POWER PURCHASE AGREEMENTS:
FINANCIAL MODEL FOR RENEWABLE ENERGIES

Berlin, 16.02.2018

White Paper

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1. THE BASICS OF POWER PURCHASE AGREEMENTS (PPAs) FOR RENEWABLE ENERGIES

1.1. PPA 101

A Power Purchase Agreement (PPA) is a long-term electricity supply agreement concluded directly (bilateral) between a buyer (electricity consumer) and a seller (plant operator). This agreement regulates the supply of electricity at a defined price or an equivalent financial compensation. The profile of the electricity quantity can be explicitly unknown. PPAs offer not only the buyer, but also the seller numerous advantages.

For the consumer, there is no longer a dependency on strongly fluctuating electricity or CO_2-prices in the event of high demand, when a PPA is concluded. A value-neutral hedge (see section 2.2) enables large companies to hedge their business against long term price risks. Due to the long duration of a PPA —up to 20 years—, strong partnerships are also built. Based on the previously mentioned advantages, a number of large software groups are shaping their sustainable branding with the "First-Mover-Image" by concluding large PPAs with wind farm and solar plant operators.

For plant operators, the main focus is on revenues for generating electricity from their renewable energy plants. These revenues are determined by virtue of a PPA over a long period of time. Therefore, financing current as well as future investments can be well facilitated, especially while governmental support for renewable energies is decreasing. Additionally, the guaranteed power supply increases the creditworthiness of the plant operator, leading to lower financing costs. Such contracts also provide the benefit of promoting entry into the energy market.

Both (buyers and sellers) benefit from the diversification of electricity procurement and customer structure. Accordingly, the counterparty default risk is mutually reduced if counterparty fails to meet its obligations.

PPAs can be divided into two categories: physical PPAs (often corporate or sleeved PPAs) and virtual PPAs (often synthesized or merchant PPAs). In the first case, the defined electricity quantity is sold directly to the consumer and delivered either through the national grid or a direct transmission line. However, if a virtual PPA is concluded, both parties will trade the defined quantities of electricity on the spot markets. Supposing that the spot market prices diverge from the set contract price (reference price), both contracting parties shall compensate each other on an annual or monthly basis. This difference is called the contract of difference. Both PPA models are schematically depicted in Figure 1.

In addition to the sale of electricity, certificates of origin may in both cases (physical and virtual PPAs) be transferred to the consumer if permitted by the regulatory framework.

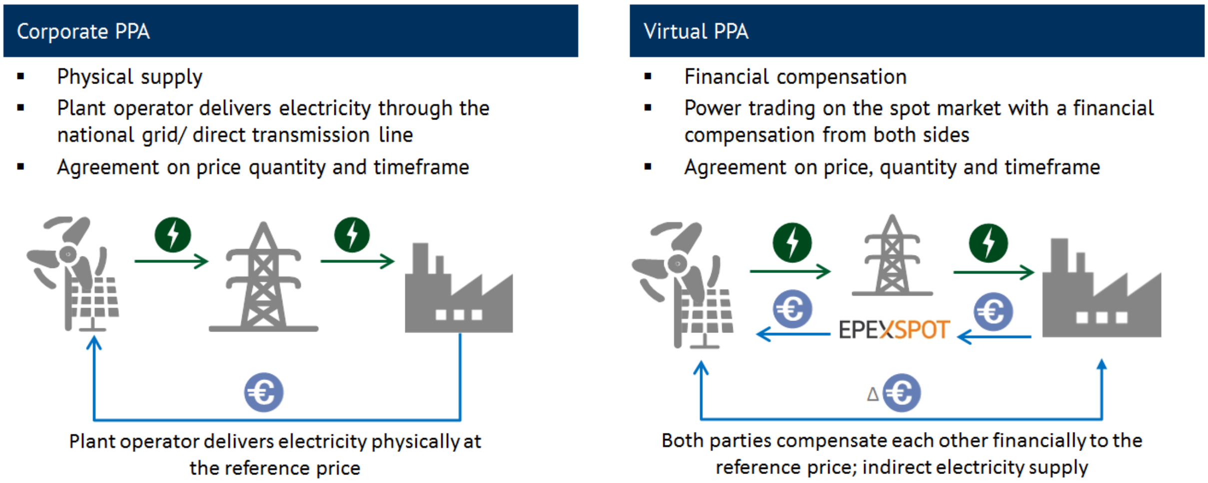

Figure 1: Two fundamental models of PPAs (Source: Energy Brainpool)

The contractual regulations on the quantity delivered and the price of electricity can be very flexibly tailored. Both can either be fixed (e. g. fixed price, fixed quantity), include upper or lower limits (e. g. minimum price, take-or-pay quantities) or they can depend on an index.

Variable volumes have been known in Germany as “take-or-pay”-contracts — mainly from the gas industry— which are commonly used due to the weather dependency of the gas business. A similar situation is evident for renewables, where wind turbine’s power generation can fluctuate by 20 percent on an annual basis[1]. Thus, the contract price of a PPA can be fixed for 6 years and then re-determined on a rolling basis. It is also possible to set prices on an even longer-term basis. However, this can no longer be hedged in the futures market (see section 2.2). Furthermore, standard options for PPAs during the term of the contract include: Inflation adjustment, price formulas (referencing to electricity prices), price floors and price caps. Thereby, a price range is prescribed instead of a fixed price.

[1] Load profiles for onshore wind farms according to EMHIRES (2017): EMHIRES datasets; [online] https://setis.ec.europa.eu/EMHIRES-datasets.

1.2. FINANCING RENEWABLE ENERGIES WITH PPAS

PPAs have emerged in the UK, the US and most recently Norway, Ireland and the Netherlands in conjunction with the promotion of renewable energies (see Figure 2). These long-term agreements are particularly relevant, where utilities are obliged to cover part of their supply with renewable energies (Renewable Portfolio Standards RPS) [2]. Moreover, PPAs appear attractive; if investors are provided with tax reliefs for investments in renewable energies (production/investments tax credits PTC/ITC). Additionally, Photovoltaic PPAs are becoming increasingly important in sunny countries, rural areas and developing countries.

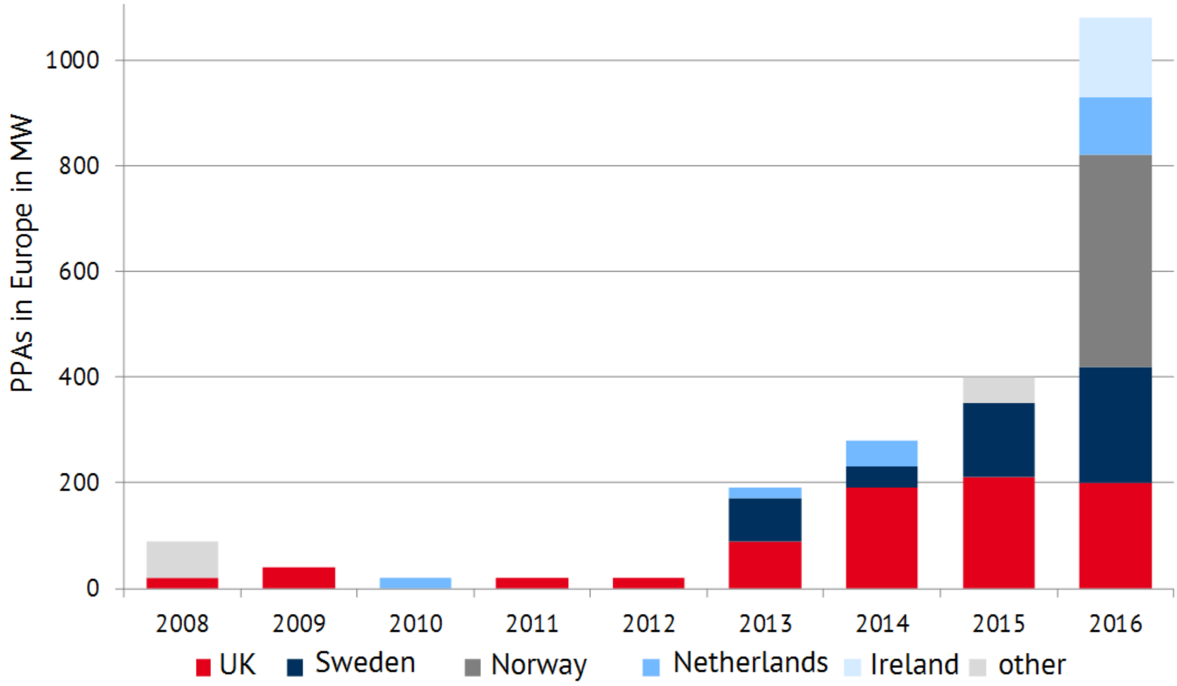

Figure 2: Capacities of renewable PPAs in Europe (Source: Bloomberg New Energy)

PPAs do not yet play a major role in promoting renewable energies on the German market. This can be attributed to the fact that renewables are still characterized by market premium models and feed-in tariffs. Power plants providing traction power are solely familiar with contractual models similar to PPAs, due to some technical reasons[3]. The current debate on the promotion of renewable energies with direct marketing using a potentially negative market premium (cf. BDEW position paper) is essentially concerned with a statutory auction of PPAs between

[2] PWC, 2012, Introduction to Renewable PPAs; [online] https://www.pwc.com/gx/en/sustainability/research-insights/assets/impact-of-minerals-metals-scarcity-on-business.pdf.

[3] Since these power plants are not free to choose whether they are feeding into the national grid or the rail network, they are subject to a risk.

plant operators and assessable end-consumers. However, this proposal does not give the end-consumer the price guarantee he is entitled to in a PPA.

With increasing electricity prices and decreasing plant costs, a detachment from the financial support provided by the German Renewable Energies Act (EEG) is in sight for the next decade. PPAs will play a key role in the long-term marketing of green energy. Nevertheless, in today's market environment, large electricity consumers and utility companies are accustomed to procurement horizons of about three years. Therefore, there is currently only a low demand for PPAs. From today's perspective, the PPA-pioneers will be innovative municipal utilities, large-scale industrial consumers and data centers. These pioneers have the common interest of partially securing their electricity demand over a long period. Assuming the creditworthiness of the consumer is guaranteed, PPAs enable additional installations to be built or operate old ones without any financial support from the government. This is achieved through namely the direct marketing in the EEG as well as the certificates of origin (if applicable, regional).

1.3. FINANCING OFFSHORE-PARKS WITH PPAS

PPAs are also a possible solution for offshore parks to deal with the growing market price risk (electricity prices fluctuate with revenues). In tenders for the financial support of such parks bids of 0 EUR/MWh were accepted[4]. Both Germany and the Netherlands are therefore very likely to build and operate non-financial offshore wind parks in the next decade. By using PPAs, these parks can hedge their market price risk.

1.4. HEDGING OF POST-EEG WIND FARMS WITH PPAS

Wind turbines, for which financial EEG subsidies will expire in 2021, will soon be facing the question: Is further operation of the turbine still technically possible; and above all economically feasible? In particular, if additional investments are necessary for further operation, the marketing revenues must be hedged for financing, which can be achieved with the an applicable PPA for the remaining operating time.

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[4] Energate (15.12.2017), Vattenfall bietet für subventionsfreien Nordsee-Windpark, [online] http://www.energate-messenger.de/news/179553/vattenfall-bietet-fuer-subventionsfreien-nordsee-wind-park

1.5. HEDGING OF ONSHORE WIND FARMS WITH LOW FUNDING RATE VIA PPAS

Last year's (2017) tendering rounds for onshore-wind farms resulted in surcharge values of 2,2 to 5,8 ct/kWh. According to the current power price forecasts, most of these plants will generate more revenue from the power market (over the funding period of 20 years) than from governmental financial support (stated in the EEG). Thus, the financial support for these new installations is a hedge for the minimum revenue. Herein, EEG payments are unlikely to be distributed. However, the market revenues are uncertain and depend on political and economic developments that can influence the power prices. Hence, PPAs can be used to hedge the revenues of these plants in the long term. Similarly, this also applies to the installations of community energy companies in accordance with EEG 2017. For instance, PPAs with a regional customer group may be a conceivable model.

EXCURSUS: CURRENT USAGE OF PPAS IN THE EUROPEAN MARKET

Some software and hardware companies, namely Google, Facebook and Microsoft, have already concluded PPAs with renewable energy parks in Europe. These PPAs are also the first cases to be publicly discussed in the German electricity sector. These companies use PPAs to generate an ecological "First-Mover-Image" to enhance their reputation and obtain a long-term stable power price. From an economic point of view, these contracts cannot be evaluated since the contract details (such as power prices) are not publicly known. However, the strong cost degression of wind energy indicates contract prices which are not substantially higher than the current power price levels. Two projects −initiated by Microsoft− are furtherly presented to illustrate the discussed concept.

In Ireland, a PPA with a 37-Megawatt wind farm and integrated batteries was concluded[5]. Over a period of 15 years, Microsoft will consume the entire power yield as well as the temporarily stored power from the battery system. Assuming the full load hours of a wind turbine is equal to

[5] Microsoft News Center (2017), Microsoft, GE sign agreement on new wind project in Ireland; [online] https://news.microsoft.com/2017/10/09/microsoft-ge-sign-agreement-on-new-wind-project-in-ireland/

2650 hours per year[6], the estimated power yield will be amounted to 1,47 TWh over the contract term of 15 years. Given an estimated contract price of 50 to 70 EUR/MWh[7], the volume could sum up to 74 to 103 Mio. EUR. The contract partner, General Electric, initially have been conducting a test phase in which the whole system will be tested. Some may ask: Why a wind farm combined with a battery system? Well, this combination avoids peaks in the power production and enables an optimized power supply. The background of this project is Microsoft's corporate strategy from 2016, where the company has committed itself to supplying its data centers with electricity from renewable energy sources on a pro rata basis[8].

Moreover, Microsoft has been part of another PPA in the Netherlands which should come into force in 2019. It covers the power consumption from the 180-Megawatt onshore wind farm "Wieringermeer"[9]. The contractual partner is the Swedish utility Vattenfall. According to Energy Brainpool's knowledge, this contract represents the largest PPA in Europe. Other companies such as Google or Facebook can also relate to similar PPA projects; some of which have already been concluded earlier.

[6] Average value for Ireland according to EMHIRES (2017): European Meteorological derived high resolution renewable energy source generation time series; [online] https://setis.ec.europa.eu/related-jrc-activities/jrc-setis-reports/emhires-dataset-part-i-wind-power-generation.

[7] This is a general estimate of the bandwidth which, from Energy Brainpool's point of view, currently reflects the future average marketing value of wind power in Ireland. In reality, the value is dependent on parameters such as individual load profiles, electricity demand, energy carrier prices, etc., which are only determined by detailed fundamental modelling.

[8] Microsoft Blog (2016), Greener datacenters for a brighter future: Microsoft's commitment to renewable energy; [online] https://blogs.microsoft.com/on-the-issues/2016/05/19/greener-datacenters-brighter-future-microsofts-commitment-renewable-energy/#sm.00000ko0aksyyodh7vtq626ialj6w

[9] Microsoft News Center (2017), Microsoft announces largest wind energy deal in the Netherlands; [online] https://news.microsoft.com/europe/2017/11/02/microsoft-announces-largest-wind-energy-deal-in-the-netherlands/

2. WHAT IS THE VALUE OF WIND POWER IN THE NEXT DECADE?

The financial evaluation of a PPA is possible on the basis of futures market prices (short- to medium-term) and fundamental power price modeling (medium- to long-term). From today's point of view, the contractual price, which can achieve an equal division of the business opportunities and risks between the two contractual partners, is described in this document as "fair value". Figure 3 depicts how the fair value (or a bandwidth) is determined for a PPA.

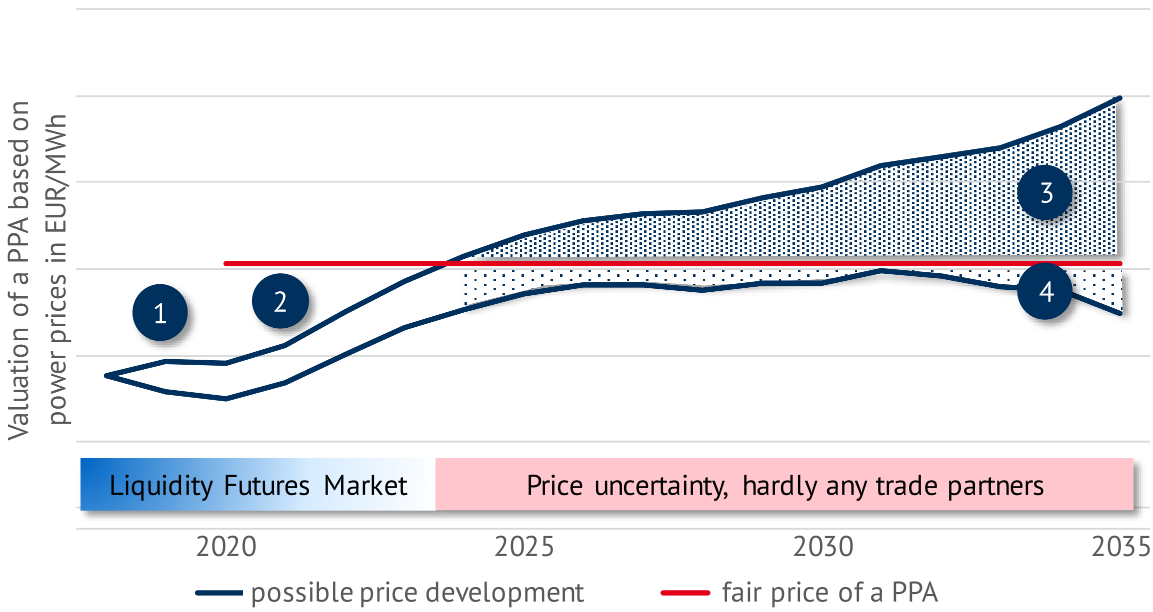

Figure 3: A possible wind power price development in Germany from today's perspective (blue curves) and a "fair value" (red curve) for a PPA with the duration of 15 years (2020-2035), Source: Energy Brainpool

The emerging development of a PPA is characterized by the current market situation with historically low wholesale power prices. Power price forecasts consistently predict a rising wholesale price for electricity over the next decade[10]. Herein, deviations mainly exist in the growth rate. The two possible price developments shown in Figure 3 illustrate a wide range of marketing values[11] that wind turbines are likely to reach. Given this background, Energy Brainpool predicts the following market development for PPAs:

1. **PPA market testing by trailblazers:** Energy Brainpool assumes that predominantly pioneers (first movers) will conclude PPAs during this decade (until 2020). This phase is

[10] There are numerous reasons for this forecast, including a European reduction in the capacity of coal and nuclear power plants, rising prices for fossil fuels and EUA certificates, as well as the expectation of a rising demand for electricity due to the emerging sector coupling.

[11] Marketing values are the average power prices at which generating plants can sell their power yield on the power market without financial support.

still characterized by low market prices and barely any wind or solar plants without financial support according to the EEG. Especially favourable (low-priced) plant locations are an interest in the innovative and green corporate image of both contracting parties. Market conditions are not yet in place for a mass market: Comprehensive market parity of renewable energies is still not expected and renewable energy farms can still rely on financial support from the EEG for their financing. Today, a liquid futures market exists for the next three years. Producers and consumers can hedge price risks and rely on a reliable price signal from stock exchange trading, for example on the EEX. However, the current price signals do not indicate any increase during this decade. A long-term price hedging is not yet customary at present.

2 **Market parity & post-EEG installation:** A growing number of old EEG plants will lose their entitlement to the financial support in the course of the next decade (2021-2030). Both, rising market prices and falling electricity production costs, emphasize an abolishemnt of the financial support. The economic feasibility of these plants depends on the development of power prices over their service life. The price risk is, therefore, crucial for the investment. Without long-term price hedging, plant financing is very expensive. However, it is not possible to hedge prices on the futures market. It is important to point out that firstly, there are hardly any trading partners for the period of more than three years ahead. Secondly, the price uncertainty is very high for this period[12]. With the background of rising power prices, an industrial large-scale consumer could now, for example, conclude a PPA over 15 years with a contract price above the then current, but below the expected power price level on the long term. The producer, on the other hand, initially receives an above-average price for his electricity, but waives potential additional revenues in the following years.

3 **High price scenario**: In this case, the industrial consumer benefits from the PPA's favourable electricity supply. Although the producer hedged his price risk, he has now waived the additional revenues.

4 **Low price scenario** (alternatively to 3): In that case, the producer will benefit more by selling his electricity. However, the industrial consumer has hedged his price risk, but is now purchasing electricity at an above-average price. A PPA has a "fair value" if, from

[12] The use of PPAs to hedge price risks can reduce liquidity in the futures market.

today's point of view, the probability of opportunities and risks (from the possible development of power prices) are equally distributed.

With a contract term exceeding ten years, volume and price risks are key challenges. In order to counteract the price risk, a well-founded assessment of the future development of power prices is required. In theory, PPAs can be hedged value-neutrally for up to six years in the future on the futures market. However, in practice, trading opportunities are limited for products only three years in the future due to the low liquidity of the product. Over the period of three to six years, the fair value can be determined using a portfolio of electricity price forecasts.

2.1. THE PRINCIPLE OF A VALUE-NEUTRAL HEDGE

A value-neutral hedge enables the fluctuating power generation of a wind turbine to be hedged and valued using the standard products of the derivatives market. This principle can be also applied for periods surpassing three years. The value-neutral hedging principle (see Figure 4) is known from the evaluation of fluctuating load profiles, but can also be used to evaluate fluctuating generation. This approach is illustrated below for a wind turbine, but can also be implemented on a photovoltaic system.

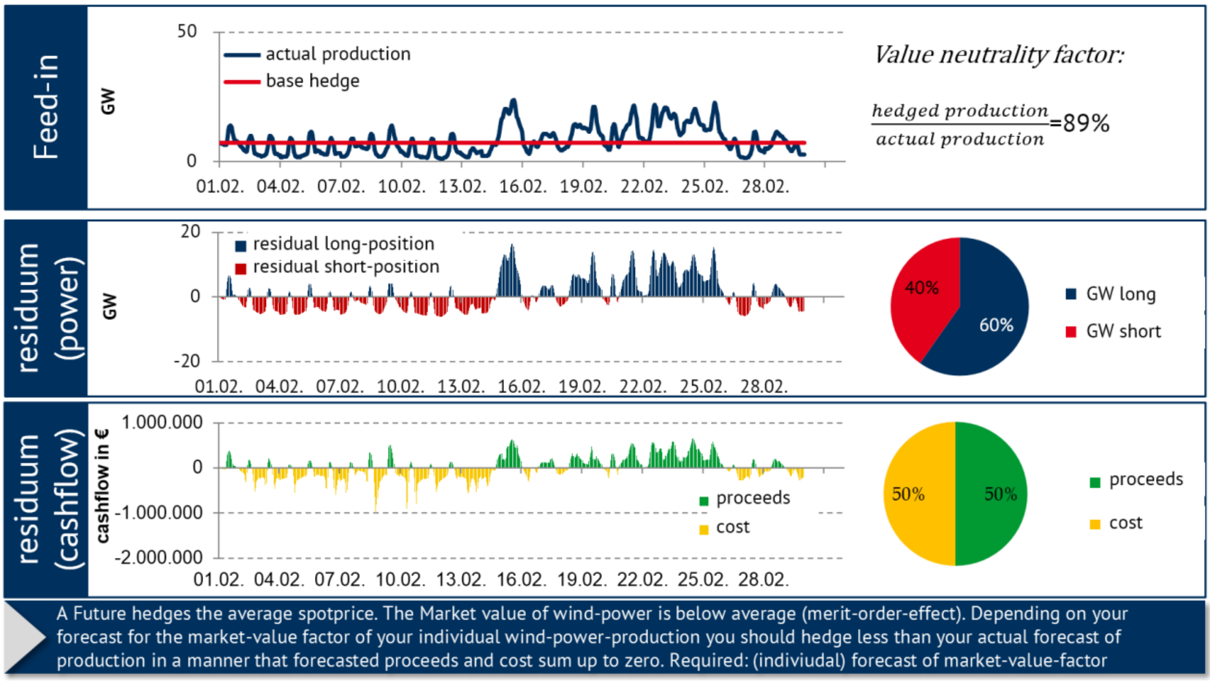

Figure 4: Determining the value-natural hedge for a wind turbine (Source: Energy Brainpool)

The weather-dependent load profile of a wind turbine does not correspond to the products in the derivatives market (base/peak). Selling wind power as a forward/future leads to over- and under-coverage or residual long and short positions in different hours. Compensation on the spot market, where the generated power can be traded to quarter-hour accuracy, generates revenues in some hours and costs in others. A value-natural hedge is provided, if one sells just enough electricity on the futures market to offset the expected revenues and costs. In the example presented in Figure 4, this is achieved by selling 89 percent of the produced power output. This factor varies with the power price structure, the load profile and the merit order effect and can be modelled on a monthly or annual basis.

2.2. VALUE-NEUTRAL HEDGE OF A RENEWABLE POWER PLANT

A value-neutral hedge was calculated for a model plant in Germany on the basis of a fundamental electricity price analysis, which will sell the electricity produced over a PPA from January 2020. During the first four years of operation, the fair value of this PPA can be hedged on the futures market. For a price hedge at the end of January 2018, the value-neutral hedge of this model plant would have been 32.47 EUR/MWh. Table 1 presents relevant values for the period of 2020-2024.

The assumed factors apply to the generation profile of a selected weather year. The price structure risk of different weather years can be estimated by fundamental price analyses. Furthermore, the calculation of a fair value of the PPA beyond the first four years of operation is based on electricity price scenarios that can reflect possible market developments and different weather years.

Table 1: Development of power prices and value-neutrality factors for the first four years of operation (Source: Energy Brainpool; own calculation)

YEAR	POWER PRICE IN EUR/MWH DEBY, CLOSING EEX 25.01.2018	VALUE-NEUTRALITY FACTOR
2020	34.67	89.16 %
2021	35.14	88.27 %
2022	36.80	87.58 %
2023	37.83	88.96 %
2024	38.80	89.00 %

3. CONCLUSION

A Power Purchase Agreement (PPA) is a long-term electricity supply agreement concluded directly between an electricity consumer and a plant operator. This agreement regulates the supply of electricity with a potentially uncertain profile at a defined price or with equivalent financial compensation. Energy Brainpool considers PPAs to be a very probable contractual arrangement between wind and solar plants and large-scale industrial consumers from the next decade onwards.

PPAs offer large-scale consumers the benefit of long-term stable power prices which will be revalued at the least by the next decade. In contrast, the seller receives a long-term hedged purchase price for his investments. Especially renewable energy plants with high initial costs and low operating costs are predestined for such a financing model. They are expected to reach market parity in the next decade. PPAs are also likely to provide financial security for operating plants that will gradually lose their entitlement to financial support from 2021 onwards.

However, with a contract term exceeding ten years, two problems arise. Firstly, the consumer is exposed to a weather-dependent volume risk in the purchased electricity quantities. Second problem is the uncertainty of a PPA's pricing. For three to six years in the future, PPAs can be valued and hedged in a value-neutral manner using standard futures market products. A PPA with a model plant for the period from 2020 to 2024 is valued at 32 EUR/MWh as of January 2018. At this price, consumers and producers share the opportunities and risks arising from the uncertain electricity price development on a parity basis.

In order to evaluate contracts beyond that period, an assessment based on electricity price scenarios is necessary. This assessment depends, among other things, on the individual asset profile, the underlying price assumptions (CO_2, coal, gas), the "cannibalization effect" of new renewable energies and the development of electricity demand as well as their flexibility.

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ABOUT ENERGY BRAINPOOL

Energy Brainpool GmbH & Co. KG offers independent energy market expertise with a focus on market design, price development and trade in Germany and Europe. In 2003, Tobias Federico founded the company with one of the first spot price forecasts on the market. Today, the offer includes fundamental modeling of the electricity prices with the software Power2Sim as well as diverse analyses, forecasts and scientific studies. Energy Brainpool advises on strategic and operational issues and offers expert training since 2008. The company combines knowledge and competence in business models, digitalisation, trading, procurement and risk management with long-term practical experience in the area of steerable and fluctuating energies.

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February 2018