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PROSUMER ENERGY DIFFUSION DETERMINANTS IN ASSOCIATION WITH LOCAL PLANS OF LOW EMISSION - SMOG - REDUCTION

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Abstract

The cognitive focus of the article concerns the measurement and aggregation of relationships between the diffusion of prosumer energy development and the effectiveness of implementing local Plans of Low Emissions Reduction. In this context, the Authors have justified that local actions in the area of low emission prevention (smog - unusual atmospheric phenomenon) are fully converged with the activities of prosumers, producing energy, among others, in order to meet their own needs. On the basis of the literature query and interviews in a group of managers of the energy and environmental management in territorial units - local perspective (in the

selected EU country), levels of energy prosumer transformation have been determined in relation to the measures in the scope of low emission prevention.

Keywords

Prosumer Energy, Prosumer Transformation Levels, Low Emission Prevention, Environmental Management, Local Plans of Low Emissions Reduction

1. Introduction

In the literature on the subject a prosumer in the subject grasp is identified with a consumer, involved in the search and manufacturing of a product or service which best meets their needs (Bremdal, 2011; Bruns, 2008; Kucęba, Pabian, Bylok, & Zawada, 2016). In turn presumption as a process is connected with the will to possess a particular consumer good accordant with the co-creator's (prosumer's) own imagination. In this respect consumer activeness who adopt prosumer qualities is demonstrated in co-creation or creation of a desired product or service (Bremdal, 2011; Bukowski, Pankowiec, Szczerba, & Śniegocki, 2014; Kucęba, Bylok, Pabian, & Zawada, 2014). Prosumer activities determined as presumption basically concern autonomous product adjustment to specific own needs, and frequently also the needs of the closer surroundings. Unique abilities to co-create or self-creating goods that are directly consumed is not a novelty. However, according to A. Toffler a so called first wave prosumer has to be distinguished, who is orientated in the process of creating or co-creating goods which are consumed by them - expecting first of all economic benefits and the third wave one expecting not only economic but also social and environmental benefits (Kucęba et al., 2016; Toffler, 1980; Prahalad, Ramaswamy, 2004).

A natural presumption area is consumption of autonomously produced energy by final recipients (Kucęba et al., 2014; Popczyk, Kucęba, Dębowski, & Jędrzejczyk, 2014). The process of energy production for user's own needs itself is common and concerns in particular production of heat for the needs of maintaining heat comfort and preparing domestic hot water. Previous common presumption frequently concerns heat production in dispersed energy sources of low quality parameters and simultaneously low-calorific fuels, among others, cheap coal of very low quality, as well as organic and non-organic waste. This presumption type corresponds with the emission growth of a series of harmful substances compared with the background level (reference), and thus, a significant growth of environment pollution with low emission products.

The group of low emission products includes: carbon dioxide CO2, carbon monoxide CO, sulphur dioxide SO2, nitrogen oxides NOX, polycyclic aromatic hydrocarbon e.g. benzo(a)pyrene and dioxins, and heavy metals (lead, arsenic, nickel, cadmium) and suspended particulate matters PM10, PM2,5 (*Directive 2008/50/UE*; Kucęba, 2016; Kucęba & Kulej-Dudek, 2016). These pollutants concentrate near these objects, where they have been created, e.g. heterogeneous use objects, roads, crossroads, waste dumps and furnaces. A negative impact of previous prosumer sources on the environment occurs in particular in highly urbanized areas, rural areas, and agglomerations, of high building density structure and differentiated terrain construction (*Directive 2008/50/UE*; Kucęba, 2016; Kucęba & Kulej-Dudek, 2016). Due to the high density of sources cumulated volume of product combustion, in small areas low emission is accompanied by the scale effect of pollutant emission into the environment (Jing-Wen Cao, Chun-Yen Chiu, Guan-Ling Chen, Zheng-Sheng Xiao, Lih-fu Chen, Wen-Liang Lai, 2016). Low emission sources due to their local distribution are defined in the literature on the subject as surface ones. They comprise areas of dense housing structure (one and multi-family) with individual heat sources, small craft or service businesses and public facilities together with local roads. It should be also indicated here that a consequence of low emission is also smog identified as contemporary civilization threat. Smog is unnatural atmospheric phenomenon which consists in co-occurrence of air pollutants caused by human activity (low emission products) and unfavorable natural atmospheric phenomena: significant air humidity (fog) and lack of wind. Low emission products generated by so called negative prosumers in local furnaces are the cause of creating unnatural atmospheric phenomenon – "acid smog". In this reference, it is difficult to include this type of presumption into the third wave by A. Toffler (Kucęba & Bajor, 2014; Toffler, 1980) and connect it with the sustainable development concept.

2. Low Emission/Smog Reduction Plans – as a local „green activity" portfolio

While indicating the previous negative impact of prosumer activity on the environment, it is important to notice the transformation of actions, and so the image of prosumer in the context of reducing low emission/smog pollutants. This transformation is in line with the scope of actions defined and determined in the Directive of the European Parliament and Council 2008/50/WE of 21 May 2008, on air quality and cleaner air for the Europe (Dz. Urz. UE L 152 of 11.06.2008) (*Directive 2008/50/UE*) and National Environmental Protection Programmes

(UE-28) (*Chief Inspectorate Of Environmental Protection*). In particular, both in the community scope of UE-28, as well as the national one, the distinguished legal regulations define and determine: goals concerning air quality in the scope of limiting and preventing its harmful pollution – which has a negative impact on human health and the environment as well as methods and criteria of air quality evaluation. The EU countries are obliged to maintain air quality compliant with standards convergent with the abovementioned legal regulations. Due to local impact of pollutants coming from surface sources – low emission/smog sources, on the basis of national legislations compliant with the Directive 2008/50/WE, territorial units (local dimension) are obliged to draw Low Emission/Smog Reduction Plans and resulting from them operational actions are delegated at the local level (the "bottom up" approach). In particular, these plans in convergence with the community legislation of UE-28 and the national one, should consider the specificity of the given region (*Directive 2012/27/UE*).

Basically, the detailed scope of Low Emission/Smog Reduction Plans concerns identifying local problems, surface pollutant emission sources and their scale. Therefore, these plans comprise the scope of actions aimed at low emission reduction – a decrease of pollutant emission to the air, in this: dusts, sulphur dioxide, nitrogen oxides and carbon dioxide emission. The following aspects are defined at the local level: cooperation, roles and tasks of entities being energy producers and/or recipients, with a particular consideration of actions in the public sector, in convergence with local strategic documents, e.g. current plans for supplies of heat, electricity and gas fuels (with consideration of spatial planning). It should be indicated that these plans should consider support mechanisms of energy efficient products and services and change stimulators of previous non-environmental consumption behaviors (Gebauer, Füller & Pezzei, 2013) of energy users – negative prosumers. A vital element of Low Emission/Smog Reduction Plans is monitoring the level of implemented tasks and emission reduction, e.g. percentage of performed tasks with reference to the planned ones for the given year. On the basis of the query of drawn and implemented Low Emission/Smog Reduction Plans in the analyzed regions and conducted interviews in the group of studied local leaders it can be concluded that the basic criterion of local operational actions selection in the scope of elimination or reduction of pollution from surface sources is correlation between the planned environmental effect and economic efficiency, at simultaneous social acceptance. For instance, in the studied territorial units (the selection results from the Authors' research concentration in these entities) according

to the accepted criterion MIN(N)=80% of respondent indications (direct interview or/and the existing documents of local Low Emission/Smog Reduction Plans) in the portfolio of basic actions in the scope of pollutant reduction of low emission/smog sources one can distinguish: elimination of old low-efficient heating devices within the implemented by municipalities subsidy schemes for replacing heating sources, development and modernizing heating networks, development of gas networks, diffusion of renewable energy sources and their integration in the "Internet of Things" environment with energy receivers on the side of the user/prosumer (in order to adjust calendar loads in households to the non-linear disposition of these sources) (Kucęba, 2011; Kucęba & Kiełtyka, 2013), thermal upgrading of buildings and supporting energy-efficient construction in the housing segment and public utility sector, modernizing public transport (decreasing traffic emission), reduction of Diesel-engine vehicles, diffusion of electric cars powered from RES sources, as well as eliminating waste combustion and limiting combustion of plant leftovers. The studied expert group also indicates that Low Emission/Smog Reduction Plans should additionally comprise support mechanisms of actions having influence on change in consumption attitudes of energy recipients, previous energy prosumers (for example through cooperation of local leaders and inhabitants with interested parties, as well as educational actions) (Funtua, 2015). In this context, it should be stressed, that nature of local actions is also direct influence on changing the attitudes, environmental awareness and social responsibility of dispersed producers and at the same time produced energy recipients. The cognitive focus of the further part of the paper concerns indication of transformation level of "Toffler's third wave" prosumer in the association with local Low Emission/Smog Reduction Plans.

3. Prosumer transformation levels in the association with local Low Emission/Smog Reduction Plans

Consumption of autonomously produced by final users energy is associated with prosumer energy (Popczyk, 2011; Popczyk et al., 2014). A contemporary energy prosumer is first of all identified as a producer of energy value not only in the technological dimension but also in the economic, organizational, environmental and social dimensions (Kucęba & Bajor, 2014). According to the United Nations Industrial Development Organizations (*United Nations Industrial Development Organizations,* 2015), prosumers are not only physical persons, but also

economic entities (in particular SMEs), entities of the Local Government Units, which within the scope of the basic or/and complementary activity produce energy (in this heat or/and electricity) in sources compliant with the air quality standards, in order to cover the whole or parts of their energy needs. Contemporary energy prosumers are characterized by their willingness to incur larger costs to improve their welfare, simultaneously being socially and environmentally responsible.

In this reference prosumer energy is defined as transformation from products (electricity, heat, transport fuels) acquired separately, as well as form sectoral (industry) energy producers and providers – towards prosumer value chains, which integrate the demand and supply on the recipient (consumer) side – with the use of: highly-efficient technologies, highly-calorific fossil fuels, and first of all dispersed RES micro-installations (Chalkiadakis, Robu, Kota, Rogers & Jennings, 2011; Kucęba et al., 2016).

At the same time, it is emphasized that energy prosumers environmentally aware do not have to be limited only to energy producers and consumers who comply with air quality standards in the scope of reducing and preventing its harmful pollution. A prosumer is also a person, entity which introduces and implements all actions directly connected with reduced demand for energy, fuels, resources, introduces highly-efficient, energy-saving technologies both on the side of production as well as consumption of produced goods. Such activity can be defined as negawatt prosumer energy. Negawatt prosumer energy can be referred to production of negawatt goods, connected, among others, with reduced demand for resources, production materials or energy, while a simultaneous reduction of threats to the natural environment takes place (Kucęba, 2011). The volume of reduced consumption is "apparent energy" – a good which is produced by the prosumer.

Taking into consideration the abovementioned taxonomic approaches, it should be indicated that an unique quality of the prosumer and thus also the prosumer energy is the ability of whole or partial separation of individual prosumers, local entrepreneurs and even regions from the centralized energy system – adopting the criterion of energy production for own needs as well as reduction of energy-intensity and resource-intensity. Diffusion of contemporary defined prosumer energy in local dimensions is a stimulant of full or partial energy autonomy of regions, creating energy value in the symbiosis with the natural environment and local community expectations. Thus, it is in line with the Low Emission/Smog Reduction Plans.

On the basis of the query of developed and implemented Low Emission/Smog Reduction Plans in the studied regions and on the basis of conducted interviews in the group of studied local leaders transformation levels have been determined – prosumer value growth depending on applied prosumer technologies compliant with air quality standards and prosumer solutions of negawatt goods production, connected, among others, with reduced demand for resources, production materials or energy.

With reference to the distinguished in point 1 of the present article local operational actions in the scope of eliminating or reducing pollutants form surface sources, resulting from Low Emission/Smog Reduction Plans heterogeneous solutions of prosumer energy have been adjusted and aggregated in the following groups:

- low emission/smog reduction in buildings
    - ✓ fossil fuels or 5th class biogenic boilers (according to PN-EN 303-5:2012 standard) of powers „≤ 50”, with automatic charge,
    - ✓ negawatt energy,
    - ✓ small power cogeneration sources (produced in cogeneration of electricity and heat),
    - ✓ RES micro-installations,
    - ✓ RES micro-installations and their off-grid integration with energy receivers on the side of the recipient,
- smog/traffic emission reduction
    - ✓ introducing catalysts in combustion engines,
    - ✓ reduction of Diesel-engine vehicles,
    - ✓ introducing hybrid drives in wheeled vehicles,
    - ✓ introducing PV electric drive vehicles (with the possibility of use as energy reservoirs) (Charan, Jaya Laxmi, Sangeetha, 2017)..

The distinguished in the two groups prosumer technologies and solutions have been evaluated according to Linkert’s scale from 1 to 5, by the group of local leaders (the research method, expert reasoning – „brainstorming”) according to the criterion of prosumer energy diffusion and efficiency of implementing local Low Emission/Smog Reduction Plans.

Pictures 1 and 2 include aggregated evaluations of prosumer technology and solutions in the groups: low emission/smog reduction in buildings, traffic emission reduction.

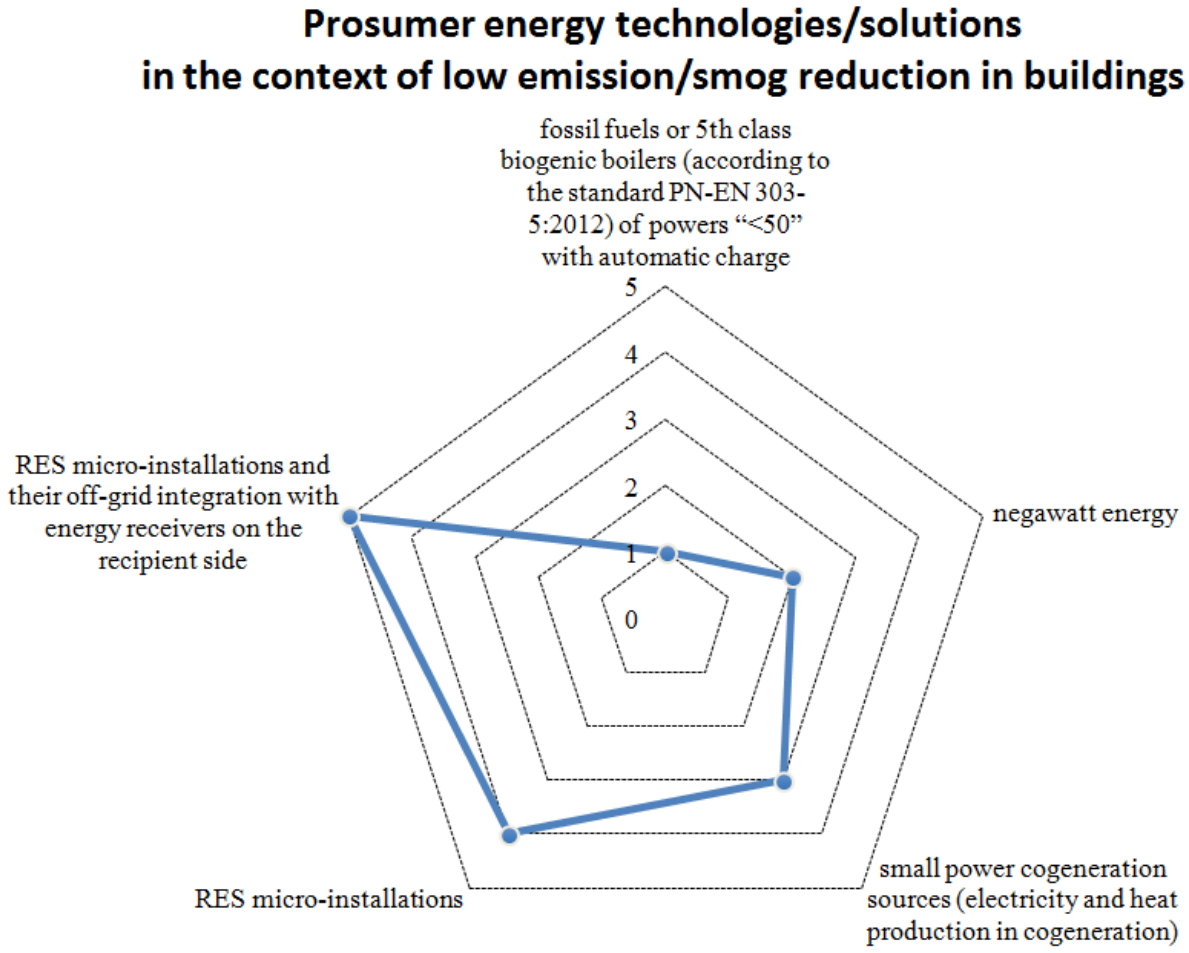

Figure 1: *Evaluation of prosumer energy technologies/solutions in the context of implementing Low Emission Reduction Plans (in buildings)*

Levels of energy prosumer transformation with reference to the actions in the scope of low emission counteracting have been determined on the basis of evaluation of the summarized prosumer energy technologies. Energy production has been adopted as a base level (in the negative scope), in particular heat production in energy sources of low combustion parameters.

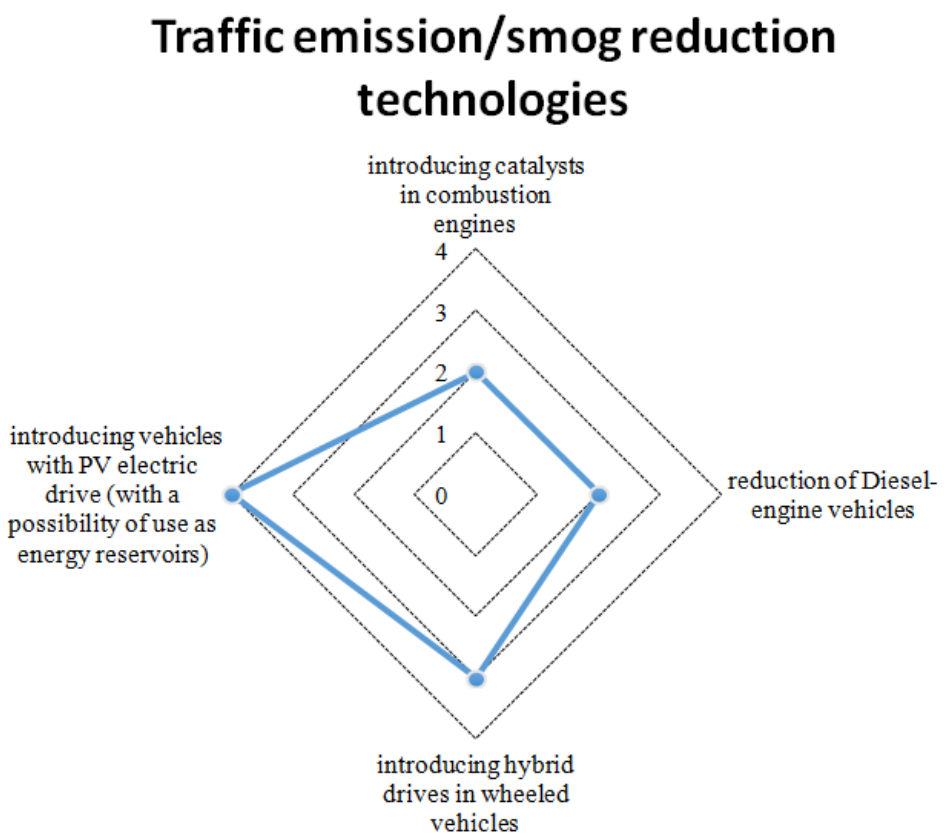

Figure 2: *Evaluation of traffic emission reduction technology in the context of implementing Low Emission Reduction Plans (traffic emission)*

This combustion concerns, among others, cheap coal of very low quality, as well as waste, e.g. hydrocarbon one. In addition, the Authors have adopted as a zero level (negative impact on the environment) pollutants introduced into the environment as a result of fuel combustion in combustion engines (traffic emission). Particular prosumer transformation levels in correlation with actions resulting from Low Emission/Smog Reduction Plans have been summarized in Table 1.

Table 1: *Prosumer transformation levels in correlation with actions resulting from Low Emission/Smog Reduction Plans*

PROSUMER TRANSFORMATION LEVEL	ACTIONS CONNECTED WITH LOW EMISSION COUNTERACTING	Effects in the scope of low emission reduction with reference to implementing Low Emission/Smog Reduction Plans EXAMPLES
0 LEVEL - NEGATIVE EFFECT	Energy production, in particular heat production in energy sources of low combustion parameters and limited height of smoke emitters. Combustion of, among others, low quality coal as well as waste, e.g. hydrocarbon one	High concentrations of low emission/smog pollutants (as a result of the scale effect due to high density of old boilers – local perspective) **Example:** Fossil fuel or 3rd class biogenic boilers (according to the standard PN-EN 303-5:2012) of powers „≤ 50" (concerns prosumers - households) e.g. carbon monoxide not less than 3000 mg/m^3, gas organic pollutants not less than 100 mg/m^3, Suspended particulate matter not less than 125 mg/m^3
LEVLE 1	Replacing low-efficient and non-environmental coal heat sources with modern environmentally-friendly boilers with automatic and controlled fuel and air dosing in the combustion process, according to the thermal needs of buildings and households and flats. Introducing catalysts in combustion engines of wheeled vehicles.	Replacing 3rd class boilers with 5th class ones contributes to 6 times reduced emission of carbon monoxide, 5 times reduced emission of gas pollutants and 4 times reduced absorption of particulate matters to the air. **Example:** Fossil fuel or 5th class biogenic boilers (according to the standard PN-EN 303-5:2012) of powers „≤ 50" (concerns prosumers - households
LEVEL 2	A set of actions decreasing energy consumption in the facility – negawatt prosumer energy. Introducing catalysts in combustion engines of wheeled vehicles. Reducing the number of Diesel engine vehicles.	In case of low-energy houses (heat losses of 300 kWh/m^2a) A possibility to reduce energy intensity by about 60% - which results in reduced demand for fossil fuels, low emission/smog pollutant reduction. Passive construction development (heat losses of 15 kWh/m^2a). **Example:** Thermal upgrading works, e.g. replacing window and door frames, insulating walls, insulating flat roofs, modernising internal heating installation of the building with automatic regulation feature
LEVEL 3	Application of cogeneration and	Application of dispersed microgeneration

	polygeneration sources generating interdependently electricity and heat, simultaneously reducing fossil fuels consumption, with reference to processes of separate secondary energy generation (e.g. separate generation of electricity and heat). Introduction of hybrid drives in wheeled vehicles.	on the prosumer side up to 50 kW generates savings of primary energy by at least 10% with reference to referential values at separate electricity and heat production. **Example:** Micro-biogas installations $10kW_{elektricity\ energy}$ +15 kW_{heat} - energy savings up to 40%.
LEVEL 4	Application of micro- and mini RES prosumer installations. Introducing vehicles with PV electrical drive (possibility of use as energy reservoirs). Limiting individual passenger transport in cities and agglomerations for the benefit of public mass transport (with reference to negawatt energy).	Effective formula of prosumer energy in the scope of low emission counteracting due to „almost zero-level emission" of pollutants coming from RES micro-installations. **Example:** Heat pumps, photothermal and photovoltaic sources, micro wind turbines, micro- or mini- biogas cogeneration, energy reservoirs.
LEVEL 5	Application of micro- and mini RES prosumer installations and their off-grid integration with the receivers on the recipient side. Controlling with the use of the „Internet of things" technology.	Flexible adjustment of energy receivers working schedule on the prosumer side to the non-linear disposition of RES micro-installations. **Example:** Off-grid zero-energy objects (*Directive 2010/31/UE*) isolated from centralized energy systems – zero-emission ones. Due to application of RES lack of demand for energy produced in the fossil fuels conversion processes.

Transition to higher levels of prosumer transformation is shifting away from fossil fuels towards almost „zero emission" RES technologies (Popczyk, 2011). At the same time this transformation is in line with the guidelines of the climate protocol 3x20 signed in 2008 by the EU member states (member states of the EU-28 are obliged to increase until 2020 the share of energy produced in RES to 20%, simultaneously reducing resources and fossil fuels by 20% and greenhouse gases in CO2 equivalent by 20% - in 2030 CO2 reduction at the level of 40%), as well as implementing strategic directions defined in the "EU Roadmap until 2050 (Kucęba & Bajor, 2014).

In this reference prosumer energy diffusion in convergence with low emission/smog pollutant reduction being in line with the Toffler's third wave, should be stimulated through transformation from energy products acquired from fossil fuels towards creating in Low

Emission/Smog Reduction plans – energy value chains of RES energy or dispersed generation. It is believed, that this can also stimulate a new group of local entrepreneurship, new work posts, new diversified investments, carry out tasks resulting from Low Emission/Smog Reduction plans and the ones resulting from local sustainable development strategies or social responsibility in the regional perspective.

It should be also stressed that technologies on the side of the electricity prosumer are not limited entirely to the summarized above prosumer energy sources (in particular level 4). Devices and technologies adapted on the prosumer demand side (level 5) are also introduced into the prosumer technological portfolio. They include, among others:

- intelligent devices (Internet of Things): e.g.: washing machines, clothes driers, dishwashers with a control system – in order to adjust to the changing tariff of energy seller,
- central systems of load, temperature and humidity management in intelligent construction – in order to adjust to the changing tariff of energy seller, electric vehicles, which limit energy consumption in transport and are energy reservoirs (charging at "power valleys") and energy sources in the periods of peak demand for energy (they smoothen daily supply characteristics of prosumers).

To sum up, diffusion of energy prosumers classified at the 4th and 5th level of their transformation (table 1), due to „almost zero-level emission" or „zero emission" of pollutants being low emission/smog products.

4. Conclusions

It should be stressed in the conclusion that local Low Emission/Smog Reduction Plans have to consider not only recommendations in the scope of technologies or solutions to reduce pollution coming from low emission sources, but also social expectations, awareness and willingness to change level. On the basis of the presented in the paper discussion, which has been based on the interviews in the local leaders groups, it is believed that prosumer energy diffusion will stimulate cultural changes in the scope of energy consumption, being in binary relationships with the environmental awareness growth of local communities. Producing energy for own needs by prosumers in sources compliant with air quality standards, identifies their ability of natural adjustment of their production capacity with the use of local energy potential. Also, their

neutrality of impact on the closer social and environmental surroundings should be distinguished here.

Low Emission/Smog Reduction Plans have to also comprise financial support mechanisms, in particular for the prosumers classified at the 4th and 5th level of their transformation, according to research:

- application of micro- and mini RES prosumer installations,
- introducing vehicles with PV electrical drive (possibility of use as energy reservoirs),
- limiting individual passenger transport in cities and agglomerations for the benefit of public mass transport (with reference to negawatt energy),
- application of micro- and mini RES prosumer installations and their off-grid integration with the receivers on the recipient side,
- controlling with the use of the „Internet of things" technology.

Thus, it should be indicated that the costs incurred by territorial units on the development of, e.g. renewable prosumer energy, and thus, pollution reduction – low emission/smog, are external costs, which can be compensated through other cost reduction (social ones), e.g. treatment costs, environmental costs.

To sum up, the relationships taking place between diffusion of prosumer energy development and efficiency of implementing local Low Emission/Smog Reduction Plans are confirmed.

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