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List of abbreviations and Acronyms

Abbreviation	Meaning
ADS	Active Demand & Supply
ALWA	AlgoWatt
AMU	Aix-Marseille Université
BC2050	Blockchain2050
BornholmsVarme	Bornholms Varme A/S
BRP	Balance Responsible Party
BSP	Balancing Service Provision
BUL	Brunel University London
CIVI	CIVIESCO srl
CM	Congestion Management
CU	Cardiff University

CVPP	Commerical Virtual Power Plant
DER	Distributed Energy Resources
DGs	Distribuited Generators
DLT	Digital Ledger Technologies
DR	Demand Response
DSO	Distribution System Operator
DRRs	Demand Response Resources
EPC	Energy Performance Contracting
ESCOs	Energy Service Companies (ESCOs
ESS	Energy Storage System
FRR	Frequency Restoration Reserve
GHG	Greenhouse gases
GoO	Guarantee of Origin (GoO)
IoT	Internet of Things
MDC	Meter data company
MES	Multy Energy Systems
P2P	Peer-to-Peer
RCS	Remote Control Systems
REGE	REGENERA LEVANTE
RES	Renewable Energy Sources
SES	Smart Energy System
SMES	Smart Mulry-Energy System
TVPP	technical Virtual Power Plant
ToU	Time of Use
TSO	Transmission System Operator
UEDAS	Uludag Electric Dagitim
USEF	Universal Smart Energy Framework
VESS	Virtual Energy Storage Systems
VPP	Virtual Power Plant

EXECUTIVE SUMMARY

The leading assumption of the deliverable is to pave the way to new and attuned services, based on the results of the outcomes of the contributing tasks (namely 2.1, 2.2 and 2.3), as well as of the emerging trends in the energy field, especially those deriving from the Clean energy for all Europeans package (the raising role of the renewable energy communities).

As such, and due to the fact that the report falls during the first part of the project deployment, the report has been largely focalised around those new tailored services already compliant with the Dir(EU) 2019/944, decoding new rules enabling the active consumer participation, the prosuming and the coupling (peering electricity and providing flexibility services through DR and storage).

Preliminary research has been carried out in order to describe the context, the actors involved, the services and the business models. In addition, in order to identify the main needs and requirements of each island, several meetings with the two lead islands of Formentera and Gökçeada and the follower islands of Bornholm, Grado and Bozcaada have been organised.

The deliverable feeds into the characterisation of the forthcoming deliverables, namely D2.4 *Report on the VPP4Islands concepts*, D2.6 *Technical specification of VPP4Islands* and D2.8 *Scenarios for studying VPP4Islands concept*.

Disclaimer: the report defines the potentially feasible services based on the state of the art, the islands' needs and the different identifiable actors' roles at a generalised level. For the specific implementation and precise identification of these services on the islands, please refer to deliverables D2.6 *Technical specification of VPP4Islands* and D2.8 *Scenarios for studying VPP4Islands concept*.

1. Introduction

VPPs integrate different plants into a single control system, combining energy production, storage and demand in an efficient manner. VPPs make it possible to join and manage different electricity production units in the same area, combined with storage systems. Photovoltaic plants, wind farms, biogas plants, hydroelectric plants, cogeneration plants, micro-grids, batteries, cooling / heating systems, and electric vehicles can converge into a VPP. The Remote Control System (RCS) is the heart of a VPP. It coordinates power flows coming from generators, controllable loads and storages. Communication is bidirectional: the VPP can not only receive information about the current status of each unit, but can also send signals to control objects. Forecasting energy production is not easy because of the fluctuating nature of renewable energy sources. Due to such errors, electricity grids with a high penetration of renewable energy sources can easily experience bottlenecks and balancing problems, which can be solved by using Energy Storage Systems (ESS).

The concept of VPPs was born towards the end of the 1990s, mainly with the energy market deregulation, but they have recently become more common due to the increasing number of renewable energy plants (RES) and greater efficiency of both production technologies and Remote Control Systems (RSC). VPPs can be connected with the energy market as a single large system, supporting the grid both in terms of energy supply and balancing and regulation services (thus ensuring greater grid security). A single control system provides a set of advantages:

- Optimisation of individual consumers' needs within the same VPP. Energy can be shared to manage demand efficiently: if one system is consuming more than it is producing, it can use energy from other systems connected to the VPP. In other words, it provides more flexibility in consumption;
- Optimal management of production, distribution and storage on the basis of virtual electricity conditions related to weather, price changes and energy demand. In other words, it provides:
  - Efficient peak management in a short timeframe;
  - Energy production at lower costs;
  - Reduction of emissions.

A single control system makes it possible to think of new service solutions and new business opportunities among the actors involved. To analyse the possible services applicable to the islands, the deliverable, after a brief analysis of the context, analyses the actors involved in the electricity market and the services provided classified in two systems. Finally, after reporting the data available from the islands, the deliverable presents an evaluation method for proposing services to the islands.

2. THE CONTEXT

The concept of distributed generation (DG) has been depicted as the power paradigm for the new millennium [1]. As reported by Simeoni et all. [2], Mancarella proposed the multi-energy system concept [3], which has evolved until the recent smart energy system (SES) concept has been settled by Lund et al. [4]. SES is an energy system in which different energy sources, vectors and needs are combined and coordinated through a number of smart grid infrastructures in order to achieve an optimal solution for each sector and for the overall energy system. SES seems to play a crucial role in facilitating cost-effective integration of renewable energy sources and in fostering end-user's participation to support power system operation and development. As reported by Connolly et al. [5], with an increasing share of renewable energies SES or smart multi-energy systems (SMES) become more decentralised and the number of actors increase significantly. Compared to traditional systems, the decentralisation of energy sources (i.e., multiple renewable energy sources (RES) located in different positions) increases variability and uncertainty and requires close control of the system flexibility.

Variability is due to changes in the energy system operating conditions across time, which can concern expected energy demand, renewable energy production and net scheduled exchange (NSI). As such changes are not exactly known, possible interruptions, contingencies and dispatchable sources that do not follow their set points cannot be neglected. All that leads to system uncertainty. Flexibility is defined in several ways in literature, but many authors agree that it can usually be measured indirectly through signs of system inflexibility, including difficulties in balancing supply and demand, resulting in load shedding; significant reductions in renewable energy; very high negative or positive market prices (i.e., penalties); and extreme volatility of market prices across time. As reported by Aggarwal et all. [6], many different resources are available to deliver grid flexibility. Flexibility can come from physical assets such as batteries and fast-ramping gas plants, but can also be the result of improved operations, such as shorter dispatch intervals, new ancillary services and improved weather forecasting. Wang [7] summarises the different literature approaches to enhance flexibility as follows:

- *Improved operations*: achieved through advanced models and algorithms to improve unit commitment and economic dispatch processes. Examples include the application a mixed-integer linear programming formulation for the start-up and shut-down ramping in thermal units [8] or genetic algorithms for cogeneration systems [9], the configuration of combined cycle units [10], the improvement of wind, sun and load forecasting [11], and the improvement of other forms of renewable energy such as waste heat recovery [12].

- *Demand Response*: incorporating dispatchable demand response resources (DRRs) into the energy market can increase grid flexibility. The emerging demand response techniques include smart thermostats, building automation systems, plug-in EVs, and others.
- *Improved Grid Infrastructure*: transmission congestion is a major bottleneck for delivering flexible power in the grid. Increased transmission capacity can facilitate electricity delivery within or among balancing areas, thus helping balance supply and demand. On the distribution side, the implementation of a large volume of sensors and smart meters, communication devices, and advanced information technologies can also help balance out supply and demand [13].
- *Fast Start Resources*: in real-time operations, fast start resources such as co-generative engines and combined-cycle units have short start up time and rapid ramp rates, and can therefore provide the necessary system flexibility [14].
- *Energy Storage System (ESS)*: abundant Energy Storage Systems including grid-scale batteries, pumped hydro, compressed air, fly wheel and others can provide flexibility on the grid [15].

Energy demand can be met in a sustainable way by a combination of SMES and battery-based Energy Storage Systems (ESS). If operated in a coordinated way, ESS in local energy communities have a large potential for increasing efficiency and self-sufficiency. Schlund et all. [16] reported that if every user focuses only on self-consumption, the batteries run inefficiently and the grid is stressed unnecessarily. On the contrary, if the batteries within the considered area are connected to form a virtual energy storage community, the overall efficiency improves, the grid workload decreases and self-sufficiency is higher. He also underlined that benefits can be achieved even at small community sizes.

When integrating distributed renewable energy sources (RES) into the existing centralised energy system, the Internet of Things (IoT) and distributed ledger technologies (DLT) are enabling technologies for the creation of a decentralised and democratised energy system. Khatoon et all. [17] reported that DLT, and blockchain in particular, are being tested for various applications in the energy sector as a means of solving security and transparency related issues as well as for improving process efficiency through the provision of a decentralised authority concept, thus creating a win-win situation for all the stakeholders. Puthal et all. [18.] distinguished different types of blockchain - on the basis of their accessibility, managing permission, and operating characteristics – in public, private and consortium blockchains. He summarised the blockchain types and their characteristics in the table below.

As the energy efficiency market is expected to grow over time, blockchain technology could significantly improve the overall administrative processes, transparency, cost, and trust between different stakeholders. Some of the key blockchain benefits, as reported by Khatoon et all. are: a) encryption of energy savings (encryption is a process of converting data or any information into a code to prevent unauthorised access); b) exchange of energy savings; c) properly value energy savings; d) increase transparency, reliability and security; and e) lower transaction costs (transaction could happen peer-to-peer directly, thus reducing costs and complexity).

	Public Blockchain	Private Blockchain	Consortium Blockchain
Access to database	Each participant can access the database, store a copy of the transaction and modify it.	There is a central authority who manages the rights to access or modify the database.	Open to the public but not all the data is accessible by the public.
Security	Extremely secure as each block has a copy of each transaction.	Only a specific group of people have access to the private blockchain so it is considered secure because participants are known.	Provides efficiency and transaction privacy. Members are known entities so they can decide who can have access to read the blockchain ledger.
Cost	Very high cost.	There is still a cost element but lower than the public blockchain.	Cost is usually lower compared to the public blockchain.
Speed	Slow as each transaction has to be verified and synced with every node [1]. Nodes are the computers which run the software.	Faster speed as only a limited number of people are involved.	Fast compared to public blockchain as it is operated by a known group of people.
Consensus Protocol [2] All the nodes on the system should accept/agree on the state of blockchain which means creating a self-auditing system [7]	Due to its public nature, everyone can participate in the consensus process.	Consensus protocol supports large network of the population involved in the system, but the rights are kept centralized, specific to just one entity.	Consensus process is controlled by the pre-selected nodes, where all nodes must sign every block to prove the validity of blocks.
Network Congestion	Network congestion is high in the public blockchain because the block size increases very frequently.	Private blockchain scales more easily compared to the public blockchain because it has a built-in access control layer protocol. This means there is a controller who can join the network and participate in the consensus process.	Consortium blockchain is controlled by the enterprise and have lower network congestion because only the known participants run the transactions.
Block Propagations	Block size keeps increasing and needs more resources to execute the transactions as anyone can join the network.	Block size is less of a problem in private blockchain as just few of the participants are involved in the network.	Consortium blockchain is partly private and run by different companies, the block size is controlled as only knowns parties are involved in the system [8].
Feasibility	Public blockchain is not always a feasible solution in terms of all the resources consumed and the associated cost.	Private blockchains are easy to maintain and are much more feasible in terms of cost to operate and the resources consumed.	Consortium blockchains have the same advantages as private blockchain and are more feasible in terms of cost but also dependent on the organizations who are collaborating as the availability of resources are subjected to the different parties involved in the system.

Table 1. Blockchain types and their characteristics [18]

Energy Service Companies (ESCOs) are looking for possible DLT applications to reduce the complexity of energy performance contracting (EPC). The prevalence of EPC business models has significantly grown over the last few years and EPCs have become a popular method of improving energy efficiency in systems and buildings. The challenge with the EPC model is that it involves multiple stakeholders who keep their own records of energy baseline data, cost of technology implementation, project expenses, and level of energy savings achieved, which can create disputes between stakeholders when payment is due. It has also been highlighted that the smart contract feature will significantly reduce transaction costs and, therefore, ESCOs will have an opportunity to undertake smaller projects because the time and costs associated with setting up and administering each EPC will be significantly reduced [19]. This can help increase the number of ESCO projects and, as a result, the total amount of energy savings that can be realised. Gurcan et al. applied blockchain technology to EPC and removed the need for third party auditors to carry out measurement and verification of large volumes of baseline and actual consumption data [20]. The American Council for Energy Efficient Economy (ACEEE) [21] discussed how energy savings could be shared in a blockchain platform to improve energy efficiency, market transparency, information security, and service reliability. In the context of energy-related certification schemes, the study carried out by Castellanos et al. [22] showed that blockchain can be used to ensure authenticity of the Guarantee of Origin (GoO), increase system transparency, and reduce transactional costs by removing the need for a third-party regulator to administer the scheme.

As previously mentioned, one way to overcome problems such as dependence on third parties, improved data security, data audits and logs, and easy management of trading in energy saving certificates, is to use smart contracts. The blockchain-enabled smart contract system will help end-users trade their energy saving certificates securely, helping one user to gain recognition for their additional energy savings and allowing another user to meet their obligation. It will also help tracking energy saving certificates with its unique identification number from its origin to the end of the process. All data access permissions are stored in the smart contracts allowing authenticated users to have access and control over the data.

3. Actors involved and types of services

The EU's strong drive towards renewable energies has enabled the transition from a centralised energy production system based on fossil fuels to a decentralised energy production system based on renewable energies. Companies and private households can install their own renewable resources, converting themselves from energy consumers to Prosumers, either drawing energy from the grid or providing it according to the needs. With this change of paradigm, energy flexibility and demand response (DR) must take new forms: Prosumers offer the potential to provide the new flexibility needed by the energy system.

To ensure Prosumers' access to the "flexibility market" and support long-term sustainability of the energy system, a new role in the energy value chain is needed, that of Aggregator. The Aggregator (AGR) bundles many small flexibility resources into a single virtual flexibility volume operating with flexibility providers (the Prosumers) and the main stakeholders of distributed flexibility, i.e., Transmission System Operators (TSOs), Distribution System Operators (DSOs) and Balance Responsible Parties (BRPs).

In the following paragraphs, a description is provided of the actors involved in the Dispatching Service Market (DSM), which must ensure the flexibility and safety of the national electricity system. The various offers of energy injected into the grid are also outlined. Furthermore, existing flexibility and balancing services have been specified, highlighting the potential role of existing market actors or new operators. The main objective is to harmonise roles and services in a more systemic vision for a transparent and virtually integrated flexibility and demand response market.

3.1 Actors and their role

In a distributed generation market, interaction and involvement among different actors are required to ensure flexibility. In accordance with the role model defined by USEF (Universal Smart Energy Framework) [23] [24], a description of the roles, tasks and responsibilities of the market actors is provided below.

PRS	*Prosumer*. It is the end user (residential, business or industrial Prosumer) consuming and producing energy, who can provide flexibility by controlling resources and changing inputs/outputs based on the Aggregator's demand. The Prosumer is also the Active Demand & Supply (ADS) owner. ADS represents all types of systems using or supplying energy. ADS devices can match the price and other Aggregator's inputs, thus providing flexibility to the market. In short, the Prosumer provides flexibility services to other actors through the Aggregator.
PRO	*Producer.* It is the actor feeding energy into the grid. The Producer's goal is to have its assets operate at maximum efficiency, and it plays an important role in energy supply security. The introduction of non-programmable renewable sources (NPRS) at lower costs than existing generation units changes the way Producers operate, but not their role.

SUP	*Supplier.* It deals with energy trade with Prosumers, that is the purchase and sale of the energy produced or consumed by them, and the correct balancing of the PRS portfolio. The Supplier also invoices energy to its customers. The Supplier and its customers agree on commercial terms for energy supply and procurement.
TSO	*Transmission System Operator*. It is responsible for the control and operation of the transmission grid (whose voltage levels usually range from 220 kV to 380 kV in Europe). The TSO also deals with voltage monitoring and control throughout the transmission grid. Its main activity is the signing of contracts with Suppliers of ancillary services including the determination of the required control reserve capacity, tendering and reserve activation, if needed. Ancillary services are paid by grid users based on the grid usage fees applied by the TSO. The TSO must coordinate with other actors (e.g., the DSO and the Aggregator) to use the resources connected to the distribution grid, even the smallest ones, with system operation close to real time due to the variability of non-programmable renewable sources and to have new resources join the DSM.
DSO	*Distribution System Operator.* It is responsible for the management and maintenance of the power distribution grid in a specific area and is the evolution of the Distribution Grid Manager. In a distributed generation market, the DSO must verify that transit limits during programming and in real time are consistent with the local grid capacity and its related services. It is vital not to have local problems so that services can be provided to the transmission grid. The DSO must cooperate with the TSO to ensure the best use of resources and safe system operation.
BRP	*Balance Responsible Party*. It is the business operator in charge of ensuring compliance with the injection/withdrawal schedule of its customer portfolio. It declares the amount of energy to be withdrawn or injected in each interval (e.g., an hour, a quarter of an hour) of the period (e.g., one day) by its customer portfolio. It must negotiate between Prosumers, Producers and Aggregators. In the event of imbalances in portfolio energy supply and consumption, the BRP must pay for balancing charges.

	Such charges can be reduced if electricity consumption is forecast correctly. There are two types of BRP: • The Supplier's BRP (BRP_{sup}), that is delegated by the Supplier and is in charge of balancing for its PRS portfolio; • The Aggregator's BRP (BRP_{agr}), that is delegated by an Aggregator and is in charge of imbalances concerning the activation of flexible resources. Activation implies imbalances in the BRP_{sup} portfolio, which must be adjusted by "energy transfer" between the BRP_{agr} and the BRP_{sup}.
BSP	*Balancing Service Provider*. It is responsible for providing balancing services to the TSO and for flexibility activation from the Aggregator. The BSP is the business counterparty through which the Aggregator provides balancing services to the TSO. Each balancing bid submitted by a BSP to the TSO is assigned to one or more BRPs. The BRP and BSP may coincide.
AGR	*Aggregator*. It collects flexibility and flexible assets from Prosumers and sells it to the BRP, DSO or TSO. The Aggregator's goal is to maximise the value of flexibility by providing it to whoever needs it most urgently. The Aggregator offsets the uncertainties of non-delivery from a Prosumer to ensure market flexibility and takes on the Prosumer's risks arising from DSM participation. The Aggregator is also responsible for billing/remuneration in the supply of flexibility to the Prosumer. Commercial terms and conditions are agreed for flexibility supply and control.
ESCo	*Energy Service Companies*. They provide auxiliary energy-related services to Prosumers. Such services include energy optimisation and remote maintenance of assets. If the Supplier or DSO is applying implicit demand response through (for example) kWmax tariffs, the ESCO can provide energy optimisation services based on these tariffs. Unlike the Aggregator, the ESCO is not active (nor exposed) on wholesale or balancing markets.
MDC	*Meter data company*. It is responsible for acquiring and validating meter data, which are necessary for the flexibility settlement process and the wholesale settlement process. In many countries, including Italy, this role is performed by the DSO.

Table 2. Actors and their role

In the energy scenario, distributed flexibility (DF) is crucial. DF is the Prosumer's ability to modify ADS output at will to meet energy demand needs through flexible loads, controllable generation capacity and energy storage ability.

Distributed flexibility can create value for different actors. The PRS can use flexibility for in-house optimisation, e.g., by optimising against variable energy and/or grid tariffs, or increasing self-consumption of self-generated electricity. As the Supplier's and the BRP's goal is to reduce sourcing costs, maximise generation revenues and avoid imbalance charges, flexibility can help them optimise their portfolio. As the DSO is responsible for the installation and maintenance of distribution networks, it can use flexibility to actively manage the available capacity. The TSO is responsible for the setting up and maintenance of the transmission system and for system stability, and it can use flexibility in a number of ways, from system operation services for balancing purposes, to constraint management (e.g., congestion management) at the high voltage level, and adequacy services.

Some actors investigated the benefits for the different actors operating in the electricity system resulting from the implementation of VPP systems. Results are synthesised in the prospect below.

Actors	Benefits
Owners of DER units	• Capture the value of flexibility • Increase value of assets through the markets • Reduced financial risk through aggregation • Improved ability to negotiate commercial conditions
DSOs and TSOs	• Increased visibility of DER units for consideration in network operation • Using control flexibility of DER units for network management • Improved use of grid investments • Improved co-ordination between DSO and TSO • Mitigate the complexity of operation caused by the growth of inflexible distributed generation
Policy Makers	• Cost effective large-scale integration of renewable energies while maintaining system security • Open the energy markets to small-scale participants • Increasing the global efficiency of the electrical power system by capturing flexibility of DER units

	• Facilitate the targets for renewable energy deployment and reduction of CO_2 emissions • Improve consumer choice • New employment opportunities
Aggregators and Suppliers	• New offers for consumers and DER units • Mitigating commercial risk • New business opportunities

Table 3. Synthesis of the results

As already mentioned, the Aggregator is the manager and is responsible for the flexibility provided by Prosumers [25]. It combines them in a portfolio and provides services by adding up individual flexibilities and offering them to electricity market actors, namely Suppliers, BRPs, DSOs and TSOs.

These services create market value that remunerates Prosumers as an incentive for flexibility. Therefore, the presence of infrastructures providing full coordination among market actors is essential.

The opening of distributed generation to the grid brings advantages in terms of flexibility as well as difficulties: Aggregators must manage many micro load and generation units, and measurement and verification of the services provided become more complex. The TSO must rely on the provision of these services, which must be delivered correctly and on time, otherwise the entire system may suffer from security risks and Aggregators may have problems. As for the DSO, it must ensure the provision of services by distributed generation and loads under certain operating limits of the distribution network (e.g., current or voltage limits).

Therefore, Aggregators act as an interface between the TSO and the DSO in the supply of services by minor production or load units connected to the network. They have an overview of all resources, and the possibility to adjust inputs and withdrawals for all customers.

Aggregation must be carried out with appropriate concentrating devices for information flows and commands, in order to exchange the necessary data and implement orders in accordance with the TSO and DSO requirements and considering the local network constraints.

Aggregation provides a whole set of benefits in terms of innovation, supply security, market integration, emission reduction and system management, and the measurement of resources turns out to be more efficient.

The main benefits of aggregation are listed below:

- Reduction of system complexity through the management of aggregate smaller UC / PU units compared to their single management;

- Increased supply security through the provision of ancillary services to the network;
- Increased market integration, as a result of which the electricity system can meet energy needs with lower installed capacity as resources are used more efficiently;
- Operational control of plants with a reduction of CO2 emissions and pursuit of PNIEC decarbonisation objectives;
- Prosumers and consumers are informed, become proactive in the competitive market and can obtain economic value from their plant;
- Push towards greater technological innovation;
- Economies of scale and value creation, through the sharing of fixed costs among all parties and the use of common know-how;
- Creation of new business models for companies including aggregation;
- Price control, with savings for aggregate customers;
- Congestion control and balancing services;
- Support to RES integration and participation as flexibility service providers.

The flexibility services provided by the Aggregator are discussed in the following paragraphs.

3.2 Flexibility services

Electricity must be supplied to users at constant frequency (on which most users depend for correct operation), constant voltage (the voltage value directly influences the power taken by the user and, therefore, its operating efficiency and life) and on a continuous basis (interruption of electricity supply in modern societies leads to interruption of almost all human activities). These conditions are guaranteed by the provision of auxiliary services by production plants: frequency regulation, voltage regulation and system restarting. The first two ensure that frequency and voltage are maintained within their nominal values. The third one is required from production plants after a blackout.

Therefore, providing ancillary services means changing injection/withdrawal schedules, i.e., injections or withdrawals in real time (through automation or voluntary actions), in order to meet the TSO and DSO requirements. The latter must ensure balance between electricity supply and demand on the grid at all times.

The increased capacity from non-programmable renewable sources has led to an increase in DSM and BM volumes for reserve generation and real-time balancing. This has several repercussions on the electricity system security, which can be listed as follows:

- *Increase in reserve requirements*: as these sources are unpredictable, there can be errors in forecasting the residual load to be balanced in real time and an increase in rising and falling frequency/power requirements (upward reserve; downward reserve);
- *Increase in start-ups*: production from renewables implies balancing reserve margins that are more complex and expensive, due to the reduction of load from conventional sources with regulation capacity. Therefore, the TSO must allow activation of conventional plants that would otherwise be shut down.
- *Greater use of fast reserve (secondary reserve):* in the case of photovoltaics, where production is limited to the hours of sunshine, the increase in production enhances the distance between minimum daytime residual load and maximum evening residual load.

In this context, the TSO must be able to manage a market with very low levels of reserves and significant need for re-dispatching. In order to have the necessary reserve margins, the TSO procures upward reserve margins in ex-ante DSM through conventional plants, to then rebalance them in the BM.

It is a precaution to protect against over-expectations of photovoltaic and wind production, with upward reserve margins to cope with possible lower-than-expected production.

However, the new European energy market has introduced new criticalities in the operation of the electricity system as the share of power produced by conventional plants is being reduced, thus leading to a reduction in the grid power available for regulation.

Randomness and forecasting difficulties are a major limiting factor for renewable sources, as they are able to provide services only when the source is actually available. Moreover, they always operate at maximum power and have no margin to provide upward services (i.e., to increase generation and the amount of energy injected into the grid).

For example, the most troublesome point in secondary and tertiary frequency regulation service is the actual availability of the reserve. As a matter of fact, some/many hours could elapse between band creation and service provision. As the primary source is quite variable, it may be impossible to provide the service because the reserve band - even if supplied - no longer exists.

Hence, dispatch can be guaranteed only by having sufficient power margin at all times. If it is not available from renewables, it must be found in conventional qualified plants. In short, due to RES characteristics it will be crucial to keep thermoelectric plants operating for increased renewable penetration.

With reference to the distribution grid, the impact of renewable penetration leads to energy flows being reversed to the transmission grid. That implies problems in terms of limited hosting capacity (i.e., limits to the generation power accepted into the grid) and congestion on weak lines, as well as problems related to varying voltage profiles, which may also require service interruption under extreme situations (generation and/or load curtailment).

In this case, flexible resources should be used directly in the distribution grid either from distributed generation plants or from load plants and storage devices, which leads to advantages in terms of operating costs. They can contribute to peak shaving or load shifting, increase in transport capacity, optimisation of power flow distribution and greater supply reliability, thus reducing the amount of investment required in the grid.

There are two types of flexibility services that can be provided depending on the beneficiary.

Some services provide *implicit* flexibility because the recipients are the Prosumers, who are exposed to market prices. These services are provided to Prosumers by an ESCO and are financially beneficial if financial incentives are provided.

Implied value is mainly created from in-house consumption of generated energy, as the variable costs of self-produced energy generated from renewable sources are much lower than the price of energy bought on the market. This is due to the cost of materials used for production from fossil sources, taxation and the losses caused by electricity transmission. ESCOs can provide higher flexibility through optimised services in usage (tariff ToU), maximum peak load control (kWmax), self-balancing services and emergency power supply.

In further detail:

- *Time of Use optimisation (ToU):* as previously said, this is based on the shift in the consumption curve from intervals of high energy cost to intervals of low energy costs (and vice versa for generation). In this context, advanced knowledge of market prices is necessary.
- *Self-Balancing*: a service provided to Prosumers generating electricity (photovoltaic/solar panels) and having access to energy alternatives. The value lies in the difference between buying/generating energy and the sale of energy produced (including taxes).

- *Maximum load reduction*: a service provided to Prosumers, whose consumption is reduced at specific times of the year (for example, one month) with an ensuing reduction of the kWmax-based cost.
- *Emergency power supply*: it is applied during grid outages, with the flexibility to activate extra supply services in case of faults or grid interruptions.

On the other hand, flexibility is defined as being *explicit* when it is enjoyed by various actors in the electricity market, such as TSOs, DSOs and BRPs.
Aggregators can provide various services to TSOs, the main ones being:

- *Congestion Management (CM):* the management of possible situations when parts of the system become overloaded and lead to grid interruption, through peak load reduction (peak load is the highest level of load reached by a system in a certain time period).
- *Reduction of loss from the grid*: this service is connected to correct grid maintenance for TSOs and DSOs, thus reducing energy loss during transportation. As energy loss is proportional to the energy being transported, total losses are decreased by reducing maximum peaks.
- *Voltage control*: it is possible to control and limit the grid voltage using production or charge flexibility, thus reducing the investments needed in the grid. For example, solar panels may generate a significant amount of energy increasing voltage on the local grid. Therefore, a decrease in total generation is needed to re-establish the voltage value. This service is provided to DSOs and TSOs.

- *Frequency control*: it is possible to control frequency through aggregation. The reactivation of frequency services (FRR[1]) is identified as aFRR, if it occurs by means of an automatic device, or as mFRR if it occurs manually. Such service is provided in agreement with the TSO only for the 50 Hz frequency.

The services provided to the BRP are the following:

- *Portfolio optimisation to reduce displacement*: obtained from the BRP, in combination with production plants, with the possibility to reduce or increase solar panels or wind turbines to reduce displacement costs.

[1] Frequency Restoration Reserve

- *Day-ahead and intraday market optimisation* choosing to purchase energy when the cost is lower.
- *Production optimisation*: optimising the performance of production units while they are preparing for their next programmed production cycle. As control speed is limited in checking power units, variation is started a few minutes earlier than scheduled, causing fluctuation in the speed profile and resulting in unnecessary combustion costs that can be avoided by activating group flexibility.

Barriers preventing businesses and Consumers/Prosumers from investing in energy efficiency include:

- A lack of trust between different actors,
- Energy efficiency does not represent an investment priority,
- A lack of stable and accessible financing tools,
- Finally, a lack of experience in the financing of energy efficiency.

The implementation of the following key points will mitigate the above-mentioned obstacles for the VPP4ISLANDS project:

- *Unified EPC contract* will be the basis for a contractual agreement between technology Suppliers and Customers; the contract will provide a transparent guarantee of energy savings, with the guarantee of results.
- *Validation*. The control will be carried out by a third party who will technically evaluate (ex-ante/ex-post) and certify the contract through the use of the blockchain.
- *Financing* provided by commercial banks to customers. Since this step is a market mechanism, it can take advantage of the support of guarantee funds, etc.

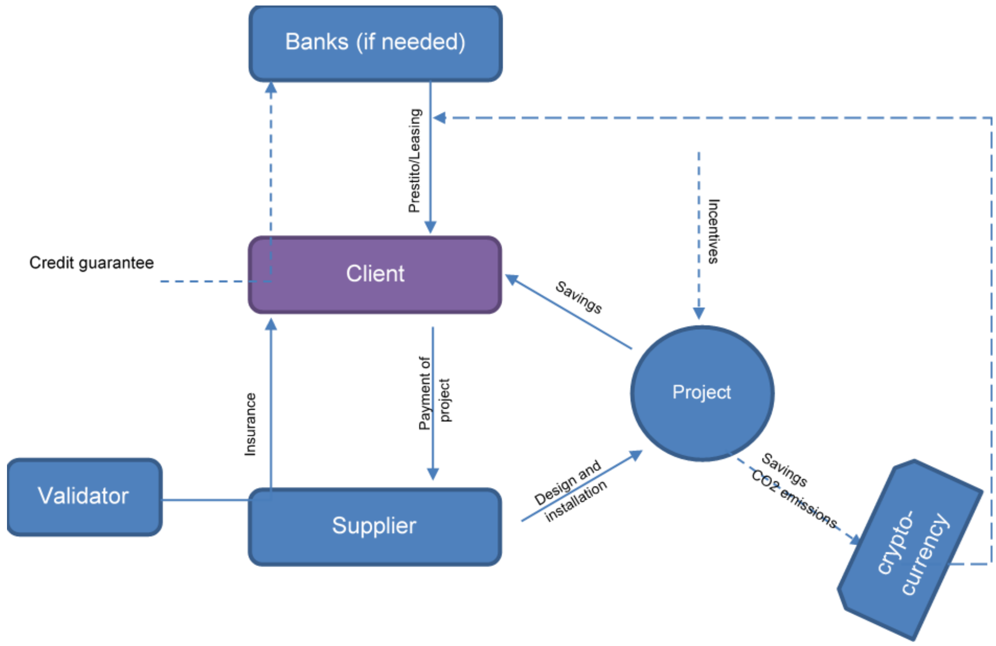

Figure 1. Schematic diagram illustrating the underlying principles of EPC

The role of the validation body will be crucial as it guarantees trust to SMEs, banks and insurance companies. The institution must:

- In case of disagreement, the institution must arbitrate between private SMEs and ESCo when the results of energy efficiency improvement actions are presented;
- Carry out the technical evaluation aimed at ascertaining the ability of the project to realise the estimated savings;
- Evaluate the experience and credentials of the ESCo;
- Develop validation standards (simple, low cost, technology focused, credible, replicable, etc.).

Energy saving will also be the starting point for certifying the reduction of climate-altering emissions ($kgCO_2$ / year) that will be the basis of the cryptocurrency. It has to be noted that the cryptocurrency should be compliant with what European Banking Authority and the legislative proposal from the European Commission in order to make consumers aware of the risks [23]. As such, we consider that as an energy wallet for Prosumers.

The growing use of small renewable energy installations, such as solar panels on roofs, can create tension on power grids designed for large centralised power plants. By enabling peer-to-peer energy trading and incentivising local consumption at the time of production, blockchain could stabilise the grid, fostering decentralisation.

By exploiting the main peculiarities of blockchain technology such as integrity, security and traceability, the renewable energy marketplace is able to guarantee a Renewable Energy Certificate (REC) negotiation regardless of the size and type of activity of the counterparties involved, whether local or international. In this way, everyone, sellers and buyers, are enabled to find rapid, traceable and certified coverage, with a view to increasingly broad integration of the electricity grid and renewable energy sources.

The blockchain could also be used for tracking electricity with at least two purposes: prizes for renewable energy generation (such as the SolarCoin cryptocurrency born in 2015 for this purpose) and renewable energy certificates or carbon credits.

For those who want to invest in renewable energy but do not have the necessary funds, blockchain technology could enable collective investments, ensuring a fair and transparent sharing of revenues. It could then solve the problem of on-site exchange of unused energy with peer-to-peer transfer in a safe, transparent and immediate manner. It would therefore not be necessary to use intermediaries and thus avoid waste and higher costs.

Thanks to the blockchain, digital devices connected to the network are introduced that account for in-house energy production. These meters are connected to smart contracts that automatically store and distribute the data in the network, certifying its value. By doing so, a transparent system is created for the enhancement of consumption and the real energy production of the community. This system also encourages private individuals, companies and accommodation facilities to adopt in-house renewable energy production systems. In fact, energy production is not intended only as a system to reduce pollution or to safeguard our planet, but also as an opportunity for savings and for the reduction of energy costs.

The possible applications of the blockchain in the energy sector could be the following:

- *Smart Contract*. Stipulation of agreements between a number of subjects with clauses that are triggered automatically when certain events occur.
- *Exchange of energy* between subjects belonging to the same energy community, for example a condominium or an electric vehicle charging system, as outlined by Renewable Energy Directive (RED II)[2].
- *Cryptocurrencies* that can be accepted for the payment of electricity or aimed at encouraging renewable electricity production. For example, Solarcoi[3] (SLR) remunerates the energy produced by RES in the measure of 1 SLR / MWh.

[2] Directive (EU) 2018/2001

[3] https://solarcoin.org/

- *Incentivisation*. Information management of energy quotas, efficiency levels, etc. on a transparent and immutable platform that guarantees fewer chances of incurring penalties.

In order to effectively define the services, as highlighted in the previous paragraphs, it is necessary to first identify the actors and the assets present on each island. This exercise allows defining the architecture of each island in an accurate way and, as a consequence, selecting the most promising and suitable services.

In addition to the classification based on the actors and Aggregators involved presented above, a further classification has been developed. In the following table, we have carried out a first theoretical mapping exercise of the services that can be implemented on the islands. The services are classified according to the category (Ancillary services, Flexibility services, Market services, Energy efficiency services, Digital services and Business services). Each single service is then differentiated according to the layers (namely VPP4IBox, VPP4INode and VPP4I Platform), the actors involved and, finally, the VPP4I Tools connected to the service.

The definition of the services has been based on the outcomes of the deliverable D2.2, "*Analysis of obstacles to innovations in islands*", realised by Brunel University. The mapping exercise carried out in this report will be further fine-tuned in the deliverable D2.6 *Technical specification of VPP4Islands*.

Category	**Services**	**Layers**	**Actors**	**VPP4I Tools**
Ancillary services	Frequency control	VPP4IBox	DSO	VESS
	Voltage Control	VPP4IBox	TSO	VESS\ Distributed control
Flexibility	Load scheduling	VPP4IBox	ECs\DSO\Prosumers	VESS
	DR management	VPP4INode	ECs\DSO\Prosumers	VESS\BSP
	ESS management	VPP4INode & VPP4IBox	ECs\DSO\Prosumers	VESS
Market	Day-ahead	VPP4INode	DER provider	Optimisation engine
	Intraday	VPP4INode	DER provider	Optimisation engine
	Building of Local Market		ECs	WP7

	P2P Local Market	VPP4INode	ECs, Prosumers, DER providers	DLT, P2P trading engine (T2.5.2)
	Certification of Origin.	VPP4IBox	ECs, Prosumers	DLT
Energy efficiency services	Energy saving	VPP4I Platform	Prosumers	Energy savings (T4.1.4)
	Auditing	I PMVP method	Islands, ECs	Exploitation and Business (T8.4)
	Energy Performance Contracting	VPP4INode/VPP4I Platform	Prosumers, islands	Exploitation and Business (T8.4)
Digital services	Planning and improvement	VPP4I Platform	Islands\ Prosumers	SPT, DSS, KB
	Short & long term Forecasting tools	VPP4I Platform\ VPP4INode	DERs, ECs	Forecasting tools (T4.1)
	DT-based Training	VPP4IPlatform	Aggregator \Islands\ DSO	DT
	Monitoring and fault detection	VPP4IPlatform	Aggregator \Islands	DT
	Carbon bilan/pollution reduction	VPP4I Platform	Islands\ Prosumers	CO2 footprint savings (T4.1.4)
	KPIs (e.g. Flexibility Index)	VPP4INode	Aggregator \Islands	User interfaces (GUIs)
Business services	Selling of technologies		prosumers, ECs, Islands	Exploitation and Business (T8.4)
	Energy Performance Contracting	VPP4INode/VPP4I Platform	Prosumers, islands	Exploitation and Business (T8.4)
	Licensing		Technology providers, RTOs	Exploitation and Business (T8.4)
	Bill management	VPP4INode	prosumers	Exploitation and Business (T8.4)
	Advertising	VPP4I Platform	Technology providers	Exploitation and Business (T8.4)
	Increasing profitability	VPP4I Platform\ VPP4INode	DER\prosumers\	Optimisation engine (T4.5)\ VESS\DT
	ROI & Investment,	VPP4I Platform	Islands, DER, Prosumers	SPT

	Labelling,		DER & prosumers	Exploitation and Business (T8.4)
	After-Sales Services		All	Exploitation and Business (T8.4)

Table 4. Classification of services

4. Aggregators' remuneration and integration [26] [27]

Aggregators sell either energy on the market or services producing profits. They provide flexibility services from their own distributed resources. By purchasing flexibility, Aggregators create a portfolio of bundled resources and make them available to market actors from which they obtain economic profits.[28]

Profits are then shared with Prosumers as an incentive for using their services.

The BRP, DSO and TSO, in other words the actors asking for flexibility, can remunerate Aggregators in various ways, depending on the Aggregator's performance in providing services, and the services created at the time of availability or activation.

Remuneration can take different forms, namely:

- *Remuneration for the energy volume (capacity):* it relates to any element of the remuneration depending on the requested volume or active volume (Baseline value minus the measurement) in kWh. Therefore, it is the remuneration paid for the availability to reduce or to increase the user's load for a determined value of power, which brings advantages in terms of grid stability and saves money for Prosumers.
- *Remuneration for the sale of energy on the market*: the energy aggregated by the Prosumers can then be sold on the market.
- *Remuneration for the provision of ancillary services*: the remuneration provided to Aggregators for the activation of implicit or explicit demand flexibility to market actors. The DSO and TSO can put in place tests to assess service quality. Before making a profit, it is necessary to assess compliance with the delivery requirements, such as ramp speed, kWmax/min, response time or duration. Aggregators failing to meet delivery requirements or sufficient quality base for the power line may incur sanctions or be banned/disqualified from professional services.

An aggregator business does not only depend on profits but also on flexibility provision costs, such as the cost of reserve booking, the cost of flexibility activation and the opportunity cost.

Activation costs are met by Prosumers and are generally paid by Aggregators.

Figure 2. Remuneration scheme for the provision of aggregate services

Coordination mechanisms between Aggregators and other market actors can be summarised as follows:

Negotiation. This first phase describes how the Aggregator (AGR) creates contracts with two entities to acquire flexibility: on the one hand with Prosumers in order to control their resources, and on the other with BSPs (if the Aggregator and the BSP are two separate entities) to sell flexibility services to the TSO. An example is provided by the aFRR (automatic frequency restoration service). The Aggregator updates the DSO on the state of its flexibility portfolio so that impacts can be managed when activating these resources. The Aggregator must register with the MDC to receive measurement data on activations.

Then the Aggregator enters into a contract with the BRP_{agr}, which is responsible for imbalances caused by flexibility activation and, in some models, also with the Supplier (SUP) to settle energy transfers sold by the Supplier and not consumed by Prosumers after activation.

The BRP_{agr} and BRP_{sup} are bound by contract for “perimeter correction”, that is to settle imbalances caused to the BRP_{sup} by the Prosumer’s flexibility activation.

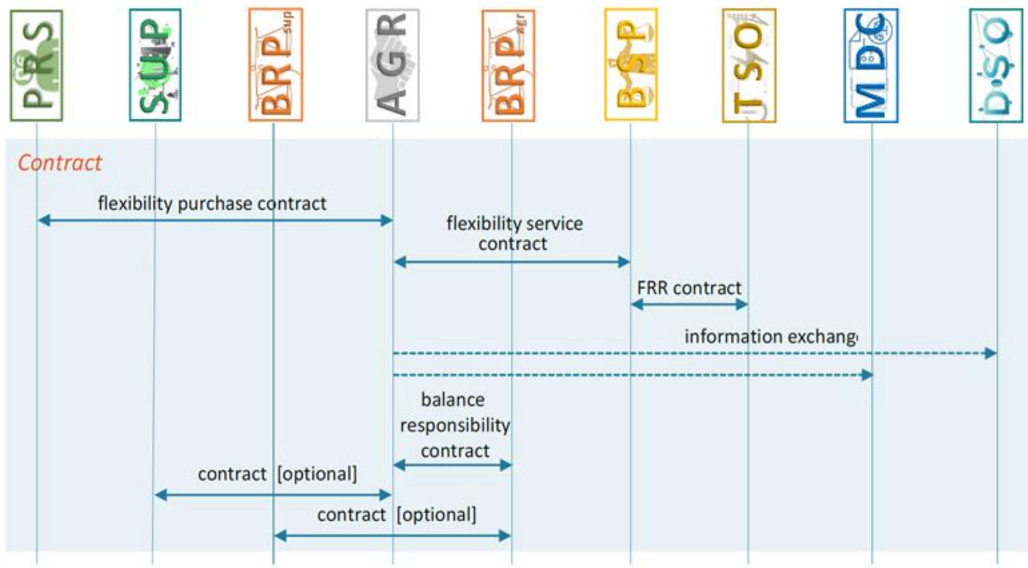

Figure 3. Negotiation phase

<u>*Planning/Validation*</u>. In this phase, the Aggregator identifies the state of its portfolio of flexible resources according to the resource management plans and forecasts provided by Prosumers. In case of constraints in the distribution network, the DSO may impose restrictions on the use of flexible resources, or request to use them to solve constraints.

With full knowledge of its resource portfolio, the Aggregator can offer its resources to the BSP, which in turn offers them to the TSO for the provision of the services required. The BRP_{agr} and BRP_{sup} provide all the necessary information to the TSO, including information on the flexibility offers submitted by the Aggregator.

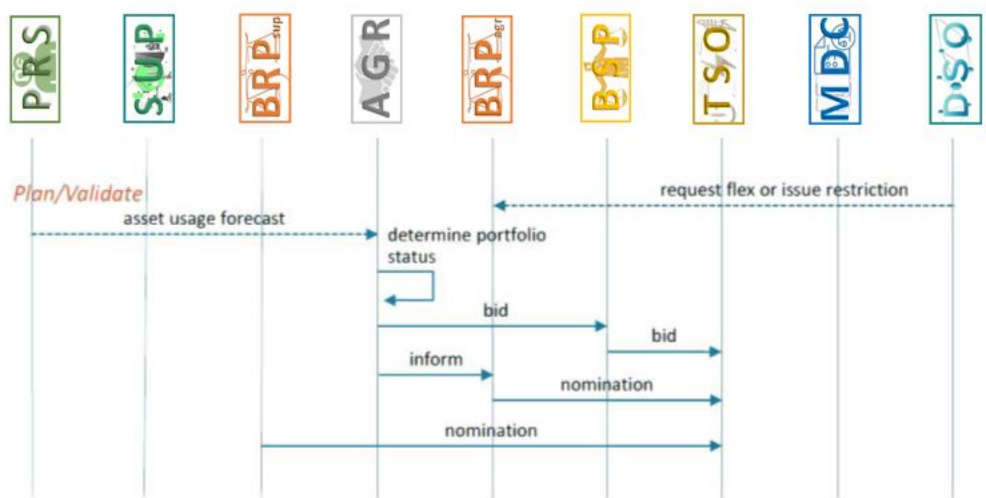

Figure 4. Planning/Validation phase

Operational phase. In this phase, the Prosumer's flexible resources are monitored. Measurements are sent to the TSO via the Aggregator and the BSP to define a Baseline before activation and to verify service provision. As soon as there is an imbalance in the system, the TSO requests its elimination to the BSP.

The BSP gets in contact with the Aggregator to request activation of a number of flexible resources, and the request is fulfilled based on Prosumers' availability.

To avoid "counterbalancing" actions by the BRP_{sup} - that has real-time measurements of the injections/withdrawals in its portfolio - the Aggregator informs it of the Prosumers' flexible resources activated in its portfolio.

The MDC collects all useful measurements to be used in the settlement phase.

By activating flexible resources, the Supplier gives less energy than planned as Prosumers have reduced demand, thus creating imbalances in the BRP_{sup} portfolio.

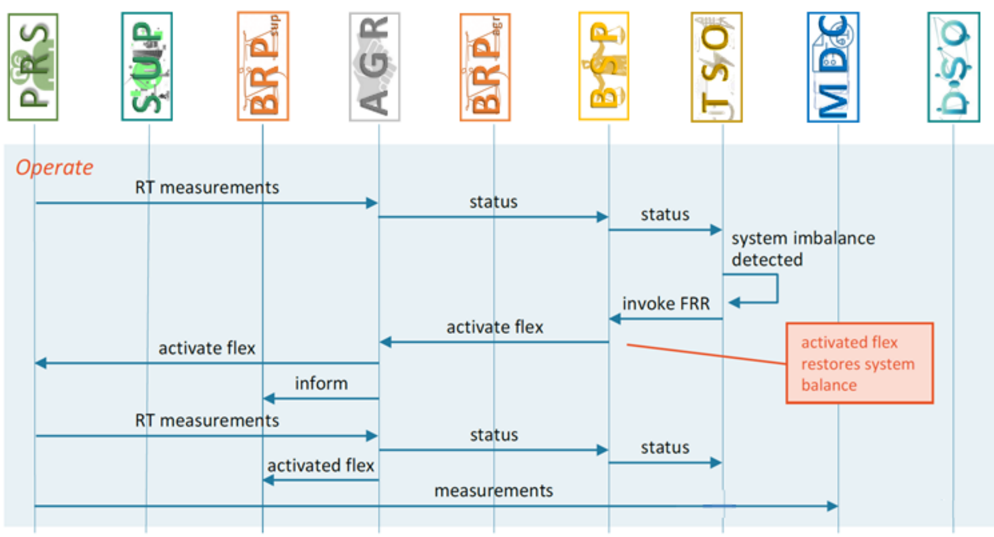

Figure 5. Operational phase

Settlement phase. The MDC distributes the measured data to all entities, so that activated flexibility can be quantified. Energy transfer is carried out between the BRP*sup* and the BRP*agr* for "perimeter correction". The Supplier is compensated since, after activating its Prosumers' services, it has supplied less energy than planned.

After the energy transfer, the BSP is remunerated for the service provided, which also generates profits for the Aggregator and Prosumers for flexibility activation.

In this context, other implementation models may apply for the Aggregator's business depending on whether a BRP*agr* is also involved in addition to the BRP_{sup}, or whether there is a contract between the Aggregator and the BRP_{sup} or not.

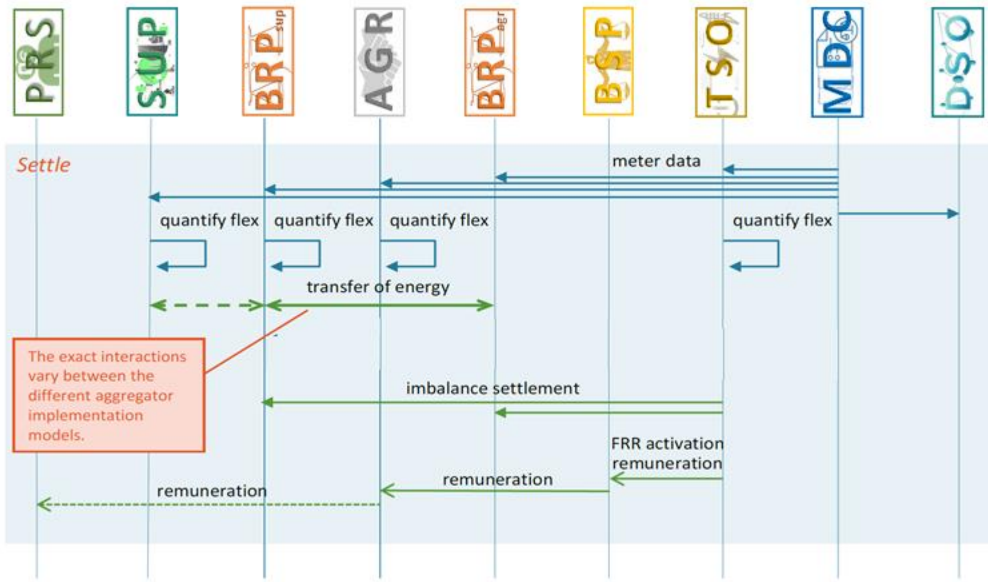

Figure 6. Settlement phase

5. Business models for aggregators

A business model for Aggregators is a model for Aggregators' business implementation in the market. It helps describe their relations with the Supplier and the Prosumer's BRP, and shows how balancing, energy transfer and information exchange are organised. The aim is to identify business models for aggregation that can be implemented.

Based on the analysis of the BestRES team [29], six business models can be identified for European Aggregators. The main difference between them lies on whether Aggregators play an independent role or a combined role.

Combined Aggregators are existing market actors that have combined aggregation to their core business, e.g., an energy Supplier acting as an Aggregator. This is the most common type.

On the other hand, independent Aggregators act independently of the Supplier and its BRP. They provide an important advantage as they can create a more competitive market.

Among them, there are three types of Aggregators with a combined role: the Aggregator/Supplier model, the Aggregator/BRP model and the Aggregator/DSO model.

There are also three types of independent Aggregators: the Aggregator as a flexibility service provider, the delegated Aggregator and the Prosumer as Aggregator.

The following sections describe the different types of Aggregator and outline the main characteristics of each type. A short diagram is added for each type of Aggregator to show the important market actors and arrangements between them, which are represented by arrows.

5.1 Combined Aggregator-Supplier

In this business model, Aggregator and Supplier coincide. The Aggregator submits proposals to the Prosumer to include its flexibility enhancement and energy supply. Therefore, energy supply and aggregation are offered as a package.

As the Aggregator is both a BRP and a Supplier, there will be only one BRP (BRPsup) per connection point as Aggregator and BRP are the same entity. The main benefits are reduced complexity and the absence of financial settlements between Suppliers and Aggregators.

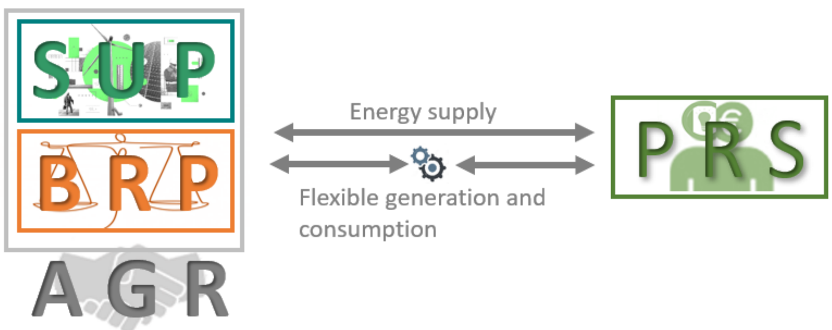

Figure 7. Combined Aggregator-Supplier diagram

5.2 Combined Aggregator-BRP

In this second model, the roles of Aggregator and BRP are combined. The Prosumer has a contract with a Supplier for energy supply and a separate contract with the Aggregator to unlock and market its flexibility.

The Aggregator sells flexibility at its own risk on behalf of the Prosumer.

Therefore, a BRP_{agr} and a BRP_{sup} are on the same connection point. Some agreements between the Aggregator and the Supplier may be necessary, as the Aggregator may use electricity produced by the Supplier and the Aggregator may influence the imbalances of the BRP_{sup}.

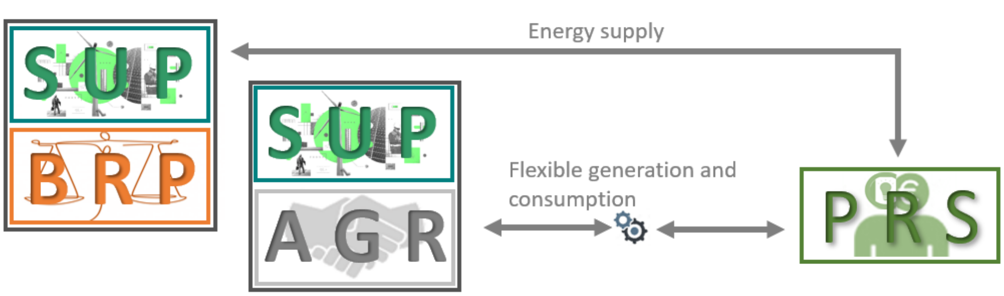

Figure 8. Combined Aggregator-BRP diagram

5.3 Independent Aggregator As A Flexibility Service Provider

An Aggregator may also act only as a service provider, just providing the means to access flexibility without selling it at its own risk. This business model does not focus on selling flexibility, but on creating a service enabling other market actors to use flexibility with Prosumers.

This service is usually provided through access to a hardware/software platform that can control decentralised resources. The Aggregator does not play the role of BRP or Supplier.

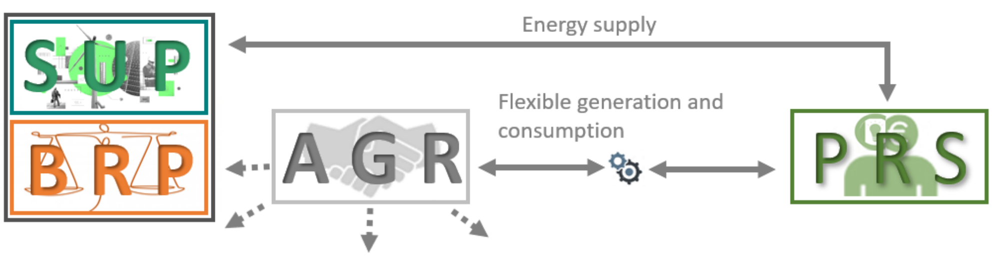

Figure 9. Independent Aggregator as a flexibility service provider diagram

5.4 Independent Delegated Aggregator

The delegated Aggregator acquires flexibility from Prosumers and sells it at its own risk to other market actors or electricity markets. This type of Aggregator does not act as a BRP or Supplier: there is only one BRP, which is the BRP_{sup} connected to the Prosumer.

Consequently, there is no BRP_{agr} and the BRP_{sup} becomes responsible for imbalances resulting from the Prosumer's flexible services.

Since the Aggregator is not a BRP, it must have an agreement with it to connect to the Prosumer.

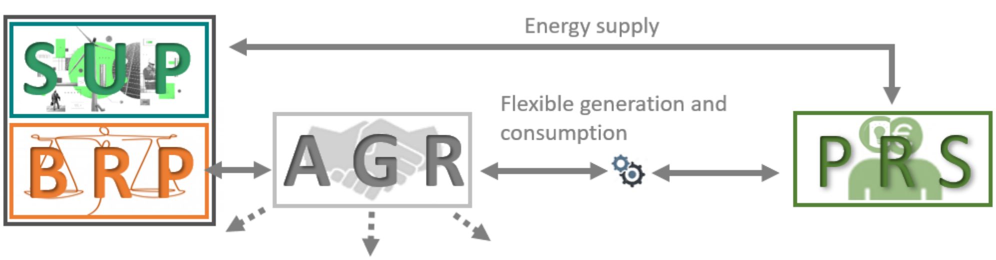

Figure 10. Independent delegated Aggregator diagram

5.5 Prosumer As Aggregator

Prosumers can choose to play the role of Aggregator for some of their assets. Their flexibility can be negotiated with other market actors or markets.

The Prosumer/Aggregator does not play the role of Supplier or BRP, but only aggregates flexibility from its own assets. It is easier to adopt this business model for industrial Prosumers because they operate on a large scale. Domestic Prosumers should use an Aggregator to combine several smaller units.

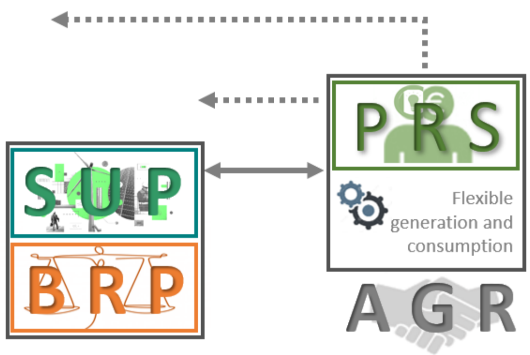

Figure 11. Prosumer as Aggregator diagram

5.6 The DSO as Aggregator

The DSO can also act as an Aggregator in a model that is very similar to the delegated model. In this case, the Aggregator and the DSO are the same entity and uses flexibility for congestion management purposes. It does not act as a BRP or a Supplier.

An agreement between the DSO/Aggregator and the Supplier/BRP is required. Flexibility activation by the DSO (acting as Aggregator) affects the Supplier/BRP and procedures must be put in place to deal with it.

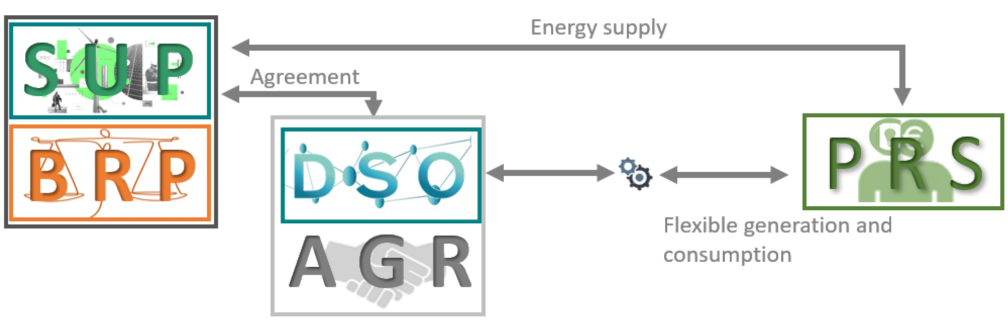

Figure 12. DSO as Aggregator diagram

The six above-mentioned models describe the most common Aggregator models in Europe.

Three types concern Aggregators with a business model combined to another primary role, i.e., energy supplier, whereas three types concern independent Aggregators with a primary model focus on flexibility.

6. THE BUSINESS MODEL CANVAS FOR AGGREGATORS

In order to be able to analyse the possible economic impact of a service to propose, in this section we hypothesise the use of a business model that will be described in the following paragraphs, this is intended to be only an initial contribution to the economic modelling of services.

A business model is a concept used to rationally describe how a business organisation creates, exchanges, and obtains value in terms of work, through a simple and intuitive scheme [30]. This concept can become a common language that allows you to have a clear understanding of the mechanics of the organisation and brings change, alternative strategies and commercial appeal to the business.

To represent this market, we use the well-known business model defined by Osterwalder, which is described with nine blocks representing the logic of how we intend to produce profit, i.e., covering the four main areas of a business: customers, supply, infrastructure and profitability. These building blocks are: customer segment, value proposition, channels, customer relationships, revenue streams, key resources, key assets, key partners, and cost structure.[31]

<table>
<tr><td rowspan="2">Keyword</td><td>Key tasks</td><td rowspan="2">Value Pro proposal</td><td>Customer relationship</td><td rowspan="2">Customer segments</td></tr>
<tr><td>Key Resources</td><td>Canal</td></tr>
<tr><td colspan="3">Cost structure</td><td colspan="2">Revenue stream</td></tr>
</table>

Table 5. Block diagram of the Business Model Canvas according to Osterwalder scheme

6.1 The business model canvas for a generalised aggregator

To summarise and conclude the job of the Aggregator the Business Model Canvas put forward by Osterwalder is used, based on the study of the European energy Aggregators and on the team projects of BestRES, the BM Canvas could be assumed as a generalised Aggregator, as well as in three other more practical forms.

The aggregators provide their services to the following clients in the market:

- *BRPs*: the BRP can optimise their portfolios and reduce deficit. To do this the BRP usually have to reduce or increase the production of Eolic or photovoltaic installations with other generation units or providers. Trading is needed to further optimise their portfolio.
- *TSOs*: the TSO, that is those responsible for the congestions and the balancing of the electric system, need to use various types of supply to respond to shortages and every type of reserve has different activation times.

  For the TSO we have obtained the following advantages from aggregation:
  - *Congestion management*: The grid operators can avoid investing in the grid and therefore the advantage of flexibility will be equal to the investment and operational (CAPEX and OPEX) saved.
  - *Reduction in loss from the grid*. The advantage of flexibility corresponds to the quality of the energy that has not been lost.
  - *Tension control with active and reactive power*. The advantage of flexibility is equal to the CAPEX and OPEX of backup and control of the saved tension.
  - *Frequency control through the reserve*.
    - DSOs: the DSO need flexibility to manage the congestion and to avoid increased tension on the grid, thus generating values equivalent to the TSO.
    - Direct sale to the electricity market. The Aggregators can choose to sell their energy to energy markets. The owners of assets for the allocated production FER receive:

      a) A fixed income Euro/MWh in the case of feed-in tariffs (all inclusive), including both the incentivised quote and the value charge of the energy injected.

      b) An incentivised and constant income for a certain period of time regardless of how it is used (injected into the grid or for self-consumption) to which the value of the energy put into the grid is then added, that is the price of the sale of the energy to the grid. Through premium feed-in tariffs.

- *Prosumers*. The Prosumers, from the business sectors, mainly concentrate on the reduction of energy costs. In this situation, the ESCo offers technical solutions to oblige increased efficiency and therefore profits from the savings generated, as well as the opportunity to become independent from the traditional fossil fuels. The Prosumers are therefore industrialists, traders and residents.

For the connection between such clients and the value of their offer in Canvas *Canali* (channels) are used. The clients are directly informed by local centres, Aggregators websites or through market platforms. These *Canali* (channels) also contribute to customer help through call centres, mail or direct information.

The income generated by the Aggregators is linked to specific costs and can be vastly different. An aggregation business can be developed exclusively for financial reasons from private investors and can gain flexibility income, or for example, from a software or technology providers that can use such business as a lever to sell and publicise their technology.

In the income flow, a part of the aggregation market can be tailor made to the client, with an income model volume dependent on, for example the saving obtained by a Prosumer who is working with an ESCo or from the use of flexible resources on behalf of a BRP. On the other hand, part of the income will be generated through a predefined supply and/or an activation quote. If then the Aggregator sells directly to the electricity market, they would then earn money when there is a spread between the cost of generation of the aggregated portfolio and the prices of the wholesale electricity market.

A defined structure corresponds to this income, of which an important part is the remuneration that the Aggregator pays the distributed resources providers. In addition, the Aggregators must develop a software platform and other technology, even if they can decide to use a pre-existing one. If no pre-existing platform is suitable to the business of aggregation the cost of this can be extremely high. Added to these costs there are the standard costs of paying staff.

Keyword	**Key Activities**	**Value Proposition**	**Relationship with customers**	**Customer segments**
technology and software providers Local service providers Financial stakeholders	How the VPP platform works Forecast of generation and consumption and sale/purchase of excess/default energy	Reduction of energy costs and additional energy flows Independence from traditional energy	Direct assistance through call centres or affiliated services Automated services via market platforms	Prosumer (residential, commercial, industrial**)** NETWORK OPERATORS

Interest (lobbying) groups		suppliers and from fossil fuels Ancillary services distributed to serve network stability Energy portfolio optimisation		BRPs and energy suppliers
	Key resources Hardware: ICT connected to DERs (distributed generation demand response accumulation)		**Canals** Direct: online services (website and/or app) + guided tours and events Indirect: service centres & market platforms	

Cost Structure	**Revenue flow**
Fixed costs of operators and employees Variable costs for the remuneration of DER owners + energy sourcing Extra costs for R&D and business development	Remuneration on energy volume services or services Remuneration on the activation of capacity Monthly registration fees

Table 6. Business Model Canvas for a generic Aggregator. [Elaborated from previous theory]

In order to carry out the Aggregator business they need the key resources, resources known as ICT, in other words technologies that control production, from the flexibility of usage to the response demand and storage. In order to balance these resources, an algorithm that allows for the forecasting of the wind and solar energy production is seen as a key resource.

The resources owned by the DER are not considered, since they act as third parties. Other key businesses correspond to the resources for the correct functioning of the network of the Virtual Power Plant (VPP). The key partners for this business model are the technology and software providers for the monitoring of production and the activation to the demand, local service partners at the production units and the financial stakeholders, such as shareholders.

6.2 Business Model Canvas for a Photovoltaic Storage Battery Aggregator

Before becoming an Aggregator, the company's business started out from the production of batteries used in the photovoltaic production. Its customer base is made up of residential Prosumers and small to medium businesses equipped with photovoltaic batteries on their property. The main advantages proposed are for the Prosumers gaining electric independence and self-consumption, with the opportunity to access electricity at lower prices as pay back from the flexibility offered, when the battery is worn down and not producing photovoltaic energy.

Simultaneously, offers to the Operators of the grid services in the primary reserve for the frequency regulation and of re-dispatching cooperated by the battery aggregate. Its main business is therefore the operating (and production) of batteries, working with the Prosumers needs for self-consumption and for services to the electric grid. The income flow is based on the renumerations from grid services, the sale of batteries and the exchange of energy on the electricity markets [32

Keyword	**Key Activities**	**Value Proposition**	**Relationship with customers**	**Customer segments**
Technology suppliers for PV storage batteries and software Financial stakeholders TSO and DSO Electric markets	Tenders for network services Management and control of the aggregate Forecast of generation and consumption and sale/purchase of excess/default energy	Reducing dependence on grid electricity supply by increasing self-consumption Network Operator Explicit Flexibility Services Energy marketing services to markets	Direct assistance through call centres or affiliated services	Prosumer (residential, commercial, industrial**)** owners of PV
	Key resources Hardware: ICT connected to the aggregate storage batteries Aggregate control software Human: operational know-how Financial: contracts with prosumers and PV suppliers		**Canals** Direct: online services Indirect: local sales and accumulation installation service centres	
Cost Structure Investments (CAPEX) (Operational Costs (OPEX) Fixed costs for operators employed and software		**Revenue flow** Remuneration for the sale and installation of batteries Remuneration for the sale of ancillary services Remuneration for trading on electricity markets		

Table 7. . Business Model Canvas for a Photovoltaic Storage Battery Aggregator

6.3 Business Model Canvas for Aggregator owner of Virtual Power Plant

The Aggregator started directly as a VPP operator in order to aggregate more DER systems in the area. Therefore, his customer base consists of commercial Prosumers and industries having several typologies of DER at their disposal, such as photovoltaic, wind, biogas, hydroelectric, co-generators and battery. The main advantages put forward for the Prosumers are the possibility of having supplementary income flows, reduced energy costs and the management of their system. In order to do this, they take advantage of the production portfolio in order to optimise buying energy when the costs are lower, offering an entire new range of stock services (primary, secondary and tertiary) through all the main markets of balancing and capacity for the regulation of the frequency of the grid. The main key resource is the VPP software, that includes forecasting for all the different types of DER and the management of the respective ICT. The income flow is mainly based on the income coming from energy trading and the renumeration for the services to the grid. The providers of flexibility are paid through individual contracts with a profit, bearing in mind the specific technical capacities or each generator.[32]

<table>
<tr>
<td rowspan="2">Keyword

Telecommunication technology suppliers

Local service providers

Financial stakeholders

TSO and DSO

Electricity market operators</td>
<td>Key Activities

Tenders for network services

How the VPP platform works

Forecast of generation and consumption</td>
<td rowspan="2">Value Proposition

Implicit flexibility services to the prosumer for ToU optimisation or maximum load reduction.

Explicit flexibility services of network operators with increased primary secondary and tertiary power reserve for network stability

Energy marketing services to markets</td>
<td>Relationship with customers
Direct contracts with the owners of production assets</td>
<td rowspan="2">Customer segments

Prosumer (residential, commercial, industrial) holders of DERs of various types</td>
</tr>
<tr>
<td>Key resources

Hardware: ICT connected to DERs

Software: VPP control algorithms

Human with competence and operational experience

Financial: contracts with DERs</td>
<td>Canals

Electricity market platforms</td>
</tr>
<tr>
<td colspan="2">Cost Structure

Investments (CAPEX)

(Operational Costs (OPEX)

Fixed costs for operators employed and technologies</td>
<td colspan="3">Revenue flow

Remuneration for the sale of ancillary services

Remuneration for trading on electricity markets

Remuneration on energy volume services</td>
</tr>
</table>

Table 8. Business Model Canvas for Aggregator owner of Virtual Power Plant.

6.4 Business Model Canvas for Aggregator as a Supplier of Assets for Renewable Generation

In this case the Aggregator started as a provider of renewable energy before entering the aggregation business. Their customer base is composed of both Prosumers and simple consumers in the residential, commercial, and industrial sector. Their main advantage is that the energy provided is 100% renewable and is the same as its specific sale, to which reduced energy costs are integrated resulting in a further advantage for the client. In further detail, they can offer all-inclusive solutions to accumulation systems for self-consumption, with guaranteed fixed annual savings on energy bills and a range of contracts Power Purchase Agreement (PPA), in other words contracts lasting for more than one year for the purchasing of energy produced by aggregated generators and with the possibility of having fixed or variable renumerations. The key resources and business are mainly related to software, with the controlling of the respective ICT for the VPP.

Nevertheless, this Aggregator possesses their own generation assets, with the purchase of flexibility only to self-balance their DER profile without selling to third parties such asrid operators or other BRP. The financial profitability is specific in trading and on the production of electricity through the wholesale market and the direct sale.[32]

<table>
<tr>
<td rowspan="2">Keyword

Technology suppliers of renewable assets and software

Local installation service providers

Financial stakeholders

TSO and DSO

Electric markets</td>
<td>Key Activities

Installation and maintenance of renewable assets

Tenders for network services and energy sales

How the VPP platform works

Forecast of generation and consumption</td>
<td rowspan="2">Value Proposition

GO-certified renewable energy assets retail services

Sale of PPA contracts for the management and sale of prosumer energy production on markets

Implicit flexibility services to the prosumer for ToU optimisation or maximum load reduction.

Energy sales to the markets</td>
<td>Relationship with customers
Direct contracts with the owners of production assets</td>
<td rowspan="2">Customer segments

Prosumer (residential, commercial, industrial)</td>
</tr>
<tr>
<td>Key resources

Hardware: ICT connected to DERs

Software: VPP control algorithms</td>
<td>Canals

Direct: online site and local points of sale

Electricity market platforms</td>
</tr>
</table>

<table>
<tr><td></td><td>Human with competence and operational experience

Financial: contracts with DERs</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Cost Structure

Investments (CAPEX)

(Operational Costs (OPEX)

Payment of contracts to the Prosumer

Fixed costs for operators employed and technologies</td><td colspan="3">Revenue flow

Remuneration for the sale of assets

Remuneration for trading on electricity markets</td></tr>
</table>

Table 9. Business Model Canvas for Aggregator and energy supplier for renewable production

7. IDENTIFICATION OF NEW TAILORED SERVICES FOR THE ISLANDS

In the following paragraph, services that can be implemented on the islands have been identified. As aforementioned, the mapping exercise carried out in this report has to be fine-tuned since the identification of the actor and the asset of each island is still at an embryonic phase. The table below relates the implementation schemes for Aggregators (namely generalised Aggregator, photovoltaic storage battery Aggregator, Aggregator with virtual power plants, energy performance contract sustainable mobility, energy performance contract real estate for energy efficiency upgrade and energy performance contract energy for biowaste) with the feasible services (identified in D2.2 and in Table 3) for their implementation, also indicating the potential actors involved (*Potential actor*s) and the islands in which such implementation schemes can be realised (*Islands*). The table also identifies whether an implementation scheme has a direct impact (tick) or an indirect on a service.

In addition, the table also presents the feasible remuneration systems (for being able to guarantee the maintenance of the VPP. The column *Revenue streams* identifies how the services will be operationally declined through this type of contract.

Implementation schemes of aggregators	Services					Revenue streams	Potential actors	Islands
	Ancillary services	*Flexibility services*	*Energy efficiency services*	*Digital services*	*Business services*			
Generalised aggregator (6.1)	✓	✓		✓		• Remuneration on energy volume services • Remuneration on the activation of capacity • Monthly registration fees	DSO TSO ESCo	Formentera Gökçeada Grado
Photovoltaic storage battery aggregator (6.2)	✓	✓		✓	✓	• Remuneration for the sale and installation of batteries • Remuneration for the sale of ancillary services • Remuneration for trading on electricity markets	DSO TSO ESCo	Formentera Gökçeada Grado Bornholm
Aggregator owner of virtual power plant (6.3)	✓		✓	✓	✓	• Remuneration for the sale of ancillary services • Remuneration for trading on electricity markets • Remuneration on energy volume services	DSO TSO ESCo	Formentera Gökçeada Grado
Aggregator as a supplier of assets for renewable generation (6.4)	✓	✓		✓	✓	• Remuneration for the sale of ancillary services • Remuneration for trading on electricity markets • Remuneration on energy volume services	ESCo	Formentera Gökçeada Grado Bornholm
Energy Performance Contract - Sustainable mobility (7.1.2)				✓	✓	• Remuneration for the sale of cars and charging systems • remuneration for the sale of car sharing service	ESCo	Formentera Grado Bozcaada
Energy Performance Contract - Real estate for energy efficiency upgrade (7.2.1)			✓		✓	• Remuneration for the sale of energy requalification works • Remuneration through energy management fee	ESCo	Formentera Gökçeada Grado Bornholm
Energy Performance Contract - Energy for biowaste(7.2.2)	✓	✓		✓	✓	• Remuneration for the sale of electricity • Remuneration for the sale of thermal energy for district heating • Remuneration for the sale of ancillary services • Remuneration for trading on electricity markets	DSO TSO ESCo	Formentera Gökçeada Grado Bornholm

Table 10. Tailored services for the islands

7.1 Opportunity of new services for Gökçeada

As highlighted by the previous deliverables [35] [36], the island population of Gökçeada varies during the year. Indeed, while the permanent population is around 9440, during the summer period, the number of people on the island increases considerably.

As highlighted in the survey prepared by the University of Brunel, Gökçeada has an installed renewable capacity of 1.8 MW derived from two wind turbines 900kW and a 210kW photovoltaic solar plant.

In addition, four diesel generators (4x770kVA) are installed on the island in case of emergency. Their capability can power the island for about a week. This solution has been implemented since Gökçeada suffers from energy interruptions caused by bird touching, box dislocation, overcurrents, voltage transformer, falling trees, disconnections, low voltage box problem, low voltage connector damages, and medium voltage overhead line maintenance.

Gökçeada's energy consumption varies according to the flow of tourism throughout the year. As a result, a peak power of 6 MW can be observed between June and August.

Finally, to balance the power output from the RES generation available, the island is connected to the Turkish mainland with a 35kV AC sea cable [36].
As reported in the deliverable [35], solar energy and wind energy generated wind turbines are considered to have great potential since the solar power plant and the wind turbines produce energy in excess compared to the needs of the island. In particular, wind power derived from wind turbines has been pointed out to be the most promising renewable energy resource on the island of Gökçeada according to the local institutions and the private sector.
With regard to other types of renewable energy resources available on the island, it has been reported that there is neither a hydroelectric power plant nor regulators for electricity generation. However, there is the possibility to install regulators (river-type hydroelectric power plants) on four ponds and on a dam lake.
Finally, biomass energy has been considered as not promising, while wave energy holds an interesting potential.

7.1.1 ENERGY PERFORMANCE CONTRACT – PHOTOVOLTAIC STORAGE BATTERY

The most interesting hypothesis for implementing an energy community on the island could be linked to the construction of distributed photovoltaic systems. This assessment takes into consideration the typology of buildings with pitched roofs, widely spread throughout the territory.
The second hypothesis would be to create one or more energy communities by sharing the roofs of the buildings. This solution would comply with the current legislation in Turkey which provides for the possibility of installing photovoltaic systems connected to the low voltage distribution network from 5kWp up to a maximum power of 11 kWp [35].
The aforementioned technology, combined with a distributed storage technology, could lead to a reduction or, at least, could limit problems deriving from the grid interruptions.
The load distribution [36] states that the minimum load request is between 01:00 and 08:00 in winter periods, while a peak load is observable between 21:00 and 22:00 in the summer season. This peak is linked to the increase in population on the island during summer periods.
Hypothetically, if we want to activate about 1000 EPC contracts for the installation of likewise plants of about 10 kWp, we could estimate the production of about 12,000,000.00 kWh per year. Of these, about 60% could be used for the self-consumption diurnal needs of the community, while the remaining part could be used for the night needs through the use of distributed accumulators.

7.1.2 Energy Performance Contract – Sustainable mobility

The project aims to make mobility totally sustainable through the concept of zero impact mobility (NZEm - Nearly Zero Energy Mobility). Taking into account the following premises:

- The energy vector, not the vehicle itself, used to start the vehicle is responsible for climate-altering emissions
- Emissions from electric traction vehicles are eliminated only if the energy taken from the grid is powered by renewable energy sources;
- There is a lack of charging stations to power electric traction vehicles;
- One of the main barriers to the diffusion/spread of electric vehicles is their refuelling time;
- The batteries of electric vehicles could be recharged even when the vehicle is not parked;
- By using solar energy appropriately, it is feasible to create electric energy accumulators to recharge the batteries of electric vehicles;

The project involves the creation of innovative distributors for the refuelling of electric vehicles consisting of:

1. Photovoltaic systems of adequate power, connected to an energy community with other systems for the daily transformation of solar energy into electricity, which will serve to power a storage for the supply of electric vehicles;
2. A storage consisting of a set of batteries of adequate power, or rather sized on the distribution capacity of the electric vehicle supply, consisting of zinc ion batteries which have the following characteristics:

- Low internal resistance;
- Made with low-cost materials such as iron, aluminium and sodium;
- The energy density is comparable to modern lithium technologies for the automotive industry. The density can exceed that of existing lithium-ion batteries on the market by more than 30%;
- High-energy density, over 110 Wh/kg;
- Low-cost materials, widely available on the market (easily available and interchangeable between materials);
- Extremely low internal resistance and high charge-discharge current;
- Hydrated electrolyte, non-flammable, non-explosive, non-toxic;

- Not dependent on lithium;
- The accumulator is composed of metal electrodes submerged in a special electrolyte, which supplies energy to the electrodes via metal ions;
- The zinc ion battery is a simple, reliable and affordable technology;
- The battery is intrinsically safe; in case of an accident, it can neither explode nor ignite, unlike lithium batteries which are flammable and explosive;
- Thanks to its composition, it does not require the BMS (Battery Management System), a fundamental system of the lithium battery to balance the cells during charging and avoid damage;
- The battery uses the phases of the oxidation state of the elements: once the maximum charge (i.e. the highest oxidation state) has been reached, the battery cannot be subjected to other transformations and therefore, it cannot be damaged;
- It does not contain toxic and polluting elements. In addition, its electrolyte is a hydrated salt: if the battery casing ruptures, there is no spillage of substances dangerous for people and the environment. All these features make the battery completely recyclable since each element of the battery is distinct within the cell and does not require a specific chemical separation process for recycling;
- The average life is 4,000 cycles in the light version and 10,000 cycles for the heavy version;
- Thanks to the thermal stability of the electrolyte (-40 ° C / + 80 ° C), it can be used in the most severe climatic conditions.

3. Battery swap box is the heart of the refuelling system consisting of a container where the discharged batteries are deposited for recharging and the charged batteries can be taken to be connected to the vehicle. The average swap time is a few minutes.

Discharged batteries are recharged using the energy of the storage which in turn is powered by the connected photovoltaic system.

The project described above can be considered as the last step necessary to create a true NZEm - Nearly Zero Energy Mobility. The architecture of the project can be considered a real method of CO_2 accumulation.

Considering the following premises:

- Today, an internal combustion engine emits on average 174 gCO_2 per kilometre;

- Each battery in the interchangeable box allows you to travel 150 km (9.2 kW battery);
- And that the project foresees the presence of at least 6 swap batteries per cabinet;

Each day it would be possible to save 156 kgCo2 (57,159 tCO2 in one year) per distributor (corresponding approximately to what 1900 trees could absorb in about one year).

7.1.3 CONTRACTS FOR THE SALE OF VIRTUAL PRODUCTION CAPACITY

Contracts for the sale of virtual production capacity allow to transfer a share of the production of any pivotal operators[4] to third parties, not attributable to the main operator, for fixed quantities and at prices determined on the basis of an open competitive bidding.

A typical form of Virtual Power Plants is that in which the main operator pays the buyer any extra income. This revenue derives from the realisation of higher prices on the stock exchange which, usually, are obtained thanks to the exercise of the market power of the operator and its ability to fix prices in the electricity markets. As a result, the operator loses interest in imposing bullish tensions on prices, as it would not benefit from this solution.

All that happen virtually, since with VPPs there is an equivalent effect, in terms of competition, to the sale of ownership of the plants without resorting to any decommissioning of power plants.

The direct consequence of this measure is a decrease in the concentration of the offer and an increase in the competitive dimension of other operators, making both trading on the power exchange and forward short term more competitive.

7.1.4 INTEGRATION OF GENERATION FROM RENEWABLE SOURCES INTO THE ELECTRICAL SYSTEM

The service involves the installation of innovative systems capable of monitoring the grid in real-time and connecting it with the use of generation from renewable sources. The monitoring system must be connected to both the distribution network and the sub-transmission network, to provide the voltage regulation and frequency/power regulation service.

[4] i.e. they are able, in different areas of the market and for many hours of the year, to fix prices of electricity regardless of the behaviour of competitors

7.2 Opportunity for new services for Formentera

As in the case of the Turkish island, also in Formentera the number of residents changes during the season ranging from 12 thousand in January 2019 to 37 thousand in August. The energy demand of Formentera ranges from a minimum of 2.5MW to a maximum of 19,5 MV during the year (2019).

The island consists of a 2MW PV solar farm, in additional to 18MW diesel generators and a 13MW gasoline turbine to serve as back-up supply [35]. The island is connected to the others Balearic Islands which are themselves connected with the Spanish mainland.

Currently, on the island, two issues can be witnessed: on the one hand there is no excess of demand derived from RES energy and on the other hand, there is not an effective mean to store energy without increasing the carbon impact of the island [35].

Regarding the implementation of RES on the island, it is important to consider that the local government regulation does not allow the installation of wind turbines anywhere on the island. In addition, there are also limitations with regard to hydro power and the construction of dams and reservoirs

7.2.1 Energy Performance Contract – Real estate for energy efficiency upgrade

In order to reduce the island's energy demand, one of the first activities to do is the energy efficiency upgrade of real estate. One of the main obstacles when carrying out energy efficiency projects in real estate (or energy efficiency, period) is financing, or the attractiveness of the projects for banks. The solutions we can identify are the following:

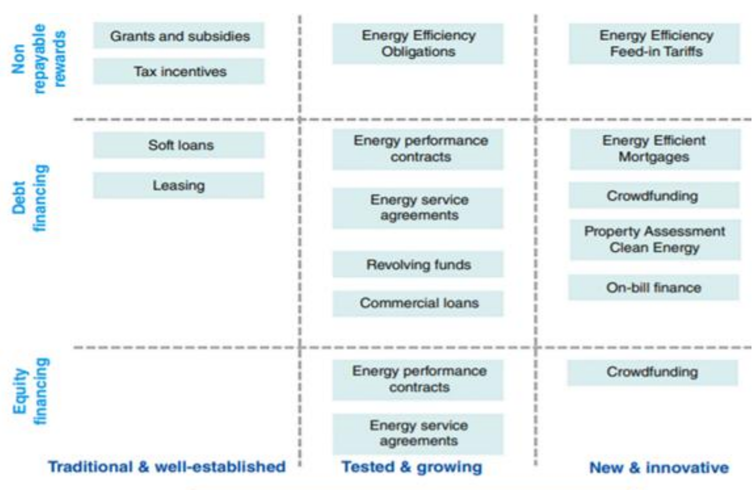

Figure 13. Schematic diagram illustrating the underlying principles of (a)EPC and (b) ESA model [38]

There are two models we prefer and that we are already using:

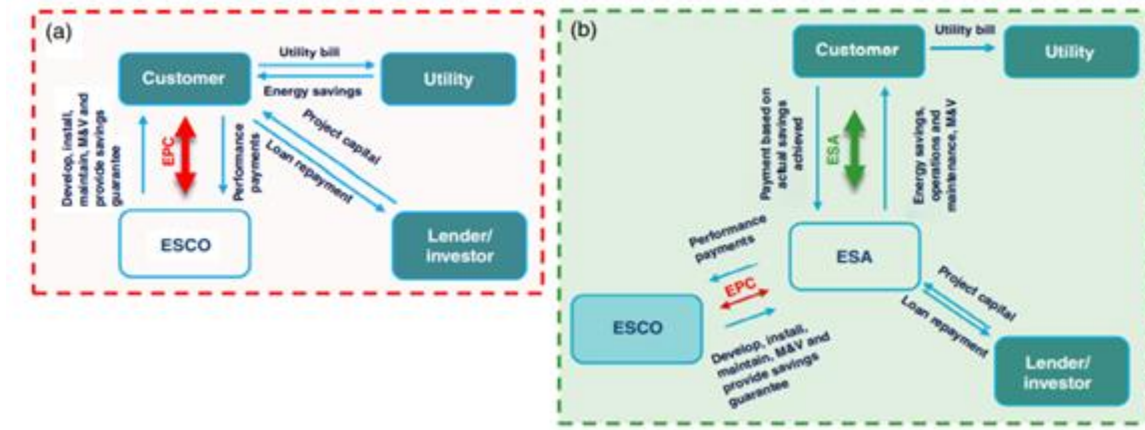

Figure 14. Schematic diagram illustrating the underlying principles of (a)EPC and (b) ESA model [38]

EPCs (Energy Performance Contract) are especially suitable for projects of energy efficiency upgrade in which investments are paid relative to the levels of energy efficiency upgrade required by a contract, or to other agreed-on criteria of energetic performance. The most common problems we encounter in the implementation of said contracts are: the split of the economic benefits deriving from the energetic efficiency upgrade between the various parties involved (also known as “split incentive” problem) and the lack of flexible contractual models. Generally, the owner (landlord) of the property shoulders the investment for energy efficiency upgrades but, at the same time, the owner does not benefit directly from the advantages generated. We can solve this problem with an EPC, splitting the benefits deriving from the efficiency upgrades between the owner and the renter. The owner has the advantage of boosting their real estate value, and they can benefit from a portion of the savings through rent; the renter benefits from a portion of the energy savings and other advantages, such as increased comfort or the sale of the energy surplus in the context of an energy community. Involving an ESCo or a Utility is a necessary precondition. This allows projects to be carried out with guaranteed performances that will be paid back through energy saving or the energy bill. Moreover, the renter makes a commitment for the duration of the renting contract, and this guarantees a stable, long-term relationship between landlord and renter; if the renter terminates the contract earlier, they might have to pay a penalty on the missed savings quota. Conflict dynamics can arise because of the different interests of people involved. On the one hand, the landlord wants to maximise profit by not involving an ESCo or utility, whereas the renter wants to involve them to minimise the costs, energy consumptions and maintenance. Taking this into consideration, we can hypothesise three scenarios: landlord and renter sign together an EPC with a ESCo or Utility; the landlord sings an EPC contract with an ESCo or Utility; the renter signs an EPC with an ESCo or Utility.

The first scenario

This is the best option to optimise the results of the energy efficiency upgrades and to please all parties involved. The essential requirement is that landlord and renter understand the need for energy efficiency upgrades and that the contract guarantees an equal split of costs and benefits. In the case of an EPC, we can guarantee a split between landlord and owner of the lease necessary to pay back the loan (bank, fund, or ESCo) and the energy service (ESCo). At the same time, it is possible to share the energy savings, so that both parties benefit from them (the landlord will take into consideration the increased real estate value and the possibility to rent it at a higher price in the future, whereas the renter benefits from decreased energetic costs). Another benefit is that in this way, costs are split between the parties, and as a result less substantial on the respective budgets.

How costs and profits are split depends on the individual case, on the type of investment made and on the expected payback period; nonetheless, we can find some valid operative guidelines.

The second scenario

In this case the landlord signs an EPC contract with an ESCo. In the most likely scenario, the landlord pays the energetic bills, and as such it is necessary to determine how the economic savings are transferred to the landlord. This scenario is more complex than the previous one and there are two different solutions to it.

If the economic savings pass onto the landlord with the consent of the renter, it is possible to use the economic savings linked to the energy efficiency upgrade to pay the ESCo (and other possible financing party's) loan. The renter can benefit from both the energy savings not used for the EPC and the non-energetic benefits (i.e. comfort, reputation, etc.). In the case of more than one renter, this option can be difficult. If the renter does not consent to pass on the economic savings to the landlord, it is still possible to create a successful EPC, as long as the renting contracts are due to expire in a relatively short amount of time and that the real estate is appetising. If that is the case, it will still be possible for the landlord to pay back the costs and to produce a successful business plan, by taking advantage of the higher rent on the new renting contracts.

The third scenario

The third and last case concludes this brief analysis. It is the case when the renter signs an EPC with an ESCo. What matters the most for the renter is the time needed for the return of investment, relative to the duration of their renting contract. The renter should make sure to stay in the property for longer than the duration of the contract with the ESCo; in case they decide to recede the renting contract earlier than that, the owner should accept to replace the renter in the contract or, alternatively, to pay the remaining value of the upgrades.

More flexibility in EPCs would allow spreading these models to rented real estate. The majority of EPCs have a fixed, long duration, especially when considerable energy efficiency renovations are included – and the duration is especially long when confronted with the usual duration of renting contracts. To overcome this obstacle, we could introduce termination clauses in the contract that would allow managing such situations, when the EPC's duration is longer than the duration of the renting contract, or when the renting contract is terminated earlier, by planning how to manage and split the costs of investment and the profit lessened by reduced consumption.

Another important aspect to take into consideration is the onus of measuring and verifying the performance (M&V). As EPCs are based on improving energy performance, it is essential to accurately define the evaluation baseline and how to measure and verify the savings of energy. M&V can impact on the transition cost of these contracts; the solution, then, could be to adopt a simplified M&V procedure, for example based on a combined approach of estimate and measurement.

7.2.2 Energy Performance Contract –Energy for biowaste

In the context of a circular economy for residential or touristic areas, biomethane has been established as another product of the organic recycling production chain. Biodigesters can produce not only compost but also biomethane, a source of natural fuel and, clearly, a valuable and innovative source of renewable energy.

The strategic direction towards which the waste management system is moving is the improvement at the source of the quality of the reusable matrices and the reduction of the quantity of waste produced. This is in order to limit the impact on human health and the environment and to allow the development of the most appropriate technologies for waste treatment.

This approach inevitably involves considerations on the sources of energy that can be used and their reflection on the environment through a broad vision that is not limited to the local budget or even the specific plant, but which considers the analysis of the entire life cycle of the materials used.

Therefore, the strategy goes through what is now a legal practice: separate collection, recycling and valorisation of secondary resources. In this context, the treatment of the organic fraction of

the waste through anaerobic digestion will be able to take on an increasingly important role in the island's recycling effort, making it possible to combine material and energetic recovery.
The application of anaerobic digestion to waste treatment allows producing both, through the aerobic treatment of the digested sludge, a stabilised residue that can be used as an organic soil improver in agriculture or for environmental restoration, and to achieve a significant energy recovery through the use of the biogas produced.
The recovery aspect is undoubtedly the most interesting, as the biogas produced, consisting mostly of methane (about 50-60%), has a high calorific value (4000-5000 kcal / Nm) [39] and therefore can be conveniently converted into almost all forms of useful energy: heat, electricity and cogeneration and traction for methane vehicles.
Considering that the island of Formentera has a population of about 12,000 inhabitants and considering a per capita production of wet fraction of about 120 kg / year per inhabitant, without considering the summer load of tourists that increases production, we would have a production of about 1800 tons / year of wet fraction with a production of biomethane equal to about 135,000 Smc / year. With an EPC contract, an ESCO could valorise this methane for the production of electricity and / or as a way of refuelling vehicles.

7.2.3 Energy Performance Contract – Photovoltaic storage battery

The most interesting hypothesis for implementing an energy community on the island could be linked to the construction of distributed photovoltaic systems. This assessment takes into consideration the typology of buildings with pitched roofs, widely spread throughout the territory.
Hypothetically, if we want to activate about 1500 EPC contracts for the installation of likewise plants of about 10 kWp, we could estimate the production of about 18,000,000.00 kWh per year. Of these, about 60% could be used for the self-consumption diurnal needs of the community, while the remaining part could be used for the night needs through the use of distributed accumulators.

8. Conclusions

The digitalisation process in energy communication, monitoring and management services, as well as the spread of distributed energy sources and the development of new technologies, have led to a change in the electricity market. In this framework, prosumers have acquired an important role in the value creation chain. This central role is a result of the production of electricity, decentralised renewable sources, from the Prosumer's contribution to the flexibility of grid consumption and the opportunity of storing energy. The abovementioned market transformation brings with it the necessity to develop new entrepreneurs whose aim is to respond to the new market needs. And among them, the role of the Aggregators has proven to be crucial since they allow prosumers to enter the electricity market by capitalising on their contribution relating to the flexibility of the grid and the accumulation of energy.

After a brief description of the context, the actors involved in the decentralised energy production system based on renewable energies have been described (namely Prosumer, Producer, Supplier, Transmission System Operator, Distributed System Operator, Balance Responsible Party, Balancing Service Provider, Aggregator, Energy Service Company and Meter Data Company). Furthermore, the services have been outlined and classified according to the categories (namely, Ancillary services, Flexibility services, Market services, Energy efficiency services, Digital services and Business services). In addition, every single service has been differentiated according to layers, actors involved and, finally, VPP4I Tools connected to the service.

The deliverable then summarised the different forms of remuneration as well as the coordination phases occurring between Aggregators and other market actors (namely, negotiation phase, planning/validation phase, operational phase and settlement phase). Moreover, six possible models for effective business implementation for aggregation have been identified (namely Combined Aggregator-Supplier, Combined Aggregator-BRP, Independent Aggregator as a flexibility service provider, Independent delegated Aggregator, Prosumer as Aggregator and the DSO as Aggregator). All in all, the main difference between these models lies in whether Aggregators play an independent or a combined role. In addition, the deliverable suggests the use of a business model canvas for aggregators aiming at analysing the possible economic impact of a service to propose.

Finally, in the last chapter, services that can be implemented on the islands as well as the implementation schemes for Aggregators, the potential actors involved and the islands in which such implementation schemes can be implemented have been identified. In addition, new tailored services for the island of Formentera and Gökçeada have been described based on the information provided by the partners.

Overall, as aforementioned, the mapping exercise carried out in this deliverable defines the potentially feasible services based on the state of the art of the islands, the islands' needs and the different identifiable actors’ roles at a generalised level. The precise identification of services on the islands will continue in further deliverables.

REFERENCES

[1.] Borbely AMKJF. Distributed generation: the power paradigm for the new millennium. 2001

[2.] Simeoni P., Nardin G., Ciotti G. , Planning and design of sustainable smart multi energy systems. The case of a food industrial district in Italy, Energy, vol.163, pp.443-456,2018, https://doi.org/10.1016/j.energy.2018.08.125

[3.] Mancarella P. MES (multi-energy systems): an overview of concepts and evaluation models. Energy 2014;65:1e17. https://doi.org/10.1016/ j.energy.2013.10.041

[4.] Lund H, Østergaard PA, Connolly D, Mathiesen BV. Smart energy and smart energy systems. Energy 2017; 137:556e65. https://doi.org/10.1016/j.energy.2017 .05.123

[5.] Connolly D, Lund H, Mathiesen BV. Smart Energy Europe: the technical and economic impact of one potential 100% renewable energy scenario for the European Union. Renew Sustain Energy Rev 2016;60:1634e53. https://doi. org/10.1016/j.rser.2016.02.025

[6.] S. Aggarwal and R. Orvis, "Grid flexibility: methods for modernizing the power grid," Mar. 2016. Available: http://energyinnovation.org/wpcontent/uploads/2016/05/ Grid-Flexibility-report.pdf

[7.] Q. Wang. Enhancing Power System Operational Flexibility with Flexible Ramping Products: A Review. IEEE Transactions on Industrial Informatics PP, 99 (2017), 1–1. https://doi.org/10.1109/TII.2016.2637879

[8.] G. Morales-Espana, J. M. Latorre, and A. Ramos, "Tight and compact ˜ MILP formulation of start-up and shut-down ramping in unit commitment," IEEE Trans. Power Syst., vol. 28, no. 2, pp. 1288–1296, May 2013

[9.] Simeoni P., Ciotti G., Nardin G, Planning and design of sustainable smart multi energy systems. Thecase of a food industrial district in Italy, vol.163, pages 443–456. Scopus: S036054421831661; DOI: 10.1016/j.energy.2018.08.125

[10.] G. Morales-Espana, C. M. Correa-Posada, and A. Ramos, "Tight and ˜ compact MIP formulation of configuration-based combined-cycle units," IEEE Trans. Power Syst., vol. 31, no. 2, pp. 1350–1359, Mar. 2016

[11.] Q. Wang et al., "The value of improved wind power forecasting: Grid flexibility quantification, ramp capability analysis, and impacts of electricity market operation timescales," Appl. Energy, vol. 184, pp. 696–713, 2016

[12.] Simeoni P, Ciotti, Cottes, Meneghetti, Integrating industrial waste heat recovery into sustainable smart energy system, Energy, vol.175, pp.941-951, https://doi.org/10.1016/j.energy.2019.03.104

[13.] Q. Wang and B. M. Hodge. 2017. Enhancing Power System Operational Flexibility with Flexible Ramping Products: A Review. IEEE Transactions on Industrial Informatics PP, 99 (2017), 1–1. https://doi.org/10.1109/TII.2016.2637879

[14.] The Brattle Group, The Value of Flexible Generation in ERCOT with High Renewable Penetration, 2015. [Online]. Available: http://www.flexiblepowersymposium.com/assets /warsila-ercot-flex-power-2015-dr. -ira-shavel.pdf

[15.] J. Despres´ et al., “Storage as a flexibility option in power systems with high shares of variable renewable energy sources: A POLES-based analysis,” Energy Econ., 2016. [Online]. Available: http://dx.doi.org/ 10.1016/j.eneco.2016.03.006

[16.] Jonas Schlund, Noah Pflugradt, David Steber, Urs Muntwyler, and Reinhard German. 2018. Benefits of Virtual Community Energy Storages compared to Individual Batteries based on Behaviour Based Synthetic Load Profiles, proceedings IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT Europe),

[17.] Khatoon A, Verma P., Southernwood J., Massey B. Corcoran P., Blockchain in Energy Efficiency: Potential Applications and Benefits, Energies 2019, 12, 3317; doi:10.3390/en12173317

[18.] Puthal, D.; Malik, N.; Mohanty, S.; Kougianos, E.; Das, G. Everything You Wanted to Know About the Blockchain: Its Promise, Components, Processes, and Problems. IEEE Consum. Electron. Mag. 2018, 7, 6–14

[19.] IEA. Energy Service Companies at the Heart of Innovative Financing Models for Efficiency; International Energy Agency: Paris, France, 2019

[20.] Gürcan, Ö.; Agenis-Nevers, M.; Batany, Y.V.; Elmtiri, M.; le Fevre, F.; Tucc, S. An Industrial Prototype of Trusted Energy Performance Contracts Using Blockchain Technologies. In Proceedings of the IEEE 20th International Conference on High Performance Computing and Communications; IEEE 16th International Conference on Smart City; IEEE 4th International Conference on Data Science and Systems (HPCC/SmartCity/DSS), Exeter, UK, 28–30 June 2018

[21.] Rogers, E. Blockchain and Energy Efficiency: A Match Made in Heaven; American Council for an Energy Efficient Economy: Washington, DC, USA, 2018

[22.] Castellanos, J.A.F.; Coll-Mayor, D.; Notholt, J.A. Cryptocurrency as guarantees of origin: Simulating a green certificate market with the Ethereum Blockchain. In Proceedings of the IEEE International Conference on Smart Energy Grid Enegineering, Oshawa, ON, Canada, 14–17 August 2017

[23.] USEF. USEF: the framework explained. 2021

[24.] USEF, “Flexibility Value Chain,” USEF White Pap. version 1.0, 2018.

[25.] USEF, “USEF : WORKSTREAM ON AGGREGATOR IMPLEMENTATION,” no. September, 2017.

[26.] USEF Foundation and Universal Smart Energy Framework, USEF: The Framework explained. 2015.

[27.] S. Burger and J. P. Chaves-ávila, “The Value of Aggregators in Electricity Systems Carlos Batlle , and Ignacio J . Pérez-Arriaga,” MIT Cent. Energy Environ. Policy Res., vol. CEEPR WP 2, no. January, p. 29, 2016.

[28.] Bruno, “Partecipazione alla domanda flessibile al MSD,” J. Chem. Inf. Model., vol. 53, no. 9, pp. 1689–1699, 2018.

[29.] BestRES, “Existing business models for renewable energy aggregators,” BestRES Proj. Rep. D2.1, no. June 2016, 2016.

[30.] S. Burger and J. P. Chaves-ávila, “The Value of Aggregators in Electricity Systems Carlos Batlle , and Ignacio J . Pérez-Arriaga,” MIT Cent.

[31.] A. O. Y. Pigneur, Business model generation. Handbook to defy business models

[32.] R. Leisen, B. Steffen, and C. Weber, “Regulatory risk and the resilience of new sustainable business models in the energy sector,” J. Clean.Prod., vol. 219, pp. 865–878, 2019

[33.] Energy Environ. Policy Res., vol. CEEPR WP 2, no. January, p. 29, 2016

[34.] European Banking 27, Crypto-assets: ESAs remind consumers about risks, 2021. [Online]. Available: https://www.eba.europa.eu/financial-innovation-and-fintec /publications-on-financial-innovation/crypto-assets-esas-remind-consumers-about-risks

[35.] UEDAS, VPP4ISLANDS Project Report D2.1, VPP4ISLANDS, 2021.

[36.] Brunel University, VPP4ISLANDS Project Report D2.2 - Analysis of Obstacles to Innovation in Islands, VPP4ISLANDS, 2021.

[37.] Politeknik Dergisi Journal of Polytechnic - Cilt:13 Sayı: 3 s. 215-223, 2010 Vol: 13 No: 3 pp. 215-223, 2010

[38.] Economidou M. and Bertoldi P.. Financing building energy renovations Current experiences and ways forward. Joint Research Centre, 2014.

[39.] Analisi e stima quantitativa della potenzialità di produzione energetica da biomassa digeribile a livello regionale. Studio e sviluppo di un modello per unità energetiche Parte 1 – Metodologia F. Reale, R. Stolica, M. Gaeta, M. Ferri, M. Sarnataro, V. Vitale