

Prosumer energy as a stimulator of micro- Smart Grids development - on the consumer side

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Abstract. In the present paper its Author introduces the taxonomy of energy prosumer in the sustainable development context. This concerns in particular micro-installations of Renewable Energy Sources dedicated directly to final energy customers. The four-layer structure of micro-Smart Grids has been indicated in the paper, which includes: the consumer layer (RES micro-installations and intelligent energy receivers), electricity networks layer, Smart Metering layer and the Decentralized Energy Management Systems. The Author has aggregated the binary associations between prosumer energy diffusion and micro- Smart Grid development – which favour creation of zero-energy micro-regions.

1. Introduction

Prosumer energy constitutes a stimulant of new and simultaneously promising, social „green initiatives” for sustainable region development. Prosumer energy is a distinguished segment of electricity sector often defined as the third production pillar – frequently isolated from Centralized Energy Systems (after large-scale/corporate energy – first pillar and dispersed and distributed energy – second pillar). Prosumer energy due to its decentralized and sustainable nature is simultaneously a stimulant of micro-regions sustainable development. Certainly, this is justified in case if it is in line with the third wave prosumer, according to A. Toffler [1]. It needs to be stressed here that A. Toffler rejected the traditional concept of a passive consumer, indicating the development of an active one, involved in the search for a product that will meet best their expectations, at economic, ecological and social justification. In his grasp prosumers are specific market entities that produce energy for own needs. In this understanding production and consumptions are the elements of the same cycle. The value is created when consumers make effort and proper meaning into the products they generate. While prosumption is a continuous process, not a single act [2]. Prosumers who participate in this process contribute their money, time, efforts and skills expecting specific benefits. A reference should be made here to postulates of D. Tapsott and A. Williams who believe that prosumption is a process connected with the will to possess a particular consumer good compliant with own imagination of the co-creator (prosumer). With this reference the activeness of consumers who adapt qualities of prosumers is demonstrated in co-creation of the desired good. Activities of prosumers defined as



prosumption concern basically self-adjustment of products to specific own needs, and frequently also the needs of the immediate environment. Consumers become co-producers who play an active role in production of goods, creating the value, brand and service, frequently being elementary socially responsible market entities [3].

On the basis of the approach by A. Toffler a modified concept of the prosumer as a new market entity has also been introduced by S. Kirsner. He proposes a term of a „professional prosumer” – the one who possesses an advanced knowledge that allows them to participate in a constructive dialogue with the producer and the environment of co-operating prosumers – which is in line with the subject matter of the present paper.

2. Prosumer energy market

Prosumer energy should be defined as transformation from energy products acquired from fossil fuels in centralized energy sources – towards energy value chains of RES energy, co-created in economic micro-spaces that generate economic, ecological and social benefits. The new energy value chains stimulate new business models on energy markets (a new paradigm) – departing from centralized towards decentralized models. Prosumer energy development stimulants can be aggregated in a generalised set, which includes:

- forecasts of electricity demand growth,
- expectations as to the future higher electricity prices,
- high cost of system electricity distribution,
- limited access to electricity generated in conventional sources (vast territory of the state, obsolete technological infrastructure, lack of energy raw resources),
- the need to make use of new technologies, in particular RES,
- growth of ecological awareness,
- the necessity to protect the environment,
- implementation of international agreements in the scope of reducing the demand for fossil fuels, reducing the emission of greenhouse gases accompanied by a simultaneous increase of RES (e.g. according to the declaration 3x20 of 2008 the UE-28 member states are obliged to increase until 2020 the share of energy produced in RES up to 20%, simultaneously reducing resources and fossil fuels by 20% and reducing greenhouse gases emission in CO₂ equivalent by 20% - in 2030 CO₂ reduction at the level of 40% [4].

It is estimated that the European market of energy prosumers (in the aggregated grasp of the EU-28) is currently at the stage of growth. It is estimated that the number of RES prosumer installations in the EU-28 amounts about 10 million [5]. For instance, in 2015 the total and cumulative power of photovoltaic installations in EU-28 that can be recognised as prosumer ones amounted 94,87 GW. A growth of those installed powers by 6,12 GW occurred in 2016. Also, a large differentiation as to the pace of prosumer energy development, in particular in the scope of RES micro-installations. The European leader in this area is Germany, with the number of 2 million of functioning prosumers, who acquire electricity mainly from photovoltaic installations, and the total power of RES amounts about 36 GW. Only in 2014 alone the new installed photovoltaic power in Germany reached 1,9 GW [6]. Prosumer energy is poorly developed in the countries of East Europe, in this the EU-28 member states. For instance, in Poland the total power of RES as of the 3rd quarter of 2015 reached 6,5 GW, in this it is estimated that the total power of installed RES micro-installations amounts barely 0,2 GW (including photovoltaic sources) [7].

However, it should be stressed here that the prosumer energy market in the EU-28 is open to new technologies – in case of prosumer energy this concerns primarily RES micro-installations¹, but also the environment of their integration in micro- Smart Grid – Virtual Power Plants. Integration of prosumer energy sources in the Smart Grid environment increases their value and is a stimulator of their diffusion. Simultaneously, a positive feedback can be observed between prosumer energy and micro- Smart Grid development – therefore, frequently energy self-contained micro-regions development. The aggregated bidirectional associations between prosumer energy diffusion and micro- Smart Grids development have been presented in the next part of the paper.

3. Prosumer energy in correlation with micro- Smart Grid

Micro- Smart Grid is a convergence of low voltage networks and tele-informatic networks. Micro-Smart Grid networks integrate heterogeneous links (e.g. technologies on energy prosumers side) in final energy value creation chains (not only the consumed value, but also environmental, economic and social values). Processes of energy creation and consumption frequently occur in the integrated links. Micro- Smart Grid – in accordance with the idea of computer intelligent networks – include also co-sharing this network's resources by various entities of producers/consumers/prosumers. This comprises also bidirectional information exchange among the cooperating entities. Micro- Smart Grid can be defined as intelligent technologies for electricity management, in order to balance the supply and demand.

In another grasp micro- Smart Grid are intelligent grids of energy transmission in local low-voltage networks, which generate bonds among the links and the processes of electricity value creation that occur in them.

Thus, Smart Grid networks are self-controlling „intelligent energy grids”, which automatically and online, balance in time – demand and supply. In addition, it is a physical, functional, logical and environmental integration environment of dispersed electricity production sources, including prosumer Renewable Energy Sources. The integrated prosumer energy sources in Smart Grid networks are basically decentralized – isolated from the central energy system. At the same time, they are differentiated with regard to technology, production factors, in this raw energy resources and the volume of installed power.

On the basis of the analysis of the logical and functional structure of selected micro- Smart Grids, as well as created in the laboratory conditions intelligent environment of prosumer micro-installations virtual integration with energy receivers, the Authors have distinguished four basic layers in these networks: Prosumer Technology – PT, Operational Technology – OT, Smart Metering – SM and Decentralized Prosumer Energy Management Systems - DPEMS. Distinguishing these layers allows for separating the technologies that fulfil operational functions (production, consumption, transmission and distribution of energy – where the order is not a coincidence) from the technologies that fulfil analytic functions (functions that support management of the heterogeneous value created in micro-Smart Grid) [8].

The first two layers are called operational ones, where technologies that create the electricity value are introduced on the side of the prosumer. In the first layer - Prosumer Technology (PT) the following technologies can be distinguished: micro- dispersed generation, RS mini-installations, energy reservoirs, controlled electricity receivers (e.g. home appliances controlled in the IoT technology) and systems of intelligent electric vehicles charging: plug-in hybrid electric vehicle (PHEV), plug-in hybrid vehicle (PHV).

The second layer of micro- Smart Grid - Operational Technology (OT) is a platform of integrating technologies and energy receivers in decentralized low-voltage networks – technological resources aggregated in the first layer – PT. Computer networks are also implemented in this layer (e.g. wireless

¹ Micro-installation – an installation of a renewable energy source of total installed electric power not higher than 40 kW, which can operate in off-grid systems, in local decentralized networks or connected to electricity networks of nominal voltage lower than 110 kV or heat power achieved in cogeneration not higher than 120 kW.

networks – Wi-Fi), which create the logical metering and controlling infrastructure, and which integrate in the virtual environment all the links of the intelligent grid. The third layer of micro- Smart Grid is Intelligent Metering Infrastructure – Smart Metering (SM), which comprises the metering infrastructure - bidirectional intelligent meters in order to measure the amount of produced energy and the volume of its consumption in particular links of intelligent grid. Metering values are the source of information and knowledge on supply and demand volumes of prosumers. Systems that control prosumer technologies of the first layer of Smart Grid are also introduced in the third layer (e.g. with the use of IoT technology). The fourth layer of micro- Smart Grid is created by Decentralized Prosumer Energy Management Systems – DPEMS. They constitute the superior part in the processes of managing the dispersed structure of micro-installations in prosumer micro- Smart Grid networks.

In the synthetic way, the logical and functional structure of micro- Smart Grid with the consideration of the distinguished four layers – has been visualized in the form of an operational and analytic pyramid of heterogeneous energy value creation in these networks (Figure 1).

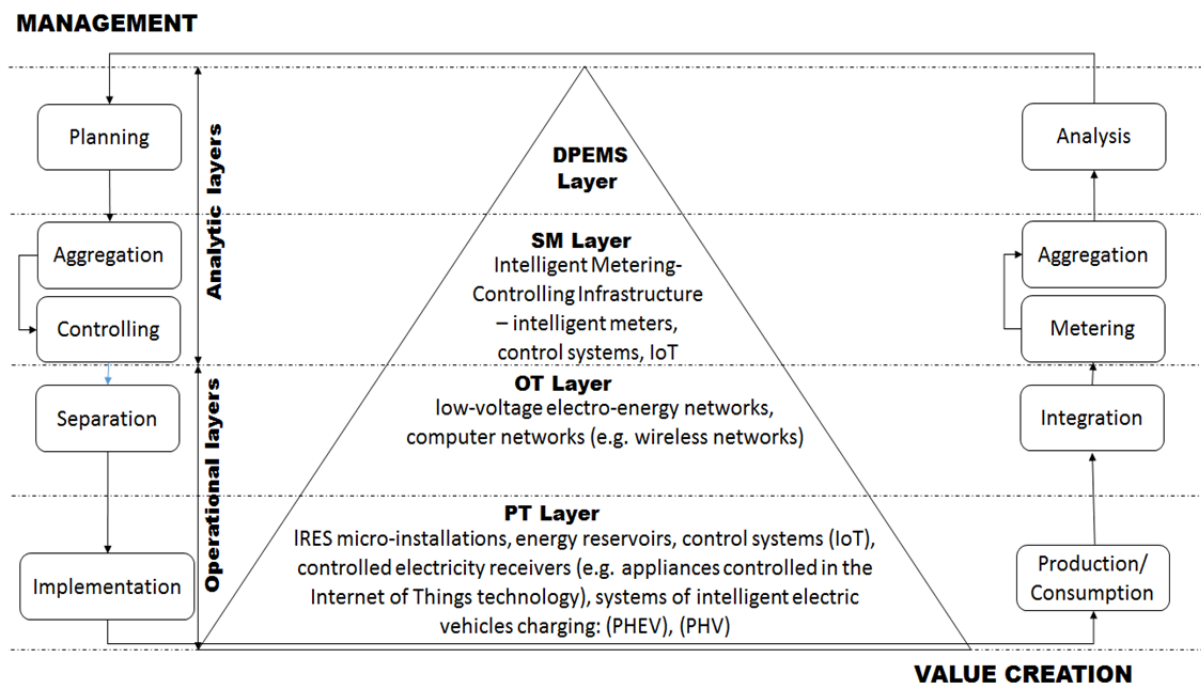


Figure 1. Logical and functional structure of Micro- Smart Grid – energy value creation pyramid.

Processes of generation and growth of energy value in prosumer RES micro-installations occur in particular layers of micro- Smart Grid. It is emphasized that the created values possess additional dimensions: environmental, economic and social ones [1]. In this context relevant values that result from the binary relations between prosumer energy diffusion and micro- Smart Grid development in the economic, environmental and social dimension have synthetically aggregated below.

ECONOMIC DIMENSION- reducing the times and costs of marginal investments of prosumer RES micro-installations through optimizing the use and supporting the management of generated energy, optimum energy use through making use of forecasting applications that support scheduling devices on the supply and demand side of the customer, reduction of exploitation costs, elimination of constant control and manual control through automatic monitoring in metering and controlling modules, supporting in the decision-making processes optimization of prosumer micro-installations operation – cost reduction.

ENVIRONMENTAL DIMENSION – monitoring the decrease in pollution of lithosphere, hydrosphere, aerosphere on the prosumer side, introducing a reliable, comprehensive environment

evaluation through integration of dispersed prosumer RES micro-installations in the virtual environment, optimizing the processes of prosumer adjustment with reference to environmental restrictions – regional perspective.

SOCIAL DIMENSION- activating prosumers in the aspect of their market game in the scope of energy autonomy, stimulating the growth of the number of energy investors/producers in prosumer RES micro-installations, creating motivating systems for energy prosumers, stimulating economic activeness, transforming the energy consumption culture that stimulates growth of pro-environmental awareness.

4. Conclusions

To sum up, energy prosumers are essential entities that participate in energy creation in the local perspective of local multi-dimensional economic, environmental and social values. Given the high density of RES micro-installations their physical and logical integration in the micro- Smart Grid environment is justified. Micro- Smart Grid in their four-layer structure are the foundations of development for regions of full or partial energy autonomy. Autonomy being the result of prosumer energy development diffusion in correlation with micro- Smart Grid development will distinguish a given region and may confirm not only its energy but also social and cultural sovereignty.

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