NEW BUSINESS MODELS ENABLED BY SMART GRID TECHNOLOGY AND THEIR IMPLICATIONS FOR DSOS

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ABSTRACT

In this paper, new business models (BM) enabled by smart grid technologies are presented and discussed. We focus on the business opportunities for four main agents, namely the Distribution System Operator (DSO), the aggregator, the end-users, and the newly envisioned data service provider. We discuss the challenges and opportunities for the DSO to implement their new BMs and interact with other BMs. We highlight the several regulatory barriers that may still exist for the implementation of each BM. Moreover, this paper also invites for a future stakeholder consultation and a quantitative economic evaluation of each BM. The result of this work in progress should lead to regulatory recommendations to foster the adoption of cost-effective business models.

INTRODUCTION

The deployment of smart grids is leading to profound changes not only in the way electricity is distributed and consumed but also in the businesses associated. The newly deployed (smart meters, network monitoring devices, or home energy management system, among others) will bring more information and automation opportunities for all types of electric consumers. Eventually, this will be translated into new business opportunities for all agents in the electricity value chain, especially at the distribution/consumption side, where most smart grid solutions are being recently deployed.

In this paper, we analyze a set of new business models (BM) enabled by the deployment of different smart grid technologies. These BMs are being studied within InteGrid, a European Research project that aims to “bridge the gap between citizens and technology/solution providers such as utilities, aggregators, manufacturers and all other agents providing energy services” [1].

For the purpose of this study, a business model is defined as a set of **strategies** chosen by a certain agent in order to generate **economic benefit**. These strategies can combine **multiple business plans,** and the economic benefits can be generated by different sources of **revenue streams** and/or **cost reductions**.

Four main agents are focused in this paper, namely Distribution System Operators (DSO), data service providers, aggregators, and end-users. Following this introduction, the next section details the business models for each of the four agents. Finally, conclusions are presented.

NEW BUSINESS MODELS ENABLED BY SMART GRIDS

New Business Models for DSOs

DSOs will assume new roles in the coming years and will conduct more active management of the grid, as already pointed out in the literature [2]–[6] and in line with the Clean Energy Package [7], [8]. Among the most important changes for the DSO, is the procurement of flexibility from local resources for a more active management of the grid.

In some sense, DSOs will get closer to the way TSOs manage their grids. DSOs may no longer resort to grid investments exclusively in order to solve potential operation constraints, also known as the “fit-and-forget” approach in distribution networks (equivalent to the “copperplate” approach in transmission networks). Instead, DSOs will balance network investments with local service acquisition in order to reach a more efficient grid cost. This evolution of the DSO understanding is illustrated in Figure 1.

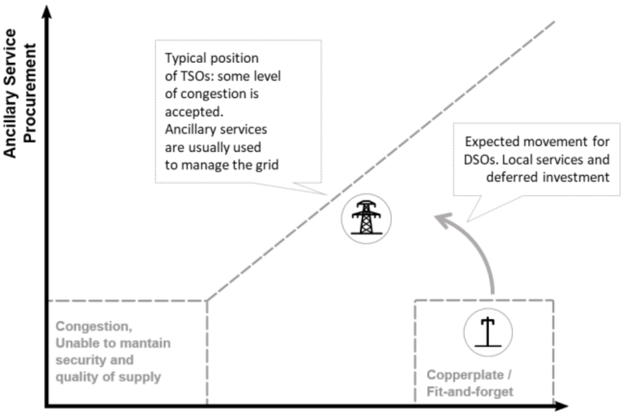

Figure 1: Expected movement for DSOs

DSO procures DER flexibility

The main aim of this business model for a DSO is to reduce the investment costs thanks to a more active grid operation, i.e., by using the flexibility provided by resources connected to the distribution grid for grid management purposes. More specifically, this BM focuses on the operational planning stage, when available flexibilities can be booked, as well as the remedial actions and flexibility

activation when this is needed in real-time.
The evolution illustrated in Figure 1 can be seen as one new business model for DSOs. They may reduce overall grid management costs by using services provided by flexible Distributed Energy Resources (DER). These services may include congestion management, voltage control, and islanded operation.
For this business model to be possible, regulation has an important role in allowing DSO to carry these changes in the way the grid is managed. We identify three main regulatory topics that may limit the possibility for DSOs to be able to procure flexibility from DER. Firstly, revenue regulation is essential to determine to what extent DSOs are encouraged to resort to distributed flexibilities in order to defer grid investments or, on the contrary, whether they have strong incentives to increase their asset base as this will result in higher profits. Secondly, network charges, and more specifically grid connection charges, are an important topic when incremental investments would be driven by the connection of new grid users. Being this the case, the applicants for connection may be forced to cover the full expenses of the connection, thus eliminating any potential gain for DSOs from the use of flexibility. Lastly, in order to contract flexibility from resources at the distribution network, regulatory mechanisms enabling DER to provide ancillary services to Transmission System Operators (TSO) and DSOs need to be in place.

DSO improves continuity of supply

In this business model, the main economic benefit for the DSO is the reduction of maintenance cost and, in case regulatory incentives are in place, the improvement in the continuity of supply indicators. The DSO achieves these objectives by improving fault detection and asset monitoring and maintenance.
On the one hand, the DSO may increase the distribution grid reliability by improving asset management. DSOs may achieve this result by performing health diagnostics and preventive maintenance planning of assets. Vital information for critical network assets (e.g., the historical oil temperature of transformers, number of short-circuits sustained, or number of switching actions performed) can be collected using advanced metering infrastructure and processed with tools that can diagnose and assess the current technical conditions and trigger probabilistic alarms to schedule maintenance actions.
On the other hand, the DSO can improve repair actions of unplanned outages using sensor data, historical information, remote equipment diagnostics, and automation. The expected result is a reduction in the outage time and, consequently, an improvement in the continuity of supply indexes.
Therefore, for the development of this business model, regulation should provide the appropriate incentives for improvement in continuity of supply indexes. Otherwise, DSOs may see little incentive to deploy the required technologies. Nonetheless, output-based mechanisms with performance-based rewards and penalties with respect to the base allowed revenues seem to be a common type of incentive for this purpose. To incentivize continuity of supply, for instance, many European countries adopt a combination of rewards and penalties [9]. Additionally, DSOs may also be incentivized through special mechanisms to deploy innovative assets, such as the enhanced monitoring and automation devices required for this business model (at least on a temporary basis for learning purposes). Finally, in addition to grid monitoring devices, smart metering data could be potentially used to improve fault location processes.

New Business Models for Data Service Providers

In the light of the deployment of smart metering technologies, more consumption information will be collected and stored. This information, although being a property for the end-user, may be the source for business opportunities, provided that data protection regulation is respected. Therefore, a new agent in the power sector may be envisioned, namely the "data service provider". This agent is expected to use the data produced by smart grid solutions (especially metered data) to provide services to other agents, such as retailers, DER owners, aggregators, final consumers, etc.
Several different services can be envisioned for the new data service provider. Hereafter some of them are listed:

- Forecast provision (with high geographical granularity): load and generation forecast based on anonymized data collected. The forecasts can be used by DSOs, TSOs, Retailers, Aggregators, etc.
- DER sizing: information for consumers/prosumers on the best size of battery storage and PV panels.
- Electricity usage intelligence: for end-users (industrial and residential consumers). Information on how and when to offer flexibility and how to improve consumption pattern according to price signals.
- Portfolio management: analysis for aggregators on the best mix of resources to compose a portfolio. The analysis may consider past load and generation data, complementarity between DER profiles, market data, locational specificities, and forecasts.
- Customer engagement strategies: retailers may be offered services based on anonymized data to improve their customer engagement strategies.

One can also notice that the data service provider can be an independent agent but can also be part of a previously existent business. ESCOs and retailers can possibly offer one or more data services. In fact, in some countries, this is already happening. Several data services are already being offered to consumers by retailers or other

companies, for instance. An example of an existing company providing consumer engagement services is the American company Opower. The company started by sending “reports and alerts, via mail and email, that compare consumers’ energy use to their neighbors’ and provide targeted energy saving recommendations” [10]. Opower’s revenues are generated by selling subscriptions of the software to utilities.
It is also important to notice that some regulatory barriers may exist for the fostering of the data service provider activity, mainly on data access restrictions. In some countries, consumption data can only be accessed by certain players (only retailers in Portugal for instance). Additionally, the model chosen for data access and management may also be a barrier to this business model. For the data service provider provide services, efficient data access must be in place, so that data can be accessed efficiently and the necessary consents from consumers can be equally managed efficiently.
Therefore, two main enablers for this business model may be listed. Firstly, a robust data management model has to be implemented for efficient data access by third parties. Secondly, consumers should feel confident in sharing their meter data, so services can be provided, given that personal data protection is ensured at all times.

New Business Models through Aggregation

Aggregation will most certainly enable different business opportunities for different agents in the power sector. In this section, we identify three main business models for aggregators, namely (1) reducing imbalance costs, (2) exploring flexibility through the Commercial Virtual Power Plant (VPP), and (3) exploring flexibility through the Technical VPP.

Reducing Imbalance Costs Through Aggregation

In this BM, the Balance Responsible Party (BRP) is the main agent. The most interested BRP for this BM is the retailer, who can use the flexibility provided by its customers to manage imbalances. As of today, retailers have to manage imbalances by either trading in the intraday market or face imbalance penalties. With the development of aggregation and the use of advanced technology such as the Home Energy Management System (HEMS), retailers will be able to use the flexibility from their clients to reduce imbalances and therefore reduce the costs associated with imbalances.
This business model, however, imposes several questions on the strategy retailers should adopt, such as which customers to consider and how to remunerate flexibility providers.
On the one hand, retailers should choose the best customers to provide flexibility and therefore maximize the effectiveness of the business model. On the other hand, for the customers that agree on offering their flexibility to the retailer, a remuneration strategy will be necessary. It is important to notice that customers will also be able to offer their flexibility to other players. Therefore, remuneration must be competitive.

Exploring flexibility through the Commercial VPP

The Virtual Power Plant is defined as the aggregation of several small DER units in a “single generating unit” that can behave as a conventional large scale unit [11]. The literature classifies VPPs in two types, namely the commercial VPP (cVPP) and the technical VPP (tVPP) [11]–[13]. The former uses aggregated flexibility to participate in energy and TSO-run markets, while the latter provides grid services for DSOs.
Therefore, this business model tackles the independent aggregator that participates in energy and service markets, acting as a cVPP. More specifically, we focus on the cVPP that participates in balancing markets, providing Ancillary Services for TSOs.
For the success of this business model, from the perspective of the independent aggregator, several aspects must be considered. Firstly, the cVPP operator has to set the DER portfolio, considering location in the grid and type of DER (residential consumer, prosumer, voltage level, etc.). Secondly, it is expected that one aggregator can act as both cVPP and tVPP. Therefore, the aggregator will have to decide on the share of the portfolio dedicated to one and to the other types of VPP. Lastly, aggregators will have to engage consumers and prosumers by offering an interesting remuneration while maintaining the profitability of the VPP.
Several regulatory topics are key to the successful development of this new business model. On the one hand, regulation on aggregation must be enhanced (loads, generation and both), especially the one regarding the independent aggregator. There are still many misaligned incentives when considering the responsibilities of BRPs, retailers and independent aggregators [14].
The implementation of the cVPP may also have an impact on the operation of distribution networks. As aggregators offer DER to TSOs, DSOs may be impacted when these resources are activated. Therefore, an adequate DSO-TSO coordination is crucial for enabling cVPP without creating congestion in the distribution network.

Exploring flexibility through the Technical VPP

This business model shares many aspects with the previous one. The main agent is still the independent aggregator that will aim profits from the aggregation activity. In this business model, however, the tVPP will provide grid services to the DSO, such as congestion management, voltage control, and islanded operation.
The independent aggregators (possible the same agent that also operates a cVPP), will face similar challenges such as portfolio management and customer engagement. Additionally, the profitability of the tVPP will be impacted

by how DSOs will procure local resources for non-frequency ancillary services. In this regards, the Clean Energy Package states that DSOs should procure these services through transparent, non-discriminatory and market-based procedure whenever possible[1]. However, a market mechanism may not be difficult to implement in situations in which the liquidity is low due to the nature of the product. Local congestion management, for instance, will rely on the position of the resource on the grid, in which a market could be limited to a single feeder. Thus, alternative mechanisms may be necessary (e.g., standardized contracts, auction-based allocation mechanisms, etc.).
In some sense, this business model is a counterpart of the DSO's business model of DER flexibility procurement. Strategies adopted by the DSO on their business model will directly impact the viability of this one.

New Business Models for End-Users

Finally, the last set of business models tackles the end-user that aims at reducing the electricity bill. As industrial and residential consumers may follow different strategies to achieve this objective, two business models are envisioned (commercial consumers should fit in one of the two business models, depending on their size).
For both of them, the regulatory topics with bigger impact are the design of tariffs and the regulation on self-generation. On the one hand, tariff design, both the level and structure (i.e., the weight of fixed, capacity-based and energy-based charges), will set the price signals to which consumers will be able to react. On the other hand, regulation on self-generation will determine what the alternatives in terms of production (or "prosumption") of electricity are. Consumers may opt for the installation of DG to reduce overall electricity expenditure, and therefore regulation will determine what taxes apply if exceeding energy can be sold to the grid, if net-metering is allowed. Lastly, the deployment of smart metering is essential for this business model as the most advanced strategies for cost reduction as well as an efficient billing of the energy self-generated require this technology. Apart from these three topics, if a consumer wants to offer services to the grid, through an aggregator or individually (in the case of industrial consumers), this possibility has to be defined by regulation as well. As of today, the participation of Demand Response (DR) in most European ancillary service markets, for instance, is not fully supported [15]. Besides explicit allowing demand response, the market design could also be inclusive for DR by setting small bid sizes, and accepting for example asymmetrical bids.

Industrial Customers Minimizing Energy Cost

Industrial consumers can adopt different strategies to minimize electricity cost. Energy Price response is the first possibility. Industrial consumers can adapt their consumption according to energy prices. For energy-intensive industries such as metals (steel, aluminum or copper), paper, chemicals, and textile may make sense to reduce production if electricity price goes above a certain level. Besides energy prices, network tariff response is also a possibility, in case they are designed in a dynamic or time-dependent way. Two network charge design options that may enable this response are the dynamic tariff response and the Time-of-Use (ToU) network tariff response.
The industrial consumer may also decide to install DER and self-generation. They can own generators (directly connected to their facilities or not). If DER is installed on the industrial facility's premises, self-generation is also a possibility, that may also increase the potential for industrial consumers to offer services to TSO and DSO, aggregated or individually.
Finally, most innovative strategies include participation in closed distribution systems and peer-to-peer (P2P) trading. Regulation already foresees the possibility of the closed distribution system (3rd Energy Package). This initiative allows industrial consumers to operate a closed network jointly and possibly reduce network costs. One possibility could be balancing the consumption on the same node. Industrial consumers may also be able to trade energy services among themselves through the use of peer-to-peer technology in the future.

Residential Customers Minimizing Energy Cost

As the industrial consumer, the residential consumer can also reduce electricity costs by improving energy consumption management and by offering flexibility to DSO, TSO, retailers, and aggregators. In this sense, some of the strategies are similar to the ones adopted by industrial consumers, such as energy price and network tariff response. Therefore, we highlight the different strategies residential consumers may adopt.
The installation of DER and self-generation by residential consumers is already a known practice, as several technologies are available such as PV, small wind turbines and batteries. Apart from that, consumers can also opt among several financial schemes to install the DER like leasing and financing.
The participation in "Energy communities" is also a novelty. Introduced by the Clean Energy Package, the Energy Communities are also a possibility for residential consumers. Although it is still not clear in the regulation the scope of these communities, they are expected to allow consumers to manage electricity consumption and therefore reduce costs jointly. In fact, several EU countries already allow local energy communities in the form of cooperatives [16], while others are implementing regulations that will allow such initiatives. Spain, for

1 Electricity Directive, Article 31(5).

instance, has recently published a new regulation that enables "shared self-consumption," meaning that several consumers will be able to group and benefit from one DER installation [17].

As for the industrial consumers, residential consumers can also provide flexibility to the DSO and the TSO, and additionally, they can also offer flexibility to retailers and Independent aggregators. Retailers would want to buy flexibility for their internal balancing management, and aggregators would resell the flexibility to system operators.

Finally, residential consumers may enter into energy performance contracts. Retailers may offer contracts based on demand-side management indicators.

CONCLUSIONS

This paper presented new business models that may be enabled by the deployment of new technologies at the distribution side of power sectors. We highlight that DSOs, aggregators, end-users and the new data service provider may profit from these business models. We also point to the interdependency of these business models, as one business model may be the counterpart of another. However, despite all the benefits that may arise from the new opportunities, several regulatory barriers still exist.

Finally, we acknowledge that this study is a work in progress. Within the InteGrid project, the business models here presented will go through a stakeholder consultation process to understand their relevance and the concerns from practitioners. In the end, regulatory recommendations to foster the adoption of cost-effective business models will be provided. This work also invites for a cost-benefit and scalability-replicability analysis, in order to verify the financial viability of each of the business models.

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