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Renewable energy – business and financial models

Carried out under the bilateral energy partnership on behalf of the German Federal Ministry for Economic Affairs and Climate Action

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Content

Summary: Renewable energy – from support-based generation to market participation

Over the past 25 years, Germany's renewable electricity has seen a remarkable expansion, with its share rising more than sevenfold between 2000 and 2021. Over the first 15 years, the Renewable Energy Law (EEG) was the unique driver of this expansion development, providing generous support to enable the investments considered to be part of Germany's "Energiewende" (energy transition).

Initially, the installations received fixed tariffs remunerating feed-in over their whole refinancing period. Thus, they did not actively participate in the electricity market, facing no price, only some production risks, operating on the basis of a simple business model which largely facilitated the financing of the installation. Ten years ago the approach changed: Direct marketing of electricity from large-scale installations was first introduced and later made mandatory, with support being henceforth provided by a market premium that is today determined in an auction procedure. This means that renewable energy installations today not only sell electricity to the wholesale market, but also offer ancillary services. Market integration has ever since been a priority of renewable policy to ensure security of supply and network stability, reflecting the ever more important role of renewable energy in the electricity system as a whole. The change in the support system led to changes in the operation of the installations and thus their business models of the assets, giving rise to market service providers and taking opportunities and risks associated with market participation into account. The corresponding financial models have become more sophisticated reflecting the changes in the business models.

More recently, a new trend has emerged: More and more installations are operated without government support. Broadly speaking, two types of business model exist: one is classical direct marketing and the other is based on Power Purchase Agreements (PPA). The former is rarer than the latter: the installation operates essentially as a conventional power plant selling electricity and ancillary services into the electricity markets. Most often it is used by installations whose support period has expired. In contrast, PPAs are gaining importance for new projects as well: Here, a counterparty acts as an off-taker to the electricity while providing a fixed remuneration to the installation owner. The counterparty may be an industrial company using the electricity directly or a trading company selling the electricity into the markets. Financial models used for the investment build on the counterparty's business model.

Like Germany, China is pursuing an ambitious renewable energy expansion policy and has added more wind and solar capacity in recent years than all EU member states combined. So far, State-Owned Enterprises play the most important role in the expansion, relying on a priority access to capital markets. Additionally, private investors, some of them international, have contributed to the renewable expansion. Recently, feed-in-tariffs have lost in importance as a policy tool being replaced by several alternative support mechanisms including, among others, green energy certificates. This challenges business models based on the rather safe income provided under FIT. New business models and thus new finance models are required.

While the scarcity of land and problems with public acceptance have plagued onshore wind projects in particular for some time, slowing down renewable expansion, the financing of today's renewable energy assets in Germany is a well-established process in the service of the installation operators and German climate policy. Moreover the development shows that renewable energy support is losing importance: more and more installations can be financed via PPA. This development may prove to be relevant for the Chinese electricity sector, in particular if the role of private investors is to gain importance. Ultimately, they as well as small actors like households or small business will be needed to achieve China's targets, in particular in harnessing the underdeveloped potential of distributed generation.

1 Business models

1 Business models

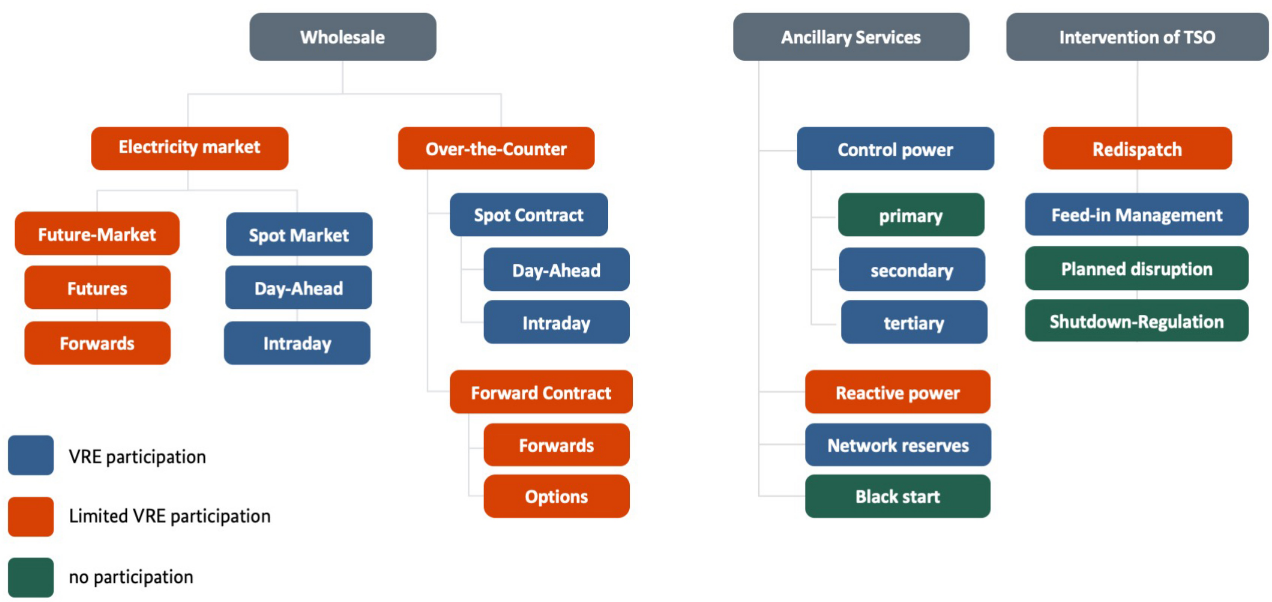
After more than a decade of renewable energy operation outside the market, since 2012 its – still support based – electricity market integration has become a priority for policy makers in Germany. A couple of years ago a new trend emerged: more and more renewable energy installations operate in the market without support. As a consequence, today several business models promoting renewable energy co-exist, some in- and some outside the EEG support framework. Moreover, the importance of flexibility assets has become clearer with the German Renewable Energy Sources Act (EEG) increasing share of variable renewable feed-in. Consequently, business models for storage and demand response have been developed over time as well.

Over the past quarter century, the share of renewable energy in the German gross electricity consumption has risen more than seven fold; in that timeframe, the installed capacity of wind onshore rose from 6.1 to 58.1 GW, the one of solar PV from 0.1 to 67.4 GW. In the first 15 years, this development was driven by support mechanisms under the policy framework known as "Energiewende" (energy transition): the German Renewable Energy Sources Act (EEG) has been providing support mechanisms enabling massive investments into wind on- and offshore, solar PV and other renewable energy assets. More recently, some installations have started operating outside the framework of the EEG support mechanisms. This chapter introduces business models for renewable energy with and without support mechanisms in Germany. The aim is to give a foundation to the subsequent discussion of investment into RE projects, covering several aspects related to the subject. First, it delves into different business models that exist within the support mechanisms, starting with fixed feed-in tariff dominating in the first phase of renewable expansion and then explaining business models with market-based support mechanisms.

1.1 Variable renewable energy generation in the electricity system

Some renewable energy sources have been part of the electricity system since the beginning of electrification, most notably hydro power that is a mature and fully flexible technology operating in the markets. Variable renewable energy (VRE) installations, based on wind or solar energy, were too expensive twenty years ago to compete against conventional electricity generation based on fossil fuel and nuclear.

Figure 1: Variable renewable energy market & system participation. Source: dena



Moreover, there were fears that the variability of their feed-in could compromise system stability. Notwithstanding, policy makers in Germany introduced the Renewable Energy Act (see box) to support these technologies with the aim of promoting a low-carbon (ultimately: carbon-free) generation mix. In the first years, VRE installations generated bulk energy for the wholesale market only.

Today they sell electricity in both the spot market and over-the-counter (OTC); moreover, they contribute some ancillary services (see Figure 1). This is a consequence of the regulatory evolution of support mechanisms as well as a reduction in investment cost that allows some VRE assets to participate in the market with support.

1.2 Business models for renewable energy with support mechanisms

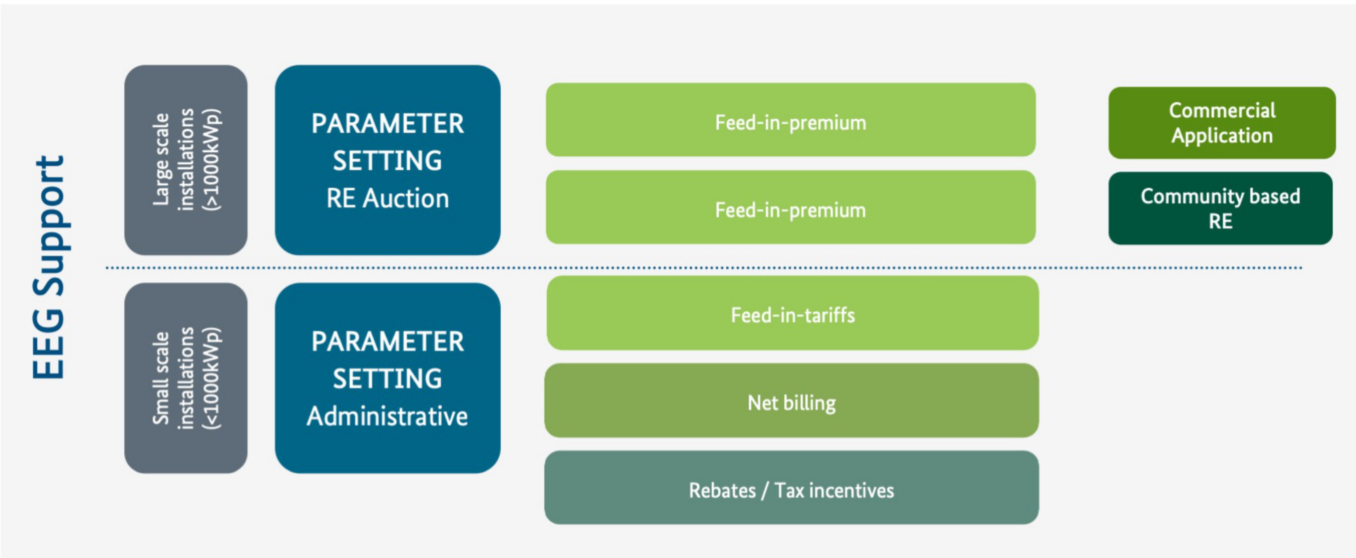
Business models for renewable energy with support under the EEG vary based on the support mechanism, which varies according to the scale of the installations (the business models of this section are shown in tabular form in the appendix, Table 9 to Table 11).

Figure 2 shows that the German EEG support scheme is designed to promote renewable energy development through two distinct mechanisms based on installation size. For small-scale installations (<1000kWp), it utilizes feed-in tariffs and net billing. Under this system, renewable energy producers receive fixed payments for the electricity they generate and feed into the grid. Any surplus energy not consumed on-site can be sold back to the grid, providing an additional source of revenue.

Large-scale installations (>1000kWp) operate under the feed-in-premium system. With this approach, renewable energy producers sell their electricity into the market, with a premium added on top. The premium system allows for more flexibility in the deployment of the installations. Today, premiums are determined in (mostly technology-specific auctions).

The EEG-based business models attract investments in renewable energy projects by offering long-term contracts (15 to 20 years depending on the technology) and predictable income streams. This support mechanism mitigates the risks associated with fluctuating energy prices, making renewable energy projects economically viable.

Figure 2: Support scheme options. Source: dena



Renewable Energy Act (German "Erneuerbare Energien Gesetz", EEG)

The German Renewable Energy Sources Act (EEG) of 2020 has two main objectives:[1]

- The first objective of the EEG is to promote the expansion and increased utilization of renewable energy sources in Germany. By providing financial incentives and regulatory support, the EEG aims to accelerate the growth of renewable energy capacity in Germany.
- The second objective of the EEG is to promote cost digression in the deployment of renewable energy technologies to eventually achieve grid parity.

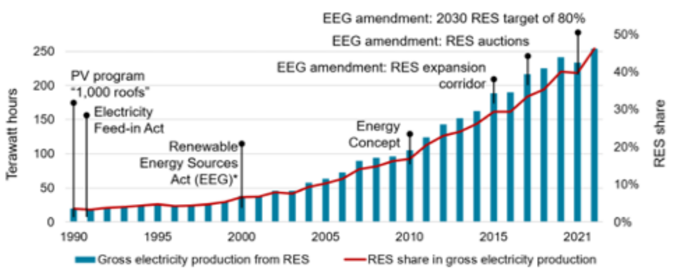
Overall, the EEG aims to promote the transition to renewable energy, reduce greenhouse gas emissions, enhance energy security, create green jobs, and promote sustainable economic development in Germany. Today, in addition to the EEG framework, there are further laws aiming at the development of specific technologies, most notably a law on offshore wind energy. Moreover, there have been significant revisions to the EEG, including updates in 2004, 2009, 2012, 2014, 2017, 2021 and 2023.

The support provided by both feed-in-tariffs and feed-in-premiums were initially financed by an EEG levy that was imposed on electricity consumers via a system administered by the network operators. Since 2022, they have been financed from the general federal budget.

Apart from providing a stable and profitable price level for renewable installations the EEG established important principles for their deployment, namely mandatory grid access and priority dispatch. This means that network operators have to connect installations and adapt the networks accordingly. And renewable energy is dispatched prior to other energy sources.

Small-scale installations today are supported either by feed-in-tariffs or under the net-billing system. The typical threshold, set by EU regulation, is 1000 kWp.

Figure 3: Deployment of renewables in Germany. Source: Guidehouse 2023 based on BMWK 2022 & UBA 2023



Net billing applies specifically to prosumers who both generate and consume energy. It allows prosumers to balance their energy consumption with self-generated electricity and receive remuneration for the surplus energy fed into the grid. In contrast, feed-in tariffs are for renewable energy producers who focus on selling electricity to the grid (an example of this can be seen in Table 8 in the Appendix). Fixed feed-in tariff system works as follows: renewable energy producers are guaranteed a predetermined payment for each kilowatt-hour (kWh) of renewable energy they feed into the grid. The EEG prescribes minimum tariffs for different types of renewable energy sources, including hydropower, landfill gas, mine gas, sewage gas, biomass, geothermal energy, wind power, and solar radiation energy. The level of remuneration for each energy source varies, taking into account factors such as technology maturity, production costs, and market conditions.

Both business models have one feature in common: the installations do not participate in the market, and the remuneration is independent from the market value of electricity.

The fixed feed-in tariff was introduced in the initial version of the EEG in 2000. To promote cost reductions and technological advancements, the EEG incorporates a nominally degressive annual reduction in the tariff rates for certain energy sources. This means that the feed-in tariffs for biomass, wind energy, and photovoltaics gradually decrease over time. The reduction rates are designed to reflect the decreasing costs and increasing efficiency of these technologies. Under the earlier versions of the EEG, the payment of the minimum tariff was regulated for a period of 20 years. However, the most significant change in the recent EEG 2023[1] is the shift towards providing fixed feed-in tariffs primarily to small-scale installations, while larger installations today participate in the market and receive an additional premium, which is determined in a competitive auction process.

[1] In the EEG 2023, §21 outlines the feed-in tariff system, offering comprehensive explanations and regulations for the remuneration of renewable energy.

Business model based on net billing

The business model of net billing for small-scale installations is primarily adopted by homeowners and small businesses in the renewable energy sector. They generate electricity for their own consumption and sell any excess energy back to the grid. Under this model, the electricity meter measures both the energy consumed from the grid and the energy supplied to the grid. The producer is billed for the net difference between the two values, either receiving compensation for surplus energy supplied or paying for additional energy consumed. The supplier has the legal obligation to operate the net billing scheme. The remuneration for excess electricity is supported through EEG, regulated by the Federal Network Agency (BNetzA). The costs associated with this business model include the fixed assets, such as installation components, measurement and control systems, and protection systems, as well as installation and operating costs like insurance, maintenance, and cleaning.

Business model based on feed-in-tariff

The business model based on the Feed-in-Tariff for installations up to 1000 kWp is another component of the German EEG. In contrast to previous business model, these installations are often owned by state entities, banks, private companies, private investors, or renewable energy communities[2]. The tariffs are predetermined and provide long-term revenue certainty for renewable energy producers, which csn benefit from these fixed feed-in tariffs, usually up to 20 years. This model ensures stable income and favorable conditions for small-scale renewable energy projects.

Also in this case, the regulator BNetzA monitors for the implementation and compliance of this business model. It concerns all the models described in this study. As an example for the case of solar PV, see table 1.

Table 1: Fixed feed-in tariffs for PV, Source: dena

Capacity kWp	Prosumer cent/kWh	Full feed-in-cent/kWh
0–10	8,20	13,00
20	7,65	11,95
40	7,38	11,43

1.2.1 Large-scale installations

Large-scale installations today participate in the electricity market, i.e. they sell their electricity or capabilities into the submarkets of the system, including the spot and ancillary service markets. The operational responsibilities are often handled by service providers[3], while the off-takers are the nearest distribution system operators. On top of their market revenues, the installations receive a (sliding) market premium.

The market premium support scheme for renewable energies was introduced by an update to EEG in 2012, and until 2017 gradually replaced the previously existing feed-in-Tariff scheme. It enables the sliding market premium business model, which represents the largest share of new wind and solar projects since its introduction. New renewable energy projects with a capacity larger than 1MW can access the support scheme by participating in an auction. Technologies supported under the scheme include onshore wind, offshore wind and greenfield solar projects, that range from commercial developers over institutional investors to so-called community based renewable projects (see box 1).

Under the sliding market premium, each project receives support payments per kWh according to a reference value that is fixed for 20 years[4]. Powerplants that operate in the scheme engage in direct marketing, selling their electricity at the spot market. Adding to the market revenue, they receive a subsidy that covers the difference between the average monthly market value for the specific technology, and the project specific support level, also called reference value. As a consequence, the market premium varies in line with the market value (it is not a fixed value).

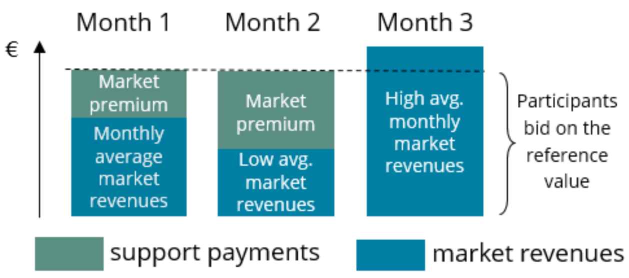
While the reference value is determined in auctions (see subsection below), the average market value is published by the grid operators on a website (see netztransparenz.de). In May 2023 the average market value was 8.095ct/kWh for onshore wind and 5.356ct/kWh for Solar PV[5].

It is noteworthy that the sliding market premium model is not a contract for difference, as the operators keep the revenue that exceed the reference value in times of high market prices, as depicted in Figure 4. This happened during the energy crisis of 2022/2023[6]. However, for that

[2] German wording: Bürgerenergiegesellschaften.
[3] German wording: Direktvermarkter.
[4] The EEG 2023 delineates the feed-in premium in §20.These section provide detailed explanations and regulations regarding the remuneration mechanisms for feed-in premium.
[5] Netztransparenz – Informationsplattform der deutschen Übertragungsnetzbetreiber, 2023, at: Marktwertübersicht, at: https://www.netztransparenz.de/EEG/Marktpraemie/Marktwerte.
[6] Richstein, Jörn/ Lettow, Frederik/Neuhoff, Karsten, 2022, Marktprämie beschert Betreibern erneuerbarer Energien Zusatzgewinne – Differenzverträge würden VerbraucherInnen entlasten, DIW aktuell, at: https://www.diw.de/de/diw_01.c.834286.de/publikationen/diw_aktuell/2022_0077/marktpraemie_beschert_betreibern_erneuerbarer_energien_zusat___ne____differenzvertraege_wuerden_verbraucherinnen_entlasten.html.

time an additional windfall profit skimming policy was introduced for most electricity producers[7].

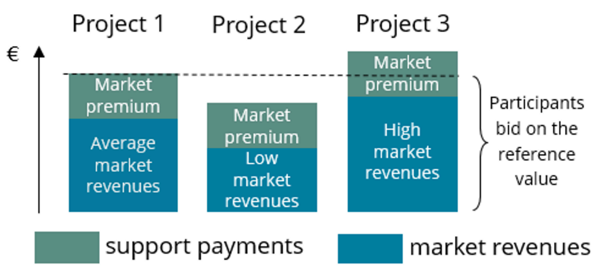
Figure 4: Sliding market premium over different months. Source: dena



As the market premium depends on the technology specific average monthly market value, the incentives to minimize production costs and maximize revenue by selling at times of highest scarcity and price are maintained. In difference to a flat feed-in-tariff, this incentivises a system friendly operation of the RE powerplants. If an RE operator sells their electricity at a lower price than the technology specific monthly market value, their revenue may lay below their reference level (see Figure 5). At the same time, optimized operation and marketing can result in revenues that exceed the reference value.

1.2.2 Extension: renewable energy auctions

Figure 5: Comparing revenue between projects in one month. Source: dena



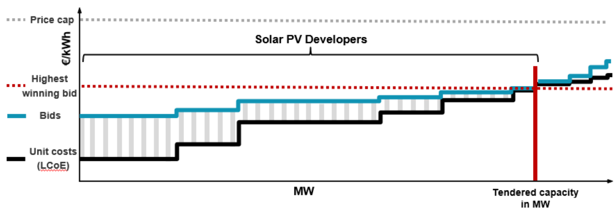
The reference value that determines the level of support for renewable installations under the market premium system is set in an auction for each successful installation. While the first pilot auctions for onshore wind took place in 2015, auctions have been fully implemented for all renewable energy technologies with a project size larger than 1MW capacity in 2017. The auctions are prepared and implemented by the federal network regulator *BNetzA* and are organized in a technology specific manner for Solar PV, Onshore Wind, Offshore Wind, Biomass; moreover, there are multitechnology auctions which accept bids from both wind and PV projects. For each technology, several rounds of auctions take place per year in varying frequencies. This publication focuses on onshore wind and green field solar, which are largest renewable electricity technologies on the German market.

Each auction is published on the website of *BNetzA*[8], specifying the tendered capacity in MW and a price cap that defines the highest accepted bid price. Bidders partake by submitting bids that consist of an offered capacity in MW and a price in ct/kWh, and are related to a specific project location. The lowest bids are accepted in the merit order until the tendered capacity is reached (one-round auction, see Figure 6). Between the correctly submitted bids, price is the only selection criterion. The auctions apply the pay-as-you-bid principle, meaning that every winning bidder receives the support level specified in their bid. The German auction design is characterized by relatively stringent qualification requirements that have to be fulfilled by bidders in order to participate. The exact rules vary by technology and are defined in the EEG.

Greenfield Solar

To participate in the auction, developers of greenfield solar PV projects have to submit a deposit of 25–50 € per kW capacity. The project must be developed to a stage where several permits & licences have been obtained. After winning the bid, a project must become operational within 24 months. Failing to meet this deadline leads to a reduced refund of the deposit. Bids that are won for a specific site cannot be transferred to another site.

Figure 6: Exemplary solar auction curve. Source: dena[9]



[7] Strompreisbremsegesetz §13.
[8] Bundesnetzagentur (2023) Ausschreibungen für EE- und KWK-Anlagen, at: https://www.bundesnetzagentur.de/DE/Fachthemen/ElektrizitaetundGas/Ausschreibungen/start.html.
[9] Based on DNV GL (2020), Presentation at DFBEW conference on RE auctions

Example sliding market premium – Citizen Wind Park Bretzfeld-Obersulm

Project Description: The project was developed by EnBW Windkraftprojekte GmbH and Bürgerwindpark Hohenlohe GmbH. Its three turbines have a joint capacity of 13.5MWp and were installed by February 2022. In its first year of operations the park produced 33.5GWh of electricity.

Costs and Financing: The windpark has an investment volume of €21mio. In the construction phase Bürgerwindpark Hohenlohe GmbH took over the entire project, using junior debt issued by six community-based RE cooperatives, a municipal supplier and 92 local citizens with a maturity of 14 years at a 3.5% interest rate.

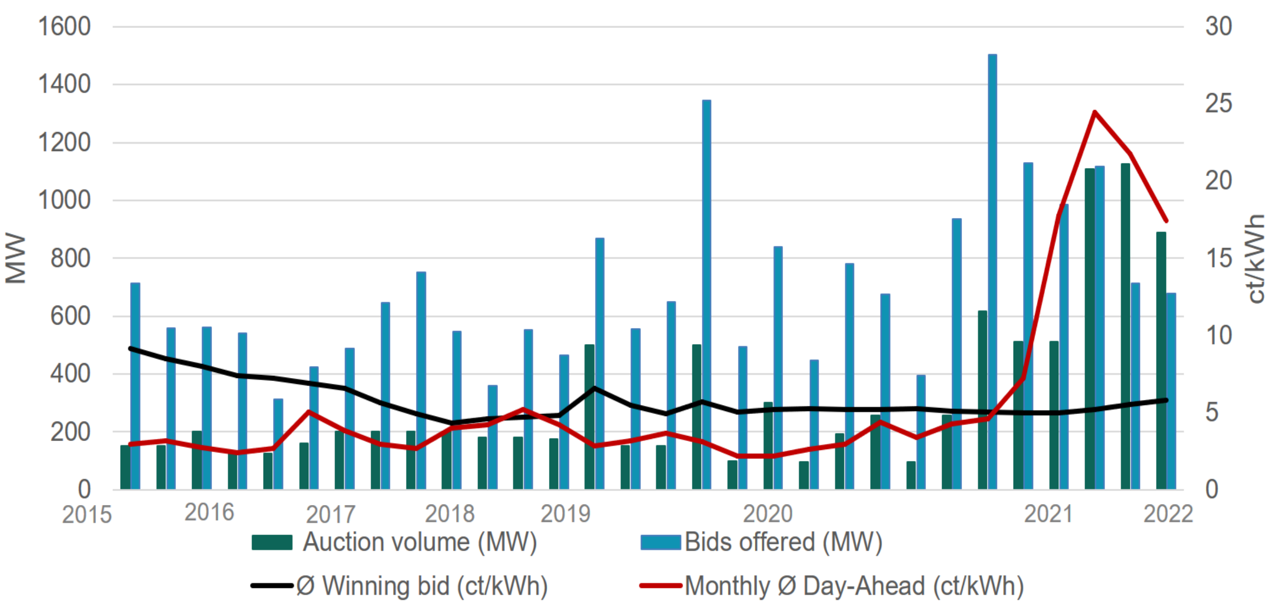
Business Model: The remuneration by the regional grid operator is set at the market level of 6.18 ct/kWh via the sliding market premium model for 20 years according to §35 Abs. 1 EEG, with potentially higher earnings when selling for higher prices at the spot market. The market level of 6.18 ct/kWh derives from the highest accepted bid at the BNetzA auction for onshore wind in December 2019.

For greenfield solar projects, the first pilot auctions started with an average winning bid price of 9.17ct/kWh in 2015, after which the average bid price was steadily reduced until 2018. Since then, winning bid prices fluctuated around 5ct/kWh, with an outlier in March 2019 (see Figure 7). The solar auctions have been generally oversigned, until the auctioned volume was increased significantly during the energy crisis starting in 2022. In combination with the supply chain delays for solar PV modules and components, this led to an increase in bid prices. As of 2023, the price cap was set at 7,37ct/kWh for greenfield solar auctions[10].

Onshore Wind

The auctions for onshore wind have additional technology specific design elements, including stricter qualification requirements. Bidders must provide a "federal immission protection permit"[11] for their selected site, to ensure that their project would not "disadvantage or significantly annoy the general public or the neighbourhood". In addition, they must submit a security deposit of 30€/kW,

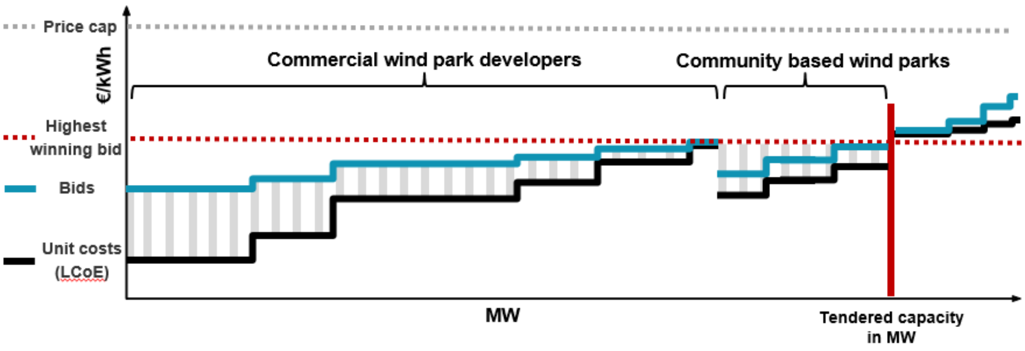
Figure 7: Greenfield solar auction results. Source: dena, based on data: Bundesnetzagentur, Energiechronik.de, energy-charts.info



[10] Bundesnetzagentur (2023) Ausschreibung Solaranlagen erstes Segment: Gebotstermin 1. Juli 2023, at: https://www.bundesnetzagentur.de/DE/Fachthemen/ElektrizitaetundGas/Ausschreibungen/Solaranlagen1/Gebotstermin01072023/start.html

[11] Bundes-Immissionsschutzgesetz (Federal Immission Control Act).

Figure 8: Exemplary onshore wind auction curve. Source: dena[13]



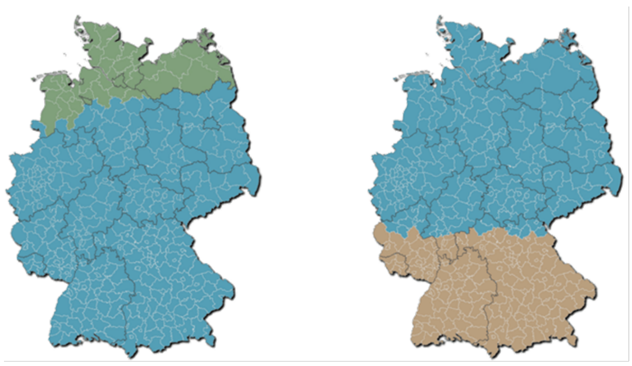
which is returned only after the project has been successfully implemented. The project must become operational within 24 months after the the auction results were published. Delays are penalized with 10€/kW in the first two months of delay and 20€/kW for the additional month. These are collected from the deposit.

In onshore wind auctions, community-based windparks (see box) receive preferential treatment, including lower participation requirements. In addition, they are exempt from the pay-as-you-bid rule. If their bid is successful in the joint auction with the commercial bids, they automatically receive the highest winning bid price. Community-based RE projects which are largely owned by local residents offer deeper integration into regional value chains, are expected to lead to higher municipal revenue and better acceptance in local populations.[12]

As a result of the preferential treatment of community-based wind parks, they crowded out some commercial develpers in early auctions, as represented in the exemplary onshore wind auction curve above (see Figure 8). Another particularity of the onshore wind auctions are zonal regulations that were introduced to address the geographically unbalanced distribution of wind installations. The strong and reliable winds in the Northern coastal areas led to a large part of the onshore wind parks being constructed there, adding to the offshore wind parks in the area. With industrial consumption centres being located in Southern Germany, this led to the congestion of the North-South transmission grids within Germany and the interconnected neighbouring countries. As a first step, a cap had been introduced for the „Grid Expansion Area" on the Northern coast in 2017 (EEG 2017), effectively splitting the auction in two parts. In 2021, the rule was replaced by a minimal quota of 15% being reserved for onshore wind projects in Southern Germany (EEG 2021)[15]. In addition, a „correction factor" is applied to installation with lower wind speeds in the Southern region, favoring them in the auction and ensuring higher revenues upon success (EEG 2023). These zonal measures aim for a more grid friendly geographical distribution of windparks within Germany (see Figure 9).

Under these circumstances, the average winning bid prices in the onshore wind auctions have been relatively stable since the first auctions started in 2017. While volume of bids outnumbered the tendered voulume in early auctions, since 2018 the onshore wind auctions have repeatedly faced a shortage of bids due to complicated and lenghty application procedures and lack of sites allocated n state level (see Figure 10). As a result, the tender volume for the concerned auction was reduced retroactively by BNetzA in several auctions.

Figure 9: Onshore Wind Zoning. Source: Ariadne Project[14]



[12] Bundesverband Windenergie (2013) Windenergie in Bürgerhand- Energie aus der Region für die Region, at: https://www.wind-energie.de/fileadmin/redaktion/dokumente/publikationen-oeffentlich/themen/01-mensch-und-umwelt/01-windkraft-vor-ort/20131206_bwe_broschuere_buergerwind_final.pdf.

[13] Based on DNV GL (2020), Presentation at DFBEW conference on RE auctions

[14] Eicke, Anselm et al. (2022) Ariadne-Analyse, Regionale Steuerungsinstrumente im Stromsektor, at: https://ariadneprojekt.de/publikation/ariadne-analyse-regionale-steuerungsinstrumente-im-stromsektor/

[15] As of July 2023, the southern quota has not been approved by the EU Commission under state aid law. Therefore, it is not yet applied in practice.

The role of service provider

Once the (large-scale) installation has been registered with the distribution grid operator and remote access to the plant has been established, the direct marketing activities commence. Typically, the (trading) service provider plays a vital role in ensuring the smooth operation of the direct marketing process.

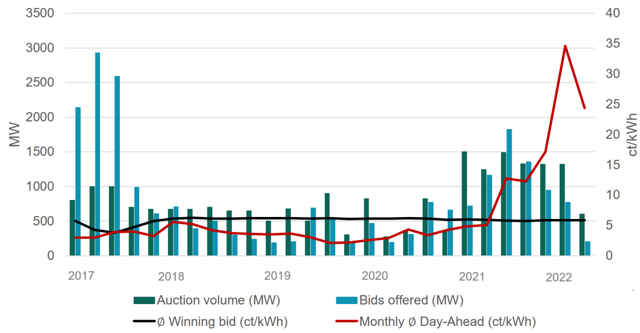
Firstly, the service provider plays a crucial role in preparing individual forecasts for each renewable energy plant, ensuring accurate estimations of electricity production. This is essential for effective trading on the electricity exchange with minimal deviations.

Secondly, the service provider is responsible for balancing any shortfalls or surpluses in intraday electricity trading. They actively manage and optimize the electricity production and consumption to ensure a balanced supply and demand.

Additionally, the service provider handles the settlement of revenues from electricity production with the plant operator. This includes the financial transactions related to the sale of electricity on the market and the distribution of earnings to the plant operator.

Examples of service providers in Germany: Clean Energy Sourcing AG (www.clens.eu); in.power GmbH (www.inpower.de); Statkraft Markets GmbH (www.statkraft.de).

Figure 10: Onshore wind auction results[16]. Source: dena, based on data from: Bundesnetzagentur, Energie-chronik.de, energy-charts.info

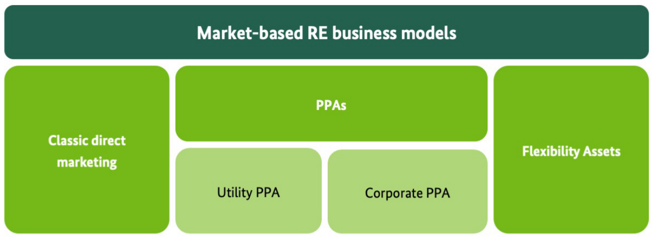


1.3 Business models for renewable energy without support mechanism

Direct marketing without subsidies is a viable option for renewable energy installations in Germany that do not qualify for subsidies or choose not to participate in the subsidized support mechanisms. The EEG provides provisions for direct marketing under the section § 21a, which allows renewable energy producers to market their electricity directly without relying on government subsidies. In practice, this option is particularly relevant for installations situated on land that is ineligible for subsidies, installations that exceed the allocated auction quantities, or installations operating after the expiration of the EEG subsidy period.

Generally speaking, direct marketing offers flexibility and independence for renewable energy producers. It enables them to negotiate contracts directly with off-takers, such as consumers or commercial entities, based on market prices and terms. This can involve various types of direct marketing (see Figure 11), including classic direct marketing and other innovative models like Green Power Purchase agreements or participation in Virtual Power Plants

Figure 11: Market-based renewable energy business models. Source: dena



[16] Please note that the time axis is not linear, as the auctions take place in irregular time intervals. The Day-Ahead prices refer to the volume weighted average monthly prices of the months in which the auction took place. Therefore, some of the price spikes of 2022 are not visible.

(VPPs). By engaging in direct marketing without subsidies, renewable energy producers have greater control over their revenue streams and can adapt to market dynamics. This approach fosters competition, market efficiency, and the development of new business models within the renewable energy sector.

Ultimately, it is the stated goal of both EU and German renewable energy policy to lead technologies to market maturity so that subsidies become obsolete. While representing a niche today, the number of installations operating without subsidies is growing and their business models (described in this section) are considered to be the future of the sector (the business models described in this section can be found in tabular form in Table 12 and Table 14 in the appendix).

Example Direct Marketing, Solar Park Gottesgabe, Brandenburg

Foto: Shutterstock / Fabrizio-Maffei

Project Description: The supplier EnBW developed the green-field solar park with a capacity of 153MWp and an expected annual production of 154GWh. The project was connected to the distribution grid and entered into service in February 2022.

Business Model: The project was built outside of any subsidy scheme. As EnBW is a supplier itself, and did not announce any PPA for the project, it is assumed that it engages in direct marketing itself.

1.3.1 Classic direct marketing; Business model: classic direct marketing

In certain scenarios, operators choose direct marketing when they have lost auctions, the EEG has expired, there are substantial costs associated with auction participation (such as deposits and organization) or the electricity prices are high (as in the years 2022/2023).

The classical direct marketing business model is regulated by several relevant regulations, including RES 2023 at § 33c, EnWG, ARegV, StromNEV, and StromNZV. Investors from various sectors, such as the government, banks, private companies, investors, and renewable energy communities, participate in this model.

The business model offers products and services in OTC markets, as well as spot markets such as the day-ahead, intraday, local flexibility and ancillary service markets. Service providers and suppliers, such as Stadtwerke (municipal utilities), operate within this model.

A diverse range of off-takers or clients can benefit from classical direct marketing, including households, large industries, and pooling systems where multiple consumers collaborate. The cost structure for this business model is similar to previous models, encompassing components such as fixed assets, installation costs, operational expenses, and income tax.

The revenues in classical direct marketing are generated through the sale of energy, with the prices for electricity production being deducted. The profitability of the model depends on market conditions, the efficiency of energy trading, and the optimization of revenue generation.

1.3.2 Other direct marketing and PPA

Other direct marketing, defined by §21a of the German Renewable Energy Sources Act 2021, RE installation operators to sell their electricity directly on the exchange or to a direct marketer without relying on EEG support. Similar to classic direct marketing, the remuneration in other direct marketing is based on either the exchange spot price or the technology-specific monthly market value. Unlike subsidized direct marketing, it does not involve feed-in tariffs or market premium subsidies. However, the green electricity attribute can be further marketed through guarantees of origin. Furthermore, fixed-price remuneration models such as Green Power Purchase Agreements[17]

[17] The term power purchase agreement is not legally anchored in German law. In discussions within the sector and in academic discussions, it is rather used as a collective term for a large number of civil law electricity supply and electricity purchase agreements, each of which is structured differently. In common usage, a Green Power Purchase Agreement (PPA) is a bilateral purchase agreement under civil law between an electricity buyer (consumer/customer) and an electricity producer (energy supplier/project developer/plant operator) of renewable energies.

offer stable and predictable revenues despite the absence of subsidies.

PPAs serve as direct marketing contracts between a legal entity and an Independent Power Producer (IPP). As the number of post-EEG plants increases, PPAs are gaining popularity to ensure the continued economic operation of these facilities. The flexibility of PPAs stems from their individual and bilateral nature, allowing various contract structures. Typical PPA contents include details regarding electricity prices, delivery schedules, volume, grid connection, outage procedures, accounting considerations, guarantees of origin, and contract duration. Pricing structures can be customized, with options for fixed-price agreements, discount-to-market structures, inflation-adjusted prices, or periodic increases in electricity prices.

PPAs are often structured for long-term commitments, typically spanning between 10 and 25 years. These extended durations align with the nature, operation, and refinancing needs of new renewable energy plants. In contrast, existing plants may opt for shorter contract terms ranging from 1 to 5 years.

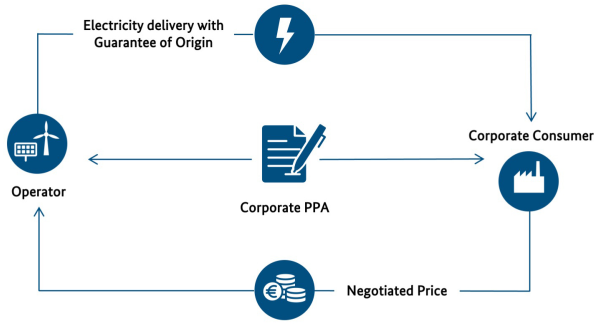
Power Purchase Agreements[18] can be classified into main distinct categories: corporate and utility PPAs.

Corporate PPA

This type of contract involves an agreement between the energy producer and the energy consumer, typically a corporate entity. It facilitates a direct transaction between the producer and the end consumer. Under this agreement:

- The corporate off-taker pays the generator a fixed rate per unit volume (MWh) of power produced.
- Separate contracts are used to manage financial risks and handle volume imbalances between the project's output and the corporate's electricity demand.
- Any shortfall or excess power is bought back or sold to the electricity supplier through a separate "sleeving" contract[19].

Figure 12: Corporate PPA. Source: Virtuelles Kraftwerk, EnBW



Utility PPA

In a utility (or merchant) PPA, the energy producer enters into a contract with an energy supplier or direct marketer. This arrangement allows the producer to sell electricity directly to market participants or intermediaries involved in the energy supply chain. Key features of a Utility PPA include:

- A utility PPA is a structure where a power supply agreement is concluded between a power producer and a supplier, also called utility company (UC).
- Utility PPAs are usually characterized by shorter contract periods compared with corporate PPAs. Moreover, in utility PPAs, UCs do not consume the electricity by themselves but sell it to their customers.
- As soon as the utility delivers the electricity to a defined consumer within this contract, the contract becomes a “corporate PPA”.
- In the context of renewable energies, utility PPAs are concluded on the supply of renewable energy by the utility and the corresponding Guarantees of Origin (GO)[20]. These GOs are voided by

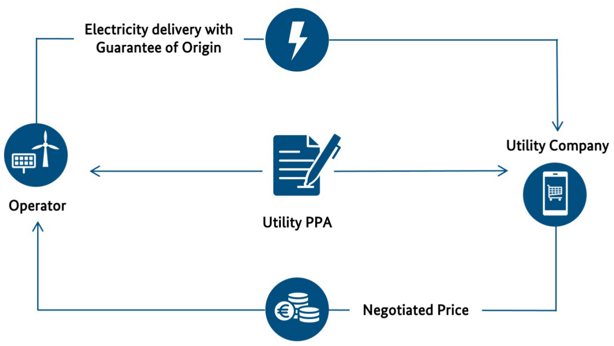
[18] There are currently no uniform definitions on the market for the various forms of green PPAs, which means that the same variants are often referred to by different terms. Therefore, this study refers to the Market Initiative Renewable Energies: "Beschaffungsstrategien für grünen Strom. Ein Leitfaden zur Beschaffung von grünem Strom für Stromabnehmer aus Industrie und Gewerbe. (dena. 2022)“.

[19] Max Baier at al., „Beschaffungsstrategien für grünen Strom. Ein Leitfaden zur Beschaffung von grünem Strom für Stromabnehmer aus Industrie und Gewerbe.“, Deutsche Energie-Agentur, 2022, at: https://www.dena.de/fileadmin/dena/Publikationen/PDFs/2022/dena_Marktoffensive_Abnahmeleitfaden_2022.pdf.

[20] A Guarantees of Origin (GO) is a digital certificate that confirms that a certain amount of electricity from renewable energies has been fed into the electricity grid. This makes the origin of the electricity transparent and the certificate ensures that the quantity produced is only marketed once as green electricity. In Germany, guarantees of origin are currently only issued for non-subsidised green electricity.

the vendor on behalf of the customer to document and prove the origin of the renewable energy.

Figure 13: Steam Cracker with Post-Combustion carbon capture. Source: dena



A further distinction between PPAs can be made with regards to the actual delivery which can be physical or purely financial.

A physical PPA involves the actual physical delivery of electricity from the power producer to the off-taker or consumer. The electricity generated by the power producer is physically supplied to the off-taker as per the terms of the agreement. The physical PPAs differ in terms of the delivery route and the accounting settlement:

- On-site PPA: direct physical offtake (local proximity), delivery does not take place via the public grid, thus saving on grid charges.
- Off-site PPA: balance-sheet offtake (local separation); delivery via the public grid, settlement via concerned balancing groups*.
- Sleeved PPA: Off-site PPA in which an energy service provider takes over the service processes between the supplier and the buyer.

A financial PPA focuses on the financial settlement of electricity transactions without the physical delivery of electricity. Instead of physically delivering the electricity, the parties agree on financial settlements based on agreed-upon price differentials in the electricity wholesale market.

The connection between utility/merchant PPA and physical/financial PPAs (see Figure 14) lies in the different approaches to electricity delivery and settlement[22]. Utility/merchant PPAs typically involve physical delivery of electricity through the utility company, while physical and financial PPAs focus on how the electricity transactions are settled either through actual delivery or financial agreements.

Example Corporate PPA, Solar park Schwarzheide, Brandenburg

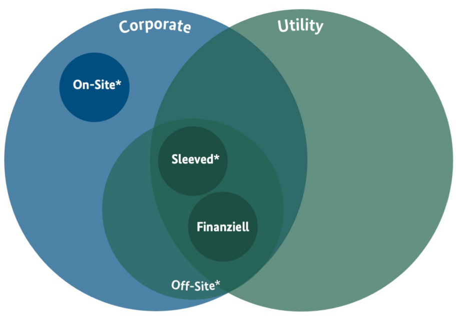
Foto: Shutterstock / zhengzaishuru

Project Description: The greenfield solar park BASF enviaM Solarpark Schwarzheid has a capacity of 24 MWp and started operating in August of 2022. It is a joint venture between the chemical producer BASF Schwarzheide and utility enviaM. Envia THERM, a subsidiary to enviaM is the developer and operates the project.

Costs and Financing: The investment costs were €13mio, with financing offered by DZ Bank.

Business Model: The chemical producer BASF Schwarzheide is also the offtaker secured through a corporate onsite PPA. No public support mechanisms were involved.

Figure 14: Overview of PPA subtypes. Source: dena. Based on: Next Kraftwerke[21]



[21] Max Baier at al., „Beschaffungsstrategien für grünen Strom. Ein Leitfaden zur Beschaffung von grünem Strom für Stromabnehmer aus Industrie und Gewerbe.", Deutsche Energie-Agentur, 2022, at: https://www.dena.de/fileadmin/dena/Publikationen/PDFs/2022/dena_Marktoffensive_Abnahmeleitfaden_2022.pdf.

[22] Next Kraftwerke GmbH: Power Purchase Agreement (PPA), in: Next Kraftwerke GmbH ., 15.11.2018, at: https://www.next-kraftwerke.de/wissen/power-purchase-agreement-ppa .

Business model: Corporate PPA

The corporate Power Purchase Agreement is a business model in which a direct contract is established between a power producer and a corporate off-taker, typically a company that consumes electricity. This model is regulated by various relevant regulations, including RES 2023 at § 33c, §21a RES 2021, formerly §20 para. 1 number 2 RES 2014, formerly §33b number 3 RES 2012, as well as EnWG, ARegV, StromNEV, and StromNZV.

In a corporate PPA, the investor can be any entity, including companies that utilize electricity, direct marketers, state entities, banks, private companies, private investors, and renewable energy communities. The products and services offered in this model are traded over-the-counter, allowing for direct negotiation and customization of the contract terms.

The operator in a corporate PPA can be either a supplier or a service provider, responsible for facilitating the agreement and ensuring smooth energy supply. The off-takers or clients in this model include multiple households, large industries, or pooling systems where electricity is consumed collectively.

The costs associated with the corporate PPA model are similar to those of previous models discussed. These costs typically include the investment and operational expenses of the renewable energy project. Revenues in a corporate PPA are generated through the sale of renewable electricity under a long-term delivery agreement. The prices for the electricity can be fixed or indexed, depending on the terms of the contract.

Business model: Utility PPA

The utility PPA is a business model that involves a contractual arrangement between a power producer and a utility company, also known as a supplier. In this model, the power producer generates renewable electricity and enters into an agreement to sell it to the utility company.

Relevant regulations such as RES 2023 at §33c, §21a RES 2021, formerly §20 para. 1 number 2 RES 2014, formerly §33b number 3 RES 2012, EnWG, ARegV, StromNEV, StromNZV provide the legal framework for utility PPAs.

Investors in utility PPAs as well as in corporate PPA can include wide range of companies that use electricity, direct marketers, state entities, banks, private companies, private investors, and renewable energy communities. The key difference lies in the specific relationship between the investor and the off-taker. In a utility PPA, the utility company acts as the intermediary between the power producer and the end consumers.

Utility PPAs can involve various products and services, including OTC trading and participation in spot market such as the day-ahead market, intraday market, local flexibility market, and ancillary service markets to a smaller extent.

Example Utility PPA, Solarpark Schornhof, Bavaria

Foto: Shutterstock / hrui

Project Description: The green field solar park Schornhof has a capacity of 120MWp. It has been built by the solar project developer and operator Anumar starting in 2020, and was inaugurated in summer 2021. Due to the project size, the park is equipped with its own substation, connecting it directly to the transmission grid.

Costs and Financing: The investment of approximately €60mio was financed by Umweltbank, under a creditline specialized to PPA-backed RE projects with a maturity of 20 years. According to Umweltbank, the LCOE of the project is below 5ct/kWh.

Business Model: Anumar, which is also operating the project, concluded two PPAs with the Norwegian utility Statkraft over 40MWp and 50MWp for 10 and 11 years. The remaining 30MWp of the project were built under the EEG sliding market premium subsidy, which is paid by the grid operator.

In contrast, the corporate PPA primarily focuses on long-term delivery of renewable electricity to the corporate off-taker.

In both utility and corporate PPAs, the operator can be a supplier or a service provider. The operator in a utility PPA may have a broader role in managing the distribution and supply to end consumers.

Utility PPAs are typically characterized by shorter contract periods compared to corporate PPAs. Utility PPAs may range from a few years to a decade, while corporate PPAs tend to have longer contract durations. Corporate PPAs can span from 10 to 25 years, aligning with the operational and refinancing period of new renewable energy plants.

Both utility and corporate PPAs generate revenues through the sale of renewable electricity. In a utility PPA, the revenue is generated from supplying electricity to the end consumers, while in a corporate PPA, the revenue is generated from the fixed amount per unit volume (MWh) of power produced and consumed by the corporate off-taker.

1.4 Decentral storage

In the envisioned low-carbon electricity supply system of the future, distributed generation will play an important role. Private households and small businesses will actively participate in generating renewable energy through units connected to the low- and medium-voltage grid. This transformation, however, introduces challenges concerning network stability and supply security due to the intermittent nature of renewable energy sources and their increasing presence in the electricity system. To overcome these obstacles and maximize the potential of renewables, decentralized storage systems have emerged as a vital solution (for an overview of technological options, see table 16 and 17 in the appendix).[23]

Decentralized electricity storage refers to a system where electricity is stored at the local or distributed level, often near the point of consumption or generation. This storage approach involves utilizing small-scale energy storage systems, such as batteries or other technologies, to store surplus electricity produced by renewable energy sources like solar panels or wind turbines. It can provide balancing energy to both transmission and distribution networks, helping to optimize the utilization of renewable energy sources and enhancing grid stability. A prerequisite for the network friendly deployment of decentral storage is, however, the introduction of regulation that enables its contracting by network operators.

These storage systems offer various applications, including prosumer storage, stand-alone storage, batteries in large-scale EE applications, and batteries used in industrial settings to manage loads. The application time for decentral storage can vary significantly, ranging from seconds to weeks, depending on the specific type of storage technology and its intended purpose.

In economic terms, storage systems can generate value in different ways:

- A stand-alone storage (often battieries) is operated in several markets of the electricity system: it leverages arbitrage opportunities in Forward, Day-Ahead, and Intraday markets, capitalizing on price differentials. Batteries also participate in reserve markets (Primary, Secondary) to support grid stability and offer various ancillary services to enhance overall grid reliability.
- Another impactful approach involves utilizing storage as part of large-scale renewable energy installations, where the storage systems increase the sales value of electricity generated by actively engaging in Forward, Day-Ahead, and Intraday markets. These batteries also participate in reserve markets (Primary, Secondary), assisting in the crucial task of grid balancing. Furthermore, they contribute to power smoothing and peak shaving, ensuring a steady supply of electricity and optimizing energy consumption. Additionally, these batteries secure faithfulness to schedule, ensuring a consistent and reliable delivery of electricity.
- Batteries operated by prosumers serve to boost the self-consumption share of renewable energy by storing excess energy and efficiently managing its use.
- In industrial settings, batteries play a significant role by reducing the cost of procuring electricity from Forward, Day-Ahead, and Intraday markets through optimized energy usage. They also help lower grid tariffs by providing flexible load management, responding to grid demand and offering demand response services in Day-Ahead or reserve markets, thereby supporting grid stability. Additionally, these batteries provide uninterrupted power supply, ensuring continuous operations even during grid outages.

Example Decentral Storage, EnspireME Battery Storage in Jardelund, Schleswig-Holstein

Project Description: The lithium-ion battery unit with a storage capacity of 51MWh and rated power of 48 MW was connected to the grid in July 2018. The project was developed by the Dutch utility Eneco and its parent company, the Mitsubishi Corporation.

Costs and Financing: The investment costs amounted to €30mio. The project received public funding of €2mio from the state of Schleswig-Holstein.

Business Model: The unit is participating in the balancing market, where it is partaking in the weekly auctions of the frequency containment reserve.

[23] Tim Mennel at al., "Decentralized Flexibility and Integration of Renewable Energy", Deutsche Energie-Agentur, 2022, at: https://www.energypartnership.cn/fileadmin/user_upload/china/media_elements/publications/2022/Decentralized_Flexibility_and_Integration_of_Renewable_Energy_EN.pdf

1.4.1 Legal framework for storage operations

In the context of German law, storages do not have a distinct legal definition; rather, they are classified based on their function at the time of charging and discharging. When a storage facility charges as a final consumer and discharges as a producer, it enjoys certain privileges.

Storages that solely consume renewable energy are considered RE-producers, making them eligible for EEG compensation. For instance, a PV-battery combination receives the same compensation regardless of whether the electricity is fed in from the battery or directly from the PV source (§ 3 EEG & § 19 EEG)[24].

However, once the storage facility consumes electricity from the public grid, it loses its definition as a RE-producer and the corresponding benefits. This legal framework ensures that storages are incentivized to operate as renewable energy producers and contribute positively to the energy system.

Specific rules governing decentral storage are outlined in §§ 6–10 of the EEG. These regulations stipulate that network operators are generally prohibited from operating storage facilities to maintain unbundling in the energy market. However, there is an exception: transmission system operators are allowed to construct and operate storage facilities as network reserves if they are deemed special network-technical resources. It's important to note that such storage facilities operated by transmission system operators under this exception cannot be utilized for energy market purposes; their use is limited to network stabilization and reliability functions.

Overall, the deployment of decentral storage systems contributes significantly to the efficient integration of renewable energy sources. By facilitating the management of intermittent power generation and supporting grid stability, decentralized storage technologies play a vital role in Germany's transition towards a more sustainable and decentralized energy system.

1.4.2 Business model: stand alone storage

Only as a stand-alone device does a storage have a business model of its own: in all other applications outlined above, storages are part of a broader business model involving other assets (cf. table 18 in the appendix). Consequently, we focus on stand-alone storage here.

The revenues generated by stand-alone storage systems are derived from their participation in the electricity wholesale and ancillary service market. They offer a range of products and services, including arbitrage opportunities in forward, day-ahead, and intraday markets[25]. Moreover, they can participate in reserve markets such as primary and secondary reserves and offer various ancillary services to support grid stability. As for the cost, stand-alone storage systems entail several costs, including fixed asset and installation costs, as well as ongoing operating expenses such as insurance, electricity meter rent, maintenance, and cleaning. Moreover, electricity losses during the storage process count as operational cost as well.

Stand-alone storages are typically operated by energy suppliers and companies like Evonik and Bosch that manage their deployment, operation, and maintenance. The off-takers or clients of stand-alone storage systems typically include network operators, purchasing ancillary services, and traders and other participants in wholesale markets who clear their positions via the flexibility offered by the storage. Among the investors in stand-alone storage systems, municipal utilities and energy suppliers are dominant, given their experience in the market and access to funding.

By employing this business model, stand-alone storage systems contribute to the efficient integration of renewable energy sources, grid stability, and overall optimization of the energy market.

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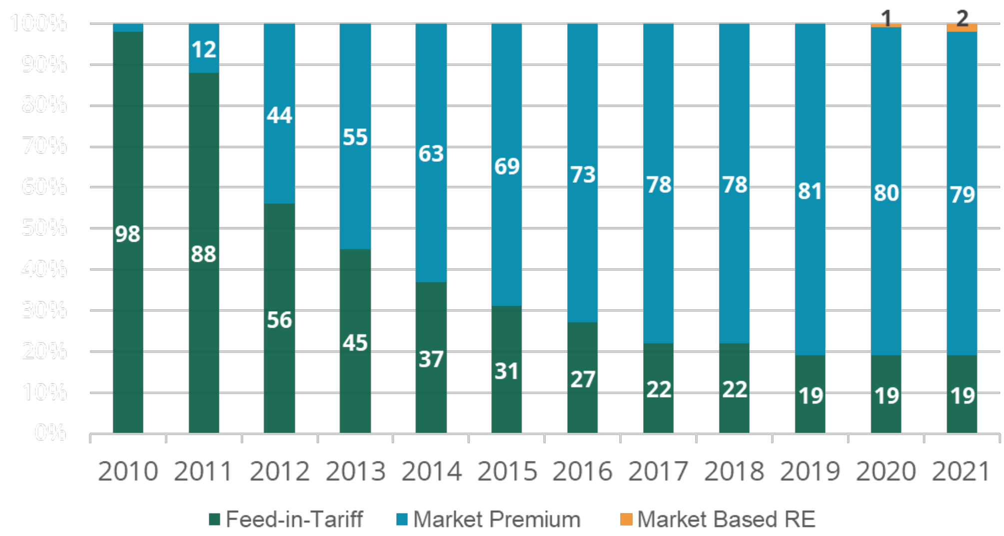
[24] Wolfgang Fritz et al., "Batteriespeicher in Netzen", Schlussbericht Projekt-Nr. 33/18, im Auftrag des Bundesministerium für Wirtschaft und Energie, 2022, at: https://www.bmwk.de/Redaktion/DE/Publikationen/Studien/studie-batteriespeicher-in-netzen-schlussbericht.pdf?__blob=publicationFile&v=1

[25] Tim Mennel at al., "Innovative distributed generation and storage – German and European experiences and perspectives for China", Deutsche Energie-Agentur, 2022, at: https://www.energypartnership.cn/media-elements/.

1.5 Overall development and outlook

Figure 15: **Share of RE electricity generation by business model in percent. Source: Bundesnetzagentur Monitoringbericht 2022**[26]



Over the past two decades, business models based on support schemes have driven the expansion of renewable energy, fostering innovation, and contributing to progress towards a climate neutral energy system. In the early phase of this development, the business models built on the feed-in-tariff system and thus relied on an administered remuneration of generated electricity outside the market. As explained in this chapter, this has changed for large-scale installations: since 2014, they must engage in direct marketing and are supported by a market premium system, leading to a more sophisticated business model. In recent times, business models without support mechanisms have emerged, highlighting the fact that renewable installations are approaching market maturity. Figure 15 highlights the devlopement.

It shows that – while still dominant in 2010 – business models building on feed-in-tariffs have lost their importance, with business models enganging in direct marketing and supported by feed-in-premia covered four fifths of installed capacity in 2021. With just 2 % the share of market-based business models is still small but growing. In parallel, the role of decentral storage devices is increasing: by 2021, two million batteries had been installed in Germany, with a total capacity of 59 GWp[27]. If deployed under the right business model they have the potential to contribute massively to the system integration of renewable energy, most notably distributed generation.

By embracing and further developing these models, Germany can accelerate the shift towards a cleaner, more resilient, and decentralized energy system.

[26] Monitoringbericht 2022, Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen, 2022, at: https://www.bundesnetzagentur.de/SharedDocs/Mediathek/Monitoringberichte/MonitoringberichtEnergie2022.pdf?__blob=publicationFile&v=3.

[27] Benjamin Wehrmann, "Solar power in Germany – output, business & perspectives", Clean Energy Wire CLEW, 13 Apr. 2022, at: https://www.cleanenergywire.org/factsheets/solar-power-germany-output-business-perspectives.

2 Investments and financial models

2 Investments and financial models

Due to the massive expansion of renewable energy over the past quarter century, project development has become standardized in many aspects. The investment phases are shaped by the respective technology's geographic requirements and the specific permits and licenses. With the emergence of market-based support for large installations and, more recently, installations operating without support both risks and opportunities of project development have increased and given raise to new business and financial models. The changes have been accommodated by the introduction of financing models that have enabled further renewable expansion in the new environment.

The purpose of this chapter is to introduce the investment cycle and different financing models for renewable energy assets. It will start with an overview of the different project phases, discussing the different options and steps needed in the planning, construction and operation phases. The chapter will mainly deal with large-scale plants. Then a look is taken at the effects of the business models on the financing models, before a concrete part on investment analysis follows. In this section, the legal construction of companies required for financing, so-called SPVs, as well as an overview of key financial figures and financial sources of projects will be presented.

Each phase consists of multiple steps that need to be completed regardless of the business model of the project.

In principle, the timeline does not differ greatly from the financing of other (infrastructural) projects. Nevertheless, there are some peculiarities within the phases that have to do with the specifics of renewable energies and the respective (financing) environment, as well as the business model. The exact timeline varies by technology, project size, developer and location.

2.1 Timeline of investment for business models

An investment into renewable energy projects goes through three phases, starting with the project planning phase, followed by the implementation and operations phases, with a subsequent deconstruction (see Figure 16 below).

In the following, we will delve into more details of project development in Germany.

Figure 16: RE Project Development Phases. Source: dena

Figure 17: Project planning phase. Source: dena

Project Planning Phase	
Secure location/ Leasing	→Finding a location for the project; WindBG (Wind energy spatial demand law): on average: 1,4% of land for wind energy (2027; 2032: 2%); solar PV (2032: 1,8 – 2,2%) →Feasibility studies; secure location in terms of land rights
Secure Funding	→Usually: establishment of Special Purpose Vehicle (SPV) →Approaching possible investors: Equity Investors / Loan & Non-recourse financing →Decision for either business model with/without supporting measures →Cash-Flow-modelling
Auction / Offtake agreement	→Participating in an auction: bank bond/guarantee must be deposited as collateral →Securing off-take agreements (virtual/physical); either utility or corporate PPAs
Securing Permits/ Licenses	→Depending on the type of RE, different laws apply and permits are required. →Spatial planning already refers to respective spaces/areas →Such as: State buildings codes; Erneuerbare Energien-Gesetz (Renewable Energy Law; EEG), Raumordnungsplan (Spatial development plans), Bundesnaturschutzgesetz (State Environmental Protection Law; BNatSchG), Grid connection permits

2.1.1 Project planning phase

In the project planning phase, the priority is to ensure all conditions for the construction and to guarantee the sustainability of the investment (see Figure 17).
At the beginning of the planning phase, the focus is on finding the most suitable location for the project itself. Often this is done in the context of site assessments and an evaluation of site conditions to ensure the most important factors for the later yield. The Wind Energy spatial demand law (WindBG) obliges the federal states and municipalities to designate at least 1.4% of the land for wind energy (2027; 2032: 2%). For solar energy, this is to be between 1.8 and 2.2% in 2032, depending on the federal state. Designated areas are then available for the energy sources, which simplifies planning approval procedures (Planfeststellungsverfahren).

Usually, there is a need for more in-depth feasibility studies in which, for example, companies carry out (wind yield) modelling based on established models. These studies are pre-structured by regulation, permitting and licensing requirements and duties. In the context of such studies, further questions arise that may have an impact on the location of a renewable energy project. These include physical & planning constraints, such as other infrastructure nearby, grid capacity, environmental & ecological considerations, access to the site and other risks.[28] Studies that include these factors are found in great numbers on the internet.[29]

Once these studies are carried out, potential funding must be secured. In many cases, it is now common for the implementer – whether that is a utility or a project developer – to establish a project company, a so-called special (or single) purpose vehicle (SPV), whose sole purpose is to raise and manage capital and to implement and manage a specific project. In this case, "Contrary to corporate finance, project finance directly ties the cost of capital to project risk".[30]

The project developer devises a comprehensive financial plan that outlines the project's capital requirements,

[28] "Wind Power Feasibility Study," Renewables First, 2015, at https://www.renewablesfirst.co.uk/home/renewable-energy-technologies/windpower/windpower-feasibility-study/

[29] Al-Addous, Mohammad, et al. "Key Aspects and Feasibility Assessment of a Proposed Wind Farm in Jordan." International Journal of Low-Carbon Technologies, vol. 15, no. 1, Oxford University Press (OUP), 18 Nov. 2019, pp. 97–105. Crossref, doi:10.1093/ijlct/ctz062.

[30] Egli, Florian, et al. "A Dynamic Analysis of Financing Conditions for Renewable Energy Technologies." Nature Energy, vol. 3, no. 12, Springer Science and Business Media LLC, 5 Nov. 2018, pp. 1084–92. Crossref, doi:10.1038/s41560-018-0277-y.

budget, and funding sources.[31] Based on this, it is possible to approach possible additional investors or lenders. This can include equity or debt financing. Relevant at this point is the feedback to the business models presented in chapter 1, which differ in the point of support mechanisms. This has a decisive influence on the planning of the responsible bodies. Whether a support service is planned, for example in the form of tariffs, not only affects the later financial returns, it must also be included in the cash flow analysis (cf. Table 2). In addition – insofar as participation in auctions is planned – provision must already be made for the collateral to be deposited. If direct marketing of the electricity is planned, this must also be considered.

The financial plan requires a cash flow model, usually transferred into a simulation which simulates the electricity yield and prices. This should simulate various technical and environmental conditions and thus present an exemplary cash flow and various scenarios.[32] Providers of equity and debt both base their assessment of performance related or fixed claims on the model.[33]

Table 2: Key Differences in Cash Flow Models for the two seperate overarching business models. Source: dena

Key Differences in Cash Flow Models for the two separate overarching business models

Cash flow model aspect	Support Mechanisms	Market-Based Approach
Revenue Streams	Guaranteed or subsidized by government policies or incentives (e.g., FITs (before 2017, Sliding Market Premium with auctions)	Tied to prevailing market conditions (e.g., electricity sales, fixed-price PPAs, market-based RECs)
Risk Profile	Lower revenue risk due to predictable income (policy and regulatory risks possible); collateral for auctions needs to be considered	Higher revenue risk due to market fluctuations, lower initial costs (equity) possible
Financing and Investment Decisions	Easier to secure financing due to predictable cash flows	More challenging to secure financing due to revenue uncertainty, higher financing costs due to risks possible
Project Viability	Supports financially viable projects that may not be feasible in the open market or for a certain set of actors	Encourages competitive projects in the market
Government Involvement	Direct government support and intervention in renewable energy sector	Government provides a stable regulatory framework with less direct intervention

[31] Henzelmann, T., „Finanzierung und Finanzierbarkeit der Energiewende“, p. 60, in: Herbes, C. & Friege, C., „Handbuch Finanzierung von Erneuerbare-Energien-Projekten“, Narr Francke Attempto, UVK Verlagsgesellschaft, Konstanz, München.

[32] Böttcher, Jörg. “4.4 Wirtschaftlichkeit Und Ausgestaltung Einer Geeigneten Finanzierungsstruktur.”, Handbuch Windenergie, De Gruyter, 31 Dec. 2019, pp. 361–92. Crossref, doi:10.1515/9783110583922-018.

[33] Böttcher, Jörg. “1. Projektfinanzierung Eines Windparks.”, p.38, Handbuch Windenergie, De Gruyter, 31 Dec. 2019, pp. 7–45. Crossref, doi:10.1515/9783110583922-002.

Table 3: Types of Investors. Source: dena. Adapted from: Henzelmann 2015

Investor type	Description	Strenghts	Weaknesses
Private equity	Financial investor with the goal of short-term Yield-maximisation	High flexibility Transaction experience	Investment horizontal short-term Focused on fewer investments
Energy suppliers	Group/company from related areas (e.g. energy supplier)	Lifting synergy-potentials Capital access (decreasing)	Inflexible Structures partly too expensive
Infrastructure funds	Closed-end funds with focus on economic and social infrastructure projects	Long term investment horizon	Expectation of very high returns in some cases
Green funds	Value-based fund for environmental awareness and sustainability	Specialized in “green” investments	Very low investment volumes in some cases
Pension fund / life insurance	Large-volume capital managers and investors	Access to Capital Long term investment horizon	less no know-how in this field

Within this cash flow model, important terms are the Cost of Capital (CoC), also known as Weighted Average Cost of Capital (WACC); the Debt Service Coverage Ration (DSCR), the loan tenor and the debt margin. The chapter by Böttcher thoroughly examines changes in financing conditions and their impact on the cash flow model.[34]
It is also important to distinguish between the different investor groups that invest in renewable energies. As a representative example, Table 3 shows an overview over different types.

Often the steps of securing financing and securing the respective land run simultaneously. Initially, leasing agreements or, less often, a purchase of the land are sought. To ensure the use of the space required for the facilities, permits and licences are needed, for example with regard to environmental protection (ideally already considered and dealt with during site selection and within the framework of feasibility studies) or social components such as noise protection and distance from settlements. Permits required for airspace may also have to be obtained, especially for wind turbines. Furthermore, any permits according to the construction process need to be secured, such as for transport of the facilities or plants. What kind of permits are needed is based on the the respective state building codes, the height of the plant, the location of the plant and so-called "public concerns". What is inherent to the process of approval by the Bundesimmissionsschutzgesetz (Federal Immission Control Act of Germany) is the distinction in between a simplified and a formal procedure. The so-called "concentration effect" of the law is also special. This allows all other permits to be examined as part of the procedure.

This leads to the next sub-stage of the planning phase, the respective auctions and/or off-take agreements (Figure 17). While there were already tenders for renewable energies before 2017, this year represents the biggest turning point: This is because the Renewable Energy Sources Act 2017 (EEG 2017) was passed, which replaced the EEG 2014. Far-reaching changes resulted above all for the marketing of electricity from renewable energies. Previously, it was possible to receive fixed feed-in tariffs, as chapter one examines. In this phase – based again on the business model chosen for the plant – either preparation for the auctions start, or the Off-take agreements are concluded. The differences for different business models are explained in the first chapter of this report. In practice, this means that operators of plants above a limit of >1000kWp are subject to the market premium model, while operators of smaller plants are entitled to a fixed feed-in tariff.

For auctions, participants must pay an administrative fee in advance and deposit a security of 30 euros per kilowatt

[34] Böttcher, Jörg. “4.4 Wirtschaftlichkeit Und Ausgestaltung Einer Geeigneten Finanzierungsstruktur.”, Handbuch Windenergie, De Gruyter, 31 Dec. 2019, pp. 361–92. Crossref, doi:10.1515/9783110583922-018.

bid, which can also be deposited in the form of a (bank) guarantee ("Bürgschaft"). Permission granted under the Bundesimmissionsschutzgesetz is also required for participation. Only then is participation in the auction procedure possible.

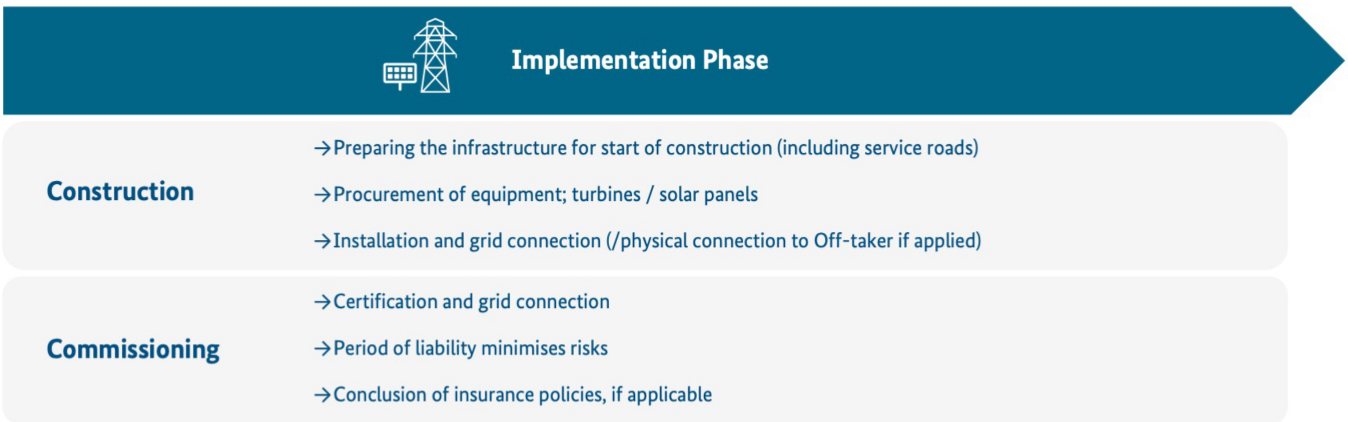
Insofar as no support mechanisms are desired, participation in the auctions is also not necessary. Here, the actors rely on direct marketing, for example through PPAs. In this case, they market the electricity generated by the plants directly to potential end customers, e.g. larger industrial companies. At this point in the timeline, bids must be made at auctions or off-take agreements, which can be included in the cash flow analysis in a reliable way. A differentiation of the various business models will take place below.

At the end of the preparation phase, all necessary financing agreements are signed in order to be able to start the construction of the project. The off-take agreements and/or building plots, rights or support services (such as the market premium) successfully acquired in auctions should also be secured. The necessary permits for the construction and operation of the plants should be in place to secure this in the next step. This phase, in which all important steps are also retraced and reviewed, culminates in the financial close of this first phase. At last, all the financial structures, such as accounts and other mechanisms should be established in order to make sure, that funds are available for the project development. Furthermore, contracts with suppliers, contractors or technology providers for the following implementation phase should be secured. Upon successful participation in the auction, the obligation to build the facility arises within two years. In the event of delays or non-performance, the bank bond is lost.

2.1.2 Implementation phase

As soon as all conditions are secured, the construction of the facilities can begin (implementation phase, see Figure 19). For this, the work site and the necessary (access) infrastructure must be prepared. The facilities/plants themselves, such as wind turbines or solar panels, including the necessary infrastructure, must be procured and brought to the construction site. The plants can then be constructed and installed, followed by the connection to the grid, or ensuring that the electricity is available to the off-taker. These connections must be tested and commissioned, followed by safety tests and quality checks to ensure environmental compliance and safety. The transition to the operational phase can then take place, and training for the operators (who may also be doing remote monitoring) may need to be carried out. The construction phase usually ends with the certification of the plants and needed facilities. A certain period of liability provided by the supplier helps to minimise risks for the implementer. Already in the construction phase, a wide range of risks appears: Lima et al. take a look at how to manage these when it comes to wind power, starting with the construction phase, going on to operational risks as well as during the deactivation phase.[35] Kamenopolous & Tsousos take a look at these risks for solar PV.[36]

Figure 18: Implementation Phase. Source: dena



[35] Lima, Fátima, et al. "Strategic Impact Management of Wind Power Projects." Renewable and Sustainable Energy Reviews, vol. 25, Elsevier BV, Sept. 2013, pp. 277–90. Crossref, doi:10.1016/j.rser.2013.04.010.

[36] Kamenopoulos, Sotiris N., and Theocharis Tsoutsos. "Assessment of the Safe Operation and Maintenance of Photovoltaic Systems." Energy, vol. 93, Elsevier BV, Dec. 2015, pp. 1633–38. Crossref, doi:10.1016/j.energy.2015.10.037.

Figure 19: Operation Phase. Source: dena

2.1.3 Operation phase

The operational phase includes the complete commissioning of the plants (see Figure 20). Here – based on the cash flow model – money is generated for the first time in the life cycle analysis of the plants.

This is done through market sales, PPAs and/or funding obtained through the auctions. It is important to note that certain conditions apply to the start of funding. As already described above, the plants must be commissioned 24 months after receiving the award, otherwise the award expires after 30 months.[37] However, extensions of the deadline are possible under specific circumstances, in order to avoid penalty rates and the loss of the bank bond. Direct participation in power exchange trading is also subject to a number of requirements which are regulated by German laws such as the Exchange Act and the EEX Exchange Rules at German level, as well as by European bodies such as European Commodity Clearing AG.[38] Indirect participation is also possible via the electricity supplier.

It is important for the operator to monitor the plant during operation and to minimise the risks. This is often done via remote monitoring, as no personnel is needed on site. Minimising risks includes the use of insurance policies that can cover plant failures. Monitoring can also lead to improved operations, if parameters are adjusted. Maintenance contracts, possibly already concluded for the entire lifetime of the plants, can also help to keep costs low. Since renewable energies are involved, electricity generation is highly dependent on external factors, especially meteorological conditions.

While these are already decisive in site selection, unforeseen events such as extreme weather can have an impact on the performance of the plants. The end of the funding period, which is already determined by the successful participation in the auctions, is in very few cases identical to the end of the lifetime of the constructed plants. Rather, they will continue to be operated after the end of the subsidy.

At the end of the plants' lifetime – at best in line with cash flow plans or even beyond – it comes to dismantling and recycling or disposal. In wind turbines, the rotor blades and their material made of carbon or glass fibre represent a challenge to recycling.[39] In the case of PV systems, operators also face major challenges, which are described by Tsanakas et al.[40] or Chowdhury et al.[41] for example. In the future, small components and pollutants in the modules will have to be better recycled at the end of their absolute lifetime. It may even be possible to market the

[37] Ausschreibungsverfahren für Windenergieanlagen an Land, Bundesnetzagentur, 2023, https://www.bundesnetzagentur.de/DE/Fachthemen/ElektrizitaetundGas/Ausschreibungen/Wind_Onshore/Ausschreibungsverfahren/start.html

[38] „Strombeschaffung und Stromhandel“, DIHK - Deutscher Industrie- und Handelskammertag Berlin | Brüssel, EFET Deutschland - Verband Deutscher Energiehändler e.V., 2020, at: https://www.dihk.de/resource/blob/16826/6b374abd68f83c368ed7d9cc68dadcd0/dihk-faktenpapier-strombeschaffung-und-handel-data.pdf

[39] Rani, Manjeet, et al. “A Review on Recycling and Reuse Methods for Carbon Fiber/Glass Fiber Composites Waste from Wind Turbine Blades.” Composites Part B: Engineering, vol. 215, Elsevier BV, June 2021, p. 108768. Crossref, doi:10.1016/j.compositesb.2021.108768.

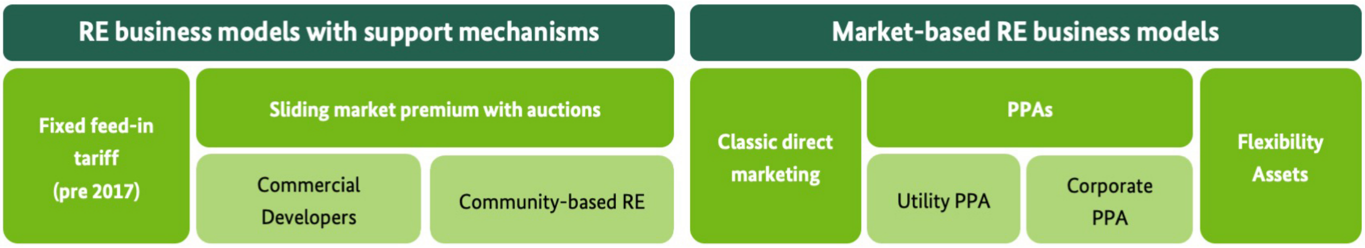
[40] Tsanakas, John A., et al. “Towards a Circular Supply Chain for PV Modules: Review of Today’s Challenges in PV Recycling, Refurbishment and Re-certification.” Progress in Photovoltaics: Research and Applications, vol. 28, no. 6, Wiley, 11 Sept. 2019, pp. 454–64. Crossref, doi:10.1002/pip.3193.

[41] Chowdhury, Md. Shahariar, et al. “An Overview of Solar Photovoltaic Panels’ End-of-Life Material Recycling.” Energy Strategy Reviews, vol. 27, Elsevier BV, Jan. 2020, p. 100431. Crossref, doi:10.1016/j.esr.2019.100431.

plants profitably at the end of their life or to sell them as a whole on the third-party market.

Last but not least, there is the question of the subsequent use of the existing area, for which any changes made to the landscape must be restored.

Figure 20: Business models relating to financial schemes. Source: dena



2.2 Financial models

The business models of RE assets determine the initial phase of financing, as different requirements and circumstances mark the planned cash flow and thus the financial model. Often this affects the entire project implementation company in the form of the SPV. Basically, the recourse to the two business models, on the one hand with the state support mechanisms, on the other hand of a market-based nature, is essential (cf. section 1.2 and 1.3). The two terms business model and financial model belong closely together, as they influence each other. But while the business model refers to the more general character of the company, its activities and cost structure, the financial model is more specific. It is fed by external requirements, such as the site conditions for the construction of the plants and, if applicable, factors that cannot be influenced, such as the (assumed) future price for the electricity generated. This also includes the capital costs, which can nevertheless vary in business models depending on the implementer, especially the refinancing costs, WACC, but also the gearing ratio debt/equity and the investment support. Already at the beginning of the project, the question arises as to which of the models can be implemented more profitably, i.e. more efficiently. This includes the initial question of evaluation of financial risks and benefits associated with various off-take options, including fixed-price contracts, variable pricing, and other structures. Insofar as a business model with support mechanisms is envisaged, it is necessary to fulfil all the prerequisites for these. This includes the auctions that enable a sliding market premium. In the auctions, bids that allow for the allocation of either pre-surveyed or general areas as well as the market premium received. An analysis of the auctions, based on individual bids of the participants, was prepared by Liñeiro and Müsgens for both wind energy[42] and solar PV.[43]

Community based developers, such as the Energy Community companies face greater challenges in this respect, which have become even greater with a phase-out of fixed feed-in tariffs, as market mechanisms have to be born. In addition, it may not be so easy for them to secure financing, through conditional lending and fewer equity capital. An overview of risks of market participants in auctions can be found in Côté et al.[44] Overall, with auctions there is usually at least an established baseline which helps to secure funding for entitities.

On the other hand, there are the market-based RE business models, for which various marketing methods are available. First of all, there are the classic direct marketing models, which rely on direct marketing of electricity to the respective end customers. PPAs include details on respective energy sales from the producer to the off-taker, which can be or corporates or utilities. In the latter case, the utility is not yet the final consumer but the intermediary. Furthermore, these agreements can be broken down into either physical or virtual PPAs. Overall, they reduce risks in terms of key financial figures, as they provide security when it comes to the price, volume, duration or operational procedures. This can lead to a less uncertain cash flow planning, influencing the financial viability of the project.

[42] Batz Liñeiro, Taimyra, and Felix Müsgens. 'Evaluating the German Onshore Wind Auction Programme: An Analysis Based on Individual Bids'. Energy Policy, vol. 172, Elsevier BV, Jan. 2023, p. 113317. Crossref, doi:10.1016/j.enpol.2022.113317.

[43] Batz Liñeiro, Taimyra, and Felix Müsgens. 'Evaluating the German PV Auction Program: The Secrets of Individual Bids Revealed'. Energy Policy, vol. 159, Elsevier BV, Dec. 2021, p. 112618. Crossref, doi:10.1016/j.enpol.2021.112618.

[44] Côté, Elizabeth, et al. 'The Price of Actor Diversity: Measuring Project Developers' Willingness to Accept Risks in Renewable Energy Auctions'. Energy Policy, vol. 163, Elsevier BV, Apr. 2022, p. 112835. Crossref, doi:10.1016/j.enpol.2022.112835.

Finally there are the flexibility assets, which are generally deemed less flexible in comparison with fossil fuels. Wind energy and solar PV are heavily dependent on meteorological conditions. However, it is possible to equip these with storage, such as pumped or battery-electric storage (see next chapter). In addition, it is also possible to connect the energy sources to the grid only in times of high electricity prices, for example, in order to achieve a higher price for the energy supplied. This needs to be accounted for in the cash-flow model: This usually goes along with longer amortization periods, higher uncertainty and possible higher financing costs. This relates especially to storage options, which are seen as underdeveloped in terms of technological potential.

2.2.1 Project development for onshore wind and solar PV

Since its implementation in the year 2000, the EEG offers a stable investment environment and a secure financial basis for project developers, investors and banks alike. Consequently, the potential financial investment volume for German EEG projects exceeds the supply of available projects and project developers are in a favorable sales position as there is high competition for investment into turnkey projects.

The scarcity of projects concerns the wind segment in particular, and to a limited extend also the PV segment. In the PV sector, there is still a higher availability of land, and so far less of an acceptance problem, while projects in the wind sector that reach the permission stage are rather scarce. Therefore, for years there has been a high level of competition in the wind sector in project development and from investors for the acquisition of projects. Due to the limited project pipeline there is only little competition in the tenders of the regulator (BNetzA), resulting in attractive bid price levels due to undersubscription of the wind tenders.

The PV segment shows a different development:

The acquisition of land is generally less complex and requires less time than in the wind sector. However, there is also increasing competition for land eligible for EEG subsidies. The high electricity prices and PV capture prices from 2022 and early 2023 have also resulted in non-EEG-eligible land being acquired for PV projects. Furthermore, a PPA market for merchant investments has established itself alongside the market for EEG projects.

Nevertheless, with the lower electricity prices in the course of 2023, this PPA market segment has decreased in attractivity and currently seems to concentrate on rather large PV projects that have an economic advantage for PPAs due to their size and the accompanying economies of scale.

The developments described in the following chapters should be evaluated against this background.

2.2.2 Role of investors, project developers and offtakers

The German market for RE projects has several market roles and players that can be structured along the project timeline (see chapter 2.1) These players are involved in the development, financing, permission, construction, and operation of RE projects.

The market roles of project developers, investors and offtakers are described in more detail in the following.

Project developers

Project developers develop RE projects from the early stages until the start of the operation. This includes site identification and evaluation, early-stage planning, site acquisition, technical and commercial planning, management of the permission process, engineering, procurement, and construction of the RE project including the surrounding infrastructure and grid connection.

Their business objective is to develop and then sell RE projects. By this, they generate a development margin that is needed to cover their cost and especially also the non-success rate of project development – regarding wind projects, the non-success rate often lies in a range of 50 to 70%. RE projects are then typically transferred to investors when they are reaching permission or are ready to start operation (so called turn-key projects). Some project developers keep the developed RE projects in their own portfolio and thereby become owner-operators of these projects.

Typically, project developers assign the following activities to separate departments: site acquisition (partly outsourced), planning and permission, construction management, financing, and sales of projects plus general organisation.

In the case of larger project developers, the staff also includes nature conservation, and electricity market and PPA experts. The staffing levels of private project developers arrange from a few people up to several hundred people, depending on regional scope and market share.

Corporations that are project developers can be characterized as followed:

- Private developers quite active in the renewable sector for a long time period (15 to 25 years) and enlarging their business activities in either solar project development coming from wind or vice versa

- German utilities, also increasingly foreign utilities e. g. from Norway, Denmark, Finland, France, Italy, Spain, Sweden
- medium-sized regional and local utilities ("Stadtwerke") with their own project development departments or an acquired project development team
- Less often: private persons and citizen energy projects and cooperatives ("Bürgerenergiegesellschaften" and "Genossenschaften")

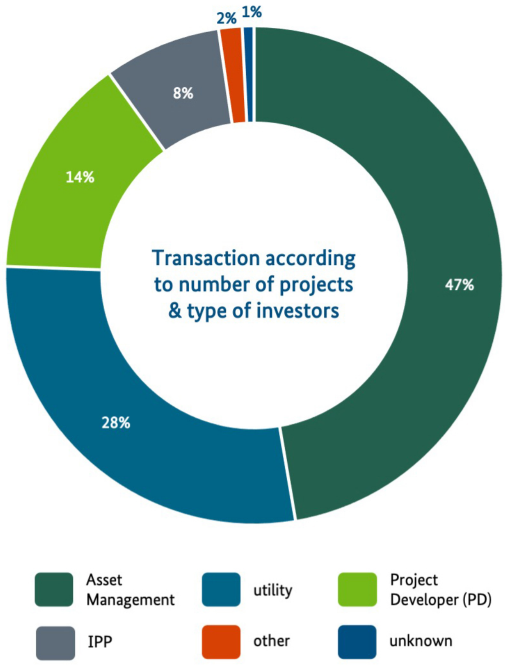
Investors

Investors deploy equity to buy RE projects from project developers in various stages of development. Their business objective is to invest equity and build a portfolio of RE assets that they own and operate as an asset portfolio. The operational tasks are often outsourced, while the investor merely manages the commercial benefits and risks from owning the RE asset. Most investors utilise debt capital (i. e. bank loans) to leverage their equity; although some investors finance their investments fully from equity and do not employ loans.

There are different types of investors that are relevant in the German RE market and can be classified as follows:

- Institutional investors such as insurances, pension funds, dedicated infrastructure and energy funds
- Energy market players like national and international utilities and regional utilities ("Stadtwerke")
- Project developers in a role of owner-operator who buy (partly) developed projects to add them to their own RE portfolio
- Private investors such as family offices, citizen cooperatives and wealthy individuals

Figure 21: Typical investors – transaction processes for an exemplary portfolio of 100 projects and 3 GW consisting of 75 % wind and 25 % solar projects. Transaction shares according to number of projects, Source: enervis



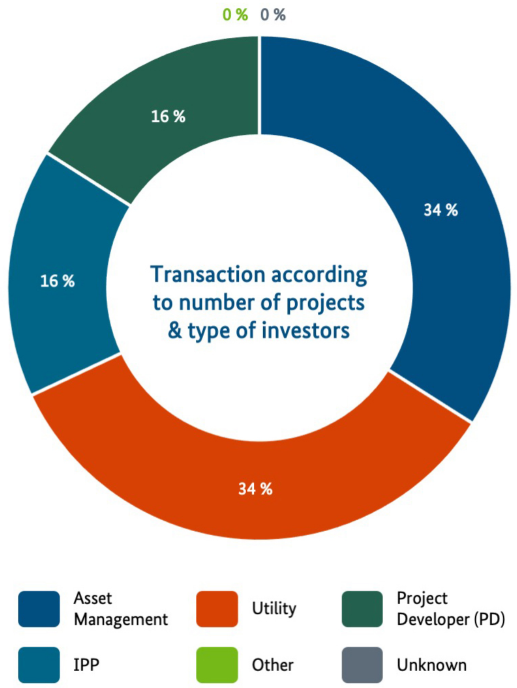
To illustrate the market shares of different players in the German market for RE projects, an analysis of recent project acquisitions in the German market was carried out. This includes a deal volume of 3 Gigawatts within the years 2021 to 2023. Based on this analysis, the market shares (number of acquired projects) of different types of investors are as follows:

- Institutional investors: ~47%
- Utilities (international, national, regional): ~28%
- project developers: 14%
- Independent power producers: ~8%
- Others: ~3%

Over the last 15 years the German market for RE project transaction was and is highly competitive as there is a high demand for investing in RE projects that meets a limited project pipeline. Hence, it can be summarized that investment capital is not a bottleneck for RE expansion.

The selected route to market is of major importance for securing project financing and project revenues over the project's lifetime. The typical route-to-market is defined by the compulsory direct marketing scheme in combination with the sliding market premium. In addition, spot market revenues (without subsidy) are relevant for post-subsidy projects (after 20 years of EEG tariff), but also for merchant assets that utilize PPAs to secure revenues. Direct wire (delivery to an electricity consumer without using the public grid) is a niche market.

Figure 22: Typical investors – transaction processes for an exemplary portfolio of 100 projects and 3 GW consisting of 75 % wind and 25 % solar projects. Transaction shares according to installed capacity, Source: enervis



Typical market players that offtake the electricity produced by RE projects include:

- Direct marketers that are contracted to handle the power market access for utility-scale RE projects. Their task is to run short-term forecasts of the RE projects' generation profiles and to structure and sell these profiles in such a way that the imbalances (forecast errors) in the system are kept at a minimum.
- PPA-offtakers conclude medium- to long-term contracts with the RE ooperators to buy the electricity for a fixed price. These offtakers are mainly utilities (often from the same group of market players as direct marketers) or industrial buyers, who often cooperate with energy utilities in the power sales process.

Other relevant market players

Site acquisitors are active only in the first stage of project development. They acquire sites for RE project development and arrange respective land lease agreements which are then transferred to project developers. They normally act on their own behalf or under a service agreement with a developer.

Industry experts and advisors are involved in certain project development and planning tasks such as yield assessments, geographical and environmental assessments, as well as commercial and legal issues of project development.

Banks provide debt financing, typically in form of non-recourse loans (see chapter on financial models).

O&M service providers are contracted for the operation and management of the RE project. This includes several elements such as maintenance (either via a full-service agreement or a contract for selected maintenance services), commercial and technical management.

2.2.3 Options for implementation and legal entities

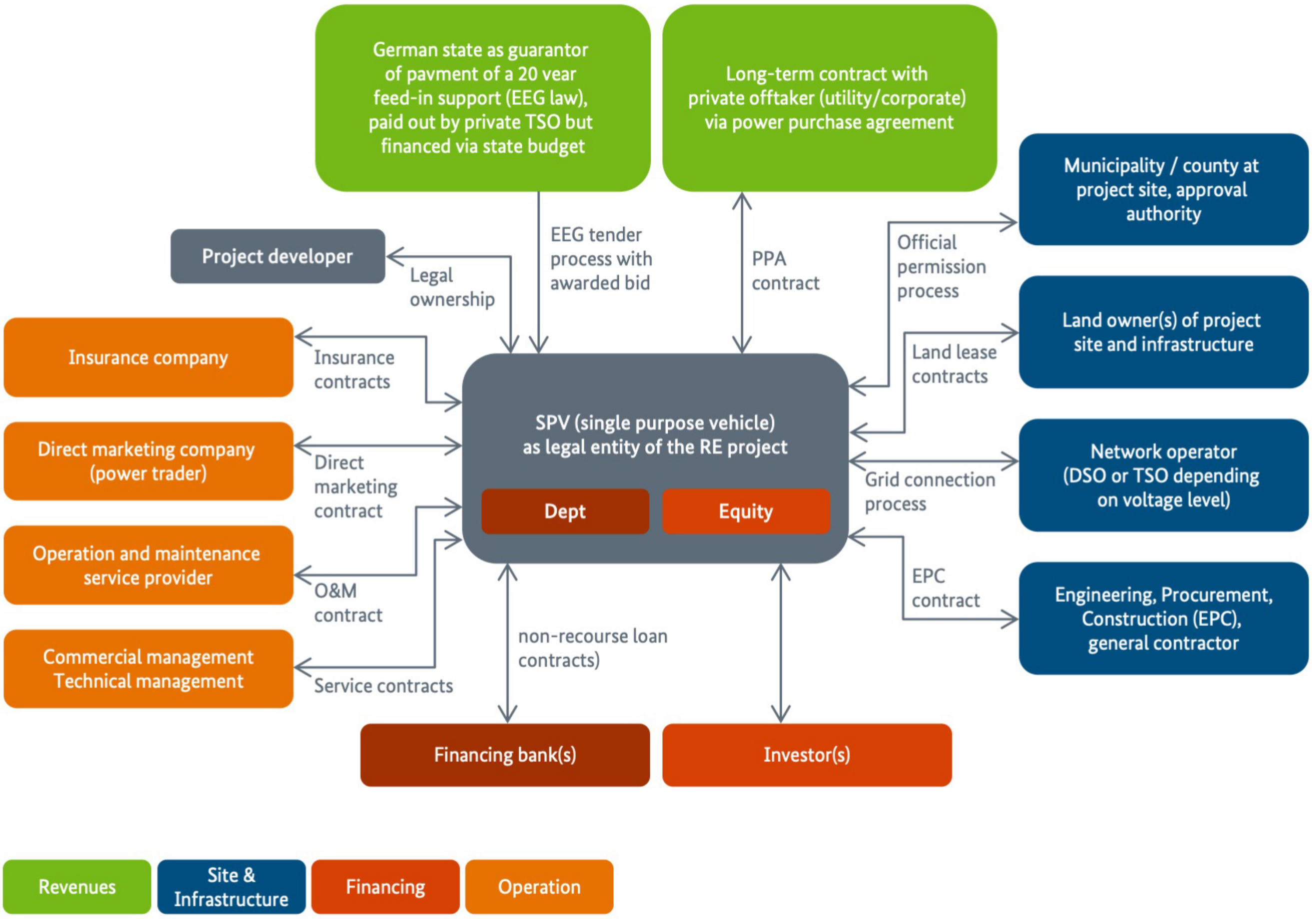
The typical business structure for RE projects in the German market is to set up a special purpose vehicle (SPV, see Figure 23) for each single RE project. The SPV is typically set up as a limited liability company (GmbH or GmbH & Co KG). The SPV owns the RE asset and holds all contracts that are necessary for the operation of the project for the whole project lifetime. This includes all financing contracts, land lease agreements, purchase of infrastructure, and contracts for the operation and maintenance. The SPV is incorporated quite early in the project development process by the project developer to function as the legal owner of all contractual issues.

The main advantage of organising an RE project in a SPV container is that all relevant contracts are kept project-specific, they are clearly attributed to the project and can therefore be managed and evaluated separately for each project. This normally also is valid for the financing contracts, which are designed as project-specific non-recourse loans. Banks typically provide project-specific loans that are designed to meet the individual project parameters. The SPV construction allows the SPV's owner to sell the corporation at any time by transaction of the shares to the new owner; all contracts are hold within the SPV and not need to be adapted as the SPV is kept unchanged as the legal project container.

The following graph in Figure 23 illustrates the described typical SPV structure of RE projects in the German market with a non-recourse financing, infrastructure, and site lease contracts, as well as third party contracts for operation and maintenance. The most important contractual relationships are presented.

Several SPVs can be part of a holding company. Setting up RE projects as part of the balance sheet of the investor's corporation is very rare, due to the above-mentioned advantages of the SPV approach.

Figure 23: Legal setup – SPV structure, Source: enervis



2.3 Examples of business and financial models with KPIs

This chapter provides an overview of current financing parameters of RE projects with non-recourse SPV financing. The financing parameters for wind and solar projects are standardized and quite similar regarding conditions and structures. The financing conditions of PPA projects, especially the required equity shares are (slightly) elevated, conditions generally less attractive when compared to projects with an EEG FiT. Table 3 provides an overview of these key financing figures. PPA-based financing is only relevant for new solar projects.

The financing conditions of RE projects are pivotal for project economics. Especially the realised debt/equity share, interest rates, accepted loan tenors and necessary security margins of revenues from the lenders decide about the economic viability of a project. A key figure for debt-sizing is the required debt service coverage ratio (DSCR), that is defined by the bank. This figure is mainly impacted by the expected project revenue vs. cost.

Equity shares usually vary between 10–30%, while an equity share of 20% of the total investment can be seen as most typical. Lately, considering the high regulatory security of EEG subsidized projects, even lower equity shares have been monitored, going down to only 5 to 10%. The remaining investment is then covered by loans from banks. Loan tenors are usually coupled with the guaranteed revenues streams of either PPAs or the subsidy mechanism, they can cover up to 20 years.

Interest rates are highly depending on the base interest rate and the German KfW index and reached levels of around 5% in 2023 after years of very low financing cost in the range of 1.5 to 3%. Banks typically require a DSCR factor of 1.1 to 1.2, defining that the secured revenues of the SPV must be 10 to 20% higher than the actual payments to the bank (interests and redemption) over the whole loan tenor and not below 1 in each single year. Mostly, a cash reserve of 50% to 100% of one year's debt service (interest plus annuity repayment) is defined. Debt repayment often starts not directly, as one to three years are granted without repayment at the start of the loan.

The target return of investors on their equity largely depends on opportunities of other equally secure investments and lately increased to levels of 6% and higher after taxes, due to an overall increased interest rate.

Some individual (institutional) investors set the target return lower, depending on capital availability and time line for investment as well as investment alternatives

Table 4 Comparison of typical financing parameters of EEG and PPA projects: Comparison of typical financing parameters of EEG and PPA projects. Source: dena

Financing Parameters	EEG-Financing (relevant for new wind and solar projects)	PPA-Financing (relevant only for new solar projects)
Equity share [%]	Equity share usually varies between 10–30%	In general, higher equity rate, depending on PPA-conditions and offtaker rating
Interest [%]	Currently approx. 5–6%, in general based on KfW 270 loan program, further increase expected	Depending on PPA-conditions and offtaker rating, interes could be slightly higher than for EEG financing
Fixed interest period [a]	10–20 years, depending on KfW program	Related to PPA tenor, slightly shorter than for EEG financing
DSCR	Between 1.1 to 1.2	Slightly higher than for EEG financing
Financing period [a]	Up to 20 years	Related to PPA tenor, slightly shorter than for EEG financing
Other	No loan repayment for 1 to 3 years possible Debt service reserve account of 50–100% of annual debt service	Similar conditions as for EEG financing
Target return on equity (IRR)	Increased from a range of 3% up to 6% and higher due to general interest rate increase, typically depending on expectations of investor	Higher IRR expectation due to higher risks (e.g. offtaker risk, shorter PPA term vs. EEG tariff), typically depending on expectations of investor

2.3.1 Key financial figures for onshore wind projects

The following overview will provide insights into the key financial figures of an average sized onshore wind project in Germany considering Capital Expenditures (CAPEX), Operational Expenditures (OPEX) and recent developments in the market.

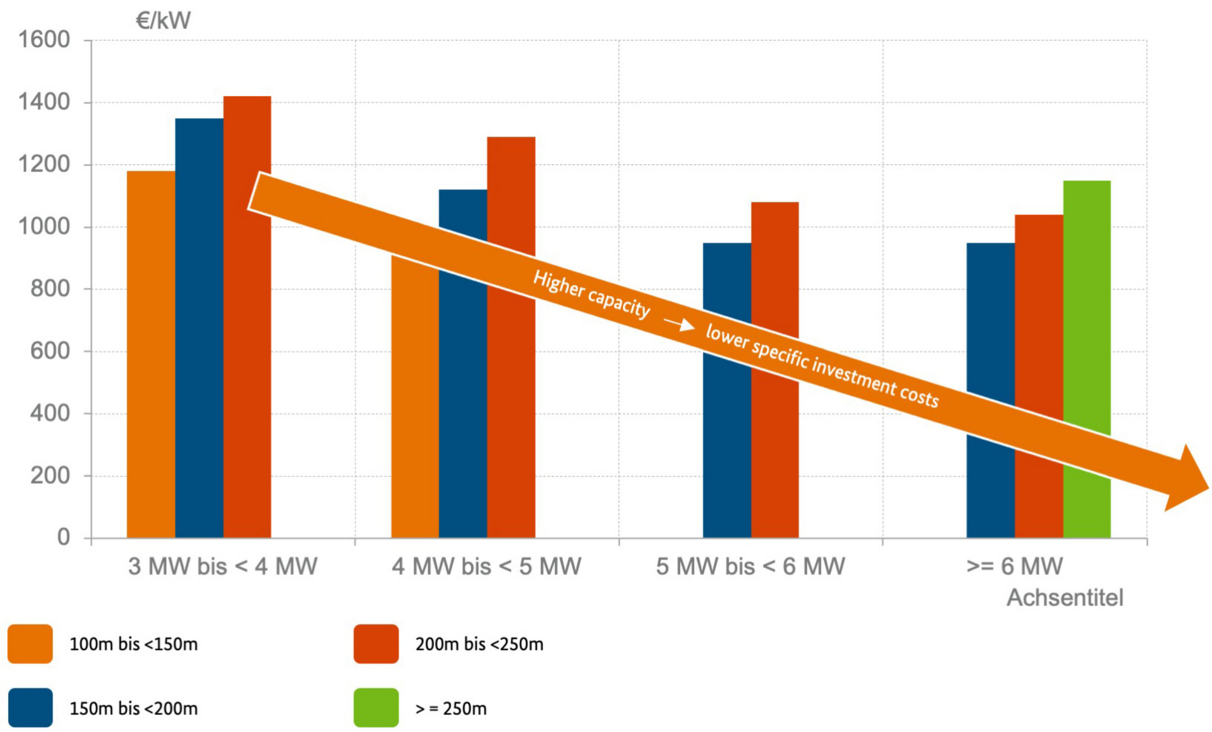
Capital Expenditures (CAPEX) wind

For onshore wind projects the overall CAPEX highly depend on the project scale, the selected turbine type and hub height. As shown in Figure 24 the higher the rated power of a turbine, the lower the specific investment costs. However, recent developments show that the decrease of specific investment costs has stagnated. Specific investment costs can vary significantly from up to around 1.400€/kW for turbines with an installed capacity below 4 MW down to around 900 €/kW for turbines as large as 6 MW.

In general, large project developers might achieve lower CAPEX per MW as they order turbines from manufacturers in larger batches, that are not only procured for a single project, while procurement of single turbines means at higher CAPEX.

Depending on the location, higher hub heights are needed to capture sufficient windspeeds. Generally, in Northern Germany as average windspeeds are higher, hub heights are lower than in Southern Germany because at some point additional investment costs for a higher tower do not sufficiently translate into additional revenues from higher windspeeds.

Figure 24: Main investment costs by capacity and hub height. Source: Deutsche Windguard



In addition to the main investment costs, there are further features of a wind farm that contribute to the overall CAPEX. This includes in particular the type of necessary foundations (e. g. gravity vs. pile foundation), grid connection and substation, specific permit requirements (BImSch) and demand-driven night-time marking (BNK) installations, crane construction areas, project development costs and other ancillary costs.

Typically, such additional investment costs range from around 400–650 €/kW. This amounts to a share in overall CAPEX of around 20% for large turbines and up to around 30% for small turbines. However, depending on location and site-conditions, additional investment costs can vary considerably. The increasing scarcity of sites for wind energy development has led to increasing costs for project development and legal support (e. g. project development, expert opinions, consultants) amounting to around 5–10% of the overall investment costs.

Operational Expenditures (OPEX) wind

After the initial investment and subsequent commissioning of the project, further operation and maintenance costs arise over the operating lifespan that significantly define the economic viability of a wind project. As a basis for economic viability calculations, typically the lifespan of an onshore wind project is set to 20 years of EEG-remuneration and another 5 to 10 years of remuneration outside the subsidy scheme, so in total 25 to 30 years of technical lifetime. OPEX for wind projects consist of the following main cost parameters:

- Land lease costs, starting at about 10% of annual revenues, reaching levels of up to 20% and more.
- Maintenance and repair costs, which are usually made up of a fixed plus a variable cost component and are specified in corresponding service contracts. Most wind projects start operation with a full-service contract that is concluded for at least 5 years duration with the turbine manufacturer.
- Further OPEX components consist of a service fee for direct marketing, technical and commercial management fees, insurance costs, dismantling costs and power purchase costs (needed for the operation of the internal electric systems)
- Other costs include e. g. tax advice, company costs, annual financial statements, management compensation, expert opinions, bat/bird monitoring, environmental compensation cost.

In general, the above-mentioned OPEX can vary significantly depending on the project set up and may also be significantly higher or lower between individual years (e. g. due to multi-year inspection intervals). Additional information is provided in Figure 26 and Table 5.

Table 5: Overview and description of market standard operating costs (OPEX) for onshore wind projects (Source: According to average data of representative enervis projects), Source: enervis

Cost type	Explanation	Costs
Lease and permission agreements	Leases vary greatly depending on the location, region and competition for areas. In recent years, there has been a general trend toward rising leases.	5% to x % of revenues; partly fixed prices
Direct marketing costs	After stable levels until the end of 2021, increased electricity prices also led to increased price levels and new contract structures.	3-4 €/MWh or 5 % of market value
Technical & commercial management (Mgmt)	Total share shown here. The cost share of technical Mgmt is usually somewhat higher than that of commercial Mgmt.	2,0-3,5 %
Insurance costs	Depending on the scope of the insurance. Includes, among others, public liability, machine outage / machine breakage insurance.	0,9-1,2 €/kW
Dismantling costs	Actual dismantling costs are assumed as an amount in €/m hub height according to market standards. Inflation to final value after 20 years and pro-rata provision over last 5-10 years of operation. Costs for deconstruction guarantee (fixed amount as a percentage of the deconstruction guarantee, often demanded by the approval authority and/or land owner): 1 % x Dismantling costs	1.000 €/m hub height or 15-20 €/kW
Power purchase	This value varies depending on the turbine type; the individually agreed power purchase costs for the wind power plant are decisive.	1.100-1.300 €/MW/a
Other costs	The other costs include all costs for tax advice, company costs, annual financial statements, management compensation, expert opinions, but also Bundeswehr modules, BNK, bat monitoring. Therefore, these can vary significantly depending on the project and may also be significantly higher or lower between individual years (multi-year inspection intervals).	15.000-35.000 €/WEA/a
Operating time	A calculation over 25 years of operation is customary. After 20 years, no more EEG tariff is paid out; the revenues of the operating years 21 - 25 are calculated on the basis of an electricity price forecast (market value wind incl. forecast of negative spot prices).	25 years
Additional revenues during the EEG term	Additional revenues, especially in the first years of operation, are quite common depending on the electricity price forecast, but for new projects only on an annual level, since an EEG award from 2023 automatically conditions the annual market value	
§51 losses during EEG term	§51 losses are usually taken into account, under the EEG 2023 the losses will be made up at least temporally in the 21st year of operation, thus a present value effect remains in particular.	Dependent on electricity price development
Maintenance / Servicing	Variety of concepts, mostly consisting of a fixed and a variable cost component, combined differently depending on the manufacturer. Often certain minimum amounts are collected, based on the annual yield, if this threshold is exceeded the variable costs for maintenance are increased. In most cases, costs are much lower at the beginning of the operating period than in the back years of operation. Bonus payments for high availability (e.g. staggered >97% or similar) are also becoming increasingly common.	30,000 – 50,000 €/WTG per year fixed costs plus 1.5 – 3.0 €/MWh variable costs (to be inflated)

Cash Flow and revenue of a sample project

Due to limited land availability, onshore wind projects in Germany typically are limited to three to five wind turbines per wind farm with an overall capacity of 15–25 MW.

Recent cost developments wind

In the past two years, with increasing commodity and resource prices, rising interest rates, supply chain interruptions and delayed delivery periods, CAPEX of onshore wind projects have increased substantially. In consequence the profitability of wind projects has reduced.

Due to project realisation periods of one to two years, the high electricity prices of the year 2022 did not improve the profitability of projects ready for construction. Consequently, this situation led to largely undersubscribed EEG wind tenders in 2022. The regulator reacted by increasing the tender ceiling price significantly. As a consequence, awarded volumes and prices increased again. However, despite increased numbers of new permits, their participation rate in the tenders is still below market expectations. The reasons for this are manifold, with supply chain issues and blocked transport permits being the most prominent ones. It is expected that these framework conditions will be improved within the coming two years, leading to more permits for wind projects being granted.

2.3.2 Key financial figures for utility-scale solar projects

Utility-scale solar projects have emerged as a major driver of PV deployment and provide an essential part of the RE landscape in Germany. This chapter provides insights into the key financial figures of utility-scale solar projects considering CAPEX, OPEX, financial parameters and investors' return expectations.

Capital Expenditures (CAPEX) PV

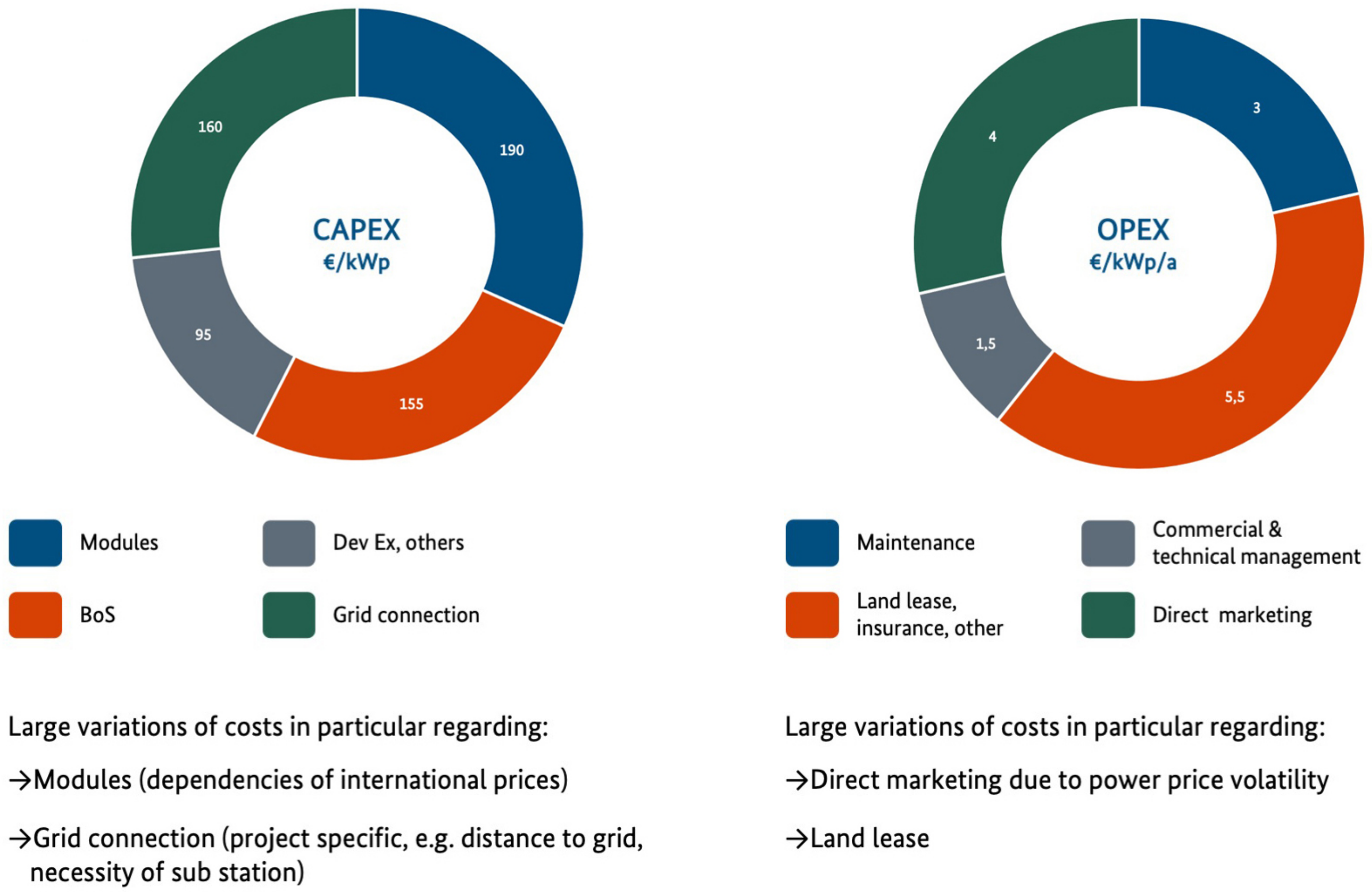
CAPEX is highly impacting the financial viability of utility-scale solar projects, as they define by far the largest share of total cost. The overall CAPEX for utility-scale PV projects currently lies in a range of 550 to 750 €/kW, being dependent on individual parameters, such as:

- Module costs (still mainly monocrystalline but increasingly bifacial modules) ranging between 20% to 30% of total CAPEX
- Balance of system costs considering substructure, cables, and other material costs at approximately 25% of total CAPEX
- Grid connection, transformers substations, metering equipment at approximately 25% to 30% of total CAPEX
- Project development costs including engineering at approximately 15% of total CAPEX
- Project developer margin in case of a transaction

Figure 25: Description of main aspects defining capital expenditures (CAPEX) of solar projects, Source: enervis

CAPEX PV	Modules	• Monocrystalline modules are the standard on the market in Germany. Increasingly, bifacial modules are also being used on the market. • Great dependence on Chinese manufacturers. • Significant discounts for large orders, large project developers have advantages.
	Balance of system (other material costs)	• Includes all material costs except modules. • Material prices (especially steel for substructure, copper for cabling) have risen sharply recently.
	Grid connection	• Costs for cable lines to the next grid connection point and, if applicable, transfer station must be borne by the project developer; costs for general grid expansion in Germany are borne by the grid operator. • Increasingly expensive (longer lines), competition and cost fluctuations..
	Project development installation, etc.	• Very mature project developer market, established processes and efficient installation teams lead to lower costs compared to other countries. • Coverage of EPC as project developer is increasingly becoming a competitive advantage, even there high margins are already called by service providers.
	Project developer margin	• In case of purchase of project rights or turn-key plants. • Not included in this cost analysis. • High competition for project rights in Germany, increasingly higher margins. • Large international investors are pushing strongly into the attractive German market.

Figure 26: Typical costs for utility-scale (>20 MW) PV projects. Differentiation of capital and operation expenditures (Source: According to average data from representative enervis projects)



During the lifespan of a solar PV asset operational costs for land-lease, operational management, maintenance, and insurances must be covered.

Land-lease costs are highly dependent on the actual project and the land used for the ground-mounted PV asset. Besides that, general cost differences between Eastern and Western Germany can be observed, whereas the land-lease rates per hectare in Eastern Germany are considerably lower.

Insurance, dismantling-, and power-consumption costs add only a minor share to total OPEX. Besides that, costs for electricity marketing (route-to-market) need to be covered. Direct marketing is executed by third party service providers. New contracts are negotiated each one to two years. The associated cost amount to around 30% of overall OPEX for PV assets.

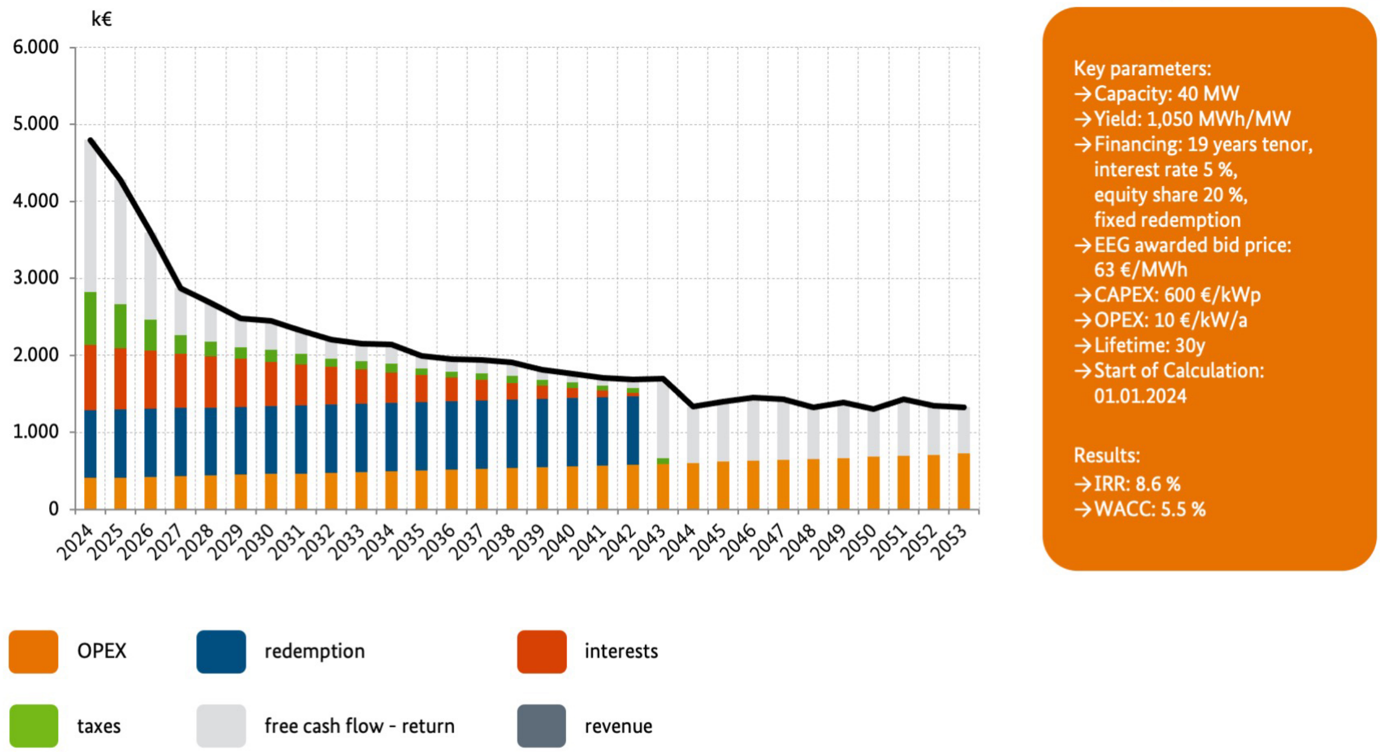
Technical and commercial management including maintenance services are usually outsourced to contractual partners of the solar SPV and can add up to approximately 35% of total OPEX. Economies of scale can be realized for larger projects.

Due to high professionalization and recent development of new maintenance strategies maintenance costs became noticeably lower.

2.3.3 Cash Flow and revenue of a sample project

Based on a sample 20 MW solar project with EEG remuneration, the cash flow is calculated and displayed in Figure 27. It includes CAPEX, OPEX, and financing parameters. Differences between EEG and PPA financed project are described in the following chapter.

Figure 27: Cash flows of an exemplary PV EEG project (Source: According to average data of representative enervis projects)



2.4 Digression: Power market revenues and PPAs

2.4.1 Scope of application and differences between wind and solar

Private power purchase agreements represent an alternative revenue scheme for renewable ground-mounted PV and onshore wind projects in Germany, which are not eligible for or chose to opt out of the EEG FiT. Via the PPA, a fixed purchase price can be secured for a certain time frame, avoiding the risk of fluctuating electricity prices in the spot market, and hence enabling the bankability of a project without an EEG subsidy (see also section 1.3.2).

The scope for PPAs varies depending on project set up and opportunities in the markets for wind onshore and solar projects. PPAs are either used to finance a merchant project that has no eligibility to receive EEG support. Or a PPAs can be combined combined with an EEG FiT under certain circumstances.

RE projects with a FIT under EEG are able to opt out of the scheme into a non-subsidy scheme while keeping the support eligibility for the remainder of the 20-year period it was granted for. This can be attractive as a temporary increase (optimization) of revenues through a PPA if it secures revenues above the EEG tariff.

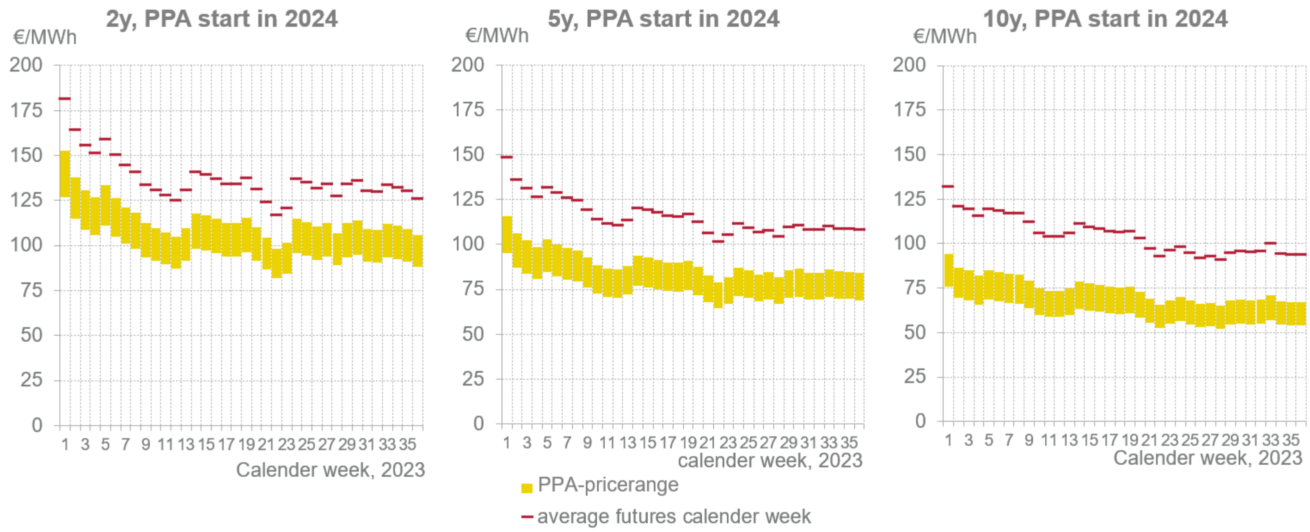
This flexibility (opt out and opt in of the EEG tariff) is quite attractive for RE projects. Therefore, most investors seek to secure a tariff in an EEG tender as a floor price and then optimize their income temporarly with a PPA, if PPA prices are sufficiently high.

This optimization approach can be observed for PV and wind onshore projects alike, that have an EEG FiT.However, in this case project financing is based on the floor price from the EEG FiT and not the PPA. Also, post-subsidy RE projects use short- and medium-term PPAs to secure revenues after the 20-year long FiT has ended; this is mainly relevant for onshore wind due to the maturity of the German wind portfolio. Such optimization PPAs usually have a duration of 1 to 3 years.

New investments that have no eligibility for an EEG tariff (i. e. large PV projects) typically utilize PPAs for securing financing, because it is the only way to grant stable revenues over a substantial time frame that corresponds to the financing period. Those PPAs have tenors of about 8 to 15 years. Due to the different tender designs, long-term PPAs are predominantly closed for new PV projects and not for onshore wind. This is due to the fact that EEG tenders for wind are generally more attractive with high auction volumes, rather low competition, and mostly sufficient FiT levels in comparison to long-term PPAs. However, for the financing of new PV projects that do not meet the criteria of the EEG funding requirements (purely merchant projects), PPAs represent the main route-to-market. This is due to several regulatory restrictions that lead to non-EEG-eligibility of certain PV projects. Firstly, the project capacity is restricted for EEG projects, currently lying at a maximum of 100 MW, but before 2023 it was already capped at 10 MW, later 20 MW. Secondly, in contrast to the onshore wind tenders, the ground-mounted PV tenders are recently heavily oversubscribed. This has led to decreasing award values and consequently increased the attractiveness of the PPA market as an alternative revenue source.

In addition to that, PPAs allow for the marketing of green electricity with issuance of Guarantuees of origin (GoOs) which is not allowed for EEG FiT projects due to the so-called double marketing ban ("Doppelvermarktungsverbot"). This makes PPA projects essential for offtakers that want to obtain certified green electricity, and that have a considerable willingness to pay for these GoOs.

Figure 28: Historical fair value PV PPA prices for PPA durations of two, five and 10 years, source: enervis



However, the duration of a PPA is commonly considerably shorter than the EEG FiT time span of 20 years. Added to that, the counterparty risk of a PPA is higher since it is a bilateral agreement between two private parties and not backed by the German state as in the EEG FiT scheme.

As PPAs are linked to higher revenue and contractual risks (also after the PPA contract expires), the financing requirements are less attractive (e. g. shorter financing periods, higher equity shares, higher return expectation on the investor side as well as possibly higher interest rates or DSCR criteria). Furthermore, as a non-standardized contract, PPAs involve administrative and organizational efforts and costs. This is due to the fact that, among other things, the energy yield, delivery obligations, availabilities, commissioning, possible events of damage and securities, as well as the type of delivery and remuneration must be regulated in the PPA.

2.4.2 PPA price formation

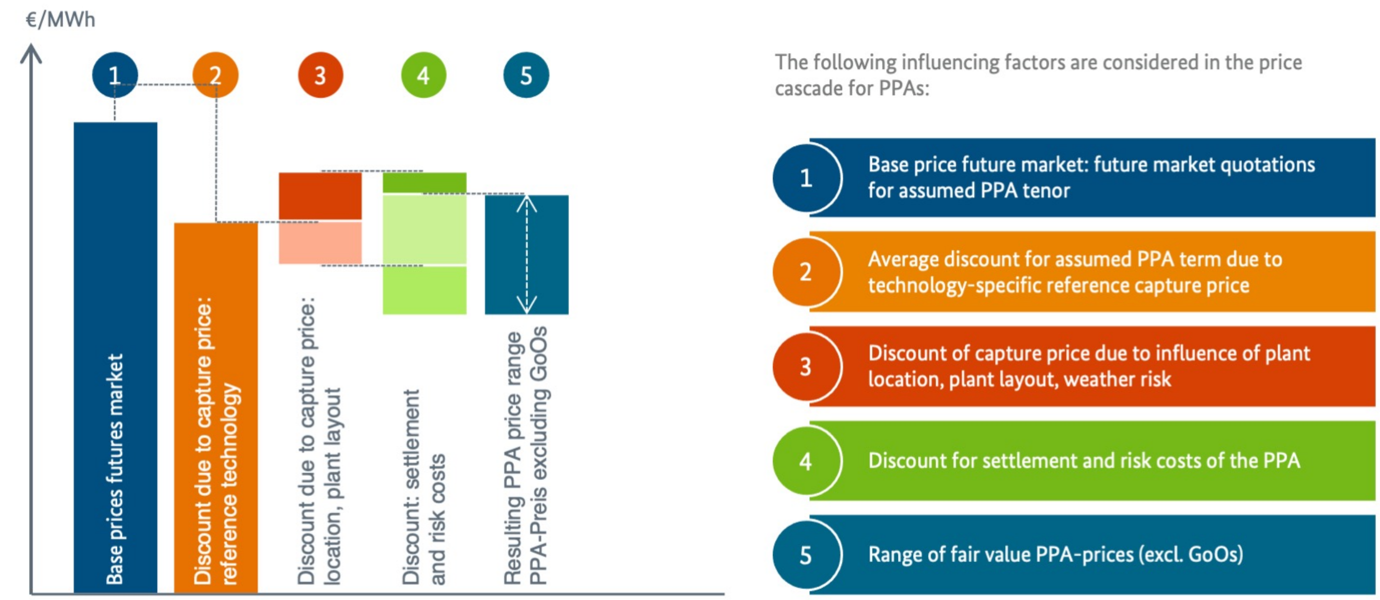
PPA prices depend, among other things, on the time of conclusion, the asset location, and the risk assessment of the offtaker. The time of conclusion is insofar relevant as it is market standard that PPA prices are benchmarked at future market quotations for the corresponding PPA tenor, as the future market illustrates the actual best guess for upcoming power price developments.

As future prices currently decrease for years lying further into the future, the longer the PPA duration, the lower is the mixed reference price for the PPA price. However, since RE only achieve their individual specific capture price due to their individually fluctuating generation, the referenced future base price must be reduced by multiplying it with the expected capture rate of the individual RE plant. The better the performance of a RE plant with a consequently higher capture rate, the less markdowns are assumed for the asset from the mixed future reference price.

The resulting price is further decreased by settlement and risk costs which can differ depending on the offtakers risk assessment and structuring capabililties. As a result, a PPA price is determined on the basis of a fair risk distribution between generator (seller) and offtaker (buyer) – it is therefore called a fair value PPA price. The additional revenue from GoOs is usually determined separately and paid by the buyer.

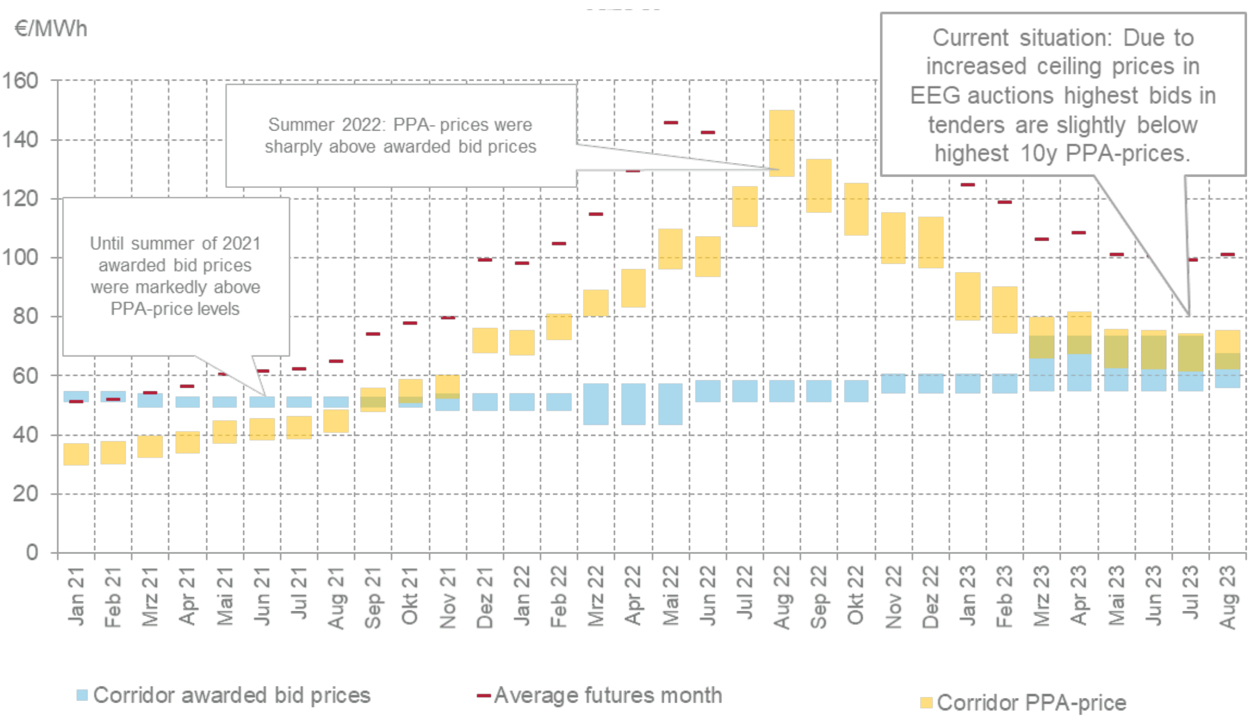
The systematic methodology for PPA price formation, starting with future power prices as a reference and considering the outlined markdowns and risks, is described in Figure 29.

Figure 29: PPA-price calculation cascade, source: enervis



Tracking the range of such fair value pay-as-produced PPA prices for a tenor of 10 years of the appendix illustrates the differences in fixed revenues between the PPA market and the awarded bid prices in the EEG tenders for ground-mounted PV projects. Historically, with longer tenors and EEG award prices higher than PPA-price levels, the EEG scheme was much more attractive for EEG-eligible projects than a PPA. With increasing futures and therefore increasing PPA prices, by the end of 2021 the demand for PPAs drastically increased despite the difference in tenor and risk. In 2023 the attractiveness of PPAs has slightly faded with increased ceiling prices in EEG tenders and decreasing future prices in the market.

Figure 30: 10y pay-as-produced utility PPA-prices vs. awarded bid prices in EEG tender (PV). PPA-price range according to fair value PPA-price calculation methodology, assuming typical markdowns. For illustrative recognisability reasons future prices above 160 €, source: enervis



3 Renewable energy and storage development in China

3 Renewable energy and storage development in China

China's ambitious RE expansion goals require strong financing structures to necessitate substantial investment in RE projects. Among the different types of entities engaged in RE development in China, Chinese state-owned enterprises (SOEs) play by far the most central role in this endavour. Following the path set out by the Chinese government, they both invest and develop RE projects on a large scale. To facilitate this important undertaking, different policy support schemes were introduced such as the Green Energy Certificate (GEC) trading scheme or the "Whole-County Rooftop Solar" pilot. These support mechanisms give rise to different business models for developing and operating RE assets in China. Currently, more government support is necessary in order to spur investments into energy storage, which will be of key importance to balance out the variability in power generation from renewables and ensure China's successful green transition.

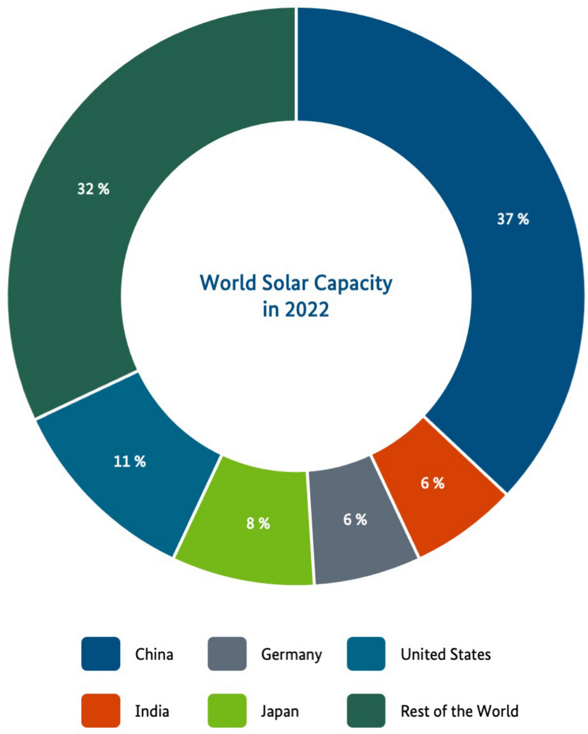
3.1 Renewable energy policy and project development in China

The Chinese government has set ambitious carbon abatement targets, aiming to peak CO2 emissions before 2030 and achieve climate neutrality by 2060. Among its objectives, the country is striving to achieve approximately 25% of non-fossil fuels in its primary energy consumption and install 1,200 GW of solar and wind capacity by 2030.[45] By 2060, China envisions non-fossil fuels accounting for 80% of its total energy consumption.[46] The development of electricity storage is also one of China's priorities: By 2030, the nation aims to reach a 100 GW storage capacity.[47]

With 1,063 GW by the end of 2021, China already leads the world in terms of installed RE capacity (see Figure 31). Last year alone, the amount of new solar capacity added (100GW) in China was more than Germany's total installed solar capacity.[48]

To achieve its ambitious long-term goals and keep up the rapid implementation pace, Chinese RE expansion needs to be accompanied by strong financing structures to necessitate substantial investment in RE projects.

Figure 31: World Solar Capacity in 2022. Source: dena, based on data: IRENA Renewable



[45] Given the unprecedented speed at which China is currently expanding its wind and solar energy capacity, surpassing these goals seems highly likely.

[46] Dena, "Innovative distributed generation and storage", 2022, at https://www.energypartnership.cn/fileadmin/user_upload/china/media_elements/publications/2023/202301_Entrans_Innovation_report_en.pdf

[47] "China Plans for Cheaper, Longer Lasting Energy Storage by 2025", Bloomberg News, 21 March 2022, at https://www.bloomberg.com/news/articles/2022-03-21/china-plans-for-cheaper-longer-lasting-energy-storage-by-2025

[48] "Solar PV", IEA, accessed at October 6th 2023, at https://www.iea.org/energy-system/renewables/solar-pv

3.1.1 Developers of renewable energy business

When discussing the landscape of RE project developers in China, it can be distinguished between three primary entities: State-owned enterprises, private sector developers and international investors (see Table 5 for an overview).

Table 7: Entities engaged in RE Project development in China. Source: dena

State-Owned Enterprises (SOEs)	Private Sector Companies	International Developers
Includes central government or local government-owned large power utilities, which usually both develop RE projects and operate the assets.	Non-governmental enterprises (oftentimes OEMs) that develop RE projects, frequently in collaboration with SOEs.	Includes large international RE companies and global investment firms, mainly focusing on profit-oriented RE investments.
Examples: *China Energy Investment Corp., State Power Investment Corporation Limited, China Huaneng Group*	***Examples:*** *Hanergy Holding Group, Trina Solar, Jinko Solar Holding Group, United Photovoltaics Group*	***Examples:*** *Enel Green Power, EDF, Siemens Gamesa Renewable Energy, CLP Power*

Although there is no restriction for participating in RE project development in China, SOEs are by far the most dominant entity in this field. The dominant position of the SOEs is characterized by their substantial financial resources, strong government backing, and well-established infrastructure. The aforementioned enables SOEs to make long-term investments and take the lead in developing and operating RE projects across the nation.

Example: SOE

China Huaneng Group

China Huaneng is is one of the five largest state-owned electricity generation enterprises in China, with a registered capital of 34.9 billion RMB. The company is primarily involved in investing, constructing, operating, and managing power generation assets, as well as producing and selling electricity.

Huaneng Group has completed a total of 152 renewable energy projects, involving 29 provinces and regions across the country.

According to its own statements, Huaneng Group plans to start construction of more than 30 million kilowatts of renewable energy in 2023, with an investment of more than 100 billion yuan.

Example: International Developer

CLP Power Group

Jinchang Solar Power Station. Copyright: CLP Holdings Limited.

CLP Power is a major power company based in Hong Kong and the largest external investor in the energy sector in Mainland China.

CLP has been actively investing in Mainland China's power sector since 1979. It has performed the roles of developer, investor, project manager and operator, with a generation and energy storage capacity of 7,180MW and investments across 16 provinces, autonomous regions, and municipalities.

In total, they have over 50 power generation assets in China, of which 23 are wholly owned. The capital investment amounts to around HK$50 billion.

Although its portfolio also includes coal assets, CLP mainly focuses on clean energy investments. As of August 2023, 67% of their portfolio consisted of non-carbon energy, including 17% wind and 6% solar projects.

Table 6: Overview of asset types and locations, source: dena. Based on: CLP China Corporate Brochure 2023

Asset Type	Gross Capacity (MW)	Location
Nuclear	2,685	Guangdong
Coal	1,776	Beijing, Hebei, Inner Mongolia, Liaoning, Shaanxi, Shandong, Tianjin
Wind	1,209	Guangdong, Guangxi, Guizhou, Jilin, Shandong, Shanghai, Yunnan
Energy Storage	618	Guangdong, Jilin, Jiangsu, Yunnan
Solar	402	Gansu, Guangdong, Jiangsu, Liaoning, Yunnan
Hydro	490	Guangdong, Sichuan, Yunnan

For a long time, Chinese SOEs mainly focused on the development of large-scale, ground-mounted solar bases or utility-scale wind parks. However, as Beijing's policy preferences began moving towards distributed energy in recent years, SOEs also began investing more in distributed generation projects. Since then, many private PV manufacturers, originally the key developers of distributed energy projects, have been gradually replaced or had their assets acquired by SOEs. For example, in 2020, China Huaneng Group acquired the assets of GCL Poly New Energy – at that time, the second-largest solar project developer.

As observed by one of the interviewed experts, SOEs see the revenue potential and Beijing's policy preferences as the most important guidelines for investment. Generally, they strive to acquire and hold as many assets as possible while maintaining dominant shareholding in projects. Moreover, they tend to develop and operate the assets from start to finish, including the sale of electricity and the decommissioning of the asset.

Private sector companies own only a small share of RE projects, as competing against the market and policy leverage of large SOEs is generally difficult. The participation of international developers in the development of RE projects in China is even more limited and their investments are strongly profit-oriented. However, with the increased participation of SOEs in the distributed energy field, collaborations between SOEs and private developers have recently become more common. Private sector companies might often have better connections e.g. to the local grid companies or local government than SOEs. As shared by one of the interviewed experts, private companies also occasionally acquire project development rights first and sell them later to SoEs.

3.1.2 Renewabke energy support schemes & related business models

In order to support the development of renewable energies, China adopted a **Feed-In Tariff** (FiT) in 2009. It began with a fixed subsidy for wind, a FiT for solar PV followed in 2011. The 20-year FiTs played a key role in driving the early adoption of RE installations in China. Both solar and wind companies were offered a guaranteed price for their energy that exceeded the market rate. The FiTs were also set at different levels in various regions to accommodate different wind and solar resources but were generally high enough to incentivize investments.

That led to a remarkable influx of developers into the renewable sector. For distributed solar, State Grid announced separate subsidies (see Table 6).

Table 8: Feed-In Tariff direct subsidy history for distributed solar. Source: dena, based on GIZ 2021[49]

2013 – 2018	RMB 0.42/kWh
2018	RMB 0.37/kWh
2019 - 2020	*Commercial and Industrial:* 1. RMB 0.10/kWh 2. RMB 0.5/kWh *Residential:* 1. RMB 0.18/kWh 2. RMB 9.8/kWh
2021	*Residential:* RMB 0.03/kWh
2022	Discontinued

The number of power projects eligible for subsidies grew so rapidly that the available funding pool was soon outstripped, resulting in frequent payment delays. By the end of 2021, the accumulated overdue subsidies reached an estimated 400 billion RMB (equivalent to approx. €50 million). More than 90% of new renewable projects constructed between 2016 and 2020 received no subsidy funds at all.[50] Eventually, as RE projects became increasingly cost-competitive over time, the FiTs for new solar and onshore wind projects were terminated by the end of 2021. The subsidy for residential solar continued until 2022.

The above-mentioned delays in FiT payment resulted in the introduction of a series of additional policy measures, meant to fill the deficit and support the renewable uptake. One of them was the voluntary **Green Energy Certificate (GEC)[51]** trading scheme, introduced in 2017 by the National Development and Reform Commission (NDRC). At the time of its introduction, this market-based mechanism provided qualified renewable projects with certificates for the amount of clean energy they produced, granted the companies relinquished any feed-in-tariff subsidy. The certificates could be then sold to corporates or individuals that need to offset their clean energy output shortfall. Secondary trading was not permitted. With that, the credits essentially represented a transfer of the FiT payment obligation from the government to purchasers, rather than establishing a market for projects

[49] Sino-German Energy Transition Project, "China Energy Transition Status Report 2021", at https://www.energypartnership.cn/fileadmin/user_upload/china/media_elements/publications/2021/China_Energy_Transition_Status_Report_2021.pdf

[50] "China to set up special purpose firms to tackle unpaid renewables subsidies", China Dialogue, 18 August 2022, at https://chinadialogue.net/en/digest/china-special-purpose-firms-to-tackle-unpaid-renewables-subsidies/

[51] GECs can be regarded as a Chinese version of Renewable Energy Certificates (RECs).

that would generate extra RE beyond the already existing capacity. Additionally, most power producers were unwilling to give up the fixed subsidy at the time the policy was introduced.[52] Furthermore, initially, only onshore wind power and solar energy projects could obtain green certificates.

Although China issued over 27 million green certificates by January 2021, the actual trade volume was relatively low, with less than 42,000 certificates (0.15%) being traded.[53] In 2022, a total of 20.6 million green certificates were issued, equivalent to 20.6 billion kWh. However, this constituted only 0.8% of the total renewable energy power generated in China for that year. A recent policy update could change this.[54] Since mid-2023 all types of renewable power are eligible to participate in the green energy certificate trading scheme.

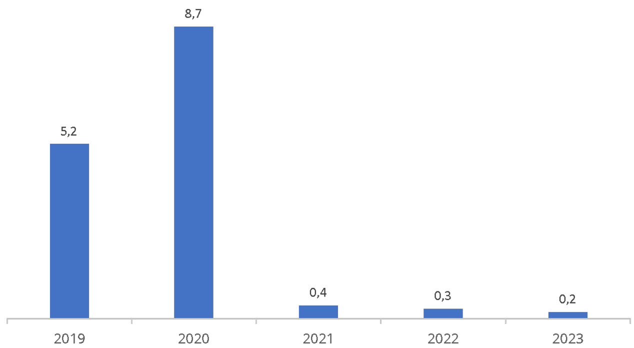
Main buyers for green electricity certificates include export-oriented enterprises, large central enterprises, state-owned enterprises, and multinational corporations with specific demands for green power consumption. As per the National Energy Administration, each green certificate represents 1,000 kilowatt-hours (kWh) of renewable energy. According to data from the China Green Electricity Certificate Subscription Trading Platform, the current certificate price translates to 0.03 to 0.05 yuan (US$0.0042–0.0069) per kWh for renewable energy providers.[55]

Since 2018, the National Energy Administration (NEA) has implemented provincial quotas for RE consumption, which are applicable to provincial grid companies and large industries, some of which have their own power supplies. The so-called **Renewable Energy Obligation** required purchasing minimum percentages of renewable electricity set for each province by the NEA. Different than similar mandates in the UK ("Renewable Obligation") or the U.S. ("Renewable Portfolio Standard") that stipulate long-term binding targets, China's obligation outlines consumption targets limited to a mere three-year period, including the current year. With that, the obligation resembles an administrative planning quota, offering minimal encouragement for market-based investments in clean energy over the long haul.[56] As shared by one of the interviewed experts, China actually tried to follow the scheme of the U.S. or UK, but in the end, the initiative failed.

In late 2022, a new policy clarified that green credits will serve as an accounting system to enforce energy consumption quotas. Furthermore, provinces were granted the ability to offset their excess consumption through the utilization of green certificates, making the scheme more attractive.

Another policy initiative introduced by NDRC in order to promote the transition towards subsidy-free projects was the auction-based program called **"The Grid Parity Projects"**. The program, launched in 2019, provided new wind and PV projects to those, who bid prices less than or equal to the prevailing coal tariff ("grid parity"), or solar projects that were to voluntarily convert to subsidy-free status, with at least 20-year negotiated PPAs.[58]

Figure 32: First batch of 2019 solar PV grid-parity projects in GW. Source: Apricum Group 2019[57]



The first batch of 168 approved grid-parity projects amounted to 20.76 GW, split into wind (4.51 GW), solar PV (14.78 GW) and so-called "distributed trading pilot projects" (1.47 GW). These projects, located across 16 provinces, are expected to be commissioned between 2019 and 2023 (see Figure 32 below). Although their develop-

[52] Sandalow et al., "Guide to Chinese Climate Policy", The Oxford Institute for Energy Studies, 2022. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2020/06/Current-direction-for-renewable-energy-in-China.pdf

[53] Liu Lican, "'Green certificates' now cover all renewable power", 10 August 2023, at https://chinadialogue.net/en/digest/green-certificates-now-cover-all-renewable-power/

[54] „国家发展改革委 财政部 国家能源局关于做好可再生能源绿色电力证书全覆盖工作促进可再生能源电力消费的通知 [Notice of the National Development and Reform Commission Ministry of Finance National Energy Administration on the Complete Coverage of Renewable Energy Green Power Certificates to Promote Renewable Energy Power Consumption], NDRC, 3 August 2023, at https://zfxxgk.ndrc.gov.cn/web/item-info.jsp?id=20256&mc_cid=9c442bb9aa

[55] Green Energy China, accessed at 6 October 2023, at http://www.greenenergy.org.cn/

[56] David Sanadalow et al., "Guide to Chinese Climate Policy 2022", The Oxford Institute for Energy Studies.; Andres Hove, "Current Direction for Renewable Energy in China", June 2022, at https://www.oxfordenergy.org/wpcms/wp-content/uploads/2020/06/Current-direction-for-renewable-energy-in-China.pdf

[57] "Towards a subsidy-free era for China's solar PV market", Apricum Group, 19 November 2019, at https://apricum-group.com/towards-a-subsidy-free-era-for-chinas-solar-pv-market/

[58] Anders Hove, "Assessing China's power sector low-carbon transition: a framing paper", February 2023, at https://a9w7k6q9.stackpathcdn.com/wpcms/wp-content/uploads/2023/02/Assessing-Chinas-power-sector-low-carbon-transition-a-framing-paper-CE4.pdf

ers have not received direct cash subsidies from the central government, they have enjoyed benefits such as reduced or waived land use fees in certain instances.[59]

In 2021, the Chinese government also launched a national **Green Power Trading Pilot.** The pilot began with wind and solar power and is planned to be extended to hydropower and other clean energy sources in near future.[60] This scheme allows green electricity producers to sell their electricity directly to customers willing to purchase green power, sold at a slightly higher price than fossil-fuelled electricity at the green power trading exchanges. Once the transaction is completed, the end user of green electricity can obtain a Green Electricity Consumption Certificate.

At present, trading volumes remain relatively modest and markets vary from one province to another.[61] Moreover, despite renewables reaching or even surpassing grid parity in numerous regions, the pricing of green power has continued to maintain a premium over spot market prices.[62] The first batch of green power trading involved a total of 259 market players in 17 provinces, with 7.935 billion kWh of electricity traded. Among them, 6.898 billion kWh was traded in the operating area of the State Grid Corporation, and 1.037 billion kWh in the operating area of the Southern Power Grid Corporation (the average price was increased by 2.7 cents/kWh). The green power transaction price increased by RMB 0.03~0.05/kWh compared with the local medium- and long-term power transaction price. From January to December 2022, the national green power provincial trading volume was 22.78 billion kWh, and in December, the national green power provincial trading volume was 2.84 billion kWh.[63] Among the enterprises participating in the green power trading, heavy industrial companies such as steel and Internet giants are the leading green power buyers.

In select provinces, typically those with curtailment issues, the government introduced a pilot for **bilateral contracts.** Guaranteed purchase hours were implemented, whereby a minimum amount of annual hours generated from wind and solar projects were guaranteed to be purchased by the local grid. Producers who exceed the minimum annual hours for generating renewable electricity were incentivized to trade their surplus in power market transactions, including Corporate PPAs. Corporate PPAs are still quite rare and the specifics of these trades, especially pricing details, are typically not disclosed.[64]Additional incentives for RE project development are provided by **carbon markets**. China has now seven regional pilot carbon markets and the National Emissions Trading Scheme (ETS)[65] in place. RE projects can generate and sell carbon credits in the carbon market, which enables additional revenue stream for developers.

Preferential tax policies such as tax exemptions and reductions for investors are also effective government instruments to stimulate investment in RE projects. For instance, as shared by one of the interviewed experts, there is a policy for new energy sources called "Three Halves," where income tax is exempted for the first three years and halved for the subsequent years. Such policies are likely to vary depending on the specific circumstances of each country and region. In order to increase the profitability of developing RE projects, other targeted subsidies at a regional or provincial level are also possible, for example, subsidies for construction fees.

As for distributed solar, the relatively low prices offered for solar sent into the grid as compared to retail electricity tariffs make **self-consumption** currently the most attractive business model. The excess generated electricity is then usually sold to an external grid.[66] According to our experts, on-site consumption is the most common approach for industrial, commercial and public customers. Investing in on-site distributed energy installations is a particularly viable option for companies with a firm commitment to achieve carbon neutrality goals, such as Jinko Solar or the Alibaba Group (see infoboxes).

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59 "China reveals details of first 15 GW of grid parity solar", PV Magazine, 22 May 2019, at https://www.pv-magazine.com/2019/05/22/china-reveals-details-of-first-15-gw-of-grid-parity-solar/

60 "开展绿色电力交易试点，推动构建以新能源为主体的新型电力系统" [Carry out pilot green power trading and promote the construction of a new type of power system dominated by new energy] , NDRC, 7 September 2021, at https://www.ndrc.gov.cn/xwdt/xwfb/202109/t20210907_1296138.html?code=&state=123

61 "China's Green Electricity Market and Certificates Explained", Seneca ESG, 20 September 2023, at https://www.senecaesg.com/insights/insights-chinas-green-electricity-market-and-certificates-explained/

62 Anders Hove, "Assessing China's power sector low-carbon transition: a framing paper", February 2023, at https://a9w7k6q9.stackpathcdn.com/wpcms/wp-content/uploads/2023/02/Assessing-Chinas-power-sector-low-carbon-transition-a-framing-paper-CE4.pdf

63 "绿电交易的回顾与评析" [A Review and Critique of Green Power Trading], Junhe, 9 March 2023, at https://www.junhe.com/legal-updates/2082

64 Yuhuan Shen; Carolyn Addy, "Renewable energy in China - here's what you need to know", Southpole, 8 April 2022, at https://www.southpole.com/blog/renewable-energy-in-china-heres-what-you-need-to-know

65 It is currently the world's largest carbon market.

66 "Renewable Energies marketing models China ", Rödl & Partner, accessed at 6 October 2023, at www.roedl.com/renewable-energy-consulting/markets/countries/marketing-models-china

Company Investment in RE:

Jinko Solar

JinkoSolar is a Chinese solar panel manufacturer and one of the world's largest photovoltaic module producers.

Goals:

In September 2020, Jinko Solar joined the RE100 and EP100 as the first global solar module manufacturer. The company committed to source 100% renewable electricity across their global operations by 2025 with an interim target of 70% by 2023.

Measures:

The company formulated a RE100 Roadmap to reach its targets. Among other things in 2022, JinkoSolar announced its first overseas "RE100 factory," relying solely on renewable energy. To ensure 100% of green electricity in production and operation, the Leshan factory in Malaysia relies on roughly 7GW vertically integrated solar cell-module capacity and external procurement.

The Chinese government also recognized the potential of distributed energy for self-consumption as a means of addressing energy poverty and empowering rural communities. This resulted in the launch of the unique **"Photovoltaic Poverty Alleviation Projects"** initiative, with over 20 billion yuan (approx. €2,5 million) invested over the 13. Five-Year-Plan (FYP; 2016–2020) period.

In June 2021, the NEA also set up a targeted program in order to boost the rooftop solar rollout on government and public buildings: The so-called **"Whole-County Rooftop Solar"** pilot. At the time the policy was introduced, there were virtually no solar installations on the rooftops of public buildings.

The policy stipulated that by the end of 2023, solar panels should cover:

- 50% of rooftop space party/government buildings;
- 40% of schools, hospitals, and other public buildings;
- 30% of industrial and commercial spaces;
- 20% of rural households.

Furthermore, by 2025 all new-build public buildings and factories should be covered at 50% by solar panels.

The NDRC reported that by the end of 2022, the program had already garnered registrations for more than 66 gigawatts (GW) of planned distributed solar projects. To put this in perspective: This amount is approximately equivalent to Germany's entire solar capacity.

Company Investment in RE:

Alibaba Group

Copyright: Alibaba Group

Alibaba Group is one of China's major tech giants, specializing in e-commerce, technology, and diverse online services.

Goals:

Alibaba Group has set ambitious sustainability goals, aiming to achieve carbon neutrality in its operations by 2030. Additionally, the company plans to transition all Alibaba Cloud data centers to run entirely on clean energy by the same year.

Measures:

Alibaba Group's sustainability measures encompass the deployment of distributed solar on eligible sites by Cainiao, its logistics arm. With 24.9 MW of rooftop solar capacity installed as of March 2022, the initiative powers all warehouse operations, with surplus electricity sold to the grid.

Additionally, Alibaba is actively engaged in on-site energy storage, recognized as the largest buyer of renewable energy among Chinese companies (BloombergNEF 2021), and invests in renewable energy and battery storage projects through green bonds.

The program is managed by local governments that launch tenders or auctions for project development rights. In the process, they select a single supplier and installer to handle all installations within an entire county-level administrative unit. This significantly decreases the costs of distributed solar, especially the soft costs related to customer acquisition and contracting.[67]

To develop the projects, the county usually does not provide any form of capital, therefore self-financing is necessary. However, as shared by an industry expert, occasionally the county may include some subsidies for specific parts of the project (e.g. one-time compensation for construction) in the tender.

As explained by NEA, the trials should be conducted in a competitive manner and be market-led, with all eligible companies able and encouraged to participate in the bidding process. Yet, according to the available public data, it appears that the majority of local governments nonetheless chose to engage SOEs to develop distributed energy projects in their counties rather than smaller private developers.[68]In fact, one of our interviewed experts revealed that it is not uncommon for the local governments to use the program to also attract other investments in the county. Considering these conditions, it becomes clear why SOEs, which typically have much better bargaining power, would have better chances to win such tenders.

However, as already mentioned in the previous sub-chapter, collaboration with private firms is particularly common in the context of distributed energy project development. A project manager at Statecloud Energy (see info box below) shared in an interview for The China Project: "*Even if they* [SOEs] *win the project in the tender phase, they often have to outsource it to companies like us in the end, because they're not local enough to do the work. They don't have the relationships with the local grid company, or the local government."* According to this project manager, the competition for the development of such projects among private developers is "cut-throat".[69]

"Green Pilot Zones" is another government scheme introduced by the Chinese government together with the People's Bank of China in order to promote investment in RE projects and technologies. So far, eight pilot green finance zones in five provinces (Zhejiang, Guangdong, Jiangxi, Guizhou, and Xinjiang) have been set up. In the pilot zones, financial institutions receive a range of incentives to fund clean and low-carbon industries. The purpose of these zones is to test various approaches to green finance in regions with different economic and developmental situations before implementing them on a broader scale. Especially in the northern province of Xinjiang, which is particularly rich in energy resources, the focus was put on mobilizing green finance to support the clean energy transition.[70]

Example Business Model

(as part of the "Whole County Rooftop Solar" pilot)

Developer:

Statecloud Energy – private solar developer

Process:

- StateCloud won the tender to install solar panels atop 90 schools and 30 hospitals in Zhangqiu District (Shandong).
- To compensate the building owner for the use of their rooftop, State Cloud will offer a 10% discount on the power rate when selling electricity to the owner. Any time the rooftop owner does not require the generated power (e.g., public holidays), the surplus electricity will be purchased by the local grid company.
- RoR target on capital: 6–6.5%
- (For comparison: International private equity often target 12%, Chinese SOEs 8%)

3.1.3 Project development & investment

As can be seen in Figure 33, in most cases, the RE project development can be generally divided into 4 phases: licensing, construction, commissioning, and long-term operation.

[67] Anders Hove, "Guest post: How China's rural solar policy could also boost heat pumps", China Dialogue, 19 June 2023, at https://www.carbonbrief.org/guest-post-how-chinas-rural-solar-policy-could-also-boost-heat-pumps/

[68] 整县分布式光伏追踪：75 个市区县敲定开发企业 [Whole County Distributed PV Tracker: 75 Urban Counties Finalize Developers], 26 July 2021, at https://mp.weixin.qq.com/s/N8-DYe0cvfsJTheERsgz4Q

[69] David Fishman, "A boots-on-the-rooftop view of China's solar photovoltaic boom", The China Project, 20 February 2023, at https://thechinaproject.com/2023/02/20/a-boots-on-the-rooftop-view-of-chinas-solar-photovoltaic-boom/

[70] Mengwei Sha, "Uncovering China's green finance pilot zones ", Green Finance Platform, 1 June 2022, at https://www.greenfinanceplatform.org/blog/uncovering-chinas-green-finance-pilot-zones

Figure 33: Renewable Energy Project Development Stages in China. Source: dena

The first phase requires applying for a number of permissions, including land permission and permission from the central and local governments based on the RE quota. In this phase, the developer also has to negotiate a long-term contract with the local power utility. Usually, a fixed price for a specific amount of time is granted.

According to our interviewees, obtaining all the necessary permissions is a very complicated process, for which private sector and international companies might not have sufficient resources. SOEs usually do not have many difficulties during this process, as they are used to handling permission applications on a routine basis and typically have it significantly easier to receive government endorsement.

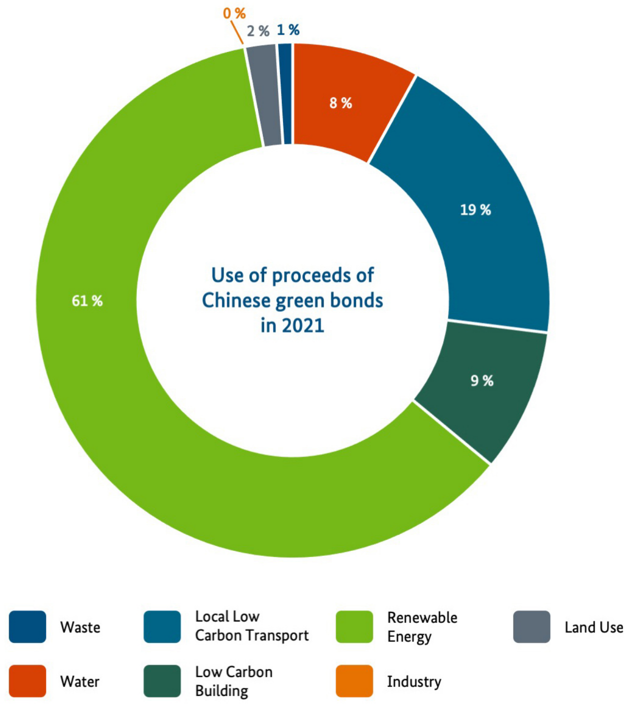
In the subsequent phase, developers generally sign contracts with OEMs and/or leasing companies. During the commissioning phase, the project is completed and connected to the grid. A role change from a project developer to a project operator is also possible at this stage. After that, the project can transition to the long-term operation phase.

According to the insights collected from the expert interviews, in the early stages of RE project development, developers mainly have to rely on **self-financing**. At this stage, the project is usually too risky for receiving external investment, which highlights the advantage of financially well-positioned SOEs in RE project development.

By the time the project transitions to the construction phase, the developers gain better access to external financing options. They can potentially seek funding via financial leasing companies, local government investment platforms, foundation funds (e.g., Energy Foundation China[71]), international investment firms[72], special government funds designated for demonstration projects, or green bonds.

China's **green bonds** market began with the release of the People's Bank of China's 2015 Green Bond Catalogue.[73] Since then, green bonds have become a widespread financing instrument in China.[74] Moreover, over the past years, various actions have been taken that brought China into closer alignment with international standards, such as removing coal projects from the bond catalogue.[75] As shown in Figure 34, RE dominated use of proceeds of Chinese green bonds in 2021.

Figure 34: Use of proceeds of Chinese green bonds in 2021. Source: dena. Based on: Climate Bonds Initiative and Syntao Green Finance 2021.[76]



At the RE project construction stage, the programs will also be evaluated by commercial banks. As soon as the

[71] Energy Foundation China is a grantmaking charitable organization, dedicated to supporting China's sustainable energy development. Through the end of 2022, Energy Foundation China had funded 3,693 projects operated by over 917 grantees in China, with total funding amount nearly 450 million dollars.

[72] In this case, the loan is typically converted to an asset after project completion.

[73] "中国人民银行公告〔2015〕第 39 号" [People's Bank of China Announcement [2015] No. 39], The State Council of The People's Republic of China, at https://www.gov.cn/xinwen/2015-12/22/content_5026636.htm

[74] By 2022, China's green bonds market was the second largest in the world.

[75] Gao Baiyu, "China's new green bond catalogue could be greener", China Dialogue, 9 July 2020, at https://chinadialogue.net/en/business/chinas-new-green-bond-catalogue-could-be-greener/

[76] "China Green Finance Policy 2021", Climate Bonds Initiative and SynTao Green Finance, at https://www.climatebonds.net/files/reports/policy_analysis_report_2021_en_final.pdf

RE project is completed, acquiring a long-term "**green loan**" from a commercial bank is possible. Such loans frequently come from large state-owned banks in China. For instance, the China Development Bank (CDB) announced that it would allocate 500 billion yuan (over €62 million) in loans to support green energy projects over the 14. FYP (2021–2025).[77] The interviewed industry experts assured us that green loans are by far the most important source of investment for project developers and frequently go to large SoEs.

3.2 Storage investment in China today

As China continues to expand its RE capacities, affordable energy storage will be of key importance to balance out the variability in power generation from renewables and ensure China's successful green transition.

Currently, high costs present a significant barrier to the large-scale deployment of energy storage systems. An industry expert pointed out that due to electricity pricing mechanisms, investment recovery for energy storage is still considered rather 'bad.'

Nonetheless, as of 2022, investments in energy storage in China totaled 2.7 trillion RMB, constituting approximately 29.3% of the overall renewable energy investment funds. Specifically, investments in lithium battery energy storage reached 2.2 trillion RMB, making up roughly 23.6%.[78]

Although, as of May 2022, 23 provinces already mandated a renewable-storage pairing ratio of at least 10%[79], such projects are more likely to be developed by SOEs. As already clear from the above described aspects in regards to RE project development, SOEs are generally more willing to accept unattractive risk-return profiles in the form of higher project risks and low economic returns, given that they can more easily access low interest rates for project financing from commercial and development banks.[80] This is different for private investors who can be easily discouraged by a lack of economic incentives from making substantial energy storage investments.

However, the 14th FYP for Energy Storage Development, released in March 2022 by the NEA, gives cause for optimism that the investment in energy storage may soon become more economically viable, also for private investors.[81] The scheme stipulates that by 2025, the per unit costs of battery storage should be reduced by 30%. Once these targets are met, the price can reach at RMB 0.8 to 1.0 (US$0.12 to 0.15) per watt-hour, making the energy storage system financially viable without subsidies. Analysts forecast once the cost reduction target is reached, an annual return rate of 15.6% for an energy storage system installed at a solar farm will be possible.[82] This should help China to reach the goal of 100GW storage capacity by 2030, as formulated in the 14th FYP.[83]

The plan also mentions the possibility of establishing an energy storage development fund for the first time. Morever, the scheme emphasizes the role of market forces, including generation utilities and independent service providers, in investing in storage projects.[84]

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[77] Xu Yihe, "China initiates green loan to finance renewable project boom", Upstream, 16 June 2021, at https://www.upstreamonline.com/energy-transition/china-initiates-green-loan-to-finance-renewable-project-boom/2-1-1025805

[78] "2022 年中国储能投资总额 2.7 万亿元、风电光伏总投资 3.4 万亿元！" [In 2022, China's total investment in energy storage will be 2.7 trillion yuan, and total investment in wind power and photovoltaic will be 3.4 trillion yuan!], Chuneng, 31 January 2023, at https://m.bjx.com.cn/mnews/20230131/1285530.shtml

[79] Such a mandate is designed to facilitate the effective integration of renewable energy into the electricity grid. By storing excess energy during peak generation times and releasing it when needed, grid stability can be ensured.

[80] Lei Bian, „China's role in scaling up energy storage investments", *Energy Storage & Saving*: Volume 2, Issue 2, June 2023, at https://www.sciencedirect.com/science/article/pii/S2772683523000110

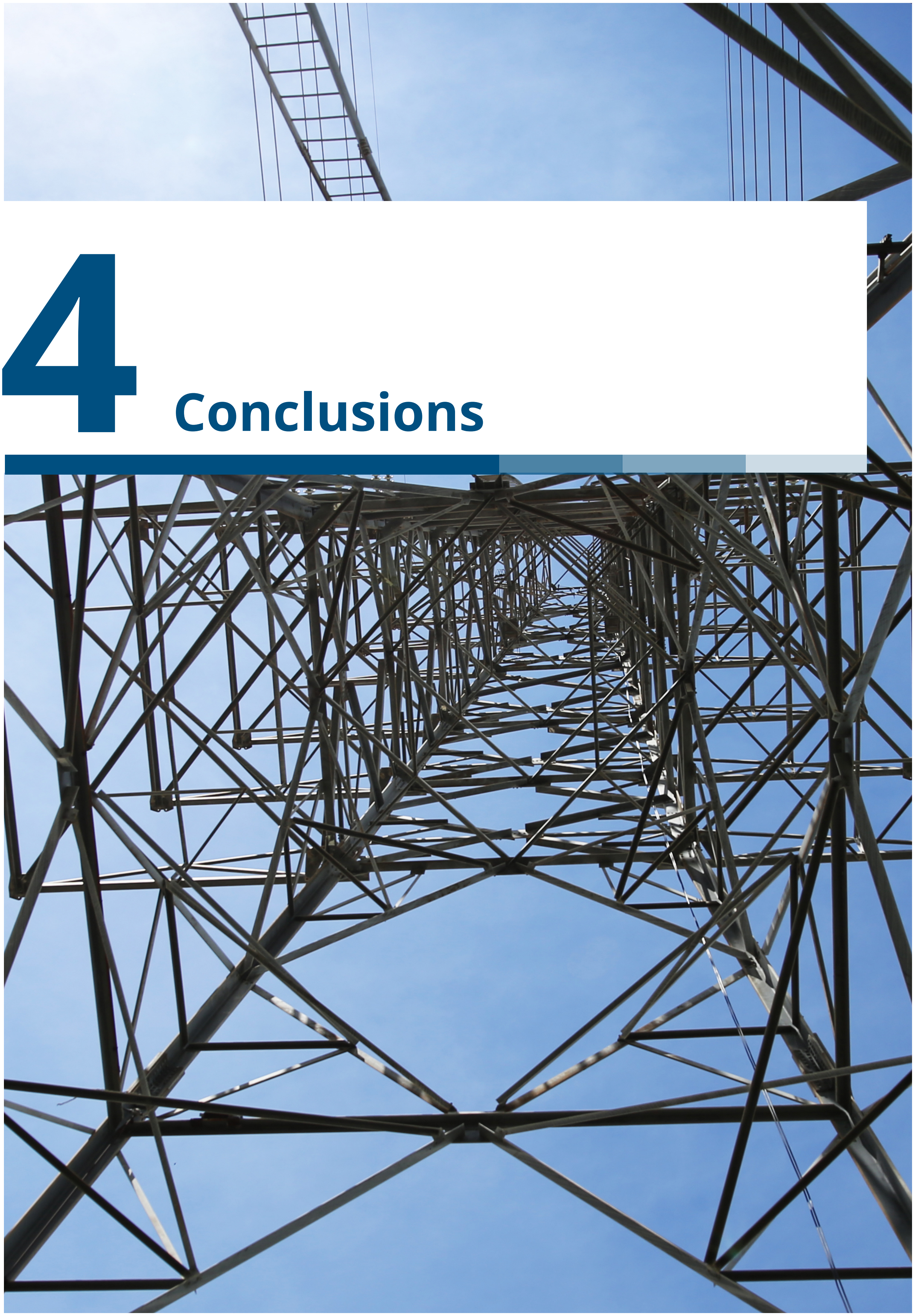
[81] 国家发展改革委 国家能源局关于印发《"十四五"新型储能发展实施方案》的通知[National Development and Reform Commission National Energy Administration on the issuance of the "14th Five-Year Plan" new energy storage development implementation program notice], NEA, 29 January 2022, at http://zfxxgk.nea.gov.cn/2022-01/29/c_1310523208.htm

[82] Eric Ng, "Climate Change: China to slash costs of energy-storage systems for industry to leapfrog the world by 2030, according to five-year plan" , South China Morning Post, 24 February 2022, at https://www.scmp.com/business/article/3168078/climate-change-china-slash-costs-energy-storage-systems-industry-leapfrog?module=perpetual_scroll_0&pgtype=article&campaign=3168078

[83] "China's Energy Storage Sector: Policies and Investment Opportunities", China Briefing, accessed at 6 October 2023, at https://www.china-briefing.com/doing-business-guide/china/sector-insights/china-s-energy-storage-sector-policies-and-investment-opportunities

[84] Yi Wu, "China's Energy Storage Sector: Policies and Investment Opportunities", 8 July 2022, at https://www.china-briefing.com/news/chinas-energy-storage-sector-policies-and-investment-opportunities/

4 Conclusions



4 Conclusions

Over the past quarter-century, the landscape in Germany has changed: In the literal sense, as more and more wind farms, biomass plants and solar installations shape the appearance of fields and – in the case of solar- rooftops. Also figuratively. The expansion of renewable energies has already transformed the German electricity sector and continues to do so. This transition has been largely policy driven with the support schemes provided by the Renewable Energy Law. It has enabled massive investments: between 2000 and 2021 the capacity of wind onshore rose from 6.1 to 58.1 GW, the one of solar PV from 0.1 to 67.4 GW. In the first decade, renewable energy installations operated outside the market: feed-in-tariffs guaranteed the price of electricity fed into the grid, simplifying the underlying business model and leaving only the quantity risk to the operator of an installation.

This changed in 2012: for large-scale installations, the government introduced direct marketing complemented by a market premium as the new paradigm for renewable development. That means that wind, biomass and solar installations can offer their output resp. their services not only in the wholesale but also in the ancillary service markets. More sophisticated business models emerged harnessing the chances and accommodating the risks associated with market participation, accompanied by financial models accounting for the new situation. The introduction of auction mechanisms to determine the market premia in 2017 was a further step towards market integration.

Parallel to this subsidy scheme, the PPA market for merchant projects, but also for revenue optimization within the EEG subsidy scheme, has been established in Germany since about 2019. It gained relevance with increasing electricity prices especially in 2021 and 2022. PPAs constitute the basis for new PV projects that are non-EEG-eligible, as it is their only option to secure revenues for a longer time-period and therefore ensure bankability. Furthermore, PPAs provide the opportunity for temporary revenue optimization of EEG-eligible projects and the continued operation of RES plants that have expired from the subsidy.

From this development, many observers conclude that renewable energy has reached the brink of market maturity, i.e. that they will be able to serve wholesale and ancillary service markets without support at some point in the future. Importantly, however, they must be complemented by flexibility assets such as – among others – decentral storage that can supply balancing and other vital ancillary services as well as peak shaving in the wholesale markets.

For ten years, China has sped up the expansion of renewable energy, adding more capacity per annum than the whole EU. So far, large SOE with a preferential access to capital markets have dominated the sector, relying on feed-in-tariffs. More recently, however, the country has also taken steps to abolish feed-in-tariffs and introduce market-based support mechanisms. New actors have emerged, including private domestic and international investors. The German example shows that a path towards full market participation is possible. In particular, the participation of renewable energy installations in ancillary service markets becomes an important requirement once variable renewable sources such as wind and solar have reached a critical share in the energy mix. China should aim for more private investment into renewable energy, based on market resp. system-friendly business models. This does not only hold true for renewable assets but also for decentral storage which plays an important role in renewable energy system integration.

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Table 9: Business model – Net billing for small scale installations, Source: dena

Renewable energy generation – net billing for small scale installations			
Relevant Regulation described in REA § 20 (feed-in premium) and § 21 (feed-in tariff)	**Investor** Houseowner, small business	**Products & Services** Self-consumption/ day-ahead market, intraday market, planned soon: balancing market	**Support (if any)** Remuneration of excess electricity
Regulator Federal Network Agency	**Operator** Investor	**Offtaker / Client** Supplier forced by law (nearest distribution system operator)	**Support (finance)** Fixed feed-in remuneration (is charged to the private or commercial end customers)
Costs Fixed asset: components of the installation, measurement and control systems, protection systems; installation costs; operating costs: (insurance cost; maintenance costs; cleaning costs).		**Revenues** Self revenue of existing purchase, remuneration of feed-in tariff	

Table 10: Business model – Fixed feed-in for large scale installations, Source: dena

Renewable energy generation – fixed feed-in tariff for large scale installations			
Relevant Regulation Described in REA § 20 (feed-in premium) and § 21 (feed-in tari)ff	**Investor** State, banks, private companies, private investors, renewable energy community	**Products & Services** Spot market (day-ahead market, intraday market, balancing market)	**Support (if any)** EEG fixed feed-in tariff remuneration for 20 years
Regulator Federal Network Agency	**Operator** Service provider	**Offtaker / Client** Supplier forced by law (nearest distribution system operator)	**Support (finance)** fixed feed-in remuneration (is charged to the private or commercial end customers)
Cost Fixed asset: components of the installation, measurement and control systems, protection systems; installation costs; operating costs: (insurance cost; maintenance costs; cleaning costs, income tax, management costs)		**Revenues** Revenues consists of profit in the various submarkets and the compensation in the event of deregulation	

Table 11: Business model – Market premium model, Source: dena

Renewable energy generation – market premium model			
Relevant Regulation RES 2012; RES 2017 (introduction auctions), RES 2023 at §§ 28-28e, § 32, §§ 36-36j, §§ 37-38b, §§ 38c-38i, §§ 39-39i, §§ 39n-39q, §§ 39n	**Investor** Everyone (state, banks, private companies, private investors, renewable energy community)	**Products & Services** Spot market (day-ahead market, intraday market, balancing market), small extent- in ancillary service markets	**Support (if any)** Feed-in premium (The support for the plant-specific funding level is determined by auctions)
Regulator Federal Network Agency	**Operator** Service provider	**Offtaker / Client** The owners of the plant market their electricity directly through power exchanges/direct marketing companies	**Support (finance)** Until 1 July 2022, it was financed by the EEG levy paid by all electricity consumers. Since then, the model has been financed by taxpayers' money.
Cost Fixed asset: (purchase or leasing costs for the PV/wind systems), installation costs, capital cost, planning and permit costs, grid connection to the energy supply company; operating costs: administrative costs (business and operational management), land rent costs, insurance costs, meter rent, maintenance costs (remote monitoring, annual analysis of the plant), cleaning costs (for PV); operational failure; income tax.		**Revenues** Market price (sales revenue on the electricity exchange) by the direct marketer + market premium (market premium is paid by the grid operator to the EEG electricity producer and results from the difference between the current electricity exchange price and the EEG remuneration) from the responsible distribution grid operator	

Table 12: Business model – Classic direct marketing, Source: dena

Renewable energy generation – classic direct marketing			
Relevant Regulation RES 2023 at § 33c, EnWG, ARegV, StromNEV, StromNZV.	**Investor** Everyone (state, banks, private companies, private investors, renewable energy community)	**Products & Services** OTC, spot market (day-ahead market, intraday market, balancing market), small extent- in ancillary service markets	**Support (if any)** None
Regulator Federal Network Agency	**Operator** Service provider; supplier (e.g. Stadtwerke)	**Offtaker / Client** Everyone (many households together; large industry; pooling systems)	**Support (finance)** Without further funding
Cost Fixed asset: (purchase or leasing costs for the PV/wind systems), installation costs, capital cost, planning and permit costs, grid connection to the energy supply company; operating costs: administrative costs (business and operational management), land rent costs, insurance costs, meter rent, maintenance costs (remote monitoring, annual analysis of the plant), cleaning costs (for PV); operational failure; income tax.		**Revenues** Revenues generated from the sale of energy, less the prices for electricity production.	

Table 13: Business model – Corporate PPA, Source: dena

Renewable energy generation – corporate PPA			
Relevant Regulation RES 2023 at § 33c, §21a RES 2021, formerly §20 para. 1 number 2 RES 2014, formerly §33b number 3 RES 2012, EnWG, ARegV, StromNEV, StromNZV.	**Investor** Everyone: companies which use electricity / direktvermarkter/ state, banks, private companies, private investors, renewable energy community	**Products & Services** OTC	**Support (if any)** None (If statutory subsidies for an existing plant expire, PPAs are a way of securing follow-up financing for plant operation
Regulator Federal Network Agency	**Operator** Supplier; service provider	**Offtaker / Client** Many households together; large industry; pooling systems	**Support (finance)** Without further funding
Cost Fixed asset: (purchase or leasing costs for the PV/wind systems), installation costs, capital cost, planning and permit costs, grid connection to the energy supply company; operating costs: administrative costs (business and operational management), land rent costs, insurance costs, meter rent, maintenance costs (remote monitoring, annual analysis of the plant), cleaning costs (for PV); operational failure; income tax.		**Revenues** Prices (fixed or indexed, depending on the contract) for long term delivery of renewable electricity	

Table 14: Business model – Merchant PPA, Source: dena

Renewable energy generation – merchant PPA			
Relevant Regulation RES 2023 at § 33c, §21a RES 2021, formerly §20 para. 1 number 2 RES 2014, formerly §33b number 3 RES 2012, EnWG, ARegV, StromNEV, StromNZV.	**Investor** Everyone: companies which use electricity / direktvermarkter/ state, banks, private companies, private investors, renewable energy community	**Products & Services** OTC, spot market (day-ahead market, intraday market, balancing market), small extent- in ancillary service markets	**Support (if any)** None (If statutory subsidies for an existing plant expire, PPAs are a way of securing follow-up financing for plant operation (i.e. covering operating costs, such as maintenance and rent)
Regulator Federal Network Agency	**Operator** Supplier, service provider	**Offtaker / Client** Many households together; large industry; pooling systems	**Support (finance)** Without further funding
Cost Fixed asset: (purchase or leasing costs for the PV/wind systems), installation costs, capital cost, planning and permit costs, grid connection to the energy supply company; operating costs: administrative costs (business and operational management), land rent costs, insurance costs, meter rent, maintenance costs (remote monitoring, annual analysis of the plant), cleaning costs (for PV); operational failure; income tax.		**Revenues** Prices for long term delivery of renewable electricity	

Table 15: Business model – Decentral storage – stand alone, Source: dena

Decentral storage – Stand alone			
Relevant Regulation EEG (network connection, feed-in), EnWG (network charges, unbundling of network operator and operating electricity storage)	**Investor** municipal utility, energy supplier	**Products & Services** Arbitrage (Forward, DA, ID markets), Participation in reserve markets (Primary, Secondary), Further ancillary services	**Support (if any)** Electricity storage connected to the power grid are exempt from grid fees for a period of 20 years, exemption relates to the purchase of the electricity to be stored
Regulator Federal Network Agency	**Operator** Energy supplier, companies (Evonik, Bosch)	**Offtaker / Client** Network Operator, trader	**Support (finance)** without further funding
Cost Fixed asset and installation costs; operating costs (insurance cost; electricity meter rent; maintenance costs; cleaning costs), electricity losses		**Revenues** Revenues according to market participation	

Table 16: Technological options for decentral storages, Source: dena

System	Advantage	Disadvantage	Availability
Sodium-sulfur battery	• High energy density and power • High efficiency while charging and decharging • Long lifetime (amount of cycles)	• High operating temperatur (security risk) • High maintenance costs • Use of corrosive materials	• Commercially available • Research of performance potential
Lithium ion battery	• High efficiency • High energy density and power	• Limited thermal staibility (fire risk)	• Commercially available and applicable on large-scale
Vanadium-Redox -Flow battery	• High capacity • Memory performance and capacity are independent from each other	• Requires electrical pump for circulation of the battery stack	• Demonstration plant (2015) • Commercially available
Zero-emission battery (Zebra)	• High efficiency • Long tifetime • High energy density	• Low performance density • Operational temperature: 270-350 degrees C • Long warm up-phase (24h cold start)	• Commercially available and applicable on large-scale
Lead-acid battery,	• Efficiency 80-85%	• High maintenance costs • Low energy density Geringe Energiedichte • Low amount of life cycles	• Commercially available and applicable on large-scale

Table 17: Technological options for decentral storages, Source: dena

System	Advantage	Disadvantage	Availability
Nickel- cadmium battery	• High electricity and performance density • High efficiency	• Cadmium is toxic • Regukation forbids new Anwendung of nickel-cadmium batteries • High costs of nickel • High selfdischarge	• Nickel-cadmium batteries are the oldest type of nickel batteries • Still in use but regulations fordbid new application
Compressed air energy storage	• High capacity • Long lifetime • Flexibily applicable	• Diabatic CAES (without thermal storage) low efficiency • Adiabatic under development	• Geographical requirement: feasible large volume air storage in cavern or similar
Double-layer Capacitor	• High stability • High performance • Fast charging and discharging • Long operation lifetime	• High selfdischarge • Low energy density	• Commercially available and widely used
Flywheel	• Fast charging and discharging • High electricity density • Infinite amount of cycles per time unit	• Requires protection measures (to prevet kinetic energy from exploding) • Small performance range	• Commercially available
Hydrogen storage (small scale)	• Long lifetime • High efficiency	• Maximum efficiency of LOHC-bound hydrogen-to-electricity storage systems of 45%	• Commercially available for residential applications

Table 18: Storage Business models, Source: dena

Asset	Market participation / services delivered
Stand-alone battery	• Arbitrage (Forward, DA, ID markets) • Participation in reserve markets (Primary, Secondary) • Further ancillary services
Battery in RE installation (large-scale)	• Increase sales value of electricity generated (Forward, DA, ID markets) • Participation in reserve markets (Primary, Secondary) • Power smoothing / peak shaving • Secure faithfulness to schedule
Battery operated by prosumer	• Increase share of RE self-consumption
Battery in industry (load)	• Reduce cost of procurement of electricity from market (Forward, DA, ID markets) • Reduce grid tariffs by flexible load • Offer demand response in DA or reserve markets • Uninterrupted power supply

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