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PVFINANCING 

EU-WIDE SOLAR PV BUSINESS MODELS

GUIDELINES FOR IMPLEMENTATION

*A guide for investors and developers on how to put into place
and finance the top business models for solar PV across the EU.*

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1. INTRODUCTION

1.1. BACKGROUND TO EU SOLAR PV MARKET

The European Union is the world leader in solar in terms of total installed capacity having in 2016 just crossed the historic milestone of 100GW of solar PV, up from just 3GW ten years earlier in 2006.

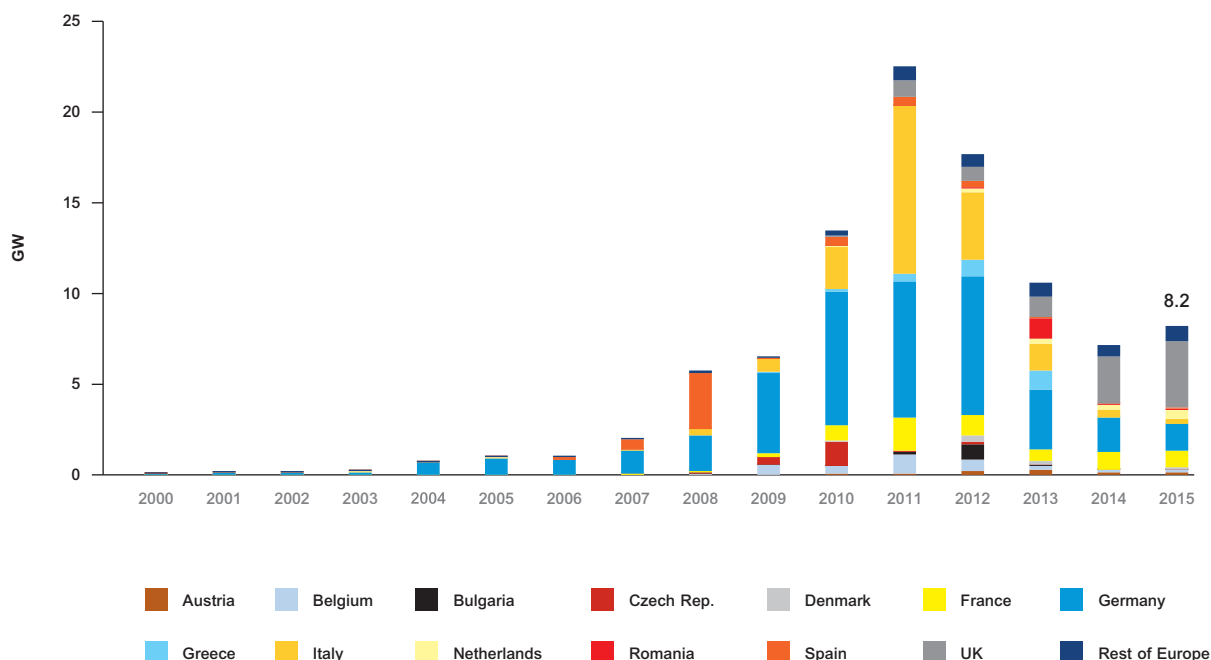
However Europe is currently only just ahead of the Asia-Pacific region which is hot on its heels at just over 96GW, and is growing much faster. China is the main driving force in the growth of this Asian solar powerhouse.

Looking back, the European solar market really took off in 2008, growing rapidly until 2011 in what was a boom period of high support schemes and declining costs. After 2011, due to damaging retroactive changes to support schemes, stop-start subsidies and other factors, the EU solar market went into decline and volumes of new solar installations reached a five year low in 2014 at 7.1GW. This is demonstrated in more detail in Figure 1.

In 2015 the European PV market started growing again with a 15% year on year increase to 8.2GW, of which 7.7GW was in the European Union. Much of this was in fact due however to a boom in the UK driven by the sudden closure of a number of support schemes. Without this activity in the UK, the EU market would in effect have remained stagnant.



Figure 1. Evolution of European annual solar PV installed capacity 2000-15 for selected countries (SolarPower Europe)

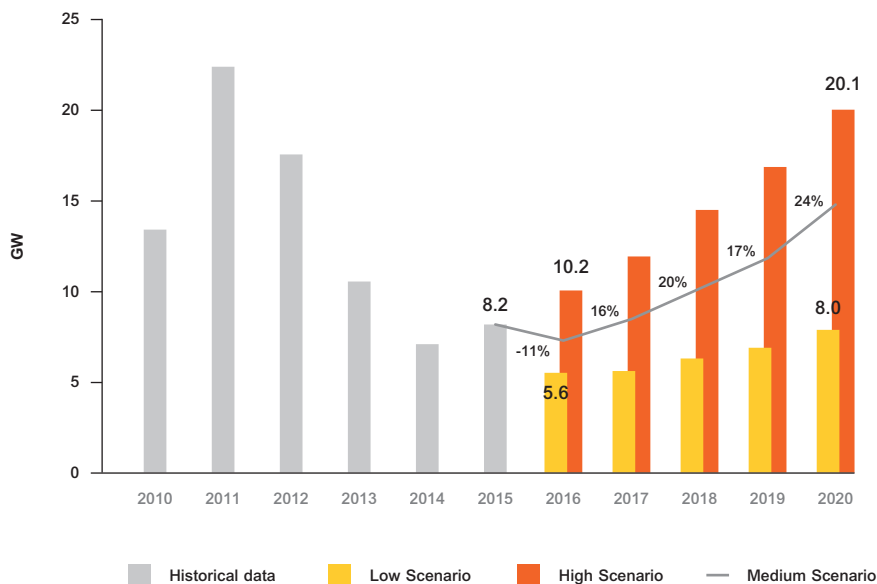


Looking ahead it is estimated that the European PV market could grow by as much as 145% by 2020,¹ as shown in Figure 2. This shows there is real potential for EU solar deployment over the coming five years.

France and Germany are set to be the biggest solar PV markets in the EU between now and 2020, both broadly forecast to be over 1GW per year out to 2020. In the best case scenario France is set to reach 2GW in some years and Germany 3GW. Italy, the Netherlands and the UK will also be sizeable markets. And although smaller in absolute size, Ireland is expected to have the highest growth rate of all with 160% growth between 2016 and 2020.

¹ SolarPower Europe analysis assuming High Scenario. More details in Figure 2 above and in SolarPower Europe "Global Market Outlook for solar power 2016-2020", June 2016. Full report available here: <http://www.solarpowereurope.org/insights/global-market-outlook/>

Figure 2. European annual solar PV market scenarios 2016-2020 (SolarPower Europe)



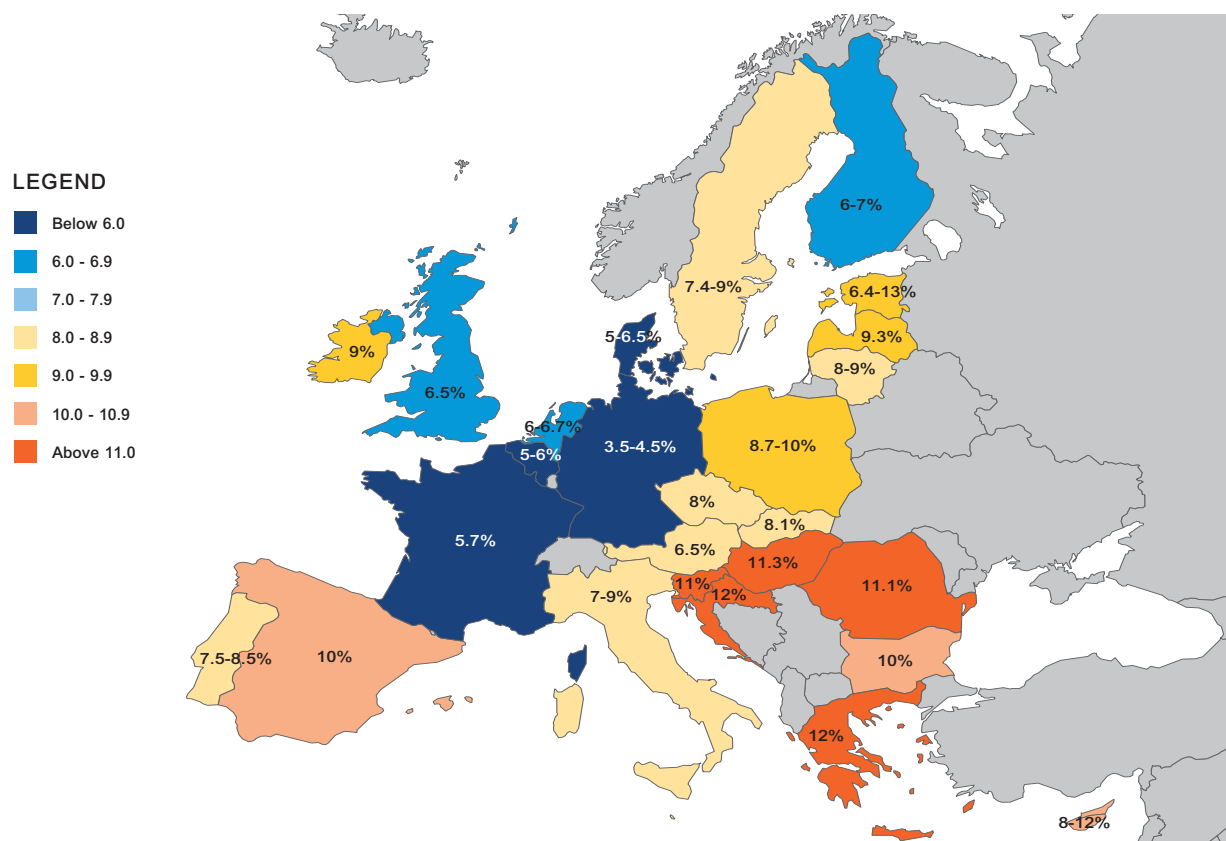
It is clear that over the last ten years European solar markets have been largely policy driven – they were determined not by the solar irradiation resource but by the regulatory frameworks and support schemes available. The national support schemes available combined with the perception of political risk in turn determined the cost of capital in that country. Equally in the larger markets the leading business model was also dictated by the support scheme, with the revenues being guaranteed by the state and therefore generally considered low risk.

Figure 3 shows the variation in cost of capital for onshore wind, demonstrating that cost of capital varies hugely across the EU. South East Europe in particular has very high cost of capital in onshore wind. Solar can be said to have a similar spread across the continent.

Like many other renewables solar PV is very capital intensive, with low operating costs. The high up-front cost is one of the barriers to investing in solar. In addition to this the benefits or revenues are spread out over 20 years or more. This is longer than many businesses or even people can confidently forecast their own existence, let alone whether they are still going to be in the same building. There is a fundamental timing mismatch between costs and revenues.

Another barrier to investing in solar is simply the fact that electricity sold on the wholesale market has so little value that projects are uneconomic and do not produce a return on investment. This is a challenge not just for the solar PV industry but also other technologies such as CCGT in parts of Europe.

Figure 3. Weighted Average Cost of Capital across the EU for onshore wind (DiaCore²)



Deploying new and innovative financing mechanisms and business models is what can overcome the high up-front costs. The combination of financing mechanisms and business models are what will allow investors to feel more comfortable investing in low-subsidy solar PV. There will always be some households and businesses with enough spare cash to be able to self-fund solar PV projects, and this will be looked at in more detail in Section 3. But finance is what will allow solar to be accessible to a maximum number of power consumers and application segments if sufficiently attractive business models and projects can be put forward.

The cost of capital or financing is usually the single biggest cost component in the Levelised Cost of Electricity (LCOE) of PV. This is particularly the case with projects that have long-term tenors or loans. Solar's LCOE is typically made up of 29% capital costs, 19% module costs and 16% operations and maintenance (O&M) costs, with other cost components making up smaller shares.³

² DiaCore project "Assessing Renewables Policy in the EU", p. 18. Available here: http://www.dia-core.eu/images/files2/DIA-CORE_Final_Brochure.pdf.

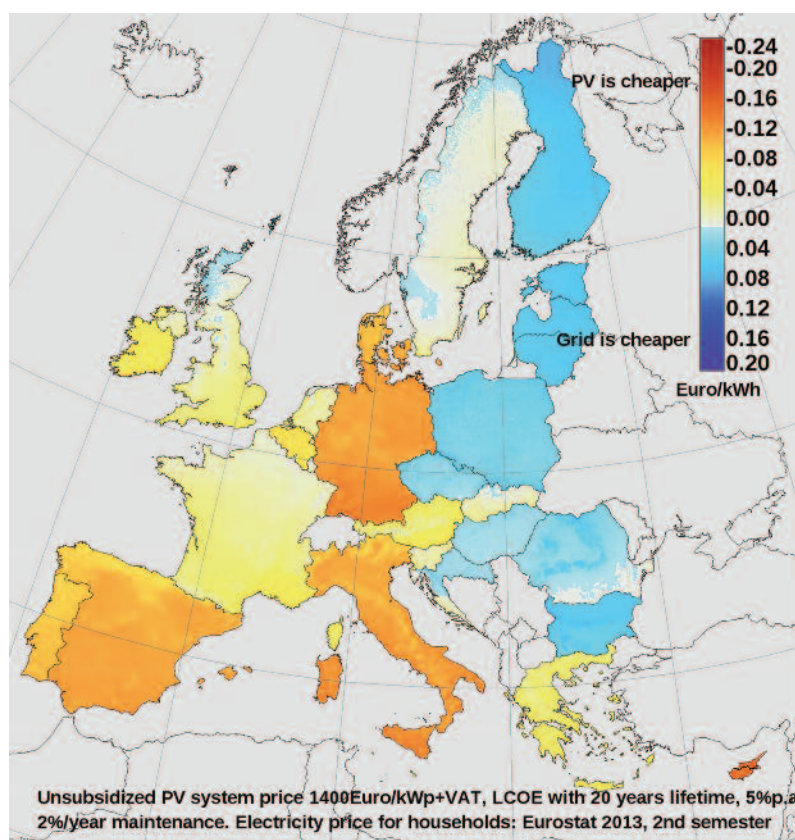
³ BSW-Solar, "PV Investor Guide: New business models for photovoltaics in international markets", August 2014, p 22.

In many western European markets solar LCOEs are already lower than the retail electricity price (see Figure 4). It is estimated that 79% of EU citizens live in locations where *in theory* solar PV has a lower LCOE than the residential retail price of electricity.⁵ This is a good sign, and shows that the fundamentals of the solar business model are in place. These crude calculations however should be taken with caution and do not necessarily mean that solar can be deployed without subsidy in those areas. Section 2.2 will outline the remaining barriers to PV deployment that are preventing projects from coming forward. For example, the system of grid charges and taxes on retail

electricity can radically alter the economics of a business model. If the charging system for grid costs changes, a project or business model can go into unprofitability.

Finally, as the level of support schemes are being reduced and solar moves into a low or no subsidy environment, the revenue stream⁶ for solar projects becomes more exposed to market forces, with wholesale electricity price fluctuations foremost among them. This makes revenues more unpredictable, and requires a more complex business model to maintain adequate rates of return.

Figure 4. Price comparison map (2014) (JRC⁴)



4 European Commission Joint Research Centre, "Cost Maps for Unsubsidised Photovoltaic Electricity", 2014. <https://setis.ec.europa.eu/sites/default/files/reports/Cost-Maps-for-Unsubsidised-Photovoltaic-Electricity.pdf>.

5 European Commission Joint Research Centre "Cost Maps for Unsubsidised PV Electricity", 2014. Available here: <https://setis.ec.europa.eu/sites/default/files/reports/Cost-Maps-for-Unsubsidised-Photovoltaic-Electricity.pdf>

6 Note that in addition to traditional revenues from a solar installation, a possible additional way of generating revenue for PV is through Solarcoin. Solarcoin is an alternative digital or virtual currency which rewards every MWh of solar energy with one SolarCoin (SLR). SolarCoin's objectives are a value of 20 USD per SLR and a million participants by 2018. A few crowdfunding platforms are already using Solarcoins to further generate revenue from their electricity. Solarcoins can be exchanged for Bitcoins, another widely accepted online virtual currency.

1.1.1. General remarks regarding this guide

This document is intended as a broad guide for both professional and non-professional investors and developers to the main solar PV application segments, financing schemes and business models in use across Europe.

In principle every PV project can be categorised as belonging to one of the application segments described in this document, is financed using one or a combination of the financing schemes and the different parties involved relate using one or a combination of the business models. This is of course a simplification for many real-world projects, however every project can be classified as per these three variables and described using a venn diagram like that in Figure 5. Of course new and innovative business models and financing schemes may be added to the list of options in Figure 6 as the industry develops. Note that off-grid applications of solar PV are not covered in this guide.

Figure 5. Venn diagram of three primary variables in a solar PV project

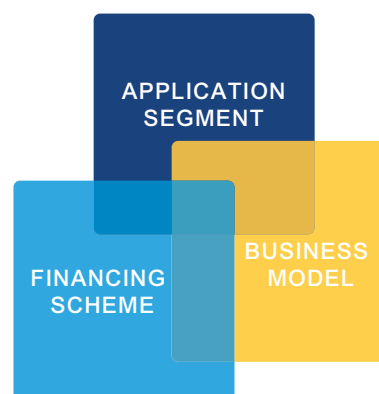


Figure 6. The different options for each of the three variables of a PV project

APPLICATION SEGMENT	BUSINESS MODELS	FINANCING SCHEMES
<ul style="list-style-type: none"> • Single family residential • Multi family residential • Commercial buildings, shopping centres and office buildings • Public and educational buildings • Industrial buildings • Solar farms 	<ul style="list-style-type: none"> • Self-consumption • Power Purchase Agreements • Cooperatives • Virtual Power Plants 	<ul style="list-style-type: none"> • Self-funding • Debt • Equity • Mezzanine financing • Leasing • Crowdfunding • Combo financing

The guide will look mainly at the self-consumption, Power Purchase Agreement, cooperative and Virtual Power Plant business models. And these business models can be combined in different ways – they are not mutually exclusive. Neither is this list exhaustive, these are simply the most promising business models in use or being considered in the EU today. For each business model a step-by-step guide to how to put it in place is provided.

However a note of caution is required before proceeding. Costs, specifics of business models and above all regulatory frameworks differ enormously across the EU. It is vital that any investor looks into the national circumstances in the target market in detail before proceeding. This guide attempts to bring together common traits from across Europe and highlight differences. Specific examples of

barriers and case studies will be given from different countries. This is useful for policy makers and businesses across the EU and beyond to learn from their counterparts and adopt best practice. For practical assistance with regards the seven PV FINANCING countries (Austria, Germany, Spain, France, Italy, UK and Turkey), please consult the national implementation guides available for each market.⁷ Note that the national implementation guidelines are available in the national language only. An English translation of key sections of the national guidelines is provided in Annex III to Annex IX. For further information please contact the author of the national guidelines. For the remaining EU countries, please contact SolarPower Europe or the national solar PV association⁸ in that member state which can assist you further.

1.2. APPLICATION SEGMENTS FOR PV

Solar PV is a very modular technology. It comes in all shapes and sizes, from the smallest caravan roof to a 300MW ground-mounted solar farm covering over 250 hectares, from a solar powered calculator to huge reservoirs covered in floating solar panels. Outside Europe, ground-mounted solar plants can even reach 1GW in size. It is important therefore to distinguish between the different application segments for this technology.

For each application segment a brief description will be given, followed by advantages, disadvantages and the outlook going forward. These application segments can also be divided simply into building mounted vs. ground mounted segments, single-occupancy vs. multi-occupancy and owner-occupied vs. rented buildings.

1.2.1 Single family residential house (owned or rented)

This is the application segment that best represents solar PV's nature as a force for the democratisation of energy. Solar allows energy consumers to become prosumers (also known as renewable self-consumers or active consumers), generating and using their own energy. This application segment can be split into two types: owner-occupied homes and rented homes. (Note that social housing is a special case and is dealt with in Section 1.2.2.1 below.)

The advantage of the single family *owner-occupied* residential home application segment is that the power consumer is also the owner of the building, and legal issues around access to the roof are therefore straightforward. The main driver in this segment is the financial return that the householder will make on his/her investment in PV, from savings on electricity bills and selling excess power back to the grid. Solar is also a hedge against rising electricity

⁷ The PV FINANCING national implementation guidelines, which each focus on business models that are particularly promising in that country, are available on the website here: <http://www.pv-financing.eu/project-results/>

⁸ A list of the national solar PV associations for each EU country can be viewed on the SolarPower Europe website by selecting 'National PV Associations' under category: <http://www.solarpowereurope.org/membership/list-of-members/>

prices. Support schemes for years provided a very stable investment environment and high returns, which only increased the financial or economic incentive for installing solar. However additional drivers are energy independence, environmental motivations, a desire for cutting edge technology, and especially if the solar installation has been done in an aesthetic way, the increase in the value of a home.⁹

A disadvantage in both owner-occupied and rented homes is that on the whole residential electricity consumption is lower during daylight hours while people are out at work and peaks in the evening. This leads to a timing mismatch of demand and solar generation and can lead to low solar self-consumption rates, often between 20-30%. Ways to overcome this are discussed in Section 4. The most promising solutions are demand response and battery storage.

Rented homes have the disadvantage of complex legal rights issues, as the permission of both the tenant and the landlord is required. The landlord/tenant dilemma¹⁰ commonly found in energy efficiency projects also applies to solar. The landlord has no incentive to invest in PV if the benefit goes to the tenant.

Two options for overcoming this are:

- **Leasing** financing schemes where a third party pays for the installation of the system and the tenant pays a monthly fee in return for the solar electricity generated. (See Section 3.4 for more details.)
- **Regulations** which oblige landlords to meet specific standards, often known as energy performance of building regulations. An example is the obligation on private sector landlords in the UK to meet Energy Performance Certificate band E by 1 April 2018. Solar is a very cost-effective way of improving the Energy Performance Certificate of a home.

⁹ For more information on the aesthetics of solar PV systems please see Campaign to Protect Rural England and BRE National Solar Centre, "Solar Design Tips: your 10-point guide" and "Ensuring place-responsive design for solar PV on buildings", October 2016. Both available here: <http://www.cpre.org.uk/resources/energy-and-waste/climate-change-and-energy/item/4384-ensuring-place-responsive-design-for-solar-photovoltaics-on-buildings>

¹⁰ The landlord/tenant dilemma is where the interests of the landlord and tenant of a building are not aligned. Often it is because the landlord has to pay for the solar PV system but the tenant pays the electricity bills and gets the benefit of the power. This is commonly recognised with energy efficiency investments, and stops projects that are cost-effective and would save energy from going ahead.

¹¹ Eurostat housing statistics, available here: http://ec.europa.eu/eurostat/statistics-explained/index.php/Housing_statistics#Type_of_dwelling

In the owner-occupied single-family home segment, the self-consumption business model (which implies self-ownership) is the most common business model in the EU today.

Finally, due to homeowners' nature as non-professional investors and their lack of technical understanding of PV technology and electricity, it is important to ensure high consumer standards in this application segment to prevent misleading sales tactics. Irresponsible or illegal behaviour can damage the reputation of a technology and industry and inhibit its growth potential further down the line. Clear, easy to understand information should be provided to consumers as part of an independent national outreach strategy.

1.2.2 Multi-family residential buildings (owned or rented)

Approximately 40% of the population of the European Union lives in multi-family residential buildings.¹¹ Latvia, Estonia and Spain in particular have the highest rates of people living in apartments.

An advantage of multi-family housing is that there is less roof space (and therefore PV capacity) per household, which leads to higher rates of self-consumption, sometimes up to 80-90%.

Furthermore if the electricity demand from communal areas of the building is high enough then solar can be installed as a self-consumption system owned and operated by the building owner or management company. Communal areas can in some cases have significant electricity demand. Lifts, lighting, air conditioning and CCTV can consume a considerable amount of power. In some Nordic countries it is common for apartment blocks to have a communal sauna, which consumes a lot of power. However in general communal power demand is not enough to justify a solar PV system.

However there are also many disadvantages to solar on multi-family apartment blocks. Despite the small advantages above this is a much more challenging application segment for solar PV when compared to owner-occupied single family homes.

Multi-family solar business models often involve a long-term contract with the tenant or occupier which can lead to major issues when that household moves home. The contract should ideally be passed on to the next occupier and be

made part of the property. In practice new occupiers will usually have an incentive to take on the long term contract as usually the cost is less than the savings so there is a net benefit for the occupier. However continuation of the contract can nevertheless be difficult to guarantee.

For *rented* multi-family residential housing the landlord/tenant dilemma described above also applies, which is another disadvantage.

In many countries there are regulatory and technical barriers to the sharing out of the cost of the investment and resulting electricity. Examples from across the EU are:

- *In Austria the law does not currently allow a single PV system to supply more than one power consumer. As in many countries, the communal cables and wires within an apartment building are considered to be part of the public electricity distribution grid and it is very difficult for third parties to use them to distribute solar power. Residents of an apartment block are also not allowed to combine their metering points in any way. An amendment to the legislation in order to allow for the use of PV within residential and non-residential shared multi-storey buildings is expected by the end of 2016. For more information on this future amendment, please see Annex VI.*
- *In Italy the onsite direct wire model (Sistemi Efficienti di Utenza in Italian) can only apply to systems with one power consumer. This is a barrier not just to solar on multi-family residential buildings but also shopping centres, multi occupancy office buildings and business parks. For more information on Italy see Annex VIII.*
- *Up until recently in France building owners were not allowed to sell electricity from a solar system directly on to the residents of a building because the connection to each apartment was owned by the Distribution System Operator. This is in the process of changing with the new regulatory framework in the country which will allow for collective self-consumption along a low voltage branch of the grid. For more information on France see Annex IV.*
- *The 2009 EU Electricity Market Directive¹² dictates that every consumer must have the freedom to select a utility of his or her choice. For certain solar multi-family residential*

business models this can be an issue as it means the common PV system can only be installed if all homeowners agree on a single electricity supplier. Future owners and tenants would be bound by this agreement, which could be in breach of the 2009 directive.

There are a number of potential business models and financing schemes that could be successfully applied in this segment to overcome the barriers and disadvantages listed above:

- **Neighbour solar supply “Mieterstrom” model (or on-site direct wire mini PPAs)** – A provider offers to supply the residents of a building with solar PV electricity from the building’s roof. If there is adequate take-up, the provider installs the solar PV system. From a legal perspective the solar electricity is not considered to have been supplied via the public grid even if technically speaking it is using the cables and wires in the building. The residents receive cheaper electricity than if they paid the retail electricity price and the provider receives a return on his/her investment in the solar PV system. Providers of this business model include public utilities, green energy suppliers, energy and housing cooperatives, homeowners’ associations, building management companies and commercial building developers. For some of these providers, and the local energy companies in particular, adding solar to their portfolio or offer can be a way of increasing customer loyalty. It is also a way of easing access to finance as the large number of power offtakers reduces the offtaker risk for the investor. The provider must also invest in smart meters in every participating apartment and an IT system to operate the metering and billing system. This business model is starting to be used in Germany in the multi-family housing segment. Some regions in Germany¹³ plan to subsidise the cost of the smart meters and network technology. The German federal government is currently considering an incentive program to promote this model by exempting it from taxes and charges. This is a variant of an onsite direct wire PPA, which will be described

¹² Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity. Available here: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0055:0093:en:PDF>.

¹³ Bundesländer in German, the federal states within Germany.

more in section 5.2.2. More detail on this model is provided in Annex III. A similar scheme may soon be possible in Austria, see Annex VI, although here power consumers will almost definitely have to own at least a symbolic share of the PV system.

- **Collective self-consumption** – this is a specific scheme allowed in the regulatory framework in France where the generating and consumer entities have to be part of a single legal entity and within a single branch of the low-voltage grid. At the time of writing the French government has yet to finalise the details of this scheme. For more information see Annex IV.
- **Leasing** – The building owner or a third party invests in one or more PV systems and leases/rents it to one or more tenants or occupiers. This financing scheme is described in more detail in Section 3.4.
- **Crowdfunding** – The solar system is funded not by a third party but by the residents coming together and crowdfunding a system on their own building. As in the neighbour solar supply model above, smart meters are generally required in every apartment to accurately measure and bill for the solar electricity.
- **Multiple technically separate solar PV systems** – Each participating apartment gets a separate installation on the roof of the building. This works best with new build residential buildings as it can then be incorporated into the design of the building. Every apartment has the freedom to choose their own utility for the residual power supply and export of excess solar electricity. The disadvantage here is that this increases the investment costs per kWp significantly, and can require the installation of a new direct wire. This model has been used in Austria in a small number of cases as it is the only way of getting around the restrictive current regulatory framework on multi-family buildings.
- **District power** – The whole building is a unified group of consumers and has one common supply contract, similar to district heating systems. In Turkey residents of a multi-family building have the option to ‘unite their consumption’ and appoint a person with full

power of attorney to act as legal representative when negotiating the installation of a PV system and supply contract. In the UK this is common in new build multi-family residential buildings. In buildings that have district heating as well as ‘district power’ excess solar electricity can if necessary be used to heat hot water which can bring self-consumption to almost 100%.

- **Estimated billing** – The investment cost is split between the apartments and the existing ‘traditional’ electricity meters are used to estimate rather than measure solar consumption in each flat. Some providers take an even simpler attitude and allocate the value of self-consumed electricity proportionally to the number of people in each household. The disadvantage of this system is that this can lead to a grossly unfair allocation of costs and benefits.

Overall this is a challenging segment but the advent of new business models such as on-site direct wire mini PPAs could transform this market segment. The key barriers are regulatory in nature, many of them unintentional as they are a legacy of how the distribution grid and metering system was originally set up.

1.2.2.1 Social housing

Social housing,¹⁴ which includes both single-family and multi-family homes, should be considered separately to other residential segments.

The big advantage for social housing providers when it comes to solar is that they have low costs of capital by virtue of receiving public support and their long time horizons. In France and Germany social housing receives direct subsidies and subsidised loans. In the Netherlands the segment receives dedicated guarantees for renovation projects and mortgage-based loans.

Social housing units also tend to undergo major renovation, which can reduce solar installation costs (cost of scaffolding and roof access already covered). Social housing providers can also achieve economies of scale by renovating (and installing PV on) hundreds of units in one go.

There are two main drivers for the use of photovoltaic panels within the social housing sector. The first is the economic driver – the return on investment for the housing association. This can be from the sale of the power to the grid or the sale of the power to the tenants at a price lower than the retail price.

¹⁴ Although there is no official definition across the EU social housing is understood as rental residential housing provided at sub-market prices and allocated according to specific rules rather than via the open market.

The second driver of solar on social housing is energy performance of building requirements. Article 9 of the 2010 Energy Performance of Buildings Directive¹⁵ states that new buildings owned or occupied by public authorities have to meet the nearly zero-energy building standard two years earlier than the rest of the new build stock i.e. in 2018 rather than 2020. In most cases this will involve high levels of insulation and on-site renewables like solar PV, solar thermal, heat pumps, biomass, combined heat and power and storage.

The disadvantage in the social housing application segment, which is always rented accommodation, are the same as in rented single family homes or rented multi-family homes. These are discussed in Sections 1.2.1 and 1.2.2 above.

Finally, research has shown that it is important to raise awareness of the PV system among the social housing tenants, as often the tenants are unaware of the solar PV system. This allows the tenants to change their behaviour and try and shift as much electricity consumption as possible to daylight hours and the middle of the day.¹⁶ This then translates into cost savings for the family or for the housing provider, which then directly or indirectly passes the savings on to the tenants.

An example of the economies of scale that can be achieved in social housing is the energy jump or *Energiesprong* programme in the Netherlands. This initiative is undertaking the wholesale renovation of thousands of social housing properties, including a solar roof, electrification of cooking equipment and space heating and a highly efficient wall envelope. In return the tenant pays a fixed monthly payment of approximately 160 EUR for energy services or a pre-specified comfort level, completely replacing the previous utility bills, and saving tenants a lot of money.

1.2.2.2 New build segment

Integrating solar PV into a building as it is being built is in some ways a separate PV segment to retrofitting the technology on existing buildings. The stakeholder here is the developer and construction companies rather than the occupiers or owners of the buildings. This applies both to the residential and non-residential building mounted segments. Generally speaking the driver for PV in this segment is building regulations. It is important to note also that when solar is sold as an add-on to an apartment in a new build development providers

have seen a higher take-up rate than when a solar system is offered to residents of an existing building.¹⁷ This is an argument for regulation and incentives for solar on new build housing.

1.2.3 Shopping centres, office buildings and other commercial buildings

This application segment can also be divided into buildings that have one single occupier and those that have multiple occupiers.

The advantage of solar projects on shopping centres is that this segment has high electricity demand and can achieve high solar self-consumption rates of up to 90%.

In some EU member states shopping centres are subject to specific building regulations. In Spain, as of 2009 all new build shopping centres and entertainment centres bigger than 5,000m² are mandated by law to meet a certain minimum of their power consumption with on-site solar PV. The minimum capacity of the system is calculated by a formula which takes into account the total building floor space and area to be air conditioned.

Office buildings similarly have the advantage that peak demand is generally during office hours and therefore times of peak solar generation. Other examples of commercial buildings that are ideal for solar are supermarkets, warehouses, cool stores, hotels and data centres. Almost all of these have high air conditioning or refrigeration loads. The load curve of cooling is an excellent match for PV's generation profile. Solar car park canopies are also an ideal option for big shopping centres, supermarkets and office buildings (although could in theory be used in any building mounted application segment).

¹⁵ Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast). Available here: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF>.

¹⁶ Research by Changeworks in social housing in the UK, more information available here: <http://www.changeworks.org.uk/case-studies/researching-the-effectiveness-of-solar-photovoltaic-panels-in-social-housing>

¹⁷ See national PV Financing Implementation Guidelines. Available here: <http://www.pv-financing.eu/implementation-guidelines/>.

The disadvantage of solar projects on shopping centres or multi-occupancy office buildings is, again, the large number of sub-tenants. However this can be overcome in shopping centres thanks to the high levels of power demand from communal areas, meaning that the solar system can pay for itself based on the communal power demand alone. Multi-tenant office buildings often provide tenancy contracts that include energy services which overcome the landlord/tenant dilemma.

The outlook for solar on shopping centres, office buildings and other commercial buildings is positive, with Power Purchase Agreements being the most promising business model.

In France 62% of big food retailers are keen to invest in a solar self-consumption solution.¹⁸ It is important to note that this market will be primarily a retrofit market, as new build large retail units are rare.

1.2.4 Public and educational buildings

The advantage of solar PV installations on public and educational buildings is that like the social housing sector, public authorities have long time horizons and very low costs of capital.

As with social housing, public authorities are subject to more stringent energy performance standards than in the private sector, creating an additional driver for solar PV.

Hospitals are public buildings in many member states and are a key target market for solar, due to high round-the-clock power consumption. They also have a large component of demand that requires “uninterruptible power supply” i.e. life-support systems or ongoing surgery that need electricity to continue even during a power cut. Solar systems can be designed to interact with existing back-up diesel generators and battery storage units to contribute to this.

However there are also disadvantages. Schools and other educational buildings have low demand during weekends and holidays which leads to low(er) overall self-consumption rates - in Germany

this is estimated at 75%. A fair price for excess exported electricity is therefore critical in this application segment.

Crowdfunding can be a good financing mechanism for public and educational buildings due to the role these buildings play in the community.

1.2.5 Industrial buildings, business parks and ground-mounted solar farms

1.2.5.1 Business parks and industrial buildings

Industrial buildings often have high power demand due to industrial processes. This makes them ideal customers for solar electricity supply.

An important factor in the industrial solar segment is property ownership. Countries where small and medium sized industrial buildings are generally owner-occupied, such as the *Mittelstand* in Germany, have higher incentives to install PV. These businesses are often family owned, have a long-term focus and strong social responsibility.

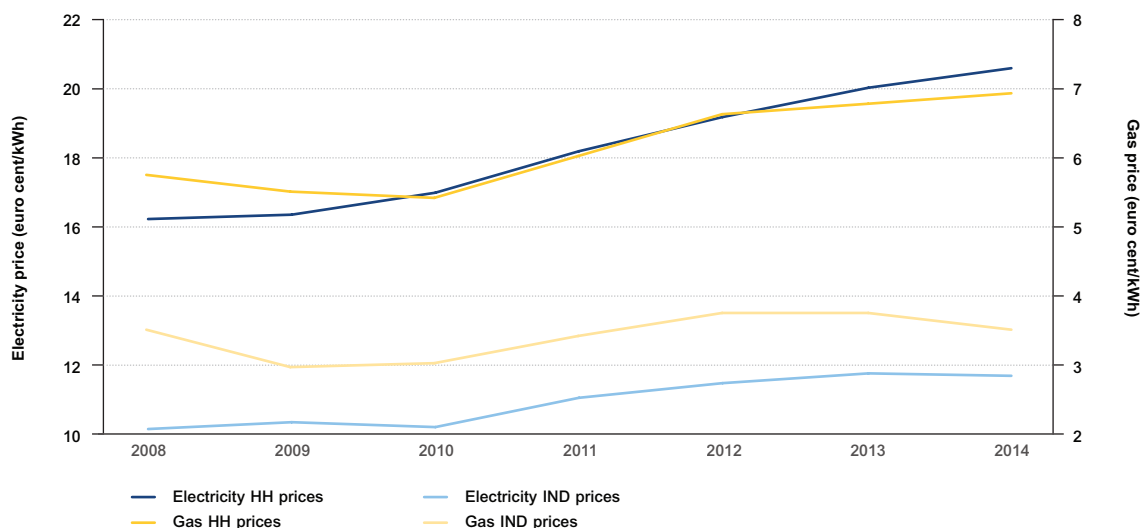
On the other hand countries where small and medium sized businesses tend to rent their buildings, as is the case in the UK and France, need more innovative financial solutions to overcome the landlord/tenant dilemma.

In most Member States the industrial sector has access to low electricity prices which acts as a disincentive to investing in solar. In 11 member states industrial users benefit from regulated end-user prices.¹⁹ In Germany and Austria solar struggles to compete with the retail prices already on offer in the industrial sector. The stark difference between residential and industrial prices can be seen in Figure 7.

¹⁸ Membership survey of the French large-scale retailers association or l'Association technique de la grande distribution (PERIFEM).

¹⁹ Agency for the Cooperation of European Energy Regulators “ACER Market Monitoring Report 2015”, November 2015, p. 10. Available here: http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER_Market_Monitoring_Report_2015.pdf

Figure 7. Electricity and gas post tax price trends for household and industrial customers in Europe, Eurocents/kWh (ACER)²⁰



The dominant business models in this segment are self-consumption and PPAs.

1.2.5.2 Ground-mounted solar farms or parks

The solar farm application segment represents one third of total solar deployment so far across the EU²¹ (Figure 8).

The advantage of solar farms is that it is much simpler from a legal perspective than roof-mounted PV. Rights issues are often simpler and standardised contracts can be applied in a one size fits all way. The only thing that can be more complicated is getting planning permission from the local municipality.

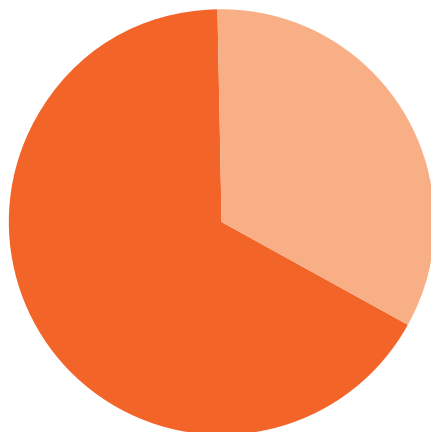
²⁰ Agency for the Cooperation of European Energy Regulators "ACER Market Monitoring Report 2015", November 2015, p. 10. Available here: http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER_Market_Monitoring_Report_2015.pdf

²¹ SolarPower Europe "Global Market Outlook for solar power 2016-2020", June 2016. Full report available here: <http://www.solarpowereurope.org/insights/global-market-outlook/>

Figure 8. Proportion of EU cumulative solar PV installed capacity by segment (SolarPower Europe)

LEGEND

- Rooftop
- Utility/
Ground mounted



Furthermore in some markets LCOEs for ground mount are lower than for roof-mounted solar.

Finally, and critically, solar farms are less risky for investors because they are built to inject into the grid and therefore there will always be a route-to-market for the electricity the plant generates. (This is not necessarily the case for a rooftop system on a building that is vacant and doesn't have a direct grid connection – see Section 2.2 for more.)

The disadvantage is that in some Member States the regulatory framework and support scheme discourages ground-mounted solar for land-use reasons. France for example encourages developers to focus on brownfield land and rooftop projects. Austria only subsidises rooftop solar.

These installations are almost exclusively designed for export to the grid, even if the power is then re-sold through an intermediary to a corporate power consumer. Low wholesale prices and reducing support schemes however mean that in many cases the business model for ground-mount solar farms could be challenging over the next few years.





2. POLICY DRIVERS AND BARRIERS ACROSS THE EU

The seven national implementation guidelines compiled as part of the PV FINANCING project have identified a number of common profitability

drivers and barriers to financing and deployment across the EU.

2.1. PROFITABILITY DRIVERS FOR FINANCING, INVESTMENT & DEPLOYMENT

The common profitability drivers across the EU are listed in this section, and the key drivers are summarised in Figure 9.



Figure 9. Key profitability drivers for solar PV projects across Europe



- **Electricity prices:** High retail or wholesale prices are the main driver when building a business case for solar PV. If the solar LCOE is lower than the retail or wholesale electricity price, then solar can be competitive. The map in Figure 4 shows an estimation of where this is already the case in Europe. It is important to also have a reliable forecast of future prices over the 20 years of the project, in addition to data on current prices.

A main driver for solar projects is how it can insure or hedge against future price increases. More and more solar systems are being sold on this basis – as a way of reducing the risk of rising costs in the future. On the whole retail electricity prices in the EU are on the high side compared to other OECD countries,²² although there are big variations within the EU.²³ Bulgaria, Hungary and Lithuania have very low retail power prices, whereas Denmark and Germany have high prices.²⁴ In the wholesale electricity market the last ten years has seen prices decline 35-45% on the major European wholesale electricity benchmarks.²⁵ As discussed above, this undermines the business case for large-scale ground mount solar PV.

²² For USA 0.1129EUR/kWh from https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a. Turkey 0.12EUR/kWh from [http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Electricity_prices_for_household_consumers_in_2015_sem_2_\(EUR_kWh\).png](http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Electricity_prices_for_household_consumers_in_2015_sem_2_(EUR_kWh).png). This also is shown in research done by FactCheckEU among other sources: <http://factcheckeu.org/factchecks/show/620/elzbieta-bienkowska>

²³ Agency for the Cooperation of European Energy Regulators "ACER Market Monitoring Report 2015", November 2015, Figure 4, p.11. Available here: http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER_Market_Monitoring_Report_2015.pdf

²⁴ Eurostat energy statistics. Available here: [http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Electricity_prices_for_household_consumers_in_2015_sem_2_\(EUR_kWh\).png](http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Electricity_prices_for_household_consumers_in_2015_sem_2_(EUR_kWh).png)

²⁵ European Commission, "Communication on energy prices and costs in Europe", 2014. Available here: https://ec.europa.eu/energy/sites/ener/files/documents/20140122_communication_energy_prices.pdf

- **Export price or price for excess electricity:** This is the amount paid, if at all, for electricity fed into the grid. In some countries this is not remunerated at all and therefore has a price of zero. In other countries it is given a price similar to the wholesale price of electricity or higher, in the form of an export tariff or Feed-in Tariff. In Austria there is a settlement centre for renewable energy which has to by law purchase excess electricity at a pre-set (low) price. Other Austrian utilities can offer slightly higher prices for export electricity, as a way of enticing the power consumer to buy their residual electricity from them. In Spain if a solar array is self-owned the consumer does not receive anything for the excess electricity injected into the grid. For more information on Spain see Annex VII.
- **Cost of capital:** This varies enormously across the EU depending on the country, application segment and financing scheme. It is broadly speaking a measure of the risk involved in the project – and often reflects the political risk of future changes in the regulatory framework. As said in the introduction, capital costs account for between a quarter and third of solar LCOEs. The cost of financing is an absolutely critical driver to whether or not a project is economic.
- **Solar irradiation:** The solar irradiation, or level of sunlight, makes a significant difference to the output and therefore rate of return of a solar PV system. Solar irradiation in the EU ranges from 750kWh/kWp in northern Scandinavia and Scotland to 1650kWh/kWp in southern Spain, Sicily and Cyprus.²⁶
- **Self-consumption rate:** For self-consumption business models, the level and pattern of power demand of the power consumer and the extent to which that matches the pattern of solar PV power generation is a key profitability driver. This is also affected by system sizing and can range from 20% to 100% depending on the power consumer. East-west systems can also be considered to increase the self-consumption rate.
- **Daily electricity price variation:** For power consumers such as industrial businesses that are subject to time of use tariffs or dynamic pricing, it is important to factor in at what time of day peak prices generally occur. Hot climates such as in Spain see summertime peak prices between 1pm and 7pm Monday to Friday, when the air conditioning load is at its highest. This is a good match with peak solar generation.
- **Building standards:** Many countries have mandatory regulations and standards for new and existing buildings that incentivise solar. Examples are:
 - In Spain new build shopping centres must have a minimum amount of solar PV (see Section 1.2.3).
 - In Vienna all new build commercial buildings must have have a 'renewable energy roof' in order to gain a building permit.²⁷
 - In Italy energy intensive industries are required to perform an energy audit every four years or put in place an energy management scheme.
 - Many other EU countries have building regulations that incentivise solar PV, driven in part by the 2010 EU Energy Performance of Buildings Directive.²⁸
- **System costs:** This is the cost of the solar PV modules, inverter, balance of systems and installation (capex) and operations and maintenance (opex). The bigger the local market size and experience the greater the economies of scale that can be achieved on e.g. shipping costs which bring down the system costs of an installation.
- **Support schemes:** All EU member states currently have some form of a renewable support scheme in place, in the form of feed-in tariffs, feed-in premiums, quotas, tradeable green certificates, net metering, tax incentives or investment grants.²⁹ However as the cost of solar PV modules falls the level of these support schemes are being reduced. It is important that this reduction of feed-in tariffs is done in a gradual and proportionate way. As was said above this makes solar PV project revenues more exposed to market prices and volatility, which can increase their risk profile.

26 European Commission Joint Research Centre, "Map of Photovoltaic Solar Electricity Potential in European Countries", 2006. <http://re.jrc.ec.europa.eu/pvgis/download/PVGIS-EuropeSolarPotential.pdf>

27 There were similar proposals in France for all new build commercial buildings, and supermarkets in particular, in specified zones to either have a solar PV installation and/or a plant based green roof. However this proposal was not enacted in the end.

28 Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings. Available here: http://eur-lex.europa.eu/legal-content/EN/ALL/ELX_SESSIONID=FZMjThLLzfmmMCQGp2Y1s2d3TjwID8QS3pqdkhXZbwqGwlgY9KN!2064651424?uri=CELEX:32010L0031

29 European Commission, Staff Working Document on guidance for the design of renewables support schemes, November 2013. Available here: https://ec.europa.eu/energy/sites/ener/files/com_2013_public_interven_tion_swd04_en.pdf

- **Grid services revenues:** This is the extent to which solar can provide and be compensated for participating in the balancing market and ancillary services to the grid such as reactive power, frequency response and voltage control. Additionally solar can help consumers avoid peak and locational grid charges. More information on the revenues from ancillary services available in the UK are detailed in Annex IX.
- **Green image:** The addition of a solar array to a building can make it more attractive to the end customer. This is a significant motivation especially in the domestic market, where investment decisions are not as “rational” as in the commercial market. An example is the new build Gran Plaza 2 shopping centre in Spain, where the large solar roof and green building image in the design proposal was a decisive criterion in winning the tender for the project.

More broadly, a real breakthrough in the domestic solar market will occur when solar is no longer viewed as a financial investment but as a sought-after desirable aspirational consumer good that people want on an emotional level, in the same way that they invest in a new kitchen or bathroom. The forthcoming Tesla SolarCity solar roofing product, which will integrate a Powerwall storage unit and a Tesla electric vehicle charging device into one offering, is an example of this. The aesthetics of domestic solar will therefore become more and more important, as will the marketing of the product. In multi-family residential buildings, we are already starting to see more of an emphasis on solar being marketed as a high-quality locally sourced electricity “product” rather than just cheap(er) electricity.

2.2. BARRIERS TO FINANCING, INVESTMENT AND DEPLOYMENT

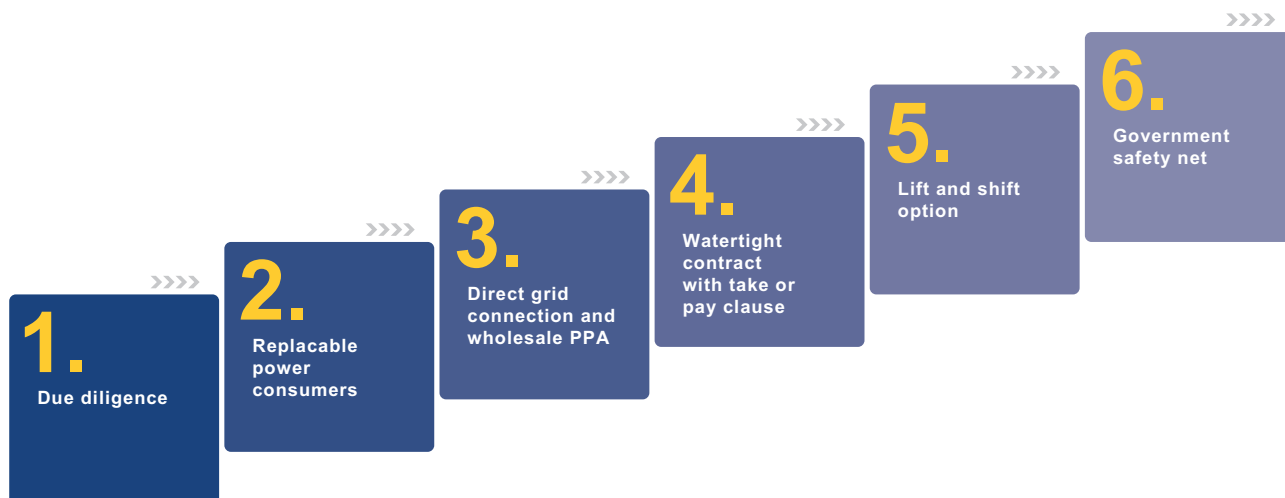
The PV FINANCING national guidelines also identified a number of common barriers across the EU.

- **Risk of power consumer changing, re-locating or going bankrupt:** A major barrier to building-mounted commercial solar PPAs across the EU is the perceived risk that the power consumer in the building could change or cease to exist. This could occur if the business that currently owns or rents the building either re-locates or goes bankrupt. Alternatively, the power consumer could change its business practices which could significantly reduce or change the pattern of power demand at the site. Ways to overcome this barrier are displayed in Figure 10 and include:
 - Conducting thorough due diligence on all potential power consumers – although the cost of this can be substantial.
 - Prioritising sites and power consumers that could easily be replaced if the business was to move or go bankrupt. For example, it is relatively easy to find a new tenant for a warehouse, more difficult for a steel plant.

There are examples of the new owner or occupier taking on a solar PPA liability together with the purchase or rent of a building, but this is not easy to guarantee and could lead to a complex re-negotiation of the contract.

- Securing a direct grid connection and a back-up wholesale PPA so that if anything goes wrong with the power consumer there is always a minimum level of back-up revenue available from the wholesale market.
- Ensuring that the PPA contract is watertight and that there are no loopholes the power consumer could use at a later date to change the agreed price or stop paying altogether.
- Including a “take or pay” clause in a PPA contract to force the power consumer to pay for power even if it does not use it. The disadvantage here is that this means the power consumer has no incentive to introduce energy efficiency improvements and reduce energy demand.

Figure 10. Possible steps to overcome offtaker risks e.g. bankruptcy or re-location



- Ensuring that the “lift and shift” option (i.e. removing the PV system from the roof and transferring it elsewhere) is a viable option as a last resort, even if in practice it is only a theoretical option to reassure investors.
- Arranging for the government to provide a safety net mechanism by which the risk of a stranded asset would be minimised.
- **Political risk:** This is where regulatory change alters or abolishes the revenue stream of a project. The worst case scenario in this case is retroactive regulatory change, which has occurred in the past for solar in Spain, the Czech Republic, Bulgaria, Greece and Italy.³⁰ This history of retroactive measures in these countries has greatly increased the cost of capital in these markets since then which has largely cancelled out the cost reduction in PV modules in recent years.

Ways to overcome this barrier include:

- Including a **change in law** clause in contracts so that if there is a change in law the contract can be re-priced to ensure the investor is no better and no worse off.
- Securing EU-wide investor protection rights and a guarantee from member states that they will not implement retroactive measures in EU legislation. This is something that is currently being discussed at EU level.
- **Quality risks:** Investors have to be careful of low-quality modules that do not perform to standard. Poor quality products provide lower electricity output which leads to lower revenues. Equally, a lack of confidence in installation businesses can be a barrier in residential solar markets.

³⁰ Keep on Track project “Policy paper on retrospective changes to RES legislation and national moratoria”, May 2013. Available here: <http://www.keepontrack.eu/contents/publicationsbiannualnationalpolicyupdatesversions/kot-policy-paper-on-retrospective-changes-to-res-support.pdf>

- **Taxes and charges:** Significant taxes and charges on self-consumed or exported solar electricity can act as a major barrier to investment. For example, in Austria if an entity consumes more than 25,000 kWh/year then self-consumed power is taxed at 0.015EUR/kWh. In Spain under certain models the export price is taxed at 7%. In Germany, systems above 10 kW are partially exposed to the payment of the EEG surcharge. Taxes can also be levied on the system as a whole instead of the electricity produced, as is the case for local business property taxes or **business rates** in the UK. There is currently a proposal to increase the business rates on self-consumption systems eightfold as of 2017 in the UK.
- **Minimum investment limits:** Large-scale solar projects can often benefit from project finance. However low cost of capital funding providers such as project finance banks, yieldcos, pension funds and insurance funds have minimum investment limits which even larger solar projects cannot meet. This can range from 25,000 EUR for some Austrian investors to 25million EUR in the case of the European Investment Bank and some major banks in the UK. A way to overcome this is for developers and Engineering, Procurement and Construction (EPC) firms to bundle multiple projects together, although this brings considerable legal challenges. It is hoped that such bundling of projects will be eligible for funding within the European Fund for Strategic Investments, a joint initiative of the European Commission and the European Investment Bank.
- **Definition of public grid within a building:** In many countries power cannot be transferred and sold from the roof of a building to e.g. apartments within that building because from a legal perspective it is considered to have used the public grid and therefore (a) is not legally permitted or (b) subject to grid charging. In Germany and soon Austria however this has been re-defined and the power is not technically considered to have used the public grid and not subject to grid charges. This best practice should be spread elsewhere across Europe in order to facilitate solar on multiple occupancy buildings.
- **Legal rights issues:** Roof-mounted projects in particular can have complex legal rights issues and accompanying legal fees that can make a project uneconomic, especially in the case of smaller projects. In some cases the building owner, occupier, tenants, sub-tenants and debt providers all require separate contract negotiations. Ways to overcome this barrier include:
 - Introducing standard contracts that become widely accepted in that market. Possible examples are provided by the PV FINANCING project template contracts, listed in Annex I. The International Renewable Energy Agency (IRENA) is also planning on publishing such template contracts in the near future.
- **Risk of curtailment:** In markets where there are high levels of grid congestion and a lack of flexibility, the risk of a solar generating asset being curtailed and what kind of compensation the asset owner will receive if curtailment does take place can have a major impact on the bankability of a project. Ways of overcoming this barrier include:
 - Guaranteeing priority dispatch and access of renewables in legislation except when there is a threat to security of supply. This is currently the case in the 2009 EU Renewable Energy Directive.³¹
 - a fair and transparent system for the compensation of curtailment
 - investments in system flexibility to allow for better integration of solar electricity.

³¹ Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources. Available here: <http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009L0028>



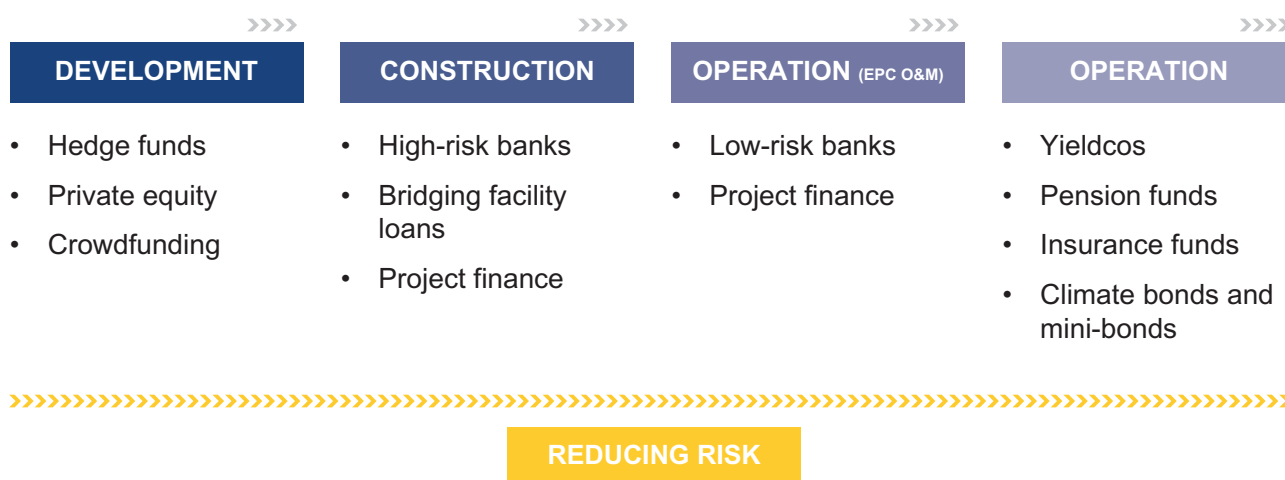
3. FINANCING SCHEMES ACROSS THE EU

There are a number of different financing schemes that can be used to raise money for solar PV. The main categories are self-funding, debt, equity, mezzanine financing, leasing and crowdfunding.

These different financing schemes can of course be combined in various ways, and different financing schemes will be appropriate at different stages of a project, as shown in Figure 11. A project can be re-financed several times during an installation's lifetime.



Figure 11. Stages of utility-scale ground mount solar PV and corresponding sources of financing



For utility-scale projects, the different phases are:

- *Project development: High-risk capital providers such as hedge funds and private equity will finance this stage, as the risk of any single project failing at this stage is high. It is rare to see debt financing at this stage, as besides the high risk often the project build time is shorter than the time required by a bank to fully assess a project. Crowdfunding and in particular cooperative financing can often be used at this stage.*
- *Construction: The risk profile lessens during this phase, and some banks that have higher risk appetites can consider lending to projects at this stage. Bridging facility loans are also available to help tide a project over from construction to operation. Some project finance banks can be willing to step in at this stage.*
- *Operational but with EPC O&M: In this phase risk profile falls again. This is the period (e.g. first 2-5 years of system lifetime) during which the EPC is responsible for operations and maintenance in order to correct any construction or manufacturing faults.*
- *Operational: This is the very low-risk operational period which provides very stable, steady returns. This would be an ideal time for green or climate bonds, yieldcos, pension funds or insurance funds to come in. Some forms of crowdfunding such as mini-bonds would come in at this stage to refinance an installation.*

Figure 12. Technical risk profile of a typical solar PV installation (Solar Bankability³²)

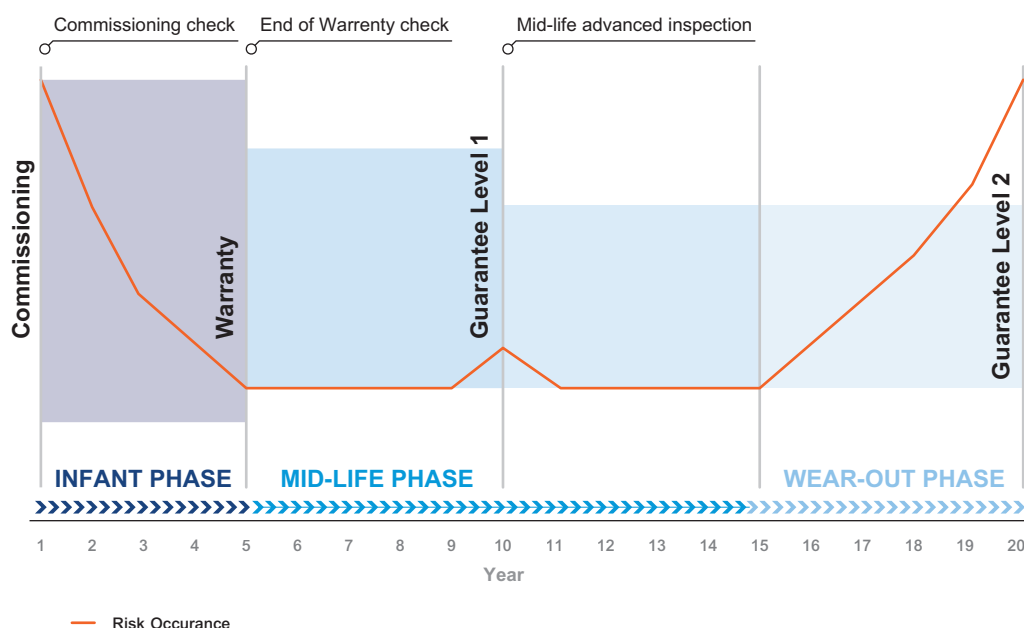


Figure 12 shows the technical risk profile of solar PV and illustrates why it makes sense to re-finance after two or five years when the risk profile dramatically reduces.

It is important also to note that in the PPA and crowdfunding business models a project is usually its own legal entity i.e. a Special Purpose Vehicle (SPV),³³ which makes it much easier to sell and re-finance a project. Many financing schemes require this as it ring-fences the project. The SPV usually bears the name of the location of the site and can be a limited partnership, trust, corporation, limited liability corporation or other legal entity.

Most of the financing schemes below require the involvement of banks and other financial institutions. This requires banks to build up sufficient know-how about solar and the various solar business models to be able to assess projects. Although many banks across the EU already have this knowledge, in general banks are often unwilling to build up this know-how unless they are confident of a significant project pipeline in that country. This can lead to a chicken and egg problem – solar projects cannot go ahead due to lack of financing and financial

institutions will not lend to solar projects due to a lack of solar projects. Big investors often just need to get over the hurdle of the first transaction in any particular technology. Once they are over that hurdle significant amounts of capital can quickly become available.

An example is the Soleil du Grand Ouest project in France, where only one bank in the whole of France was willing to lend to the project. However in the German and UK markets, Deutsche Bank, Maquarie Group and National Australia Bank are examples of banks who have built up in-house teams of engineers and technicians who will test and approve all the components that are to be used in the project.

Below each financing scheme is examined in detail, including variants of the main financing schemes.

³² Solar Bankability project. More information available here: <http://www.solarbankability.org/home.html>.

³³ This is also known as a Special Purpose Entity (SPE), Single Purpose Vehicle (SPV) or Financial Vehicle Corporation (FVC).

3.1. SELF-FUNDING³⁴

Self-funding is the simplest financing scheme,³⁵ where the system owner, usually also the power consumer, uses his/her own cash to pay for the system outright. Over the last ten years of solar PV development in Europe, much of which has been driven by support schemes, this has been the most

common financing scheme in the smaller scale residential and commercial application segments.

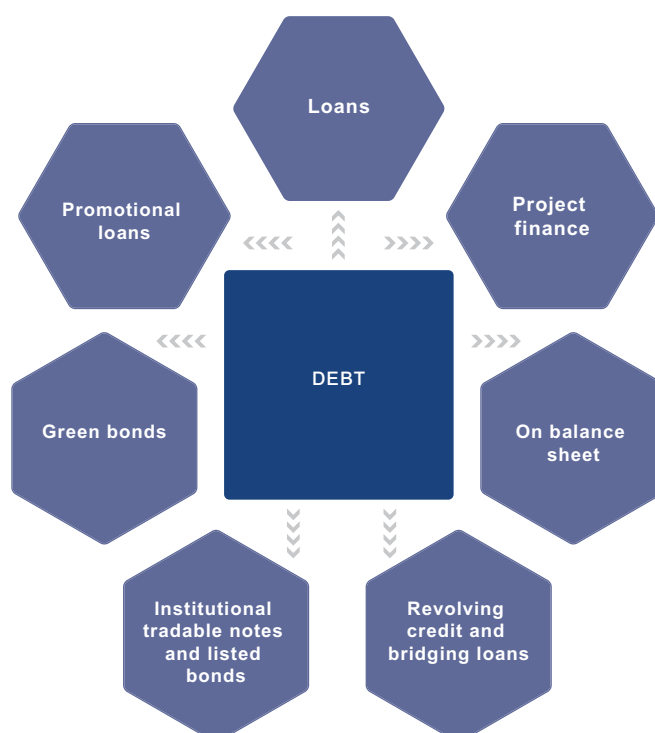
It is important to not rely entirely on this however as self-funding limits solar projects to sites and owners who have large amounts of cash readily available.

3.2. DEBT

Debt financing, which comes in many different forms, is where the owner borrows part of the money needed to pay for the solar PV system – the

different types of debt are shown in Figure 13 and described in detail below. Most projects are financed by a combination of debt and equity.

Figure 13. Types of debt commonly used in solar PV sector across Europe



³⁴ This financing scheme is also referred to as self-funded equity.

³⁵ If you assume that the word 'financing' refers to the provision of capital to another entity, self-funding is not technically a form of financing. However it is a way of raising money for solar PV, so is included here.

3.2.1 Loans

Personal loans are available for solar in the same way that they are used to purchase a car or pay for building renovation. Indeed most existing building renovation loans can also be used for solar panel installations. Banks will look at the owner's debt-to-income ratio when deciding how much to lend and at what interest rate. These loans can be secured on the owner's home or other assets. Solar loans can also be unsecured although this of course attracts a higher interest rate.

The terms of the loan usually depend more on the creditworthiness of the owner than the details of the solar PV system (unlike in project finance below where the terms are based on the project revenues). This means that often it is simpler and more effective if the owner applies to his/her usual bank for a loan, as that bank already knows and has a relationship with that customer, rather than shopping around and receiving multiple quotes from different banks.

In Belgium it is estimated that 70% of the residential systems are paid for with personal loans of this kind. AlphaCredit, a subsidiary of BNP Paribas, are an example of a bank that offers personal solar loans in Belgium. Residential installations in Turkey are sometimes funded by eco or green bank loans.

3.2.2 Project finance

Project finance is debt financing where the cash flow generated by the project, usually held within a Special Purpose Vehicle, is used to repay the loan. Project finance is generally used for large-scale infrastructure investments.

Project finance banks will base the financing amount on the available cash flows and the ability of the project to service its debt. A certain equity contribution is expected to cover the remaining amount. This means the project owner will have to combine project finance with another form of financing to allow the project to go ahead.

Project finance banks, together with the pension funds and yieldcos, require stable long-term revenues with a low risk profile, and therefore usually are only interested in re-financing operational projects. These low-risk investors also have the most stringent due diligence requirements.

Project finance banks are always very careful about guarantees and covenants,³⁶ as in the event of a project failure they risk not getting their money back. The bank will also usually establish a reference Debt Service Coverage Ratio (DSCR) that needs to be broadly maintained. If the client has a low DSCR for an extended period of time this can result in the covenants of the contract being enforced.

3.2.3 On balance sheet

This is where a project developer, EPC or corporate consumer funds a project by borrowing against the company's balance sheet. The bank or financial institution lends funds based on the creditworthiness and track record of the borrower.

3.2.4 Revolving credit facilities and bridging facilities

A revolving credit facility is where a bank or investor lends to a specific company on the basis of its relationship with that company to do a specific technology, and where the borrower can drawdown, repay and redraw funds as and when it wishes. It lends to a company as a whole, not a project. An example is Octopus Investments which finances Lightsource Renewable Energy in the UK and Ireland.

A bridging facility is a short-term loan designed to help a developer bridge the gap between construction and operation.

3.2.5 Institutional tradable notes and listed bonds

Tradable notes and listed bonds are debt instruments which in many ways resemble project finance loans but can be bought and sold on a secondary market and can be split between several providers of finance. This is considerably more complex than more traditional financing schemes such as project finance.

³⁶ A covenant is a promise in any formal debt agreement that certain activities will or will not be carried out.

3.2.6 Green bonds

This is where an investor lends a specified amount of money to a project or bundle of projects for a pre-defined amount of time at a pre-determined interest rate. The majority of green bonds are use of proceeds bonds³⁷ or asset-linked bonds.³⁸ In Germany these are issued by *Kreditanstalt für Wiederaufbau* (KfW) via private banks, and the proceeds of these bonds finance their promotional loans described in the section below.

3.2.7 Promotional loan

These are loans with good terms supplied by a financial institution such as KfW, the public investment bank in Germany, generally for promoting particular public policy objectives such as renewable energy.

3.3. EQUITY

A project can also be financed through equity³⁹ where an investor gains part or whole ownership of the asset. Most projects are a combination of equity and debt. Equity shareholders can then receive a regular dividend or a share of the profits, but are also more exposed if the project incurs losses. If a project goes bad equity is used to cover losses. Only if all equity has been used does the project default to debt financing.

Equity is riskier for an investor as compared to debt financing, and therefore requires a higher return on investment. Equity is a more expensive form of financing than debt. Equity investors tend to prefer high risk, high return investments, and will often get involved in projects during the development and construction phases.

Examples of equity participants in solar are investment funds, publically listed yieldcos, utilities and institutional investors. Some EPCs, manufacturers and corporate PPA off-takers also use their own balance sheets to fund projects.

Equity is often combined with debt, although the proportion depends on how the financial institution judges the creditworthiness of the project and the debtor. In Germany the equity share required by banks in order to lend has gone up from 20% to up to 40% depending on the size of the system, due to the decreasing feed-in tariff revenues. The lower the proportion of equity to debt in a project the higher the equity return.

³⁷ Where the money is lent on the basis that it will be used for a specific purpose.

³⁸ Where the money is lent to a pot or portfolio that is then used to give out loans to e.g. solar projects.

³⁹ The definition of equity is where an investor has a share in a project, or ownership of the asset. Equity participants are less protected than debt participants – i.e. the bank/lender would get its money first if project went bankrupt. That is part of why debt participants have lower costs of capital.

3.4. MEZZANINE FINANCING

Mezzanine financing is a layer of financing between debt and equity in terms of seniority. It can also be thought of as a hybrid between the two. It can take the form of unsecured debt or preferred shares. It is more expensive than regular debt financing, but cheaper than equity so can be used to minimize the equity share and therefore the cost of capital overall.

Some forms of mezzanine financing give the lender the right to convert to an equity interest in the company in case of default, after other senior lenders have been paid. Mezzanine financing often requires less due diligence than other types of financing.⁴⁰

3.5. LEASING⁴¹

Leasing is an innovative and very promising financing scheme for solar PV. Here the solar leasing company designs, purchases and installs a PV system on a consumer's roof and receives a monthly rent payment or leasing fee over a long period of time (10-20 years). In many countries there is an option to buy the system at the end of this period, making it akin to renting a house but with an option to buy the house at the end of the contract.

In the leasing model the consumer or homeowner operates the system and either self-consumes the free electricity, or exports it back to the grid via an export price or net metering mechanism. Importantly it is the consumer who is responsible for ensuring the system is properly maintained – if something goes wrong it is his/her responsibility to fix it. If the solar PV installation stops working for a month for example and no revenue is generated, the leasing fee will still be liable for that month.

Leasing always involves three contracts: a rooftop access contract, a leasing contract and a maintenance contract. The maintenance contract can be between the lessee e.g. homeowner and a third party service provider.

There are three alternative ways of setting up a leasing business model:

1. *A utility, solar installer or investor leases the system to the building owner.*
2. *A utility or similar leases the solar installation to the tenant, but signs a contract with the landlord for permission to use the roof space.*

3. *The building owner leases the system to the tenant.*

In all cases the lessor finances the system through a combination of debt and equity.

Like other financing schemes the leasing model avoids the up-front costs that are often a barrier to deployment for solar and spreads them over a long period of time. As long as the leasing fee is less than the savings and revenues, the consumer starts saving money from day one of the project. Also, leasing schemes can often receive special tax treatment which can be an advantage.

A disadvantage is that the situation can get complicated if the tenant or homeowner moves home. Generally speaking the lease can be transferred to the new occupier. However that depends on (a) the new occupier agreeing to take on the lease; (b) the new occupier being of a similar financial solvency or creditworthiness; and (c) the solar leasing model being sufficiently well understood that it does not put off potential homebuyers. In principle it should not be difficult to convince the new occupier to take on the lease because it should lead to a net saving on electricity bills. Interestingly in Germany leasing often cannot

⁴⁰ This and other definitions of financial concepts in this report have been adapted from Investopedia. For more details on mezzanine financing please see: <http://www.investopedia.com/terms/m/mezzaninefinancing.asp>.

⁴¹ Also referred to as 'contracting'.

apply to a Building Integrated PV (BIPV) installation, presumably as it would in theory be more expensive to “lift and shift” i.e. move the installation elsewhere.

A potential barrier to the leasing financing scheme is that national property regulations need to allow for a third party to own an asset that is fixed to the roof of a privately owned property. Mortgage lenders also have to be comfortable with the model. In the UK leasing can only be used in owner-occupied homes as opposed to rented homes. A similar model in the UK called the “rent a roof” scheme where a third party company installed solar on homeowners’ roofs and in return provided the homeowner with free solar electricity has in some cases caused problems with the re-sale of the home at a later date.

Finally another issue is who is held responsible in the case of the system causing damage or harm to a third party. In France there was a case when a wind farm caused an accident and the lessor e.g. the bank was held ultimately responsible.

This model has become very popular in Germany in applications where there is one single power consumer, partly because it is a way of not having to pay surcharges such as the *Erneuerbare Energien Gesetz* (EEG) within the current regulatory framework. It is also used in the United States where SolarCity and SunRun are the leading providers. It is in theory possible under certain self-consumption models in Spain but at the time of writing is not thought to have been used yet.

3.4.1 Sale and lease back⁴²

This is where an owner, often the developer, sells the project to an investor and then leases it back from that investor for small regular payments over a long period of time. It is a way for companies to raise capital from their existing assets to then re-invest in or finance other projects. Leaseback financing schemes can give the seller tax advantages.

3.6. CROWDFUNDING

Crowdfunding is a very promising solar financing scheme where a large number of people each put in small amounts of money into a scheme in order to raise money for a PV project.⁴³

Some forms of crowdfunding such as cooperatives can be both a business model and a financing scheme, and so cooperatives will also be covered in detail in the business model section of this report in Section 6 below.

Crowdfunding platforms provide financing in the form of loans, equity or grants, with equity crowdfunding being the most common.⁴⁴ The different types of crowdfunding are shown in Figure 14. In equity crowdfunding the investors become

co-owners or shareholders in the project, also known as shared ownership. This brings together a large number of smaller private and non-professional investors that then have an experienced investor – the crowdfunding platform – act as an intermediary for them.

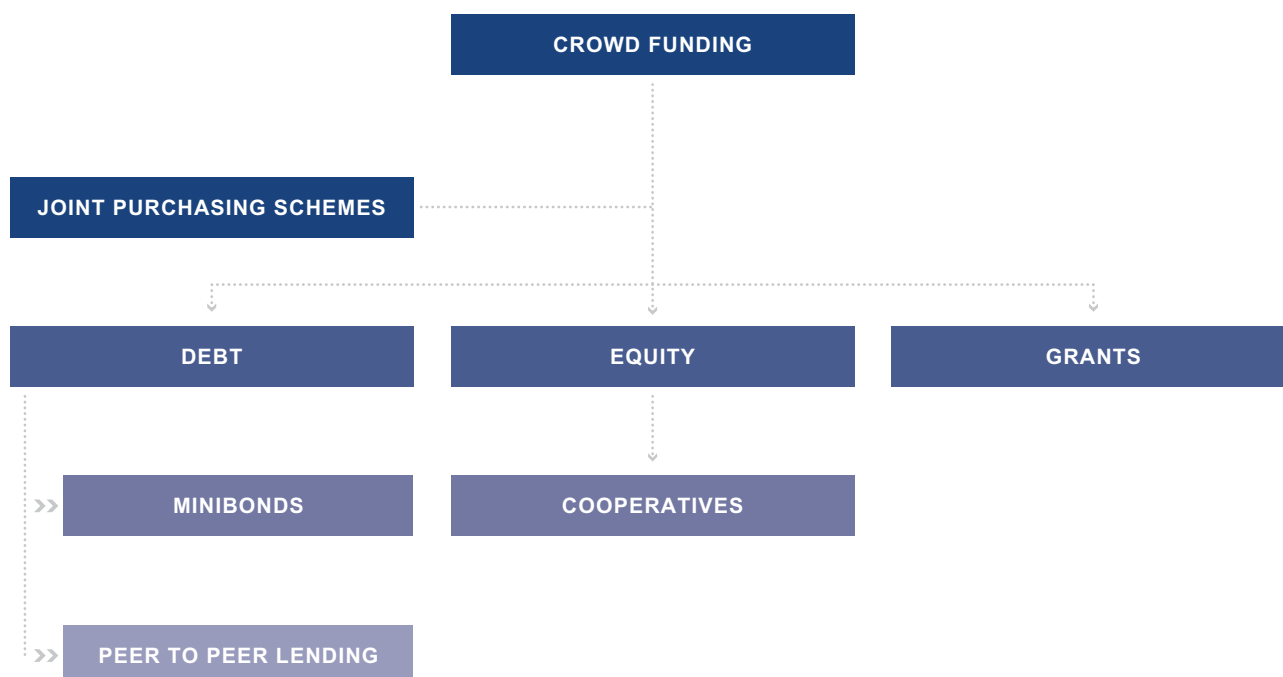
Grant crowdfunding is very rare but has been used on a small number of occasions where for example parents have helped finance solar PV on a school.

Crowdfunding is often combined with bank loans or equity and can help communicate a project to the local community, especially when local acceptance is required. There are also often substantial tax benefits to crowdfunded finance. It is also sometimes used when a project might struggle to get other forms of financing, especially for innovative and small-scale projects. Crowdfunding platforms might have different due diligence processes as compared to banks. It is therefore a financing scheme that can provide finance to a broader range of projects and increase the number

⁴² This financing scheme is also known as ‘leaseback’ for short.

⁴³ More information about crowdfunding for renewable energy is available from the ongoing CrowdFundRES project, available here: <http://www.crowdfundres.eu/>.

⁴⁴ There are also quasi crowdfunding platforms such as Citizen Energy that simply redirect citizens to local projects, however these are not considered here.

Figure 14. Types of crowdfunding for solar PV

of projects that can go ahead. Crowdfunding often provides more expensive capital than bank loans or equity funding.

Certain types of crowdfunding are generally a better fit for bigger projects that have sufficient scale to bear the management costs as the platform will often take a commission of 5-10% of funds raised.

Crowdfunding is popular in Germany, the UK and France. Examples of debt crowdfunding platforms are Abundance in the UK and Lumo in France.

3.6.1 Mini-bonds

Mini-bonds are a type of debt crowdfunding usually used to re-finance an existing installation. This is a low risk investment as the installation is already operational, and investors are asked to invest a pre-determined amount of money and will receive a pre-determined interest rate in return. The Big60million project in the UK is an example of mini-bond refinancing.

3.6.2 Peer-to-peer lending

This is a form of debt crowdfunding, often done via innovative online platforms. Like regular crowdfunding peer-to-peer lending requires a detailed business plan, appraisals, financial statements and details of the key people who are going to be leading the business. Examples are Open Energy and Mosaic in the United States. Abundance Investment offer a similar peer-to-peer investment product in the UK with debentures and Innovative Finance Individual Savings Accounts (ISAs).

3.6.3 Cooperatives

Cooperatives are a form of equity crowdfunding, where the investor-members jointly own and run the project and share out the proceeds of the project. They are profit-driven companies but allow members to own shares in renewable projects, share the profits of the projects through dividends and often get their electricity supply at a fair price from a local renewable energy supplier instead of a big utility. Decisions are made in a democratic manner within the members of the cooperative, with each member having an equal say in the running of the organisation.

Cooperatives come in all sizes, and there are examples of cooperatives with 60million EUR of capital and 100MW of generating capacity. There are approximately 6,500 renewable cooperatives across the EU representing 650,000 EU citizens. Examples of energy coops are Ecopower in Belgium which has 50,000 members, Enercoop in France which has 40,000 members and the Bristol Energy Coop and Cooperative Energy in the UK. EWS in Germany also runs a local distribution grid. Som Energia is a leading cooperative in Spain.

The cooperative business model will be discussed in more detail in Section 6.

3.6.4 Joint purchasing schemes

Joint purchasing schemes are not exactly a financing scheme but included here as they take a similar approach to crowdfunding. In this case a large number of consumers come together to jointly purchase residential solar PV systems on their homes. The homeowners achieve a better price per system due to their joint bargaining power and economies of scale for the installer. The scheme is usually run through a reversed auction. If the households participating in the joint purchasing scheme all live in the same neighbourhood, this further reduces costs for the installer. Joint purchasing schemes can also apply to residential households securing electricity supply contracts, where a lower cost per kWh can be achieved. An example is the Essex Energy Switch or the Money Saving Expert Cheap Energy Club in the UK, or iChooseR in the Netherlands, France and Belgium.

3.7. FINANCING SOLAR IN COMBINATION WITH OTHER TECHNOLOGIES

Solar could also be supplied and financed as part of a package of products and services. Solar can for example be combined with:

- *smart meters*
- *storage*
- *electric water heating devices*
- *devices to better manage electricity consumption*
- *energy efficiency measures*
- *heat pumps*
- *electric vehicles*
- *Balance Responsible Party (BRP)⁴⁵ services*
- *demand response aggregation services (i.e. ramping electricity demand up and down)*
- *purchase of excess electricity*
- *aggregator services to provide access to the wholesale and balancing markets*
- *a full energy service i.e. the provision of all types of energy to the building with the aim of achieving a certain comfort level instead of charging per kWh*

⁴⁵ BRPs are tasked with maintaining the balance between electricity injected and withdrawn from the grid in a certain time frame e.g. 15 minutes. BRPs can trade with other BRPs for e.g. the same or following day. If there is an imbalance in their portfolio then an imbalance tariff is applied.

Many industry commentators are predicting that the pure-play solar sector is likely to transition more and more into a solar+services provider. During the era of high support schemes, the business model was often dictated by the support scheme and the installer merely supplied the labour and components. Now that support schemes are being reduced, developer-installers will likely have to deliver a whole energy solution within which solar is but one part. In Italy, developers have found that it can be easier to finance solar PV projects if they are combined with energy efficiency projects. An

example of this is SolarCity in the United States, which is selling solar in combination with a Nest Learning Thermostat to allow consumers to save even more electricity.⁴⁶ Another is the *Energiesprong* social housing programme in the Netherlands, where the housing association invests in an in-depth renovation of the property in the return for a fixed payment for the provision of all energy services thereafter (see Section 1.2.2 for more details). The Domus Energetica case study in Section 4.4.2 is another example of an energy services solar business model and financing scheme.



⁴⁶ SolarCity in New Zealand is taking a different approach and offering customers a free coffee machine with the purchase of a solar PV system.



BUSINESS MODELS IN EUROPE

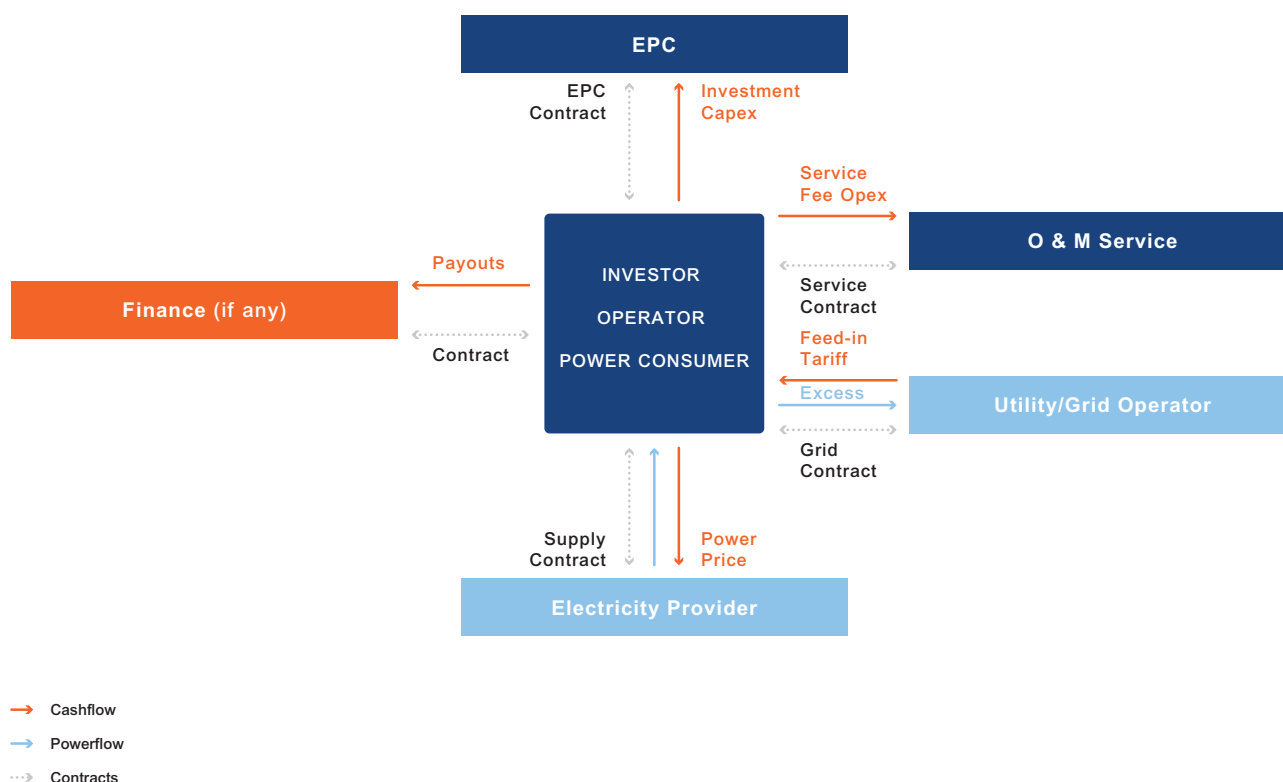
In this section we will look in detail at the self-consumption, Power Purchase Agreement, cooperative and virtual power plant business models that are in use across Europe. Note that these business models should not be seen as either/or options, but can be combined in

innovative ways. These can be combined with traditional Feed-in Tariff based business model. The neighbour solar supply or onsite direct wire mini PPAs business model is covered in section 1.2.2.2 on multi-family residential buildings.

4. SELF-CONSUMPTION BUSINESS MODEL

The self-consumption business model, which could be given the fuller name of the self-consumption and self-ownership business model, is defined as where the power consumer, investor and plant operator are the same entity.

This most often applies to a household, business or non-residential building. It therefore applies to all application segments described in Section 1.2 apart from ground-mount solar farms, which are very rarely designed for self-consumption.

Figure 15. Typical self-consumption business model

The key point about self-consumption is that the power consumer or building occupier aims to consume as much solar power itself as possible as in so doing it displaces the electricity it would usually have to buy in from the grid at high retail electricity prices. The model assumes that the retail price of electricity is higher than the export price for excess electricity fed back into the grid, and that therefore there is a financial incentive to self-consume. (There are some Member States where this does not apply – such as any country that has pure net metering and France and Turkey where the export price can be higher than the retail price. For more information on Turkey please see Annex V.) The self-consumption model is usually defined as where there is only one power consumer, and therefore that is the segment where it is most used. However there are some variants of self-consumption models with more than one power consumer, see Section 4.2 below.

As can be seen in Figure 16, the Investor, Operator and Power Consumer are the same entity in the self-consumption business model. The Power Consumer contracts with an Engineering, Procurement and Construction (EPC) firm to build the system. If the system is self-funded there is no need to contract with a finance provider but if the system is being financed by debt, equity or one of the other financing schemes described in Section 3 then a contract needs to be signed and the capital repaid. Excess electricity is sold to the grid for a price (often referred to as the feed-in tariff or export tariff). The Power Consumer then gets its residual electricity from an electricity provider and contracts with an Operations and Maintenance (O&M) provider for maintenance, if necessary.

All the financing schemes outlined in Section 3 above can be used to finance self-consumption, although the most common are self-funding, debt and leasing.

4.1. REGULATORY FRAMEWORKS FOR SELF-CONSUMPTION

There are major variations in the regulatory framework for self-consumption across Europe, with some countries heavily incentivising it and others doing the opposite. It is widely expected that the revised EU Renewable Energy Directive due to be finalised in the coming years will contain a new chapter on self-consumption, self-generation and the concept of ‘prosumers’ – electricity consumers who both produce and consume electricity.

There are a number of key determining regulatory factors in a self-consumption business model.

The first key factor is which of the three components of the retail electricity bill can be saved by self-generating and self-consuming electricity: the wholesale electricity price, grid charges and taxes. In many countries all three components can be saved, however going forwards there is more uncertainty around the framework for self-consumption and how self-consumed electricity is viewed in terms of grid charges and taxes. A shift from volumetric tariffs to capacity-based tariffs as has happened in the Netherlands and is ongoing in Italy, or increased taxation on self-consumed electricity has a major impact on the business case for solar.

The second key factor is what price the excess electricity can get for being exported to the grid, if electricity can be injected into the grid at all. This is where Feed-in Tariff schemes often come into play, offering a guaranteed price for excess electricity. Furthermore, whether or not a country decides to move to dynamic pricing⁴⁷ is an important factor within this, as the displaced retail price and the export price could then vary depending on the time of day and supply and demand. Ways to mitigate these risks include a guarantee of a minimum price for exported electricity and the remuneration of ancillary services to the grid.

The experience in many European countries has made clear that taxing self-consumed electricity acts as a major barrier to the transition to a more flexible, smarter and more decentralised energy system, and should therefore be avoided or kept to a minimum.

Furthermore, grid charges should be designed in such a way to be friendly to prosumer customers, as disproportionately high capacity-based grid charges can disincentivise self-consumption. Energy consumers should be incentivised to invest in technology that will increase system flexibility such as storage, aggregation, remotely controlled distributed assets and smart home energy management.

In Spain power consumers who self-consume solar electricity have to pay both fixed and variable charges on the self-consumed electricity, with a few exceptions for small systems and islands. See Annex VII for more details on Spain.

In Austria self-consumed electricity is taxed when a single entity consumes more than 25,000 kWh/year.

France and Turkey are both examples of countries where the export price is or was higher than the retail price. In Turkey the export price is 0.133USD/kWh whereas the retail price is 0.06USD/kWh. In France the export price for feeding electricity into the grid from small building integrated PV (BIPV) systems was set at 0.24 EUR/kWh. The retail price of electricity was just 0.15 EUR/kWh. This meant that households had no economic incentive to self-consume at all, and designed systems to export everything to the grid. This is very much the exception across Europe however – generally speaking grid congestion and charging means that it is more efficient from a whole system perspective for consumers to use as much of the electricity they can on-site. The French regulatory system is now changing and major utilities such as EDF and Engie are now beginning to offer solar self-consumption packages. EDF is now offering a package called “My sun and me” or *Mon soleil et moi*. A specific pilot tender for technology neutral commercial self-consumption projects was also launched in August 2016.

⁴⁷ Also known as advanced time-of-use tariffs.

4.2. VARIANTS OF SELF-CONSUMPTION

4.2.1 Multi power consumer self-consumption

Although the self-consumption business model is generally defined as where there is one power consumer and that power consumer is the owner and operator of the installation, it is also possible to have variants where there is more than one power consumer. Two examples from across the EU are interesting in this regard.

The first is the potential new Austrian “Gemeinschaftliche Erzeugungsanlage” shared generation facility model for multi-occupancy buildings where each occupier in the building, whether it be residential or commercial, owns either a significant or symbolic share of the SPV that operates the shared solar installation on the roof the building, and self-consumes a portion of that electricity. More information on this model can be found in Annex VI.

The second is the new collective self-consumption model in France. However although this is called self-consumption it is not strictly speaking self-consumption, as here one or more generators and one or more consumers can sell to each other as long as they are part of the same legal entity e.g. a cooperative and are located along the same branch of a low-voltage line. Here the cooperative (or other legal entity) will self-consume the power, but each consumer within the cooperative is buying power from another party to that cooperative. More information on this model can be found in Annex IV.

4.2.2 Net metering

Net metering is not strictly speaking a business model or a financing scheme. It is in effect a support scheme or regulatory framework for solar (like a feed-in tariff, premium or green certificates system) that creates a different business model for self-consumption style systems.

In a net metering or net billing support scheme excess solar electricity is remunerated via either (a) reverse metering or (b) financial credits. It in effect uses the grid as storage for excess electricity.

With a net metering scheme it is critical to check what the billing period or compensation period is – the time frame over which the two are balanced out. The longer the period allowed for compensation e.g. one year, the more profitable the investment in solar PV. If the compensation period is relatively long the scheme incentivises consumers to maximise the size of their system as there is no need to size the system to demand on-site. Generation throughout the time period simply has to be less than total power demand for that power consumer.

The advantage of a net metering scheme is that it incentivises high levels of PV deployment in application segments where the demand curve of individual consumers does not match solar’s generation profile, even though the whole system’s demand curve does. Because net metering schemes usually lead to larger system sizes as compared to systems for self-consumption with a low export price, all available roof space is maximised and this reduces the installed cost per kWp overall. This is also the best strategy if the goal is to have the highest possible deployment of PV in the electricity system – in some ways if you are sticking one solar module on a roof you might as well use all the space available.

The disadvantage is that it places a significant amount of pressure on the often inflexible and centralised grid, which is in effect used as a storage system for excess solar electricity. One of the benefits of PV in general is that it allows electricity to be generated and consumed on site and therefore minimises the need for the often expensive transmission of power across large distances. Net metering does not make the most of this benefit, and could over time lead to increased grid costs when compared to the alternatives. It also does not take into account the variation in electricity prices across the day, week or year.

The Netherlands, Belgium, Hungary, Romania, Greece and Turkey all have or had net metering schemes in place. Italy had a net billing system, where the electricity fed into the grid was credited on a consumer’s bill in monetary units rather than kWhs, but that is being phased out and replaced by a system that provides a lower export price.

4.3. BROAD STEPS FOR SELF-CONSUMPTION PROJECT IMPLEMENTATION

The broad steps for the implementation of a PV system with a self-consumption model in the EU are listed here. For more details in specific countries please refer to the national implementation guidelines available on the PV FINANCING website. Note that in reality many of these steps (and those in the sections below) would be progressed simultaneously. The broad steps for implementing a self-consumption project are:

1. Assess the **electricity demand pattern** of the power consumer, across the day and the year. *The higher the daylight electricity demand the better. In the residential segment standard demand profiles can be assumed, although some adjustment can be useful based on whether the householders are at home during the day. In the non-residential segment the building's demand should ideally be monitored for several typical days in order to build an accurate picture of demand on-site. In many cases additional data on consumption patterns is available via an analysis of bills or upon request from the electricity supplier. In some countries large businesses are metered for electricity in 30 minute segments, which can be used to build up a picture of demand.*
2. Gather information on the **retail electricity tariff** paid by the power consumer, and if there are any variations in the electricity price paid throughout the day or year.
3. Confirm what **price excess electricity** sold back to the grid will get, and whether that will increase over time. Note in some Member States this may be zero.
4. Commission one or more PV installers to survey the site, roof space and provide a **quotation** for installing a PV system. It is generally recommended to obtain minimum three different quotes in order to be able to *compare the prices on offer. Obtain references for the installers or EPCs, or select them from a list or database of quality-approved installers. The orientation, slope, shading and dimension of the roof should be analysed. An east-west option should be considered as well as the usual south facing system.*
5. Forecast the **operation and maintenance** costs and include also any corporate or local property taxes the power consumer may be liable for as a result of the PV installation.
6. Confirm if the self-consumed solar electricity will be **liable for any taxes or grid charges**. These can have a transformative effect on a business model, and it is key to monitor any regulatory changes in this field.
7. Conduct a full **profitability analysis** on the project, and determine what size system would result in the highest rate of return and maximise the self-consumption rate. Using all available roof space for PV is often not the optimal system size as far as return on investment is concerned.
8. Secure a **grid connection** and confirm the cost of and technical requirements for feeding into the grid.
9. Obtain permission from the local municipality⁴⁸ or a **construction permit** for the project, if required. In the UK this is not required for residential properties and subject to an accelerated process for commercial rooftops up to 1 MW in size. In France permission is required for residential properties. In Portugal there is a simplified procedure for smaller systems. In France every commercial solar project has to have a mandatory project presentation with the local fire brigade before it is granted a construction permit.

⁴⁸ This is known as planning permission in the UK or *permis d'urbanisme* in France. In many EU Member States urban and rural development planning is done through a 'zoning' system.

10. Secure financing for the project, using one of the financing schemes mentioned above such as self-funding, debt, equity, leasing or crowdfunding.

11. Commission the installer or EPC to build the solar installation. This takes anything from a day to several months, depending on the size of the system. Full health and safety requirements must be complied with when working at height on roofs. In many cases the electricity to the building needs to be temporarily switched off while the connection is made.

12. Complete any administrative processes. In many EU Member States the system has to be registered or notified on a central self-

consumption register or with a national authority or grid operator. It is usually at this stage that the project is registered for the national support scheme, if any. Some countries require an electrical safety check from an official body.

13. For larger systems, secure an operations and maintenance service provider who can provide continuous monitoring, thermography, regular visual inspections and cleaning. The SolarPower Europe O&M guidelines⁴⁹ can provide further detail in this step.

14. Generator power for the system's lifetime.

4.4. EU-WIDE SELF-CONSUMPTION SENSITIVITY ANALYSES

The profitability analysis of any individual project in any EU country will vary hugely from one country, location and system size to another. Therefore any EU-wide profitability analysis should be conducted and used with extreme caution, as averages from across the EU do not represent any particular market or project.

In this section we will conduct sensitivity scenarios on a broadly EU-average base case. The following assumptions were used in the base case:

- *The project is a typical residential 4 kWp system.*⁵⁰
- *The system is 40% self-funded and 60% financed by personal loan debt financing.*
- *The specific system cost for a residential system of this size is 1540 EUR/kWp, which is broadly in line with the cost in mature solar markets such as Germany and the UK and has been used in previous EU-wide analyses of residential solar PV.*⁵¹
- *The interest rate is 3.1% and discount rate⁵² is 4%, again from previous EU-wide studies.*⁵³ However it is important to note that this varies hugely from country to country and between different application segments.

- *The degradation is 0.5% per annum, as recommended by the EU PV Technology Platform.*⁵⁴
- *The yield is assumed to be 1,105 kWh/kWp/year which is that found in Frankfurt, Germany, as that is broadly recognised as the geographical mid-point of the European Union.*⁵⁵

49 SolarPower Europe "Operation and Maintenance Best Practices Guidelines", June 2016. <http://www.solarpowereurope.org/insights/operations-and-maintenance-om/>

50 SolarPower Europe analysis has shown that a typical residential solar system in the EU is 3.6 kWp in size, which in this model is rounded up to 4 kWp.

51 SolarPower Europe, "Ahead of the Pack: Solar the new gateway for the decentralised energy system", May 2016. Available here: <http://www.solarpowereurope.org/insights/solar-and-storage/>.

52 The discount rate is in effect the interest rate that person could get elsewhere, which means that future money is worth less than current money.

53 SolarPower Europe, "Ahead of the Pack: Solar the new gateway for the decentralised energy system", May 2016. Available here: <http://www.solarpowereurope.org/insights/solar-and-storage/>.

54 EU PV Technology Platform "PV Costs in Europe 2014-2030", June 2015. Available here: <http://www.etip-pv.eu/publications/other-publications/pv-costs.html>

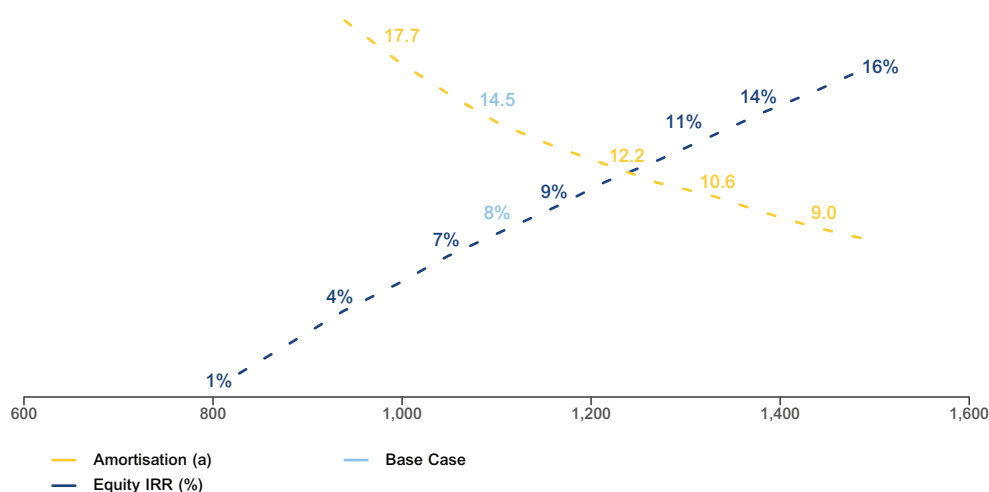
55 The yield for Frankfurt was estimated from: http://re.jrc.ec.europa.eu/pvgis/cmaps/eu_cmsaf_opt/PVGIS_EU_201204_publication.png.

- The retail electricity price is assumed to be 0.21 EUR/kWh as that is the EU-28 average according to Eurostat.⁵⁶
- No self-consumption tax is assumed in the base case, but a sensitivity analysis is conducted on this later in this section in order to show how variations in such a tax can have a major impact on a business model.
- The Feed-in Tariff or export price is assumed to be 0.15 EUR/kWh as that is representative of a good export price in a number of leading solar markets with adequate support frameworks. This is considerably higher than the wholesale price of electricity across Europe.⁵⁷
- The self-consumption rate is assumed to be 35% as that is the average of the national analyses conducted within the PV FINANCING project.

The main profitability drivers in a self-consumption model are: self-consumption levies, fees and grid charges, the retail electricity price, the export price for excess electricity and the self-consumption rate.

A sensitivity analysis was conducted on the yield of the location. As stated in Section 2.1, location and therefore solar irradiation levels influence the output of a PV installation. This graph in Figure 16 shows that as yield increases payback period falls and the equity IRR increases. However it is important to bear in mind that as you move from one regulatory framework to another and yield goes up or down the cost of capital can also vary hugely, as does of course the regulatory framework.

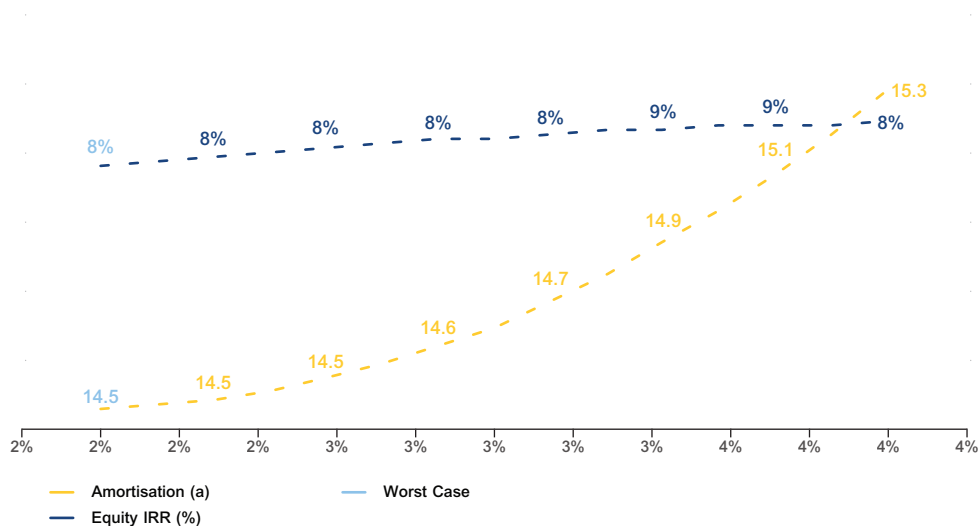
Figure 16. Sensitivity analysis for self-consumption based on yield



⁵⁶ Eurostat energy statistics: [http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Electricity_prices_for_household_consumers_in_2015_sem_2_\(EUR_kWh\).png](http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Electricity_prices_for_household_consumers_in_2015_sem_2_(EUR_kWh).png)

⁵⁷ Agency for the Cooperation of European Energy Regulators "ACER Market Monitoring Report 2015", November 2015, p. 75. Available here: http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER_Market_Monitoring_Report_2015.pdf

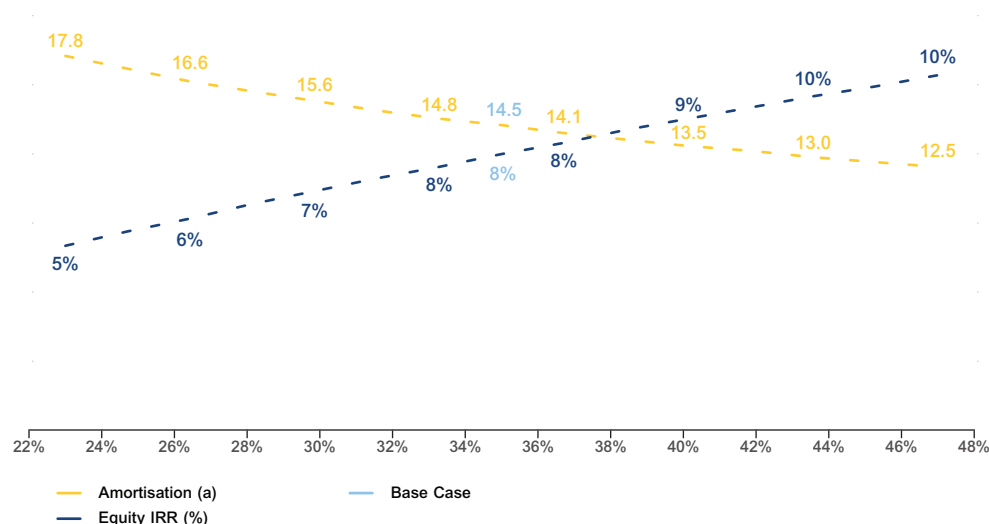
Figure 17. Sensitivity analysis of self-consumption based on debt interest rate⁵⁸



A further sensitivity analysis was conducted based on the debt interest rate (Figure 17) to simulate what happens as the cost of capital increases, as happens from country to country and depending on the creditworthiness of the power off-taker. It shows that as the debt interest rate increases the payback time (or amortisation) also increases significantly making projects less and less economically attractive.



⁵⁸ This graph should be interpreted as a gradual increasing of the interest rate with decimal values instead of integers.

Figure 18. Sensitivity analysis of self-consumption based on self-consumption rate

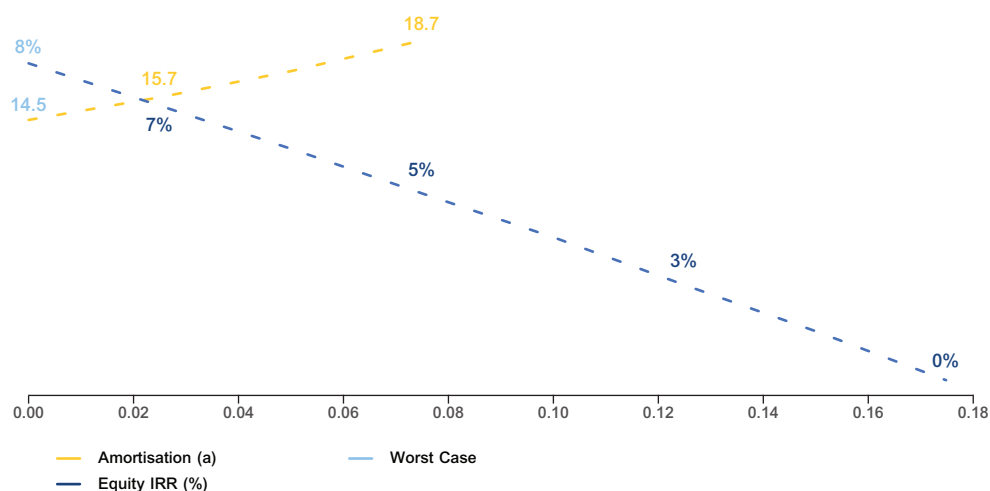
A further sensitivity analysis was conducted on the self-consumption rate (Figure 18).

The assumed 35% self-consumption rate in the base case above is typical of a household that does not take any further measures. It is possible for a household to increase the self-consumption rate further with the use of the measures described in Section 3.7 such as battery storage, smart meters, heat pumps and electric vehicles. Load shifting or altering consumer behaviour to use power during daylight hours with household appliances such as dishwashers and washing machines can push the self-consumption rate up to 40%. The analysis in Figure 18 above shows that as the self-consumption rate increases the payback time reduces and the equity IRR or rate of return on the project increases.

A note of caution is required with regards battery storage however. Up until now battery storage systems have been too expensive to justify the additional savings and decrease rather than increase the financial returns of a solar investment. A recent study⁵⁹ showed that adding storage lowers the IRR of a solar PV installation in Germany, the UK and Portugal.

⁵⁹ SolarPower Europe "Ahead of the Pack: Solar the new gateway for the decentralised energy system", May 2016. Available here: <http://www.solarpowereurope.org/insights/solar-and-storage/>.

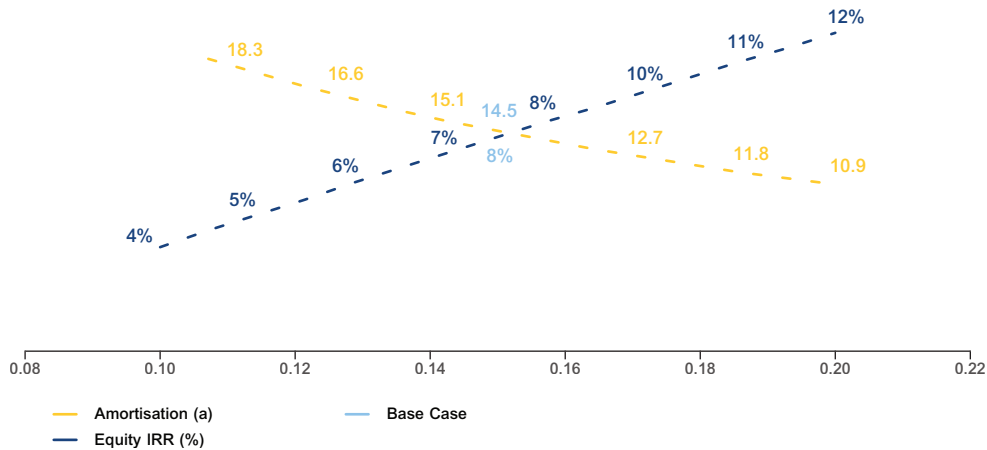
Figure 19. Sensitivity analysis for self-consumption based on levies and fees on self-consumed electricity



The analysis in Figure 18 above assumes that there are no taxes or charges on self-consumed solar electricity. However in Figure 19 above we look at what happens if you start applying such levies and fees on self-consumption. As levies and fees increase from zero upwards equity IRR reduces to zero and payback increases to almost 19 years. To put this in the context of current charges and fees across Europe, Austria applies a 0.015EUR/kWh fee and Spain an average of 0.01787EUR/kWh fee on self-consumed power for clients on a specific tariff, putting both towards the left hand side of the x-axis in the figure below.



Figure 20. Sensitivity analysis of self-consumption based on Feed-in Tariff level



Finally a sensitivity analysis is conducted on the Feed-in Tariff or export tariff offered to the installation (Figure 20). As you would expect the return on investment increases and payback period falls as the Feed-in Tariff increases.

A conservative assumption would be to assume that solar PV installations receive an export price of 0.05EUR/kWh, which is similar to the average wholesale price in many markets. This would be slightly beyond the left hand side of the x-axis. However even assuming that solar will be rewarded with average wholesale prices could be seen as an optimistic assumption as once there is more and more PV deployed at times of peak PV generation wholesale prices may reduce due to the Merit Order Effect. In Portugal exported electricity gets 90% of the average wholesale price that month, with the percentage reducing gradually as there is more and more solar PV on the system. In the UK solar is awarded a fixed inflation linked export tariff of 0.05664EUR/kWh designed to be broadly in line with the wholesale price.

These sensitivity analyses show that self-consumption business models vary depending on a broad range of factors.

4.5. CASE STUDIES

4.5.1 Dairy farm - France

Figure 21. Wittelsheim GAEC dairy farm
(Web-agri/Terre-net Média.)



The first case study of a self-consumption business model is in Wittelsheim in the Alsace region in France, where the Wittelsheim *Groupeement Agricole d'Exploitation Collective* (GAEC) dairy farm installed a PV system.

The dairy farm had a 14 kWp PV system installed on its roof. The system produces almost 15,000 kWh/year, practically all of which is self-consumed. The output covers 22% of the site's total demand. Dairy farms use electricity for the pumping system and processing and refrigerating the milk.

The system cost just under 23,000 EUR in total, or a specific system price of 1,630 EUR/kWp. The retail electricity price for the dairy farm is 0.1525 EUR/kWh.

Approximately 10% of the system funding was through subsidies. Overall this resulted in a particularly short payback period of just over seven years.

4.5.2 Domus Energethica - Italy

Figure 22. Domus Energethica building,
Tradate, Italy (F.Ili Bertani S.p.A.)



The “Domus Energethica” is a new build six storey mixed residential and commercial building with about 40 apartments and several shops on the ground floor. It is located in Tradate near Varese, in the Lombardy region of Italy.

The building is an energy efficient building with Energy Performance Certificate A. It has 80 kWp of PV on the roof. It also has electric space heating, cooling and hot water which maximizes the electricity demand in the building despite the high energy efficiency. A geothermal installation also supplies heat to the building.

The PV installation cost 100,000 EUR, or 1,250 EUR/kWp. It was financed together with the financing of the construction of the building.

The PV plant is and will remain under the ownership of the building company which will use an Energy Services Company (i.e. a company that is contracted to provide all types of energy to the building with the aim of achieving a certain comfort level or range of temperatures) to sell a holistic energy package to the occupiers.

The total annual electricity demand is forecasted to be just over 100 MWh, and the PV system is expected to generate 95 MWh/year. The self-consumption rate is expected to be higher than for residential only buildings thanks to the shops on the ground floor.

The Energy Services Company (ESCO) will save between 16,000 and 20,000 EUR/year thanks to self-consuming the PV electricity rather than buying it from the grid at the retail price of 0.23 EUR/kWh. Because this is done with an energy services model, the developer has been able to guarantee to tenants that the energy costs will be maximum 750 EUR per year per apartment, replacing their utility bills.

4.6. OUTLOOK

The self-consumption business model is likely to become more and more of relevance across the EU as retail electricity prices rise and financial support schemes are reduced. Many national markets across Europe see it as the most promising and future-oriented PV business model.

The main regulatory challenge is ensuring that self-consumption is (a) permitted in general and (b) not overly taxed or subject to unfair grid charges. It is important for regulatory authorities to recognise the role that self-consumption and locating generation at the point of demand can play in reducing pressure on electricity transmission and distribution infrastructure. Electricity self-consumed is electricity that does not need to be transported across large distances.





5. POWER PURCHASE AGREEMENTS (PPAs) SUPPLY CONTRACT BUSINESS MODEL

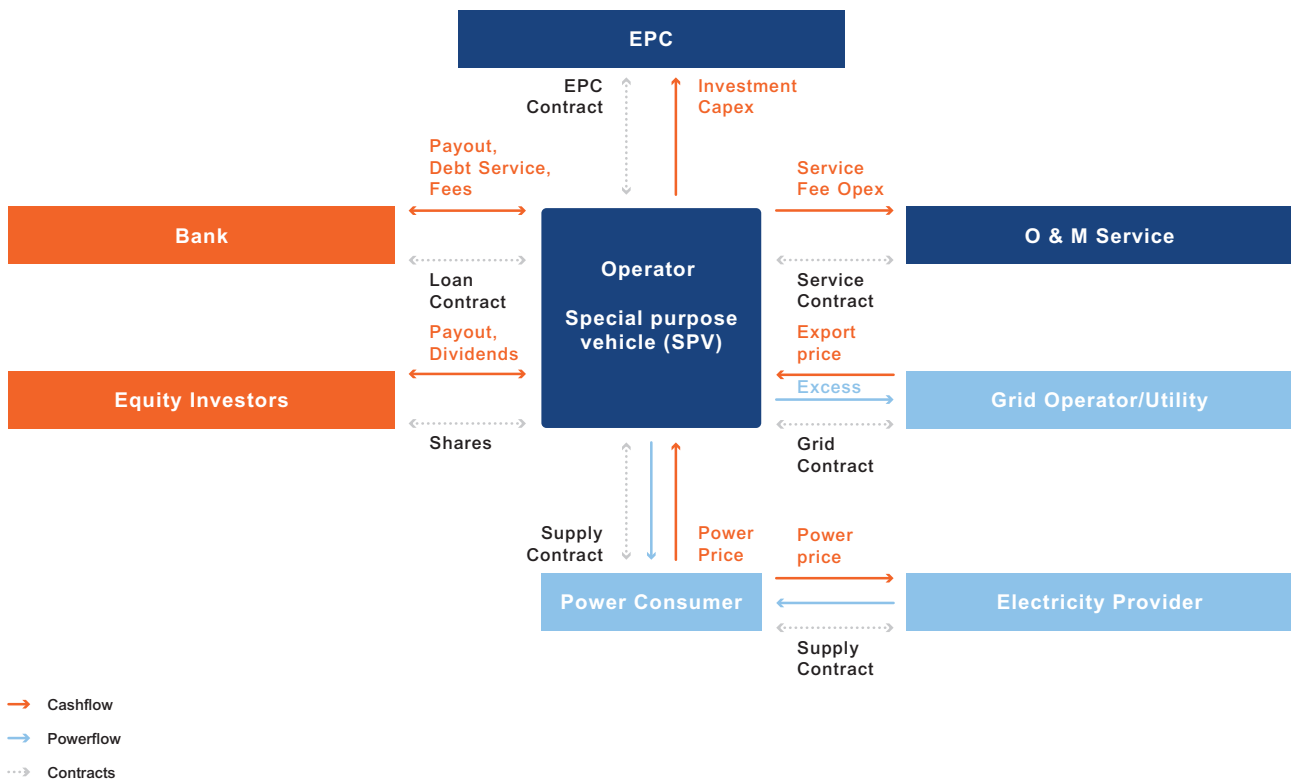
A Power Purchase Agreement is a contract between an electricity generator and an offtaker (a consumer or reseller) which sets a price per kWh for a relatively long period of time e.g.

5-20 years. Additionally the contract usually states a defined minimum amount of electricity to be supplied per year. Figure 23 shows a typical PPA business model.

Here the operator is a self-contained entity called a Special Purpose Vehicle (SPV). See Section 3 for more details on SPVs. The Power Consumer (of which there can be more than one) then contracts with an electricity provider for the residual electricity. The operator SPV contracts with the O&M service provider, the grid operator/utility to sell excess electricity (currently often via a Feed-in Tariff), the EPC for construction and the bank and equity providers for financing.

The PPA price can be set in several ways:

- A fixed PPA price for the duration of the contract
- A set discount on the wholesale or retail electricity price, known as a “tracker PPA”
- A dynamic discount on the retail electricity price, where the higher the increase in the price the greater the discount.

Figure 23. Typical onsite private wire PPA business model structure

PV is an ideal technology for long-term fixed price contracts as most of the costs of a system are up-front costs at the beginning of the project. Where PPAs track the electricity price, there is a risk to the investors of a sudden decrease in electricity prices, but this can be mitigated with floor and roof prices. Some PPA contracts also include a buyout clause where the power consumer can buy the system outright after a period of time, usually 5-8 years, and switch to a self-consumption business model without having had to pay out the full amount at the beginning of the project.

The fact that the PV system is owned by a third party is beneficial because it shifts the investment decision to an entity that often has a longer-term investment horizon and longer-term criteria than the corporate power customer. PPAs are generally financed with debt, equity or crowdfunding.

More information on the PPA framework and various revenue streams in the UK is available in Annex IX.

In Germany this business model is used when there is more than one power consumer.

5.1. REGULATORY FRAMEWORKS FOR PPAS

The regulatory framework for PPAs varies a lot across the EU and Europe as a whole. It is important to distinguish between corporate and wholesale PPAs. More detail on this is below, however broadly speaking corporate PPAs are with a business whereas wholesale PPAs inject electricity into the grid and sell it on wholesale markets.

There are many countries such as the UK, Germany, Italy, the Netherlands and across Scandinavia where corporate PPAs are very common. However in some other markets corporate PPAs are not authorised.

In order to be able to set up a corporate PPA you need a few basic regulatory elements in place. First, power consumers should be free to choose their electricity supplier and be able to have two electricity supply contracts at the same time (e.g. one solar PPA and one for the residual demand). If this is not permitted in the regulatory system, it could still in theory be possible to get a solar PPA but this would have to be combined into a single contract and provided by a licensed supplier. Second, any taxes and grid charges levied on the solar electricity should be reasonable so as not to disincentivise solar projects. Third, for onsite direct wire PPAs it has to be possible to build a private

wire. Fourth, competition authorities must allow SPVs to sign long-term PPAs with customers as ultimately this is a way of creating more not less choice in the market, even if the counterparty is sometimes a market dominant utility player.

PPAs are not currently authorised or have not been legislated for in France, Spain and Turkey. In Spain a power consumer is not allowed to have two electricity supply contracts. In Turkey the power consumer, operator and investor cannot be different entities for projects less than 1 MW in size. Austria only allows wholesale PPAs and special forms of corporate PPAs like onsite direct wire PPAs.

Note that in some ways Feed-in Tariff support schemes are state-guaranteed mandatory PPAs with utilities, grid operators or public authorities, often at a higher than market price.

In France it is also very difficult to build a 'private wire' between two locations adjacent or near to one another. The only exception is if it can be proven that the private wire provides a better service than the grid. There is currently only one example of a private wire in France, that belonging to the *Compagnie Nationale du Rhone*, which deals with transport and energy on the river Rhone.

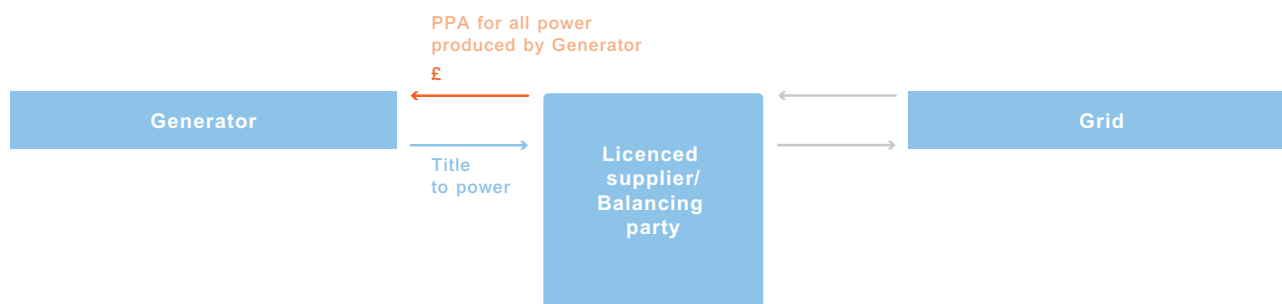
5.2. VARIANTS OF PPAS

In this section a number of variations of the PPA model are examined. A lot of the innovation in solar business models is in this field.

5.2.1 Wholesale PPA

The wholesale (or utility) PPA business model is used for ground-mounted solar farms feeding power into the grid and selling power on the wholesale market. In this business model the installation is owned by a company, the generator, usually a Special Purpose Vehicle (SPV). This company establishes a Power Purchase Agreement contract with a grid operator such as a licensed electricity supplier or balancing party. The licensed supplier or balancing party then sells the electricity on the open market and to its customers.

Figure 24. The wholesale PPA model (Solar Trade Association/Bird&Bird⁶⁰)



The PPA contract can be signed for a long period of time e.g. 15 years however if wholesale electricity prices are difficult to forecast the price will only be fixed for the first period e.g. 3 years and then track the wholesale price thereafter.

With wholesale PPAs there are no offtaker risks – under normal circumstances the power will always be remunerated, the question is just how much. This makes them much less risky than corporate PPAs. It is also a simple model and so legal costs are low.

The disadvantage of the wholesale PPA is that the forecast for wholesale electricity prices does not provide for a good business environment as prices across Europe are currently low and likely to remain low.⁶¹ This means that the financial returns of ground-mounted wholesale PPA projects are currently low. Ironically because of the Merit Order Effect the more zero marginal cost renewables like wind and solar there is on the system the lower wholesale prices will become at times of peak generation. It would be beneficial if policy-makers could put in place a “market-stabilising” framework to ensure that the business case for new wholesale PPAs can continue.

5.2.2 Corporate PPAs

Given low wholesale prices, developers have innovated to try and increase the value of the solar electricity and be able to sell that power at a price closer to the retail power price rather than just the lower wholesale power price. The following business models are all variants of corporate PPAs i.e. models where the final consumer of the power is a corporate consumer that is using the solar electricity to save money on energy costs.



⁶⁰ The PPA variant diagrams are from the PV Financing UK National Implementation Guidelines. Solar Trade Association “Making Solar Pay: The Future of the Solar PPA market in the UK”, October 2016. Available here: http://www.pv-financing.eu/wp-content/uploads/2016/11/D4.1_UK.pdf.

⁶¹ European Commission, “Communication on energy prices and costs in Europe”, 2014. Available here: https://ec.europa.eu/energy/sites/ener/files/documents/20140122_communication_energy_prices.pdf

5.2.2.1 Onsite private wire PPA⁶²

In the onsite private (or direct) wire business model the generator SPV builds a solar installation on the power consumer's side of the grid meter, usually on the building's roof. The generator SPV contracts via a corporate PPA with the power consumer to sell them all or most of the power.

Where possible, the generator then signs a spillover or excess PPA with a licensed supplier and any excess electricity (e.g. power generated at weekends or public holidays) goes via a separate connection between the installation and the grid. (Note that such a separate connection point is not always available.)

The spillover PPA, which is competing with wholesale prices, will get a lower per kWh price than the onsite direct wire PPA, which competes with retail prices.

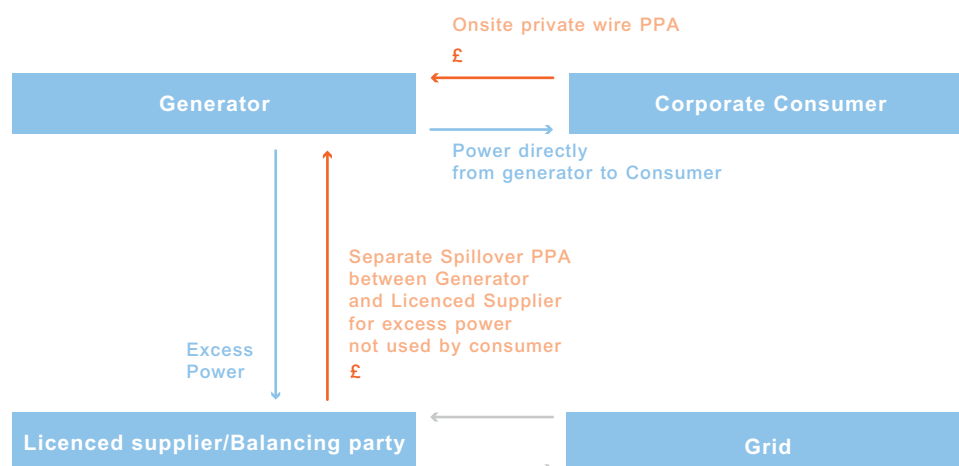
It is possible for both the onsite direct wire PPA and the spillover PPA to be bundled together into one contract from a single supplier.

The advantage of the onsite private wire PPA is that the electricity is not transmitted via the public grid and therefore, in most countries, is not liable for grid charges.

The disadvantage is the offtaker risk. The corporate consumer has to be considered sufficiently creditworthy to facilitate the financing of the solar installation over a long-time period. As described in Section 2.2, the risk of the corporate consumer going bankrupt or moving away can make a project like this too risky to finance.

The neighbour solar supply or onsite direct wire mini PPA model for multi-family residential buildings described in Section 1.2.2 is a sub-variant of this model.

Figure 25. Onsite private wire PPA model (Solar Trade Association/Bird&Bird)



⁶² In Italy this is similar to the system called "Sistemi Efficienti di Utenza".

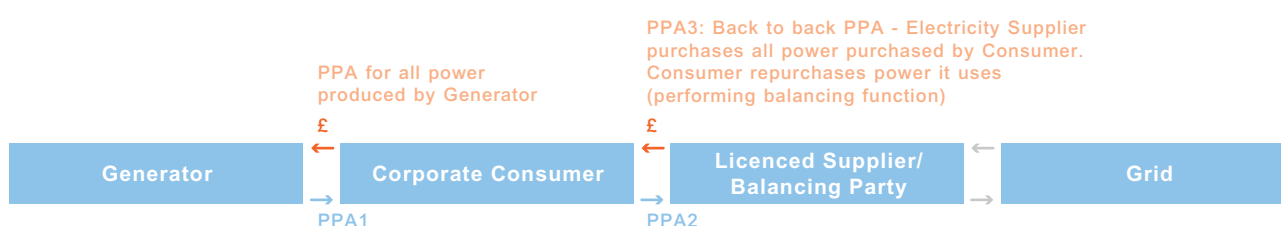
5.2.2.2 Sleeved off-site PPA

A sleeved off-site PPA⁶³ is therefore an attempt to maximise the value of the solar electricity to a value closer to retail prices but avoid the offtaker risk by creating a model where there are a multitude of potential offtakers.

In a sleeved off-site PPA the generator company sells to a corporate consumer (PPA1) at the point at which the solar installation is connected to the grid ("meter point"), who then immediately on-sells

the same volume of power on to the utility (PPA2). The utility then sleeves the power through the grid and sells the equivalent amount of power (PPA3) back to the corporate consumer at its site elsewhere in the country. The utility performs a balancing service by topping up the renewable electricity with non-renewable electricity when needed. Both the power and the legal contracts are sleeved through the corporate consumer, licensed supplier and grid and then back to the corporate consumer.

Figure 26. Sleeved PPA model (Solar Trade Association/Bird&Bird)



The advantage is that the risk that the corporate counterparty might go bankrupt is not so important, as other offtakers can always be found, although perhaps not at the same price. The physical ground-mounted solar project has a grid connection so the electricity can always find a route to market.

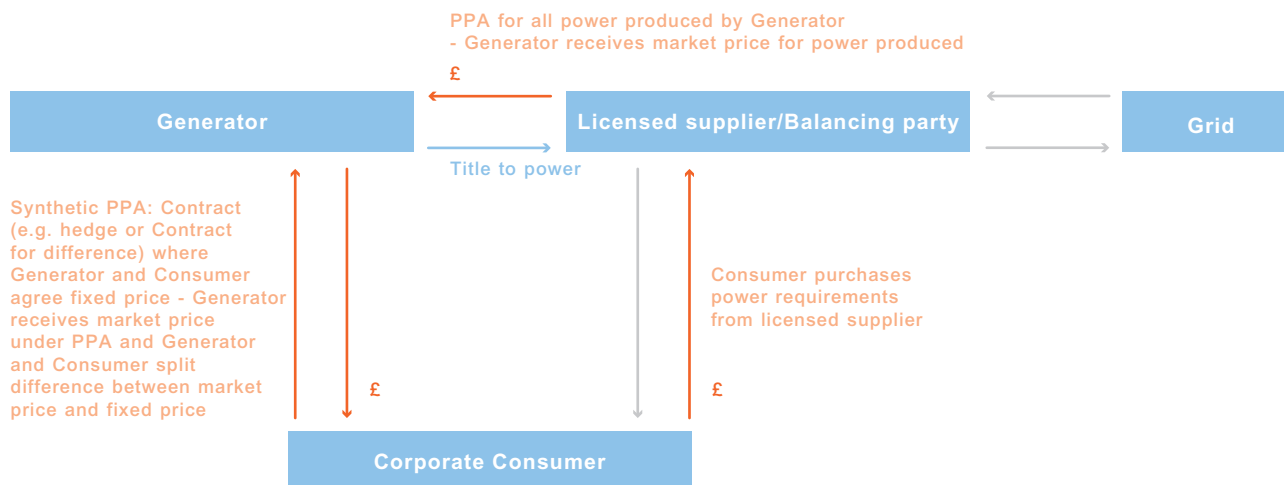
The disadvantages are that it is a relatively complex model and the licensed supplier acts as a middle man, setting prices and adding costs for its sleeving and balancing services. The next model, the synthetic PPA, therefore seeks to eliminate this price risk.

5.2.2.3 Synthetic PPA

The synthetic PPA is the same as a sleeved PPA but with the addition of a direct contract between the generator SPV and the corporate power consumer which fixes a certain volume of electricity at a certain price over a long period of time. The fixed price is often similar to the market price, but fixed over a long period of time, which is a benefit for both the generator and the power consumer.

It is useful here to consider an example. Assume that the Generator and the Corporate Consumer set a price of 100EUR/MWh as their fixed price. The sum of the Corporate Consumer's contracts with the Generator and the Licensed Supplier must always come to 100EUR/MWh. If retail prices go up and the Licensed Supplier starts charging the Corporate Consumer 110EUR/MWh, then the Generator has to pay the Corporate Consumer 10EUR/MWh. If retail prices go down (which rarely happens) and the Licensed Supplier starts charging the Corporate Consumer 90 EUR/MWh, then the Corporate Consumer has to pay the Generator 10EUR/MWh.

⁶³ Also known as a back-to-back PPA.

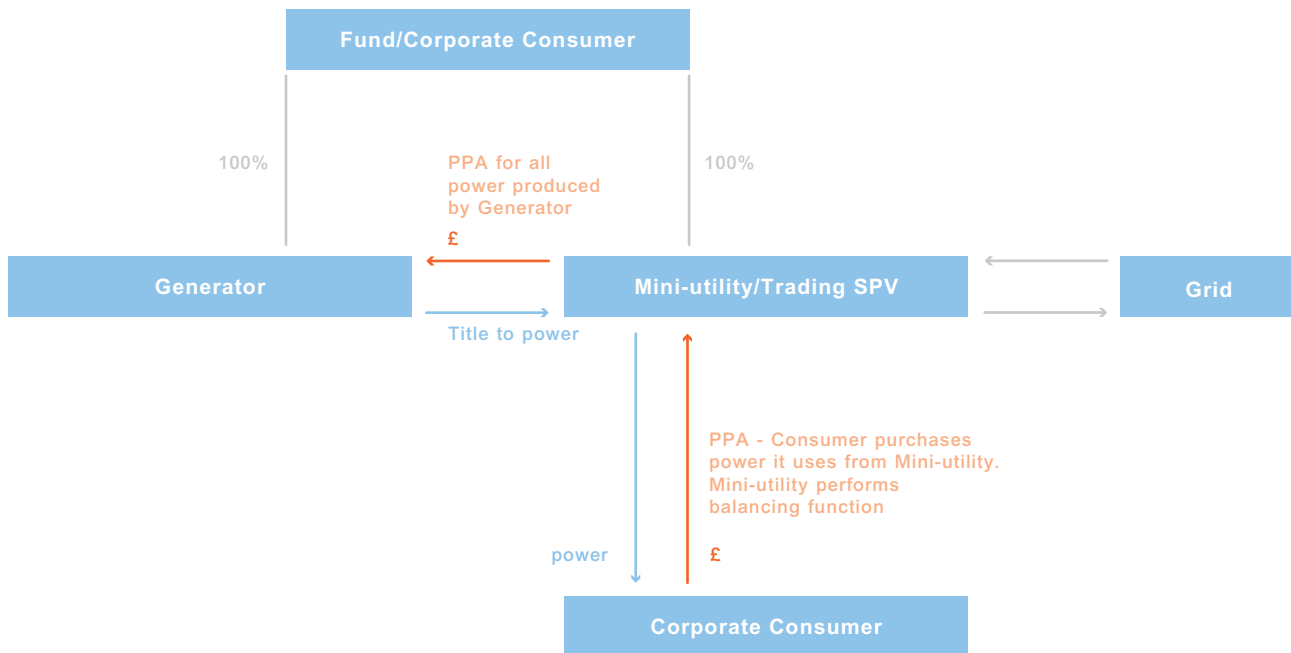
Figure 27. Synthetic PPA model (Solar Trade Association/Bird&Bird)

The Generator benefits as it gets a higher than wholesale price for its power. The Corporate Consumer is effectively taking a gamble that retail prices are going to rise over the next 20 years, and is locking in its power prices at a low level over the long term. It is a hedge against rising prices.

This is the model that Google have used in the USA. In this case the electricity can be consumed at multiple locations. It is good for large power consumers with multiple sites, and could be of particular interest to utilities or other big licensed suppliers.

A disadvantage of this model is that as wholesale price forecasts are becoming more uncertain power consumers are less willing to lock in at a fixed price over a long period of time. Also the financial flows within the business model depend on the prices offered by the Licensed Supplier. The next business model, the mini-utility PPA, is an attempt to try and cut out this middle man.



Figure 28. Mini-utility PPA model (Solar Trade Association/Bird&Bird)

5.2.2.4 Mini-utility PPAs

The mini-utility business model is where the generator sells the power to a licensed supplier wholly owned by either the generator or the corporate consumer, called a trading SPV. The trading SPV then contracts to sell the power on to the corporate power consumer.

EU-level electricity market design regulation can be used to encourage this kind of model. This business model is currently in use in Ireland in the wind sector and in the US.

The advantage is that it cuts out a link in the chain and therefore reduces costs overall, allowing the generator to get more money for its power and/or the Corporate Consumer to save more on its bill.

The disadvantage of this business model is the very high up-front costs (often about 1million EUR) of obtaining a supply license.

Another disadvantage is that there is a risk that the trading SPV could go bankrupt if it misjudged its balancing strategy. This adds more risk to the model.

Another disadvantage is that the mini-utility PPA business model requires large volumes of power in order to be viable. It is difficult at present to scale these business models down to smaller sized projects due to the overhead costs of gaining a supply license.

5.3. BROAD STEPS FOR PPA PROJECT IMPLEMENTATION

These steps encompass both ground mount and rooftop projects. The steps to implement a PPA are very similar to those for the self-consumption model. Therefore these steps will not repeat the steps listed above, but highlight differences when it comes to PPAs

1. **Locate appropriate site.**
2. Assess the **electricity demand pattern** of the power consumer, if any.
3. Gather information on the **retail electricity tariff** paid by the power consumer.
4. Conduct a **full analysis** of the project to determine whether PV can undercut the power consumer's retail electricity price and by how much, or compete with the wholesale price in the case of a wholesale PPA. Generally speaking the power consumer needs to see a saving of at least 10-20% on its electricity costs in order to make consideration of a PV system worthwhile.
5. Secure **grid connection**. For rooftop systems, confirm whether it is possible to have a separate direct grid connection – this is important for spillover PPAs. Confirm what price excess electricity sold to the grid will get.
6. Commission one or more EPCs to survey the site, roof space and provide a **quotation** for installing a PV system.
7. Forecast the **operation and maintenance** costs.
8. Obtain permission from the local municipality or a **construction permit** for the project, if required.
9. Secure a **Letter of Intent** from the corporate offtaker to confirm their commitment. The letter should specify the PPA rate and duration of the contract, as these should already have been pre-negotiated.
10. Secure **financing** for the project. PPAs are not generally self-funded, and so are financed using debt, equity or similar.
11. Sign the **PPA contract**, specifying the price, duration and minimum amount of electricity to be supplied. Note there are a number of template PPA contracts for the countries covered by PV FINANCING available for download on the project website .
12. Commission the installer or EPC to **build the solar installation**.
13. Complete any **administrative processes**.
14. Secure an **operations and maintenance** service provider.
15. **Generate power** for system lifetime.

64 The contract templates can be downloaded on the PV FINANCING website here: http://www.pv-financing.eu/project-results/#Contract_Guidelines

5.4. EU-WIDE PPA SENSITIVITY ANALYSES

As mentioned above, an EU-wide average analysis always has to be approached with caution as the project described below will not correspond to any individual country. National implementation guidelines should be used for more detail on any particular market.

In this section we will conduct a number of sensitivity scenarios on a broadly EU-average base case. In this analysis the same assumptions as in the self-consumption analysis in Section 4.4 were used apart from:

- The project is a typical commercial 100 kWp system.
- The retail electricity price for commercial customers is assumed to be 0.18 EUR/kWh as that is the EU-28 average according to Eurostat.⁶⁵
- It was financed with 70% debt and 30% self-funded equity.

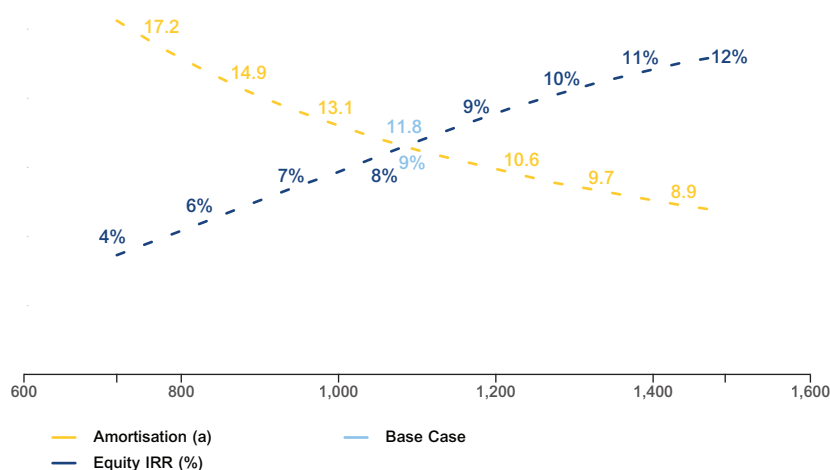
- A PPA price of 0.144 EUR/kWh was assumed as that is 20% less than the commercial retail power price (see Section 5.3 above).
- The specific system cost for a commercial system of this size was assumed to be 1,366 EUR/kWp, which was an average of the costs for systems of this size used in the national implementation guidelines.

The main profitability drivers for corporate PPAs are retail electricity prices, as that is what the PPA is competing with, the risk of the power consumer changing, re-locating or going bankrupt and the self-consumption rate, especially the pattern of the power consumer's demand across the day.

Sensitivity analyses were conducted on a number of different variables.

Figure 29 provides a sensitivity analysis on yield or location. The left of the x-axis represents Scotland or Scandinavia and the right represents the south of Spain, Sicily and Cyprus. As yield increases returns go up and paybacks reduce.

Figure 29. Sensitivity analysis of PPA project based on yield



⁶⁵ Eurostat energy statistics: [http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Electricity_prices_for_household_consumers_in_2015_sem_2_\(EUR_kWh\).png](http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Electricity_prices_for_household_consumers_in_2015_sem_2_(EUR_kWh).png)

Figure 30. Sensitivity analysis of PPA model based on PPA price escalation

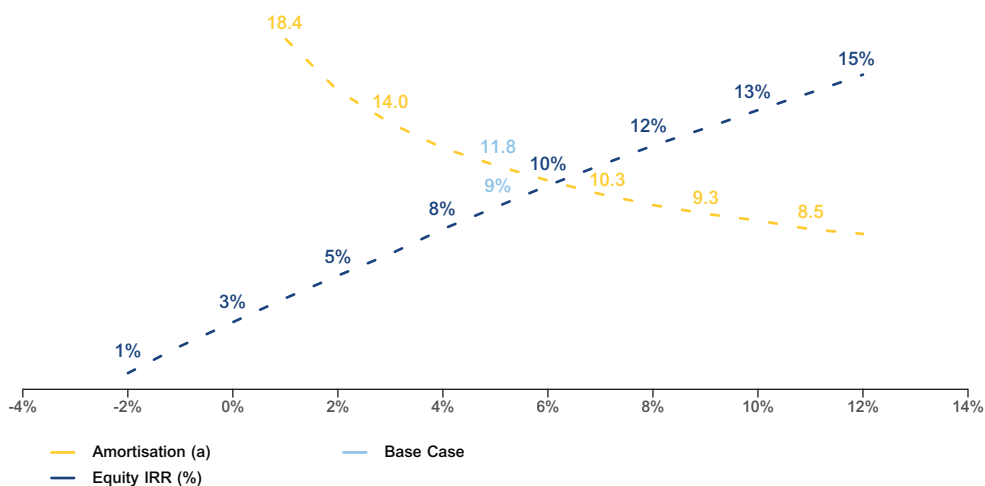
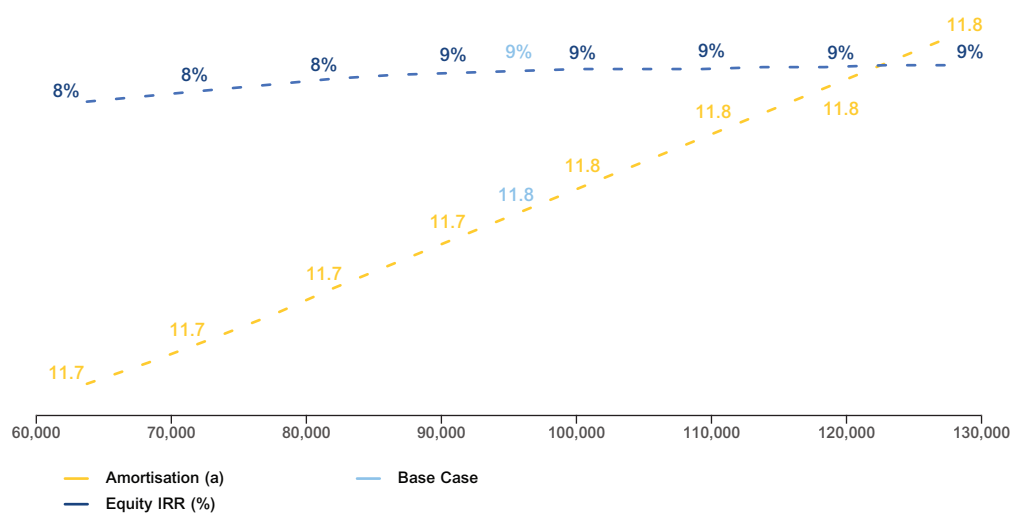


Figure 30 shows a sensitivity analysis of the PPA business model to the extent to which the PPA supply price is set to rise over the course of the contract, usually designed to be in line with inflation or electricity price escalations. Many PPAs track wholesale or retail prices in the later years of a PPA contract. The L'Oreal case study in section 5.5.1 is an example of this, where the PPA supply price tracks the retail price for that business. The more price escalation in the PPA price, the more returns increase and payback times drop.

Figure 31. Sensitivity analysis of PPA model based on debt



Finally Figure 31 shows that as the amount of debt in the project, which has a total system cost of 136,600 EUR, the equity IRR and payback period pretty much stay the same, displaying an small increase as the debt amount doubles.



5.5. CASE STUDIES

5.5.1 L'Oreal PPA – Italy

Figure 32. L'Oreal building, Torino, Italy (Qualenergia)



This 3 MW rooftop PV installation is located near the town of Turin in Piedmont, Italy on the roof of the L'Oreal building.

This PV system cost just over 3,000,000 EUR which corresponds to a specific system cost of about 1,000 EUR/kWp and is owned by an Enersol SPV, with Enersol being the main investor in the project. The solar electricity generation estimated for the plant is 3,600 MWh/year, with a specific yield of 1,200 kWh/kWp. The power is sold to L'Oreal through an onsite direct wire PPA, and is the largest PPA project in Italy. The PPA price tracks the retail electricity price for the company minus a discount of between 8-12%. It received no support scheme or tax incentive. It is assumed the solar system will supply about 30% of the power required on site.

The PV installation complements the existing biomass boiler and district heating system.

5.5.2 Ketton Cement Works – UK

Figure 33. Ketton solar farm, Ketton, UK (Lark Energy)



The Ketton Cement Solar Farm is located just outside the village of Ketton on a former quarry, in the county of Rutland in the United Kingdom. The solar farm is 12 MW in size and is on land adjacent to and owned by the cement factory. It is a rare example of a ground mount onsite private wire PPA.

The project is currently 100% self-consumption for Hanson Cement, but a connection to the local distribution grid exists as a back-up. A third of the power is provided to Hanson free of charge (in lieu of land rental payments) and the rest is sold at a fixed PPA price.

Over the course of the project lifetime the solar farm will reduce the cement factory's energy bill by approximately 10million GBP, although the main driver for the project was reducing CO₂ emissions. Overall the project generates enough energy to cover 13% of the cement work's annual demand. The project was developed by Lark Energy in partnership with Armstrong Energy and Hanson Cement, who own the cement factory. The funding was provided by Downing.

Lark Energy designed the solar farm to enable active and reactive power management and to protect the grid from reverse current. This has a number of advantages, including minimising the need for costly 33kV distribution grid upgrade work, reducing the energy costs for Hanson and enabling the inverters to be used as capacitor batteries storage at night. This was the first time inverters had been used in this way in the UK.

5.6. OUTLOOK

The outlook for PPAs in solar is excellent. This is a business model where there is a lot of scope for innovation. However regulatory barriers need to be overcome in a number of key markets including Spain, France and Turkey. These are usually regulatory barriers to selling electricity on-site or in the local area.

The financial challenge for wholesale PPAs is that the wholesale price obtained for the power is at present often not high enough to incentivise investment in solar.

The financial challenge for synthetic PPAs and mini-utilities is that they require large volumes of power in order to be viable business models. It is difficult at present to scale these business models down to smaller sized projects. In the case of synthetic PPAs this is because it is a business model that is suited to power consumers with a large number of different sites, each with significant power demand. In the case of mini-utilities this is because the business model requires the creation of a trading Special Purpose Vehicle (SPV) with a supply license, and this license can cost 1million EUR to obtain. This adds a major overhead cost to the project.





6. COOPERATIVE SCHEMES

Cooperatives, which from a financing scheme perspective are a form of equity crowdfunding, have a separate legal status and management structure to other business models.

They should be distinguished from debt or grant crowdfunding which are purely financing schemes.

6.1. REGULATORY FRAMEWORKS FOR COOPERATIVES

The benefit of cooperative schemes is that regular citizens can own and benefit from a share of energy generating assets. An experienced investor or actor can act as an intermediary for a large number of smaller private and non-professional investors. They also facilitate and promote social acceptance of renewable energy projects.

However again a certain number of regulatory basics have to be in place to implement a cooperative model, as there has to be a level playing field for cooperatives to enter the market.

In France a new provision has recently been brought in for collective self-consumption, where electricity can be sold between a number of producers and consumers within a single low-voltage branch of the grid. This opens the way for community and cooperative business models. This model is described further in Annex IV.

Cooperatives are not yet common in Italy but is a promising scheme, especially as the tax benefits for residential solar are also applicable when the project is financed through a cooperative.

In the UK community involvement in renewable projects is incentivised both within the Feed-in Tariff support scheme and, in the case of Scotland, generous tax benefits. Community Interest Companies are a common business structure for this type of project.

In Turkey, the legal framework for an energy cooperative exists and cooperatives benefit from subsidised loans and tax incentives but at the time of writing no energy cooperative has yet been established.

6.2. BROAD STEPS FOR COOPERATIVE PROJECT IMPLEMENTATION

The broad steps for implementation of a cooperative or crowdfunding project are similar to those for self-consumption and PPAs. To avoid repetition this section will only look at the additional steps in a cooperative project.

1. Go through the relevant steps listed in sections 4.3 and 5.3 above.
2. When choosing a site or project it can be useful to prioritise those that are either **located in the target community** for raising funds and/or have particular social importance, such as on a school, social housing project or in a disadvantaged area.
3. When project reaches the stage of having to secure financing, **contact a local energy cooperative** (or select a crowdfunding platform). Consider founding a local energy cooperative if one does not already exist. If using a cooperative it will be an equity scheme. Decide whether the crowdfunded finance is going to be combined with regular debt or equity. Investigate past projects and obtain project references from the cooperative. Determine whether the platform operates an 'all or nothing' policy – whether the project will be dropped entirely if the target amount is not achieved.
4. Submit a **funding application** to the cooperative, including a profitability analysis. The crowdfunding platform may also ask for an overview of the other funding sources, insurance contracts and the project owner's Debt Service Coverage Ratio.⁶⁶
5. **Sign a contract** with a crowdfunding platform, which will specify the commission taken by the platform. Some platforms operate at a fixed fee, others take a percentage commission. Careful attention should be paid to any early withdrawal clauses.
6. **Advertise and market** the project to the target audience, raising as much awareness as possible. Often this is the cooperative's responsibility.
7. **Secure individual investors** and sign standard contracts with them as regards the interest rate payable etc. This often an automated online process facilitated by the cooperative. The cooperative will on the whole represent the interests of the investors in this process. In Germany interest rates for debt crowdfunding are generally 3-8%.
8. Receive the **transfer of funds** if and when the target amount has been raised.
9. Commission the installer to **build the solar PV project**.
10. Submit any **regular financial updates** to the cooperative members or crowdfunding platform as required by the agreement and pay out interest or dividend payments.
11. Hold an **Annual General Meeting (AGM)** of the cooperative investor-members, as required to make decisions on the operation of the project.
12. If you want to finance multiple projects through the same organisation, consider signing a **framework agreement** with the platform in order to streamline the process for the next projects.

⁶⁶ The Debt-Service Coverage Ratio (DSCR) is a measure of the cash flow available to pay current debt obligations. The ratio states net operating income as a multiple of debt obligations due within one year, including interest, principal, sinking-fund and lease payments.

6.3. EU-WIDE COOPERATIVE SENSITIVITY ANALYSES

The PV FINANCING cash flow model does not have cooperative specific inputs and the analysis is therefore similar to that carried out in the business models above. In a cooperative project the transaction costs of acquiring, signing and communicating with hundreds if not thousands of investor-members could conceivably increase running costs slightly.

However a cooperative project, indeed any community energy project, is arguably a lower risk project as community acceptance and therefore planning permission from the municipality should be a much easier process. If the cooperative financing is combined with regular debt or equity then that finance should or could therefore in theory be provided at lower cost.

6.4. CASE STUDIES

6.3.1 Heidelberg cooperative – Germany

Figure 34. *Neue Heimat buildings, Heidelberg, Germany (Heidelberger Energiegenossenschaft)*



The *Heidelberger Energiegenossenschaft* “Neue Heimat” cooperative family homes in Germany have seven east-west solar PV systems installed on their buildings that together add up to 445 kWp. The total generation is around 370,000 kWh per year. The buildings are located in Nußloch, near Heidelberg. The total investment cost for the installation was 525,000 EUR.

All 116 tenants were given the opportunity to invest in the PV facility and become shareholders of the *Heidelberger Energiegenossenschaft*, allowing them to benefit from dividends from the company’s profit. Tenants are offered a “package” of 1000 EUR consisting of an 800 EUR loan and two shares with a nominal value of 100 EUR each. The loans are repaid over 20 years at 3% interest. At the end of the 20year period the tenant will have received about 1400 EUR back. This is therefore an example of a cooperative or equity crowdfunding scheme where the investor-members also lend money to the cooperative, a debt crowdfunding scheme.

The PV system electricity is combined with a residual electricity supply from Naturstrom AG that allows the tenants to purchase electricity at a price lower than the price they would pay if they purchased electricity at retail prices, and this price is guaranteed for 20 years. The tenants buy the electricity direct from the roof at a rate of 0.254 EUR/kWh plus a monthly fee of 6.95 EUR.

6.3.2 Oakapple single family new build homes – UK

Figure 35. Single family new build homes, UK (Oakapple Renewable Energy)



The Oakapple Renewable Energy project is a series of PV systems installed on new build single family homes. The project raised 480,000 GBP via debt crowdfunding platform Abundance Investment Ltd to purchase 435 kWp of PV installations. The project received generous support from a Feed-in Tariff support scheme.

Abundance used debentures for this project, which are long-term unsecured loans to a company which will be repaid at a specified date. Abundance also provides ongoing services in relation to the debentures, including acting as registrar, arranging payment of cash returns to debenture holders and communicating information back to the investors. Projects on Abundance could often offer individual investors returns on investment that were higher than regular savings account and higher than the inflation rate, making these investments very attractive.

In this example Oakapple will repay its debenture after 20 years and throughout that period will pay investors between 7.4% and 8.6% interest per year in twice-yearly payments.

6.5. OUTLOOK

In many countries cooperatives and crowdfunding in general are seen as very promising business models as it can sometimes be a way of securing finance at a cheaper cost of capital and can allow projects that would not be able to secure financing through conventional means to go ahead.

Som Energia's *Generation kWh* project in Sevilla, Spain is another excellent example of a cooperative project that does not rely on a support scheme or feed-in tariff.

The minimum investment in a crowdfunding platform across Europe is generally 50-100 EUR, although some platforms accept investments from as little as 10 EUR. However the average investment is usually significantly higher, with one French platform reporting that average investment was approximately 1000 EUR. It is important to promote innovative cooperatives and crowdfunding models that are accessible for individuals with low purchasing power from disadvantaged communities to allow for broad-based involvement.



7. VIRTUAL POWER PLANTS

Virtual Power Plants (VPPs), also known as aggregators, are a business model where different technologies and users are combined or aggregated into one pool of electricity and are operated together as if they were one power generation facility.

On the supply side this can include solar, micro combined heat and power, wind, biogas, small hydro, back-up diesel generators and battery storage. On the demand side this includes power consumers that have capacity to increase or decrease their power demand, including interruptible load such as heating and cooling and electric hot water heaters.

The aggregator company sells the electricity or ancillary services via an electricity exchange. The goal is to create a generation profile that allows the participants in the Virtual Power Plant to take advantage of peak prices at certain times of day.

For individual installations a VPP can increase the wholesale or excess power price.

In the long-term this business model will gain in importance as many feed-in tariff or similar support schemes only include a mandatory offtaker for 20 years. As many PV systems are likely to last for ~35 years this means that over the next 10 years or more there is going to be an older generation of small-scale often domestic systems coming online that are still generating but no longer getting a guaranteed offtaker. It is possible that the owners of these systems will look to include their systems in an aggregator mechanism for the remainder of equipment's lifetime, if residential owners are willing to invest in equipment that allows for remote control of the installation.

7.1. REGULATORY FRAMEWORKS FOR VIRTUAL POWER PLANTS

As regards the regulatory framework, aggregators need access to electricity markets which requires a liberalised electricity market. Aggregators also ideally need to be able to offer their services without the prior approval of the power consumer's electricity supplier. The pre-qualification criteria for market participation should not be too stringent as this adds overhead costs for the VPP. In France for example aggregators are just starting to establish

themselves since the new energy policy framework was introduced in 2016.

Data and privacy concerns can also be a concern for regulators when creating policy for Virtual Power Plants, and a balance needs to be found between allowing these innovative new business models to flourish and protecting citizens' and companies' privacy.

7.2. BROAD STEPS FOR VPP PROJECT IMPLEMENTATION

A VPP business model is different to the self-consumption, PPA and cooperative business models as it often provides a route-to-market for operational plants. Many of the steps are the same as in the steps for the implementation of the previous business models.

1. Go through the relevant steps listed in sections 4.3 and 5.3 above.
2. Sign a **contract** with an aggregator platform. The aggregator will need to come and install its remote control equipment on the solar

installation and will conduct an analysis to offer the customer a estimate price for opting into the aggregator, or the plant owner may be required to do this him/herself.

3. The aggregator will then participate in the **wholesale and balancing markets** on behalf of the installations in the Virtual Power Plant and maximise the value of the solar plant and its electricity.
4. The aggregator **transfers revenues** to the plant operator.

7.3. EU-WIDE VPP SENSITIVITY SCENARIOS

The aggregator business model is very complex and involves complex algorithms and software designed to generate the most value out of small changes in price in the electricity market. To complicate matters further, some aggregators give their partners or clients the option to opt out of the system at any time. (This is important as a hospital always needs the option to take back control of its rooftop solar system as part of its Uninterruptible Power Supply in case of a power cut.)

Aggregators are very sensitive to medium-term and long-term trends in wholesale prices. Price variations across the day are another driver. Finally a key variable is the extent to which solar and the other technologies in the VPP's portfolio have access to grid services markets such as the balancing market and ancillary services to the grid such as reactive power, frequency response and voltage control.

7.4. CASE STUDIES

There are growing number of examples of aggregators across Europe, including EDP, Oekostrom and Good Energy. Each functions in a slightly different way. Here we will look at two specific case studies.

7.4.1 Next Kraftwerke - Germany

Next Kraftwerke is an example of a Virtual Power Plant in Europe which bundles around 3,000 small and medium scale power generators and consumers. All units are owned by their individual owners but operated through the Virtual Power Plant's central control room. Next Kraftwerke use an algorithm to successfully manage supply and demand allowing them to maximise profit for the participants. Next Kraftwerke operates in Germany, France, Belgium, Austria, the Netherlands and Poland.

7.4.2 Limejump – UK

Limejump is a Virtual Power Plant and Licensed Supplier in the UK that aggregates solar, wind, biogas, hydro, energy from waste, diesel and energy storage and offers fixed price and tracking price PPAs. They act as the balancing party for these generating assets. They also work with businesses who can be flexible with their energy demand such as retailers, water utilities, data centres, hospitals and commercial refrigeration. They aggregate all these actors together to access the electricity markets in the same way a conventional power station would.

7.5. OUTLOOK

The BestRES project, funded by the Horizon2020 programme, has shown that aggregators are a very promising business model moving forwards. However one key observation is that there is a lack of contract standardisation in this space which increases legal and transaction costs. Work needs to be done to bring these business models into the mainstream and establish market standard contracts, in particular to allow this model to tap into the potential in smaller PV segments.



8. BUILDING A PROJECT: COMBINING APPLICATION SEGMENTS, FINANCING SCHEMES & BUSINESS MODELS

The sections above have analysed and dissected each of the different elements and options within the three variables of a project – application segments, financing schemes and business models. However as was said in the introduction, an individual project can be a combination of a number of different financing schemes, a mix of business models and can be on buildings that have more than one application segment within them.

Broadly speaking all the different options within the three variables can be combined in various permutations. Mathematically this means there are over 140 different ways of building a solar PV project. Furthermore, there may be financing schemes and business models that have not yet been applied to solar, so the number could get bigger over time.

In this section we will look at what are the most common project combinations of the three variables, which could be the most promising and which are unlikely to work in the near future:

- *Single-family owner-occupied residential homes generally use self-funding, debt or leasing financing schemes and self-consumption business models, despite relatively low self-consumption rates. Perhaps the most promising project type in this segment would be a combination of self-consumption with a PPA for export done using a Virtual Power Plant financed using leasing, and provided together with other products and services.*
- *Multi-family residential building projects are generally done using corporate PPA and cooperative business models using all kinds of financing. The neighbor solar supply model is potentially the most promising business model in this segment.*
- *Public and educational buildings could be financed through pretty much any financing scheme and use any business model.*
- *Commercial buildings such as shopping centres, office buildings and industrial buildings today use self-consumption or corporate Power Purchas Agreements. PPAs appear to be the most promising model in this segment.*
- *Ground-mounted installations are presently generally done as wholesale PPAs, and can also be cooperative projects. Self-consumption schemes are very rare in the ground-mount sector. Solar farms use different financing schemes depending on the stage in the project as described in Section 3. Corporate PPAs are likely to be the most promising scheme going forwards. It is unlikely that the leasing model could be applied to solar farms.*

In sum it is precisely when financing schemes and business models are combined in a new and innovative way to an application segment that you can make projects attractive to financiers and create breakthroughs in the financing of solar.





9. CONCLUSIONS

Many of the financing schemes and business models described above are promising models in a low or no subsidy world. From sleeved off-site Power Purchase Agreements to leasing models, from neighbour solar supply to crowdfunding platforms, solar's modular nature allows it to be financed and deployed in many different ways.

A key lesson is that innovation in financing mechanisms and business models is only possible when the basic regulatory framework allows for new entrants and ways of doing things. If the regulatory framework is overly restrictive, new low-risk models that can facilitate the up-front investment required cannot come forward. It is critical that electricity markets rules are opened up across Europe to allow for more decentralised electricity generation and supply.

The key to finding the next generation of solar business models is reducing the risk involved for investors. The lower the risks – such as the risk of the corporate power consumer re-locating – the more comfortable investors will feel about investing in solar.

Equally it is clear that there are many business models that favour established players like utilities, as solar can be a way of increasing customer loyalty in for example neighbour solar supply and leasing.

Another lesson is that it is of critical importance to help banks and other financial institutions gain a better understanding of PV as a technology and the different business models involved. Of course Europe is further ahead on this learning curve than the rest of the world, but nonetheless there is evidence that more know-how is needed on solar within financial institutions. Once it has been established that solar can generate a decent return on investment and there are projects waiting for money, capital will be made available. It is often that initial lack of know-how that can prevent banks from taking that first leap into the solar market.

It is also important to bear in mind that with small and medium sized applications of PV, semi-professional investors or investors that are not familiar with PV are often involved. This means that often even when the returns are high and on paper the conditions are excellent, homeowners and small businesses will not go ahead with a project due to a lack of time, understanding and self-confidence when dealing with the technology. It is important that guidelines like this are therefore translated into material for a non-professional audience in order to enable them to invest.

All in all it is clear that the future is bright for solar in Europe, and that there are myriad ways of setting PV projects up. This report is merely a springboard for investors and developers looking for new and more creative ways to do things – the next step should always be detailed analysis of the national market concerned. We hope these different business models from the many corners of the EU will help to spread good practice across the continent and support the transition to a zero carbon decentralised electricity system.





LIST OF ABBREVIATIONS

DSO	Distribution System Operator
EPC	Engineering Procurement and Construction (NB this acronym can also be used for Energy Performance Certificate, but in this report only the former meaning is used.)
GW	Gigawatt
IRR	Internal Rate of Return
kW	Kilowatt
kWp	Kilowatt-peak
LCOE	Levelised Cost of Electricity
MW	Megawatt
MWp	Megawatt-peak
O&M	Operations and Maintenance
PPA	Power Purchase Agreement
VPP	Virtual Power Plant



ANNEXES

ANNEX I: NATIONAL TEMPLATE CONTRACTS FOR SOLAR BUSINESS MODELS

These template contracts were developed to give examples of the legal contracts needed for solar business models in Austria, France, Italy, Spain, Turkey and the UK. The guidelines for the implementation of these business models are available for download on the PV FINANCING website. The contracts are only available in the national language. Click on the links below to download the document or visit www.pv-financing.eu.

AUSTRIA

Dachvermietung (Österreich)

Pachtvertrag (Österreich)

Vereinstatuten (Österreich)

FRANCE

Modèle d'autoconsommation collective d'électricité (France)

Modèle de contrat de vente du surplus d'électricité dans le cadre d'une autoconsommation collective (France)

ITALY

Contratto di locazione operativa di impianto fotovoltaico (Italia)

Accordo per la costruzione di impianto dedicato e somministrazione di energia elettrica secondo lo schema del sistema efficiente di utenza (Italia)

TURKEY

FV sistemlerin kiralanması için Örnek Kontrat

Kontrat tipi 1: Kamu Hizmetleri (Elektrik), yatırımcı ve solar tedarikçi model I (Türkiye)

Fotovoltaik Elektrik Arzı ve Örnek Elektrik faturası için Örnek Elektrik Arzı Sözleşmesi (Türkiye)

SPAIN

Contrato de cuentas en participación para la explotación de una instalación fotovoltaica ubicada (España)

Contrato de representación de mercado para la venta de excedentes de una instalación del autoconsumo (España)

Plantilla de estatutos corporativa (España)

UNITED KINGDOM

Power Purchase Agreement (United Kingdom)

ANNEX II: CASH FLOW MODEL

A cash flow tool is available on the PV Financing website here. This includes both a simple web-based model and a more complex Excel-based model for each target country which can be downloaded in the bottom right hand corner of the webpage. The inputs to the model include timing, construction, operations,

revenues and savings, operational expenditure, funding, equity and macroeconomics. The model allows users to choose between Feed-in Tariffs, Self-consumption, Net metering and Power Purchase Agreements business models.

A screenshot of the cashflow model used for all the business models, available on the PV Financing website, is shown below:

Figure 36. Screenshot of self-consumption cash flow model used as base case

Assumptions
PV Financing

Timing

Start: 1/1/2010
End: 31/12/2025

Construction

Start: 1/1/2010
End: 31/12/2010
Cost: 100,000

Operations

Start: 1/1/2011
End: 31/12/2025
Cost: 100,000

Construction

System Cost: 100,000
Total System Cost: 100,000
Investment Subsidy: 0
Additional CapEx (e.g. NetEx): 0
Applied System Cost: 100,000

Payment Profile

Construction Month: 1/1/2010
Relative Costs: 100%, 85%, 75%, 65%, 55%, 45%, 35%, 25%, 15%, 5%

Operations

System Size: 100
Degradation: 0.05%
Overall Efficiency: 1
Yield: 1,000
Performance Ratio: 1.0
Specific Yield: 1,000
Applied Yield: 1,000

Revenues and Savings
PV Business Model Selection

Feed-in Tariff: 0
Self-consumption: 0
Net-metering: 0
Power Purchase Agreement: 100%

Feed-in Tariff

Specific Tariff Calculation: 0.1000
Lower Box Limit: 0.0800
Upper Box Limit: 0.1200
Tariff: 0.1000
Step Distribution: 0.0800, 0.1000, 0.1200
Applied: 0.1000

Self-consumption

Electricity Tariffs w/o VAT: 0.21
Residential: 0.21
Commercial: 0.18
Industrial: 0.15
Selected: 0.18

Price Forecast

Price Evolution: 0.1000, 0.1050, 0.1100, 0.1150, 0.1200, 0.1250, 0.1300, 0.1350, 0.1400, 0.1450, 0.1500, 0.1550, 0.1600, 0.1650, 0.1700, 0.1750, 0.1800, 0.1850, 0.1900, 0.1950, 0.2000, 0.2050, 0.2100, 0.2150, 0.2200, 0.2250, 0.2300, 0.2350, 0.2400, 0.2450, 0.2500, 0.2550, 0.2600, 0.2650, 0.2700, 0.2750, 0.2800, 0.2850, 0.2900, 0.2950, 0.3000, 0.3050, 0.3100, 0.3150, 0.3200, 0.3250, 0.3300, 0.3350, 0.3400, 0.3450, 0.3500, 0.3550, 0.3600, 0.3650, 0.3700, 0.3750, 0.3800, 0.3850, 0.3900, 0.3950, 0.4000, 0.4050, 0.4100, 0.4150, 0.4200, 0.4250, 0.4300, 0.4350, 0.4400, 0.4450, 0.4500, 0.4550, 0.4600, 0.4650, 0.4700, 0.4750, 0.4800, 0.4850, 0.4900, 0.4950, 0.5000, 0.5050, 0.5100, 0.5150, 0.5200, 0.5250, 0.5300, 0.5350, 0.5400, 0.5450, 0.5500, 0.5550, 0.5600, 0.5650, 0.5700, 0.5750, 0.5800, 0.5850, 0.5900, 0.5950, 0.6000, 0.6050, 0.6100, 0.6150, 0.6200, 0.6250, 0.6300, 0.6350, 0.6400, 0.6450, 0.6500, 0.6550, 0.6600, 0.6650, 0.6700, 0.6750, 0.6800, 0.6850, 0.6900, 0.6950, 0.7000, 0.7050, 0.7100, 0.7150, 0.7200, 0.7250, 0.7300, 0.7350, 0.7400, 0.7450, 0.7500, 0.7550, 0.7600, 0.7650, 0.7700, 0.7750, 0.7800, 0.7850, 0.7900, 0.7950, 0.8000, 0.8050, 0.8100, 0.8150, 0.8200, 0.8250, 0.8300, 0.8350, 0.8400, 0.8450, 0.8500, 0.8550, 0.8600, 0.8650, 0.8700, 0.8750, 0.8800, 0.8850, 0.8900, 0.8950, 0.9000, 0.9050, 0.9100, 0.9150, 0.9200, 0.9250, 0.9300, 0.9350, 0.9400, 0.9450, 0.9500, 0.9550, 0.9600, 0.9650, 0.9700, 0.9750, 0.9800, 0.9850, 0.9900, 0.9950, 1.0000, 1.0050, 1.0100, 1.0150, 1.0200, 1.0250, 1.0300, 1.0350, 1.0400, 1.0450, 1.0500, 1.0550, 1.0600, 1.0650, 1.0700, 1.0750, 1.0800, 1.0850, 1.0900, 1.0950, 1.1000, 1.1050, 1.1100, 1.1150, 1.1200, 1.1250, 1.1300, 1.1350, 1.1400, 1.1450, 1.1500, 1.1550, 1.1600, 1.1650, 1.1700, 1.1750, 1.1800, 1.1850, 1.1900, 1.1950, 1.2000, 1.2050, 1.2100, 1.2150, 1.2200, 1.2250, 1.2300, 1.2350, 1.2400, 1.2450, 1.2500, 1.2550, 1.2600, 1.2650, 1.2700, 1.2750, 1.2800, 1.2850, 1.2900, 1.2950, 1.3000, 1.3050, 1.3100, 1.3150, 1.3200, 1.3250, 1.3300, 1.3350, 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1.9650, 1.9700, 1.9750, 1.9800, 1.9850, 1.9900, 1.9950, 2.0000, 2.0050, 2.0100, 2.0150, 2.0200, 2.0250, 2.0300, 2.0350, 2.0400, 2.0450, 2.0500, 2.0550, 2.0600, 2.0650, 2.0700, 2.0750, 2.0800, 2.0850, 2.0900, 2.0950, 2.1000, 2.1050, 2.1100, 2.1150, 2.1200, 2.1250, 2.1300, 2.1350, 2.1400, 2.1450, 2.1500, 2.1550, 2.1600, 2.1650, 2.1700, 2.1750, 2.1800, 2.1850, 2.1900, 2.1950, 2.2000, 2.2050, 2.2100, 2.2150, 2.2200, 2.2250, 2.2300, 2.2350, 2.2400, 2.2450, 2.2500, 2.2550, 2.2600, 2.2650, 2.2700, 2.2750, 2.2800, 2.2850, 2.2900, 2.2950, 2.3000, 2.3050, 2.3100, 2.3150, 2.3200, 2.3250, 2.3300, 2.3350, 2.3400, 2.3450, 2.3500, 2.3550, 2.3600, 2.3650, 2.3700, 2.3750, 2.3800, 2.3850, 2.3900, 2.3950, 2.4000, 2.4050, 2.4100, 2.4150, 2.4200, 2.4250, 2.4300, 2.4350, 2.4400, 2.4450, 2.4500, 2.4550, 2.4600, 2.4650, 2.4700, 2.4750, 2.4800, 2.4850, 2.4900, 2.4950, 2.5000, 2.5050, 2.5100, 2.5150, 2.5200, 2.5250, 2.5300, 2.5350, 2.5400, 2.5450, 2.5500, 2.5550, 2.5600, 2.5650, 2.5700, 2.5750, 2.5800, 2.5850, 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ANNEXES CONTINUED

ANNEX III: GERMANY – THE “MIETERSTROM” NEIGHBOUR SOLAR SUPPLY MODEL

This is a translation of a section from the PV Financing Implementation Guidelines for Germany, “Geschäftsmodelle Mit Pv-Mieterstrom”. For more information please download the German version of the guide or contact the author BSW Solar who may be able to provide more detail.

In recent years the neighbour solar supply model (or Mieterstrom in German) has become common in Germany. It involves multiple mini onsite direct wire PPAs where electricity is generated on-site by solar, Combined Heat and Power (CHP) or other decentralised electricity generation and is consumed on-site by the tenants or owner-occupiers of residential and commercial multi-occupancy buildings.⁶⁷

The electricity is generated and sold on-site and is also referred to as direct electricity or building electricity. The key feature of direct electricity is that it is not considered to have used the public electricity grid when it flows from the place of generation (e.g. building rooftop or basement) to the place of consumption (e.g. apartment).

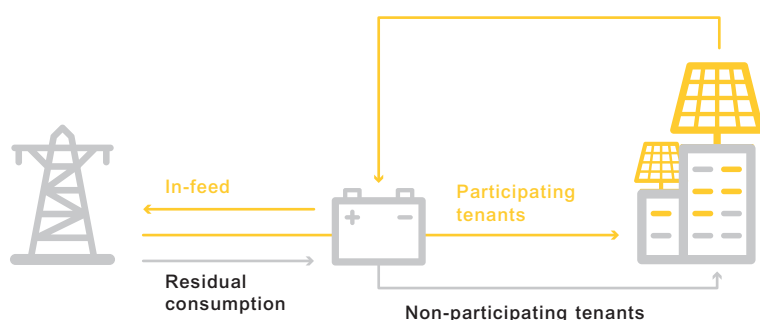
The tenant or owner-occupier in the multi-occupancy building is also provided with additional or residual grid electricity. This can be from a different supplier to the provider of the neighbour solar supply model.

Not all tenants or owner-occupiers have to take part in the scheme, a building can have participating and non-participating tenants.

Providers of the neighbour solar supply model deliver electricity to final consumers and must therefore satisfy the requirements of a licensed supplier as stipulated in the Energy Industry Law (EnWG). However the legislation states that within the neighbour solar supply model, supply only occurs within a “customer installation”, which leads to less of an administrative and regulatory burden on the supplier.

The neighbour solar supply model, which is within a single building, must be distinguished from other models such as regional electricity, borough electricity or neighbourhood electricity, all of which do use the public grid. (See Figure 2 for more info.)

Figure 37. Diagram of the neighbor solar supply model (BSW-Solar)



⁶⁷ In addition to tenants in the apartment building, members of a homeowners' association can also become neighbour solar supply customers.

The neighbour solar supply model can also be used in office buildings, business parks and public buildings. Hospitals, schools or swimming pools may also be interested in the model as that could allow them to pay a lower EEG levy.

The power consumers save money on their electricity bills as the on-site solar electricity is cheaper than electricity purchased from the grid at the retail price.

It is expected that the neighbour solar supply model will be incentivised in delegated legislation due to pass in Germany in 2017, specifically the amendment of the German Renewable Energy Act (EEG) 2017. This model is being strategically encouraged and targeted as being worthy of support in order to spread the benefit of solar PV to the multi-occupancy building segment, and it is hoped that this market will grow in the coming years.

Figure 38. Comparison of business models for on-site, local or regional electricity (BSW-Solar)

BUSINESS MODELS	ON-SITE CONSUMPTION AND LEASE MODEL	NEIGHBOUR SOLAR SUPPLY	REGIONAL ELECTRICITY, BOROUGH ELECTRICITY AND NEIGHBOURHOOD ELECTRICITY
Supply relationship	The plant operator and final power consumer must be the same entity. Note: This is established through the lease contract or sale of the PV installation to the power consumer.	Supply to third parties	Supply to third parties
Grid use and grid charges	No use of the public grid. Consequently, no grid charges are due.	No use of the public grid. Consequently, no grid charges are due.	Use of the public grid. Grid charges are due.
EEG levy (tax)	Up to 40% of the EEG levy is due. For small installations the "small installation regulation" applies where electricity from installations with a maximum capacity of 10kWp up to an on site consumption of 10 MWh/year, is 100% exempt from the EEG levy.	100% of the EEG levy is due, although this is due to change shortly (with the EEG amendment 2017) and the installation will be power will be exempted from a percentage of the levy.	100% of the EEG levy is due.
EEG remuneration or feed-in tariff	For the self-consumed quantity of electricity, in accordance with EEG, no remuneration is paid.	For the directly-consumed quantity of electricity, in accordance with EEG feed-in tariff, no remuneration is paid.	The quantity of electricity fed into the grid will be remunerated at the valid EEG feed-in tariff rate for 20 years.

ANNEXES CONTINUED

ANNEX IV: FRANCE – THE COLLECTIVE SELF-CONSUMPTION MODEL

This is a translation of a section from the PV Financing Implementation Guidelines for France, “Guide de mise en oeuvre de projets PV en France”. For more information please download the French version of the guide or contact the author Observ’ER who may be able to provide more detail.

This section looks at the collective self-consumption model, where the solar PV installation(s) and consumers need to be located near to one another.

The consumer does not bear the cost of the initial investment, but purchases the PV power at a price defined by a PPA contract with the generator, usually below the retail price of electricity supplied from the grid.

A recent government order in France has created a legal framework for these kinds of projects called ‘collective self-consumption’, where electricity can be sold between one or more generators and one or more consumers. Note that the details of this regulatory framework have not yet been completely finalised and could change further as per the application decrees that are going to follow the order.

France currently allows on-site direct wire PPAs where the installation is either on the building’s roof or where the generator and consumer are connected via a private wire. The European directive that authorises private grids has not yet been transposed into French law. A private wire is very difficult to set up in France because by law it has to be proven that the private wire will provide a better service than the public grid.

Off-site PPAs where a generator sells power to a power consumer via the public grid are being introduced in France. In France this model involves aggregators, who buy electricity from a large number of generators and sell it on to consumers.

A requirement of the collective self-consumption model is that the players in the model need to all be part of a single legal entity. Possible options could be associations, cooperatives or a co-owners management body (similar to a tenants association), but there is a lot of freedom as to the type of legal entity.

It is understood that collective self-consumption could potentially be used for multi-occupancy buildings, or small neighbourhoods. It could also be used in the social housing sector. This depends on one key aspect of the text as it stands: collective self-consumption is only allowed within a low-voltage branch of a grid, or low-voltage connection. This limits de facto the size of the projects. This would not allow projects at the scale of large neighbourhoods or boroughs for example. Ideally this limitation needs to be got rid of. It may be that the government will want to proceed gradually on this issue. More will become clear when the regulatory details are finalised and projects start being implemented on the ground.

ANNEX V: TURKEY – REGULATORY FRAMEWORK OVERVIEW

This is a translation of a section from the PV Financing Implementation Guidelines for Turkey, “Ulusal Uygulama Rehberi”. For more information please download the Turkish version of the guide or contact the author Gunder who may be able to provide more detail.

In Turkey solar PV is awarded a feed-in tariff of 0.133USD/kWh, for systems between 0-1MWp that are installed before the end of 2020. This is paid for just 10 years and there is a lot of uncertainty around whether a solar installation’s power will be able to be sold after that period and what price it will get. The Feed-in Tariff payments are paid in Turkish Lira according to the official exchange rate, for the billing day any electricity exported or injected into the grid, as declared by the Central Bank of Turkey and set by a market mechanism.

In the past if an installation used components that had been manufactured in Turkey the Feed-in Tariff increased, however this no longer applies.

There are a number of other measures in place to support renewables in addition to the Feed-in Tariff:

- *The distribution and transmission operators give priority for the connection of renewable energy installations.*
- *The distribution operators have to ensure that 20% of the electricity supplied to certain customers is renewable.*
- *Renewable installations are exempt from the annual license fee for the first eight years of operation and pay only 1% of the regular license fee.*
- *Renewable installations only pay 15% of the system usage fees for the first five years of operation.*
- *Renewable installations get a 85% discount on transmission infrastructure investment fees.*

In Turkey solar projects can either be licensed or unlicensed.

Licensed projects - Applications or bids for solar licenses were being accepted by the Turkish government in June 2013 as part of a tender process. In these tenders the state identifies areas of land (e.g. Konya or Karapinar) which are flat, no tree cover and low agricultural output, and guarantees that it will build the transmission lines to that site. Most of these projects should have been finished by the end of 2015. The government tendered for 600MW of capacity but received applications for over 9GW. (The General Directorate of Renewable Energy (YEGM) then announced another round of applications in April 2015 but that was later suspended.)

Unlicensed projects – unlicensed solar installations are intended to be primarily for self-consumption, are permitted up to 1MWp in size and benefit from the Feed-in Tariff. In theory a system can be a maximum of 30 times the power demand of the consumer. Therefore in theory demand of 33kW would allow you to install a 1MWp installation. All unlicensed PV projects must be approved by the Turkish Electricity Distribution Company (TEDAS) and a lack of grid capacity is a significant source of delay and uncertainty for developers looking to implement unlicensed projects. In addition, projects of this size must apply to the local DSO for a grid connection and pay grid charges on any electricity injected into the grid. The system usage fees are published every year on the website of the Electricity Market Regulation Authority (EPDK). The fees change depending on the system size. In Turkey the distribution grids are run by 21 regional monopolies who receive licenses from the Energy Market Regulatory Authority.

Systems above 1MWp do not receive Feed-in Tariff payments.

Retail electricity prices in Turkey are very low which undermines the economics of solar PV projects, especially in the agricultural and industrial sectors and in Organised Industrial Zones. In January 2014, the retail electricity price was at 0.088USD/kWh in certain segments, which is less than the Feed-in Tariff of 0.133USD/kWh. The only possible exception is the commercial sector where

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there can be an economic incentive to self-consume solar electricity from an unlicensed project. In this case, normal profitability drivers apply such as the load profile, self-consumption rate and the retail electricity price. Other drivers are peak shaving and green image.

The Turkish Electricity Market Law No 6446 from March 2013 and the update of the License Regulation from November 2013 state that in order to generate electricity a license has to be obtained from the Energy Market Regulatory Authority (EPDK). Licensees must either be limited liability partnerships or publicly listed companies, as per the Turkish Commercial Code.

Licensed companies can enter into power purchase agreements with themselves when they own a generation asset or with third parties.

Most investors judge that the incentives and returns on solar PV in Turkey are not yet sufficient to trigger investment at scale, but there is nonetheless great potential in the Turkish solar market.

ANNEX VI: AUSTRIA - POTENTIAL “GEMEINSCHAFTLICHE ERZEUGUNGSANLAGE”⁶⁸ SHARED GENERATION FACILITY MODEL

This is a translation of a section from the PV Financing Implementation Guidelines for Austria, “Leitfaden zu PV-eigen-verbrauchsmodellen”. For more information please download the German version of the guide or contact the author PV-Austrian who may be able to provide more detail.

NB This model is currently the subject of political debate and the regulatory framework to enable this model has not been decided or finalised. These political discussions should be borne in mind when reading this section.

Generally, the self-consumption model can offer economic benefits in the multi-occupancy buildings segment as well as in the single-occupancy segment. This allows tenants/occupiers who do not have access to their own roof space to nevertheless actively participate in the energy transition. New build housing developers can offer additional value to environmentally conscious tenants by granting access to green PV electricity. And this segment allows solar PV to be expanded in urban areas where a large amount of unused roofspace is available. On commercial buildings such as shopping centres or office buildings, the installation of PV systems can contribute towards a “green” and sustainable image and thus become more attractive for prospective tenants and customers.

A number of requirements within the Austrian Green Electricity Act (EIWOG 2010) hinder the installation of PV systems in multi-occupancy buildings:

- *It is not possible within the current legal framework to assign a single PV system to multiple power consumers.*
- *Combining several metering points is prohibited.*
- *The cables within the building (but not inside the individual flats) are considered to be the public grid and the electricity cannot be transferred via the public grid. Only utilities with grid licenses are permitted to use the public grid. The term ‘direct transmission’ does not apply to multi-occupancy buildings.*

Due to these requirements, the use of PV electricity in multi-occupancy buildings is currently restricted to installations that serve the building’s communal electricity consumption or several technically completely separate PV systems. Neither model is economically viable or easy to implement.

However a number of key legal amendments are currently under discussion to try and fix this situation.

An amendment of the Electricity Act (EIWOG 2010) is currently under discussion to legislate for a “common generating plant”. This term will be technology neutral and hence applies to various forms of on-site renewable energy, including solar PV.

⁶⁸ This term can broadly be translated as “shared generation facility”.

The following specific regulatory changes are currently being discussed:

- *It will be permitted for a common generating plant to be connected to the building's main power supply line (which also supplies the individual occupiers) and will receive its own metering point.*
- *Currently, various possibilities for tenants/occupiers to voluntarily take part in the scheme are under discussion. For instance, tenants who choose to take part could do so by buying a "symbolic" share in the plant. The freedom for every consumer to choose his/her own supplier is therefore guaranteed, as required by EU law.*
- *The plant is operated with a focus on self-consumption with only excess electricity being fed into the grid.*
- *All rules governing the distribution of the operating costs, revenues from the excess electricity, and the distribution of self-consumed electricity shall be covered by a contract between the common generating plant SPV and the tenants/occupiers.*
- *Both the solar PV system and every tenant/occupier must be equipped with a smart meter. The utility or grid operator is responsible for metering each flat/office's electricity consumption and billing the consumers per metering point.*
- *It must be guaranteed that by connecting the system to the building's main electricity line, the tenants/occupiers would not be liable for grid charges, as this would then no longer fall under the definition of the public grid. However, under this amendment it would still not be legally possible to sell the produced electricity to third parties, e.g. buildings across the street (unlike the German Mieterstrom model). It can only be used by occupiers within the building if they become part of the SPV operating (and own a symbolic share) of the PV system.*

- *The amendments to the Green Electricity Act described above will not alter other laws and regulations on e.g. residential tenancy, property law or building permits.*

These legal amendments, widely expected to be adopted in the coming months, would create an economically viable model for solar PV on multi-occupancy buildings.

ANNEX VII: SPAIN – REGULATORY FRAMEWORK OVERVIEW

This is a translation of a section from the PV Financing Implementation Guidelines for Spain, "Pautas de Implementacion Nacional". For more information please download the Spanish version of the guide or contact the author Creara who may be able to provide more detail.

Solar PV deployment in Spain is currently very rare, mainly due to the high levels of uncertainty created by the many retroactive regulatory changes that have been implemented since 2010. These are listed below:

- *In 2010 the government passed the Royal Decree-Law 14/2010, which required all electricity generators to pay a fee of 0.0005EUR/kWh for electricity fed into the grid in order to reduce the electricity sector's tariff deficit.*
- *Later in 2010 the Royal Decree 1565/2010 modified government support for electricity produced from existing solar PV plants. Existing Feed-in Tariffs (FiTs) were cut by:*
 - *5% for small-size roof installations (< 20 kW)*
 - *25% for medium-size roof installation (> 20 kW)*
 - *45% for ground mounted installations*

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- *In January 2012 the Spanish government imposed a moratorium on the Spanish Feed-in Tariff mechanism for new renewable energy installations.*
- *Later in 2012 the Royal Decree-Law (RD) 9/2013, completely abolished FiTs with retroactive effect.*

It was widely expected that a net metering law was going to be put forward, however in the end it was substituted by a self-consumption regulation (October 2015). This new law regulates the administrative, technical and economic arrangements for generation and supply of electricity for self-consumption. The Self-consumption RD 2015 sets both a fixed and a variable fee on self-consumers, who can sell the excess electricity only under certain conditions. In Spain self-consumption models therefore base their return mainly on savings on electricity bills, as with some types of self-consumption schemes the owner receives zero revenue for any excess electricity exported to the grid.

Other solar PV business models and support schemes such as Power Purchase Agreements, net metering and Feed-in Tariffs either do not exist or are not economically viable.

Before the last elections (December 2015) several political parties signed an agreement which stated that if they form a government they will introduce a series of positive changes within the self-consumption regulation. At the time of writing the political situation in Spain is changing rapidly.

It should be noted that the Royal Decree (hereafter RD) affects all supply points connected to the electricity distribution network. Isolated or off-grid facilities, i.e. installations which do not have any grid connection point, are exempt from complying with the RD.

The new law establishes two types of self-consumption with different conditions, which are summarised in the following table.

Figure 39. Main characteristics of different self-consumption schemes in Spain

	SELF-CONSUMPTION 1 (JUST FOR SELF-CONSUMPTION)	SELF-CONSUMPTION 2 (SELF-CONSUMING AND SELLING)
Consumer	<ul style="list-style-type: none"> There is only one power consumer for the installation 	<ul style="list-style-type: none"> There might be a consumer and a producer for the same installation
Owner	<ul style="list-style-type: none"> The owner of the installation must be the same as the owner of the supply point 	<ul style="list-style-type: none"> The owner of the generation facility may differ from the owner of the supply point
Registration	<ul style="list-style-type: none"> It is not necessary to register the generation facility as an electricity production facility However, it is necessary to enlist it in the self-consumption register (<i>Registro Administrativo de autoconsumo</i>, Royal Decree Law 24/2013, of the Electricity Sector) 	<ul style="list-style-type: none"> It is necessary to register the generation facility as an electricity production facility in the electricity production facilities register (<i>Registro Administrativo de instalaciones de producción de energía eléctrica</i>, Royal Decree 413/2014)
Contracted power	<ul style="list-style-type: none"> Contracted power of the consumer/supply point can be up to a maximum of 100kW and the generation facility's capacity cannot exceed the supply point's contracted power 	<ul style="list-style-type: none"> The generation facility's capacity shall not exceed the supply point's contracted power, but there is no limit as in self-consumption 1
Excess electricity	<ul style="list-style-type: none"> The consumer does not receive payment for the excess electricity injected to the grid 	<ul style="list-style-type: none"> The consumer may receive compensation for the excess electricity injected to the grid by selling the electricity on the spot market
Measuring equipment	<ul style="list-style-type: none"> It is mandatory to install measuring equipment to register net generation 	<ul style="list-style-type: none"> It is mandatory to install bidirectional measuring equipment to register net generation as well as measurement equipment at the associated consumption point

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For Type 2 self-consumption, the only way to receive remuneration for the excess PV electricity is by selling it on the spot market at current prices (“precio del pool”). In order to do so the owner must obtain several licenses (self-consumption and electricity production facilities registration forms, electricity trading license etc).

The procedure of obtaining the various certificates and licenses is very laborious for both Type 1 and Type 2 self-consumption and is regulated by Royal Decree 1699/2011, which refers to all grid-connected installations.

Complying with the procedure established in the Royal Decree 900/2015 is the only legal option to receive remuneration for the injected excess electricity. In order to be able to sell electricity on the spot market the consumer can either:

- *Become an electricity trader in order to be able to sell the electricity on the spot market himself; or*
- *Hire an electricity trader who sells the electricity on the spot market for the generator.*

Either option includes additional costs that reduce the revenue from the excess electricity, especially for a small producer.

It is worth mentioning that the sale of electricity is subject to the payment of a tax (Impuesto sobre el Valor de la Producción de Energía Eléctrica) in Spain, as regulated by the Law 15/2012. Thus, those consumers injecting the excess electricity into the grid would have to pay 7% in tax of the remuneration received (excluding VAT).

Consumers who decide to self-consume under the RD 900/2015 will have to continue paying the electricity access tariffs for consumption like any other consumer. At the same time, they will have to bear additional charges. For now, these charges are divided into two types (the law indicates that this might change in the future as the charges have only been set for 2016 and 2017), which present different exceptions regarding its payment:

- *Fixed charges, based on capacity:*
 - *PV systems up to 100kWp with neither a meter which measures the overall consumption of the consumer (not legally required) nor a battery system are exempt from paying the fixed charges*
 - *Cogeneration production facilities are exempt from fixed charges until December 31, 2019.*
- *Variable charges for self-consumed electricity (kWh), based on the contracted electricity tariff:*
 - *Consumers whose contracted power is less than or equal to 10 kW are exempt from paying the variable charges for self-consumption.*
 - *Cogeneration production facilities are exempt also from variable charges until December 31, 2019.*
 - *Mallorca and Menorca have reductions in the variable charges for self-consumption and the Canary Islands, Ceuta and Melilla and Ibiza-Formentera’s electrical systems have total exemptions of these payments.*

ANNEX VIII:

ITALY – SUPPLY CONTRACT PPAS OR “SISTEMI EFFICIENTI DI UTENZA”

This is a translation of a section from the PV Financing Implementation Guidelines for Italy, “Impianti Fotovoltaici Linee Guida per l’Implementazione”. For more information please download the Italian version of the guide or contact the author Ambiente Italia who may be able to provide more detail.

In Italy solar PV supply contracts or Power Purchase Agreements are governed by the “Sistemi Efficienti di Utensa” (SEU) regulatory framework. This section will provide an overview of the regulatory framework.

Resolution no. 578/2013/R/eel by the Regulatory Authority defined SEU (and SESEU) as systems for production and consumption made up of at least one production plant and a power consumer, directly connected by a private wire without the obligation for a connection with a third party. They are also connected, directly or indirectly, to the public grid.

Getting the SEU qualification or certificate is critical as the grid and system tariff conditions on the self-consumed electricity are much better than without SEU status. Since 2015, the “system levies” are due on both the self-consumed energy and the electricity taken from the grid, at a rate of 5%.

If no SEU qualification is requested, then the developer must pay the general levies on the self-consumed PV electricity. This also applies to the plants in operation before 2015. To benefit from the dedicated SEU tariffs, power consumers and generators must apply to the energy regulator (GSE) on their dedicated web portal for a SEU certificate.

However it is important to note that there are both variable and fixed levies on electricity bills in Italy. The fixed levies remain the same with or without a solar PV system and the possible future shift towards levies being applied to the fixed part of the bill is a major risk for the self-consumption and PPA business model in Italy.

Other details of the SEU framework were published in resolution no. 578, the Application Guidelines published by the energy regulator (GSE) as well as additional resolution from the Regulatory Authority.

Note that small PV plants (lower than 20 kWp) are exempted from the SEU framework and fall under a “scambio sul posto” net billing scheme, for which the levies are applied only on the grid electricity and not self-consumed electricity. For PV plants using the “scambio sul posto” mechanism, the SEU certificate is automatically released by GSE.

In order to be certified as a SEU, a system should have the following characteristics:

- *One or more on-site electricity generation installations with a maximum total installed capacity of 20 MWp. They have to be*

managed by the same entity, but this can be a different entity to the power consumer. These can be either renewable energy installations or high efficiency cogeneration.

- *The meter point can only belong to one power consumer. This therefore excludes buildings with multiple users and a number of interesting application segments, such as shopping centres, multi-family residential buildings, office buildings, airports.*
- *The installation must be located in an area owned or managed by the final power consumer, and this area must be given/rented/donated and fully available to the generating entity.*

Another key regulatory issue is the reform of the electricity dispatching system, which is under consultation at the moment. According to these proposals PV plants could receive revenues not only for selling electricity but also for additional grid services such as curtailment, demand response and voltage management. Combined solar and storage systems could provide more grid services.

Another key regulatory factor for PPAs is the reform of the electricity bill. Through Resolution no. 582/2015/R/EEL, the Regulatory Authority has introduced a reform which will be implemented in full by 2018. The reform changes the system tariffs so that instead of being proportional to consumption it will be a fixed fee for all domestic customers:

- *Costs for measuring, commercialising and distributing electricity will be covered by the fixed charge per customer (€/year) and according to the power level (€/kW per year);*
- *Transmission costs will be covered by the variable part of the grid charges (EUR/kWh);*
- *Costs for system levies will be different for residential customers, for which they will be entirely on the variable part (EUR/kWh), and for non-residential users, for which they will be a combination of fixed charges and variable charges.*

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Once these changes are implemented, 75% of the bill will still depend on variable consumption, which will therefore still incentivise energy efficiency.

The changes will introduce many different power levels, so that the consumer can choose the one best fits his/her needs. The experimental tariff for heat pumps will be extended to 2016, also considering its potential application to other domestic clients.

As a summary, the gradual introduction of the reform foresees the following steps:

From January 2016:

- *The current “step tariff” is maintained.*
- *Changes introduced to flatten the progressive effect of grid charges on consumption.*
- *Fixed share of grid charges increased.*
- *Data regarding the maximum power demand is collected and made available to customers.*

From January 2017:

- *Non-progressive grid charges implemented.*
- *Beginning of changes on system levies, to flatten the progressive effect of these charges.*
- *Introduction of all the new power levels.*

From January 2018:

- *Reforms fully implemented, including the fixed system levy tariffs.*

Let us consider the following example. For residential consumers, from 2018 the bill total will be 25% fixed charges (per connection point and per kW of power) and 75% variable charges (per kWh of electricity consumed).

For more detail please download the Delibera 582/2015/R/EEL from the energy regulator's (GSE) website.

ANNEX IX: UNITED KINGDOM – POWER PURCHASE AGREEMENT REVENUES

This is a section from the PV Financing Implementation Guidelines for the United Kingdom, “Making Solar Pay: the future of the solar PPA market in the UK”. For more information please download the full version of the guide or contact the author, the UK Solar Trade Association.

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.

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.

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*
- (ii) *Project capital expenditure (capex)*
- (iii) *Project ongoing operational expenditure (opex)*
- (iv) *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.

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)*
- (iv) *Tax incentives (although not strictly revenue it acts in a similar nature)*
- (v) *National Grid auxiliary services revenues.*

Three primary tariff mechanisms have been used in the UK to date, namely the Feed-in Tariff, Renewables Obligation Certificates (tradable certificates) and Contract for Difference (tenders) 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.

There are a number of types of PPA counterparties.

The first are licensed suppliers and balancing parties

In this situation, the Owner will sign an agreement with a ‘traditional’ off-taker, such as: one of the major utilities, known in the UK as the ‘Big Six’; a balancing party member who does 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.

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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.*

Another potential PPA counterparty is a corporate PPA provider.

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. Corporates would be able to 'lock-in' price certainty for longer than was available through wholesale PPAs, and Owners 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" electricity⁶⁹ 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.

There are also a number of other project revenues other than the revenues from the PPA.

An example is auxiliary services provided to the National Grid.

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

⁶⁹ The Renewable Energy Guarantees of Origin (REGO) scheme guarantees that electricity is from a renewable source.

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.

**Another revenue sources
is 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. 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.

**Finally solar projects can also
receive tax relief.**

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.







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