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Complementary business models for distribution system operator in a peer-to-peer electricity market

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Abstract— As more distributed renewable energy resources are connected and peer-to-peer energy trading frameworks are forming, the traditional business model of the distribution system operator and energy retailers faces emerging load and price risks. In this paper, two sustainable and complementary business models for the DSO the new energy ecosystem are proposed: DSO as the platform operator of the P2P energy exchange framework (including flexibility market and electric vehicle market) and DSO as the service supplier. The two complementary business models exploit the competitive advantages of the DSO (infrastructure, expertise) and provide the DSO with sustainable income stream to complement the revenue reduction under intermittent scenario of demand and DRES production.

Index Terms— Business Model, Distribution System Operator, Peer-to-peer energy ecosystem.

I. INTRODUCTION

The changing landscape of the energy sector influences the Distribution System Operators (DSO) and their role, with regulation and policies being a driving force. Scenarios of distribution networks show possible future active distribution networks with increased flexibility, distributed energy resources (DER) and the role of prosumers. This adds new complexity and responsibilities to the role of the DSO, often being the monopolistic operator of their grid and requires investments to be made to handle the evolution of the grid. These future networks will require rethinking of how DSOs are remunerated for the new services they would be required to provide in addition to their traditional roles of grid operators. Technologies and regulations supporting the energy transition will create new business opportunities in the electricity domain. Capturing this value will enable DSOs to tap into a new revenue stream and finance the transition and

their role in the evolving regulations that defines their responsibilities.

A. Peer-to-peer energy transaction – a future energy market scenario

Towards the decarbonized scenario, as the rate of individual DER integration increases, the distribution network has been transforming to host a bi-directional power flow. The generation is partly shifted to local level with renewable energy sources, hence improved efficiency, to reduce carbon footprint. On one hand, this raises the renewable and clean energy proportion in the power system and reduces the investment pay-off duration for DER. On the other hand, many new actors (e.g. DER owner, microgrid and prosumers, etc.) are included into the ecosystem and the energy market at local level can be formed [1]. As a result, the traditional reliance on electrical grid is reduced while auto-consumption degree and the resilience in disaster relief are improved.

A local energy market level can support peer-to-peer (P2P) transactions at different scales: intra-microgrid, inter-microgrid and inter-distribution grid (or DSO) [2]. This bottom-up interaction and exchange of electricity requires the advanced solutions in both microgrid technologies and energy market policies. It is noteworthy to remark that the energy ‘markets’ is not necessarily limited to retail markets, but also energy and power markets for balancing purposes and ancillary services.

In a P2P energy trading ecosystem, the consumers become prosumers and are matched with their peers to exchange surplus and deficit electricity (with or without the possibility of bidding). A P2P market implementation in reality is however challenging due to: unbalance between supply and demand due to the intermittency of renewable energy production at local level, lack of supporting infrastructures and the trust issues among participants. P2P contract, payment

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and execution happen in different timings, given the nature of the exchanged item – i.e. electricity. Without the presence of a trusted middle-man, distributed ledgers (i.e. liberal P2P models) are being proposed as a mean to implement P2P market [3]. This approach reduces the transaction fees and the unbalances buy/sell prices, as well as the vulnerability of single point of failure and privacy leakage [4].

B. DSO role in the future P2P energy trading landscape

The emergence of P2P energy trading frameworks threatens the sustainable revenue of the DSO and energy retailers (18%–74% decrease as pointed out in [5]), mainly from load risk and price risk [6]. The traditional business model of electric utility is based on electricity production and supplying to the public through the electric grid, charging the customer a price per kilowatt-hour of electricity that allows for the recovery of fixed costs, operation expenses, and a rate of return on their investments. The development of smart grid, with an increasing penetration of DER, smart meters, EVs, DGs, heat pumps and storage, disrupts this model (i.e. increase management and ancillary service cost, stagnant electricity demand due to demand-side management strategies and energy efficiency efforts) and requires the DSO to consider alternative business models to remain viable and realize the potential benefits of its portfolio of responsive demand, storage and controllable generation assets that can be used to actively contribute to both distribution network and wider system operation [7], [8].

The P2P ecosystem consists of a complementary mix of centralized and distributed resources including generation, energy storage, power flow and stability control devices, and control systems including sensing devices and load management capabilities. These resources are owned and controlled by a number of parties, including utilities, merchant distributed generators, merchant energy storage, demand aggregators, and energy services firms and customers. DSO will play a key role in managing the electricity network in smart grid, with increased support for DERs and collection of distribution network data. The DSO tasks, including planning, operating and maintaining of distribution network, could be disaggregated into a set of DSO services, which are necessary to the good functionality of the P2P energy trading network.

From this analysis of the status-quo, we propose in the next sections the complementary business models for DSO, taking into account the competitive advantages and the position of the DSO in a P2P energy ecosystem.

II. BUSINESS MODEL EVOLUTION IN FUTURE SMART DISTRIBUTION GRID

A. Business model in future smart distribution grid

The concept of business model might mean different things in the literature according to the domains, the components that go into the analysis and the models used to conceptualize these components. Along the development history, the concept has been evolving from very basic

definition of business strategy [9] to the structuration [10] and the conceptualization of value creation, proposition and capture [11]. Nowadays, a business model is seen as a means for exploring and exploiting future opportunities and competitive advantages [12]. The business model is required to be defined in an ecosystem perspective among network of companies and stakeholders [13].

In general, a business model aims to describe the way an entity creates, delivers and captures value, be it real assets, opportunities or competitive advantages. Particularly, in the context of future intelligent distribution grid, the business model of a DSO plays an important role in network investment planning and innovations and dictates how DSOs can invest in future smart grid technologies and fulfill their responsibilities as grid operators at the same time. Natively, the traditional business model in power system was seen as a basic value creation (energy generation), value proposition (transmission and distribution) and value capture from its clients. This business model has slightly shifted alongside the deployment of electronic management and metering, marketing and payment, etc. However, the core of the business model, depending on the unidirectional power system, stays more or less the same.

In response to the requirements of providing better support for a higher penetration of Distributed Renewable Energy Sources (DRES) and introducing a wide range of beyond state of the art applications based on integration of ICT, the traditional power system has been evolving itself into a multi-layered smart grid [14]. Distribution level DRES allow consumers to become prosumers as they can feed back the generated energy to the grid. P2P trading framework benefits both the network operators (in term of peak load management, regulation of voltage/frequency, etc.) and the end users (in term of energy security, shortening the payback period and reducing carbon footprint) [15]. These developments change dramatically the way the power system functioning and pose serious challenges as well as opportunities to the current energy business model. Various initiatives are registered in a common effort to redesign the business model towards a P2P transaction power system, including idealized free energy market using advanced distributed ledger technologies [16] but as highlighted in [3], several technological and regulatory challenges need to be overcome.

The future business model for Distribution Service Operator (DSO) has to be positioned in the vision of future multi-domain, multi-vector ecosystem (i.e. smart city) and P2P perspective, exploring and taking into account the competitive advantages (e.g. the existing grid, Quality of Service expertise) and future opportunities (e.g. prosumer, flexibility market, decentralized architecture). In that vision, DSO may shift from the traditional asset providing business model to a portfolio of advanced network services providing business model: Energy transportation, power quality, access service and market facilitation services. With the development of cloud computing and artificial intelligence (AI), as-a-Service (aaS) architecture can be employed to reduce

investment cost and securely and efficiently deliver the service [17].

B. Challenges and opportunities

The DSO business model has to be defined in the evolving ecosystem with parallel consideration of the architectural transition from unidirectional to bi-directional in the power system itself (e.g. new stakeholders in the energy value chain, the creation of a flexibility market [18]). However, along with the advantages, maintaining the quality of service is now much more challenging for the DSO, while the penalties for not delivery is also a concern for prosumers and microgrid.

In this context, we can highlight the key drivers on business model transformation in Table 1.

Table 1: Key drivers for the transformation of business model in future distribution grid.

Regulatory aspect	Economic policy – austerity vs. fiscal expansion
	Deregulation / liberalization of the energy markets
	Policy for energy mix, emissions, dynamic pricing etc.
	Decentralization
	Revenue incentives to DSO/utilities
	Trend for further autonomy of the energy consumers
Technological aspect	Availability of and access to resources (fuels and materials unreality, ignorance)
	Digitalization
	Breakthroughs in key enabling technologies (e.g. compact and cheap storage assets)
	Technological fears about the ability of the network to implement the distributed generation
	Grid security and resiliency
	Demand growth, new loads (e.g., EV) and effects on load distribution
	Outdated system
	Intelligent energy management.
	Transformation of energy consumers to prosumers
	New services to grid and clients
	New stakeholders in the energy value chain

The traditional asset management business model may not be the most adapted to these challenges and it is the opportunity for new ones, be it for liberal P2P energy transaction stakeholders or for the DSO. Technically, it requires an infrastructure transformation at grid scale because the smart grid, even distributed, is holistic and integrated. In terms of regulation, the slow pace of adaptation is posing a barrier to the paradigm shifting and adaptation of new technology (e.g. blockchain) [16]. Some transitive models were proposed in the literature [19]. Notable common points of these models can be summarized in Table 2.

Table 2: Common points of transitive business models.

Reform of Rate structure	Shifting from the traditional cost of service (COS) rate structure to Performance-based Ratemaking (PBR) structure for improving performance.
Prioritization of DRES integration	Harmonization of both utility scale and DER into the power system without penalty.
Customer Engagement	The customer has greater control over their consumption program and flexible negotiation of energy price with the utility. The consumer becomes prosumer and feeds back their energy to the grid.
Incentives and Revenues	The structure differs from model to model and leads to different consequences for stakeholders. These models will benefit participating customers and society at large.
Sustainability	Generally unsustainable in the scenario of low electrical load growth and high DER penetration. The utility suffers from electrical demand drops while the maintaining cost remains unchanged (or increased due to high DER penetration). New revenue source needs to be investigated for the utility in this ecosystem.
Regulatory problem	Uneven fiscal impacts
Limitations	Once a saturation point is reached, additional DER will have limited value to the overall system. Physical and fiscal limitations of peer-to-peer transactions.

III. COMPLEMENTARY BUSINESS MODELS FOR DSO

In our vision, the values of the DSO in a P2P ecosystem that can be used as their competitive advantages are:

- **Value 1:** The DSO is responsible and has the necessary infrastructure and expertise to transport and to supervise the delivered electricity according to the smart contract.
- **Value 2:** The DSO possesses the necessary tools and expertise in maintaining the power quality over the network via monitoring, control and feedback, voltage control, frequency control, thermal capacity control, flexibility forecasting, and network load feedback. While the participating energy suppliers may ensure the power quality at their output, it is the DSO who coordinates all those power inputs and demands to guarantee network stability and to deliver the best quality power to the end users. In the case of a P2P framework among microgrid, the DSO can provide these services to the microgrid operators for the regulation inside the microgrid, via outsourced SCADA or via SCADA-as-a-service approach for an additional income.
- **Value 3:** DSO while being a market platform operator can efficiently play the role of middle man and trust service to match the demand and supply from users.
- **Value 4:** Along with the advanced services, the DSO collects throughout its network a huge amount of historical and real-time data, which is a very valuable input for the

advanced applications (e.g. artificial intelligence, digital twin, real-time forecasting, etc.). A possible business model for the DSO is leasing the data to the required third parties as an information broker, or acting as a trust service to validate their applications against the real functioning data.

- **Value 5:** Another potential value of the utility that can be a revenue stream is the deployment of EV charging infrastructure.

Based on this analysis, two high-level complementary business models for the utility in a P2P energy trading ecosystem are proposed thanks to its competitive advantages.

A. DSO as a P2P platform operator and Market maker

The main idea of this business model is the transformation of the DSO from the traditional supplier to a P2P platform operator and market maker. The utility may arrange contract with the market players (generators, retailers, prosumer, microgrid, etc.) to contribute to the uptake and the maintenance of grid stability. This may benefit not only the consumers but also the utility and the market players as the power quality increases and the grid stability (i.e. the energy transaction platform) is maintained. In this business model, benefits for the DSO no longer come from energy supplying as in traditional model, but rather come from the different charges from transactions, membership and extra-services.

- **Commission:** The DSO charges a commission (percentage) from each transaction that goes through the platform.
- **Subscription fee:** a membership fee is required to be able to access to the marketplace.
- **Listing fee:** A fee could be added when providers post new listing of their products (i.e. energy, smart appliances, installation and calibration).
- **Lead fee:** Lead fees is a tax between the listing fee and the commission models where customers post requests on the platform, and providers pay in order to make a bid for these customers.

Regardless of the chosen option, it is important to ensure a seamless management and integration of the market place and the electrical delivery, as well as to be transparent in the business model (commission, subscription, etc.). An important element that needs to be considered in the establishment of the business model is the cost of reserve and back up. Nowadays, the grid is considered a critical infrastructure and is insured via a variety of back up method (e.g. frequency reserve, backup generators, flexibility, etc.) in case of outage. This insurance cost is now covered by the utility (via a percentage of the electricity price or via helps from the government. The insurance methods will benefit also the prosumer and the DRES installation owners in a P2P framework (i.e. grid uptake, power quality). Therefore, the utility should be compensated for these costs.

This business model incentivizes the utility for the integration of DRES from third parties as permitting it to receive revenue as an intermediary that connects energy consumers and retailers, actualizes the energy delivery and ensures the power quality. Issued from the ecosystem, the pricing aspect of the business model has to reflect the new dynamics of the market, including needs for quality, elasticity of demand, environmental and service preference, ability to provide services as resources, increased volatility, availability of more granular data, etc.

Another perspective for DSO as the platform operator is balancing services market and electric vehicle market. The electrification of transportation is one of the largest potential revenue streams for the utility. The deployment of public charging infrastructure requires wide spread reach and good management of congestion that the utility operator is capable of.

Besides the aforementioned advantages, the proposed business model also has some limitations that may influence its applicability to massive DRES deployment in distribution grid. In distribution grid with a small amount of residential transactions, the premium will be relatively high and the DSO will have a hard time finding customers. The DSO however cannot expand its customer base outside of its designated area. Additionally, DRES markets will be affected by seasonality (especially PV), and the volume of transactions will vary greatly depending on geographic location. Distribution markets might not develop into mature, robust markets, which will limit the utility's transaction fees.

All in all, while benefiting both the DSO and the prosumers/microgrids in the P2P framework, the business model still not sufficiently sustainable for the DSO because of the dependency of the revenue stream on the customers base and the intermittency of DRES generation and demand. A combination with additional business model is needed.

B. DSO as a service supplier

The massive integration of DERs has transformed regional distribution networks into systems with a series of network-connected resources of demand, energy storage and generation resources. As the intermittency of production raises, it is required that the DSO and the DRES installation implement rigorous energy services and balancing operations to maintain the power quality as well as the good functionality of the power grid. The DSO, with advanced control and communication capabilities at their disposal, has significant competitive advantages to provide energy services to their customers and to offer energy services to adjacent DSOs.

The potential services that can be provided by the DSO to support the operation of P2P market platform are investigated in the following.

1) Personalized Customer Engagement Services

Business models are changing and becoming more customer-centric and dependent on customer interactions,

especially for the P2P energy exchange framework. Via the data collected by the AMI, the DSO can provide a personalized customer profile and customize the proposal of demand-response or the individual electricity price.

2) *Market Analytics*

Usually the electricity suppliers perform real-time analysis of the wholesale and retail market to determine return-on-investment for optimizing profitability or for reducing costs. In a P2P framework, the DSO can then provide these analytic expertise and tools as advising services on power market design and grid regulation, on the implications of power market rules, trading mechanisms, electricity tariffs and ancillary services structures to assess their effect on the business. Market analysis services include the forecasting of electricity and gas market prices, spot and forward, as well as the risk management of uncertainties like weather forecast, fuel prices, demand forecast, and unpredictable events. Besides, market analysis may include methods to study grid congestion in power markets and finally being able to provide services to their users, what could be a very important issue for providing P2P energy exchanges both locally and to the wholesale market.

3) *Demand and Renewable Forecasts*

Renewable sources of energy are not constant and with high level of intermittency. At the same time, the electrical loads in the distribution system are highly variables, especially when new types of loads such as electric vehicles, heat-pumps, etc., are being increasingly used. In order to control and to ensure stability of a distribution grid with high level of penetration of renewable energy as accurately as possible, the development of a short-term (or ideally very-short term) forecasting of load and renewable generation plays a very important role. Errors in electricity demand and production forecast generate a considerable amount of risk for suppliers due to the involved financial penalties. To avoid this, the DRES installation need to use the service of third party companies specialized on load/production forecasting, via utilizing their forecasting software platform or procuring them directly with the results of their own forecasting studies (Forecasting-as-a-service).

Thanks to its high level of experience and knowledge in the field, the DSO is capable to provide highly accurate energy demand and renewable energy generation forecasts. In return, this service would represent sustainable revenue for the DSO in the P2P ecosystem.

4) *Flexibility Capacity Forecast*

The flexibility capacity forecasting is as important as demand and renewable forecast, especially in case of unbalance of demand and supply. The evaluation of the DR potential could be done ex-ante, analyzing a set of variables that might contribute to participation like the availability of dynamic pricing and smart meters or the deployment of smart appliances. Besides, there could be important differences in

the estimated potential by region taking into account factors such as the prevalence of air conditioning or electric heating.

An efficient flexibility capacity forecast requires real data already collected from smart meters, smart appliances or Energy Management Systems and apply mathematical models and adaptive analytics to better account for serial correlation. The DSO can contribute greatly to this analysis as they have access to the required data and have the analytical tools to execute the evaluations. Aggregators have, as one of their key functions, the forecasting of the demand flexibility, in both the short and long term. This estimation allows the aggregator evaluating the impact of different control strategies and therefore, choosing the most appropriate ones for market participation and portfolio optimization. It could also be used to identify the best candidates for a certain DR program. Additionally, the aggregator may need to forecast the aggregated load demand response of a group of customers already subscribed to a direct or indirect load control program.

As in return, the DSO may request a subscription to their service or a commission according to the accuracy of their forecasts.

5) *Advanced controls as a service*

The high ratio of DER integration at distribution level leads to technical difficulty to preserve the security and reliability of network operations and to ensure the fulfillment of the established voltage quality standards. The DSO, with their expertise can offer their advanced control to the microgrid owner or the prosumers, which would be cheaper than developing their own solutions. At a lower level, energy efficiency projects or maintenance of equipment (HVAC, smart appliances) can also be offered to the end customers.

Furthermore, beyond the traditional business model that is limited to the designated area of the DSO, the algorithm can be packed and commercialized to interested parties.

6) *Trust service and information broker – Data-as-a-service*

As aforementioned, trust issue is an important risk in a P2P energy trading ecosystem. The DSO, as the middle man or not, while being the trusted party can provide trust and insurance service for the P2P participants.

Moreover, the trust service is not limited to the guarantee of participant profiles but also to the correctness of information and data. With the rapid expansion of machine learning and artificial intelligence application in the field of energy management, it is very important for the developer to get access to correct and exhaustive data (historical or real-time) of the network. Good data means exact and precise algorithms, hence, better profit.

The DSO, as the network operator and owner of the AMI, has access to these data and may provide them as a service to the developer to get an additional but sustainable income. Involving the process of data gathering, monitoring or data exchange, the issues of privacy and confidentiality should be taken into account. Evidently, the exploitation of this data

service need to respect data protection regulation and the DSO should antecedently gather consumer's agreement before any commercial agreement between the Supplier and the third-party aggregator.

IV. CONCLUSION

In this paper, the emerging risks and the necessity to develop new sustainable business models in a P2P energy ecosystem are highlighted.

We proposed two novel complementary business models for the DSO in an ecosystem of P2P energy exchange:

- DSO as the platform operator of the P2P energy exchange framework, including flexibility market and electric vehicle market: The model provides an integrated structure and organization to facilitate P2P energy and flexibility trading among energy suppliers, aggregators, consumer and prosumers.
- DSO as the service supplier: exploiting the competitive advantages of the DSO (infrastructure, expertise) to provide energy services to their customers and to offer energy services to adjacent operators. The model provides the DSO with sustainable income stream to complement the first model, under intermittent scenario of demand and DRES production.

These analysis and propositions aim to providing inputs to establish future financial strategy and commercialization roadmap of the DSO.

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