Business models for PV in a digitised and decentralised energy market

Business | The combination of rapidly evolving technologies and the trend towards decentralisation is demanding increasingly sophisticated commercial models. Simon Göß looks at some of the emerging solutions and considers the place of blockchain technology in tomorrow's energy system

PV has experienced a dramatic decline in costs. While this is important, many developers of PV power plants have also struggled to generate profits, as reimbursements via feed-in tariffs or other remuneration schemes have likewise declined. Is it still possible to earn money with PV and what are the consequences for PV business models? This article looks into several business models for PV and also provides a glimpse into a disruptive future with community PV power fuelled by storage and blockchain technology.

The underlying setting

Since 2008 prices for PV modules have fallen by 80%, while investment costs for PV power plants in Germany have declined by almost 75% since 2006. This is an average of 14% per year as documented early this year by the Fraunhofer Institute for Solar Energy Systems in its report, 'Recent facts about photovoltaics in Germany'. The drop in average end customer prices – the net system price – for installed rooftop systems with rated power of the PV plant from 10 to 100 kWp is depicted in Figure 1 [1].

The drop in prices was also reflected in the feed-in tariffs paid to PV system owners, which fell to about 10 cents/kWh for rooftop system and to about 7 cents/kWh for ground-mounted or bigger rooftop systems. The implications are vast, as gross domestic electricity prices for both households and industry are now above PV feed-in tariffs.

Current business models

In terms of business models for PV two main cases can be distinguished: grid-parity and generation-parity business models.

As soon as PV power reaches grid parity, electricity consumers might rather cover some part of their demand with electricity from PV than buying more expensive power from the utility. At a later point when PV reaches generation parity, it competes with generation prices of other power generators. According to German trade body BSW Solar business models for PV can be distinguished according to these two different levels of competitiveness, where Figure 2 gives an overview [2].

GRID PARITY	GENERATION PARITY
PV competes with grid electricity, i.e with costs of generation and distribution at point of consumption	PV competes with generation prices of centralized generation, i.e avoidance of distribution cost cannot be leveraged
Self-consumption	Utility PPA
Net-metering	Virtual Power Plant
Direct line PPA	PV-hybrid mini grid

Figure 2. Differentiation of various business models for PV

A short sketch of the some of the above models follows, where a more exhaustive analysis of the underlying assumption for business models can be found in the BSW Solar report referenced below.

Self-consumption

In the case of self-consumption the owner of the PV system and the consumer of the electricity generated by the system are identical. Electricity is directly consumed at the site without using the grid. Any excess might then be sold to third parties, e.g. the grid operator for a feed-in tariff. A key driver for models based on self-consumption is the difference between electricity from the grid and levelised cost of energy (LCOE) from the PV system.

Net metering

The assumptions are quite similar to self-consumption. The main difference however is how excess electricity from the PV system is handled. Power fed into the grid is balanced by credits or reversed metering and thus lowers the electricity bill for the consumer.

Direct line PPA

In a business model based on direct line PPA the owner of the PV system sells the

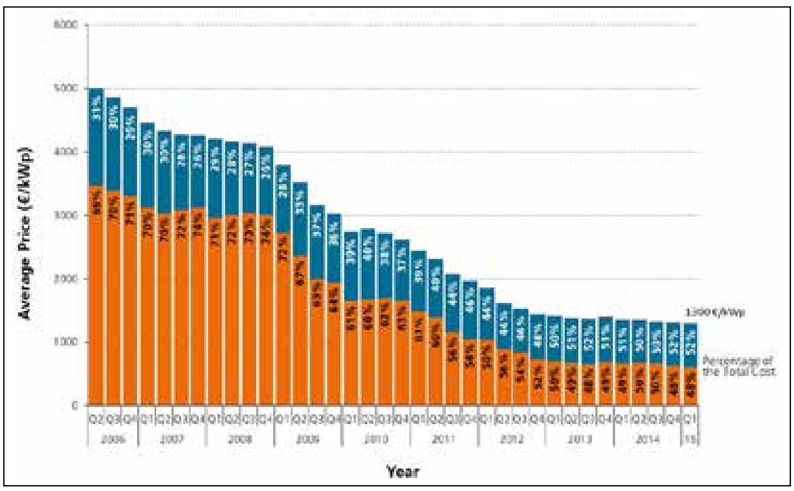


Figure 1. Average end customer price (net system price) for installed rooftop systems with rated nominal power from 10 to 100kWp (blue: BoS including inverter; orange: modules)

electricity within the same building or via a direct line to a consumer in the vicinity of the power plant. Its profitability is driven by not using the public grid and thus the non-applicability of regulative issues. In addition, the cost of electricity from the grid is nowadays in many cases more expensive for a third-party consumer than sourcing power directly from a PV facility.

This business model may become more attractive in Germany especially due to the new amendment of the renewable energy act which will come into effect in January 2017. This new amendment reduces or in some cases abolishes the renewable energy levy for PV systems operated by a third party and supplying tenants of a building.

The economic viability of business models based on grid parity largely depend on the levies and taxes on electricity that have to be paid by the owners of the PV power plant.

Utility PPA

When PV power reaches generation parity it may directly compete with other generation units and selling the electricity directly to a utility or the grid operator may be a viable alternative. The PPA's underlying remuneration has to be structured in a way suitable for PV.

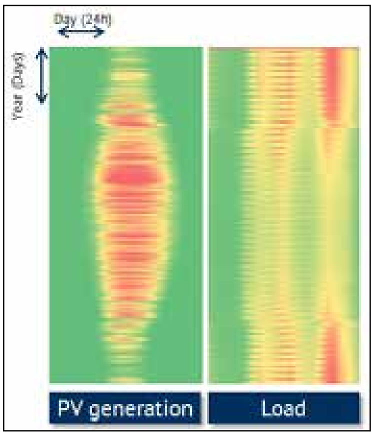
Virtual power plant

In this business model, electricity from PV power plants is directly sold at an electricity exchange. Pooling of a number of different PV systems and possibly other sources of power generation (e.g. wind or biogas) allows the creation of a generation profile that can take advantage of peak prices that occur during the day. Flexibility of generation can be increased by pooling different sources and thus also have positive impacts on grid operation.

Business models in a digitised and decentralised energy system

PV in particular offers a way towards a decentralised power system that also democratises energy generation. For the following section we will therefore mainly look into those business models which we classified as grid parity ones in the previous section. The generation profile of PV with its peak during the day and no generation at night is however not entirely suitable for such a system by itself. However a range of possible combinations of PV systems, battery storage and smart IT technology has the potential to facilitate a real decentralised energy system.

Figure 3. Generation of a 5.5kW PV system and load of household during every day (horizontal) of one year (vertical)



Calculations and source: Energy Brainpool

The generation profile of a household PV system along with the load profile of the household is shown in Figure 3. Obviously, in the morning and the evening, as well as in winter the load is higher than the generation by the PV system, while the trend reverses during noon and summer.

This gives leverage for applying storage systems on a household scale. Ultimately, combining a PV system with battery storage allows households to achieve higher levels of self-consumption of up to 50% without exceedingly high costs. This is especially true when battery costs decline to levels forecasted by the industry. The cost of energy storage technologies is to decline by up to 70% within the next 15 years, where batteries might have levelised cost of storage of about €100/MWh [3]. The important step for PV developers is to get to grips with the technical details of PV-battery storage systems and how to provide additional benefit through services to users.

Alongside this focus on mere private self-consumption, business models revolving around direct line PPAs or PV-for-tenants (German: "Mieterstrommodelle") are increasingly attractive, as they allow house owners to supply their tenants with electricity. Thus this opens up new possibilities for cooperation between PV developers and housing associations, particularly in cities, where the installation of a PV system cannot be undertaken by a single party in apartment buildings. Certainly, such PV-for-tenants approaches require "smart" devices that can meter the consumption of each of the different parties supplied by the PV system.

New business models

So far, we have covered the combination of PV systems and storage that allows households to achieve high levels of autarky in terms of electricity. To be sure, all the above also applies for businesses, which can use PV systems to cover parts of their electricity demand.

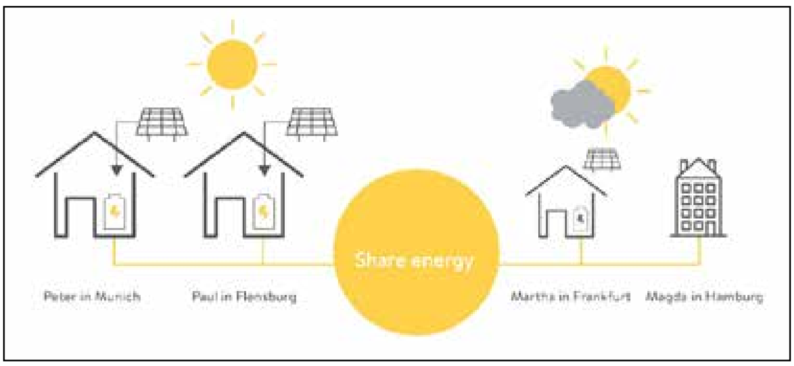
And now, we arrive at the point where a whole new world of business models might evolve. A range of businesses in Germany are already experimenting with and have actually put business models into practice that combine PV systems, battery storage along with smart energy management. These business models build upon the idea of so-called energy communities (Sonnen) [4] and flat-rate electricity prices (Beegy) [5].

But one by one: What do community energy business models entail?

Essentially a member of an energy community (generally an owner of a PV and a battery storage system) is able to be supplied by another energy community member with green electricity. Thanks to the balancing group system, the service provider is able to feed surplus from PV systems into a virtual energy pool. A user who needs more electricity than his system generates is then supplied from the virtual energy pool rather than from the utility. The aggregator and the operator of the virtual energy pool also provides a software platform that links all community members and monitors their generation and demand. Members of an energy community do not need a conventional energy provider and they are at least accounting-wise supplied by solar power all the time.

Figure 4 schematically shows how such an energy community works. The aggregator – the energy management or service provider – facilitates all the balancing and

Figure 4. Scheme of electricity sharing among members of an energy community [4]



billing processes and "sits" between the different prosumers that might consist of single households with PV systems, businesses or PV-battery system owners.

The algorithm on which the aggregation and balancing software is based is a crucial part of such a business model. In some cases the providers of such a service also provide a flat-rate electricity price for its members. Often companies such as Sonnen or Beegy also deliver the battery storage system. For PV developers a business model based on such a community approach may provide additional activities and also directly link the customers to their business, not only for being a contractor of the PV system, but as a service provider for the entire energy community ecosystem.

How does blockchain technology enter the game?

We just heard about the possibilities of energy communities and the possibilities for a service provider to act as an aggregator of the distributed PV-battery storage systems. Now, imagine you own a PV system and you are able to sell excess electricity to your neighbour (not directly using the public grid) or any other consumer (using the public grid) without any intermediary.

A technology that could make such a vision reality is the blockchain technology [6].

The blockchain is a decentralised register, which stores all transactions running on the blockchain. In contrast to conventional databases, the blockchain and its content is not located on a central server and consequently accessible not only for one or several selected actors, but various copies store the blockchain in a decentralised manner. Each party that participates in the blockchain has access to the most recent status of the transactions, as each participant's computer or server features one copy of the blockchain. The administration of this public database consequently takes place in a decentralised manner via all connected PCs. The verification of transactions is achieved by so-called miners, who are solving the crypto problem. The results and the verification of the transactions will be distributed as copies to the decentralised peer-to-peer network. By distributing a high number of copies the blockchain cannot be manipulated. Everyone is able to join the peer-to-peer network. All in all, blockchain technology has the potential to abolish the middleman in transactions, because through its system of verifying transactions in an immutable and publicly transparent way, trust between the ones exchanging – in our case – electricity for money is not necessary. Therefore transaction costs can be considerably reduced.

Recently, a new generation of blockchain functionality has been established, the so called 'smart contracts', which are able to execute and verify transactions of many different business models. Smart contracts (algorithms) allow certain specified commands to be conducted in an automated way.

Such a smart contract might therefore specify the conditions under which you sell electricity to your neighbour (e.g. whenever your demand is already met by the PV system and you have excess electricity), it automates all settlement and billing procedures and simultaneously records all the transactions in a transparent and immutable way. The first peer-to-peer electricity trade between neighbours has already been performed via the blockchain in New York earlier this year [7].

The application of the blockchain technology is certainly not only restricted to peer-to-peer electricity sales, but can also be used by aggregators or providers of energy management systems. A range of possible use cases for the blockchain technology in a decentralised energy world, several of them already described above, are the following:

- Physical delivery of energy managed via the blockchain
- Physical delivery of eMobility solutions managed via the blockchain (charging, car-sharing)
- Sharing (donating, no money involved), trading (selling and buying) of own-generated electricity
- Batteries/storage sharing
- Building up and supporting energy communities
- Connecting customers (buyers) with asset owners (renewable energy products) [8].

The combination of ever-cheaper PV systems, along with battery storage on a household scale and the utilisation of smart energy management systems that possibly build upon blockchain technologies for billing processes and the registration of transaction could well cause havoc for utilities and their business models. PV developers that are fast enough to react to those new conditions may however transform from mere contractors to service providers for integrated energy management systems in a digitised and decentralised energy market. ■

Energy sales via the blockchain in New York

Two Brooklyn residents used the Ethereum blockchain in April 2016 to facilitate a transaction that let one sell energy directly to the other.

The joint venture TransActive Grid, between the green energy startup LO3 and decentralised applications startup ConsenSys, allowed Brooklyn resident Eric Frumin to sell excess renewable energy generated from his own solar panels directly to Bob Sauchelli, a former programme manager at EnergyStar, a government-backed green energy initiative.

Every unit of energy created by Frumin is being counted and logged on the Ethereum blockchain. Programmable smart contracts are then used to make those units of energy available for sale on the open market. 195 credits were purchased for US$0.07 each.

As the power grid is typically set up in his neighbourhood Frumin was able to off-set his own energy-consumption with a series of solar panels on his rooftop in Brooklyn. But any excess energy he generated has to be sold back to the power company at a wholesale price.

This exchange of electricity between neighbours demonstrates that peer-to-peer exchange of electricity is possible without any intermediary. Furthermore, this pilot ensures that electricity generated from renewables, in that case PV, is also consumed locally. The value chain for electricity generation can thus be put on a track that is renewable, local and democratic.

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