D2.6 Business Model Report

United Kingdom

An analysis of future viable business models in a lower-subsidy world

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

Contents

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Overview

The UK solar market has proven to be one that is both adaptable and innovative in the face of changing regulatory regimes. As the UK moves towards a reduced-subsidy environment, this resilience and flexibility will be crucial for continued market success. This report examines some of the potential business models that could become profitable in a low or no-subsidy world.

Given the nature of government proposals that are currently awaiting decision, there is potential to misunderstand this report as evidence that zero subsidy solar works now. This report examines at a theoretical level the models that may work in a low or no subsidy environment in the future and analyses their profitability using today's assumptions. However, it does not suggest that subsidies are not needed in the short term. The STA has already produced a significant body of work on a path to zero subsidy[1], an alternative to the Feed in Tariff proposals[2], and is in discussions about the possibility of a "subsidy free" CfD[3]. Declining, stable policy support through subsidies will enable zero subsidy solar by the end of the decade through cost reductions across the entire supply chain, enabling these models to flourish.

Any changes in policy resulting from decisions on these subsidy schemes will be reflected in a future update of this report if they significantly alter the investing environment or relate to specific business models such as the Lower Tariffs domestic model.

The analysis findings in summary are that there are potential business models that can be profitable, but that these are not yet possible under normal assumptions. Extreme and rare scenarios such as very high electricity prices, very high self-consumption rates and very high irradiation (yield) may deliver profitability, but these are based on taking all possible "best of the best case" assumptions, and do not indicate widespread replicability.

In order for these models to be successful, costs must come down across the whole sector. This will come from continued international manufacturing efficiencies and, crucially, must also come from supply chain efficiencies from a growing market. Analysis by the STA has shown that zero subsidy solar in the UK is possible[4], but that cost reductions need to happen mainly on the non-equipment costs[5], mostly through volume deployment reducing per-unit costs. As an example, sales and marketing costs drop halve per system when double the installations are performed.

Solar in the UK has a bright future, but only if given the right framework to allow the market to succeed at scale.

[1] http://www.solar-trade.org.uk/the-solar-independence-plan-for-britain/
[2] http://www.solar-trade.org.uk/sta-1-plan-feed-in-tariff-proposals/
[3] See for example Policy Exchange, Committee on Climate Change, Renewable UK
[4] http://www.solar-trade.org.uk/the-solar-independence-plan-for-britain/
[5] http://www.solar-trade.org.uk/consultation-on-a-review-of-the-feed-in-tariffs-scheme/

Introduction

Background and Context

This report is being written while the government proposes to significantly cut the main subsidy scheme, the Feed in Tariff[6], as well as to remove support for larger projects under the Renewables Obligation[7]. Additional uncertainty remains about the future of the Contracts for Difference (CfD) programme[8] which supports large ground-mounted solar systems through a cross-technology competitive auction. The UK government's "energy policy reset" in November 2015 focussed on gas, nuclear and CCS as the key component of a new energy strategy, marginalising solar. Other negative policy decisions such as the removal of pre-accreditation[9], the halt of the Zero Carbon Homes policy[10] and the removal of a carbon-based levy exemption on renewably generated electricity[11] have been made since the Conservative government was elected in May 2015. The sum of these decisions is a clear direction of travel for the new government.

The STA has clearly stated the damaging nature of these proposals on destabilising the industry, causing boom and bust and wasting previous government investment through subsidies to develop supply chains which reduce costs. An alternative plan was set out in the June 2015 Solar Independence Plan[12] and the STA's view of the proposals is set out in the specific consultation responses[13,14,15].

Whatever the final decisions are on the subsidy proposals, it is clear that the UK government sees the renewables can "stand on their own two feet"[16]. It is therefore critically important to look at the innovative business models that could work without subsidy, and what would be required to make these profitable.

This analysis is not intended to indicate that subsidy-free (specifically, feed in tariff free) models are viable now. It is intended to present a theoretical economic discussion of the types of models that could be developed over the medium term without a feed in tariff. The STA asserts that as a minimum, the government adopts its £1 emergency plan[17], providing a stable glide path for the industry along the path to zero subsidy. A solar market can thrive in a zero subsidy environment, but it order to succeed the transition must be gradual, rather than sudden.

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6 https://www.gov.uk/government/consultations/consultation-on-a-review-of-the-feed-in-tariff-scheme
7 https://www.gov.uk/government/consultations/changes-to-financial-support-for-solar-pv
8 http://renews.biz/100419/cfd-announcement-by-christmas
9 https://www.gov.uk/government/consultations/changes-to-feed-in-tariff-accreditation
10 http://www.theguardian.com/environment/2015/jul/10/uk-scraps-zero-carbon-home-target
11 https://www.ofgem.gov.uk/sites/default/files/docs/2015/10/ccl_exemption_faq.pdf
12 http://www.solar-trade.org.uk/the-solar-independence-plan-for-britain/
13 http://www.solar-trade.org.uk/consultation-on-a-review-of-the-feed-in-tariffs-scheme/
14 http://www.solar-trade.org.uk/decc-consultation-to-close-the-ro-for/
15 http://www.solar-trade.org.uk/decc-consultation-on-feed-in-tariff-accreditation/
16 https://www.politicshome.com/energy-and-environment/articles/news/amber-rudd-speech-conservative-party-conference
17 http://www.solar-trade.org.uk/sta-1-plan-feed-in-tariff-proposals/

Sectors, Business Models and Assumptions

This section describes in broad terms the basis on which the analysis has been done, describing the market sectors and business models that have been chosen for analysis. Additionally, some of the general assumptions taken in the report are described.

Sectors

There are three separate market segments that are considered in this report:

The domestic market covers systems of sizes up to around 4kW, which are installed on the rooves of homes. For simplicity in this report we only consider homes that are owned by their occupants, although future relationships could not develop between landlords and tenants (particularly social landlords) involving solar electricity. Previous research undertaken for the PV Financing project demonstrated that owner-occupiers are the principal investors in domestic solar, and that landlord-tenant based systems are rare.

The commercial market covers systems of many shapes and sizes from 10kW-5MW, installed on the rooves of commercial buildings. The demand profile and roof capacity of commercial building varies significantly. For the analysis, the system was assumed to be a typical 250kW system, on a building that will self-consume all of the electricity: this is an optimistic assumption and will not be the case in every commercial system.

Utility scale solar refers to large-scale ground mounted systems. There has been a significant amount of deployment in this sector over the past 3 years (roughly 5GW). The sizes of these systems range from <1MW to 70MW[18]. For this analysis, we assume a 5MW system co-located with significant demand, reflecting a similar scenario to the Good Practice example of Ketton Cement Works. This reflects the industry view that a profitable future for ground-mounted systems could lie with direct supply to demand, rather than export to the public grid.

Historically, the market has been dominated by the domestic market, and more recently, the utility market. The commercial market, particularly larger commercial rooftop, has underperformed compared to these other markets due to market blockages, but provides interesting potential in a zero-subsidy world.

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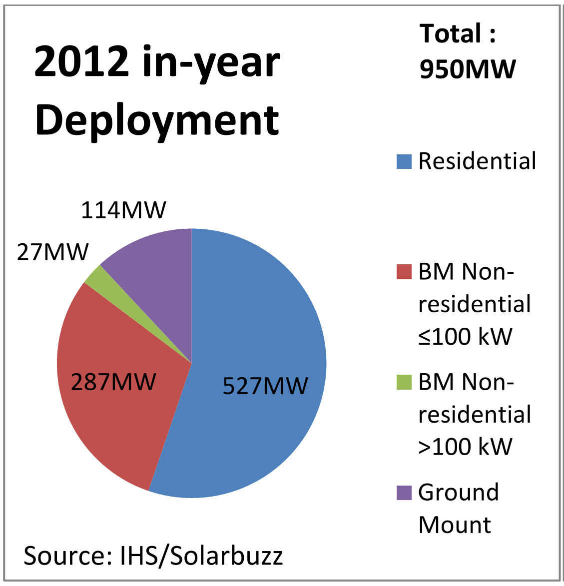
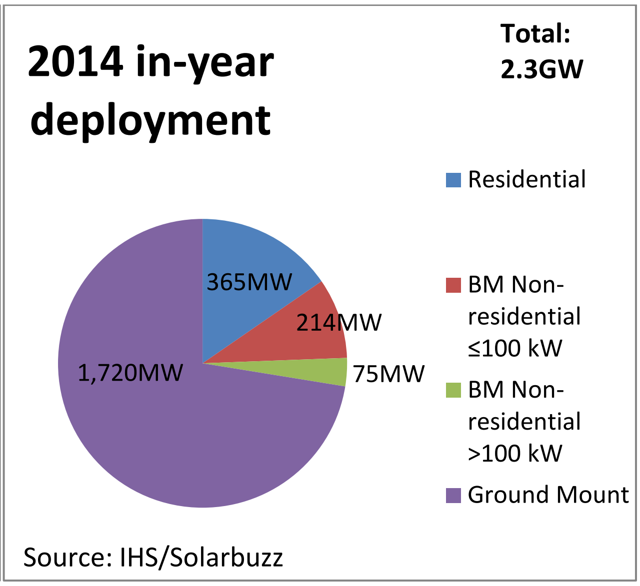
18 http://www.solarpowerportal.co.uk/news/the_government_just_completed_the_uks_largest_solar_farm_56342





Business Models

The models that are examined in this report are listed below.

Figure 1: Business models under analysis

Each of these models is discussed under their respective section, and a profitability analysis undertaken using assumptions for 2016 costs in a low or zero subsidy environment. A wide range of other models exist, including third party PPAs (for domestic), leasing or net-metering. However, this report focusses on those models that already exist with some success with subsidies, rather than those requiring a significant overhaul in the regulatory regime or marketplace.

As clarified in the Background and Context, this report does not aim to suggest that these business models are viable now or that the subsidy schemes will be removed – instead providing a theoretical analysis on some of the potential models that could work in a future without subsidy.

Assumptions

There are some assumptions in this analysis which are common over all scales of solar and are described in this section. Specific assumptions for particular business models will be described individually.

Yield/Performance Ratio

The irradiation (yield) used for domestic and commercial roof-mounted systems is 890kWh/kWp, based on three pieces of evidence. As the evidence is based on real data, other factors such as availability and performance ratio are built into the load factor itself.

Firstly, the UK government Feed-in Tariff load factor analysis from December 2014[19]. Using all the data from this report, the load factor from 275,000 real installations is 9.89%, corresponding to 866kWh/kWp. Secondly, a research paper by Taylor et al[20] used 2,500 real installations monitored for up to 7 years to obtain a long-term mean yield of 886kWh/kWp. Thirdly, the MCS installation guide provides load factors per region, which are legally required to be used by domestic installations when quoting to customers. Zone 11, the centre of the country (Sheffield) has a figure of 893 kWh/kWp[21].

For utility scale systems, as siting can be optimised, a figure of 950kWh/kWp has been used, based on evidence provided by members of the STA.

Electricity prices + increase

A value of 14.4p/kWh (0.20€/kWh) was used for the variable component of domestic energy as published by DECC[22]. This excludes the standing charge, as solar does not offset the requirement for an energy connection. For commercial, we have assumed a cost of 9p/kWh (0.12 €/kWh) based on evidence submitted by members to the government Feed in Tariff consultation. Finally, for utility, a value of 6p/kWh (0.08€/kWh) was used.

Market Segment	Electricity Price	
	p/kWh	EUR/kWh
Residential	14.4	0.20
Commercial	9.0	0.12
Utility	6.0	0.08

For price escalation, DECC project a ~1-2% annual increase in electricity prices[23]. For the purposes of this analysis the electricity prices are increased by 2%, and this value is varied as a sensitivity variable.

[19] DECC, Feed-in Tariff load factor analysis Dec 2014, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/386897/FiT_load_factor.pdf

[20] "Monitoring thousands of distributed PV systems in the UK: Energy production and performance", University of Sheffield, April 2015.

[21] http://www.solar-trade.org.uk/wp-content/uploads/2015/10/MCS-Sheet.pdf

[22] DECC, Quarterly Energy Prices: September 2015, table 2.2.4. 14p in 2014 £, inflated to 2016 £ and removed VAT.

[23] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal, Table 9.

Degradation

Panel manufacturers guarantee performance of 80% after 25 years, which would imply a degradation factor per year of roughly 0.8%. However, this is a *minimum guaranteed* performance, so not necessarily indicative of expected real-world performance. The STA has used a figure of 0.5% per year, based on the median reported value by NREL[24] and others[25]. This corresponds to performance of 90% after 20 years and 88% after 25 years.

System Lifetime

The system operation lifetime differs between domestic and commercial systems. Panel performance in domestic installations is typically guaranteed for 25 years, making this an acceptable assumed lifetime. For commercial installation, commercial entities cannot guarantee the project beyond the 20 year tariff lifetime so 20 years is appropriate. It is important to note that these lifetimes do not necessarily correspond to the expected lifetime of a system, but the lifetime that can be used for a financial calculation i.e. a discounted cash flow. For utility scale systems, planning permission is typically given for 25 years which makes this a reasonable assumption of lifetime.

Market Segment	Assumed system lifetime (years)
Residential	25
Commercial	20
Utility	25

One exception to this case is the STA £1 Plan, which contains a domestic Feed in Tariff lasting for 20 years. As it was not possible to break out tariff lifetime and usage lifetime, the project lifetime was set as 20 years for this model.

System costs

Broadly, costs are those used from a recent UK government report[26]. However, particularly in the commercial and utility sectors, these costs are based on very few responses and therefore are not robust. For the commercial sector industry knowledge and discussions were used to adjust the cost data, and in the utility scale a recent STA cost report[27] was used for additional evidence.

Other assumptions

An exchange rate between GBP and EUR of 1.37 was used, based on the 2015 average interbank rate[28]. The analysis was done on a real, undiscounted basis, matching the approach that is taken for the UK government setting the Feed in Tariff rates.

[24] http://www.nrel.gov/docs/fy12osti/51664.pdf
[25] J. Taylor, J. Leloux, L. Hall, A. Everard, J. Briggs and A. Buckley, "Performance of Distributed PV in the UK: a Statistical Analysis of Over 7000 systems" in 31st Eur. PV Solar Energy Conf., Hamburg, September 2015.
[26] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/456187/DECC_Small-Scale_Generation_Costs_Update_FINAL.PDF
[27] http://www.solar-trade.org.uk/wp-content/uploads/2015/03/LCOE-report.pdf
[28] Calculated using http://www.oanda.com/currency/average

Domestic solar market

Drivers in the domestic market

The driver in the domestic market over the last few years has mainly been economic, with publications such as Which?, Money Savings Expert and This Is Money advising people to install solar as a sound financial decision, rather than an environmental one. Environmental drivers do remain, but for most over the last few years the environmental benefits have been the cherry, rather than the whole cake. In a low subsidy world, the main driver is likely to remain the economic case, but other factors will become more and more important.

As more and more of the 660,000 solar homes are bought and sold, more data will become available on how solar is reflected in house prices. Doing up a kitchen or bathroom isn't seen as an investment with an IRR and payback, but instead as a way of improving the value of a home for reselling.

solar should start to be viewed in the same way: not as an investment with a payback, but as an investment reflected in the house price. Research in this area has already begun – for example, a recent Barclays report showed that solar panels were the most desirable technology to add to a home, with homeowners saying they would be happy to pay on average £2,000 more for a solar home[29].

Other drivers such as technology (wanting a cutting edge home with the latest in smart technology), aspiration (keeping up with ones peers) and energy independence (not buying energy from the Big Six) will also start to come into play in a low-cost, low-subsidy world.

[29] http://www.newsroom.barclays.com/r/3261/barclays_mortgages_reveals_the_top_technology_that_can

Drivers to domestic solar installations

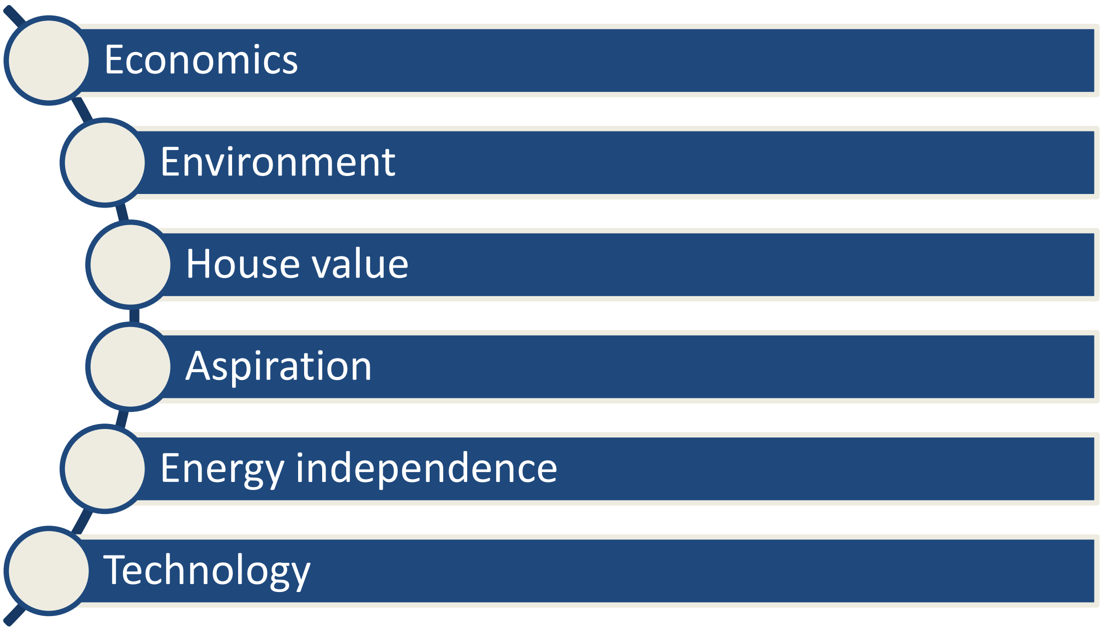


Figure 2: Drivers in the domestic market

Future Business Models in the domestic market

In the past, financial returns from solar PV have been highly reliant on subsidies. With a smaller and smaller generation tariff (and alongside falling costs) the electricity bill savings start to dominate as shown below.

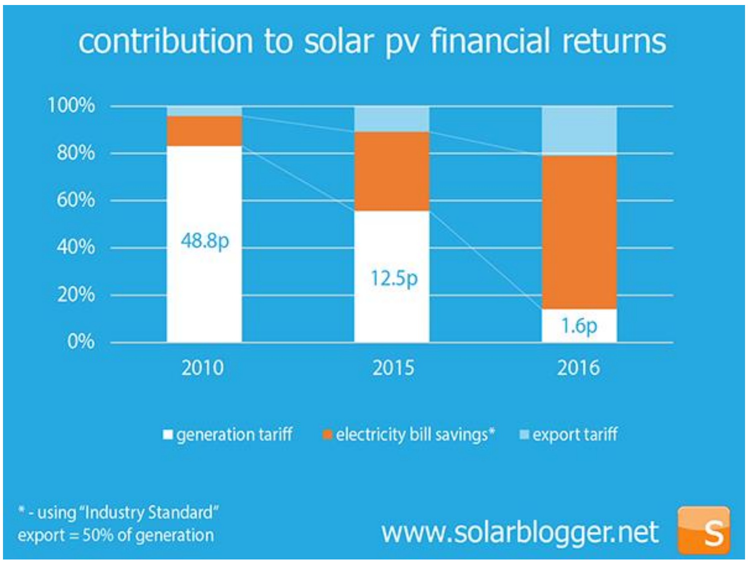


Figure 3: Contributions to Solar PV financial returns. Source: SolarBlogger

However, 50% self-consumption has long been an over-assumption - evidence shows that more realistic values are around the 15-35% mark. In a zero-subsidy world, where self-consumption is the key revenue stream, this can make or break the financial model.

How can the customer offering be made viable without subsidy? Either the export value needs to rise – although it would have to by a lot to make a difference – or self-consumption needs to rise. Increases to the export tariff rate, net-metering or selling the excess electricity locally all require regulatory change. In the current environment this seems unlikely so maximising self-consumption seems the best bet for making the economic case more viable. Some of the ways of doing this are discussed in the box below.

Although the many approaches described to increase self-consumption hold a lot of promise, Rome was not built in a day and consumers will not change their habits overnight. In the meantime, to smooth the cliff for the industry the STA developed its £1 Plan, a bridging strategy to help the industry continue to reduce costs on the path to zero subsidy. The analysis in this report focusses on two business models: lower tariffs (corresponding to the STA £1 Plan) and zero tariffs with maximising self-consumption, from either having a storage system or having a smaller system. It is important to note that this doesn't mean the STA expects zero tariffs in January – the analysis is based on a theoretical, future scenario with zero tariffs.

With decreasing generation tariffs, self-consumption will need to increase in the long term to provide an economic return. However in the shorter term, lower tariffs could bridge the gap, keeping the economic case while giving the other drivers described in the previous section time to develop. We analyse the profitability of these two business models in this report.

- Lower Tariffs – a continued Feed in Tariff model based on the STA's suggested "£1 Plan" tariffs to provide a bridging mechanism to zero subsidy.
- Maximising self-consumption – through smaller systems or the introduction of smart technologies such as storage, this zero subsidy model is based on increasing self-consumption and reducing electricity exported to the grid.

Figure 4: Domestic business models analysed

Both of these business models use a similar structure, which is described below.

Maximising Self-Consumption Business Model Structure

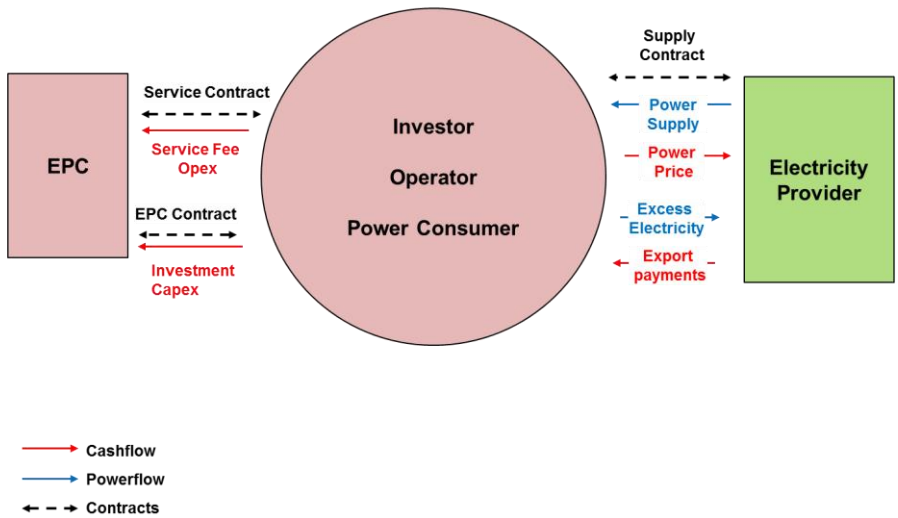


Figure 5: Maximising self-consumption: business model structure

This business model comprises of three major actors:

- Investor/Operator/Consumer: the homeowner. This entity owns their house, invests fully in the system and raises no debt financing against this system. They are also the operator and the power consumer.
- Engineering, Procurement and Construction (EPC): this is the responsible party who, in exchange for the capex, installs the system, and in exchange for opex, maintain the system on an ongoing basis. In theory the operations and maintenance contractor may not be the original EPC, but this is mostly the case at the moment in the domestic market.
- Electricity provider: this company provides the operator with their grid electricity connection, and buys any excess electricity produced by the solar system in exchange for the export payments, which we have assumed as the current export price under the Feed in Tariff. They also provide any required electricity to the consumer that is not produced by the solar system, and pay the Feed in Tariff (generation tariff) for generated solar power.

Debt financing is not included within this simple model as, without very low-cost finance (which seems unlikely in the current regulatory framework) this model becomes unprofitable. There is also no relationship between the homeowner and the grid operator directly, although the installation will need to be approved by them for connection to the grid and the power flows will physically go through the grid rather than through the electricity provider.

Lower tariffs

This model continues the current Feed in Tariff scheme, with reduced tariffs as developed by the STA for their £1 Plan. These tariffs were developed as part of the response to a recent consultation from

the government to reduce the tariffs by up to 87%. The STA's proposal was to cut the tariffs by less and reduce them toward zero over the 3 year period.

The STA believes that this can provide a bridging mechanism allowing the industry to adjust to the new economics of solar with no subsidy, and changing the consumer viewpoint from one based on financial payback from government subsidies to one of a longer-term view on energy prices, the true value of solar on homes and development of other drivers such as aspirational or technological.

Profitability Analysis

The STA £1 Plan domestic tariff in 2016 (8p/kWh, 0.11EUR/kWh) is based on an ideal 4kW system, which provides returns of around 6-8% and a payback period of 10-12 years. Using a less ideal 3kW system with a lower self-consumption rate, the returns are around 4.5% with a payback of 13 years[30]. This is a lower return than those that have we have seen in the market over the past few years, but could potentially allow continued (if reduced) deployment if costs reduce. The tariffs drop in a transparent and clear way over the next 3 years, ending up at 3.2p in 2019. During this time, the industry can develop business plans and consumer offerings around reduced tariffs and will be in a better position to manage the transition to zero subsidy.

Project Overview

PV Project		
PV System Size	kWp	3
Specific System Cost	GBP/kWp	1,584
Total System Cost	GBP	4,751
Investment Subsidy	GBP	-
Total System Cost incl. Subsidy	GBP	4,751
Fixed Operation Costs	GBP p.a.	24
Variable Operation Costs	GBP/kWh	-

PV Generation		
Specific Yield	kWh/qm/a	1072
Performance Factor	%	83%
Specific System Performance	kWh/kWp/a	890
Degradation	% p.a.	0.50%

Investment			
Project Duration		Years	20
Equity		GBP	4,751
Debt (Gearing)	-	GBP	-
Loan Tenor		Years	-
Interest Rate		%	-
Discount Rate		%	0.0%

PV Business Model				
Category		Share	Unit	Price
Feed-in Tariff		100%	GBP/kWh	0.0800
Self-consumption		30%	GBP/kWh	0.1440
	Fees		GBP/kWh	-
Net-metering		-	GBP/kWh	-
	Fees		GBP/kWh	-
	Excess Electricty		GBP/kWh	-
PPA Tariff		50%	GBP/kWh	0.0485
	Fees		GBP/kWh	-
	Oversupply Price		GBP/kWh	-
	Undersupply Penalty		GBP/kWh	-

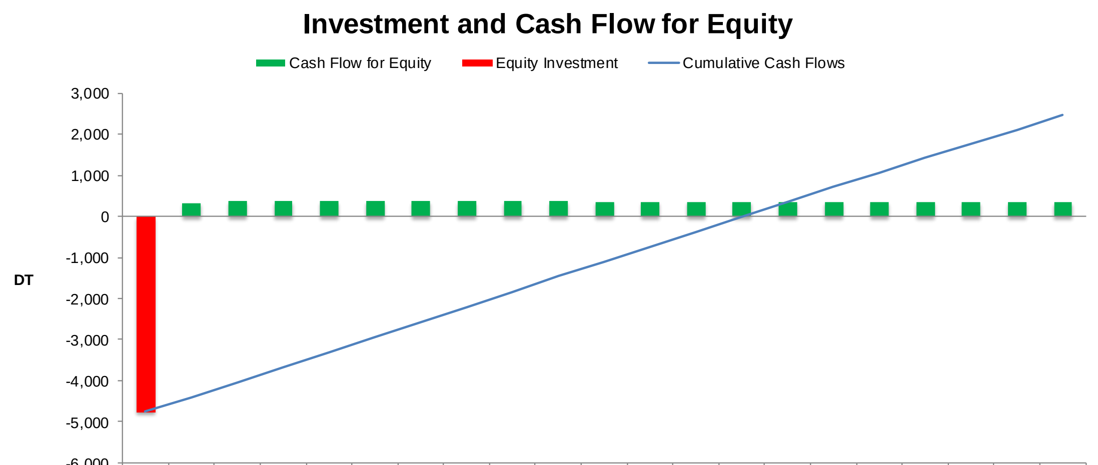
Results		
Net-Present Value	GBP	2,456
Project IRR	%	4.42%
Equity IRR	%	4.42%
Payback Period	Years	13.03
LCOE* (w/o subsidy)	GBP/kWh	0.11
LCOE (w subsidy)	GBP/kWh	0.11
Min DSCR**	x	-
Min LLCR***	x	-

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

Figure 6: Project overview for lower Feed in Tariff

[30] Note that this is artificially low due to the projection duration being set at 20 rather than 25 years, as tariff and self-consumption life could not be split. A 25 year duration gives a return of 5.7%.

Project Cash Flows



	-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Equity Investment	(4,751)																				
Cash Flow for Equity	-	337	370	370	369	370	368	368	367	367	365	364	363	362	359	357	355	354	350	347	343
Cumulative Cash Flows	(4,751)	(4,413)	(4,043)	(3,674)	(3,304)	(2,934)	(2,566)	(2,198)	(1,831)	(1,464)	(1,099)	(735)	(372)	(10)	350	707	1,062	1,416	1,766	2,113	2,456

Operations Year

Figure 7: lower tariffs cashflows

Maximising Self-consumption

This business model focusses on maximizing self-consumption in a zero generation Feed in Tariff environment. This could come from additional components such as storage or power diverters to increase self-consumption or sizing a system much smaller focusing on reducing costs. Any remaining electricity that is not self-consumed is sold through an export PPA mechanism, assumed to be the same as the current Feed in Tariff export mechanism. The export is also assumed to be directly measured, rather than assumed (as 50%) at present.

Firstly, the base scenario of current self-consumption rates (30%) with no storage and a large 3kW system at 2016 prices is not profitable – not paying itself back over the period. This is due to the low level of self-consumption (which is high value: 0.20 EUR/kWh) and the high level of export (which is low value: 0.07 EUR/kWh). Therefore, in order to make a profitable project, either the self-consumption needs to be increased or the value of the exported electricity needs to be significantly increased.

The exported electricity is assumed to be based on the export tariff: even in a low or no subsidy world, the export guarantee for 20 years is likely to remain. This is intended to be based on the real value of that electricity to a supplier. However, there is a theoretical potential for others to buy that electricity in a peer-to-peer way. This is already happening at a commercial level with a trial marketplace running for 6 months[31]. However, the regulatory framework for this is not in place at the domestic level, and is unlikely to be in the short term. This analysis therefore focusses on increasing self-consumption, rather than increasing the value of the exported electricity.

[31] https://piclo.uk/

How do you increase domestic self-consumption?

There are many options out there to increase self-consumption. Some of these are listed below.

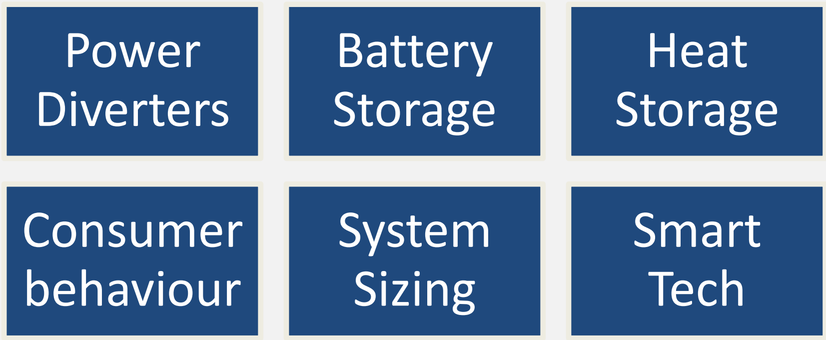


Figure 8: Tools to maximise self-consumption

Power diverters are very popular at the moment given that export is deemed. These work by diverting power that would otherwise be exported, typically to immersion heaters for hot water. For a few hundred pounds, self-consumption can be significantly increased, but the economic benefit is not as significant as it is usually offsetting lower-value heating fuel (typically gas) rather than higher-value electricity.

Heat storage can be a low-cost alternative to battery storage. Storage heaters have been around for years, and innovative heat storage solutions are currently being developed. However, this does suffer from the same problem as power diverters in terms of economics – the downgrade of value from electricity to heat.

Battery storage and Electric Vehicles (EVs) have a very bright future with solar, with report after report saying that solar + storage + EVs are a gamechanger for the energy industry. The domestic storage industry isn't quite geared up yet, and costs are still high, but breakthroughs in EVs may spark the domestic storage revolution.

Changing **consumer behaviour** can also have an impact: if more power is used during the day, rather than in the evening, it will increase self-consumption. However, it is difficult to change a consumer's lifestyle around solar so there is only a limited amount of impact this can make.

Sizing systems to demand can definitely provide higher self-consumption. Historically systems have been sized to the tariff bands (maxing out a roof to 4kW) but without tariffs, the balance of size and self-consumption could lead to smaller systems more appropriately sized to demand, particularly when matched with some real consumption profile data.

Smart tech in the home linked with the internet of things could provide active demand side management: if your fridge could overcool in the daytime while the sun is shining, switching off later, that could increase self-consumption. Together with pricing signals from time of use tariffs, managing the demand, rather than the supply, could be a productive way of increasing self-consumption.

Profitability Analysis

This report does not analyse the difference scenarios for increasing self-consumption above in detail, as it requires a significant amount of additional modelling. This report could be enhanced at a later date with other scenarios from additional modelling done through this project or by the STA. In this report we take two simple cases to discuss their profitability.

1. A system including storage
2. A smaller PV system

We recognise that these scenarios are examples, and not a full analysis. The self-consumption rates and costs (particularly on storage) are assumptions that are made. However, it provides a starting point for profitability analysis.

The key assumptions used and analysis results from these different scenarios are tabulated below:

	Zero tariffs - Maximising self-consumption	
	Storage	*Smaller system*
System size (kW)	3 kW (+ 3kWh)	1 kW
Aggressive cost assumptions for 2016	£4750 (+ £2100) €6508 (+€2877)	£3200 €4384
Self-consumption (%)	70%	65%[32]
Export (%)	30%	30%
IRR (%)	1-2%	~0%
Payback (years)	20-25 years	25-30 years

Scenario 1: Enhanced self-consumption rates through storage

The first scenario involves the use of technology such as electricity storage, power diverters to hot water heating or electric vehicle charging to increase self-consumption of a 3kW solar system. The additional technology, while coming at a cost, in theory pays for itself by increasing self-consumption and minimising export to the grid.

Taking an assumption of £700/kWh[33], a 3kWh battery system and an uplift of self-consumption to 65% (all fairly optimistic assumptions), the system gives a return of 0.38%, with a payback of 24 years.

[32] The self-consumption export in this scenario does not sum to 100% due to losses from the storage system.
[33] Based on the low end of Li-ion costs from the Decentralised Energy Transition, http://www.solar-trade.org.uk/the-decentralised-energy-transition/

Project Overview

PV Project		
PV System Size	kWp	3
Specific System Cost	GBP/kWp	2,280
Total System Cost	GBP	6,840
Investment Subsidy	GBP	-
Total System Cost incl. Subsidy	GBP	6,840
Fixed Operation Costs	GBP p.a.	21
Variable Operation Costs	GBP/kWh	-

PV Generation		
Specific Yield	kWh/qm/a	1060
Performance Factor	%	84%
Specific System Performance	kWh/kWp/a	890
Degradation	% p.a.	0.50%

Investment			
Project Duration		Years	25
Equity		GBP	6,840
Debt (Gearing)	-	GBP	-
Loan Tenor		Years	-
Interest Rate		%	-
Discount Rate		%	0.0%

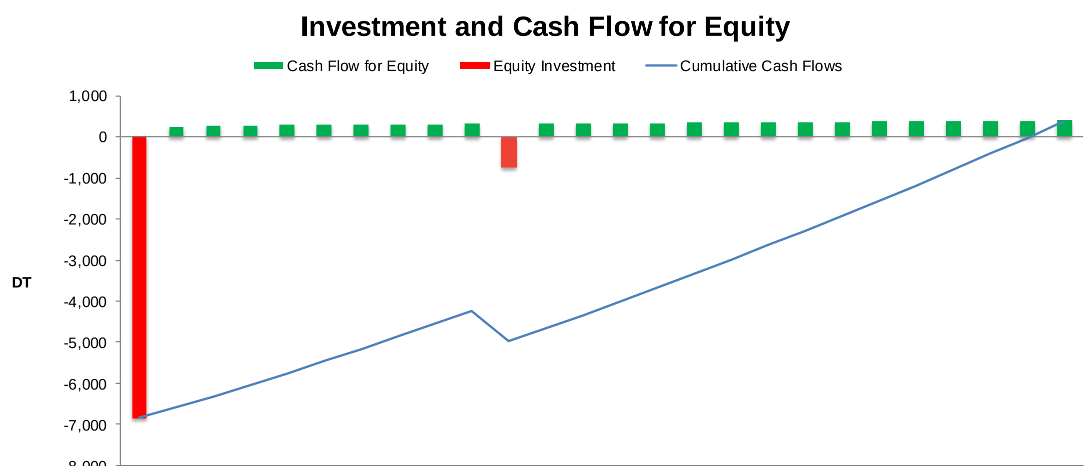
PV Business Model			
Category	Share	Unit	Price
Feed-in Tariff	-	GBP/kWh	-
Self-consumption	65%	GBP/kWh	0.1440
Fees		GBP/kWh	-
Net-metering	-	GBP/kWh	-
Fees		GBP/kWh	-
Excess Electricty		GBP/kWh	-
PPA Tariff	30%	GBP/kWh	0.0485
Fees		GBP/kWh	-
Overysupply Price		GBP/kWh	-
Undersupply Penalty		GBP/kWh	-

Results		
Net-Present Value	GBP	368
Project IRR	%	0.38%
Equity IRR	%	0.38%
Payback Period	Years	24.07
LCOE* (w/o subsidy)	GBP/kWh	0.13
LCOE (w subsidy)	GBP/kWh	0.13
Min DSCR**	x	-
Min LLCR***	x	-

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

Figure 9: Overview of Solar + Storage analysis

Project Cash Flows



	-	1	2	3	4	5	6	7	8	9	10	11	12	13
Equity Investment	(6,840													
Cash Flow for Equity	-	248	277	281	286	291	295	300	305	310	(736)	319	324	330
Cumulative Cash Flows	(6,840	(6,592	(6,315	(6,033	(5,748	(5,457	(5,162	(4,862	(4,558	(4,248	(4,983	(4,664	(4,340	(4,010

	14	15	16	17	18	19	20	21	22	23	24	25
Equity Investment												
Cash Flow for Equity	335	340	345	352	356	362	368	374	379	385	391	399
Cumulative Cash Flows	(3,676	(3,337	(2,992	(2,641	(2,285	(1,924	(1,557	(1,183	(805)	(420)	(30)	368

Operations Year

Figure 10: Cashflows for solar + storage domestic system

This, clearly, is not currently a viable business case. However, the costs of storage are following a similar pathway to the cost reductions in solar over previous years, which may make this model more attractive in the coming years, particularly with higher electricity prices. Additionally, other less expensive technology such as power diverters which heat water with the excess electricity may have

an impact on the returns by increasing self-consumption at a lower cost. However, as in many cases this technology is not decreasing *electricity* consumption but *gas* consumption, the offset is lower. This more nuanced picture warrants more analysis on the impact different smart technologies can have on self-consumption, as well as a full analysis of future profitability of solar + storage systems.

Scenario 2: enhanced self-consumption rates through smaller system

This scenario does not pay itself back over the 25 year period, and therefore does not have an IRR. The projected payback would be 30 years, if the lifetime of the system were extended. Costs need to come down in order for this model to have an impact, both through simplifying installation practice (e.g. modular scaffolding and simplified mounting systems) and volume deployment (installing on an entire street).

Project Overview

PV Project			
PV System Size		kWp	1
Specific System Cost		GBP/kWp	3,200
Total System Cost		GBP	3,200
Investment Subsidy		GBP	-
Total System Cost incl. Subsidy		GBP	3,200
Fixed Operation Costs		GBP p.a.	22
Variable Operation Costs		GBP/kWh	-

PV Generation		
Specific Yield	kWh/qm/a	1060
Performance Factor	%	84%
Specific System Performance	kWh/kWp/a	890
Degradation	% p.a.	0.50%

Investment			
Project Duration		Years	25
Equity		GBP	3,200
Debt (Gearing)	-	GBP	-
Loan Tenor		Years	-
Interest Rate		%	-
Discount Rate		%	0.0%

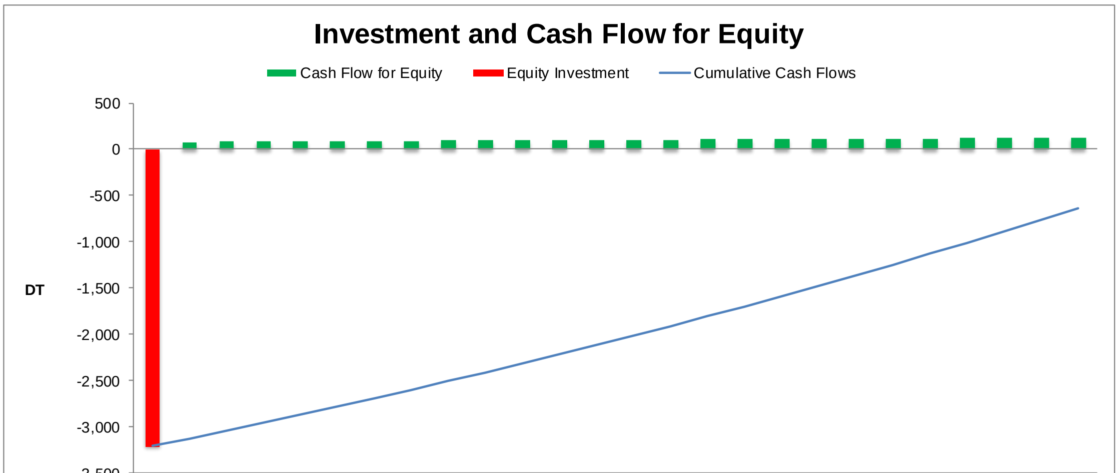
PV Business Model			
Category	Share	Unit	Price
Feed-in Tariff	-	GBP/kWh	-
Self-consumption	70%	GBP/kWh	0.1440
Fees		GBP/kWh	-
Net-metering	-	GBP/kWh	-
Fees		GBP/kWh	-
Excess Electricty		GBP/kWh	-
PPA Tariff	30%	GBP/kWh	0.0485
Fees		GBP/kWh	-
Overysupply Price		GBP/kWh	-
Undersupply Penalty		GBP/kWh	-

Results		
Net-Present Value	GBP	(642)
Project IRR	%	0.00%
Equity IRR	%	0.00%
Payback Period	Years	#NUM!
LCOE* (w/o subsidy)	GBP/kWh	0.18
LCOE (w subsidy)	GBP/kWh	0.18
Min DSCR**	x	-
Min LLCR***	x	-

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

Figure 11: Maximising Self-consumption project overview (smaller system)

Project Cash Flows



	-	1	2	3	4	5	6	7	8	9	10	11	12
Equity Investment	(3,200												
Cash Flow for Equity	-	73	83	85	87	88	90	91	93	95	97	98	100
Cumulative Cash Flows	(3,200	(3,127	(3,043	(2,959	(2,872	(2,784	(2,694	(2,603	(2,509	(2,414	(2,318	(2,220	(2,119

	13	14	15	16	17	18	19	20	21	22	23	24	25
Equity Investment													
Cash Flow for Equity	102	104	106	108	110	112	114	116	118	120	122	124	127
Cumulative Cash Flows	(2,017	(1,913	(1,808	(1,700	(1,591	(1,479	(1,366	(1,251	(1,133	(1,013	(892)	(768)	(642)

Figure 12: Cashflows for small size domestic PV system

As the self-consumption return is heavily based on future electricity prices, the model is sensitive to changes in the electricity price escalation (i.e. how electricity prices will change over time). An annual increase of 5%-10% in electricity prices are required for this model to be profitable, markedly different from the average 1.3% that the government predict over the next 30 years.

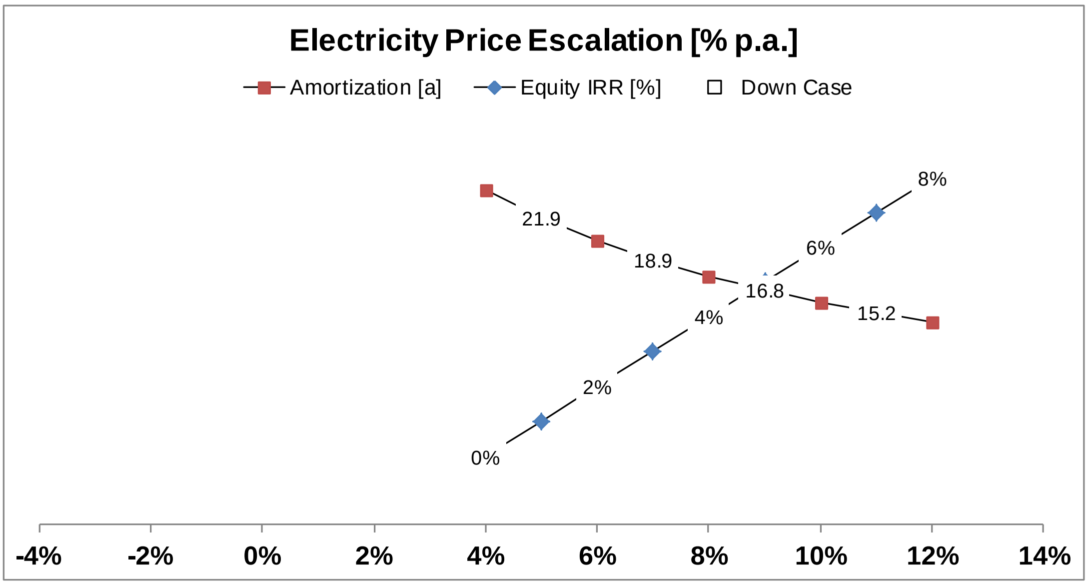


Figure 13: Sensitivity analysis on electricity price escalation for system sizing scenario

Conclusions: the domestic market

The analysis shows that the tariffs proposed by the STA as part of their £1 Plan would deliver a profitable outcome under the assumptions made and could provide a bridging mechanism to a zero subsidy market.

For maximising self-consumption, neither future scenario provides the rates of return required for a significant market at 2016 prices. There is potential flexibility and innovation to be developed over the coming years – reducing costs through the use of low-cost components and volume deployment can decrease solar PV installation costs. From a UK perspective, the removal of the EU-China Minimum Import Price (MIP) for panels provides one part of the picture in terms of cost reduction. However, stability and volume are required in the market to deliver these cost reductions.

Further analysis is warranted, focussing on future cost reductions, optimisation of system sizing and self-consumption, and the impact storage and other smart technologies have on self-consumption.

Zero subsidy models do not yet work in the UK and models need time to develop. Maximising self-consumption is one long term solution, but the costs of storage and PV need to come down for this to work. Policy stability is key for market and consumer confidence – this can be improved as subsidies are less relied on but additional support is required in the short term for the domestic market to emerge as a healthy market in a zero subsidy world.

Commercial rooftop market

This market segment has historically been relatively small in the UK, dwarfed by the domestic and large-scale markets. However, it is one that could potentially thrive in a lower subsidy environment. The term commercial rooftop also covers a huge range of sizes and usage profiles, from small agricultural buildings to large datacentres. The analysis we have developed focusses on those models and scales that could be most successful, recognising that as the market is so varied inevitably each project will be unique.

Drivers in the commercial market

The drivers in the commercial market are economic – even more so than the domestic market – and businesses typically have a much shorter view that domestic customers. This means the required payback is typically less than 10 years, and the required IRR at least 10%. In most cases, solar is not a core investment, and therefore the business case for solar has considerably outperform the other options in order to secure internal buy-in and investment. Alternatively, the focus can be shifted from an investment to a cost-saving exercise through the use of a PPA-based model to change the economic parameters, allowing the company to save money immediately rather than outlaying a significant amount and then recouping it through self-consumption bill savings.

Crucially in the commercial market, decision making processes are much longer than either that of a homeowner (for the domestic market) or that of a landowner (for the utility market). Because of this,

long-term policy stability is paramount. As the UK's solar policy has changed so much in the last 5 years, many projects have been started only to be shelved due to policy uncertainty.

The installation of "greening" measures including solar can be a driver for the market, but in most cases this is as part of a strategic approach to corporate social responsibility. For example, Marks and Spencer's Plan A[34] includes a commitment to 100% renewable energy (50% of this from small scale renewables by 2020[35]) as part of a suite of ethical and environmental goals. This matches many other large companies who are part of the RE100[36] - companies committed to renewable energy will be likely to use solar as a proportion of these 100% renewable energy supply.

Independence from energy price volatility is a key future driver for the commercial market: if solar as a service (i.e. a PPA-based model) can provide a proportion of the building's power at a rate that is locked in at a rate lower than the electricity price, this can be highly attractive. However, the PPA rate and escalation, hassle factor (business interruption) of installation and likelihood of the business moving are key sensitivities than can make or break the business case.

Future Business models in the commercial market

There is great potential for solar to work without subsidy in the commercial market. The combination of efficiencies of scale on cost, high demand (leading to high self-consumption) and high electricity prices (commercial prices per kWh are typically 60-70% of the residential tariff and double that of wholesale) mean that the economic argument for commercial rooftop could be highly attractive.

However, despite the UK government promising to ignite "rocket boosters" under the commercial market in 2014[37], uptake in this area has been less than expected. The market moves slower than the domestic market, and models will need to be demonstrated as attractive and proven to become widespread.

There are two models that are analysed as part of this report.

- Firstly, for those businesses willing to invest and own themselves, we consider 100% self-consumption and self-ownership, together with a loan of 80% of the project capex.
- For those businesses who want to reduce operating costs (energy bills), but choose to not invest directly in the plant, a PPA model may be appropriate. We therefore consider a 100% direct PPA from a third party owner to the power consumer, with no capital invested by the consumer.

For the profitability analysis, a typical commercial installation of around 250kW is considered. This has typically has been the size of choice due to the banding of subsidy schemes, and in a low subsidy

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[34] http://corporate.marksandspencer.com/plan-a
[35] http://corporate.marksandspencer.com/plan-a/our-stories/stores-operations/solar-energy
[36] "RE100 is a collaborative initiative of influential businesses committed to 100% renewable electricity, working to massively increase corporate demand for renewable energy." http://there100.org/
[37] http://www.solarpowerportal.co.uk/news/barker_promises_to_put_rocket_boosters_under_commercial_and_industrial_3367

environment this stratification of system sizes is less likely. Additionally, 100% self-consumption is not necessarily possible in every case: however, industry evidence shows there are many commercial buildings with high demand that would provide the initial market for zero-subsidy commercial rooftop, with others coming later after the models are more proven, more efficient and more attractive.

Self-ownership and self-consumption

This model takes the case where a company owns the system themselves, and pays back the investment solely through the self-consumption.

This business model is structured as below:

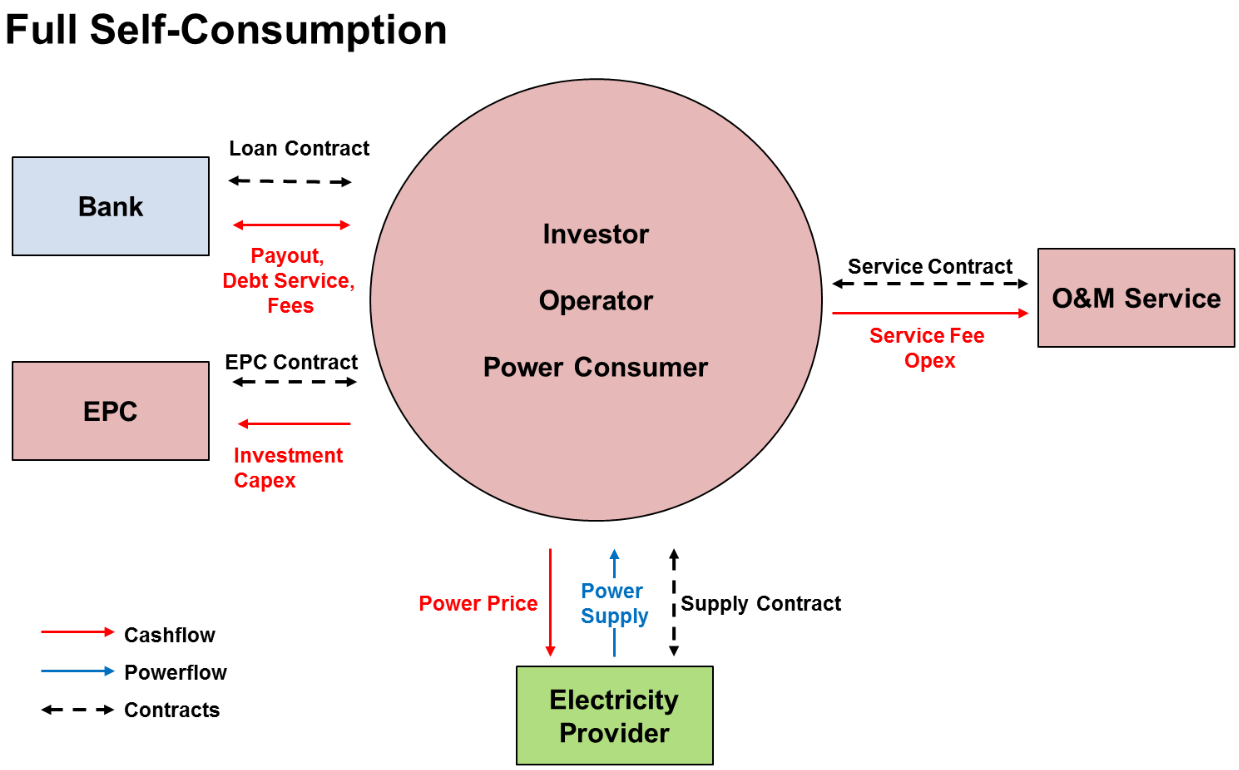


Figure 14: Business structure for commercial and utility Full Self-Consumption

- Investor/Operator/Consumer: the building owner. This entity owns the building, invests fully in the system and takes out a loan in order to pay for the system. They are also the operator and the power consumer.
- EPC (Installer): this is the responsible party who, in exchange for the capex, install the system.
- Electricity provider: this body provides the power consumer with their grid electricity connection, and provides any non-solar generated power requirements in exchange for the power price.
- O&M service: this company, which could also be the EPC, provides maintenance and monitoring of the system, in exchange for a service fee (opex) paid for by the operator.
- Bank: a bank or other lending body provides the debt financing for a proportion of the capex.

In this model, no excess electricity is produced as all the electricity generated is used on-site.

Profitability analysis

The profitability analysis for this model assumed that 60% of the capex of the project was funded through a loan. With aggressive cost assumptions and all the electricity self-consumed, the project gives an IRR of around 7% and a payback period of 19 years. This would be unlikely to be attractive to a commercial customer.

Project Overview

PV Project			
PV System Size		kWp	250
Specific System Cost		GBP/kWp	900
Total System Cost		GBP	225,000
Investment Subsidy		GBP	-
Total System Cost incl. Subsidy		GBP	225,000
Fixed Operation Costs		GBP p.a.	1,575
Variable Operation Costs		GBP/kWh	-
PV Generation			
Specific Yield		kWh/qm/a	1060
Performance Factor		%	84%
Specific System Performance		kWh/kWp/a	890
Degradation		% p.a.	0.50%
Investment			
Project Duration		Years	20
Equity		GBP	90,000
Debt (Gearing)	60%	GBP	135,000
Loan Tenor		Years	10
Interest Rate		%	5.5%
Discount Rate		%	7.0%

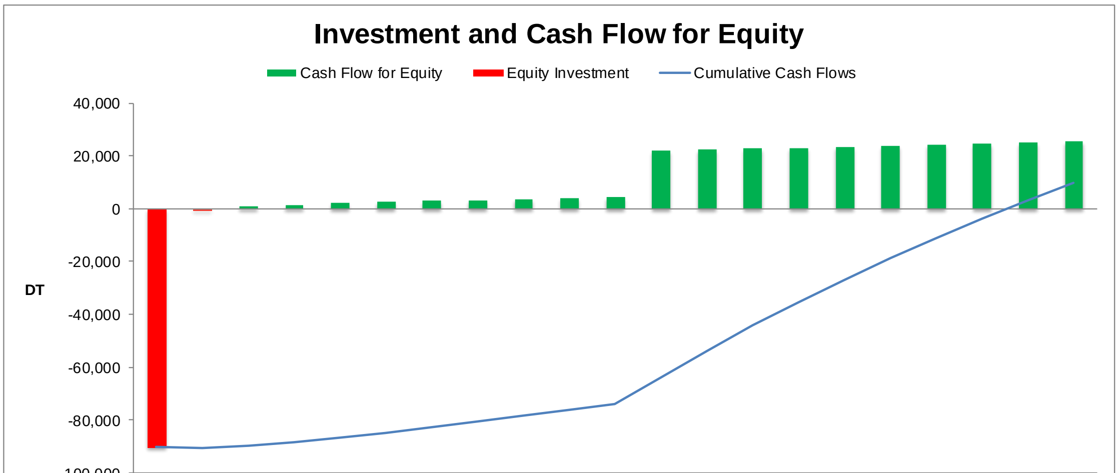
PV Business Model			
Category	**Share**	**Unit**	**Price**
Feed-in Tariff	-	GBP/kWh	-
Self-consumption	100%	GBP/kWh	0.0900
Fees		GBP/kWh	-
Net-metering	-	GBP/kWh	-
Fees		GBP/kWh	-
Excess Electricty		GBP/kWh	-
PPA Tariff	-	GBP/kWh	-
Fees		GBP/kWh	-
Overysupply Price		GBP/kWh	-
Undersupply Penalty		GBP/kWh	-

Results		
Net-Present Value	GBP	10,059
Project IRR (modified discount rate)	%	6.98%
Equity IRR (modified discount rate)	%	7.47%
Payback Period	Years	18.56
LCOE* (w/o subsidy)	GBP/kWh	0.10
LCOE (w subsidy)	GBP/kWh	0.10
Min DSCR**	x	0.95 x
Min LLCR***	x	1.13 x

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

Figure 15: Project overview for commercial self-consumption model

Project Cash Flows



	-	1	2	3	4	5	6	7	8	9	10
Equity Investment	(90,000										
Cash Flow for Equity	-	(832)	1,141	1,448	2,398	2,773	3,036	3,362	3,693	4,091	4,369
Cumulative Cash Flows	(90,000	(90,778	(89,781	(88,599	(86,770	(84,792	(82,769	(80,676	(78,527	(76,302	(74,081

	11	12	13	14	15	16	17	18	19	20
Equity Investment										
Cash Flow for Equity	21,988	22,339	22,762	23,057	23,424	23,796	24,245	24,558	24,947	25,343
Cumulative Cash Flows	(63,634	(53,715	(44,270	(35,328	(26,838	(18,778	(11,102	(3,837)	3,062	9,611

Operations Year

Figure 16: Cash flows for commercial self-consumption model

Sensitivities

There are two key sensitivities that could enable some scenarios to be profitable, but the extremes of the sensitivities must be taken for this to be case.

Firstly, the analysis on system price (capex) sensitivity shows that this could be profitable (>10% IRR and ~10 year payback) if capex costs drop by 35%.

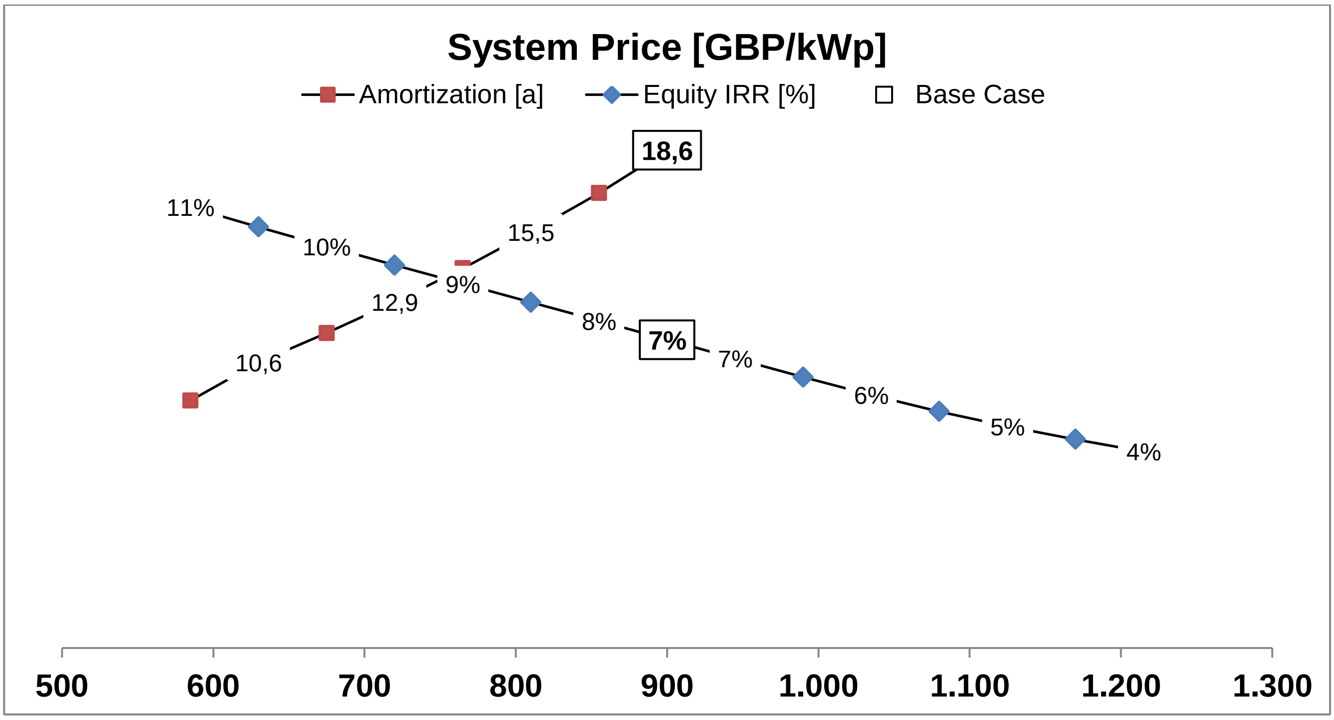


Figure 17: Sensitivity of Commercial Self-consumption business model to capex

Secondly, the electricity price escalation has a significant effect on the economic case. If instead of using a 2% yearly increase, a 10% figure is used, the project IRR is around 20% with a payback of 10 years.

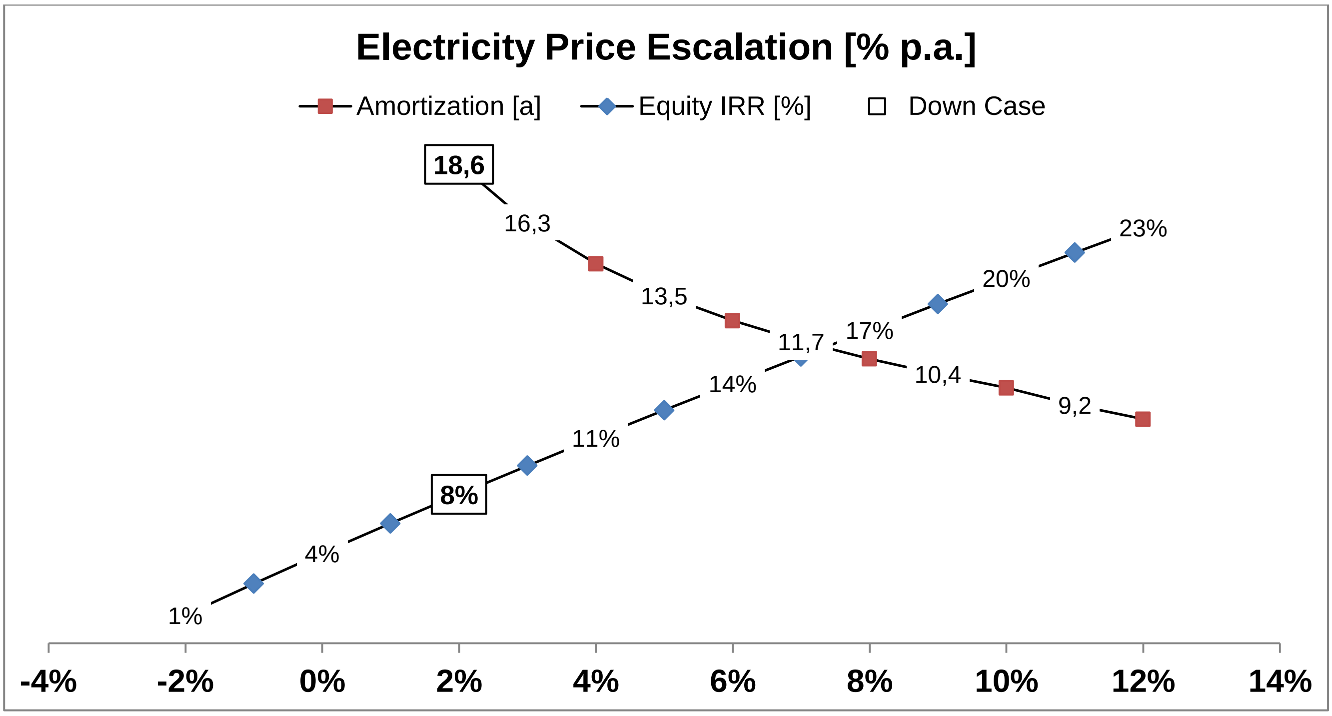


Figure 18: Sensitivity of Commercial Self-consumption business model to electricity price escalation rates

In summary, this model can be profitable for businesses, but only with significantly reduced costs or electricity price escalation assumptions.

Third party ownership: PPA

An alternative model is where the building owner pays nothing for the installation, instead purchasing lower-cost energy from the third party owner of a system. This type of model already exists in the UK and has been developed in systems ranging from domestic to large commercial systems.

However, many of these models can offer a very low PPA rate (or even free electricity in the case of rent a roof free solar), because the third party receives the benefit of a subsidy for the generation. In a low or zero subsidy world, PPA rates will need to be set at a level that is still attractive for the consumer, i.e. is lower than their current electricity price, while also being attractive for the third party owner by providing a financial return.

One of the recently studied best practices was a PPA-based project, Hitachi Rail[38]. The model described here uses insights from that project. The business model is structured as follows:

[38] http://www.pv-financing.eu/wp-content/uploads/2015/10/10-UK-Industrial-Park-Hitachi-Rail.pdf

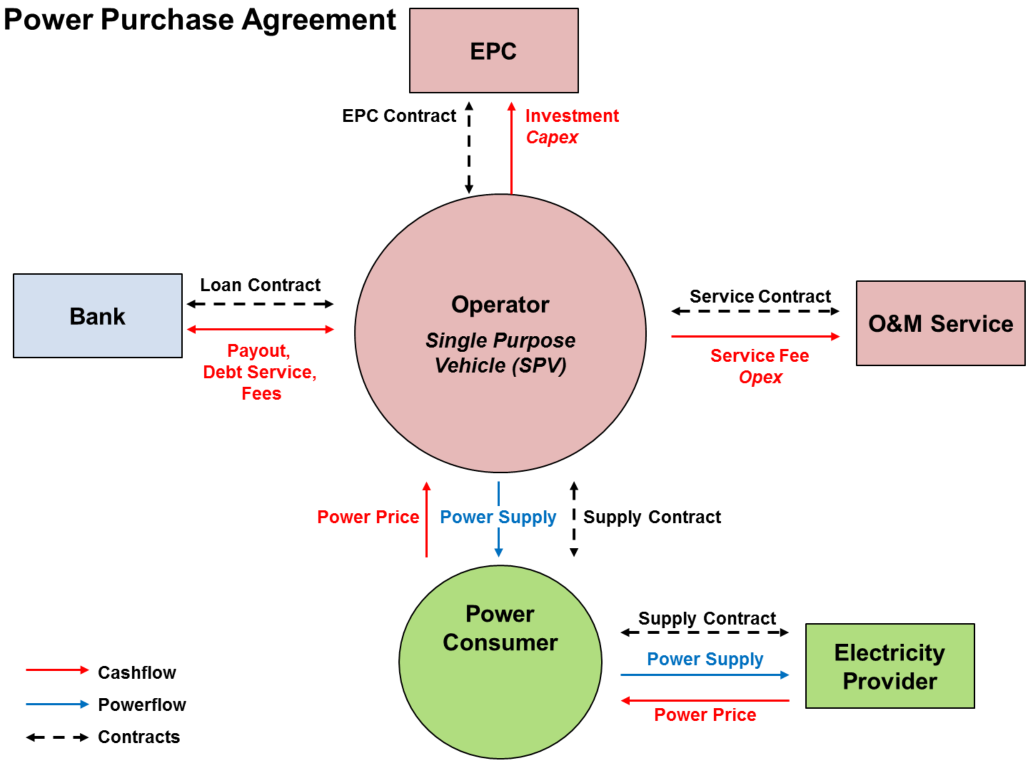


Figure 19: Commercial and utility PPA business model structure

- Investor/Operator: this SPV owns the generating plant, and sells the generated power to the power consumer in exchange for a PPA.
- Power Consumer: the building occupier. This entity typically owns the building (other than the solar array), and uses the electricity generated by the solar system, paying for it through the PPA. Their remaining power needs are met by the electricity provider.
- EPC (Installer): this is the responsible party who, in exchange for capex from the operator, install the system.
- Electricity provider: this body provides the power consumer with their grid electricity connection, and provides any non-solar generated power requirements in exchange for the power price.
- O&M service: this company, which could also be the EPC, provides maintenance and monitoring of the system, in exchange for a service fee (opex) paid for by the operator.

Profitability analysis

The analysis for this focusses on the third party, rather than the power consumer. As the power consumer does not pay any money upfront, they do not have a rate of return as such, but simply reduce their energy bills immediately by buying a proportion of their energy through the PPA.

As with the self-consumption example, we consider a consumer with 100% consumption of the solar electricity. The PPA rate is assumed as 8p (0.11EUR/kWh), although this is varied through sensitivity analysis. Note this is higher than the roughly 6p (0.08 EUR/kWh) for the Hitachi Rail example: in a lower subsidy environment, PPAs will need to increase in order to substitute for the lack of revenue from the Feed in Tariff.

With these assumptions, and aggressive cost assumptions, the project does not pay itself back over the lifetime of the project. Costs must come down, or PPAs must rise, in order to make this model profitable. Given that the market has not experienced significant growth in the last year, despite higher profitability and government strategic focus, it will take time for the market to adjust.

Project Overview

PV Project			
PV System Size		kWp	250
Specific System Cost		GBP/kWp	900
Total System Cost		GBP	225,000
Investment Subsidy		GBP	-
Total System Cost incl. Subsidy		GBP	225,000
Fixed Operation Costs		GBP p.a.	1,688
Variable Operation Costs		GBP/kWh	-

PV Generation		
Specific Yield	kWh/qm/a	1060
Performance Factor	%	84%
Specific System Performance	kWh/kWp/a	890
Degradation	% p.a.	0.50%

Investment			
Project Duration		Years	20
Equity		GBP	225,000
Debt (Gearing)	-	GBP	-
Loan Tenor		Years	-
Interest Rate		%	1.0%
Discount Rate		%	6.0%

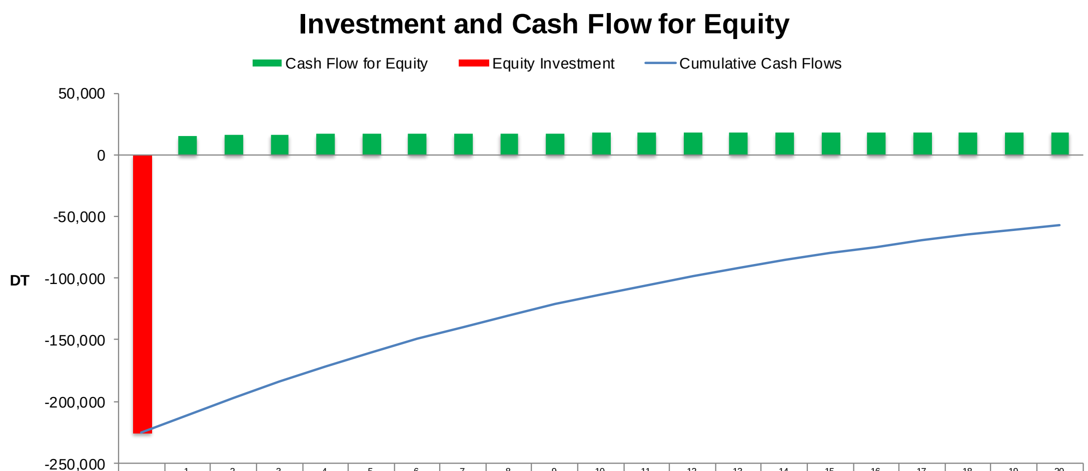
PV Business Model			
Category	Share	Unit	Price
Feed-in Tariff	-	GBP/kWh	-
Self-consumption	-	GBP/kWh	-
Fees		GBP/kWh	-
Net-metering	-	GBP/kWh	-
Fees		GBP/kWh	-
Excess Electricty		GBP/kWh	-
PPA Tariff	100%	GBP/kWh	0.0800
Fees		GBP/kWh	-
Overysupply Price		GBP/kWh	-
Undersupply Penalty		GBP/kWh	-

Results		
Net-Present Value	GBP	(15,678)
Project IRR (modified discount rate)	%	5.85%
Equity IRR (modified discount rate)	%	5.65%
Payback Period	Years	#NUM!
LCOE* (w/o subsidy)	GBP/kWh	0.10
LCOE (w subsidy)	GBP/kWh	0.10
Min DSCR**	x	-
Min LLCR***	x	-

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

Figure 20: Project overview for Commercial PPA

Project Cash Flows



	-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Equity Investment	(225,00																				
Cash Flow for Equity	-	14,792	16,438	16,598	16,754	16,960	17,058	17,204	17,346	17,539	17,615	17,741	17,861	18,033	18,080	18,177	18,266	18,407	18,413	18,470	18,515
Cumulative Cash Flows	(225,00	(211,30	(197,21	(184,03	(171,72	(160,17	(149,42	(139,38	(130,01	(121,24	(113,08	(105,47	(98,382	(91,752	(85,596	(79,866	(74,534	(69,560	(64,952	(60,672	(56,700

Operations Year

Figure 21: Commercial PPA cashflows

Conclusions in the Commercial market

There is great potential for the commercial market to succeed in a lower subsidy environment. However, the cliff edge and lack of certainty provided for future subsidies have caused many companies to shelve projects.

For self-investment and ownership, the model can be successful in the long term, but costs are too high, and returns too low, for the decision to be an obvious one without the additional support of subsidies. Costs therefore need to come down in order to make this a viable business case.

Third party ownership and PPAs can potentially decouple the owner from the power consumer, providing the financial return to another body that has longer-term investment criteria, while still enabling a reduction in energy bills for the power consumer. This approach has been successful with subsidies, but again, costs will need to come down and required returns reset in order for this model to be successful.

Given that the market has not taken off over the last year, even in a profitable environment with subsidies, the positive outlook needs to be tempered with knowledge that although the economic case is strong, non-financial barriers can cause the overall market to take a long time to grow.

Utility ground-mounted solar market

The utility scale sector in the UK has had the largest growth of any sector in the UK over the last 3 years. As costs have come down, and with a stable and profitable subsidy scheme, there has been around 5GW deployed in the last 3 years. Spikes in deployment in March 2014 and 2015 coincided with drops in subsidy rates provided through the Renewables Obligation, and in May 2014 the

government proposed[39] (and then confirmed in October) to remove the Renewables Obligation for >5MW utility solar from April 2015. This caused a rush of projects, with has been repeated by the proposal to remove the Renewables Obligation for <5MW solar from March 2016, proposed in July 2015[40] with a government decision yet to be made.

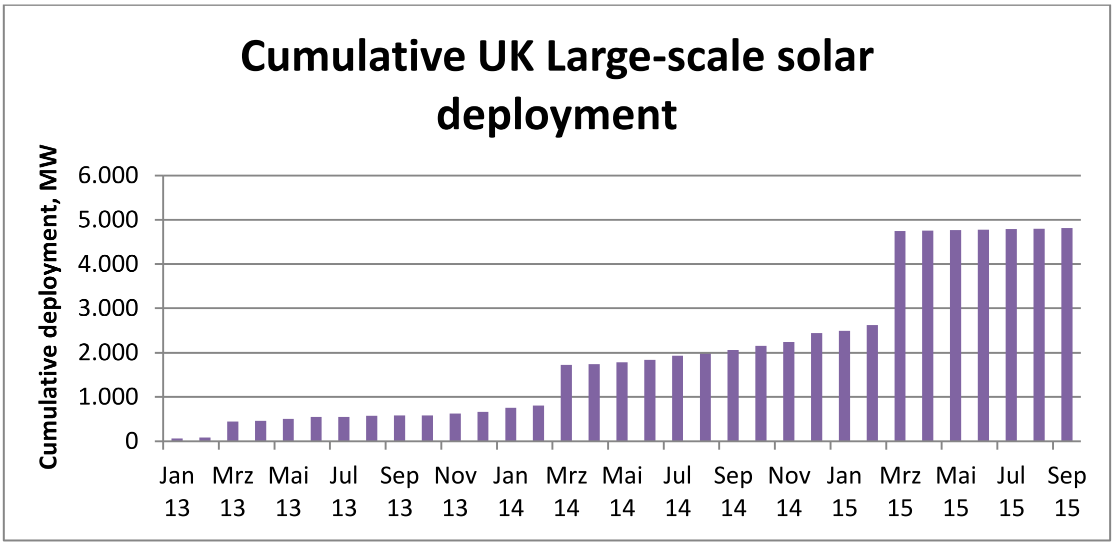


Figure 22: Cumulative UK large-scale solar deployment

Drivers in the utility market

The growth of the UK utility solar market has caused a range in terms of returns and quality. The key drivers for investors are for high-quality sites (both in terms of construction and in other ways such as the STA's 10 commitments[41]) and for low-risk, stable returns.

Initially, required returns were high, as the asset class was unproven. However, now solar is well known as an investment in the UK, meaning that required returns have dropped. However, it is unclear at this stage whether projects will be able to hit returns targets, even those reduced through experience, without subsidy.

Future Business models in the utility market

In the past, utility solar has been built and accredited through subsidy schemes, and the electricity sold to a PPA provider who sells it on the open market (usually as part of a portfolio). Renewable Obligation Certificates (ROCs), the subsidy scheme for larger-scale renewable projects, are typically sold as part of the PPA, as suppliers are obligated to buy a certain proportion of their energy with these certificates. This essentially gives a premium to renewable energy.

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39 https://www.gov.uk/government/consultations/consultation-on-further-changes-to-financial-support-for-solar-pv
40 https://www.gov.uk/government/consultations/changes-to-financial-support-for-solar-pv
41 http://www.solar-trade.org.uk/sta-solar-farms-10-commitments/

In the future, this electricity must be sold without a premium over other energy sources. This means that it is likely that the supply will be co-located with demand, rather than selling through a PPA provider. There is potential for economies of scale to be expanded to very large schemes (~50MW) and then this energy sold to the open market, but projects like this may well be rare simply due to their size.

There are two business models that have been analysed for this report: either the company owning the system themselves or a third party owning the system and selling it through a direct PPA to the demand owner. These are similar to those as described above for commercial rooftop, but the difference is that the solar is typically ground-mounted rather than building mounted, so the definition of co-location of generation and demand is slightly broadened in this case to the site, rather than solely the building.

Many industrial sites have a huge energy demand, and therefore use all the electricity that is produced by the solar system. For example, Ketton Cement Works, one of the examined best practices[42], is a 12MW solar plant, which provides power through a direct PPA to a cement works. Despite the size of the solar array, it only provides 13% of Ketton's energy requirements.

Self-ownership and self-consumption for industrial applications

This model is where a company owns the system themselves, and pay back the investment solely through the self-consumption. The business model structure is the same as for the commercial self-consumption model and is not discussed again in this section.

Profitability analysis

The analysis considers a 5MW plant, co-located with a significant demand such that all the energy is used on-site. Even using aggressive cost assumptions and high electricity prices, this model does not pay itself back over the 25 year lifetime – with a negligible IRR.

[42] http://www.pv-financing.eu/wp-content/uploads/2015/09/12-UK-Industrial-Park-Ketton.pdf

Project Overview

PV Project			
PV System Size		kWp	5,000
Specific System Cost		GBP/kWp	700
Total System Cost		GBP	3,500,000
Investment Subsidy		GBP	-
Total System Cost incl. Subsidy		GBP	3,500,000
Fixed Operation Costs		GBP p.a.	87,500
Variable Operation Costs		GBP/kWh	-

PV Generation			
Specific Yield		kWh/qm/a	1131
Performance Factor		%	84%
Specific System Performance		kWh/kWp/a	950
Degradation		% p.a.	0.50%

Investment			
Project Duration		Years	25
Equity		GBP	2,625,000
Debt (Gearing)	25%	GBP	875,000
Loan Tenor		Years	8
Interest Rate		%	6.5%
Discount Rate		%	8.0%

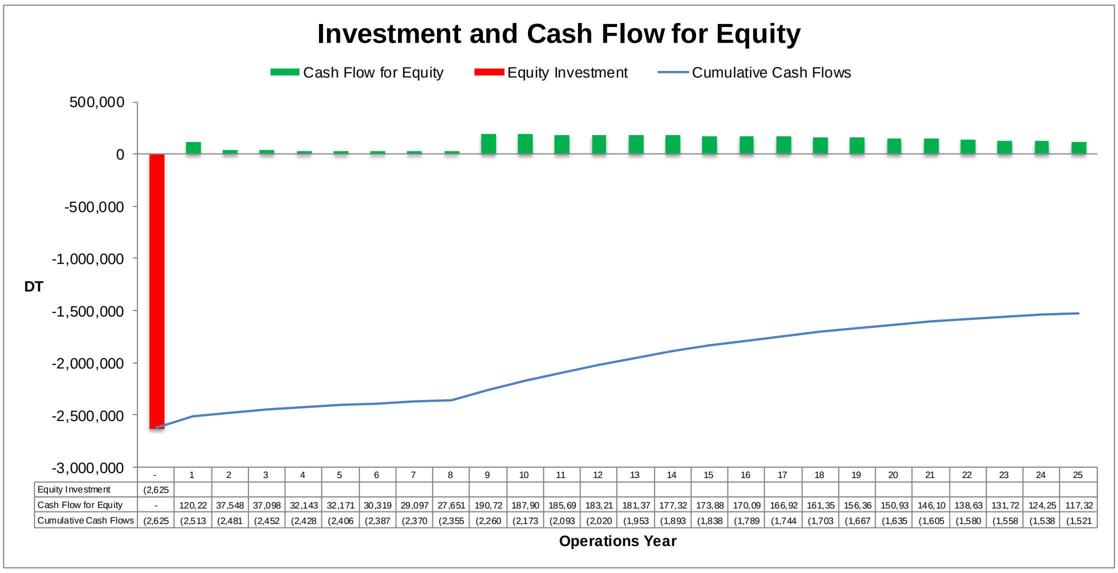
PV Business Model				
Category		Share	Unit	Price
Feed-in Tariff		-	GBP/kWh	-
Self-consumption		100%	GBP/kWh	0.0600
	Fees		GBP/kWh	-
Net-metering		-	GBP/kWh	-
	Fees		GBP/kWh	-
	Excess Electricty		GBP/kWh	-
PPA Tariff		-	GBP/kWh	-
	Fees		GBP/kWh	-
	Oversupply Price		GBP/kWh	-
	Undersupply Penalty		GBP/kWh	-

Results		
Net-Present Value	GBP	(1,505,342)
Project IRR	%	1.75%
Equity IRR	%	1.12%
Payback Period	Years	#NUM!
LCOE* (w/o subsidy)	GBP/kWh	0.10
LCOE (w subsidy)	GBP/kWh	0.10
Min DSCR**	x	1.17 x
Min LLCR***	x	1.17 x

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

Figure 23: Project overview for utility self-consumption

Project Cash Flows



	-	1	2	3	4	5	6	7	8	9	10	11	12
Equity Investment	(2,625												
Cash Flow for Equity	-	120,22	37,548	37,098	32,143	32,171	30,319	29,097	27,651	190,72	187,90	185,69	183,21
Cumulative Cash Flows	(2,625	(2,513	(2,481	(2,452	(2,428	(2,406	(2,387	(2,370	(2,355	(2,260	(2,173	(2,093	(2,020

	13	14	15	16	17	18	19	20	21	22	23	24	25
Equity Investment													
Cash Flow for Equity	181,37	177,32	173,88	170,09	166,92	161,35	156,36	150,93	146,10	138,63	131,72	124,25	117,32
Cumulative Cash Flows	(1,953	(1,893	(1,838	(1,789	(1,744	(1,703	(1,667	(1,635	(1,605	(1,580	(1,558	(1,538	(1,521

Figure 24: Utility self-consumption cashflows

Third party ownership: PPA

In a similar way to the third party ownership under the commercial schemes, at the utility scale there is potential for large projects owned by a third party, with the electricity generated sold to an

offtaker directly through a private wire. The business model structure is the same as for the commercial PPA model and is not discussed again in this section.

Profitability Analysis

As with the commercial PPA business model, the analysis here is not focussing on the electricity consumer, but the owner of the PV system, and therefore the profitability requirements are different.

As the projects are typically connected to large commercial sites which have a long lifetime, the system lifetime was considered as 25 years for this analysis. This reflects the fact that typically planning permission on industrial sites is more flexible, and it is more likely that the industrial sites will still be operational in 25 years (as compared to a commercial building still being standing).

Taking aggressive cost assumptions and a 4p PPA rate, the model does not pay back the investment over the 25-year lifetime.

Project Overview

PV Project			
PV System Size		kWp	5,000
Specific System Cost		GBP/kWp	700
Total System Cost		GBP	3,500,000
Investment Subsidy		GBP	-
Total System Cost incl. Subsidy		GBP	3,500,000
Fixed Operation Costs		GBP p.a.	87,500
Variable Operation Costs		GBP/kWh	-

PV Generation		
Specific Yield	kWh/qm/a	1131
Performance Factor	%	84%
Specific System Performance	kWh/kWp/a	950
Degradation	% p.a.	0.50%

Investment			
Project Duration		Years	25
Equity		GBP	2,980,451
Debt (Gearing)	15%	GBP	525,000
Loan Tenor		Years	8
Interest Rate		%	5.0%
Discount Rate		%	7.0%

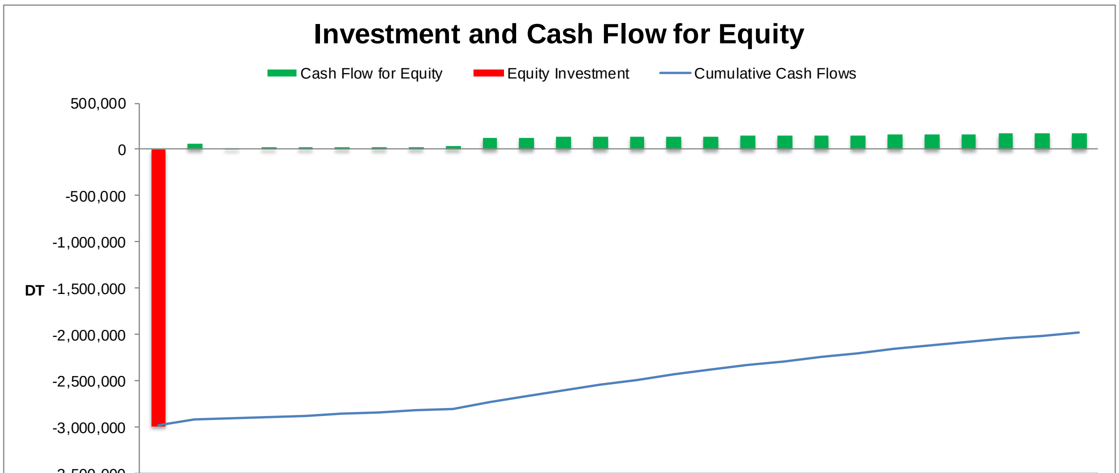
PV Business Model			
Category	Share	Unit	Price
Feed-in Tariff	-	GBP/kWh	-
Self-consumption	-	GBP/kWh	-
Fees		GBP/kWh	-
Net-metering	-	GBP/kWh	-
Fees		GBP/kWh	-
Excess Electricty		GBP/kWh	-
PPA Tariff	100%	GBP/kWh	0.0400
Fees		GBP/kWh	-
Oversupply Price		GBP/kWh	-
Undersupply Penalty		GBP/kWh	-

Results		
Net-Present Value	GBP	########
Project IRR	%	0.00%
Equity IRR	%	0.00%
Payback Period	Years	#NUM!
LCOE* (w/o subsidy)	GBP/kWh	0.09
LCOE (w subsidy)	GBP/kWh	0.09
Min DSCR**	x	1.18 x
Min LLCR***	x	1.26 x

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

Figure 25: Project overview for Utility PPA

Project Cash Flows



	-	1	2	3	4	5	6	7	8	9	10	11	12
Equity Investment	(2,980												
Cash Flow for Equity	-	62,794	16,597	19,071	21,586	24,704	26,743	29,386	32,073	126,12	128,31	131,13	134,00
Cumulative Cash Flows	(2,980	(2,921	(2,907	(2,891	(2,875	(2,857	(2,839	(2,821	(2,802	(2,734	(2,669	(2,606	(2,547

	13	14	15	16	17	18	19	20	21	22	23	24	25
Equity Investment													
Cash Flow for Equity	137,54	139,88	142,89	145,95	149,74	152,23	155,45	158,72	162,75	165,41	168,85	172,33	176,63
Cumulative Cash Flows	(2,490	(2,435	(2,384	(2,334	(2,287	(2,242	(2,199	(2,158	(2,118	(2,081	(2,045	(2,011	(1,979

Figure 26: Cashflows for Utility PPA

Conclusions on utility scale

Essential requirements:

- Costs to come down
- Higher PPAs or offset electricity costs?
- Stability providing reduced cost of capital
- Some niches such as very large systems or those with high electricity prices, but not mass market.

As with the commercial market, there are possible circumstances in which utility scale models could work. However, in both self-consumption and PPA models, the profitability analysis shows that neither of these models can work now.

There are some niches where the models could potentially work: either

Principally, costs need to come down through continuing cost reductions based on a maturing, stable UK supply chain. Alongside this, a stable policy framework must be put in place to reduce cost of capital and required returns – long-term certainty on policy allows long-term certainty on investment.

Additionally, the government's strategic focus has shifted away from utility solar, with many Conservative MPs considering them ugly: this may mean that future policy stability or reduced uncertainty is unlikely.

Contracts for Difference, a new subsidy mechanism planned to provide energy price stability through a technology-neutral auction process, may increase profitability but this is unproven for solar and in the last auction only 5 solar projects were successful, at least 2 of which were at unviable levels.

A combination of stability in the market through reduced policy uncertainty, further cost reductions and a recalibrated investor market could produce a profitable market for utility scale solar when co-located with demand: but all of these are required to deliver a viable zero-subsidy market.

General Conclusions

Solar clearly works in the UK. Driven by subsidies, the installed base has increased from negligible levels in 2010 to around 9GW in just 5 years. Along the path towards zero subsidy, the economic profitability will inevitably change as markets and supply chains mature and new smart technologies and business models enable the industry.

However, the cliff edge cuts that have been proposed or implemented in the last year have caused the market to react, developing boom and bust scenarios. This kind of short-term policy uncertainty damages the potential for the UK solar industry to survive without subsidy, by not enabling companies to invest or plan for the longer term.

In the short term, business models are difficult to make profitable without subsidy. Our analysis shows that none of the models presented show a particularly attractive proposition using 2016 assumptions.

In the medium term, costs need to come down through continued volume deployment to enable these models to develop in a lower-subsidy world, along the path to zero subsidy. Niches can be found, but these do not reflect a significant market.

In the longer term, solar has a bright future as these models become more attractive to a wider market in a zero subsidy world, but how far away “long term”, and the structure of the future industry, is highly dependent on current government proposals.