely to be perceived being credit-worthy enough to support debt or institutional equity financing.

4.2.3.5. Scale

The Sleeved PPA market has undertaken rapid expansion in recent years, with many more corporate consumers keen to secure their electricity costs for the long term in an unstable economic climate. As contractual norms have become more established it has become less expensive (both from a generator and corporate consumer perspective), however in comparison to the Wholesale PPA market it is a more expensive structure to implement. This additional cost means that for smaller projects (e.g. <5MW), it may not make financial sense to pursue this structure unless the projects are grouped together in a portfolio with the same generator.

4.2.4. Profitability analysis

This section covers the profitability of the sleeved PPA model. As there are likely to be further regulatory changes, cost reductions and shifting market prices, only the near future situation is considered.

4.2.4.1. Near future profitability: 2017/18 project

This analysis of the profitability considers the near future situation of a 10MW ground mounted solar farm. Many of the issues with this model structure stem from the credit worthiness of the off-taker, rather than the profitability of the model per se, but profitability is an important aspect.

This model is not profitable using standard assumptions, from a combination of PPA price falls due to changes in forward price projects and the loss of ROCs. There are significant cost reductions or increases in PPAs which would be required to make this model profitable.

PPA prices would need to be significantly higher (c. £85/MWh) for project to work without subsidy – and this is much higher than corporates are

Table 4: Present Profitability – Sleeved PPA

PV Project			PV Business Model			
			Category	Share	Unit	Price
PV System Size	kWp	10,000	Renewables Obligation Certificates	–	GBP/kWh	–
Specific System Cost	GBP/kWp	750	Self-consumption Fees	–	GBP/kWh GBP/kWh	– –
Total System Cost	GBP	7,500,000	Net-metering Fees	–	GBP/kWh GBP/kWh	– –
Investment Subsidy	GBP	–	Excess Electricity		GBP/kWh	–
Total System Cost incl. Subsidy	GBP	7,500,000	PPA Tariff	100%	GBP/kWh	0.0480
Fixed Operation Costs	GBP p.a.	135,000	Fees		GBP/kWh	–
Variable Operation Costs	GBP/kWh	–	Oversupply Price		GBP/kWh	–
			Undersupply Penalty		GBP/kWh	–
PV Generation			Results			
Specific Yield	kWh/qm/a	1131	Net-Present Value		GBP	(2,984,384)
Performance Factor	%	84%	Project IRR		%	2.38%
Specific System Performance	kWh/kWp/a	950	Equity IRR		%	2.38%
Degradation	% p.a.	0.50%	Payback Period		Years	N/A
Investment			LCOE* (w/o subsidy)		GBP/kWh	0.09
Project Duration	Years	25	LCOE (w subsidy)		GBP/kWh	0.09
Equity	GBP	7,500,000	Min DSCR**		x	–
Debt (Gearing)	GBP	–	Min LLCR***		x	–
Loan Tenor	Years	8				
Interest Rate	%	5.0%				
Discount Rate	%	7.0%				

* LCOE: Levelized Cost of Electricity
** DSCR: Debt Service Coverage Ratio

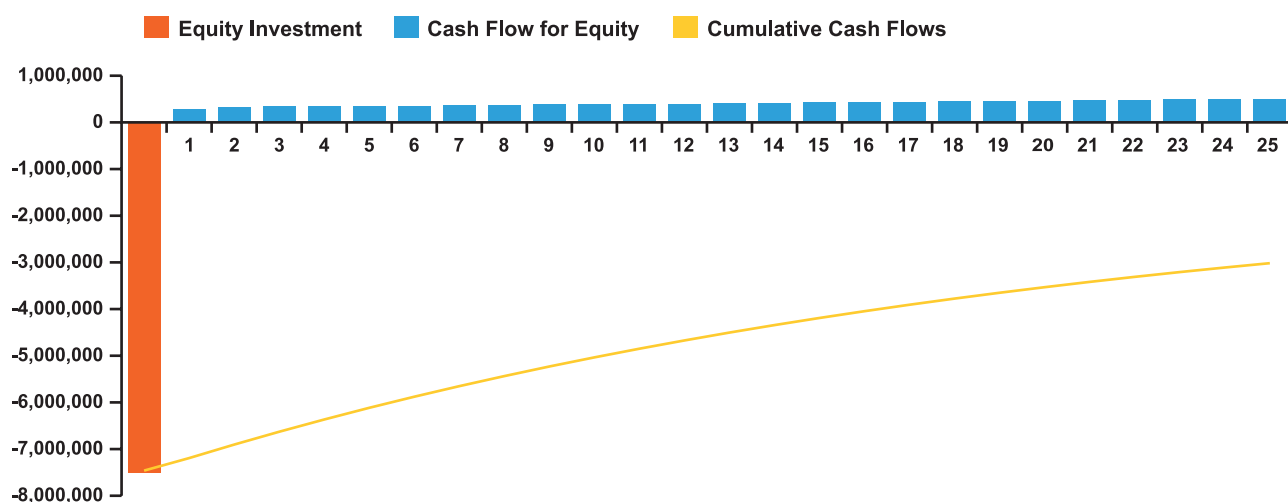


Figure 8: Present Profitability – Sleeved PPA (Cashflow)

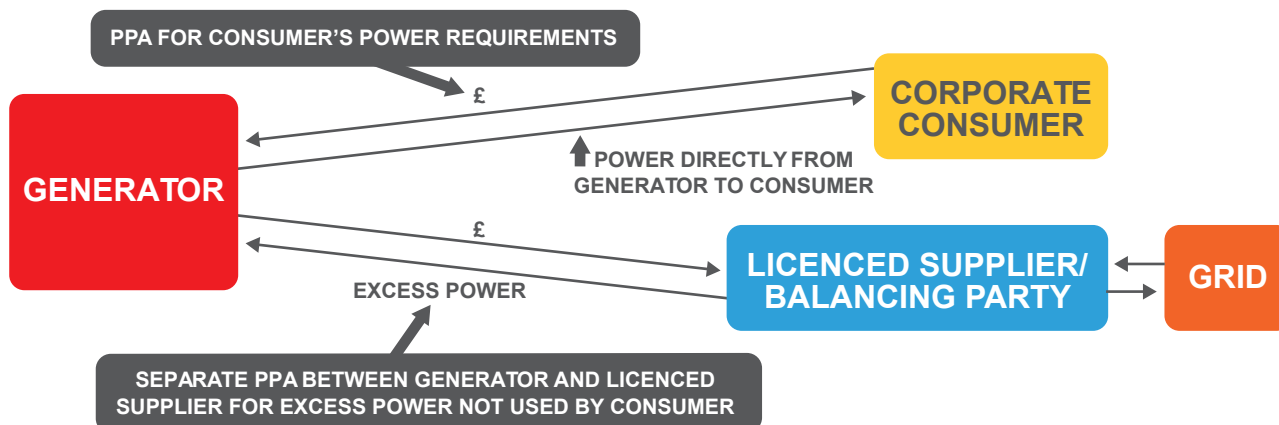


Figure 9: PPA Structure (Onsite direct wire)

expected to pay, as it would give them significant losses against business-as-usual electricity buying.

4.3. Onsite direct wire (Private wire)

4.3.1. General description of structure

Onsite direct wire project structures (also known as “private wire”) allow large electricity users to benefit from buying their electricity from a renewable electricity source onsite or near-site and avoid many of the non-commodity costs associated with buying electricity through the grid. A PPA structure would also mean that the corporate does not have to pay for the generating asset themselves. In physical terms this structure looks very similar to a self-consumption model; however, it bears very little resemblance to this contractually. As with previously outlined structures, in the Private Wire situation the generator will again be an SPV, who will contract directly with the corporate consumer to supply them with electricity. This typically will be for the majority of the export of the project. To enable the corporate consumer to avoid paying for the use of the grid, the connection to the project will take place on the customer side of the grid meter. This structure requires a separate connection to the grid in addition to the corporate consumer connection. In order to have a route to market in a situation of corporate consumer default, and for any electricity generated which is in excess of the demand of the corporate consumer. This grid connection could be in the control of either the

generator or of the corporate customer (who will already be connected to the electricity grid). To provide route to market through this grid connection the generator will sign a PPA with a licensed supplier or balancing party, termed a ‘spillover’ PPA.

4.3.3. Onsite direct wire PPA Project Investment Model considerations

4.3.3.1. Revenues (PPA)

This structure enables the corporate customer to avoid grid charges (such as DNUoS and TNUoS and various other levies) additional to the wholesale electricity price for imported electricity from the grid for electricity supplied by the solar PV scheme. This means that they are typically able to pay the generator a £/kWh price higher than the prevailing wholesale rate whilst still retaining a significant saving to electricity imported from a licensed supplier for themselves. As such from a generator’s perspective the Private Wire structure has the potential to receive the highest price PPA of the options presented in this paper. Historically, both FIT and ROC rules have allowed such generators to receive subsidy support in addition to the PPA provided that metering arrangements were carefully designed. Without subsidy support it is conceivable that projects with sufficient economic foundation could still be financeable utilising this structure.

4.3.3.2. Capital expenditure (Capex)

This structure is suitable for both rooftop and near-site ground mounted projects, as is

illustrated by the case studies below. The structure potentially enables the project to use the corporate consumer's existing grid connections. For particular cases this means that expensive contestable and non-contestable works can be avoided with a minimum of upgrade works being required for the existing corporate consumer's connection. On the other hand, in some instances there will be a requirement for duplication of electrical equipment, which would make capital expenditure in excess of an equivalent Wholesale or Sleeved PPA arrangement. In addition to physical equipment, transaction fees associated with this structure will typically be considerable as there will likely be in depth negotiations to determine the risk allocation between the various counterparties.

4.3.3.3. Operating expenditure (Opex)

O&M and replacement capital costs are likely to be similar to Wholesale PPA and Sleeved PPA structures. However, rental costs may be different in some Private Wire structures if the project's landlord is in fact the corporate customer themselves. This may lead to a situation that some of the effective PPA value is in fact passed to the generator through a below market rent (either for a roof-mounted or ground-mounted project).

4.3.3.4. Cost of capital

Cost of capital considerations are likely to be similar to those described above for Sleeved arrangements with the caveat that financiers will likely insist upon being able to cover their investment in a downside sensitivity whereby the onsite consumption is not maintained for the assets full life and the generator has to rely upon exporting to the grid for normal Wholesale PPA or Sleeved PPA products. This places a great deal of focus upon the physical arrangements for accessing the grid connection, with a successful financing due diligence outcome often requiring complete comfort that route to market (i.e. to the grid) is secure even in low probability scenarios (such as off-taker default). Analysis of onsite demand and the correlation of this with project supply in terms of timing will also be critical in

determining financiers' investment decisions. corporate customers with predictable daytime loads with few breaks will be greatly preferable to those where there is less visibility of corporate consumer usage.

4.3.3.5. Scale

By their very nature, Private Wire structures are location and situation specific. To be successful, most of the following requirements will have to be met:

- Corporate consumer demand load must be sufficiently large, consistent and time matched to allow solar PV generated electricity to be well suited to meeting the load;
- The corporate consumer must have a strong enough organisational desire and capability (especially access to legal skills) to engage significant amounts of time and effort to assist the project developer and other associated parties to agree the contracts;
- The corporate consumer must be deemed sufficiently creditworthy to facilitate the financing of the generator's assets;
- A suitable physical location (whether ground mounted or roof mounted) must be available to host the site on-site or near site. Private wires more than just a few km are likely to make the project prohibitively expensive;
- The local DNO or TSO must be willing to work with the project developer and the corporate consumer on complicated grid access sharing arrangements
- Sufficient capacity must be available on the local electricity grid to allow for full grid export in a downside sensitivity scenario; and
- A commercial arrangement which works for all parties must be reached, allowing for the significant transaction costs of such a bespoke contracting structure.

Obviously, this is a challenging set of requirements and so the market depth for such a structure is not as deep as more straightforward arrangements. However, the potential for higher

Table 5: Present Profitability – Onsite direct wire PPA

PV Project			PV Business Model			
PV System Size	kWp	5,000	Category	Share	Unit	Price
Specific System Cost	GBP/kWp	750	Renewables Obligation Certificates	–	GBP/kWh	–
Total System Cost	GBP	3,750,000	Self-consumption Fees	–	GBP/kWh GBP/kWh	– –
Investment Subsidy	GBP	-	Net-metering Fees	–	GBP/kWh GBP/kWh	– –
Total System Cost incl. Subsidy	GBP	3,750,000	Excess Electricity		GBP/kWh	–
Fixed Operation Costs	GBP p.a.	75,000	PPA Tariff	100%	GBP/kWh	0.0750
Variable Operation Costs	GBP/kWh	-	Fees		GBP/kWh	–
PV Generation			Oversupply Price		GBP/kWh	–
Specific Yield	kWh/qm/a	1131	Undersupply Penalty		GBP/kWh	–
Performance Factor	%	84%	Results			
Specific System Performance	kWh/kWp/a	950	Net-Present Value		GBP	292,746
Degradation	% p.a.	0.50%	Project IRR		%	7.32%
Investment			Equity IRR		%	8.10%
Project Duration	Years	25	Payback Period		Years	21.64
Equity	GBP	1,708,913	LCOE* (w/o subsidy)		GBP/kWh	0.08
Debt (Gearing) 55%	GBP	2,062,500	LCOE (w subsidy)		GBP/kWh	0.09
Loan Tenor	Years	10	Min DSCR**		x	0.96 x
Interest Rate	%	5.0%	Min LLCR***		x	1.14 x
Discount Rate	%	7.0%	* LCOE: Levelized Cost of Electricity			
			** DSCR: Debt Service Coverage Ratio			

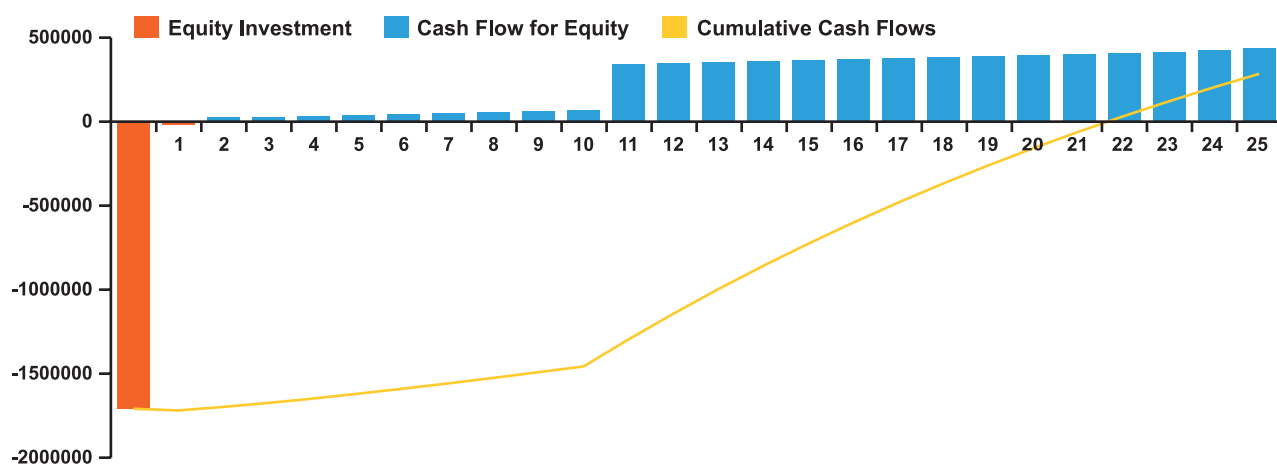


Figure 10: Present Profitability - Onsite direct wire PPA (Cashflow)

£/kWh PPA prices which this structure facilitates does give it more of a chance of being replicable without a subsidy. Due to the considerable upfront transaction costs, it is likely that it only makes sense to adopt such a strategy with utility scale projects (e.g. 1 MW plus). It is also likely that there are only a limited number of sites that are suitable for this type of model. A separate issue is on “stranded asset risk” – i.e. what happens if the corporate consumer no longer requires the solar PV output through, for example, shutting down the physical site which the solar PV is connected to. This risk, which may reduce or eliminate the value of the electricity generated by the solar PV project, will need to be carefully considered by both lawyers and funders in projects of this nature.

4.3.3.6. Near future profitability: 2017/18 project

Considering the limited availability of large industrial parks with a significant amount of space available for a solar farm or large solar rooftop, the size of project considered in this case is 5MW. As discussed previously, the considerable transactional costs make it unlikely that projects smaller than 1MW will adopt this approach.

The smaller size and additional grid connection complexity causes a slightly increased cost per kW, which is offset by the increased PPA price per kWh.

As can be seen, this is a theoretically profitable model, with an IRR of around 7-8% and an NPV of £300k. However, given that this electricity at 7.5p/kWh would typically be less than market rate of 9-10p/kWh, the savings rather than returns may make this an attractive model. It is important to note that a more bankable offtaker would demand a lower price, and therefore the balance of bankability of offtaker against profitability is key for this model.

As discussed in the previous section, the opportunities for applying this model may in practice be small due to the challenging set of requirements.

4.4. Comparison of observed PPA structures

A summary is provided below of the different observed PPA structures described in this chapter, in terms of their business model fundamentals.

BUSINESS MODEL	REVENUES	CAPEX	OPEX	COST OF CAPITAL	SCALE	PROFITABILITY
Wholesale PPA	Low: Wholesale market price	Historically high due to policy-led “rushes”	Can be high due to access issues with landowner	Dependant on wholesale electricity projections and how volatile or accurate these are	Plenty of scale possible as all that is needed is land, grid and an off-taker	Was profitable with ROCs and high price forecasts, now not profitable
Sleeved PPA	Medium: competing with retail prices, but including grid costs	Same as above, although transactional costs high due to complicated legal structure	Same as above	Dependant on credit-worthiness of corporate consumer, which has proven challenging	Similar to above, but transactional costs quite high, so not suited to smaller projects	Was profitable with ROCs, now may not be profitable
Onsite direct wire (Private wire)	High: competing with commercial retail prices, avoiding grid costs	Potential reductions through e.g. grid efficiencies, but potential challenges from geographical constraints	Same as above, although rental costs and access may differ on consumer-owned sites	Dependant on credit-worthiness of corporate consumer, which has proven challenging. Additional challenges from “stranded asset” risk	Limited market size, as challenging set of requirements	In theory profitable, but challenges remain making projects viable

5. Observed PPA project structures in other jurisdictions and their potential viability in the UK in the post subsidy era

5.1. Mini Utility (offsite)

5.1.1. General description of structure

The Mini Utility structure builds upon the Sleeved PPA arrangement but removes the need for a third party licensed supplier, as this role is performed by an entity wholly owned by either (or both) of the generator or corporate consumer. This is a structure which would be used in offsite situations. As with Wholesale PPAs, the generator would simply contract and sell its electricity to a balancing party or licenced supplier, who, in this form, would be the Trading SPV. This Trading SPV would be registered as a licensed supplier and would contract with the corporate consumer for some (or all) of their electricity needs. The Trading SPV would also be able to buy electricity from other grid-connected parties to meet any

shortfalls which the generator would be unable to meet. This structure has been used in the Irish market.

5.1.3. PPA Project Investment Model considerations

5.1.3.1. Revenues (PPA)

This structure allows the Trading SPV to be aligned in its interests with those of the generator and corporate consumer (who will likely own it). This overlapping interest incentivises the Trading SPV to give both the generator and the corporate consumer what they want, namely long tenor fixed price contracts, without having to consider the potentially conflicting interests which other licenced suppliers would have to allow for. This potentially means that the Trading SPV will be able to pass more value onto the generator

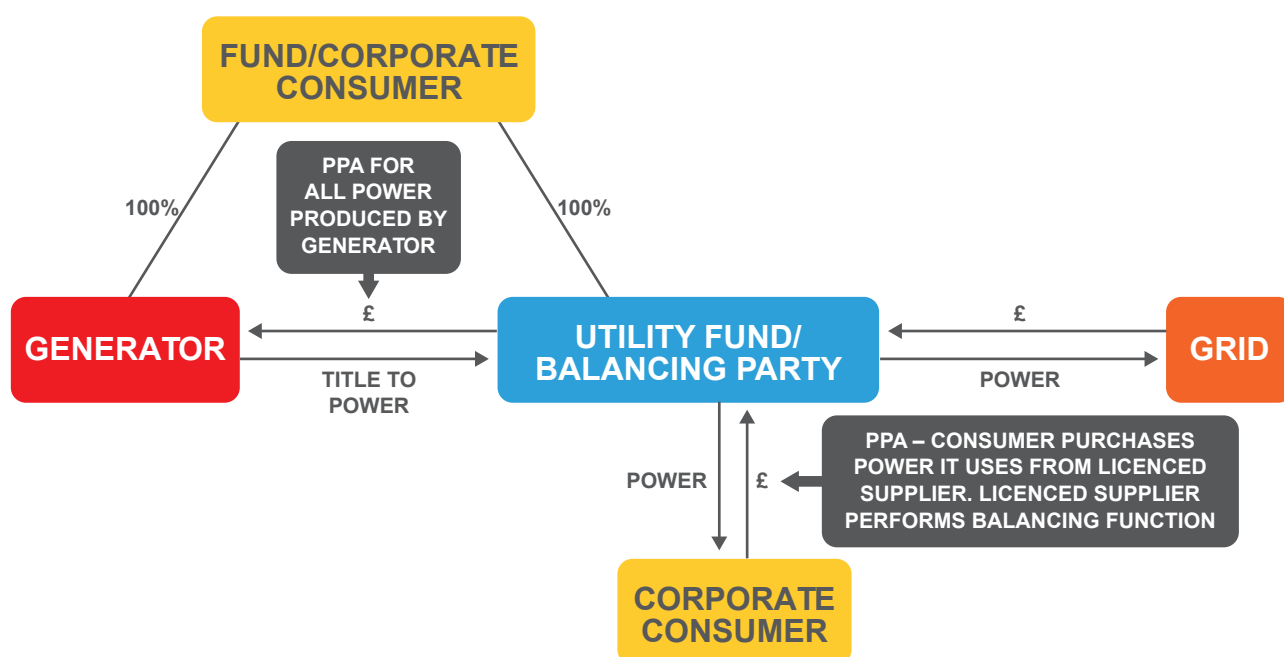


Figure 11: PPA Structure (Mini Utility)

than would be the case in either a Wholesale PPA or Sleeved PPA structure. As the structure still relies upon the use of the electricity grid, the corporate consumer would still need to pay all non-commodity charges associated with its usage. This means that they would not be in a position to pass more value to the generator (via the Trading SPV) whilst still saving in comparison to a normal contracting strategy.

5.1.3.2. Capital expenditure (Capex)

In terms of physical infrastructure, this contracting structure does not place any additional burdens upon the generator. However, the legal side is likely to be expensive, as this structure requires either (or both) the generator and the corporate consumer to create a Trading SPV, and this Trading SPV to be registered as a licensed supplier and party to the balancing code.

5.1.3.3. Operating expenditure (Opex)

In terms of O&M and replacement capital, the use of this contracting structure would place no additional burdens upon the Generator than would be expected under a Wholesale PPA or Sleeved PPA model. However, the cost of maintaining the Trading SPV will likely be significant, as this body will likely have to have contracts with some outsourced providers of balancing services, as well as administrative functions to enable it to meet its contractual obligations to the corporate consumer if electricity provided by the generator is not sufficient to fully meet the consumer's needs fully (as would most likely be the case). In short, the Trading SPV would have to be more than just a paper entity.

5.1.3.4. Cost of capital

This structure raises questions about the competence of the Trading SPV as both the generator and the corporate consumer place reliance upon it to provide balancing services. Given that the purpose of utilising the structure is to minimise the cost to both sides of Trading SPV, the risk is that this middle party will concentrate too much on saving costs and not enough on its balancing strategy. This could increase the chance of instances of default or insolvency. Investors

and funders of the solar PV project would need to be confident that this structure does not create significantly more risk, and that corporate governance structures are capable of managing the relationships between the various entities. As with any new structure, the first instances of its deployment will most likely require expensive capital to fund them, with project finance and other low cost of capital providers only being interested in being part of such structures once precedents in the UK market have been proven.

5.1.3.5. Scale

To date we are unaware of this structure having been executed in the UK, however several of the largest Owners are known to be considering using it. With the additional upfront and on-going costs of using this structure in comparison to the Sleeved PPA, it can be assumed that only owners with considerable assets under management or very large corporate consumers would consider its usage. However, once the structure is in existence, the lack of a third party Utility may make this structure more suitable for use with smaller generators.

5.1.4. Profitability analysis

Given that there are no known existing projects in the UK using this structure, a profitability analysis has not been completed.

5.2. Synthetic PPA

5.2.1. General description of structure

This alternative structure, which again builds upon the Sleeved PPA arrangement, has become the preferred structure for large off-takers in the USA such as Google and a limited number of projects have been completed in the UK. In this structure the generator sells electricity to a third party licensed supplier or balancing party in the same way that they would in a conventional Wholesale PPA, with the licensed supplier themselves selling onwards to the corporate consumer in the normal manner. However, where the structure differs is that parallel to the conventional contracts, there is a second contractual relationship between the

generator and corporate consumer directly. This second contract is essentially a derivative instrument which allows both parties to fix the electricity at a given price. If designed effectively, the Synthetic PPA structure allows both the corporate consumer and the generator to access the long term and fixed price revenue/cost certainty which they desire, without the need for the licensed supplier or balancing party to be party to the arrangement. In some circumstances it may be that this structure would be preferable to the Sleeved PPA or Mini Utility models. One advantage it offers over the Sleeved PPA structure is that the corporate consumer is not required to define where the electricity is used. This could make it useful for users who have multiple, disparate electricity loads and who want to retain the flexibility to change their facilities. It also enables the generator to sell to a different party to the one supplying the Corporate. This is attractive in the US where the grid and utility market is highly fragmented and sleeved PPAs are often not possible. The synthetic PPA enables a Corporate's consumption from multiple regions/ projects to be aggregated into one large PPA.

5.2.3. Synthetic PPA Project Investment Model considerations

5.2.3.1. Revenues (PPA)

Under this structure the generator will likely receive market based floating revenue from the licensed supplier or balancing party. The arrangement between the generator and corporate consumer will effectively fix the price of the electricity by either pulling up the market price (if the market price is below the fixed price) or pulling it down (if the market price is above the fixed price). Contractually a 'Contract for Difference' structure could be used or alternatively, a hedge option or commodity hedging frameworks could be adopted. Overall it is unlikely this structure would allow the generator to receive a higher level of revenue than through other arrangements but it may allow for more fixing in times when licensed suppliers or balancing parties are unwilling to do so.

5.2.3.2. Capital expenditure (Capex)

Physical infrastructure costs will be the same as under normal market arrangements. Legal fees will be more considerable, though we anticipate

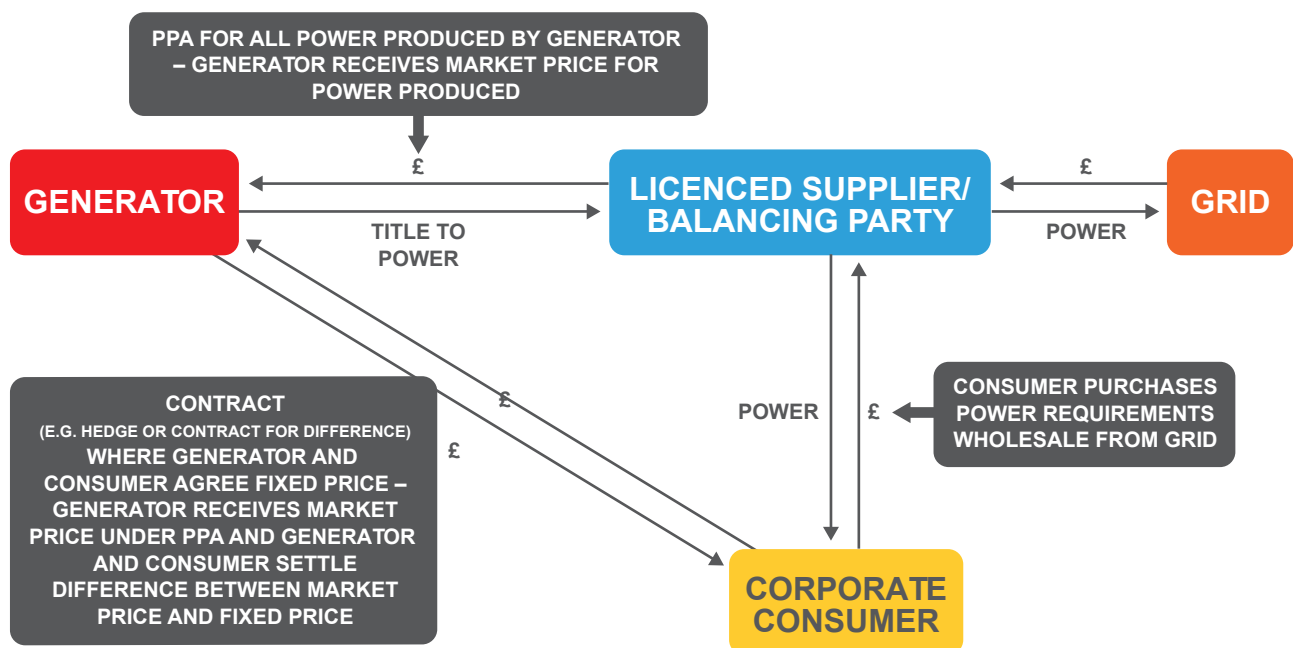


Figure 12: PPA Structure (Synthetic PPA)

that they will not be as high as the Mini Utility arrangement as this structure does not require the creation of a separate entity.

5.2.3.3. Operating expenditure (Opex)

The O&M and replacement capital for this this contracting structure would place no additional burdens upon the Generator than would be expected under a Wholesale PPA or Sleeved PPA model.

5.2.3.4. Cost of capital

From the generator's perspective, this structure could enable more price certainty in situations where licensed suppliers or balancing parties are unwilling to provide it, which could help to lower the cost of capital. If long term fixed price contracts with market off-takers are available, then this structure is likely to be deemed to be less creditworthy as, it raises the number of credit counterparties the generator faces. As with the Mini Utility case, until the structure is established in the UK market, it is unlikely that low cost of capital providers would be willing to consider it.

5.2.3.5. Scale

To date we are only aware of a few instances of this structure having been used in the UK. Unlike the Mini Utility model, the barrier to entry for its adoption is relatively low and the fact that it does not rely upon the licensed supplier or balancing party to

offer long term fixed contracts, nor to 'sleeve' a corporate PPA, perhaps it makes it more likely that licenced suppliers will promote it. As with all the other off site structures, a Synthetic PPA does not rely upon particular location of generator or corporate. Equally there is nothing immediately evident which would prevent this arrangement from being used for smaller scale as well as utility scale generators, provided the PPA set-up fees for the corporate consumers do not outweigh the benefits from the relatively small volume of fixed price electricity.

5.2.4. Profitability analysis

As with the Mini Utility model, there are few known existing projects in the UK using this structure. Therefore, a profitability analysis has not been completed on this particular structure.

5.3. Comparison of potential future PPA structures

A summary is provided below of the different potential future PPA structures described in this chapter, in terms of their business model fundamentals.

BUSINESS MODEL	REVENUES	CAPEX	OPEX	COST OF CAPITAL	SCALE	PROFITABILITY
Mini Utility	Potentially high as competing with retail prices, but liability for grid costs remains	No geographical constraints, so market level Capex	Similar to Wholesale PPA model	High, as this model has not yet been proven and there are potential default risks	No projects in the UK yet, although it is being considered. It would need a large portfolio and/or large corporate	Unknown in the UK
Synthetic PPA	Fixed revenue for the generator, similar to a CfD. Unclear how high the fixed price could be	Same as above	Similar to Wholesale PPA model, although some additional costs to manage hedging arrangement	High, as this model has not yet been proven in the UK, particularly the hedging element	Very few projects to date in the UK. Transactional costs and setup are unknown which may prove a barrier to projects	Unknown in the UK

6. Improving the PPA Project Investment Model fundamentals

6.1. Capex reductions

There are a number of factors that could reduce Capex and enable the PPA rates that can be offered to be attractive. These include the removal of the Minimum Import Price and anti-dumping tariffs, global manufacturing efficiencies and supply chain efficiencies through market scale.

First, taking a simplistic sensitivity analysis approach to Capex for the Wholesale PPA model demonstrates that a Capex reduction of greater than 35% (implying a Capex of <£500k/MW) would be required to achieve a >6% return. For comparison, a Solar Trade Association report on large scale cost reductions only reached a Capex of £650k/MW by 2030, equating to a return of approximately 4%. This is not to say that these cost reductions will not be met – indeed, projections of solar cost reductions are almost always underestimated.

For the Onsite Direct wire model, it is not so much the Capex (and therefore IRR) that limits the model's uptake, but more the risk profile. Cost reductions will improve the IRR, but the cost of capital and hurdle rates are more important sensitivities to examine.

6.2. Opex reductions

There are a number of cost efficiencies that could reduce Opex for both existing and new projects. These include harmonisation across the market on accepted standards and specific technologies for solar O&M. This could include for example the use of drones to examine PV module and electrical defects, automated cleaning technologies and specific solar farm vegetation mowers. However, it is unlikely that Opex reductions alone will fundamentally shift the economics of new projects.

6.3. Revenue increases

The traditional solar PV project is generation-led, and any unused generation is simply exported to the grid. However, this is the most basic way of using a solar PV project. Various other services can be provided by solar, including:

- Being tied with a variable demand such as industrial processes, energy storage or power to gas production, enabling export to grid to be minimised or eliminated.
- Synthetic inertia, reactive power, frequency response and other grid services through using the inverters of the solar project.

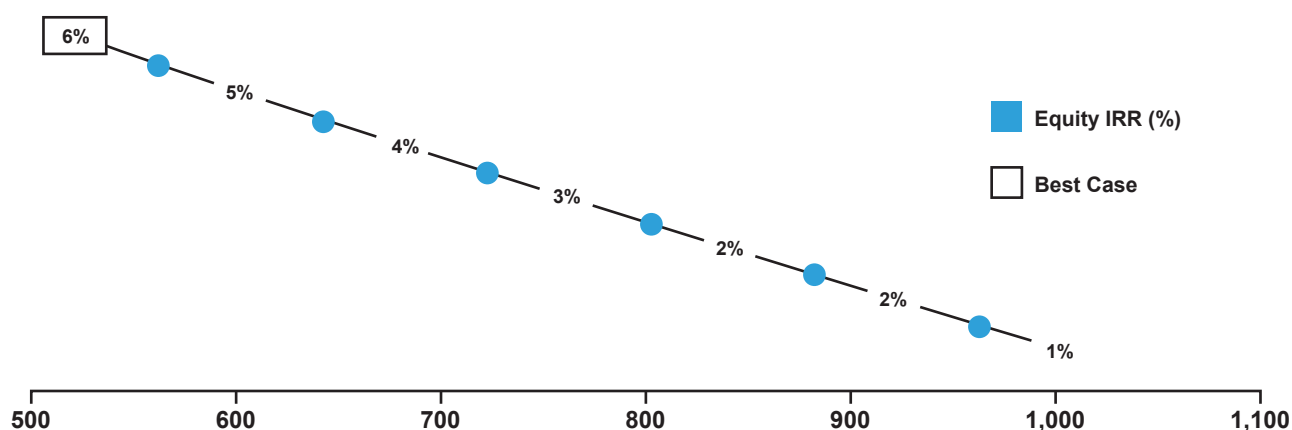


Figure 13: Sensitivity analysis of reducing capex for Wholesale PPA model

- Curtailment or paid diversion of solar electricity from the grid at times of grid stress.

Many of these potential services and revenue streams are currently not available or able to be monetised directly.

These additional revenue streams are not modelled explicitly, as the value of the streams or their

makeup is not yet known, but it remains a potentially interesting avenue to explore and watch for the future, especially in combination with emerging energy storage technologies. At the larger scale, the sharing of a grid connection where wind, solar and energy storage all provide different functions (electricity, grid frequency and balancing services, for example) could create an attractive package for investment.

Alternative financing and the rise of crowdfunding

The UK has become a hub for alternative and peer-to-peer financing. In an era of low interest rates and private investors hungry to attain returns, returns of 5-8% are possible when savings accounts rates are less than 1%. This has included renewable energy crowdfunding through platforms like Abundance, Ethex and Trillion Fund.

For many cases, there is a “social good” aspect for this investment, in addition to the pure financial return. See Figure 14 for an example advert recently run by one crowdfunding platform, Abundance Investment:

Key aspects of crowdfunding are a low barrier to entry – allowing investors to invest small amounts – and security. Almost all projects funded so far have been secured against subsidised projects, which are viewed as secure as the government has committed to not retroactively change the rates of these. The risk is therefore low. Typically, crowdfunding projects do not take construction risk or development risk.

Crowdfunding solar projects in this way could provide financing at a lower cost than would typically be available in the market, while also giving the public the chance to invest and engage with their energy system. The challenge with crowdfunding remains achieving sufficient scale to enable these economies to be realised.

Other changes such as the introduction of the Innovative Finance Individual Savings Account (IF ISA) which provides a tax-free savings allowance for individuals investing in peer-to-peer finance could provide the catalyst for more crowdfunded or community-driven solar projects.

CAPITAL AT RISK. INVESTMENTS ARE LONG TERM AND MAY NOT BE READILY REALISABLE. ABUNDANCE IS AUTHORISED AND REGULATED BY THE FINANCIAL CONDUCT AUTHORITY (525432).

“Sure I’d like to make a decent return, but not at any cost.”

We get it. We like turning your money into more money, but we like being able to look at ourselves in the mirror too.

Find out how we do both at abundanceinvestment.com

abundance

Figure 14: Abundance investment example advertisement

6.4. Cost of capital decreases

Cost of capital, and by association the view of the investment community of a particular asset class and environment, is a critical component of the profitability of a solar project. The cost of capital has been steadily falling as technology matured and financiers developed experience within the market, and became more comfortable with solar as an asset class. However, the regulatory and political changes in the UK over the last 24 months have caused concerns for some investors, which has raised the cost of capital. Additionally, there are increased risks from relying on the credit-worthiness of a private off-taker rather than a government-mandated support scheme.

Despite these setbacks, there are some niches by which low cost capital could be brought forward, and reasons why cost of capital can be reduced in the market:

- Alternative financing such as crowdfunding or ISAs could provide capital at a “retail” cost rather than a “wholesale” cost (see box on following page).
- Local government authorities are starting to fund projects directly, and can borrow at very low interest rates, while also having a long-term view.

6.5. Scale

Both market scale and project scale can enable the UK PV industry to continue to deploy, but there are causes for concern on both of these, and the outlook from a scale point of view is negative rather than positive.

Market Scale

The market in the UK for solar has matured significantly over the last 5 years. This has meant that lawyers and financial advisors, planning consultants, grid experts, technical consultants and training providers have developed skills and brought costs down as the market has grown. However, with the reduction in the market expected over the coming years, these skills might be lost. As a result, costs are likely to increase making the already challenging economics more difficult.

Project Scale

One reaction to the recent removal of support schemes has been to look at the possibilities of megaprojects. Whereas the largest project at the moment within the UK is 70MW, industry experts have discussed the possibility of 300-400MW single sites. The economies of scale both in terms of buying electricity and operational management are significant, but there could equally be additional problems from a planning or environmental point of view with a project this size, and it is therefore likely that they will be rare.

7. Conclusion

The economics of solar are fundamentally difficult in the current environment. Whereas over the last 5 years returns were sufficient to attract a wide range of equity participants and revenue streams were secure enough to attract a wide range of debt providers, the profitability and changes in risk profiling following the recent changes makes the development of new projects much more challenging.

For the Self-consumption Project Investment Model, changes to FIT has meant that economics must only be a part of the model. Energy independence as well as other non-financial factors must drive deployment in the short term until the economics become viable to domestic and small commercial customers.

At the larger scale, PPA Project Investment Models will continue to evolve and shape around the risks and regulatory framework.

The Wholesale PPA and Sleeved PPA structures are the classic models that have been used historically in the industry. Our analysis shows that they will not be profitable in the short term unless there are significant cost reductions through scale or site-specific efficiencies. This is even more so while wholesale price projections remain low.

The Onsite direct wire (Private wire) structure has been discussed at length within the industry, as a way of bridging the gap between wholesale prices and retail prices, effectively increasing the PPA price that could be offered to a generator. However, we find that there are a significant number of challenging requirements that this structure has, ranging from the number of eligible sites to the credit-worthiness of the off-taker. Although this structure is shown to be theoretically profitable, the market for these projects is likely to remain niche for the time being.

More innovative structures such as the Mini Utility and Synthetic PPA could potentially bypass some of the issues with existing models by cutting out the energy supplier and providing a secure fixed income respectively. The possibility of these

models being profitable is challenging to evaluate, as very few projects have been completed so far using these structures.

There are a number of key factors that can improve the fundamentals for solar in the UK. As module and balance of system costs continue to reduce through manufacturing and market maturation, the amount of investment required per MW will fall. Although Opex reductions are less significant, efficiencies are still being found through consolidation of portfolios and use of innovative technologies. The cost of capital will always be the key factor alongside Capex, and some niches such as crowdfunding and local authority funding could provide some further reductions in the cost of capital. Project scale could provide efficiencies in cost if acceptable to local communities, and market scale in general is key for reducing overall costs.

The future profitability of different models within the UK solar market is far from certain, but with continuing cost reductions and innovative solutions, there remains the potential to create a winning formula of low-cost, clean energy for consumers at all scales, with attractive returns for the Owners.



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