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Edyta Ropuszynska-Surma,

Ph.D., Wrocław University of Science and Technology, Poland

Magdalena Weglarz,

Ph.D., Wrocław University of Science and Technology, Poland

A VIRTUAL POWER PLANT AS A COOPERATION NETWORK

Abstract. *The significant issue for Polish economy is to fulfil the requirements of the EU's climate and energy policies according to the share of renewable energy sources (RES) in total energy production by 2020 should be equal to 15%. At the end of 2016, the share of RES in total energy production in Poland was only 13.54%. The development of Virtual Power Plant (VPP) is the chance to complete the goal set for 2020 and to increase the development of RES. The VPP is an IT structure which integrates different types of distributed energy sources, flexible consumers and energy storage with each other and with other market segments in real time through a smart grid. The VPP has positive effects on the electricity grid, like the improving energy security as well as grid stability and reliability, optimizing energy resources use, lowering the load – demand response and giving the possibility to manage of electricity surplus in small dispersed energy sources. The main aim of the article is the proposal of a new business model for Virtual Power Plant in Polish conditions. The main aim is accomplished by secondary aims such as (i) describing the concept of virtual organizations, (ii) the review of business models and (iii) the presentation of the legal capabilities to create the virtual power plants. First of all, the literature studies made by authors, point out there is a lack of complex analysis related to the establishing the VPP and its business model. The complex analysis means the analysis consists of technical, legal, economic and ecological aspects. The literature review provides information about virtual organizations in the context of the virtual power plant. The VPP is one of the types of virtual organizations, but the definitions of a VPP are primarily focused on its technical aspect and insufficient attention is paid to the aspect of management and, especially, to a business model. Therefore, in this paper, the legal background to establish the VPP has presented as well as the legal opportunities and threats for creating the VPP in Poland. The legal analysis is the starting point for each practical project. There are shown the legal regulations related to prosumers and supporting energy micro-clusters. These issues require the creation of new products, such as VPP. Next, the review of the business model was made to choose an adequate model. Three models emerge from the analysis, which can be used to build a VPP business model to a greater or lesser extent. The first of them emphasize that the business model is mainly the characteristic relations between customers, clients, partners and suppliers. The second of them underlines the significance of the company's resources, which can be expanded and used (new customers – new dispersed energy sources), as well as potential sources of future economic benefits (new products – power market, megawatts). The third of them combines the key resources and the key relations which are important for VPPs, and it is compliant with the systemic approach. This approach was chosen for further analysis. The authors presented a new business model concept, where the attention is paid to a cooperation network between different kinds of energy entities (e.g. VPP owners, prosumers, the owners of micro-installations and others). The segmentation of potential clients of the VPP was made and eight potential segments were identified in Polish conditions. Two segmentation criteria were used: (i) the kind of product, (ii) the kind of market. The business model is perceived as a method of increasing and exploiting of company's resources for preparing new products or services for customers in order to obtain the added value (expanding the competitive advantage or increasing profitability). The examples of added values were defined in relating to the identified VPP client segments: (i) a large buyer buying energy under a long-term bilateral contract, (ii) an energy cooperative, (iii) an owner of micro-installation, (iv) a company that owns energy storage, e.g. hybrid vehicle charging stations, storages, (v) energy cluster. Additionally, for all customer segments there are specified (1) relations which connect VPP with the representatives of a specific customer segment and (2) communication channels which significantly affect the final impression on the client. In the knowledge economy, the IT tools are the main kind of communication channel, and IT resources are the key function in the VPP business model. Future research should focus on describing the remaining elements of the business model for each customer segments such as revenue streams, key resources, key activities, key partners and cost structure. In the next step economic capabilities to create*

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the VPP should be analysed with special attention paid to the evaluation of the economic efficiency of the VPP. Different scenarios including consumer segment and value proposition should be taken into consideration. It is necessary to perform an economic analysis of the data coming from a real pilot installation.

Keywords: business model, micro-cluster, network, virtual power plant, consumer's segments.

Introduction. The development of RES in Poland is an important issue within the context of the EU's climate and energy policies. The level of development of RES have a worrying trend, at the end of 2016, the share of RES in total energy production in Poland achieved only 13.54% (CSO, 2017). The present rate of development of RES indicates that in 2020 the share of RES in total energy production will be less than 15%. For 2020 the result of polynomial regression is 14.7% with a coefficient of determination R-squared equal 0.9722 (see figure 1). Additionally, the recent changes in the law regarding the development of RES suggest that the rate of development of the RES will decrease.

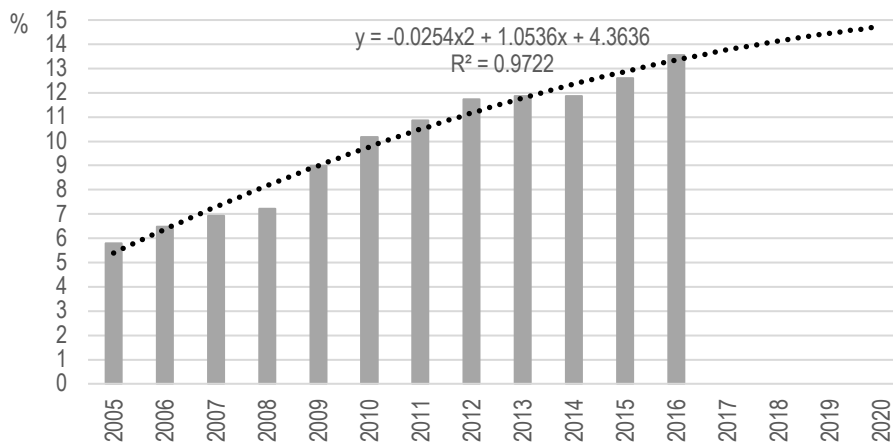


Figure 1 – The share of RES in total energy production in Poland

Sources: developed by the authors based on (CSO, 2017)

A relatively new type of organization in Poland is a virtual power plant (VPP). They operate in highly developed economies, in which liberalization of the energy sector, innovative information and communication solutions, smart metering and smart grids, micro-installations and accompanying legal regulations, analogous to those recently implemented in Poland, have been previously implemented and is at a more advanced level than in Poland. Examples of those economies are Germany, France, Australia, or Scandinavian countries. A VPP is the effect of the possibilities created by the technology – the development and diffusion of information and communication technologies (ICT) and the associated network phenomenon (in the social, organizational and economic context). A VPP is a kind of virtual organization that can operate at the level of domestic networks and sources of electricity connected to high voltages that support a wholesale energy trading. There is also a technical possibility of creating a VPP on the retail electricity market, i.e. serving the final customers connected to the medium and low voltage networks. A specific type of such a market is the so-called local market linked to sources of lower capacity which location is geographically dispersed, but relatively close to the end users of electricity. This situation is conducive to the creation of so-called energy islands also known as autonomous energy regions. If the produced electricity comes only from renewable energy sources (RES), there is a technical possibility to meet the needs of a given local community in a significant part of RES. Examples of

energetically self-sufficient municipalities can be found in other countries, *e.g.*, Germany or Austria (Szalbierz & Ropuszyńska-Surma, 2014).

The VPP, through the optimal use of production capacity and the ability to control the demand side, contributes to the limitation of production potential, and the same investment costs as well as environmental pollution. In most cases, VPPs focus on the optimal use of production capacity, but there are also models based on controlling energy storage and optimizing its consumption using outside and dispersed electricity-installations. In this situation, for the entity who plans a virtual organization, it is necessary to develop a business model of a VPP.

Analysis of recent researches and publications. Taking into consideration the main goal of this article, which is accomplished by secondary aims, the literature review contains a review of (i) virtual organizations in the context of the virtual power plant, (ii) and business models.

Virtual organizations are not an unambiguously defined concept. The first works and concepts of virtual organizations were created in the 1980s along with the development of information technologies (IT), so the first such organizations were created in this sector. A characteristic feature of virtual organizations is the use of IT in business management, including its organization, which reduces the resources involved (work, time, and capital) and, as a result, increases the company's efficiency. In virtual organizations, there was a change in production factors (labour, time, capital) caused by increasing the involvement of IT and knowledge. A virtual organization will not be established if more IT systems are installed in the organization, but when they will give added value through the use of knowledge in order to optimize the selection of resources from the organization's environment to perform specific tasks due to the adopted objective function. That is why resources are usually not an integral part of virtual organizations (Kucęba, 2011a).

Virtual organizations primarily enabled reduction of employment costs by changing work organization (telecommuting, the conception of a virtual office with hot-desking, telecentre, mobile working, hotelling, virtual teams) and reducing the number of employees as a result of replacing office workers and "knowledge workers" with information systems and expert knowledge bases. Such work organization brings tangible benefits, *e.g.* AT&T believes that in the years 1991-1998 it managed to save over USD 500 million in the results of the reorganization of office space along virtual lines (The Virtual, 2009). In the scope of development of virtual organizations, companies that are not part of the IT industry, *e.g.* those related to traditional sales, have positive experiences. The Economist gives an example of the Virgin Group, which, thanks to the use of modern technologies, has gained a 5% share in the British cola market employing only 5 people (The Virtual, 2009). Even before 2001, other organizations successfully introduced the concept of a virtual organization. Some examples should be mentioned (Pang, 2001): French pharmaceutical and agricultural company Aventis, American Dell Computers, British Telecom, an American supplier of the graphics and photographic products and services, as well as leaflets and press releases – Crowley Communications.

Virtual organizations resemble traditional organizations in regard to inputs and outputs. These organizations differ in the way they use and organize the resources needed to provide the service. Often these resources come from outside of the organization, they are "rented" to perform a specific task. They can be compared to freelancers. The selection process and the manner of engagement of these resources use modern IT technologies and network relations. It can be assumed that a virtual organization is based on the use of a network, most often on the Internet, where independent contractors, who are not employed in a given organization, can sell their own products or provide services in a smooth manner, which makes the organization much more flexible. Such a phenomenon began to be described already in the 1990s as e-lance work or e-lance workers, and then the notion of e-lance economy emerged.

It should also be noted that in the case of virtual organizations, resources, most often work, must also have appropriate characteristics (skills). Freelancers are professionals and other specialized resources.

This is similar to Hollywood, where directors with actors and the rest of the film crew meet to fulfil specific tasks. An actor, screenwriter, or director must be a specialist in the field so that others will look for him and want to cooperate with him. Although Hollywood is a cluster, some similarities can be seen through this analogy, with the fact that in the case of virtual organizations ICT is an important element, whose role is, among others, to search for these resources and associate them with the appropriate tasks to do.

In virtual organizations, mainly related to the ICT industry, the virtual online community plays a special and fundamental role. A similar role of the network can be noticed in virtual organizations that are not part of the IT industry, which processes or resources are acquired as part of e.g. outsourcing, franchising, agency agreements (Niemczyk, et.al, 2012), etc. Therefore, virtual organizations cannot be considered without a network context. With regard to the VPP, which is the subject of this paper, it is necessary to mention energy clusters, which can be the basis for establishing and developing wider cooperation in the form of a VPP. It should be emphasized that the concepts of virtual organization and network organization are not identical, although they are closely interrelated, because the VPP is one of the types of virtual organizations. The definitions of a VPP are primarily focused on its technical aspect and, as rightly pointed out by Kucęba, insufficient attention is paid to the aspect of management (Kucęba, 2011a). The article adopted the definition of Asmus (2010), which defines a virtual power plant (VPP) as „software systems to remotely and automatically dispatch and optimize generation or demand side or storage resources in a single, secure Web-connected system. In short, VPPs represent an “Internet of energy” tapping existing grid networks to tailor electricity supply and demand services for a customer, maximizing value for both end-user and distribution utility through software innovations”. Despite various definitions of the virtual organization in the literature (look at Table 1) of the subject, it is distinguished by several features:

- it consists of resources, which are independent, unconnected with the virtual organization, most often there are human resources, so-called freelancers, but other resources also subsist, e.g. independent, distributed sources of electricity. Therefore, the network organization has a flexible structure, which is dynamically changing depending on external and internal requirements;
- independent resources are connected with the IT network, often also controlled by it (dispersed energy sources connected in a smart grid and controlled by smart metering);
- added value is created by using ICT technology and expert knowledge, which results in more effective and optimal use of all resources (e.g. on the demand side – joint settlement of various clients reduces individual risk, reduces the price but increases convenience, and on the supply side – optimal use of sources with the assumption of minimizing production costs);
- integration, which involves the combination of various entities (participants of a virtual organization) in order to achieve success and achieve the synergy effect (Pang, 2001) (VPPs clients can be micro-installation owners who will achieve greater benefits while working on the network);
- the direct contacts between participants of a virtual organization do not take place or they are limited, which results from the use of ICT.
- cooperation based on trust is required (Pang, 2001), as well as in clusters (between VPP and client);
- due to the fact that participants or resources of a virtual organization are not related to one place or time, a virtual organization may expand the number of participants located in different places or characterized by mobility (measurement of dispersed energy sources to VPP can include entities located in different places).

Depending on the described case of the virtual organization, other common features occur (Kucęba, 2011a; Pang, 2001), but due to the subject of this paper, they will not be quoted here. The development of information technologies, such as smart grid and smart metering, will enable broader development of management of the demand side of end-users and the creation of so-called VPP offering negawatts, which mean saved power units (Lovins, 1990).

Table 1 – Virtual organization definitions

Definition	Author
The organizational network as a set of integrated entities in a virtually managed environment.	L. Owoc, M. Sitarski
A network of entities combining key competencies in their structure (institutional nature). Their virtual activities and cooperation should focus on the implementation of integrated competences of individual entities (functional nature).	T. Oleksyn J. Kubicka-Daab
It involves the inclusion of all or just some people from various organizations to work together on the market.	K. Zimniewicz
An organizational network created on a voluntary basis to participate in its structure without any time or subject limit. The virtual organization works in the so-called cyberspace, and its operation requires the existence of computer networks.	J. Kisielnicki
The organization with a variable organizational structure – a structure flexibly suited to the needs of the demand side (final customers). It is integrated on the basis of virtually integrated dispersed entities.	A. Sankowska, M. Wańtuchowicz
The organizational structure created by sharing its resources. Cooperation in the Virtual Organization is temporary. Its structure is constantly changing, it is dynamic and progressive.	B. Mikula, A. Pietruszka-Ortyl, A. Potocki
Virtual (semi-virtual) organizations are geographically dispersed organizations whose participants are bound by a long-term goal or common interest, and who largely communicate and coordinate their work through the use of information technology.	M. Grabowski, K.H. Roberts

Sources: developed by the authors based on (Kucęba, 2011a).

The term business model was first used in the 1950s by R. Bellman & C. Clark. However, in the area of strategic management, it appeared along with the development of information technologies and the increasingly widespread access to the Internet. It was mainly applied to enterprises operating in virtual space or simultaneously in virtual and real space (Wierzbiński, 2017). However, even though the concept is often and willingly used by practitioners and theoreticians, one coherent definition has not been developed yet. In Table 2, the most frequently appearing models in literature is presented in chronological order.

Table 2 – A summary of different concepts of business models

Author, year	Basic assumptions of the model
1	2
P. Timmers, 1998	The business model is perceived as the architecture of the flow of products/services and information, detailing the so-called business actors and their roles with a description of the potential benefits they refer to, and a description of revenue sources. The basis for determining the business model architecture is to conduct a value chain analysis.
B. Mahadevan, 2000	The business model consists of three key flows: value stream (for buyers and business partners), revenue stream and logistic stream (structure of the unit value chain).
G. Hamel, 2000	Four elements defining the business model were distinguished: 1) strategy, 2) strategic resources, 3) relations with buyers, 4) value chain. They are interrelated by the benefits for the customer, a unique configuration of competences, assets and processes, and the type of outsourcing (external or within the value network).
R. Boulton, B. Libert, S. Samek, 2000	The model is a unique combination of tangible and intangible assets that determine whether an organization is capable of creating value or destroying it. Creating value is determined by four challenges: project, risk management, asset management, measurement and reporting of the entire range of assets. Assets are potential sources of future economic benefits, not necessarily controlled by the entity, including also, for example, a relation system that is not regulated by contracts.

Table 2

1	2
P. Weill, M. R. Vitale, 2001	The business model is defined as a description of the role and relations between consumers, clients, business partners, suppliers. These relations define the flow of products, information and cash and the main benefits to stakeholders. The model can be presented in the form of a diagram that should contain: – entities entering into specific business relations; – flows of products, information and cash; – benefits generated by individual entities included in the business model, including sales revenues.
J. Magretta, 2002	The business model is treated as a story that explains how the company operates. In particular, the relevant questions are: What type of customers does the company handle? How is the value created for those customers? How does the company generate profit? How does the company provide value to customers at reasonable costs?
H. Chesbrough, R. S. Rosenbloom, 2002	The business model is perceived as a list of functions that it performs: creating value for the customer, identifying market segments, defining the value chain structure, estimating the cost structure and profit potential, describing the position of the company, formulating a competitive strategy. There are no defined relations between the individual functions of the business model.
A. Afuah, Ch.L. Tucci, 2003	The business model is "a method of expanding and using resources adopted by the company in order to present to customers the offer of products and services, the value of which exceeds the offer of competition and which at the same time provides the company with profitability".
R. Amit, C. Zott, 2001	The business model presents the content, structure and transaction management system designed to create value through the use of business opportunities. The model is a set of actions that should be performed and the relation between them, pointing also who is responsible for the implementation of specific activities – enterprise or external partners. Business models emphasize a system-level, holistic approach to explaining how firms „do business“. Business models seek to explain how value is created, not just how it is captured.
D. J. Teece, 2010	The essence of a business model is in defining the manner by which the enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit. It thus reflects management's hypothesis about what customers want, how they want it, and how the enterprise can organize to best meet those needs, get paid for doing so, and make a profit. The business model is presented in a process approach.
W. K. Smith, A. Binns, M. L. Tushman, 2010	A business model is a project in which an individual makes strategic decisions (about the market, about clients) that can create value, and then uses the available organizational architecture (people, competencies, processes, cultural systems and measurement principles) to create this value and retain it.
A. Osterwalder, Y. Pigneur, 2010	The business model describes the reasons behind the way in which the organization creates value and provides and derives profits from this generated value. It is a systemic approach. The fundamental elements of the model are customer segments, value proposition, channels, customer relations, revenue streams, cost structure and key resources, activities and partners.

Sources: developed by the authors based on: Timmers, 1998; Mahadevan, 2000; Hamel, 2000; Boulton et al., 2000; Weill & Vitale, 2001; Magretta, 2002; Chesbrough & Rosenbloom, 2002; Afuah & Tucci, 2003; Amit & Zott, 2001; Teece, 2010; Smith et al., 2010; Osterwalder & Pigneur, 2010.

Many authors (Teece, 2010; Zott et al., 2011; Wierzbiński, 2015; Kamieniecka, 2017; Nogalski, et al., 2017) conducted a literature review and state that there is a consensus concerning the fact that a business

model articulates the logic and provides data and other evidence that reflects how to achieve a satisfactory return on assets for owners and delivers value to customers. In addition, it must be emphasized that enterprises operate in a turbulent environment, which causes the necessity of constant changes, adaptation to changing conditions, keeping up with trends. Hence, new business models are constantly emerging. And an enterprise wishing to maintain a competitive advantage must constantly renew its business model.

Business models are necessary features of market economies where there is consumer choice, transaction costs, and heterogeneity among consumers and producers, and competition. Profit-seeking firms in competitive environments will endeavour to meet variegated consumer wants through the constant invention and presentation to the consumer of new value propositions. Business models are often necessitated by technological innovation which creates both the need to bring discoveries to market and the opportunity to satisfy unrequited customer needs (see: Teece, 2010; Chesbrough & Rosenbloom, 2002; Baden Fuller, & Haefliger, 2013). "Technological innovation does not guarantee business success – new product development efforts should be coupled with a business model defining their 'go to market' and 'capturing value' strategies" (Teece, 2010). Technological change often provides the impulse for new and better ways to satisfy customer needs. The Internet and the communication and computer revolution have empowered customers, and both allowed and required more differentiation in product service offerings (Teece, 2010).

T. O'Reilly, CEO of O'Reilly & Associates stated that: „There's not a single business model (...). There are really a lot of opportunities and a lot of options and we just have to discover all of them" (after Osterwalder & Pigneur, 2010). Three models emerge from the analysis, which can be used to build a VPP business model to a greater or lesser extent. The models described by Hamel (2000), Weill & Vitale (2001) and Gołębiowski (2008) emphasize that the business model is mainly the relations characteristic between customers, clients, partners and suppliers. On the other hand, the Afuaha & Tucci (2003) models, as well as Boulton, Libert & Samek (2000) underline the significance of the company's resources that can be expanded and used (new customers – new dispersed energy sources) as well as potential sources of future economic benefits (new products – power market, megawatts). Since both resources and relations are important for VPPs, the systemic approach that combines all these elements is chosen. The best-known representatives of this approach are Osterwalder & Pigneur (2002).

They perceive a business model through a scheme called the Business Model Canvas, which describes the essential elements of the model and the relations between them (Osterwalder & Pigneur, 2012). They distinguished nine fundamental elements, i.e.: client's segments, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partners and cost structure. All elements can be graphically represented and assigned to four thematic areas. One of them (central) is the "value proposition" (offer) for customers, which is perceived widely and constitutes not only the core product or service provided but also their other features, e.g. innovation, product performance, their adaptation to individual needs, brand and prestige, design, price, product availability or convenience of use. Hence, values can be perceived according to the concept of relational marketing (4xC), taking into account all those elements related to business which offer potential customers any value, for example, environmental protection. The second thematic area is the "client", which consists of such elements as customer segments, customer relations and distribution channels. The third highlighted area is the so-called "infrastructure" by which one should understand both the resources in the classical economic sense and the necessary activities undertaken by the enterprise as well as key partners. All these elements will create costs in the enterprise and are necessary to create value for the client. The fourth area is "finance", which includes the structure of costs and revenues. Between these elements there are cause-and-effect relations, e.g. the cost structure is not a spontaneous element of the business model, but it is a derivative of the method of providing value to clients, which consists of activities or resources used to create them,

as well as established relations with business partners, which covers the area "infrastructure". Revenues that directly result from the value provided to clients should be seen similarly, however, derived from all elements included in the "customer" area.

Unsolved issues as part of the problem. The literature focused on the technical aspect of VPP and a insufficient attention is put on the management aspect and, especially, on the business model. There is a lack of proposal of a business model for VPP, which will describe clients, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partners and cost structure, and the relations between them. The lack of a value proposition for customers is particularly important.

Therefore, the main problem is what resources are needed to create the VPP in Polish conditions. Others are: how they should be organized to outputs technical, economic and ecological efficiency. This article first steps to solve this problem by focusing on assumptions and organizing aspects related to the business model of the VPP.

Aims of the article. The main aim of the article is to propose a new business model for the Virtual Power Plant in Polish conditions. The paper is limited to defining two areas of the business model, such as the offer and the client. The particular attention is put on value proposition (offer) for customers. The offer is understood as a set of products and services that generate value for a specific customer segment. Clients are understood as different groups of people and organizations that VPP wants to reach with their services, how they communicate with individual customer segments and describe the relationships that VPP connected to a specific segment of customers.

Five segments of customers are specified, for which value proposition is suggested: (i) a large buyer buying energy under a long-term bilateral contract, (ii) energy cooperative, (iii) owner of micro-installation, (iv) a company that owns an energy storage, e.g. hybrid vehicle charging stations, storages, (v) energy cluster. The main aim is accomplished by secondary aims such as (i) describing the concept of virtual organization, (ii) the review of business models and (iii) presentation of the legal capabilities to create the virtual power plants.

Characteristic of Legal and economic conditions. In recent years, two amendments have been introduced to the Act on Renewable Energy Sources (RES) (Journal of Laws of 2015, item 478), meaning: Act of December 29, 2015 amending the Act on renewable energy sources and the Energy Law Act (Journal of Laws of 2015, item 2365) and the Act of June 22, 2016 amending the Act on Renewable Energy Sources and some other acts (Journal of Laws of 2016, item 925). The new regulations relate primarily to local retail markets.

In the energy context, these regulations introduced the definition of prosumer, with responsibilities and duties. The prosumer is a final customer with a comprehensive energy sales contract established with the selected seller, producing electricity only from renewable energy sources in micro-installations with a capacity not exceeding 40 kW and not using energy generated for the needs of the business (Journal of Laws of 2015, item 478). The prosumer status can be obtained by all final energy consumers with micro-installation and meeting the above-mentioned requirements, e.g.: local government units, schools, kindergartens, sports facilities, churches, parishes (Gochnio & Kulesa, 2017). The prosumer can freely choose energy seller – if one does not want to look for a seller, this duty is to be performed by an obligated seller appointed by the President of Energy Regulatory Office (ERO) for the distribution network to which the prosumer's micro-installation is connected.

The Act on Renewable Energy Sources (Journal of Laws of 2016, item 925) provides power storage with the role of supporting installations generating electricity from RES. This is a beneficial situation to RES installations with capacities above 500 kW, which will sell the produced energy directly on the market, without the intermediation of obligated sellers. In the case of energy storage combined with micro-installations and installations up to 500 kW, the obligated seller is required to buy it. The purchase price of electricity is 100% of the average electricity sales price on the competitive market in the previous quarter

announced by the President of ERO. For prosumer' micro-installations, the role of the power storage is played by the "distribution network" together with the energy register received by the seller from the prosumer (Gochnio & Kulesa, 2017).

It is necessary to emphasize the differences between a prosumer and an "energy producer in a small installation", which is a regulated activity within the meaning of the above-mentioned Act and requires an entry in the register of producers doing business. If the owner of the micro-installation is not a prosumer and uses the produced energy for the needs of his business, he is subject to the following accounting principles (Gochnio, 2016):

- the obligated seller has the obligation to purchase the surplus of produced energy over the used for own needs; the obligated seller is appointed by the President of ERO for a given distribution network. The surplus can also be bought by another seller if the price and delivery conditions (together with offered continuity of supply) will be accepted by both parties;

- the micro-installation owner may establish an electricity sales contract with the obliged seller, in which the settlement for the difference between the amount of electric energy taken from the network and the amount of electricity transferred into this network is carried out in the given half-year. This means that the settlement will concern the quantitative balance of both types of energy. Then the seller in a given half-year only either buys the energy balance or sells it. This settlement in the so-called net metering;

- entrepreneurs, owners of micro-installations who produced electricity for the first time before the entry of Chapter 4 of the RES Act, or modernized it is after its entry, are entitled to the certificate of energy origin, i.e. green certificates;

- entrepreneurs, owners of micro-installations, have been granted the right to switch to the auction system and while remaining outside the auction system and entering into an amended agreement with an obligated seller, the option of settlements in the net metering system. After switching to net metering, micro-installation loses the right to energy certificates.

Despite previous research work on energy clusters, among others by IASE in Wrocław (Borgosz-Koczwara & Herlender, 2007, 2009) and theoretical proposals of clusters and cooperation networks in the energy sector (Szalbierz & Ropuszyńska-Surma, 2014), (Bojar et al., 2010) only an amendment to the Act on Renewable Energy Sources from June 2016 introduced definitions of local energy structures – energy clusters and energy cooperatives. Energy cluster is a civil-legal agreement, which may include natural persons, legal persons, scientific units, research institutes or local government units. The cluster deals with the generation and balancing of energy needs, distribution or trading from renewable energy sources or from other sources or fuels, within a distribution network with a rated voltage of less than 110 kV. The cluster's area of activity does not cross the borders of one powiat within the meaning of the Act of 5 June 1998 on powiat self-government (Journal of Laws of 2016, item 814) or 5 gminas within the meaning of the Act of 8 March 1990 on local government (Journal of Laws of 2016, item 446). The energy cluster is represented by the coordinator, which may be any member of the energy cluster or the cooperative, association, foundation (Cichosz & Wiącek, 2017) set up for that purpose. Conducting business activities within the cluster is carried out as part of a concession issued for the energy cluster coordinator or as part of the energy cluster coordinator's entry in the register. The operator of the electricity distribution system with which the energy cluster intends to cooperate is obliged to establish an agreement on the provision of distribution services with the energy cluster coordinator.

According to the definition, energy cooperatives are associations that aim to produce energy for own use (members) and the possible sale of surpluses to the network. The law on cooperatives determines the functioning of the cooperative, the production volume and the area of functioning of the members. Members of the cooperative (which may be self-government units, prosumers, electricity producers, whose RES Act does not count as prosumers, but who are also not energy companies, suppliers of new services and others) must be located in one gmina (in Poland „gmina” is the smallest administrative region). The

total energy production inside the cooperative is limited depending on the energy carrier – electricity (unit power up to 10MW_e), biogas (capacity up to 40 million m³ per year) and heat (heating power up to 30MW_e). The law in force in Poland does not limit the permitted subject of the cooperative activity. Therefore, the cooperative can be established to build and operate a source of RES producing energy primarily for the needs of the local community (Frąckowiak & Szambelańczyk, 2015), or to provide new services, e.g. ESCO types, insurance companies.

The RES Act introduced a new auction system to support the production of energy from RES, but it is limited:

- prosumers cannot enter it (RES installations not bigger than 40 kW);
- micro-installations of entrepreneurs and installations launched or modernized after the entry of Chapter 4 of the RES Act can but do not have to enter it;
- other RES installations if they want to get support, have to enter it.

Auctions shall be carried out separately for the sale of electricity generated in installations with a total installed electrical capacity not exceeding 1 MW and those exceeding 1 MW. The President of ERO announces, organizes and conducts auctions at least once a year. The obligated seller purchases electricity generated in the RES installation with a total installed power of <500 kW, from the producer who won the auction, at a fixed price set in the auction and only in the amount specified by the producer in the submitted offer. The costs of energy trade balancing are covered entirely by the obligated sellers. Producers with installations with installed capacity ≥500 kW, who won the auction, will sell their own energy individually on the competitive market and they will cover the costs of trade balancing (Gochnio & Kulesa, 2017).

The concept of the business model. In the proposed business model of a VPP, the following resource assumptions have been made. Their number, in accordance with the concept of virtual organization, is minimized. The VPP consists of:

- information system (Kucęba, 2011b) – information platform – (virtual management system), databases, and the necessary hardware infrastructure (including servers, computers). Theoretically, hardware and software and databases could be leased, but for security reasons, it was assumed that they would be the property of the enterprise (VPP);
- energy storage (batteries) – this resource could also be for example leased, but it was assumed that some part of the storages will be owned by VPP;
- network administrator.

The remaining resources are obtained from the VPP environment, they are e.g.:

- installations of RES;
- additional energy storages (e.g. possibility of using a pumped storage power plant),
- telemetry system – Smart Metering;
- human resources: programmers, experts (e.g. analysts);
- databases (necessary for creating VPP work graphics).

The VPP will provide its services to several customer groups. It will use the above resources and will work with key partners. The specificity of the energy market with potential customers and key partners is presented in Figure 2.

The following customer's segments are specified: (i) a large buyer buying energy under a long-term bilateral contract, (ii) energy cooperative, (iii) owner of micro-installation, (iv) a company that owns an energy storage, e.g. hybrid vehicle charging stations, storages, (v) energy cluster. In particular tables (3 – 7), for each of them, it was described what follows: value propositions, or a set of benefits offered by VPP to its clients; communication channels, the i.e. point where contact between the client and VPP occurs, which significantly affect the final impression of the client; relations that connect VPP with representatives of a specific customer segment.

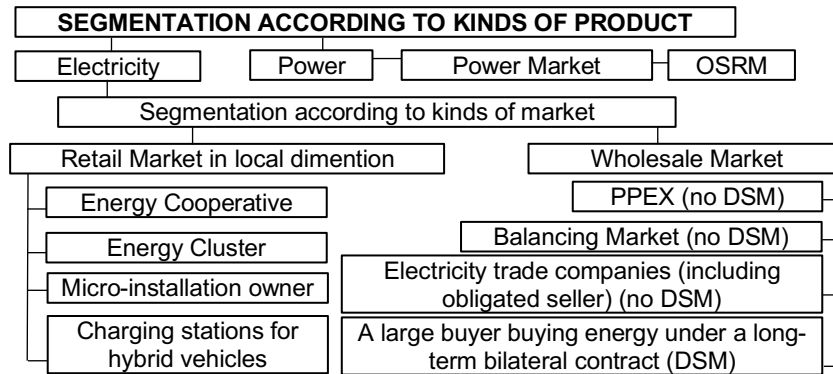


Figure 2 – Segments of potential clients of VPP

Notes: PPEX – Polish Power Exchange; no DSM – without DSM in VPP; DSM – with DSM in VPP; OSRM – System Operator from the Power Market

Sources: developed by the authors

Table 3 – Proposal of values, relations and channels for a large buyer

Segment	Examples of value propositions	Relations with clients	Communication channels
A large buyer buying energy under a long-term bilateral contract	<ul style="list-style-type: none"> – supply of energy in the case of a shortage – the low purchase price of energy – security of energy supply – convenience and speed of service – availability of a dedicated 24h customer manager – savings due to the consultation about energy management 	<ul style="list-style-type: none"> – a dedicated customer relationship manager; – free software; – automated service. 	direct telephone and internet contact, contact through the customer's panel

Sources: developed by the authors

Table 4 – Proposal of values, relations and channels for energy cooperative

Segment	Examples of value propositions	Relations with clients	Communication channels
Energy cooperative	<ul style="list-style-type: none"> – attractive price of energy sales – savings due to lower energy costs – convenience and ease of use – megawatts 	<ul style="list-style-type: none"> – a dedicated customer relationship manager – free software – automated service 	direct telephone and internet contact, contact through the customer's panel

Sources: developed by the authors

Table 5 – Proposal of values, relations and channels for the owner of micro-installation

Segment	Examples of value propositions	Relations with clients	Communication channels
Owner of micro-installation	<ul style="list-style-type: none"> – higher revenues from sales of energy – convenience and ease of use – lower risk of selling energy – megawatts 	<ul style="list-style-type: none"> – a dedicated customer relationship manager – free software – automated service 	direct telephone and internet contact, contact through the customer's panel

Sources: developed by the authors

Table 6 – Proposal of values, relations and channels for a company that owns an energy storage

Segment	Examples of value propositions	Relations with clients	Communication channels
A company that owns an energy storage, e.g. hybrid vehicle charging stations, storages	<ul style="list-style-type: none"> – megawatts – additional revenues from energy storage – convenience and ease of use 	<ul style="list-style-type: none"> – a dedicated customer relationship manager – free software – automated service 	direct telephone and internet contact, contact through the customer's panel

Sources: developed by the authors

Table 7 – Proposal of values, relations and channels for energy cluster

Segment	Examples of value propositions	Relations with clients	Communication channels
Energy cluster	<ul style="list-style-type: none"> – lower energy balancing costs – lower risk of energy balancing – optimizing the use of energy sources – convenience and speed of service 	<ul style="list-style-type: none"> – a dedicated customer relationship manager – free software – automated service 	direct telephone and internet contact, contact through the customer's panel

Sources: developed by the authors

Conclusions and directions of further researches. The reasons for the emergence and development of VPP in Poland are legal solutions and new forms of association of entities on local energy markets established in order to achieve the benefits of network cooperation in the form of energy cooperatives and energy clusters. Technological innovations in local power engineering (smart grids, smart metering, micro-installations) and in ICT technologies play an equally important role. The VPP business model must be individually designed for each entity, taking into account the key customer segments that will provide a revenue stream in exchange for the benefits provided by VPP. Already at the stage of segment identification, the stereotype of the customer of electricity perception as the end-customer should be overcome. The potential values provided by VPP indicate that energy cooperatives, clusters and micro-installation owners who run their own business will also be clients. Prosumer, in the meaning of the RES Act, will not be able to be a VPP customer in the event that VPP is not the operator of the power distribution system. The value provided to individual key customer segments also depends on legal conditions, e.g. energy cooperatives can only sell surplus energy to the grid. In addition, the auction support system, for entities that may be participants in the auction, defines the lower price that it can offer to such clients. Thanks to the use of knowledge and IT technology, a virtual power plant can gain a competitive advantage. It should be remembered that it will compete with other entities involved in trading in electricity, e.g. with electricity trading companies. Potential sources of competitive advantages for particular customer's segments are presented in Tables 3-7. Future research should focus on describing of remaining elements of the business model for each of customer's segments such as revenue streams, key resources, key activities, key partners and cost structure. In the next step economic capabilities to create the VPP should be analysed with special attention on the evaluation of economic efficiency of the VPP. Different scenario including consumer's segment and value proposition should be taken into consideration. To perform an economic analysis of the data coming from a real pilot installation is necessary.

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E. Ропушинська-Сурма, Ph.D., Вроцлавський університет науки і техніки (Польща);

М. Венглаж, Ph.D., Вроцлавський університет науки і техніки (Польща).

Віртуальна електростанція як мережа співробітництва

Значною проблемою польської економіки є виконання вимог кліматичної та енергетичної політик ЄС, у відповідності до яких частка відновлюваних джерел енергії у загальному обсязі виробництва енергії до 2020 року повинна становити 15%. Так, наприкінці 2016 р. частка відновлюваних джерел енергії у Польщі становила лише 13,54%. У рамках даного дослідження, автори розглядають розвиток віртуальних електростанцій як можливість збільшення частки відновлюваних джерел енергії в загальній структурі виробництва електроенергії. Автори визначають віртуальну електростанцію як ІТ-структуру, яка поєднує різні види джерел енергії, споживачів та виконує функції зберігання, обміну або продажу як в самій системі, так із іншими сегментами ринку в режимі реального часу за допомогою смарт-мережі. Позитивний вплив віртуальних електростанцій на електромережу полягає у забезпеченні енергетичної безпеки, стабільності та надійності експлуатації, оптимізації використання енергетичних ресурсів, зниженні навантаження та балансуванні надлишком електроенергії в малих розподільних електромережах. Головна мета статті – розробити нову бізнес-модель віртуальної електростанції в умовах Польщі. Для досягнення поставленої мети було встановлено наступні завдання: (i) опис концепції віртуальних організацій, (ii) огляд наявних бізнес-моделей та (iii) правових можливостей для створення віртуальних електростанцій. Автори досліджують основні нормативно-правові акти, які регулюють права споживачів та особливості функціонування мікрокластерів, що підтримують ідею створення інноваційних продуктів та послуг на енергетичному ринку, таких як віртуальні електростанції. У статті представлена нова концепція бізнес-моделі, в якій увагу приділено мережі співпраці між різними видами енергетичних об'єктів. Нова концепція розглядається як інструмент збільшення та оптимізації використання наявних ресурсів компанії для створення нових продуктів або послуг відповідно до потреб енергетичного ринку з метою отримання додаткової вартості (збільшення конкурентних переваг або підвищення рентабельності).

Ключові слова: бізнес-модель, мікрокластер, мережа, віртуальна електростанція, споживчі сегменти.

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