Ref. Ares(2021)4545906 - 13/07/2021

Business Models & Incentive Schema Definition

D2.3

June 2021

Twinergy has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957736

Deliverable

PROJECT ACRONYM	GRANT AGREEMENT #	PROJECT TITLE
TWINERGY	**957736**	**Intelligent interconnection of prosumers in positive energy communities with twins of things for digital energy markets**

DELIVERABLE REFERENCE NUMBER AND TITLE

D2.3

Business Models & Incentive Schema Definition

Revision: <v1.0>

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Funded by the Horizon 2020 programme of the European Union
Grant Agreement No 957736

DISSEMINATION LEVEL

✔	**P**	**Public**
	C	Confidential, only for members of the consortium and the Commission Services

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Version History

REVISION	DATE	AUTHOR	ORG...	DESCRIPTION
V0.1	17.05.2021	Ivan Sulev	WEC	First Draft of Report
V0.2	23.06.2021	Ivan Sulev	WEC / Mytilineos	Applying edits and comments from Mytilineos
V0.3	28.06.2021	Ivan SUlev	WEC/STAM	Applying edits and comments from STAM
V0.4	29.06.2021	Ivan Sulev	WEC/ BCC	Applying edits and comments from Bristol City Council
V0.5	29.06.2021	Dr. Alex Papalexopoulos	WEC	Edits and Comments
V0.6	30.06.2021	Ivan Sulev	WEC	Final version submitted to the PC
V1.0	30.06.2021	Ivan Sulev	WEC	Draft submitted to EC by the PC

Statement of Originality

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

Legal Disclaimer

Executive Summary

The purpose of this document is to provide an overview of the existing business models from the energy sector and provide propositions for improved ones, which can be demonstrates and tested in real conditions at the demo sites of the TwinERGY project (TwinERGY is a project funded by the HORIZON 2020 Programme of the European Commission under the Grant Agreement No. 957736.)

With better understanding of the existing business models, we are able to go deeper in the process of value proposition and value creation, and with that in mind, to propose improved business models, which can create a shift from the utility-centric business model, towards models that will be fostering transactive energy principles to utility distribution systems and business models and to utility-customer relations. This is possible by applying several principles, such as, digitization, decentralization, transactive energy paradigm etc., all of which are enabled by the steady growth and exploitation of DERs and IoT smart devices.

Our findings indicate that energy markets are faced with a need for more flexibility, fuelled by the increased use of renewable energy sources and in addition of the digitization factor in the equation. There are, now, technical possibilities to integrate small and medium sized prosumers into DR activities. This creates clear opportunity to improve the existing models, because now, it is possible to use innovative platforms to bundle loads and capacities, enabled of course, with the wider use of smart devices and appliances.

Moreover, as we are evaluating the possibilities for improving the DR business models, one cannot but notice the paradigm shifts from centralized to decentralized networks of distributed prosumers. This opens an additional field of potential for improved business models, where consumers are encouraged and empowered to participate actively, both, in the consumption and generation aspects.

With the wider availability of contemporary software platforms, technology innovation, digitization and decentralization, increased adoption of DERs and IoT devices, the possibility of creating and improving Transactive Energy (TE) and dynamic Virtual Power Plants (VPP) business models is also evaluated in this report.

At last, but not least, we evaluate the possibility of implementing the improved business models in TwinERGY demo sites, having in mind the geographical and regulatory differences and obstacles, in order to bring the benefits of the improved value proposition and value creation closer to the communities.

A proposition of a business model with TE framework that will be built for the 21stcentury grid, characterized by active "prosumer" (both producer and consumer of energy) participation in energy markets, bidirectional power flows (e.g., net metering of Behind-The-Meter (BTM) resources), and sophisticated financial transactions between prosumers, utilities, and third-party service providers is something that can create this positive improvement of value and is a business model worthy of a future. TE transactions BTM and In Front of the Meter (IFOM) are already on a hockey-stick shape of growth as they are now merging with the increased adoption of smart Internet of Things (IoT) devices, such as connected thermostats and other newly networked Distributed Energy Resources (DERs) such as renewable energy sources, electric vehicles (EV), and Electric Storage Resources at the edge of the grid.

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Abbreviations

Acronym	Full Name
BRP	Balance Responsible Parties
BTM	Behind the Meter
CHP	Combined heat and power
CPP	Critical-Peak-Pricing
CRM	Capacity Remuneration Mechanism
DER	Distributed Energy Resources
DR	Demand Response
DSO	Distribution System Operator
DSR	Demand Side Response
EE	Energy Efficiency
EES	Energy Efficiency Service
ESCO	Energy Service Company
EV	Electric Vehicles
G2V	Grid-to-Vehicle
ICT	Information Communication Technologies
IFOM	In Front of the Meter
IoT	Internet of Things
PV	Photovoltaics
P2P	Peer-to-Peer
RES	Renewable Energy Sources
RTP	Real-Time-Pricing
TE	Transactive Energy
TEP	Transactive Energy Platform
TOU	Time-of-use
TSO	Transmission System Operator
VPP	Virtual Power Plant
V2G	Vehicle-to-Grid

1. Introduction

In recent years, we are witnesses of multiple movements and transformations in the energy flexibility markets, fuelled by several factors which are impacting this transformation, such as: digitalization, decentralization, shifting towards CO2 neutral energies etc. All of these factors have enabled entrance of new players on the energy markets, therefore, there is substantial need to develop new business models, which will be improving the already existing ones and offer better value propositions in the market. These improved models need to be defined and introduced for third-parties that will facilitate consumer involvement and represent them in energy market transactions, thus tackling barriers relating to consumers' lack of knowledge about market mechanisms and energy transactions, as well as, the non-availability of consumers to follow energy market transactions in real-time (TwinERGY Project Proposal, 2020).

Such business models and actors (namely aggregators, utilities and other emerging actors realized under the umbrella of local energy communities) will pull together demand response, storage and on-site power production technologies, towards optimizing energy management and saving residential customers money, through participation in implicit (price-based), explicit (grid-based) or hybrid (implicit/ explicit) demand response programs, on the basis of standardized service contracts. Mass demand response will only happen if these third parties act on behalf of consumers, but for this to happen, the business case must be viable. Aggregators have to be able to extract enough value (flexibility) from a pool of resources, to maximize benefits for consumers (and persuade them to hand over control) through, firstly, energy management optimization (in the case of implicit demand response) and, secondly, demand aggregation (for the provision of flexibility to energy networks in explicit demand response), thus tackling, in the latter case, market capacity restrictions that cannot be addressed by individual consumers (with a limited nominal power and flexibility capacity). Hand in hand with the business aspects, comes the issue of end-to-end interoperability between energy networks, home energy management systems and smart devices (IoT) (TwinERGY Project Proposal, 2020).

1.1 Method

The method which we are using in order to deliver this report starts by identifying the existing business models and their structure, identifying their components and understanding the business model satisfaction. With this aspect reviewed, we move into evaluation of the current Demand Response (DR), Virtual Power Plant (VPP) and Transactive Energy (TE) business models, based on literature analysis, in order to be able to provide suggestions for improving the business models in flexibility energy markets. By providing an overview of the elements of digitization, decentralization and other EU market aspects, we are able to provide examples of improved business models for flexibility energy markets. Moreover, by touching upon the TE business models we are able to provide suggestions for improvements and innovations in TE and VPP business models, which can hold significant value proposition for future applications, exploiting elements of digitization and decentralization. At the end we are providing a short overview of the four pilot sites which are part of the TwinERGY project and the potential that the improved models will hold, if there is possibility for their implementation, or at least, lead to charge and open the way for future improvements in the business models, altogether.

2. Existing Business Models

As described in Giehl et al. (2020), there are multiple research papers and publications done regarding the effects of energy system transformation and changing framework conditions on business models. They are in the ranges of:

- Examining political, regulatory and organizational factors influencing the business models of small electricity producers (Lobbe and Hackbarth, 2017).
- Analysing the development and change of business models (Woodhouse and Bradbury, 2017).
- The expected impact of digitization on existing energy business models (Diaz-Diaz et al., 2017).
- Analyse the influence of technologies on the development of the energy system transformation (Papalexoupoulos et al., 2016).
- Development of generic business models for photovoltaic applications, demand-side management and (thermal) energy storage (Richter, 2012).
- Analysis of individual prototypical business models of energy companies in the energy system transformation process (Richter, 2012).
- Generic business models for the use of renewable energy resources (Richter, 2012).
- Decentralized combined heat and power applications combined with energy services (Burger and Luke, 2017).
- Analyses of business models for smart grid applications on the prosumer level.
- Identifying business models within the smart grid value creation network (Diaz-Diaz et al., 2017).
- Focusing on the further development of generic business models in the context of rising e-mobility (Alvaro et al., 2016).
- Developing basic business models for the electro-mobile value chain within the changing energy system

- (Papalexoupoulos et al., 2016)

The literature review on business models includes various studies referring to individual, specific business models, technologies, and use cases. The classical value chain is often the basis for the analysis in the aforementioned examples. Few cases give an overall view of the energy system or a systematic approach to the determination and derivation of theoretical business models. Analysis shows the predominant use of existing approaches to characterize business models. These only partially consider the unique features and structural breaks of the energy system in the context of decarbonization, decentralization, and digitization.(Giehl et al., 2020).

Therefore, a gap has been created, where the existing business models are not sufficient to characterize the business models of system transformation, with no exhaustive overview of currently existing energy business models and no adequate approach to describe the effects of the energy system transformation on the interactions between business models and the structure of the energy industry (Giehl et al., 2020).

With this reasoning, in this deliverable, we will focus on how to best address the above-mentioned gap and examine the potential to improve the utility-centric business model, apply the transactive energy principles to utility distribution systems and business models, and to utility-customer relations – all enabled by the growth of DERs and the IoT revolution.

2.1 Business Models and Structure

In order to properly examine the existing business models and reach our project goal for improving the traditional, centralized energy business models with decentralized business models based on transactive energy principles, one should first analyse the current situation in the energy sector and the major market and regulatory forces which are driving the transformation of the energy system. For this reason, we have conducted research collecting primary and secondary date from different sources, stakeholders, and publications, in order to have full comprehension of the situation in this aspect (Lobbe and Hackbarth, 2017).

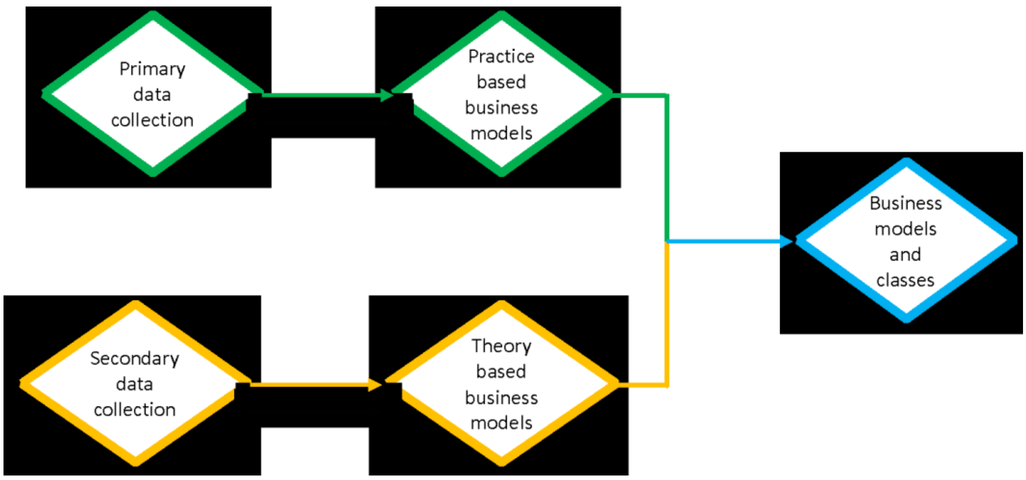

Figure 1 - Business model data collection and classification (Giehl et al., 2020)

Following this framework, we have identified three main characteristics (Value Proposition, Customer Segment and Revenue Model), as seen in Figure 2, which are shaping the evolving energy business models. In addition, we have identified several other characteristics (Utilized Technology, Required and Offered Data, Influencing Factors, The Value Creation Network and

Partners), which also influence the formulation of the energy business models. Lobbe and Hackbarth (2017)

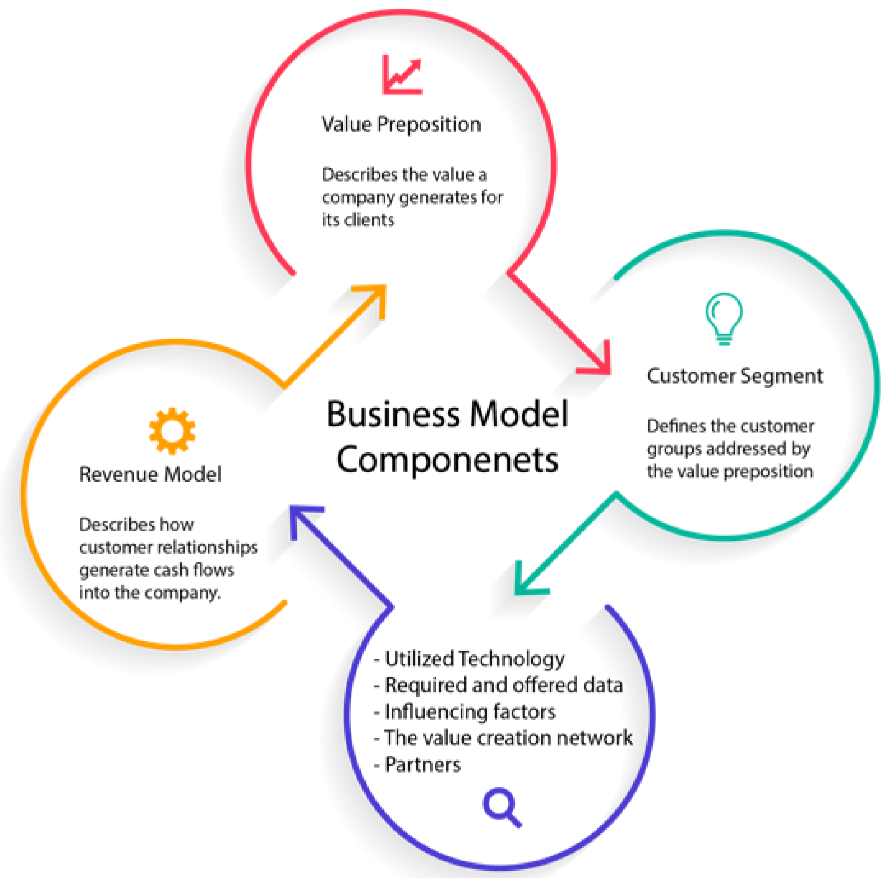

Figure 2 - Descriptive components of the business models (Giehl et al., 2020)

2.1.1 Business Models Components

In evaluating the business models properly, understanding of the main components is the essence of the analysis. As seen in Figure 3, the value proposition, revenue model and customer segment are three characteristics that are strongly influencing the business models and are in large part shaping the form in which they will be presented in the energy sector where they operate (Woodhouse and Bradbury, 2017). In addition, the other components are subsumed under the main three and in many cases, they can influence or change the business model from their perspective. For example, if the business models use a differentiated technology, a differentiated value proposition and revenue model can also be expected. Since the three main components already have a wide range of different possible characteristics, no further components are utilised for business models evaluation. The further components provide a detailed description of concrete business models (Giehl et al., 2020).

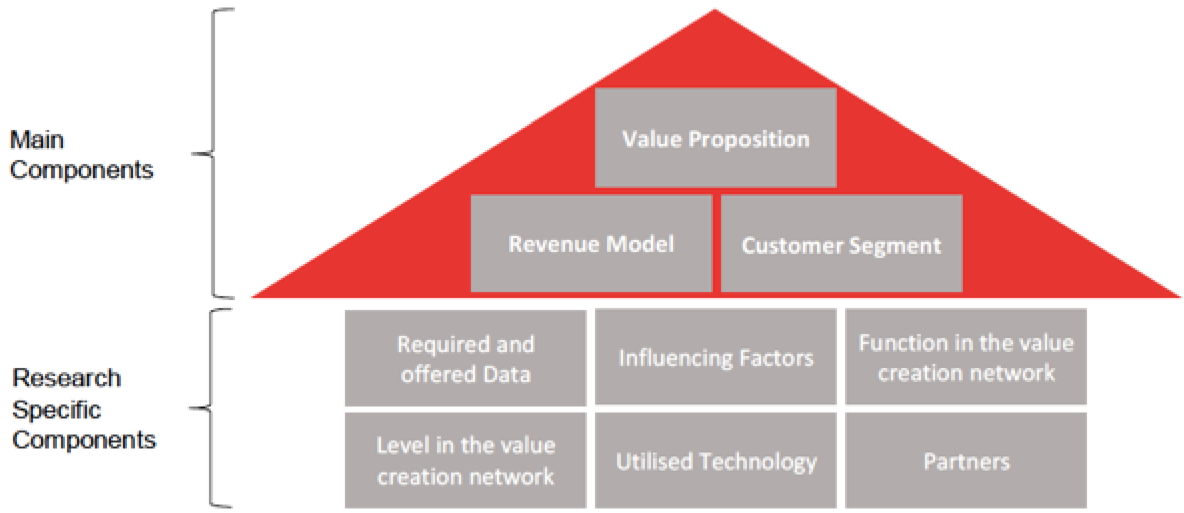

Figure 3 - Overview of the components of the business model framework (Giehl et al, 2020)

2.1.2 Business Models Classification

The dimensions of consumer proximity and core activities of the energy industry are used for the classification of the business models. Double allocation of one business model to two or more classes is not permitted (Giehl et al., 2020). The classification takes the disruptive character of the energy system transformation into account by forming explicit individual classes based on decarbonisation, digitisation, and decentralisation (Burger and Luke, 2017) Furthermore, one-fifth of the business model descriptions in literature were general and without reference to a region. The splitting of two dimensions of consumer proximity and core processes of the energy industry into traditional business models and modern business models shows the changing structure of the sector (Giehl et al., 2020).

Figure 4 illustrates the overview of the classes within the value creation network, where one can clearly see the distinction between the core and supporting activities which influences the value creation process in the energy sector. Moreover, for our project, it is important to distinguish the difference in value creation between the traditional and the modern value creation systems and structures.

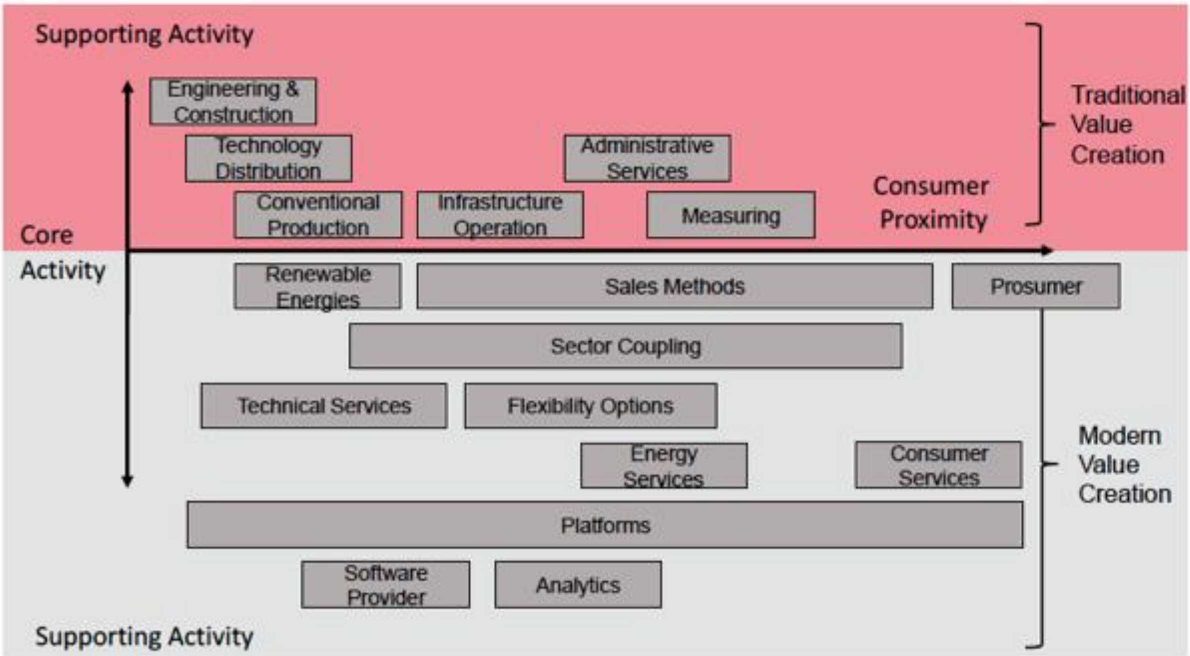

Figure 4 - Overview of the business model classes (Giehl et al., 2020)

2.2 Demand Response (DR) Business Models

DR is defined by the European Commission as "voluntary changes by end-consumers of their usual electricity use patterns—in response to market signals"(Ma et al., 2017). It is a shift of electricity usage in response to price signals or certain requests. DR reduces peak load, electricity cost, and improves system reliability. Electricity consumers can participate in energy-load balance through DR. Controllable appliances that contribute to DR include commercial buildings like (heating, ventilation, and air-conditioning) HVAC systems, home appliances, energy storage and industrial processes (Ma et al., 2017).

Furthermore, Ma et al. (2017) identifies two programs of the DR Model. Those two are named as explicit (also called incentive-based) and implicit (also called price-based) demand response and the two types are activated in different time intervals and serve different purpose on the market. Consumers can participate in both programs, the difference is that, in the price-based DR program they get lower electric bill, while, in the incentive-based DR program they can receive direct payment for their participation (Bertoldi et al., 2016).

Incentive-based DR programs (explicit) are categorized in two main categories: traditional-based and market-based. In the traditional-based category there are DR programs like direct load control, interruptible pricing etc. In the market-based category, there are programs such as emergency demand response programs, capacity market programs, demand bidding programs, and ancillary services market programs (Ma et al., 2017).

In the explicit DR programs, demand competes directly with supply in wholesale, balancing, and ancillary services markets through services by aggregators or as single large consumers (Gharesifard et al., 2016). Load requirements (size of energy consumption) need to comply to participate in DR programs. Therefore, small consumers only can participate by contracting with DR service providers via aggregations. DR service providers can either be third-party aggregators or customer retailers. Through incentive-based programs, consumers receive direct payments to change their electricity consumption upon request (e.g., to consume more or less) (Ma et al., 2017) Incentive-based DR is more flexible in terms of helping DR service providers acquire DR resources. Direct load control enables DR service providers to control appliances within a short notice. Explicit DR provides a valuable and reliable operational tool for system operators to adjust load to resolve operational issues (Lamprinos et al. 2017).

From the angle of the implicit (also called price-based) DR programs, their main attributes refer to the voluntary program in which consumers are exposed to time-varying electricity prices or time-varying network tariffs (such as a day/night tariff). Compared to incentive-based DR with direct load control, the price-based DR provides less flexibility from the perspective of energy suppliers. Implicit programs depend on the cost of electricity production at different times, and on consumers' own preferences and constraints. For instance, in real-time pricing, consumers reduce electricity usage at peak periods or shift their usage to off-peak periods. These prices are always part of their supply contract (Ma et al., 2017).

There are several players on the DR market which are summarized in Figure 5.

Actors	Offers	To
Aggregator	Pay for BRPs' energy loss	BRP
	Market access DR incentives	Consumer
	Ancillary services Tariff	Transmission System Operator (TSO)
	Network balancing services Tariff	Distribution System Operation (DSO)
Supplier/retailer	Incentives and contract package for the implicit DR program	Consumers
Regulator	DR incentives DR regulations DR awareness	All actors
Consumer	Demand profile	Aggregator
	Direct control	Supplier/retailer
	Large consumers can directly provide energy flexibility to the DR market	Demand Response (DR) market

Figure 5 - Actors in DR (Ma et al., 2017)

Using the business model framework by Osterwalder and Pigneur, Ma et al. (2017) proposes the analysis of 4 Business Models for Buildings to participate in the energy aggregation market. Furthermore, they define Buildings into three types (residential, commercial, and industrial). Due to the requirement of volume threshold for aggregation markets they divide buildings into two categories according to their energy consumptions: small and large energy consumers. The majority of residential buildings and some commercial buildings are small energy consumers. Comparatively, industrial buildings and some commercial buildings are large energy consumers (Lamprinos et al. 2017; Ma et al., 2017).

The four business models in the aggregation market are sublimed in Figure 6.

Aggregation Market	Types	Business Model	Direct Participants	Indirect Building Participants
Demand Response	Implicit DR (price based)	1—buildings participate in the implicit DR program via retailers	Retailers	All buildings
	Explicit DR	2—buildings (small energy consumers) participate in the explicit DR via aggregators	Independent aggregator	Buildings with small energy consumption
		3—buildings (large energy consumers) directly access the explicit DR program	Buildings with large energy consumption	-
Virtual Power Plants	Trading, balancing, network services	4—buildings access the energy market via VPP aggregators by providing DERs	VPP aggregators	DER owners (buildings which equip the DERs)

Figure 6 - Business models in the Aggregation Market (Ma et al., 2017)

2.2.1 Business Model of participation in implicit DR program via Retailers

In accordance with what is stated above, Figure 7 summarises the Business Model of participation in implicit DR program via Retaulers.

Partners	Activities	Value Proposition	Customer Relation	Customers
• Regulators • Billing companies • Electricity retailers	• Customer analysis to provide different DR offers; • Customer education to promote the offers; • Customer consulting due to customer constraints; • Billing system integration • Staffs/expert recruitment	Buildings receive a lower electricity bill	• Different DR offers due to buildings' own preferences and constraints for existing customers • Increase existing customers' satisfaction rate due to lower bills	All buildings
	Resources		**Channels**	
	• Price signal • Regulators' support		Part of the electricity supply contract	
Cost Structure			**Revenue Streams**	
Integration of DR offers into electricity supply contract (which might need DR experts and facility purchasing) Price signal sending to customers (facilities and staffs)			Optional choices for existing customers	

Figure 7 - Price-based DR Business Model via Retailers (Ma et al., 2017)

2.2.2 Business Model of participation in incentive-based DR (explicit) program via Aggregators

In the same way as the previous point, Figure 8 notes the business model of participation in explicit DR via Aggregators.

Partners	Activities	Value Proposition	Customer Relation	Customers
• Regulators • BRPs • DSOs • TSOs • Control system providers • Energy suppliers (retailers)	• Access customers via energy suppliers or other channels • Provide consulting and analysis of customer demand pattern • Participate in DR market (wholesale, balancing or ancillary market) • Control customers' appliances • Payment to customers for energy flexibility	Buildings receive direct payment by participating in the explicit DR market via aggregators	• Payment system • Incentives by regulation, TSOs and DSOs • Consulting service (e.g., training, building energy behavior analysis) • Control system operations and maintenance	Buildings (who are small energy consumers)
	Resources		**Channels**	
	• Local control system • Customer data (demand pattern) • Market information		• energy consulting directly by aggregators • access customers via energy suppliers (retailers)	
Cost Structure			**Revenue Streams**	
• DR control system (customer side and aggregator side) • Payment to customers • Tariffs to DSOs and TSOs • Payment/compensation to BRPs • Market access fees to the DR markets			• Payment from the DR market (including reserve capacity payment from TSO) • Incentive from TSO/DSO and regulators	

Figure 8 - Incentive-based DR Business Model via Aggregators (Ma et al., 2017)

2.2.3 Business Model with direct access to the incentive-based DR program

In continuation, Figure 9 deals with the business model with direct access to the incentive DR.

Partners	Activities	Value Proposition	Customer Relation	Customers
• Technology providers • TSOs • BRPs • Energy consulting • DSOs • Regulators	• Install energy control system; • Analysis and integration of DR into the existing building management system; • Directly participate in the DR markets.	Buildings receive direct payment by providing energy flexibility to the market	• Allow direct load control by TSOs in the reserve market as ancillary service; • Comply to market rules in wholesale and balancing markets	DR market (wholesale market, and ancillary service to TSOs)
	Resources		**Channels**	
	• Energy flexibility from appliances in the buildings; • Building energy control systems		• Direct participation in the wholesale and balancing market; • Bidding in the reserve market (there are rules for bidding and ancillary capacity, and control in the reserve market)	

Cost Structure	Revenue Streams
• Employees' salary or expert consulting • Control system installation/upgrade • Market access fee (rules for participation in wholesale and balancing markets) • Fees to BRPs by contract • Tariffs to DSOs and TSOs • Cost due to energy behavioral changes (influence production or occupants' satisfaction in buildings)	• Payment by providing demands in wholesale and balancing markets • Reserve capacity payment from TSOs • Incentive from TSOs/DSOs, and regulators

Figure 9 - Business Model with direct access to incentive-based DR (Ma et al., 2017)

2.2.4 Business Model with access via VPP

At the end, Figure 10 illustrates the business model with access via VPP.

Partners	Activities	Value Proposition	Customer Relation	Customers
• Technology providers • TSOs • BRPs • Energy consulting • DSOs • Regulators	• Install control system • Customer service (analysis and package deals)	Buildings can access the market with direct payment and low risk	• Customized market access strategy • Payment system • Forecast information • Direct control system	Building with DERs (e.g., PV, micro-CHP)
	Resources		**Channels**	
	• Accurate forecast of supply and demand • DERs		• Direct contact; • Via DER technology/equipment providers; • Via electricity retailers	

Cost Structure	Revenue Streams
• VPP control system • Employees' salary (including expert payment) • Market access fee (rules to participate in the wholesale and balancing markets) • Fees to BRPs by contract • Tariffs to DSOs and TSOs	• Trading via wholesale market • Balancing service offered to BRPs • Reserve capacity payment from TSOs • Network service offered to DSOs

Figure 10 - Business Model via VPP (Ma et al., 2017)

3. Improving the Business Models for higher Flexibility on Energy Markets

As Leutgob et al. (2019) indicates, energy markets and especially electricity markets are faced with a strong need for more flexibility, mainly due to the fact that the share of renewable energy sources in energy supply is steadily increasing. The current model of ensuring demand-supply match mainly by investments into supply and transmission infrastructure needs to be complemented by demand-centric solutions, usually summarised under the term demand response (DR) (Lamprinos et al., 2017). Due to digitalisation the technical possibilities to integrate small- and medium-sized prosumers (residential, tertiary, decentral power and heat storages, micro-grids etc.) into DR activities are continuously expanding. Innovative platforms allow for bundling of small/medium-sized capacities, transaction cost are reduced through automated dispatching, communication with switchable, "smart" appliances is becoming cheaper, new technologies are available to ensure secure data handling for easier forms of "smart contracts", etc. But hand in hand with expansion of DR potentials, there is also a need to adapt and further develop current DR business models to cope with new challenges (Diaz-Diaz et al., 2017).

3.1 From Centralized to Decentralized System

There is a noticeable paradigm shift, or change, or one might say, evolvement of the system, from centralized energy generation to a decentralized network of distributed prosumers. Consumers are increasingly being encouraged and empowered to actively participate in the energy network with respect to consumption and generation. The future energy system will be a smart system, where all energy entities are given the opportunity to participate in the marketplace (Leutgob et al., 2019).

With the increase of the renewable sources of energy which are one of the main elements of the energy transition, it is also implied that the system that needs to be managed will be more complex because of its volatility. This is coming from the fact that the supply of the renewable sources is greatly impacted by seasonal factors and fluctuation, thus, the network will have to be managed properly and adopted to smaller and more decentralized units in order to guarantee grid stability (Richter, 2012; Leutgob et al., 2019).

As Leutgob et al. (2019) states, one important element in coping with the challenge of increasing need for flexibility is the demand side. If the demand side patterns are better adjusted to the supply patterns of the renewables this will reduce investments required on the supply side. This concept, as mentioned above, is called demand response (DR): Peaks and shortages of electricity supply are communicated to the consumers who reply by adapting their current consumption (Lamprinos et al., 2016).

For many of the large power consuming players and actors on the energy market, the DR concept is already familiar and a concept which they have been using for some time already. However, the challenge still remains for the small and medium-sized consumers, especially from the residential sector. Technical solutions that support the extension of DR towards small and medium sized prosumers are already in place, but there is still a need for the development of appropriate business models (Gharesifard et al., 2016). There is some incentive for all parties involved to make use of DR as it reduces costs for consumers, whereas for suppliers it can work as a tool to better balance their portfolio and optimise the sourcing costs. DR service providers also may be third parties that act as DR aggregators, who conclude contracts directly with consumers, pooling together their DR capacities and selling them on the flexibility market. Clarifying the roles and responsibilities of all these players needs to be accomplished in order to create a sound DR environment (Leutgob et al., 2019).

3.2 Explicit vs. Implicit Use of DR

The term flexibility market is understood as a part of the electricity market, where electrical loads of end use consumers are shifting over time their consumption or are curtailed to balance the system. This includes loads of consumption of electricity (heat pumps, ventilation, cooling, etc.) and of decentral electricity production and storage (PV, batteries, CHPs, etc.) as well as micro-grids. Possible activities are: switch loads on/off as well as adaptation of load levels (Leutgob et al., 2019).

On one hand the Explicit use of DR, or explicit demand-side flexibility is defined as committed, dispatchable flexibility that can be traded (similar to generation flexibility) on the different energy markets (wholesale, balancing, system support and reserves markets). This is usually facilitated and managed by an aggregator that can be an independent service provider or a supplier (Lobbe and Hackbarth, 2017). This form of demand-side flexibility is often referred to as "incentive driven" demand-side flexibility and its main income stream is remuneration for flexibility services from Transmission System Operator (TSO) Distribution System Operator (DSO) or Balance Responsible Parties (BRP) (Leutgob et al., 2019).

On the other hand, Implicit use of DR, or implicit demand-side flexibility is defined as the consumer's reaction to price signals. Where consumers have the possibility to choose hourly or shorter-term market pricing, reflecting variability on the market and the network, they can adapt their behaviour (through automation or personal choices). This type of demand-side flexibility is often referred to as "price-based" demand-side flexibility and its main income stream is the energy cost savings that are achieved by shifting loads (Woodhouse and Bradbury, 2017).

3.3 Improving the DR Through Digitization

The main problem why small and medium-sized consumers are not part of the current equation is the technology constraint as main barrier. Even if the potential load-shift is a significant number, it is still very hard to accomplish this, because of the high transaction and operation cost associated to it (Gao et al., 2017). Therefore, many (see the Digitalization element as a game changer which can bring back the small and medium-sized consumers into the energy "game" Leutgob et al., 2019).

Smart devices are one piece of the puzzle, and they are fundamentally important for participation into a DR program, as the whole process depends on how easily these smart and switchable devices can be incorporated into a digital platform. Thus, integration of smart devices, building automation systems, storage systems and decentralized electricity production is crucial for facilitation of DR programs (Leutgob et al., 2019).

Another important element for facilitation of DR is proper software solution for DR aggregation. In recent years, several platforms have been developed in different energy markets, mainly coming from aggregators and paired with hardware which is supporting that specified platform (Hamwi et al., 2020). However, further development is much needed, with additional features and functionalities of the software platforms especially in the fields of

- Handling small and medium loads; user clustering; grid stability assessment and load forecast (mainly for the case of clustering of small loads); (Gao et al., 2017)
- Improvement of price forecasting tools; (Ghavidel et al., 2016)
- Enhancement of interoperability features; (Plancke et al., 2015)
- Virtual Power Plant (VPP) services to enable improved management of energy storage systems in conjunction with RES generation (Leutgob et al., 2019).

Furthermore, recent developments in smart contracts and blockchain is another aspect of the digitization process that positively affects the adoption and facilitation of DR programs in such markets. Conclusion of contract, as well as, monitoring and contract implementation represent a significant part of the transaction cost in DR programs. With the aforementioned smart contracts and blockchain, such actions can be automated with a high degree of immutability, security, traceability and transparency, which in great effect will ease operations in this field (Leutgob et al., 2019).

3.4 EU Regulatory conditions

In a highly regulated market, such as the energy market, technology solutions for DR need to comply with the existing regulatory framework. Even though the EU market has been marked as liberalized, the regulatory framework conditions for the participation of market players in DR vary across European countries (Lobbe and Hackbarth, 2017).

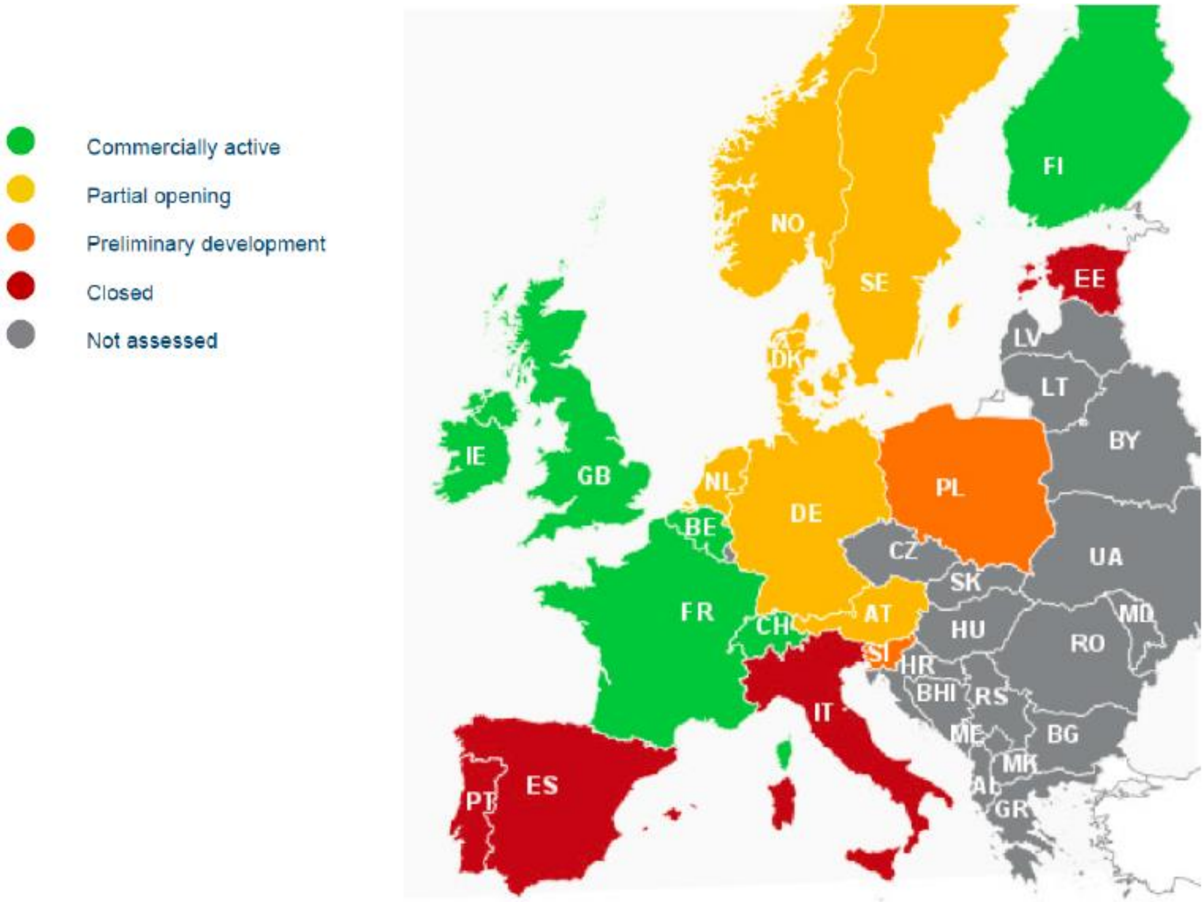

Figure 11 - Map of Explicit DR in EU (SEDC 2017)

As shown in Figure 11, and already discussed, the EU market is very scattered with different conditions from country to country. Narrowing down the assessment to the chances for participation of small and medium sized loads in the flexibility market, we find out that even in the advanced markets there exist several barriers (Leutgob et al., 2019).

- Clear definitions of the roles of market participants, especially of independent aggregators and their relation to balancing responsible parties/retailers and other market participants: In several countries demand response potential (i.e. switchable electrical loads) may only be offered to independent aggregators with the approval of the energy providers (Burger and Luke, 2017). This makes participation in the flexibility market more complicated and it increases transaction costs that are a main barrier for small and medium loads. However, in some countries templates exist and due to the liberalisation of the electricity market, energy providers can be changed easily (Leutgob et al., 2019).
- Adaptation of technical requirements for flexibility products: Traditionally, demand response products on the electricity market were created for large generation units (Leutgob et al., 2019). Today, system needs and technical requirements have changed and this should be reflected in the definition and requirements of products (Lamprinos et al., 2016). For example, the minimum size of aggregated loads, maximum duration of availability, recovery periods and standardised procedures for prequalification (aggregated loads instead of technical units; one prequalification for several products etc.) are important factors necessary to intensify participation of DR. This is of high relevance especially for demand response applications where a large number of small and medium loads should be aggregated automatically (Gao et al., 2017).
- Roll-out of smart meters: Integration of small and medium loads requires short term (real time) metering of electrical power on the side of consumers, extended by smart devices that allow for changing loads or switching devices automatically (Leutgob et al., 2019). As the roll-out of smart meters has already started in most of the European countries, this may help to integrate small and medium loads in flexibility markets. However, not all smart meters will have the functionality for remote control necessary for demand response. Additionally, measurement and verification also require adequate metering (Woodhouse and Bradbury, 2017).
- Clear requirements for measurement and verification: Measurement and verification is required in order to quantify the effect of demand response actions (e.g. reducing electrical load for a certain period of time) (Gharesifard et al., 2016). Compensation will be given for load curves without any demand response event. Similar to Measurement and Verification (M&V) in energy performance contracting, demand response requires a high temporal resolution (hours to minutes) and it should take place at the level of aggregated loads. A commonly agreed (simple) methodology is a main precondition for the reduction of transaction cost (Leutgob et al., 2019).
- Appropriate tariff structures should be able to incentivise demand response while including price signals for the integration of renewable energies (Leutgob et al., 2019). This should not only include tariffs for energy consumption (time-of-use tariffs) but

Twinergy has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957736

also flexible grid tariffs that reflect the status of the grid and the need for balancing demand and response in the electricity system (Gao et al., 2017).

In the end, Leutgob et al. (2019) concludes that regulatory framework conditions are positively improving in many jurisdictions. Regulators have identified the need for expansion of DR balancing markets with a clear goal in their mind to increase competition among market players, in order to provide improved democratization and decentralization in their energy markets.

3.5 Improving the DR Business Models

Against the background of improving technical opportunities due to digitisation, and taking into account regulatory frameworks that are incrementally adapting to the integration of DR, it is time to look at the aspect of improved DR business models for small and medium-sized prosumers. Over the last few years, the DR market has developed several business models by which the value of potentials for load shift is priced, offered and sold on the flexibility markets (Gharesifard et al., 2016).

By assigning specific roles to stakeholders (Figure 12) we are able to define these improved business models.

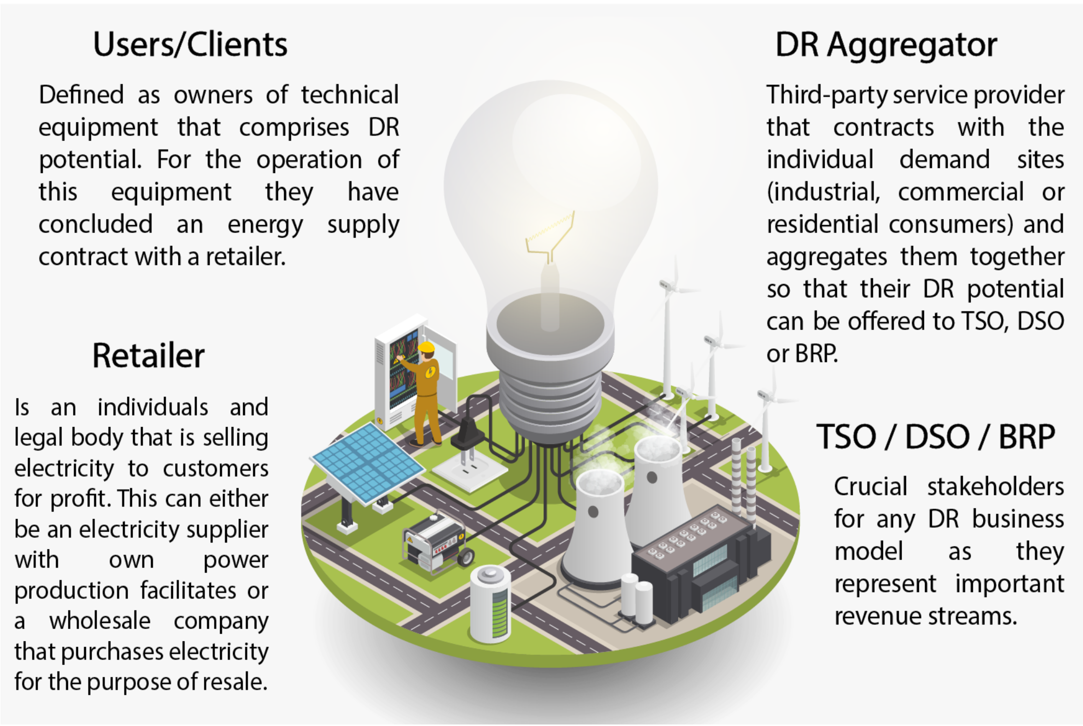

Figure 12 - Stakeholders roles (Leutgob et al., 2019)

A usual way to categorise DR business models is related to the different nature of the related income streams: Explicit DR or implicit DR. Furthermore, one business model is related to the specific case of microgrids (Leutgob et al., 2019).

• Explicit DR as stand-alone service (Lamprinos et al., 2016)

• Explicit DR combined with EES (Gharesifard et al., 2016)

• Implicit DR service for optimal use of time-of-use (TOU) contracts (Plancke et al., 2015)

• Implicit DR including power supply (Richter, 2012)

• Microgrid Management (Provance et al., 2011)

3.5.1. Explicit DR as a stand-alone service

In this business model, a DR Aggregator is bundling DR potentials from different clients, which are too small as stand-alone potentials to be offered to the various flexibility markets (Leutgob et al., 2019). As seen in Figure 13, there are several characteristics of this business models such as: the aggregator as a facilitator, the income streams and that the service of DR aggregation has no interlinkage to power supply. The first one is where the aggregator acts as a facilitator, having control, access and management over the DR potential of the client in order to manage them toward different flexibility markets, such as electricity balancing or group load balancing participation by BRP (Richter, 2012). The income streams in this business model originate from payments either from the TSO/DSO or from the BRP (Ghavidel et al., 2016). Depending on the contractual agreement, the aggregator will usually pass on a certain share of these payments to the clients in his portfolio. Lastly, the fact that the service of DR aggregation in this business model has no interlinkage to power supply means that the model has many interfaces which need to be properly managed (Leutgob et al., 2019).

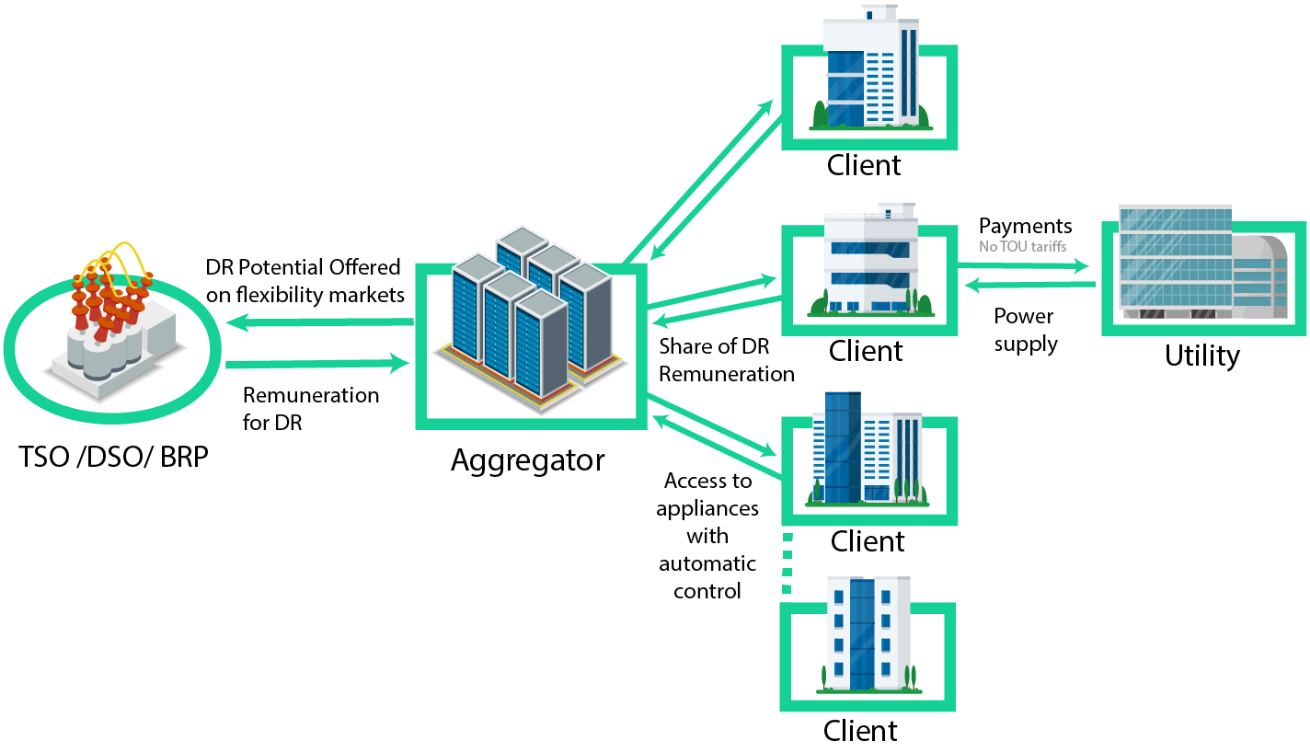

Figure 13 - Explicit DR as a stand-alone service (Leutgob et al., 2019)

The improvements proposed to this model are in relation with:

- **Improvements to software solutions** - for aggregation of small and medium-sized loads (e.g. bundling of small loads, availability forecast, automatic dispatching functions) (Diaz-Diaz et al., 2017).

- **Easy access to a large number of switchable devices** (i.e. smart devices) (Diaz-Diaz et al., 2017).

- **Attractive value proposition** to the clients - since in the beginning most of the rewards promoted to the participant will be reasonably small, the value proposition has to be built on strong grounds with incentive schemes which will make the program more attractive (Leutgob et al., 2019).

- **Distribution channels and customer relationships –** in many cases the sustainability of the improved program is greatly dependent of how fast economies of scale to cover the cost of operations, because the aggregator will have to cover a lot of subjects at a low cost for the program to work (Leutgob et al., 2019).

3.5.2. Explicit DR with EES

In its general approach, this business model is similar to explicit DR as stand-alone service, but the DR aggregation service is embedded into a more comprehensive Energy Efficiency Service (EES) (Figure 14) (Leutgob et al., 2019). One of the main characteristics of this model are trade-off between energy efficiency and demand response, since, load shifts usually leads to increased energy consumption (Figure 14). Therefore, the main challenge of this action is to find the optimal balance and trade-offs on a day-to-day bases in this dual service scenario (Burger and Luke, 2017). The other one is that, EES and DR services require different fields of expertise and competencies. Whereas the core knowledge of EE service providers (frequently called ESCOs) is related to the operation of technical equipment, the success of DR service providers (usually provided by a DR Aggregator) is mainly based on a thorough understanding of the flexibility markets. Therefore, the combination of both services into one integrated offer is not easy and requires clear and transparent definition of the ESCO's and the DR Aggregator's role (Alvaro et al., 2016).

As (Leutgob et al., 2019) indicates, there is no evidence that the dual service model is being used in the European markets as of yet, but the potential for its adoption and the DR potential which can be harvested through this model is pretty much visible. This energy business model can monetise energy saving by exploiting their potential to be used in DR market and give higher market penetration to EE (energy efficiency) upgrades to building and installation of RES (renewable energy sources).

The proposed improvement of this system will be successful if there is a package of EES and DR services with clear conditions of operation between the ESCO and the DR Aggregator. In this context, the functionality of price forecasting gains increasing importance as it supports solving the trade-off between energy efficiency and load shifting in optimised way (Burger and Luke, 2017). Furthermore, the adaptation to a specific customer attributes is highly recommended in respect to the remuneration and explicit versus implicit DR structural elements.

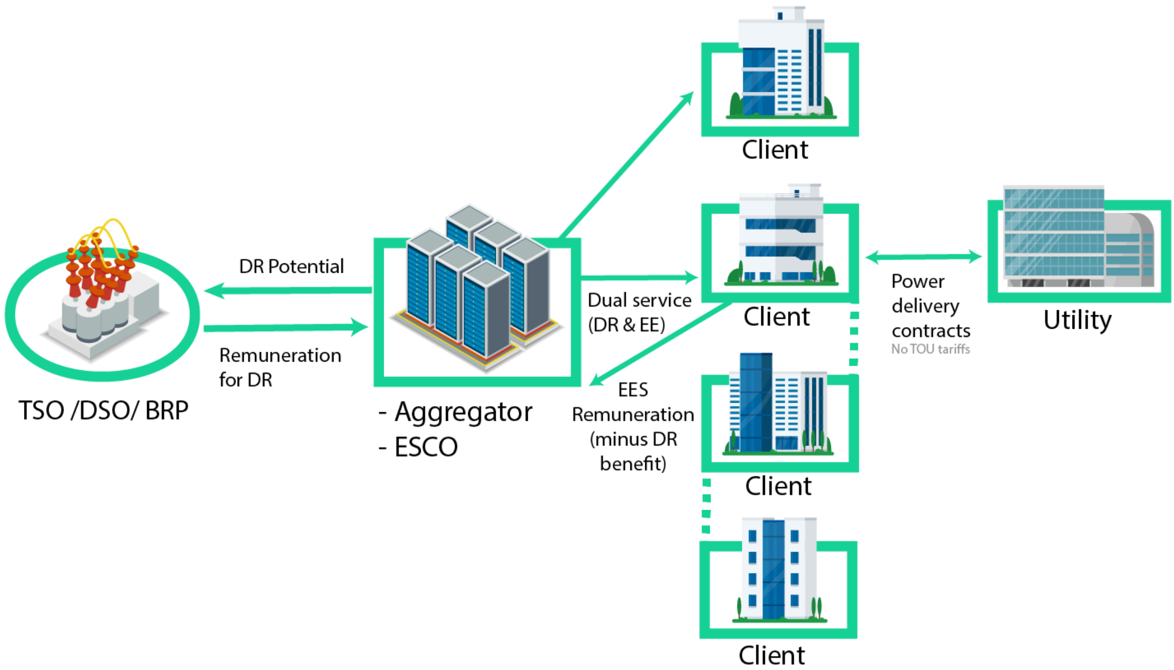

Figure 14 - Explicit DR combined with EES (Leutgob et al., 2019)

3.5.3. Implicit DR for optimal use of TOU

For this model to work we are starting with the assumption that certain group of consumers already have different price levels on their tariffs depending on the time of consumption. Different price arrangements are described as: Time-Of-Use (TOU), Real-Time-Pricing (RTP) and Critical-Peak-Pricing (CPP) (Leutgob et al., 2019).

- Time-of-use (TOU) refers to a flexible pricing structure incorporating different unit prices for usage during different time periods within a day. TOU rates reflect the average cost of generating and delivering power during those time periods. The simplest way of TOU tariffs are day-night tariffs, but more disaggregated tariff structures are developing currently on the market (Gao et al., 2017; Leutgob et al., 2019).

- Real-time-pricing (RTP) refers to pricing based on real-time movements in electricity prices based on trade in spot markets, balancing markets or other exchanges. It links hourly or half-hourly prices to corresponding changes in real-time or day-ahead power costs. In this case, customers need to be informed about expected RTP prices on a day ahead or hour-ahead basis to elicit load response (Leutgob et al., 2019; Plancke et al., 2015).

Critical peak pricing (CPP) is a hybrid combining traditional time of use rates and real time pricing design. The basic rate structure is time of use. However, provision is made for replacing the normal peak price with a much higher predetermined critical peak pricing event price under specified conditions (Alvaro et al., 2016; Leutgob et al., 2019).

As Leutgob et al. (2019) explains, in European markets the time dependent structure of the tariff may be influenced by two components, either separately or both together in correlation. These two components are electricity delivery and the utilization of the grid. At the moment only TOU is available for use to the small and medium sized prosumers. As many different types of TOU are expected in near future, additions of CPP model is also expected for medium sized prosumers who are searching for time-dependent tariff for a whole pool of facilities.

There are several factors identified to improve the business model related to Implicit DR for services related to TOU (Figure 15). Those elements are: service provider, tariff structure, stand-alone services, embedded services, facility management, technical-know how (BMS, price signals) (Leutgob et al., 2019). To start from the top, the service provider should be responsible for the load shifts management and equipment management of the client in the most beneficial way in order to maximise benefits from TOU tariffs (Gharesifard et al., 2016). Following this, one should also look at the tariff structure, particularly of the spread between high and low prices. This is a very important moment, because on this basis the client can see if there will be sufficient benefit in order to engage into DR. In the near future, it is expected that dynamic pricing models, such as, CPP and RTP will be increasingly available on the market. In continuation, the model will be even further maximising its benefits, if it is embedded in package of other services already offered to the client (i.e. facility management, consultancy services) (Lamprinos et al., 2016). Moreover, the most beneficial target group will be the ones which have already outsourced its own facility management to an external partner with a huge potential of exploiting possibility for cross-selling points across the board. It is worth to mention here that a good relation between the facility management and the DR Aggregators is a must for proper functioning. At the end, it is noted that proper know-how in building management operations and capability to manage information about price signals, potentially dynamic price signals is the cherry on top of the cake in order to improve the current business model (Leutgob et al., 2019).

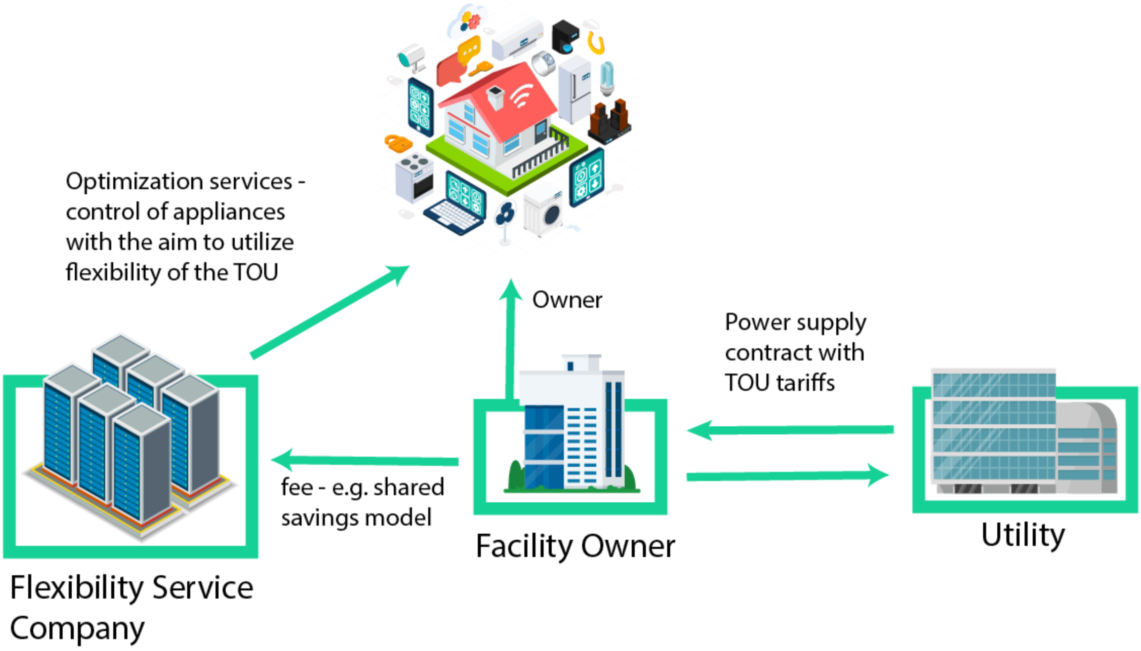

Figure 15 - Implicit DR for optimal use of ToU-contracts (Leutgob et al., 2019)

3.5.4. Implicit DR including power supply

This business model combines the DR service with the role of the retailer in the energy markets (Figure 16). One of the key aspects of the business model in this case is that the retailer has access to the DR potential at the customer's site in addition to its other functions of selling electricity. The retailer is allowed to shift loads within the contractually agreed limits. Therefore, the business model goes beyond offering TOU tariffs, but includes active management of DR potentials at the customers (Leutgob et al., 2019). In this respect, this creates the value proposition of the model as the access to the DR potential represents clear value. Moreover it may lead to savings both in wholesale prices and in balancing energy payments, since these prices are subject to high fluctuations depending on time of purchase (Gao et al., 2017). The more the retailer will be able to adapt the consumption patterns of his customer to the off-peak times on the market, the better will be his average wholesale price (Alvaro et al., 2016). In addition, the business model is particularly attractive for retailers that are also producers with a high share of fluctuating renewables sources (wind, PV) in their supply portfolio. By activating DR potentials, they can reduce the gap between supply and demand and thus reduce balancing energy payments (Burger and Luke, 2017).

This is a business model with high potential of transferability to small and medium size prosumers and for further improvement there are several factors which should be applied. Starting from the fact that retailers should be able to get a good starting position to get to DR Potentials as they have already established working distribution channels and customer relationships, mean that they should further exploit this relationship by offering DR programs (Leutgob et al., 2019). The customer, by default, will be expecting and requiring an incentive in order to grant access to system and these incentives could range from receiving a favourable tariff, but also in some cases, because of the market situation as well as regulatory conditions, the incentives should be in the form of non-financial benefits. Because of comparably low transaction cost for retailers when accessing their customers, we assume that the business model may be also applicable to the household sector (Lobbe and Hackbarth, 2017). Here the main barrier is the access to switchable devices in a way that they can be automatically managed. Furthermore, in this model the retailers should facilitate the process of adoption of smart devices in combination with a special tariff and where possible subsidise their usage and adoption in order to allow Implicit DR. This will greatly increase the participation of the small and medium sized prosumer in the business model (Woodhouse and Bradbury, 2017). At the end, a crucial part of this model is the fact that a suitable software platform is required in order to properly harvest the benefits of the DR Potentials. The retailer will have core interest in the platform's ability to synchronise the use of DR potentials with productions patterns, if the retailer is also an electricity producer, and/or with price signals on the wholesale market (Leutgob et al., 2019).

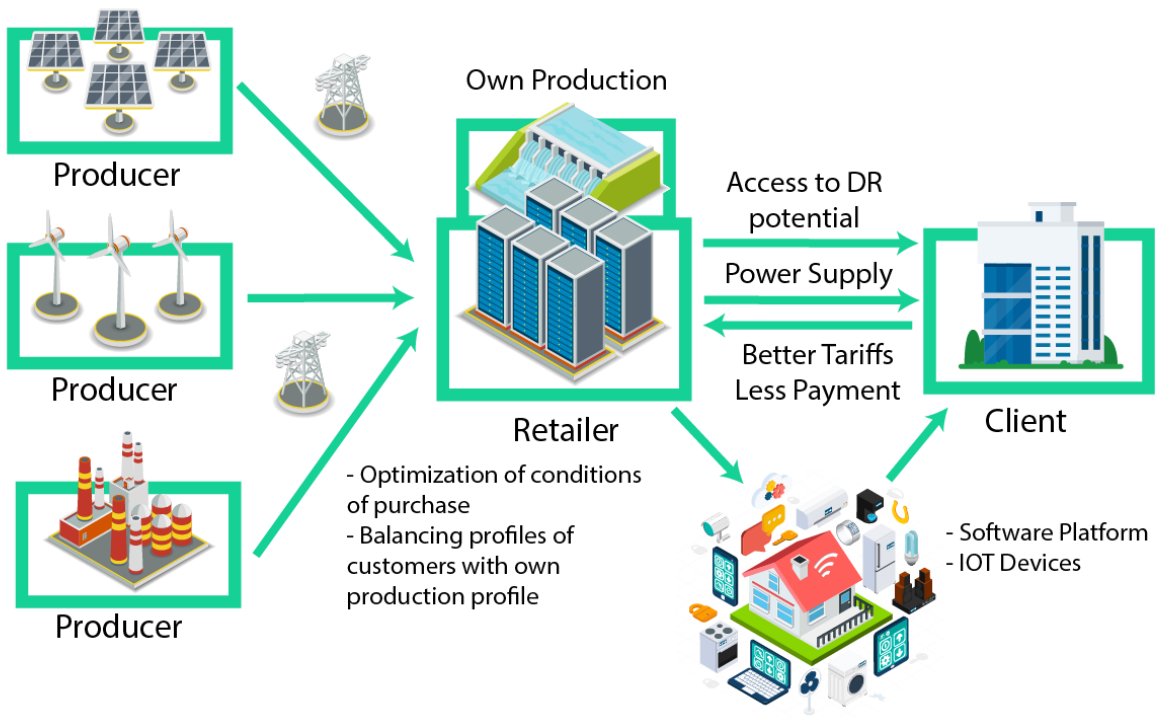

Figure 16 - Implicit DR including power supply (Leutgob et al., 2019)

3.5.5. Microgrid Management

Many authors define microgrids (Leutgob et al., 2019; Cazalet et al., 2017) as a group of interconnected loads and distributed energy resources (such as distributed generators, storage devices, or controllable loads) within clearly defined electrical boundaries that acts as a single controllable entity with respect to the (macro)grid. The microgrid can operate both in grid-connected or island-mode. When it operates under island mode, the microgrid has to ensure that at each given point of time the supply is adequate to cover the demand for power which is needed (Plancke et al., 2015). The DR potential plays a crucial and decisive role in this mode. When it is in grid-connected mode, though, the DR potentials which are internally available can be used to maximize the model. In this way, offer the loads in tenders to TSO, DSO or BRP (explicit DR) of optimised electricity cost by adapting the load profile of the microgrid to dynamic pricing (implicit DR) (Leutgob et al., 2019).

The findings suggest that microgrid business model is extremely important for further activation of medium-sized DR potential that qualifies for formation of a microgrid (Figure 17). The most relevant application fields for this business model will be those cases where a complex demand structure is complemented by decentral renewable energy production on the site or nearby the site (e.g. university campus, green-field neighbourhood development, business parks etc.) (Leutgob et al., 2019).

Although EU regulations are creating regulatory barriers for fast implementations of microgrid, pilots are still coming out in the marketplace and even further implementation of this business model can be quite beneficial for the whole energy market in general (Ghavidel et al., 2016).

For a future improvement of the model, a comprehensive software platform which will cover all aspects and will be able to manage and dispatch various loads, is a crucial factor which must be put in place, regardless in which mode of operation the microgrid will be.

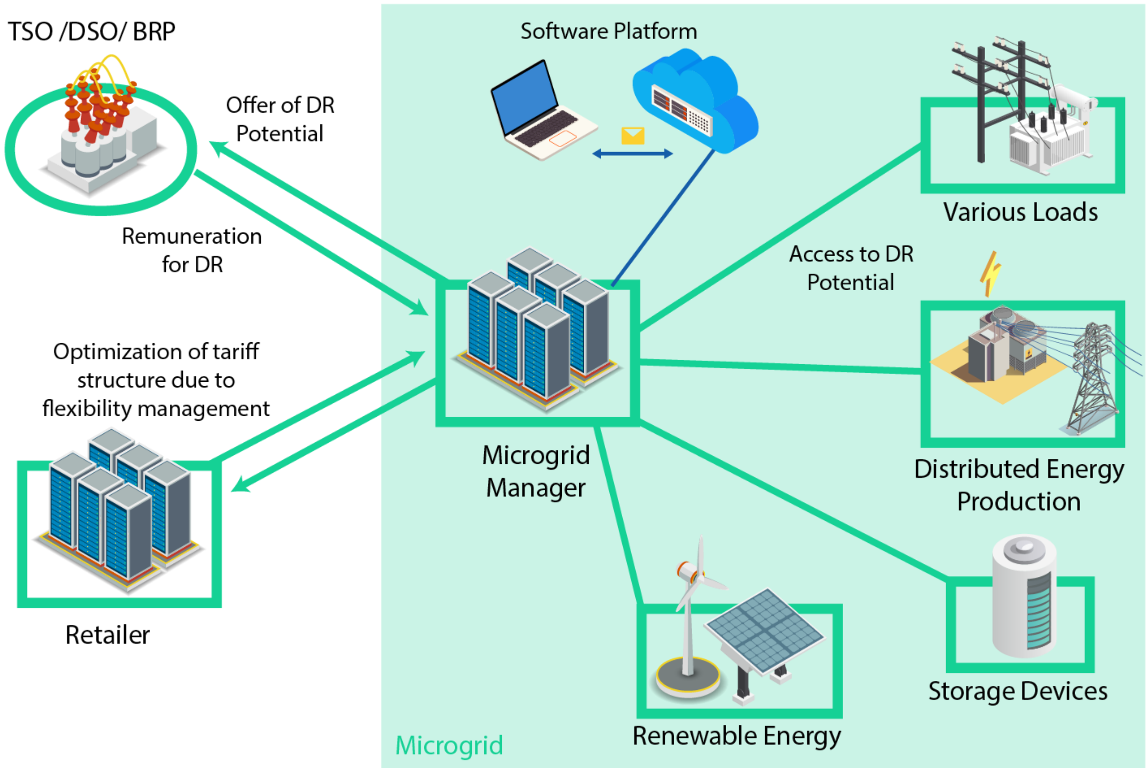

Figure 17 - Microgrid Management (Leutgob et al., 2019)

3.5.6. Suggestions for Improved Business Models

The future of the energy business models field will be greatly led and dominated by developing technologies and especially the progress of digitization. This is especially crucial for the ability for small and medium sized prosumers to join and participate in the flexibility markets. In order to cope with this, improvement of the current business models is strongly suggested and following the finding for improved business model will prove beneficial in the long run (Leutgob et al., 2019). As analysed in the sections above, following of most important improvements can be summarised as:

- Adoption and easy access to IOT and smart devices (Diaz-Diaz et al., 2017; Leutgob et al., 2019)
- Real significant value propositions – At the moment what is offered on the market is very rudimentary and not bringing any real value for the participants, thus the DR-participation is limited (Leutgob et al., 2019). The suggestions presented for different kind of incentives can greatly stipulate participants to join the programs as they will have a significant value proposition and, in this way, create benefits and maximise the effect of the DR program (Ghavidel et al., 2016). Although in many EU markets there are regulatory barriers that are making monetary incentives problematic, still there are plenty of non-monetary incentives which can stimulate participation. Such non-

monetary incentives can be in the range of: vouchers, environmental benefit, improved data security, transparency and trustworthiness, smart contracts, guarantees of availability etc. (Cazalet et al., 2017).

- Reduction of transaction costs – As the financial savings may be small for the single user, all cost related to distribution and communication with the potential customer need to be very low, too. Therefore, it will be decisive to make use of existing distribution and information channels related to the target groups addressed (Leutgob et al., 2019).
- Service package offers – By offering more services at once, economies of scale will be relatively easier to be achieved and with that participation of smaller and medium-sized players on the market, it will make greater benefit for them by creating greater value, as mentioned above (Alvaro et al., 2016).
- DR Aggregator platforms – this is certainly one field that will need a lot of attention since it holds huge potential and operators should greatly focus their attention on creating innovative platform solutions for better operations. Ranging from better incorporation of loads and automatic dispatching, to keeping updated price signals, information is a crucial factor for success (Alvaro et al., 2016).
- Petition regulatory DR framework – Although in recent years the regulatory conditions have greatly improved, still they are far away from satisfactory level for unobstructed DR program operations. Change is needed, but change can only be inspired by action (Leutgob et al., 2019). Operators should be proactive and push for this change to happen sooner rather than later. For example, clear definition of the role and responsibility of independent aggregators and their relation to BRPs/retailers and/or other market participants; reduction of administrative efforts and upfront costs; definition of technical standards (e.g., for data exchange), standardised procedures for prequalification for participation in balancing markets and requirements for measurement and verification, should be further developed (Leutgob et al., 2019).

4. Transactive Energy (TE) Business Models

4.1 Transactive Energy Business Model

In today's world there is certainly a need for developing new energy business models, which will better serve the needs of the market and create values and benefits for all actors involved.

From the perspective of defining business models, the key word in this definition is "value." The objective of TE is to bring DER into the electric system based on its value to consumers and the electric system as determined by market prices (Cazalet et al., 2016). TE is seen as a way to empower consumers, lower costs, increase resiliency and realize environmental benefits. Such electricity markets would have different business models than today's electricity industry (Alvaro et al., 2016). Businesses would need to create value for prosumers and consumers alike and to capture enough of that total value for themselves to be financially viable. New types of businesses will be needed to serve prosumers and the roles of some existing organizations may change. For a TE market to succeed, these businesses and organizations must have viable business models (Cazalet et al., 2016).

4.2 Business Models for TE Markets

As Cazalet et al (2016) explains, TE markets will likely alter the behaviour of many electricity consumers and thus change the business models of the organizations in the electric marketplace. For most, revenues will no longer be based on cost of service but rather on the ability to create and capture value. The needs, priorities and decision-making characteristics of consumers will determine their willingness and ability to participate in electricity markets as prosumers in aggregations of consumers. Effective business models will thus need to anticipate and be responsive to ongoing patterns of value creation and destruction, how they differ among customers, and how these behaviours change as markets evolve (Alvaro et al., 2016). Some business models may evolve from long-standing current business models while others may be created specifically for transactive markets and still others may have started in earlier stages of the electric markets but may blossom in TE markets (Gao et al., 2017). In addition, with TE markets, electric distribution would change considerably and, in more ways, than just facilitating the two-way flow of electrons. Several new and as-yet hypothetical business models would also be essential to the operation of a transactive marketplace depending on the market design (Cazalet et al., 2016).

New business models will emerge to serve consumer needs in TE markets and others may change to meet the needs of those markets. Some new market participants will likely be customers or aggregations of customers that supply electric services to the transactive marketplace (Cazalet et al., 2016).

4.2.1 New Market Participants Business Models

Figure 18 describes different aspects of the New Market Participants Business Model and which value propositions come out as possible benefits from exploitations of this model.

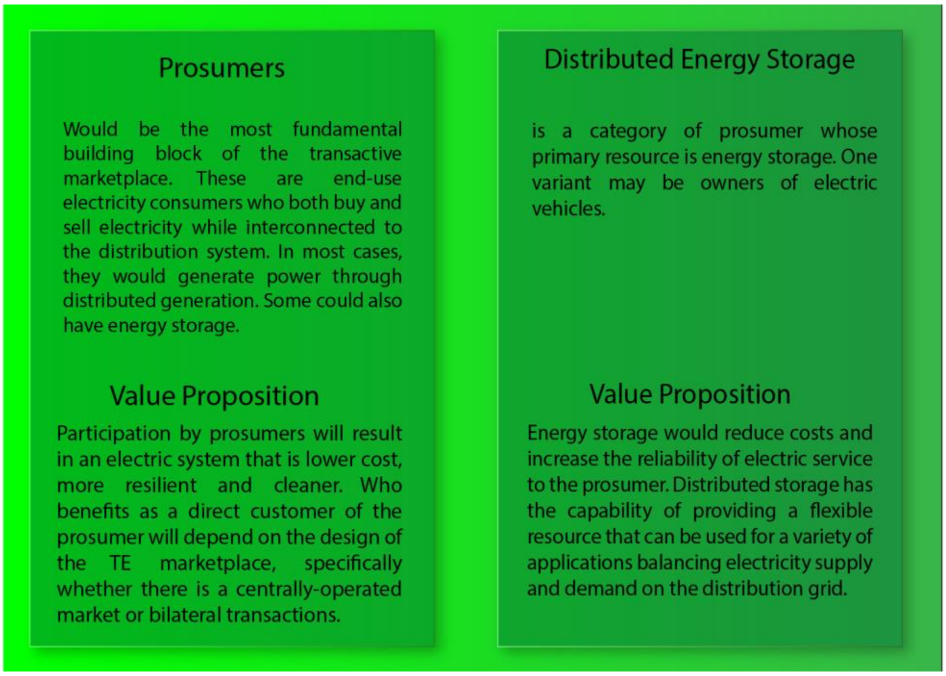

Figure 18 - New Business Models (Cazalet et al., 2016)

4.2.2 Business Models Combining Aggregation and Integration

Figure 19 describes different aspects of the Business Model with combination of Aggregation and Integration and which value propositions come out as possible benefits from exploitations of this model.

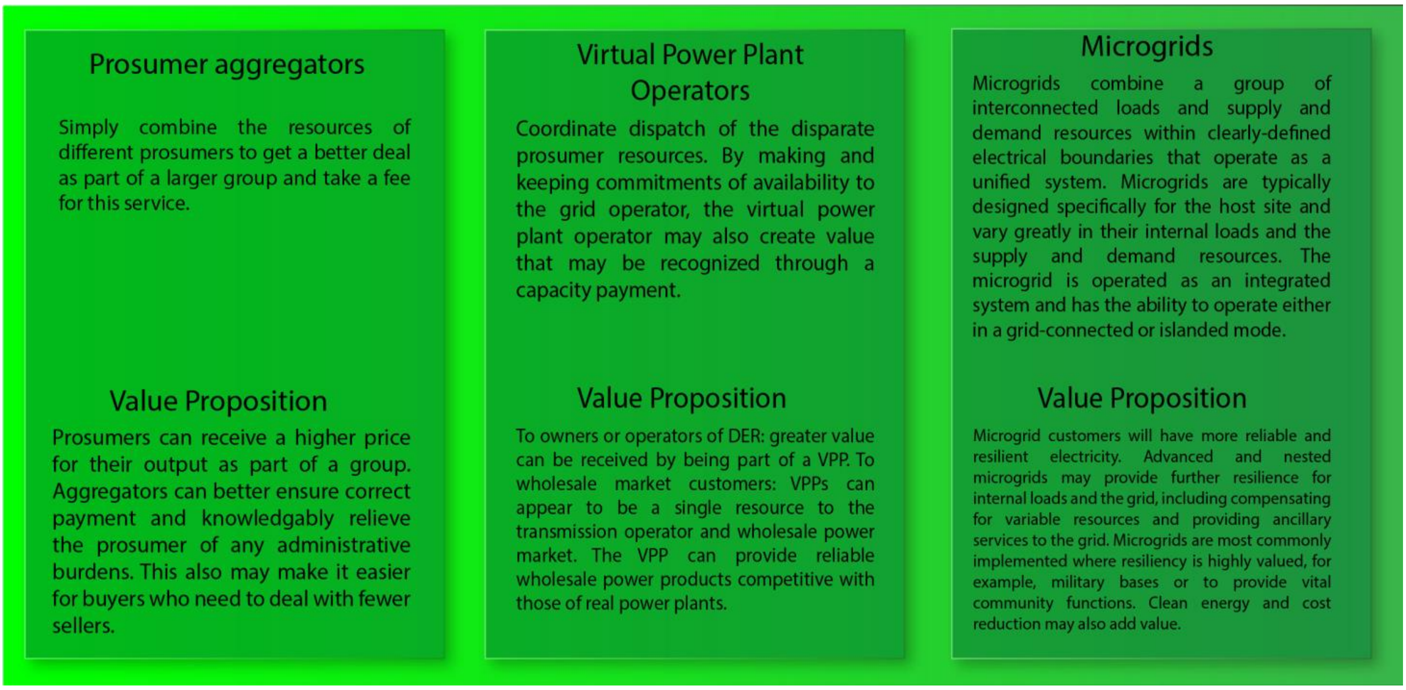

Figure 19 - Prosumers combining operations through Aggregation and Integration (Cazalet et al., 2016)

4.2.3. New Market Design Business Models

At the end, Figure 20, provides overview of new market design business models, taking in consideration the analysis provided above and provide value propositions for increased benefits in the business models concepts.

Figure 20 - New Market Design Business Models Source: Cazalet et al. (2016)

4.3 Factors Influencing TE Business Models

Many of the new business models proposed in the energy sector will not come into play so easily. This field is highly regulated, and on top of that many factors exist which can greatly influence the operational capability of a certain business model. There should be favourable conditions in a certain market in order for specific models to be emerging in operations. They will emerge as conditions that enable them are created along three mutually-supportive pathways: technology penetration, government policy and regulation, and economics. Emergence of these markets will change the risks faced by those who conduct business in the electric sector, creating risks for some and reducing it for others (Cazalet et al., 2016).

- Technology Penetration is a fundamental question whether consumers will invest in and operate DER technologies as well as participate in a transactive market. Enough market participants must use the technologies to be buyers or sellers in a reasonably liquid market and they must receive enough benefits to continue market participation (Cazalet et al., 2016). This will not happen all at once and simultaneously throughout the country (Burger and Luke, 2017). Uneven progress may give competitive advantages to those that successfully compete in early markets and use these markets as a base for entering later markets (Gao et al., 2017).

- Next in line are many policy and regulatory questions that will need to be resolved in different markets. Countries will most likely make their own policy and regulations and at the moment there are not many countries which are fully transactive in their energy market (Cazalet et al., 2016.) Market designs and regulations need to accommodate change over time to improve market performance, to increase participation and to ensure adequate functionality as needed improvements are identified (Plancke et al., 2015).
- Transactive energy markets are intended to create the basis for electricity products and services to be bought and sold based on value to the ultimate consumers (Cazalet et al., 2016). Prices are intended to be determined by supply and demand and to provide clear value incentives, and the market conditions determined in part by market designs must permit this. These markets would need to incentivize both economically efficient investment in DER and their cost-effective operation (Cazalet et al., 2016). Furthermore, these incentives should relate fairly to incentives for large-scale facilities on the transmission system. This implies a need for both long-term market signals for efficient investments throughout the entire electric system in addition to short-term market signals for dispatch Ghavidel et al. (2016).

5. Improved models - TE and VPP for the Future

In an energy sector increasingly characterised by complex value creation networks, the integrated combination of material and services is gaining in relevance. In particular, existing business models with direct end customer contact are dependent on the integration of additional services in the long term. In this context, the analysis confirms that digitisation drives and enables the transformation of energy systems (Giehl et al., 2020). Many new companies are entering the market with innovative products based on digital solutions. Companies from the information and communication sector and other companies from outside the industry increasingly drive the change (Diaz-Diaz et al., 2017). This is, in particular, valid for new services that go beyond the mere supply of energy. For example, software, automation and platform solutions or solutions for sector coupling with the related areas of mobility and heat are gaining importance. Here, new entrants from other sectors can provide essential skills for the provision of innovative value propositions by entering the energy sector. However, traditional companies in the energy industry can also expand their product portfolio based on their expertise within their value creation network (Giehl et al., 2020).

5.1 Digitalization in the Energy Sector

As indicated by Kufeoglu et al. (2019), digitalisation in the energy sector involves the creation and use of computerised information and processing of the vast amounts of data which is generated at all stages of the energy supply chain. It promises a lot for every segment of the energy ecosystem: households, prosumers, distribution, transmission, generation, and retail and is frequently stated as likely to lead to a transformation of the energy system. It is often associated with 'smart' energy, the Internet of Things (IoT) and Blockchain technology. The main aim of digitalization is to improve efficiency. It enables better, cheaper, and faster monitoring, recovery and maintenance of the assets and components through 'smarter' grids (Diaz-Diaz et al., 2017). Smart households facilitate households' own solar energy production. The Internet of Things (IoT) will integrate smart appliances for savings and grid services (Diaz-Diaz et al., 2017). For instance, smart charging of Electric Vehicles can be a key provider in demand response. Blockchain which involves decentralized transaction verification will potentially empower individual customers to trade power and make payments in a seamless way. Digitalization can help with better network and congestion management, assisting with the renewable generation intermittency problem, allowing more effective network monitoring and more efficient network operation. It also provides digital platforms for demand response, and Peer-to-Peer (P2P) energy and carbon credit trading (Kufeoglu et al., 2019).

5.2 Virtual Power Plant (VPP)

Virtual Power Plants (VPPs) aggregate DER units and offer them to the energy market. The aggregated DERs maintain reliability of renewable energy resources and address grid congestion. VPPs can be managed by third-party aggregators, BRPs, or suppliers. VPPs provide a variety of services to power plant operators, industries, public services, energy suppliers, and grid operators. VPPs create new business opportunities for aggregators and suppliers. Moreover, VPPS, provide various opportunities to stakeholders, such as energy trade, network services, and balancing services (Ma et al., 2017).

A VPP consists of generation units, energy storage, and Information Communication Technology (ICT) and they can be used in operations as VPPs for Trade, Balancing, and Network Services. The actors in the VVP structure are sublimed in Figure 21.

Actor	Offers	To
VPP aggregator	Market access Ancillary services Balancing services Buy and sell electricity Network services	DER owners TSO BRP Wholesale Market DSO
DER owner	Produce electricity Direct control	VPP aggregator VPP aggregator
BRP	Settle the imbalance Accurate forecast of supply and demand Bilateral contracts [29]	Market VPP aggregator VPP aggregator
Policy maker	Energy rules	All actors

Figure 21 - Actors in Virtual Power Plants (VPPs) (Ma et al., 2017)

Designed to provide flexible grid services that are not highly dependent on the specific locations of the DER assets, VPPs are ideal for applications such as frequency regulation, peak demand management and secondary and tertiary reserves. They also enable energy trading in wholesale markets on behalf of DER owners who would otherwise not be able to participate on their own. VPPs can act as an arbitrageur between DERs and diverse energy trading floors (Papalexopoulos 2021).

It is important to note that this is in contrast to the location-specific (e.g., tied to locations of specific assets such as feeders), primarily distribution system-focused grid services enabled by distributed energy resource management systems, or DERMS (Papalexopoulos 2021).

Today's VPPs offer an ideal optimization platform for providing the supply and demand flexibility needed to accommodate the fast-ramping needs of renewables, to balance wind and solar intermittency and to address corresponding supply forecast errors. For example, if one wind power source generates more energy than predicted and another generates less, a VPP will balance the two, resulting in a more accurate forecast. In addition, the wind power becomes a more reliable source of capacity in the market. Often, in energy markets, market participants fire up large and less efficient power plants to grapple with small gaps in demand. They may deploy a 600-MW gas plant when only 5 MW is needed. With a VPP, when the TSO asks for 5 MW, the VPP will do two things. It will look for places to reduce load, so the system may not need all of the 5 MW. It will also look for places where it can self-generate electricity by discharging batteries, or dispatching wind or solar facilities (Papalexopoulos 2021).

VPPs incorporate short-term load, distributed generation forecasting and aggregation capabilities. They perform near real-time shifting of commercial and residential net loads to provide the services needed by the grid. Under the control of a VPP, demand on the system can be optimized and tweaked automatically, making day-ahead call-outs a thing of the past (Papalexopoulos 2021).

VPPs have the ability to go beyond simple load curtailment and to leverage continuous communications and bi-directional control to deliver dispatchable grid support. As a result, aggregated DERs can be orchestrated by VPPs with second to minute response speeds (Papalexopoulos 2021).

By design, VPPs can coordinate and control more efficient and clean sources of distributed energy so there's no need to overbuild or deploy fossil-fuel plants to balance electric demand and supply. The objective is to feed an automatic generation control signal to VPP that indicates the TSO's needs a certain amount of capacity at a certain point in time. The system can then go get that capacity within the bounds of what is currently available, at a specified confidence range, such as 2 MW with 95% confidence or 3 MW at 70% confidence (Papalexopoulos 2021).

5.3 Aggregation of Load Flexibility Tranches

As DERs proliferate and opportunities for active or flexible demand grow, "Aggregators" of these resources (or DER Aggregators or DERA) for the creating of the VPPs have the potential to help unlock the value of distributed resources and bring them into energy markets at scale. Aggregation is defined here as the act of grouping distinct agents in a power system (i.e., consumers, producers, prosumers, or any mix thereof) to act as a single entity when engaging in power system markets (whether wholesale or retail) or Transactive Energy trading (Papalexopoulos 2021).

It is important to analyze the mechanisms by which aggregations create value. In many cases, aggregators are performing roles today that may not deliver value to power systems but rather reflect opportunities to arbitrage inadequate regulation. In other cases, aggregation delivers real value, but this value may become less significant in the future, as technological change reduces the costs of information provision, coordination, or transactions. Other activities may deliver enduring value (Papalexopoulos 2021).

Aggregation has system value if it increases the social welfare of the power system. Private value is an increase in the economic welfare of a single agent or subset of agents. Private value creation may or may not align with system value creation. Aggregations with private value may create economic value for certain agents at the expense of system-wide economic efficiency (Papalexopoulos 2021).

We distinguish three broad categories of aggregation as follows:

1. Aggregations with *"fundamental"* value
2. Aggregations with *"transitory"* value
3. Aggregations with only *"opportunistic"* value

5.3.1 Fundamental Value of Aggregation

Fundamental value stems from factors inherent in the act of aggregation itself. In the context of the power system, aggregation may create fundamental value by capitalizing on economies of scale and scope and by managing uncertainty. Participation in electricity services markets incurs certain unavoidable costs. First, one must acquire or engage the owner of one or more energy resources (either centralized or distributed resources); second, if these resources are to interact with the market, they must be equipped with some level of information and communications technologies; third, energy resources and their owners must comply with power system regulations and market rules (Papalexopoulos 2021).

Many of these costs include fixed and variable components. The existence of fixed costs may lead to a situation where the average cost of providing a service is higher than the marginal cost. In that case, the average cost of providing the service declines as the quantity of services provided increases. **Thus, to the extent that there are fixed costs associated with participating in electricity services markets, there may be value in aggregation via *economies of scale*. Furthermore, to the extent that providing multiple services or products entails common technologies, transaction costs, acquisition costs, or**

knowledge bases, aggregation may create value through *economies of scope* (Papalexopoulos 2021).

Finally, market parties have different risk preferences and capabilities to hedge against risks. A small agent may not be able to hedge against price risks while hedging products may be available to large agents (through contracts for differences for example). Therefore, DER Aggregators create value by managing uncertainty acting as intermediaries between a large number of small DERs and volatile markets to provide hedging solutions to market players (Papalexopoulos 2021).

In a nutshell, fundamental aggregations provide value by harnessing economies of scale and managing risks and uncertainties for participating DERs.

5.3.2 Transitory Value of Aggregation

DER Aggregators may create value as the power system transitions from current regulations and technologies to a more advanced smart grid future. Temporary value is not inherent to aggregation, but it may be unlocked by DER Aggregators. Opportunities for agents in the distribution system to increase system efficiency by engaging with the bulk power system are increasing as information and communications technologies enable loads to become more price-responsive and as DERs are increasingly deployed. However, market complexities, information gaps, lack of engagement, and other biases may prevent the value of DERs from being unlocked. DER Aggregators can create system value by managing or eliminating these factors. An agent may be capable of providing a service (or set of services) to the system but may lack the information required to do so effectively. For example, small DERs often lack information in a number of areas: when system peaks occur, what the prices are for various services they consume, what technologies are available to help them control consumption, what the prices of these technologies are, etc. (Papalexopoulos 2021).

A DER Aggregator may be able to intervene to close gaps in information between an ISO and the various agents. Furthermore, a DER Aggregator can gain from economies of scale by processing information from multiple DERs, whereas costs would otherwise be multiplied by the number of DERs processing this information independently. It can also handle complex registration and bidding processes on behalf of the DERs they serve, enabling the system to benefit from the services these DERs provide and enabling them to benefit from previously untapped revenue streams (Papalexopoulos 2021).

5.3.3 Opportunistic Value of Aggregation

Opportunistic aggregation may emerge as a response to imperfections in market design, regulation, or policy. This form of aggregation occurs when different DERs located at one or more sites aggregate to obtain private value in ways that don't increase the economic efficiency of the system as a whole. Opportunistic aggregation may work to restrict competition, especially for small DERs. We identify three categories of rules that can give rise to opportunistic aggregation: a) rules related to the procurement of balancing or ancillary services, b) rules related to the allocation of balancing costs or penalties for non-delivery of committed services to DERs, and c) inefficient locational price signals and/or network charges (Papalexopoulos 2021).

5.4 Value Creation Framework - Virtual Power Plant (VPP) Example

With the evaluation of the traditional energy business models and proposition of improved and decentralized business models, one can conclude that transactive energy models and dynamic VPPs are the way forward to achieve and harvest all technological potential that is at our disposal at this very moment (Giehl et al., 2020). With so much technological innovation and advancement, the players in the energy sector are obliged to look outside of the "traditional box" of solutions and provide new and advanced solutions for a better tomorrow.

An example of such solutions can be illustrated if one looks at the value network for the Virtual Power Plant Business Model. As seen in Figure 22, it shows a map of services, data, products, and energy flows of the business model prototype 'Virtual Power Plant'. Payment flows are opposite to the services and products and not depicted (Exceptions are possible, for example within the framework of mandatory notification obligations, which can result by information flows without a financing stream) (Giehl et al., 2020). The result illustrates the multitude and variety of customers, suppliers, and partners that a Virtual Power Plant requires. It also shows that a Virtual Power Plant only transports data. Concerning the electricity flow, the Virtual Power Plant is neither directly involved in generation nor transport. Such network can be created for all business models, identify gaps, help to close them, and offer practical use. Incentives can be established to fill these gaps in order to promote local value creation. For this purpose, the value creation network can identify gaps in the local business model landscape. Companies can use a value creation network for their business models or those of their customers to identify potential for (Giehl et al., 2020).

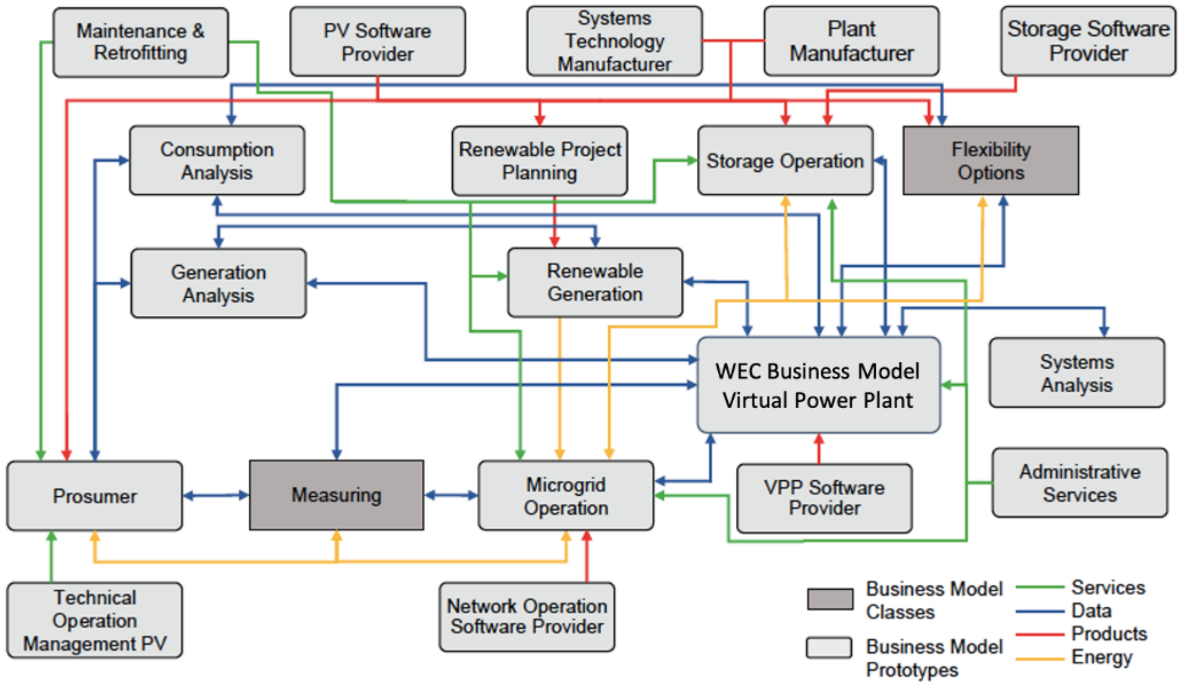

Figure 22 - Value creation network of a virtual power plant (VPP) (Giehl et al., 2020)

5.5 Blockchain and Decentralization in the Energy Sector

In their research, Kufeoglu et al. (2019), refers to Blockchain as a novel technology that eliminates one single central authority by creating a new consensus mechanism, which could be quite useful in energy trading. This is mainly because, the use of this technology enables creation of a platform which can connect supply and demand directly and solve the issue of lack of trust between the participants in the energy grid. Moreover, this trust creates the opportunity of reduced cost of transactions by eliminating the intermediary which is there to provide that trust in the first place. Blockchain as a disruptive information technology, is a consensus system that can build trust between transaction parties thus helping to achieve a fair, thrustless, transparent, and flexible environment. Particularly, for the energy sector, Blockchain can initiate the shift of the trading ecosystem from a centralised to decentralised one. And this is done by several actions, such as: removing the dependencies of intermediaries, multiple integrated services, consolidation of daily energy consumption etc. (Kufeoglu et al., 2019).

5.6 TE Platform (TEP)

With the massive penetration of IoT smart devices installed at the edge of the grid it is possible, for the first time, to enlist enormous amount of data in digital platforms, and provide methods and tools to enable the grid transformation and ensure that DERs can compete against traditional generation in wholesale and retail markets (TwinERGY Project Proposal, 2020). The TEP will be designed to implement organized nodal electricity markets for the distribution grid, which will revolutionize the relationships among customers, energy companies, and the grid under the new emerging transactive energy paradigm. The platform makes the transactive energy paradigms reality by allowing customers, either as individuals or in aggregate, to actively engage in energy markets by negotiating and responding to "value signals," based on price, demand, time of the day, and other grid and market considerations (TwinERGY Project Proposal, 2020). The transactive energy model, enabled by the TEP, will turn DERs (from solar to storage to EVs and smart appliances) into grid assets which can be deployed to solve grid problems. DERs enable consumers to become prosumers and provide flexibility and other services to the grid. In TwinERGY, it is envisioned that the TEP paradigm will enable grid **decentralization** and **democratization** by connecting the micro-grid operators to the DER managers and their customers (TwinERGY Project Proposal, 2020). It will provide an integrated energy business model through energy service expansion, customer engagement and financial inclusion. The Transactive Energy Platform, as illustrated in Figure 23, will use the Ethereum network and technology to create a thrustless auction house where flexible capacity and demand from DERs will be auctioned off, through encrypted, shared, immutable, and publicly auditable Smart Contracts. A cryptocurrency ecosystem is created, which reserves the cryptocurrency asset value, solves volatility problems, and ensures high transaction processing speed. Use Cases where the emerging transactive energy model will offer effective approaches for engaging DERs to achieve Demand response, balance the grid at various levels and maintain grid power quality and reliability are:

- Peak heat day and energy supply
- High penetration of Photovoltaics (PV) and Voltage Control
- Electric Vehicles (EV) on the neighbourhood transformer
- Islanded microgrid energy balancing
- Multi-bilateral trading with product differentiation (such as peer-to-peer trading based on prosumer preferences).

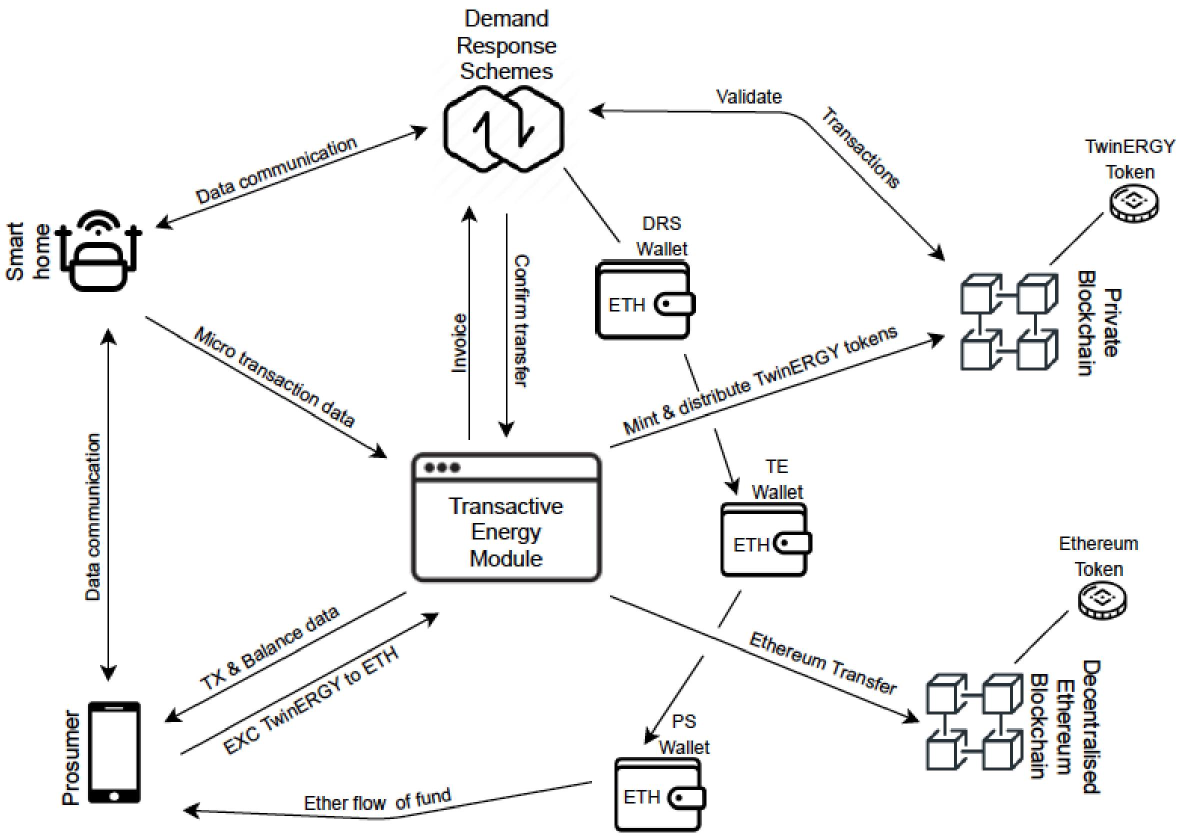

Figure 23 - WEC's Transactive Energy Platform

6. UK Pilot Site

6.1 Bristol City as part of TwinERGY Project

In January 2019 Mayor Marvin Rees launched the first iteration of Bristol's One City Plan. The plan sets out our city's key challenges up to 2050 and brings the city together around a shared vision. Drawing from feedback, input and consultations throughout the year, the City Office has produced the second iteration of the One City Plan. In summary, the City's One City Plan20 aspires to deliver the following themes and outcomes which the TwinERGY programme will support in terms of practical actions. By 2050 everyone will be well-connected with digital services and transport that is efficient, sustainable and inclusive; supporting vibrant local neighbourhoods and a thriving city centre. TwinERGY directly supports this objective through active better energy management tools and approach. What is more, TwinERGY explores measures that enable energy to be more affordable through intelligent grid DNR control processes and management which directly supports the efforts of the city to ensure its citizens mental and physical health (TwinERGY Project Proposal, 2020).

Overall, at the heart of the Bristol pilot will be to explore the use of Digital Twin (DT) technologies for consumer and citizen engagement, improved energy efficiency and sustained behaviour change towards more green and sustainable attitudes of energy use. We will also investigate the potential contribution of the approach to business model and service innovation, especially from a perspective of public value. This will be done with a particular mind towards groups underrepresented in the debate of emerging and future energy markets (e.g. young people, minority groups, homes in fuel poverty etc.) (TwinERGY Project Proposal, 2020).

6.2 UK Market Overview

Great Britain (GB) was the first country to open several of its markets to consumer participation in Europe (Bertoldi et al., 2016). Although in recent years the balancing markets are open to DR, still one can conclude that this process has not been very effective between the stakeholders on the energy market. Therefore, as a result, measurement, baseline, bidding and many other procedural and operational requirements are still inappropriate for demand-side resources, noticeably reducing the number of demand-side MWs in the system (Bertoldi et al., 2016).

In addition, as the BRPs and Aggregators have still not clarified it relationship, it will be of crucial importance that this factor has been taken out of the equation in order to fully open wholesale and balancing markets, as in the moment, the aggregators are using an operational gap in the regulation in the sense that they are not required to contract the retailer/BRP directly (Chase et al., 2016).

As National Grid is under growing 'distress' because of the growth of embedded generation, interconnection and large transmission-connected renewables, and also DNOs encouraging more innovative products, the opportunity for Demand Response is in principle higher than ever (Bertoldi et al., 2016).

6.2.1 UK Regulations

Independent aggregation is enabled in GB. The aggregator has direct access to customers, can take load from the entire country and can manage it without the need to ask permission or inform the retailer to load curtailment (Bertoldi et al., 2016). On the other hand the consumer is required to inform the retailer about his intended participation in the program (Chase, et al. 2016). For the future, there is indication that several actions will have to be undertaken in order to legalise and regulate the relationship between the ability of aggregators to freely operate while also protecting the retailer/BRPs from losses caused from DR activities (Hill et al., 2020).

Concerning BRP's imbalances caused by load curtailment, the customer has no obligation to maintain a consumption profile and British legislation does not address this issue (Bertoldi et al., 2016).

6.3 Demand Side Response (DSR)

Demand Side Response (DSR) is a well-established mechanism in the UK for electricity grid balancing operations. National Grid ESO runs a number of balancing schemes whereby commercial organisations are invited to reduce their electricity demand at peak times, in return for incentive payments (REGEN, 2018).

Recent projects and pilots done, suggests that there is increased interest and possible technical solutions for engaging DSR programs for small-sized consumers/prosumers (Chase, et al. 2016). With the increasing use of smart meters and smart devices and facilitation of IOT and DES and shift in the regulatory policies it is expected to bring the market to wider adoption of these models and even go step further by improving the business models and substituting them with better ones driven on technology and decentralization (Chase, et al. 2016). In addition to this goes the fact that there are also a number of DSR companies established in

GB, currently focusing on commercial and industrial customers, as well as a vibrant start-up sector assessing opportunities for targeting smaller users (Bertoldi et al., 2016).

6.3.1 Consumer engagement with DSR

The key point of engagement with DSR is to formulate positive strategies for enrolment, active response of the consumers and to ensure that the playfield is attractive enough for them to stay enrolled in the model (Hall et al. 2020). Getting consumers to enrol and keeping them enrolled is of crucial importance for the success of DSR (Chase, et al. 2016). In continuation, here, it is important to state the fact that consumer engagement is a multidimensional subject which requires many different actions in order to positively motivate consumers to engage into a program. Moreover, the level on which a consumer is engaged is also important since, bigger commitment and positive response to incentives of the consumer to the DSR means better operational outcomes and benefits for all participants in the system (Chase, et al. 2016). However, this is connected with a wide range of complex influences which are in detail elaborated in another deliverable of the TwinERGY project.

Based on several research papers evaluated, we can separate the engagement characteristics in three very general and broad categories. Although this is broad generalization, it will still help us understand the basics behind engagement and will help us formulate the business models (Chase et al., 2017) (Figure 24).

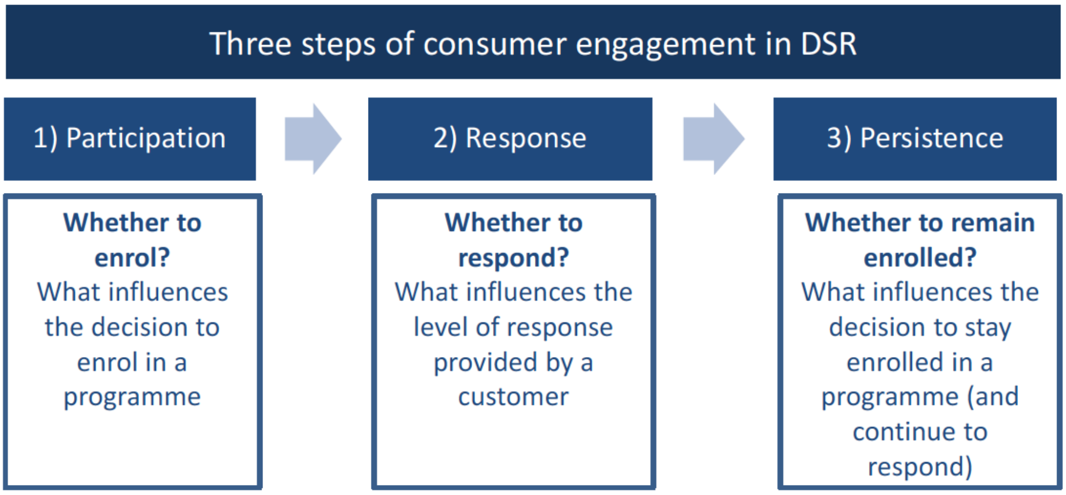

Figure 24 - Consumer engagement in DSR (Chase et al., 2017)

6.4 Business Models for Pilot

The Bristol Pilot, according to information provided in collaboration with Bristol City Council (2021), as part of TwinERGY, would focus on developing a participatory platform to guide domestic consumers through the DR schemes suitable to their household. It would provide advice and access to:

- Time of Use tariffs (price-signal response) supported by Household Energy Management Systems (HEMS)
- Aggregation through remote management of IOT-connected devices
- Self-generation and domestic storage
- Domestic Electric Vehicle charging

Elements from the improved business models in section 3.5, 5.3, 5.4, 5.5, 5.6, and 6.5 can be applicable in this pilot as well as some of the suggestions specified below.

6.4.1 TOU and Local Generation Tariffs

The simplest form of DR in the UK is Time of Use (TOU) tariffs. These allow consumers to manage their own demand in respond to price signals. UK suppliers can set up Time-of-Use tariffs which encourage reduced demand at peak times, and organisations providing services in this space can support householders in reducing their demand during high price periods through the use of Household Energy Management Systems (HEMS). This can be as simple as devices that provide advice to householders, devices that allow householders to manage their own appliances using IoT technology, or potentially remote management of appliances to reduce demand in response to householder-determined price signals. Householders benefit from reduced costs in their energy usage by avoiding demand during high cost periods. The extent of this benefit depends on the degree to which householders are prepared to react to price signals, which will be reflected in the control regimes they set up and the degree of participation in managing their demand (Bristol City Council, 2021).

With the creation of a virtual link between local generation and consumption and with the use of smart meters, the supplier can provide local generation tariffs, because they will know exactly the real-time use of power and virtually pools and shares the local generation between all customers using power at the time of generation (REGEN, 2018).

The local generation tariff can be a flat rate throughout the day or a static ToU tariff, however for cases where both the demand customers and generation are active at the same time, the dynamic TOU tariff is required for more accurate matching (REGEN, 2018). Benefits of implementation of these models can come from multiple sources (A clear example of this model is illustrated in Figure 25). One of them is increased adoption of renewable energy generation in the area where this model is in place, since its operations has already established a direct link between local generation and local energy use (Hall et al., 2020).

Another clear benefit from this model is that it enables access to sources of value to help reduce bills of customers by price time shifting, sharing profit margins from the supplier side in order to recruit and retain more customers and offer greater DSR flexibility (Chase et al., 2017). Furthermore, it uses smart meters and elective domestic HH settlement which is on the same frequency as the national strategy of the country (Chase et al., 2017).

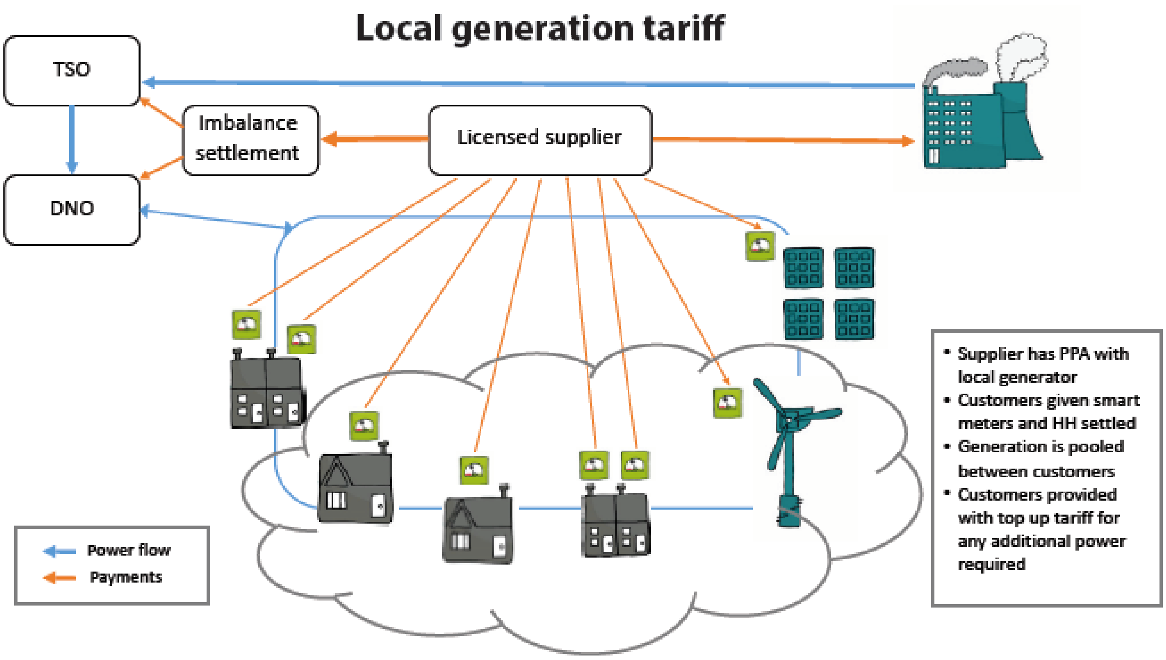

Figure 25 - Local Generation Tariff Business Model (REGEN, 2018)

6.4.2 Aggregators

Aggregators combine and sell flexibility services on behalf of multiple consumers. These flexibility services can include demand side response, storage and turning up/down onsite generation. Aggregators exist because current flexibility markets are only open to large players. Some aggregators are licensed suppliers, but independent aggregators are not required to be licensed if they provide only aggregation services. Therefore, independent aggregators provide payments for flexibility services separately from the supply and billing for power (REGEN, 2018).

The main benefits of implementation of this business model is that it has the ability to enable access to the flexibility markets to the small and medium sized consumers, which were unable to join these markets otherwise (Figure 26). In addition, this model can provide sources of value to its participants which have flexible loads or generation, which in turn, will stipulate the usage of different DERs (e.g. EV, Batteries, PV) (Leutgob et al., 2019).

Aggregators operate by combining managed demand across a number of supplies, which the Aggregators themselves manage remotely, in order to participate in National Grid managed DSR schemes. This can be done through, either turning down demand by remotely switching off or down appliances, or by activating additional generation such as standby generators or drawing upon stored electricity to reduce grid demand in peak periods (e.g. immersion heaters in hot water tanks). Householders benefit from a share of fees paid to the aggregator for both participation in the scheme, and for event responses if and when activated. The key point is that Aggregators are given remote control of the appliances being managed, and the Aggregator determines which appliances would be involved in any given grid response (Bristol City Council, 2021).

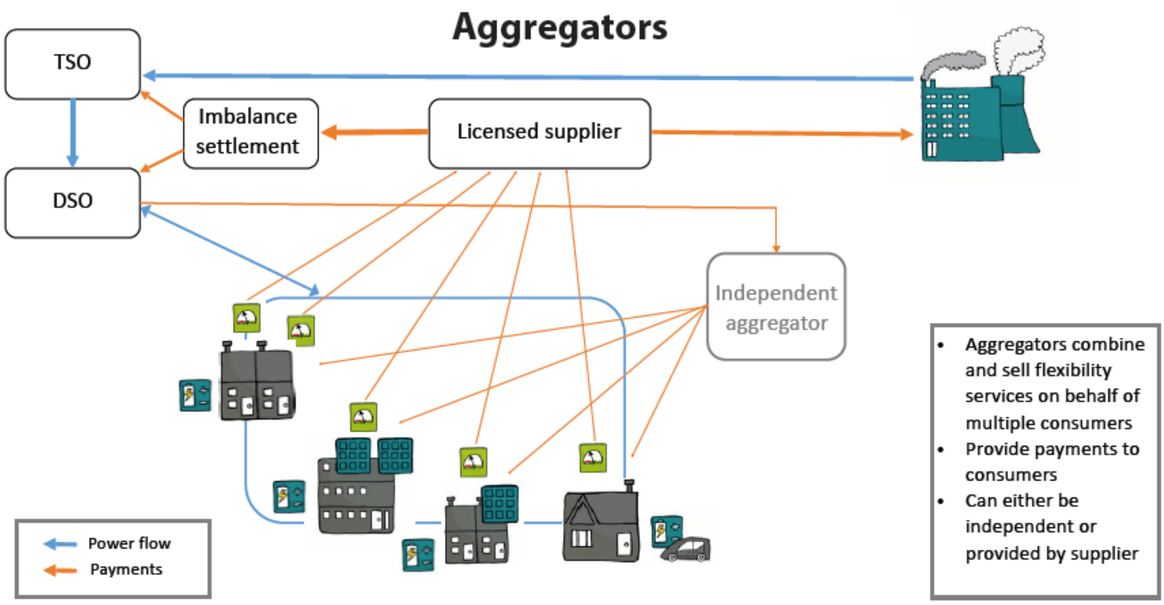

Figure 26 - UK Aggregator Business Model (REGEN, 2018)

6.4.3 Microgrid

According to UK regulations, Private wire networks, or microgrids, enable a direct connection between generators and consumers, and if the distributor is providing less than 2.5 MW of power to domestic customers (roughly corresponding to 500 households), it can be classed as licence exempt supply. This makes it possible to cut out the standard use of system charges and other obligations that apply to licensed suppliers (REGEN, 2018).

As elaborated in the previous section of this report, the microgrids can operate in two modes: grid-connected or island mode. Most remain connected to the public network to enable the export of excess generation or to top up when generation is low (Leutgob et al., 2019; Cazalet et al., 2017).

In connection to UK regulatory conditions, it is necessary to set up a separate entity from the exempt supplier to own and operate the private wires. This local network operator sets its own use of system charges, which are passed onto the customers via the exempt supplier. The supplier sets its tariffs based on the cost of local generation, use of the private wires, balancing and import from the public network via a licensed supplier. There is potential to incentivise local matching through a ToU tariff or automation of demand to keep the tariffs low (REGEN, 2018).

The benefits of this model mainly (Figure 27) are packed in the box of facts where it can shift the energy market towards sustainability, with stimulation of renewable resources generation and by providing incentives for this action. Doing this can lower carbon emissions, which in fact, is of crucial importance for the World in which we live in (Leutgob et al., 2019). Furthermore, it improves the value proposition with a better process for generated energy, avoiding or reducing public networks dependence and with that reducing costs and charges. And lastly, if the generation and demand are properly matched it can seriously minimize the need for energy import in the system (REGEN, 2018).

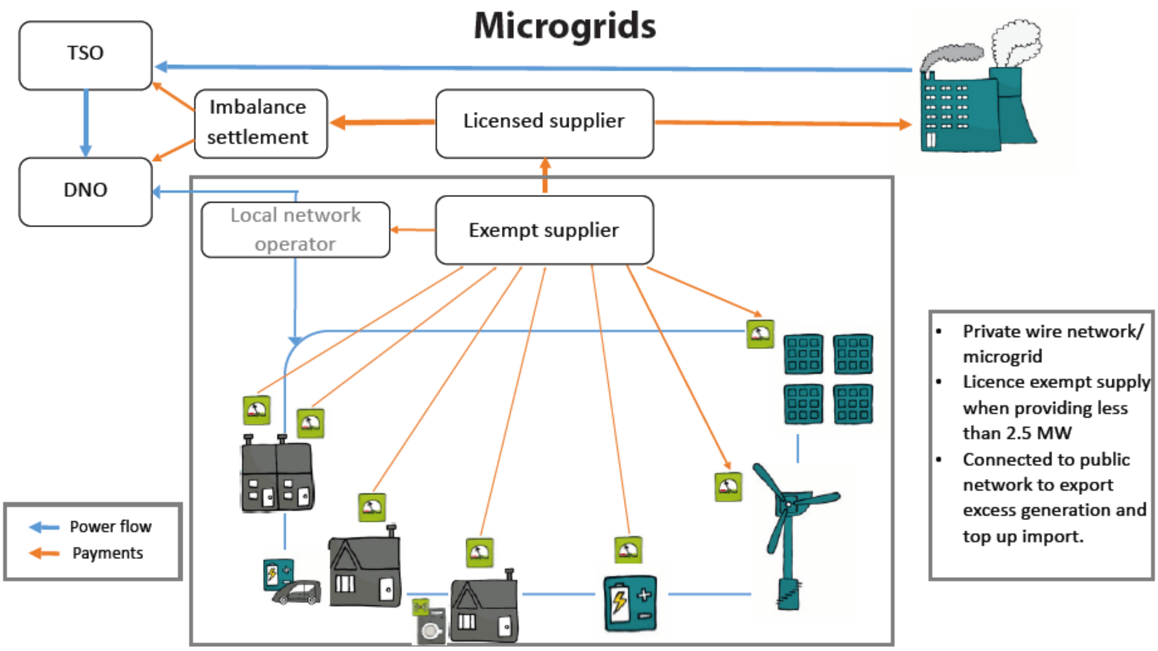

Figure 27 - UK Microgrid Business Model (REGEN, 2018)

Twinergy has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957736

6.5 TE Platform Business Model

Peer-to-peer (P2P) energy trading is the buying and selling of power directly between generators and end users. Transactions can take place over trading platforms that are either supported by licensed suppliers or blockchain technology. Anyone with Distributed Energy Resources (DERs), such as generation, storage or other forms of flexibility, could sell these services, including households (Hall et al., 2020).

P2P trading platforms run by licensed suppliers enable generators to set the price for their power and consumers to identify the generators that they would like to buy from. This is a form of 'sleeving', but takes place over a platform, where, there is greater visibility and range of generators to choose from. The better the price and/or the greater the support for a particular generator, the more matching is likely to take place. But the consumers do not necessarily save money as they still have to pay the use of system charges and for the top up service provided by the licensed supplier (REGEN, 2018).

An alternative model removes the licensed supplier from the transaction, which instead happens over a platform supported by blockchain technology or a third-party intermediary. Blockchain technology has the potential to hold a register of DERs, data on their trading preferences, provide access to trading platforms and verify transactions (REGEN, 2018).

The benefits of this business model (Figure 28) come, firstly, from the fact that there is a direct link between the consumer and the producer, with the scale tilted towards the consumer as he can choose, on its own, from where they will purchase their power. This decentralises the situation dramatically and provides additional value to the consumers because of the increased competition in the market. Secondly, the additional value proposition of this model comes through price-time-shifting as consumers have total visibility when they are purchasing power and from where. All this helps the market to achieve greater matching of demand and generation which can reduce network pressure and creates benefits for the consumers through flexibility markets, and reduced charges and enables generators to sell power at better prices in order to maximise their exposure (REGEN, 2018).

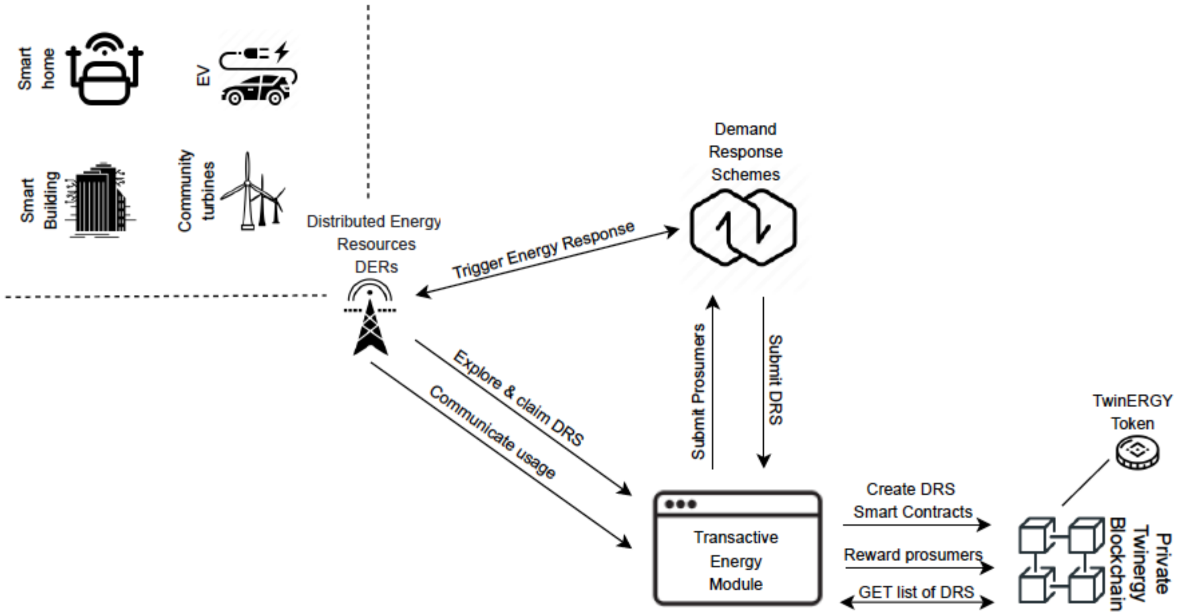

Figure 28 - WEC's Transactive Energy Platform for Pilot Sites

7. German Pilot Site

7.1 Hagedorn as part of TwinERGY Project

The village of Hagedorn in Steinheim is located at the district of Höxter, North Rhine-Westphalia and has 38 houses with 103 inhabitants. It is connected to the medium-voltage grid and is supplied with electricity by two local network stations (transformer stations), shown at figure beside. The total consumption of Hagedorn in 2016 was 147 MWh and the total feed-in generated by photovoltaics was 88 MWh. The southern part of the village is connected to the transformer station "Im Dorfe" (T1) (TwinERGY Project Proposal, 2020).

All units are connected to the public low-voltage grid. A central smart meter (SM) measures the total power requirement of the quarter. This subunit produces 40.2 MWh Solar power in 2019. Overall, it uses 14.5 MWh and purchases 8.2MWh from the public grid. All units share a charging station for an EV. The installed PV system (38.2 kWp) generates electrical energy, which is measured separately. The generated PV power can be assigned to the respective unit via virtual smart meters (v. SM). One smart meter per unit also records the electrical energy requirement. Different concepts are used for space heating and hot water, since they have been appointed as the second major sources of power consumption (TwinERGY Project Proposal, 2020).

7.1.1 Pilot Site potential

According to its climate protection plan, the city administration aims to achieve efficient energy use and a higher degree of integration of renewable energies as well as a significant increase in consumer interest in energy-related measures. Through TwinERGY, both the use of energy should become more renewable, and people should be inspired by energy-related issues (TwinERGY Project Proposal, 2020).

In the model village of Hagedorn, the low-voltage infrastructure is to be improved and expanded to include advanced measurement technology, electrical circuit technology, communication technology and electrical storage. This will make this micro-grid highly flexible and form the perfect basis for developing and testing modern energy management systems. Based on this, dynamic structures (price / CO_2 emissions) will then be distributed to the individual participants/ HEMS devices and form a dynamic Peer2Peer energy trading system. By integrating the electrical storage and managing it in the neighbourhood, the entire pilot will be able to use a larger share of self-produced solar power locally. This will stabilize the microgrid and, in the context of a superordinate consideration, the microgrid will also support the medium-voltage grid. In order to make the entire neighbourhood Smart Grid-compatible, the installation of smart meters for all participating households is planned. In addition, the Westfalen Weser Netz will install up to 10 switch boxes, which will enable him to influence large loads in accordance with the law and provide the possibility of sending information from the power grid side to the households' energy management systems. All services connected to the public low-voltage grid are designed and coordinated by Westfalen Weser Netz (TwinERGY Project Proposal, 2020).

For the demonstrator, a wide range of data is collected and evaluated. Subsequently, the hardware to be installed, the further measurement technology, and also the use of wearables is suggested. User clusters (consumer archetypes) will be formed from the data and targeted advice and assistance for energy-related actions will be offered in order to increase satisfaction and social benefits. The use of different concepts for the most important consumption sources will be an additional help in the calibration of personalized services and will strengthen the already created prosumer environment (TwinERGY Project Proposal, 2020).

Smart meters and the use of block chain technology will make it possible to test innovative business models for demand response and energy management. Smart communication tools will increase end-user participation by 50% and enrich the service package offered by the project. The use of electric vehicles with intelligent charging and V2G technologies will demonstrate the capacity increase of the network through the use of electromobility and new services will prove themselves in practice. Within the framework of the project, the bidirectional charging of electric cars in combination with an energy management system will also be tested in the German pilot. TH OWL will project manage the pilot activities, in cooperation with the city of Steinheim (TwinERGY Project Proposal, 2020).

7.2 German Market Overview

As noted in several studies dealing with the German energy market, there are two sides of the coin. From one side it can be easily concluded that the market regulation is very rigid and is creating difficulties for aggregators and DR programs and needs to improve in order to harvest the full potential that the country is bringing on the table. On the other side though, Germany, is one of the world leaders in DES and RES as well as smart devices so microgrids, smart grids and p2p platforms, EV-mobility etc, are business models which can be fully applied in this market (Bertoldi et al., 2016; Stede, 2016; Valdesa et al.,2019).

Currently, German market regulation creates significant barriers to most forms of Demand Response programme types, including both those provided by retailers and independent aggregators. However, the government is aware of these barriers and is undergoing a regulatory review to facilitate change (Stede, 2016).

With an announced plan to achieve 35% of renewable electricity supply by 2020 and the phasing out of nuclear power by 2022, the German energy system will integrate more and more de-centralised variable energy generation (wind, solar) as well as de-centralised energy generation by biomass and biogas, and will increase its needs in de-centralised flexibility. Situations where variable generation from wind and solar plants surpasses the general demand in the grid are expected to happen more frequently in the future (Bertoldi et al., 2016).

Today, a significant portion of demand-side flexibility in Germany remains untapped and will remain so, until important barriers are removed. Though Demand Response is legal, aggregation is only enabled for the retailer and these also face significant entry barriers. The wholesale market and re-dispatch (incl. winter grid reserve) are closed for Demand Response. Intra-day markets are open for consumers working through their retailer (assuming the retailer offers this service) (Valdesa et al.,2019).

An aggregator may work as a service provider to a retailer. In this case the aggregator is pooling loads in one retailer's balancing group. Though it is positive to see Demand Response services offered by retailers, this limitation hinders market growth by lowering competition and limiting the range of customers who can participate within the portfolio of a particular retailer. It also does not take into account retailer's business model challenges with Demand Response (Bertoldi et al., 2016).

As participation in DR programs is lower than in EE, it has been argued that Germany lacks a comprehensive strategy to enable greater load aggregation and response for SMEs. Nevertheless, although SMEs (and residential) explicit DR remains untapped, this situation is expected to change. In its Third Electricity Package, the EU committed member states to an (electrical) smart meter roll out target of 80% by 2020. The actual installation and expected installation targets in Europe are unequal, and Germany is among the countries with lower smart meter penetration and targets. Germany started to implement the EU Directives in 2017 after a complex and complicated legislative process and decided to stick to the 80% penetration limit (Valdesa et al.,2019).

According to the Act on the Digitization of the Energy Transition enacted in 2016, Germany implements the EU Directives 2009/72/EG and 2009/73/EG into German law. The Act introduces specific and detailed requirements, both for the design of smart meter devices and for the transmission of data, a subject of great controversy due to the necessity of solving data protection issues. The overall goal of the new law is not only the introduction of dynamic pricing but also gradually achieving a total digital transformation of the German energy market while ensuring a high standard regarding data protection (Valdesa et al.,2019).

7.3 Business models for Pilot

Elements from the improved business models in section 3.5, 5.3, 5.4, 5.5, 5.6, and 6.5 can be applicable in this pilot as well as some of the suggestions specified below.

7.3.1 Prosumers in Germany

In Germany, according to the Renewable Energy Sources Act EEG 2017129 (3 No. 19) self-consumption legally exists, if three criteria are fulfilled (Hall et al. 2020):

- plant operator and electric consumer are the same person, (Valdesa et al.,2019)
- immediate spatial proximity between generation and consumption, (Bertoldi et al., 2016)
- no usage of the public grid. The regulatory framework for self-consumption favours small systems under 10 kWp (Hall et al. 2020)

7.3.2 Community Microgrid Business Model

According to Stadler and Nasle (2019) the conceptual design of the microgrid and proper combination of all elements are of crucial importance. Proper evaluation and analysis of all elements must be done before the microgrid business model is proposed. A new generation of conceptual design tools is emerging, and such tools use mathematical optimization techniques, which allow finding the true optimal combination of technologies by "built" in "iteration" techniques, so called solvers (Stadler and Nasle, 2019).

The proposed model is a microgrid (Figure 29), which is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. As stated several times before, microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode (Stadler and Nasle, 2019).

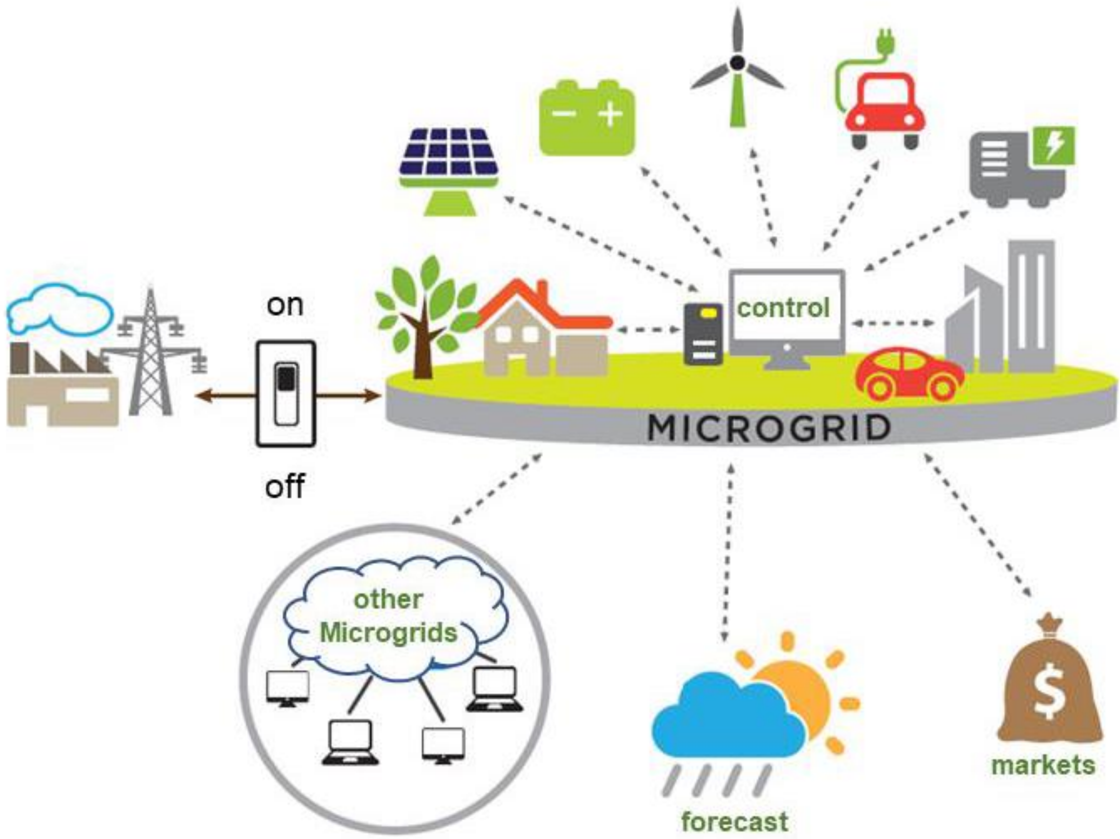

Figure 29 - Community Microgrid Model (Stadler and Nasle, 2019)

The benefit from this model can be seen from many different aspects, one of which is the **social purpose** aspect. By engaging in renewable and clean energy, we are talking about primary objectives that speak to the social development priorities of the local communities they intend to serve (Eales et al, 2019).

Social and environmental challenges are two sides of the same coin, and it is imperative that to maintain a SDG7 contribution SMSE have environmental objectives in their governing documents. In addition to a clear goal of utilizing low carbon solar energy in comparison to fossil fuel competitors, the community microgrid can go further to monitor, evaluate, and reduce their environmental impact. This can be achieved by auditing project carbon emissions (especially from transport), investing in system life-cycle analysis research, and disposing of components such as batteries in a responsible manner (Eales et al, 2019).

In addition, this will spark **community engagement and participation**. An emerging trend for communities to take greater responsibility for their own socioeconomic development is evident, and social ventures with a focus on community engagement have the potential to deliver benefits over and above economic outcomes as they closely engage with people with a shared interest in the creation and management of these ventures. Importantly, for energy focused social enterprises, local people are involved in active dialogue on the future of the energy system for their community, fostering agency, ownership, and engagement (Stadler and Nasle, 2019).

7.3.3 Improving the Microgrid

As stated previously, with the use of advanced technologies and the process of digitization, there is possibility to improve the business model in question, via optimization techniques and algorithms allowing instant assessment of loads and load shifting potential (Figure 30). This needs to be combined with utility information, and technology data as well historic weather information (Stadler and Nasle, 2019).

Digitization, smart devices and automated data collection processes can be linked, then the system can assess the situation almost instantly and provide the optimal plan as a feedback and lead the DER capacities to an optimal operation based on the selected objective (Stadler and Nasle, 2019).

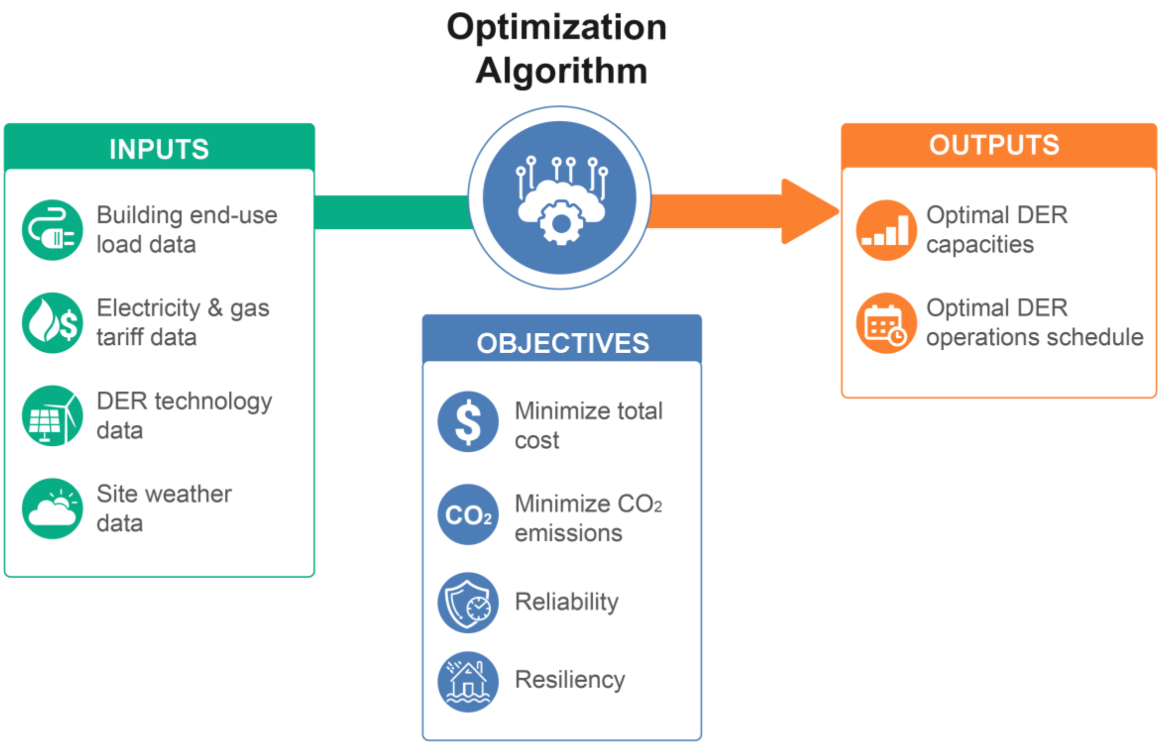

Figure 30 - Optimization of Microgrids (Stadler and Nasle, 2019)

7.3.4. Optimized and Smart Microgrids

As indicated previously, Figure 31 provides optimized model of a microgrid structure in order to rip improved possibilities.

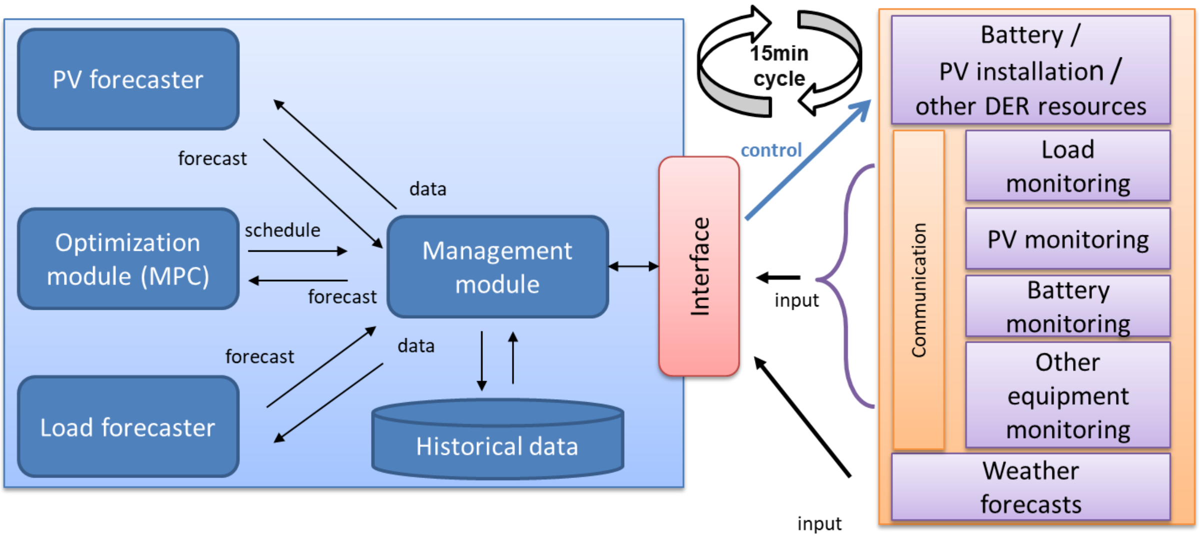

Figure 31 - Optimized Microgrid Model (Stadler and Nasle, 2019)

7.3.5 EV Mobility model

Network Charging

In some cases, customers can access a network of stations to charge their EVs with renewable energy (Figure 32). In addition, it is possible to offer a pilot that encourages off-peak charging at home at night and on weekends, in addition to the network charging (Bird and Hutchinson, 2019). In order to attract engagement, with a plan to power the EV charging network with 100% wind or solar energy, customers can enrol, either in a pay-as-you-go plan, which tabs customers per minute charged, or a membership plan that charges a fixed rate per month (Bird and Hutchinson, 2019).

Managed Charging

Through managed charging programs, customers, utilities or even automakers can control the timing of EV charging to align with clean energy availability and grid needs, while still meeting customer needs. In this business model, customers agreed to delay charging for up to an hour each day to better align with available renewable energy, in exchange for lower charging rates (Bird and Hutchinson, 2019).

Charging with On-Site Renewables

EV charging can be paired with on-site renewable energy generation---most commonly by co-locating EVs with on-site solar energy systems, and in some cases batteries, either with or without managed charging (Bird and Hutchinson, 2019).

For instance, this program can give customers access to extra charging stations and, when not in use, the solar energy is stored in a battery system (Bird and Hutchinson, 2019).

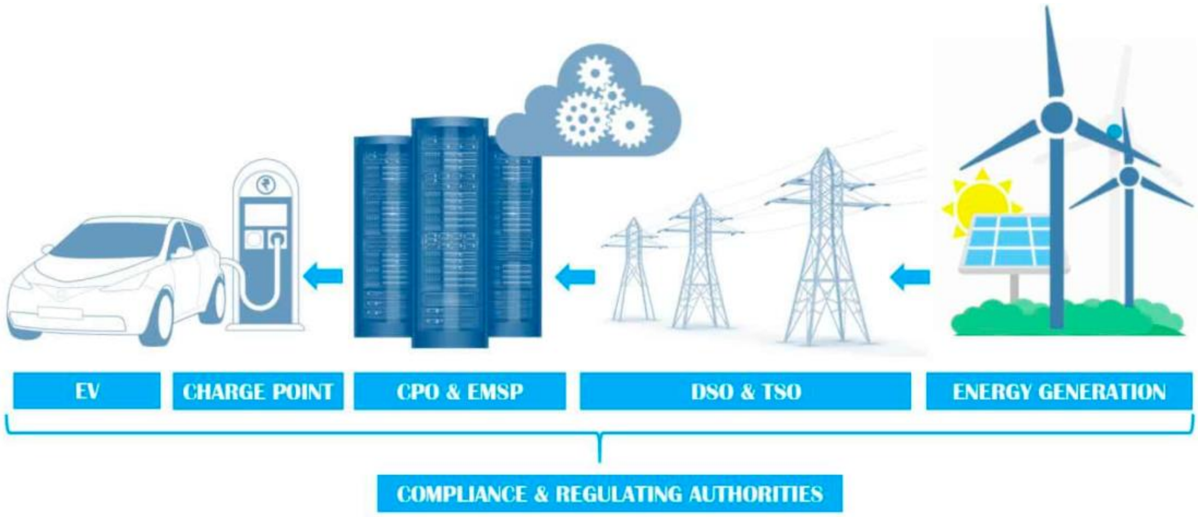

Figure 32 - EV Mobility Model (Alkawsi, et al., 2021)

7.3.6 Smart Microgrid and E-Mobility

From combination of sources, Alkawsi et al. (2021), proposed elements that must be evaluated so this model can go live are:

- Integration of stochastic renewable resources
- V2G and G2V issue :
  - Policy/Protocol required for using EVs batteries as power storage
  - V2G, EVs providing power:
    - High priced interval
    - Emergency power need
  - G2V, EVs consuming power:
    - Low price interval
- Wireless and sensor based infrastructure:

    - Monitoring battery charge
    - Battery charging and discharging schedule and execution
- Integration of community based battery bank
- Communication and control required over microgrids for power generation and consumption
- Management System for Intelligent Power Transmission and Distribution between microgrids
- Transition between "grid connected" and "islanded" mode of microgrids
- Smart Metering
- Frequency and voltage regulation
- Cyber Security

8. Italian Pilot Site

8.1 Benetutti as part of TwinERGY Project

Benetutti is a commune (municipality) in the Province of Sassari in the Italian region Sardinia. The Ministry of Productive Activities has granted the Municipality of Benetutti the concession for the distribution of electricity on medium and low voltage distribution networks for delivery to final customers. The Municipality, therefore, carries out transport and transforms the electricity on medium and low voltage distribution networks for delivery to final customers. With an area of 98 km2, Benetutti has a population of 2000 people with a yearly energy consumption of 3.700.000 kWh. Benetutti is the 1st Sardinian Smart Community (TwinERGY Project Proposal, 2020).

The poor connection of the region and in particular of the Benetutti municipality with the national power grid, together with the non-existent connection with the natural gas network, is pushing Sardinia towards an electrification of their energy system, as well as an increase in its resilience. With an annual photovoltaic power producibility of 2,200 MWh, the Benetutti community, currently puts on the network 708 MWh / year and draws 2.820 MWh / year. The percentage of self-consumption is around 70% during the summer, with an annual consumption per inhabitant of 2,280 kWh against the 1,300 kWh of average domestic consumption in Sardinia. It is therefore a municipality that, thanks to photovoltaic source self-production, has already migrated part of its thermal consumption to electricity. The municipality aims in developing a flexible and sustainable energy grid by solving power fluctuation problems, which in some periods (especially in summer and up to October) determine levels of zero absorption and consequent sale to the grid and by increasing the RES integration levels, along with heightening consumers participation in energy related processes. Through TwinERGY, the pilot will fully exploit the various devices already installed in the demo-site, which will involve a group of 20 buildings both residential and public. Within the project, it will be able to monitor real time power loads, RES generation and grid's storage capacity of the whole community and control them utilizing demand response programs, aiming to reduce consumption during the peak hours while increase it during low energy cost periods and to improve predictability of consumption and consumer behaviour patterns (TwinERGY Project Proposal, 2020).

8.2 Italian Market Overview

In recent years, the electricity market has been characterized by rapid growth of renewable generation and by a decrease of electricity consumption. Italy relies mostly on hydro and gas for its flexibility needs, while the frameworks for Demand Response participation in the ancillary service market, the balancing or the wholesale market, are slowly getting in place (Bertoldi et al., 2016). The only exception is the interruptible contracts programme, which is a dedicated Demand Response programme separate from the balancing market. The enrolment of interruptible loads is currently about 4 GW, with a minimum size of 1 MW to participate. The payments are attractive and related mostly to availability payments rather than real utilisation. The programme has been called very few times during the last decade. In fact, it is unclear if it has ever been activated. Flexibility can access the day-ahead market, but only as demand bids with indication of price, through the retailer/BRP. The possible opening of balancing products to demand-side resources could lead to an increase of load participation (Bertoldi et al., 2016).

8.3 Business Models for Pilot

8.3.1. Demand Response Models

In this case, our analysis made in section 3.5 for Improved DR Business models is applicable, therefore, relation should be made to that section in order to promote models for the Italian Demo site. Particularly, the Explicit DR models will be considered in order to increase the facilities self-consumption.

8.3.2. TE and VPP Business Models

The same can be concluded for this section as well. In section 5 are elaborated the improved models of TE and VPPs, with special emphasis on the improved value proposition of the models. In sections 5.3, 5.4, 5.5, 5.6 and 6.5 one can see, in more details, the proposed improved business models for TE, which can be implemented in this pilot test site and it is developed on the back of decentralized, democratized technologies with the exploitation of Blockchain and Smart Contracts.

8.3.3 Technical Overview of the Models Expectations

Within the project, it will be able to monitor real time power loads, RES generation and grid's storage capacity of the whole community and control them utilizing demand response programs, aiming to reduce consumption during the peak hours while increase it during low energy cost periods and to improve predictability of consumption and consumer behavior patterns (TwinERGY Project Proposal, 2020).

On a building level, the energy consumption of each unit will be optimized through demand response programs, where forecasted energy consumption at load level will allow the system to identify potential sources of flexibility i.e. loads that can be dispatched and how. The consumers participation in these DR programs will be promoted through offering economic incentives to consumers, by taking advantage of dynamic pricing mechanisms and decision support, utilizing user friendly interfaces for acquiring personalized feedback from the operative DSO regarding energy related actions (TwinERGY Project Proposal, 2020).

On a community level, the forecasting capabilities will create a knowledge base (community digital twin) that will allow the exchange of energy between different actors through an energy vector optimization system, that will keep track of energy transactions and create a system to monitor and manage them based on smart contracts and blockchain technology. This will have as a fundamental output the maximization of effectiveness of RES, while improving higher stability on the energy infrastructure and lowering energy costs. Therefore, it will allow a further step towards the decarbonization of the energy system and, being Benetutti a fully operative DSO, will improve overall grid management. Finally, the proposed integrated solutions will be used to validate the scalability and replicability potential of the project, for bigger communities, sharing similar social and technological features (TwinERGY Project Proposal, 2020).

9. Greek Pilot Site

9.1 Athens as part of TwinERGY Project

The Greek pilot site will involve a group of residential and commercial buildings belonging to the clientele (counting over 180,000 consumers) of MYTILINAIOS (consortium partner), used for experimental testing of new solutions and located in Athens, Greece. Metering, energy use and demographic data from a selected pool of the customers of the company (residential buildings) will be actively involved in the demonstration activities of the project, to enable the realization of human-centric implicit demand response programmes, based on dynamic pricing of electricity. All of them are located in the broader area of Athens, in the districts of Chalandri, Vrilissia & Agia Paraskevi (TwinERGY Project Proposal, 2020).

The residential pilot testbed of MYTILINEOS, is located in the north-east suburbs of Athens and consists of over 45 residential dwellings, hosting approximately 150 residents, familiar with concepts of energy services and smart technologies. Dwellings covering a total area of 4,000 sqm are powered with electricity only (total annual consumption of approx. 150.0 MWh). The total annual cost of energy rises to €16,000 for electricity. Half of the building premises will set the residential pilot test bed at the Greek demo site. Pilot buildings included in the Greek pilot are partially already equipped with variety of sensors and smart meters/ actuators (from H2020 - HOLISDER and H2020 - UtilitEE), including temperature, humidity, luminance and CO2 sensors, smart thermostats, smart dimmers and plug meters enabling the measurement of electricity consumption at device level (along with EV chargers data) and allowing for the accurate profiling of their energy behavior and (sub-sequent) their flexibility, in a non-intrusive and highly effective and engaging manner (TwinERGY Project Proposal, 2020).

9.2 Greek Market Overview

Greece is still working to liberalise its retail energy prices and complete the deregulation of its market in accordance with the Third Energy Package (Bertoldi et al., 2016). In recent years, electricity prices have risen steeply, in response to the removal of price caps and market liberalisation. This has further stressed an already difficult monetary situation. Due to the severe recession the Greek electricity sector was hit in 2012 by a liquidity crisis. This was created by several factors, such as unpaid electricity bills, unsustainable support schemes for renewables, liquidity tensions in the Greek banking system and structural deficiencies of the Greek energy market (Bertoldi et al., 2016). Both the main incumbent retailer PPC and the market operatory LAGIE SA had accumulated unsustainable debts. These have had to be restructured and prices have risen sharply both for residential consumers and industry (Bertoldi et al., 2016). It will be important that consumers are offered services and the ability to better control their costs as soon as possible. This will be greatly impacted, in a positive matter, by the frequent adoption of smart devices by the customers (Bertoldi et al., 2016).

At the moment there are establishing two Demand Side interruptible programs, to complement their existing Ancillary Services market. These do not as yet allow for aggregation but unlike the programs in Italy and Spain, they will be dynamic, auctioned on a monthly basis and intended for frequent use. Greece is also carrying out a full regulatory review in preparation for a CRM Capacity Remuneration Mechanism, and plans to define aggregation within this framework (Bertoldi et al., 2016).

9.3 Business Models for Pilot

9.3.1 Demand Response Business Models

In this case, our analysis made in section 3.5 for Improved DR Business models is applicable, therefore relation should be made to that section in order to promote models for the Italian Demo site.

9.3.2 VPP Business Models

The same can be concluded for this section as well. In section 5 we have elaborated the improved models of TE and VPPs, with special emphasis on the improved value proposition of the models. In sections 5.3, 5.4, 5.5, 5.6 and 6.5 one can in more details see the proposed improved business models for TE which can be implemented in this pilot test site and it is developed on the back of decentralized, democratized technologies with the exploitation of Blockchain and Smart Contracts.

9.3.3 Technical Overview of the models expectations

The Greek demo case will focus on engaging local consumers in implicit demand response programs that are realized through the combination of dynamic pricing schemes, feedback mechanisms and human-centric features that allow consumers to alter their energy consumption patterns and provide flexibility to the electricity retailer, without compromising their comfort and well-being (TwinERGY Project Proposal, 2020).

In more detail, metering and sub-metering data from local consumers/ clients of Mytilineos, IoT and sensing data from consumer premises, energy price information, demographic information, EV charging information (chargers are planned to be installed in the demo premises prior to the initiation of the demonstration activities) and weather data will be blended together and properly analysed to allow for the behaviour profiling of each individual consumer, along with the extraction of highly accurate forecasts for the short- and mid-term. In addition, advanced analytics will be executed upon the collected information to enable the delivery of each individual consumer's flexibility profile (against varying electricity prices) and their capability to shed or shift the operation of specific loads to satisfy emerging needs of the electricity retailer (Mytilineos) (TwinERGY Project Proposal, 2020). Such profiles will be jointly analysed and processed for the definition of optimal Virtual Power Plants in the respective Neighbourhood Demand Flexibility Profiling module, which will embed all functionalities pertaining to the tool chain for segmenting and classifying flexibility profiles at different spatio-temporal granularity and clustering/ managing them in order to establish optimal Virtual Power Plant (VPP) composition for the delivery of added value services to the electricity retailer. Its main innovation will be that rather than matching the assumed flexibility profile to a generic class and then extracting flexibility estimations, it will cluster and segment flexibility sources and profiles based on their actual, locally estimated flexibility (incorporating where available detailed information about low-level devices existing at the demand side and how they are used by consumers) (TwinERGY Project Proposal, 2020).

The demo will build on top of the baseline personal data analytics of TwinERGY to enable the realization of consumer-centric demand response programs. Detailed comfort profiles will be advanced to context-aware demand flexibility profiles to enable the realization of novel and engaging feedback mechanisms and semi-automated home management services, towards shedding or shifting demand away from high electricity price hours and, thus, satisfying in real-time emerging requirements for improving the energy performance of buildings according to the business needs of the electricity retailer, without compromising comfort of consumers or significantly affecting their daily schedules (TwinERGY Project Proposal, 2020).

Apart from the profound benefits for the consumers involved (regarding energy savings, energy cost reduction, comfort preservation, smart home services), Mytilineos themselves are expected to enjoy significant optimization of their business processes and operations in terms of: (i) significantly reducing imbalances caused by forecasting errors, thus avoiding extremely high imbalance charges; (ii) examining advanced billing concepts (e.g. dynamic energy pricing) by segmenting, clustering and analysing consumption behaviours, inferring the elasticity of specific clusters against varying energy pricing levels and deploying highly effective implicit demand response strategies, towards optimizing the performance of their portfolio while hedging against non-anticipated imbalances; (iii) monitoring their compliance to Energy

Efficiency obligations imposed by the European Commission and adopted by the Member States and designing appropriate demand response strategies and campaigns to achieve the anticipated targets; and (iv) analysing spatio-temporal patterns of their portfolio, identifying trends and outliers and receiving valuable knowledge for the design and delivery of added value services per individual customer or clusters of them to satisfy their needs for energy cost reduction through targeted innovative energy service bundles (TwinERGY Project Proposal, 2020).

10. Conclusions

From the analysis provided throughout this report, we can come to a general conclusion that there are lot of possibilities for new and improved business models in the energy markets that need to be supported by positive regulatory conditions, in which they will be able to fully operate on the wings of the digitization and decentralization concepts.

With a positive push in this direction, we have provided suggestions of improved models which will significantly increase the creation of improved value, making the business case viable, where all participants can rip increased benefits from their involvement. With joint pool of resources, optimization concepts, digitization and use of technology improvements, such as smart devices (IoT), it becomes evident that there is possibility for maximised benefits for everyone, from consumers to aggregators and other players in the energy markets.

We have successfully reviewed the existing business models and provided suggestions for improved business models which can be demonstrated and tested in our TwinERGY demo sites, by touching upon the potential of improvement and shift from the utility-centric business model, through the use of transactive energy principles and the growth of DERs and smart devices (IoT), to an improved business model with increased value proposition and value creation.

These finding are the first step in our quest, as the TwinERGY project, to understand the market potential of the technologies, which this project is exploring, and identify the factors which will lead to adoption and engagement of them in the wider European energy market, with the increased importance which this market is giving to the DR schemes.

The improvement of the models can be further justified by the fact that recently energy markets are faced with increased need for flexibility, driven by several factors, such as, increased use of renewable sources, and smart devices. Hand in hand, business models which were more rigid before, nowadays, with the use of digitization, can be improved to a level of creating possibility for integrating small and medium sized prosumers into DR activities. Moreover, they can be empowered to participate, both, in the consumption as well as generation aspect of the energy market, thus, creating improved value proposition and value creation for the new business models in place.

At the end, digital solutions and decentralization principles, such as, sophisticated algorithms, Blockchain and smart contracts, which we have analysed, are providing a nice entry point for the transactive energy principles to forge the TE business models for the future. **A proposition of a business model with TE framework that will be built for the 21stcentury grid,**

characterized by active "prosumer" (both producer and consumer of energy) participation in energy markets, bidirectional power flows (e.g., net metering of Behind-The-Meter (BTM) resources), and sophisticated financial transactions between prosumers, utilities, and third-party service providers is something that can create this positive improvement of value and is a business model worthy of a future. TE transactions BTM and In Front of the Meter (IFOM) are already on a hockey-stick shape of growth as they are now merging with the increased adoption of smart Internet of Things (IoT) devices, such as connected thermostats and other newly networked Distributed Energy Resources (DERs) such as renewable energy sources, electric vehicles (EV), and Electric Storage Resources at the edge of the grid.

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