Analysis of Flexibility-centric Energy and Cross-sector Business Models

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2023 19th International Conference on the European Energy Market (EEM) | 979-8-3503-1258-4/23/$31.00 ©2023 IEEE | DOI: 10.1109/EEM58374.2023.10161816

***Abstract*— The new energy policies adopted by the European Union are set to help in the decarbonization of the energy system. In this context, the share of Variable Renewable Energy Sources is growing, affecting electricity markets, and increasing the need for system flexibility to accommodate their volatility. For this reason, legislation and incentives are being developed to engage consumers in the power sector activities and in providing their potential flexibility in the scope of grid system services. This work identifies energy and cross-sector Business Models (BM) centered on or linked to the provision of distributed flexibility to the DSO and TSO, building on those found in previous research projects or from companies' commercial proposals. These BM are described and classified according to the main actor. The remaining actors, their roles, the interactions among them, how value is created by the BM activities and their value propositions are also described.**

***Index Terms*— cross-sector business models, distributed energy resources, flexibility, flexibility business models**

I. Introduction

The global electricity demand keeps growing [1], and, at the same time, there is a pressing need to reach sustainable development. Renewable energy sources (RES) such as wind and solar power have gained significant attention due to their potential to help in reducing the dependency from fossil fuels, reducing carbon emissions, and mitigating climate change. As RES penetration increases, conventional fossil fuel power plants, easily dispatchable and traditionally the main providers of system flexibility, are also being decommissioned. However, as many RES are highly variable, balancing production and consumption can become a significant challenge [2] which explains why additional flexibility is needed. At the same time, the increment of Distributed Energy Resources (DER) is increasing the complexity of distribution grid operation and the needs of additional flexibility. In this scope [3] provides a review on conventional and new system services needs.

To achieve these economic and environmental goals, the European energy sector is undergoing significant changes. In the European Union (EU) new policies and regulations are being introduced to promote the integration of RES into the existing energy infrastructure. For instance, the Clean Energy for all Europeans package [4], the Energy Union Strategy [5] and the Fit for 55 [6] are some of the measures aiming to create a more sustainable yet secure energy system. These legislations require active Renewable Energy Communities (REC) and Citizens Energy Communities (CEC) to be integrated with electricity markets, and to promote the development of flexible demand and generation. However, today, most of the prevailing Business Models (BM) in the energy sector still ignore the possibility of consumers being active participant in the market (both wholesale and flexibility markets) [7]. In this setting, it is essential to conceive new possibilities and explore innovative BM that support the creation of distributed flexibility by identifying and improving its value for all the involved parties.

In this context, this paper provides an analysis and thorough review of relevant energy and cross-sector BM related to the provision of flexibility from DER for grid operation. The structure and main characteristics of these BM are described, and the main roles, the interactions among them and the value created for these main roles are also identified.

To carry out this review, the content and main outcomes of several research projects and research journal publications were studied. In addition, we also analysed models already adopted or being proposed by companies and the services and solutions provided by several firms linked to the energy sector. The projects and companies revised were organized in the following areas: DER provision (Iberdrola, EDP, Connected Energy, AlphaESS, SunPower), Energy as a Service (EaaS) (Repsol, Plico Energy, Otovo, Veea, WattLogic, Tridens), consumers (InteGrid, Nobel Grid), REC/CEC (FLEXCoop, REScoop), health and/or safety services (Interconnect, Control4, Smarthomes Solutions), EV charging (FLOWER, Bia, WeaveGrid) and power grids operation (InteGrid, Nobel Grid, EUniversal). The relevance of each source was evaluated, and the gathered information synthesized to identify key areas and trends. In view of this, the main contributions of this work are:

- A comprehensive analysis of multiple BM for the flexibility-centric value chain, either found in projects or developed by industrial and services companies.

- A review of the roles and role interactions, as the building blocks of existing and new BM, which produces new or complementary contributions to the Harmonised Electricity Market Role Model (HEMRM) developed and maintained by ebIX, EFET and ENTSO-E, and that go beyond the power system sector. Indeed, BM are materialized when real actors decide to adopt different sets of roles, and in such a way they are here described. In this sense, more complex BM to stack up more value and increase the participants value are built by the wise adoption of advanced and complementary roles by the involved actors.
- The provision of insights into the structure of each BM, to help stakeholders in making informed decisions when adopting them.

Aside from this introductory section, the complete role model is described in section II, with the most relevant roles and their interactions identified, section III describes the main BM analysed, and section IV concludes.

II. Role model and Roles Interactions

The approach followed is based on the assumption that BM can be described and designed by the different roles assumed by the involved actors, provided that the main roles and the conceptual interactions among them are properly identified. Across the reviewed literature, a role is usually defined as an intended behaviour of a business party, which is unique, cannot be shared, and intends to satisfy a service or a transaction [8], [9]. Roles are performed by actors and each actor can perform one or multiple roles at the same time. Therefore, while a role expresses a set of skills, competencies, and responsibilities and is more associated with business processes and/or tasks, an actor is usually associated with a human user or an organization [10]. Moreover, although each role can typically be performed by several actors and actors can aggregate several roles, legal limitations may come from the existing regulatory setting [11]. The majority of the roles considered in this paper are those defined in the HEMRM [12]. Still, this roles definition is much focused on the power sector activities, and some new roles were also added to complement with other related activities.

A. *Roles description*

The available BM include a total amount of 20 roles, which are, in alphabetic order, the following.

- Balance Responsible Party (BRP) – accountable for managing its energy imbalances [12];
- Billing Agent – responsible for sending invoices to other parties [12];
- Consumer – purchases and consumes electricity [12];
- Data Exchange Platform (DEP) Operator – owns and operates a communication system to transfer data [12];
- Data Provider – has a mandate to provide data to other parties [12];
- DER Manager – responsible for controlling DER, similar to the one described in [13]. It was segregated from the ESCo role which is more oriented to consultancy (see below);
- DER Provider – responsible for installing and/or maintaining assets related with distributed energy equipment (e.g., PV panels, batteries, smart-devices), which are provided or sold to other market participants [14], [15];
- Distribution System Operator (DSO) – responsible for the security of supply and reliability of a distribution grid [12];
- Energy Community Manager (ECM) – responsible for managing business activities within an Energy Community (EC) [16], such as a REC or a CEC;
- Energy Service Company (ESCo) – offers energy related services, but without direct participation in the energy value chain [12]. Provides insights and energy management services [12], and implements both energy efficiency and renewable energy projects [17];
- Energy Supplier (or retailer) – supplies or takes electricity from a party connected to the grid [12];
- Financing Entity – party, in a financing arrangement, that provides money, property, or other assets to a certain financed entity [18];
- Flexibility Market Operator (FMO) – links entities providing flexibility with the entities procuring it [19];
- ICT/SW/DP Provider – supports other entities with ICT (Information and Communications Technology), Software (SW) or Digital Platforms (DP) [20];
- Manufacturer – manufactures specific products [21], which are later supplied to other market agents;
- Meter Data Collector – responsible for meter readings and for their quality [12];
- Prosumer – consumer who can produce energy [22], joining the roles of Consumer and Producer [12] under one role;
- Resource Aggregator – collects and combines several flexibility offers from multiple resources, calculates the available flexibility for its portfolio [12], [19] and is able to sell, buy or auction in electricity markets [23];
- Service Company (SCo) – it provides non-energy related services and, as such, its revenue comes from providing services instead of selling products [24], [25]. The SCo can offer cross-sector services.
- Transmission System Operator (TSO) – responsible for the security of supply and reliability of a transmission grid [12];

By establishing relations between the actors and the roles performed, multiple BM can be described and created. The possible and most relevant interactions between all the described roles are represented in Fig. 1 as the basis for the description of all BM. Colored arrows represent different interactions in terms of energy, flexibility, monetary, data and assets/services provided. In the center are the Prosumers, as the potential flexibility providers. On the left-side are the roles related with flexibility assets provision, including financing and energy services; on the top, the roles related with energy supply and energy metering; on the bottom, the roles related with data management and cross-sector services and ICT and software tools and platforms providers, that can profit from these data to implement those services and tools; finally on the center and right, the roles related to flexibility aggregation, market management, and flexibility acquisition.

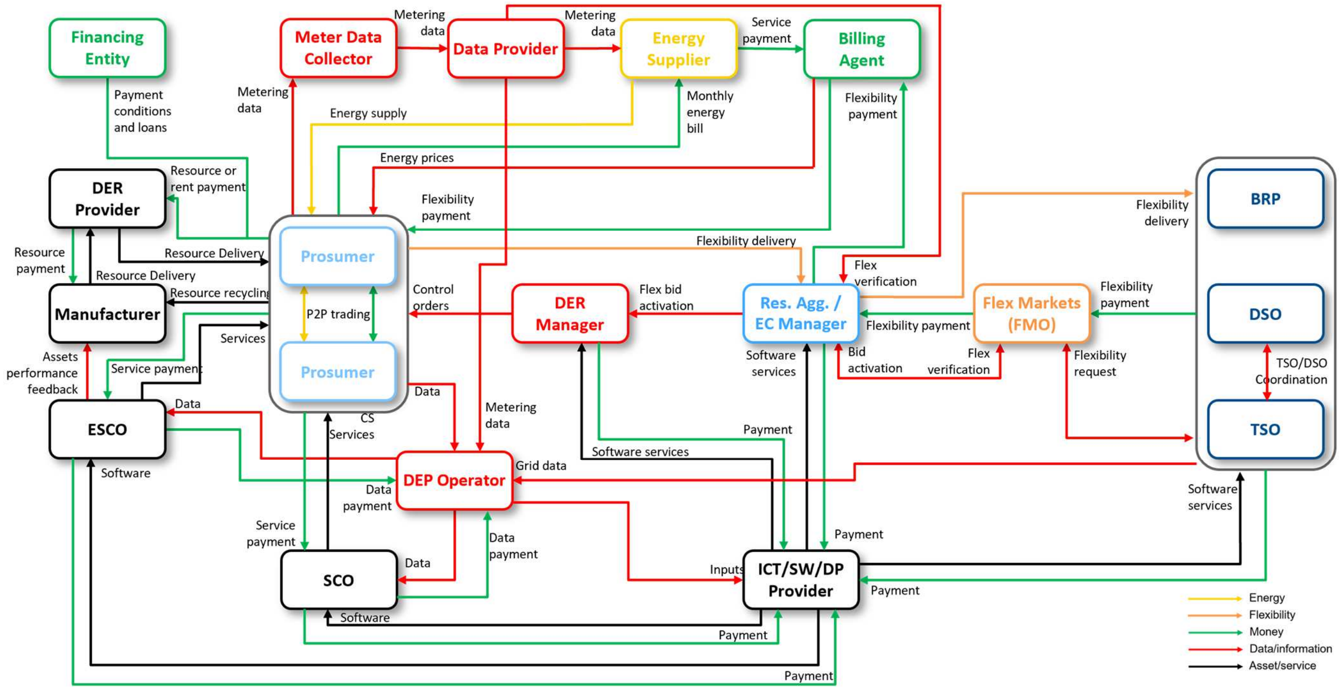

Figure 1. Main roles and roles interactions in the flexibility value chain

III. Energy and Cross-sector Business Models

A BM describes a set of actors involved in related activities and the value they generate for the related stakeholders, including how they are paid or rewarded for their participation. In the context of sustainable development, BM shall describe the logic of how value can be generated and stacked (not only from an economic perspective but also considering social and environmental aspects), and how the value flows among the actors of the value chain, and to society in general [26]. Energy BM focus mainly on the energy related activities and have been analysed and described in previous works [7], [27], [28]. Cross-sector BM embrace multiple sectors, including electricity, buildings, and mobility, and aiming at adding value by profiting from other complementary activities and services [29]. By linking different activities, energy can be produced and consumed more intelligently, and system security can be enhanced by exploring cross-sector flexibility [30]. Moreover, DER can provide additional value, allowing Consumers to offer their own flexibility to the grid operators [31].

A. *BM1: Traditional retailing business model*

The first BM corresponds to the traditional energy commercialization model, as a result of the liberalisation of the energy retail market, being the predominant BM in this sector [32]. The correspondence between actors and roles is given in TABLE I. , where the retailer company takes the roles of Energy Supplier and Billing Agent, and the DSO, as it is often the case in the EU, the role of Meter Data Collector [33]. In the liberalized retail market, Retailers make their profit by buying electricity from the producers in the wholesale market and selling it to the Consumers [34], and can freely set up their commercial offers. In the more traditional model, the electricity comes from large-scale power plants, often powered with non-renewable sources [32]. More recently, green energy can also be sold to the Consumers, guaranteeing that the electrical energy sold by the Retailer was bought from renewable generation power plants, as in [35], [36]. In this BM, no flexibility is provided to the grid by Consumers.

TABLE I. MATCH BETWEEN ACTORS AND ROLES IN BM1

Actor	Roles
• Retailer	• Energy Supplier • Billing Agent
• Consumer	• Consumer
• DSO	• Meter Data Collector • Data Provider

B. *BM2: Consumer acquires flexible assets*

This BM is meant to equip regular Consumers with flexible assets. Actors and roles are given in TABLE II.

TABLE II. MATCH BETWEEN ACTORS AND ROLES IN BM2

Actor	Roles
• Manufacturer	• Manufacturer
• ESCo	• ESCo • DEP Operator • DER Manager
• DER Provider	• DER Provider
• Financing Entity	• Financing Entity
• Retailer	• Energy Supplier • Billing Agent
• Consumer	• Consumer • Prosumer
• DSO	• Meter Data Collector • Data Provider
• SW Company	• ICT/SW/DP Provider

The Consumer purchases assets such as DER and/or smart devices from a DER Provider, who acquires them from a Manufacturer. A Financing Entity can assists the Consumer in acquiring those assets with several financing schemes being available for that purpose [27]. Again, the Retailer supplies energy and bills the Consumers, with the DSO acting as Meter Data Collector. At this point, Consumers can manage their assets by their own, or contract an ESCo with the DER Manager role to help them based on its expertise. The ESCo can provide services such as asset maintenance and energy optimization, allowing Consumers to benefit from their implicit flexibility [37] by adapting their behaviour to price signals. A SW Company acting as ICT/SW/DP Provider can also sell its services to the ESCo, supporting them with data management and data processing tools [38]. At the end of their life, the assets can be returned to the Manufacturer for recycling, enabling other BM [39] according to circular economy principles [40] such as second-life battery storage.

C. BM3: Retailer offers EaaS

Retailers can equip Consumers with assets in an EaaS BM approach, where a product is provided to a Consumer as a service [41]. This means that the assets are not sold but rented to the Consumer who is charged for using them. As such, the Consumer switches capital for operational expenses, with the DER Provider maintaining and repairing the assets during the contract [42]. There are several companies, including multiple Retailers, using this BM and its variants, such as Solar-as-a-Service [43], Energy-Storage-as-a-Service [44] and others. As a result, in this BM the Retailer typically assumes many roles, as shown in TABLE III. Again, the Retailer acts as Energy Supplier and Billing Agent, but also acts as Financing Entity and DER Provider, providing the DER in exchange of a regular fee. It can also act as ESCo, DER Manager and DEP Operator (due to its privileged relationship with the Consumers in his portfolio and energy data), controlling the DER installed at the Consumer's property based on the received data. Once the Retailer has control over its Consumers' assets, it can also profit from the flexibility of those assets for its own benefit, such as to reduce energy imbalances [45], by providing some energy discount or explicit flexibility payment to their clients.

TABLE III. MATCH BETWEEN ACTORS AND ROLES IN BM3

Actor	Roles
• Manufacturer	• Manufacturer
• Retailer	• Financing Entity • Energy Supplier • Billing Agent • DER Provider • ESCo • DEP Operator • DER Manager • BRP
• Consumer	• Consumer • Prosumer
• DSO	• Meter Data Collector • Data Provider
• SW Company	• ICT/SW/DP Provider

D. BM4: Retailer facilitates DER acquisition

In this BM, the Retailer facilitates the purchase of DER by offering favourable conditions to its Consumers to acquire them, taking the roles of DER Provider and Financing Entity, as shown in TABLE IV. However, unlike BM3, in this case the Retailer does not have ownership over the DER, which belongs to the Consumer. The Consumer controls these assets or can contract an ESCo to do it in his behalf. Moreover, Consumers owning flexible assets can join a Resource Aggregator and offer their flexibility to other entities, as described in the next BM. The role of Resource Aggregator can be taken up by the Retailer or by a specific actor called Aggregator. Since aggregation is a role still not clearly regulated in many countries (see for example [46]), and whose revenues may be low if coming only from the value the flexibility buyers may be willing to pay [47], Retailers often assume also this role.

TABLE IV. MATCH BETWEEN ACTORS AND ROLES IN BM4

<table>
<tr><th>Actor</th><th>Roles</th></tr>
<tr><td>• Manufacturer</td><td>• Manufacturer</td></tr>
<tr><td>• ESCo</td><td>• ESCo
• DEP Operator
• DER Manager</td></tr>
<tr><td rowspan="2">• Retailer</td><td>• Financing Entity
• Energy Supplier
• Billing Agent
• DER Provider</td></tr>
<tr><td rowspan="2">• Resource Aggregator</td></tr>
<tr><td>• Aggregator</td></tr>
<tr><td>• Consumer</td><td>• Consumer
• Prosumer</td></tr>
<tr><td>• DSO</td><td>• Meter Data Collector
• Data Provider</td></tr>
<tr><td>• SW Company</td><td>• ICT/SW/DP Provider</td></tr>
</table>

E. BM5: Flexibility for grid management

After joining a Resource Aggregator (this role being assumed by a Retailer or an Aggregator, see TABLE V.) Consumers can provide their flexibility to grid operators or BRP via a flexibility market [48] managed by an FMO [12]. In this case, this BM is more focused on the flexibility value, in terms of what the flexibility procurers may be willing to pay, either to solve grid problems in case of the system operators, or expected imbalances in case of BRP, and the benefit this flexibility provision may provide to the Consumers. Since this flexibility value may be low compared to the initial investments and complexities associate to its provision, BM6 described next intends to complement this BM by increasing the Consumers value with additional revenue streams or services.

TABLE V. MATCH BETWEEN ACTORS AND ROLES IN BM5

<table>
<tr><th>Actor</th><th>Roles</th></tr>
<tr><td>• Manufacturer</td><td>• Manufacturer</td></tr>
<tr><td>• ESCo</td><td>• ESCo
• DEP Operator
• DER Manager</td></tr>
<tr><td>• DER Provider</td><td>• DER Provider</td></tr>
<tr><td>• Financing Entity</td><td>• Financing Entity</td></tr>
<tr><td rowspan="2">• Retailer</td><td>• Energy Supplier
• Billing Agent
• BRP</td></tr>
<tr><td rowspan="2">• Resource Aggregator</td></tr>
<tr><td>• Aggregator</td></tr>
<tr><td>• Consumer</td><td>• Consumer
• Prosumer</td></tr>
<tr><td>• DSO</td><td>• Meter Data Collector
• Data Provider
• DSO</td></tr>
<tr><td>• FMO</td><td>• FMO</td></tr>
<tr><td>• SW Company</td><td>• ICT/SW/DP Provider</td></tr>
<tr><td>• TSO</td><td>• TSO</td></tr>
</table>

F. BM6: Consumers acquire cross-sector services

Consumers who own houses equipped with sensors, smart appliances and flexible resources can also profit from cross-sector services provided by SCo, as in TABLE VI. These cross-sector services can be, for instance, related to healthcare of vulnerable people and security by using smart meter data to generate alarm signals associated to abnormal changes in the load profiles [49]. Although they are not directly linked to the flexibility provision, they result from or complement it, by profiting from the flexible potential and participation of the Consumers in flexibility services. In this sense, for example, EV charging can become smart or even respond to flexibility solicitations by adapting its charging profile [50], health or surveillance services can be built on top of the energy data [49] that result from the active participation in the energy chain, and energy data can be sold to third parties [51], such as SW companies, to allow them to improve forecasting tools [45], DER control and aggregation algorithms and tools [52].

TABLE VI. MATCH BETWEEN ACTORS AND ROLES IN BM6

<table>
<tr><th>Actor</th><th>Roles</th></tr>
<tr><td>• Manufacturer</td><td>• Manufacturer</td></tr>
<tr><td>• ESCo</td><td>• ESCo
• DEP Operator
• DER Manager</td></tr>
<tr><td>• DER Provider</td><td>• DER Provider</td></tr>
<tr><td>• Financing Entity</td><td>• Financing Entity</td></tr>
<tr><td rowspan="2">• Retailer</td><td>• Energy Supplier
• Billing Agent
• BRP</td></tr>
<tr><td rowspan="2">• Resource Aggregator</td></tr>
<tr><td>• Aggregator</td></tr>
<tr><td>• Consumer</td><td>• Consumer
• Prosumer</td></tr>
<tr><td>• DSO</td><td>• Meter Data Collector
• Data Provider
• DSO</td></tr>
<tr><td>• FMO</td><td>• FMO</td></tr>
<tr><td>• SW Company</td><td>• ICT/SW/DP Provider</td></tr>
<tr><td>• SCo</td><td>• SCo</td></tr>
<tr><td>• TSO</td><td>• TSO</td></tr>
</table>

G. *BM7: Flexibility provided by Energy Communities*

Consumers can decide to join an EC as it starts to occur in several countries. In this case, the EC Manager acts as Resource Aggregator, as in TABLE VII. For a Consumer, entering an EC brings several advantages as benefiting from cheaper electricity, selling generation surplus, reducing grid dependence, sharing costs and risks and eliminating high upfront costs [28]. The EC Manager, apart from directing the community, can aggregate the available flexibility and offer it to system operators in flexibility markets [28].

TABLE VII. MATCH BETWEEN ACTORS AND ROLES IN BM7

Actor	Roles
• Manufacturer	• Manufacturer
• DER Provider	• DER Provider
• Financing Entity	• Financing Entity
• Retailer	• Energy Supplier • Billing Agent
• Consumer	• Consumer • Prosumer
• DSO	• Meter Data Collector • Data Provider
• FMO	• FMO
• EC Manager	• EC Manager • Resource Aggregator • DER Manager
• SW Company	• ICT/SW/DP Provider

IV. CONCLUSION

This paper presented a review of some of the main flexibility-centric BM to help unlocking the flexibility potential of the final Consumers. The main roles and interactions among these roles in the flexibility-centric value chain were identified, not only those directly linked with the energy value chain, but also others considered essential to boost the provision of flexibility, such as flexible resources and software tools provision or cross-sector activities. Then, BM were described by identifying which complementary roles the power sector actors can assume to increase the value proposition of all involved actors.

It can be concluded that, in the context of energy transition and digitalisation, several new BM are arising with the focus on the provision of flexibility. Some are already implemented or at least proposed as commercial initiatives by companies, while others are still being further developed at a more academic level. Obstacles related to implementing new BM are tied to regulatory issues, that still do not regulate properly several aspects of the flexibility provision, such as local energy and flexibility markets or the aggregation role, but also to the willingness to pay for flexibility by the flexibility procurers, together with the complexity of operationalizing the provision of flexibility by final Consumers. These obstacles may disincentivize the active engagement of Consumers in such BM. This is why it is especially worth analysing the existing regulation to reduce barriers, and the whole flexibility value chain to create the means to facilitate the engagement in such BM, by establishing market and contracting places at different steps of the flexibility value chain, but also considering cross-sector BM to complement the flexibility provision by increasing the participants return, either monetary or with other kind of incentives.

ACKNOWLEDGMENTS

The research leading to this work is being carried out as a part of the BeFlexible project (European Union's Horizon 2020, No. 101075438). The sole responsibility of this publication lies with the author. The European Union is not responsible for any use that may be made of the information contained therein.

The authors would also like to express their gratitude to the BeFlexible partners that have, to some extent, helped us to elaborate this integral BM vision.

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