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A perspective on the potential role of renewable energy for sustainable development on a local scale

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Abstract: The idea of sustainable development is increasingly being introduced into the energy management of many municipalities. This trend can be seen in the countries of the European Union, in particular, in Germany, Austria and Denmark, where the integrated policy for development of local energy and economy with social progress is implemented. In Poland, these solutions are still in the phase of intentions; however, attempts are made to take action in this respect. The paper discusses innovative solutions for the local energy management based on renewable sources with regard to their adaptation to the local conditions in Poland. The parameters affecting the development of the local energy sector are discussed. An emphasis is placed on the initiatives undertaken with the purpose of engaging local communities in the development of the renewable energy production and implementation of solutions, making use of examples of other schemes currently in force in Europe.

Keywords: sustainable energy, renewable energy, local scale

JEL codes: P18, Q42, Q55

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1. Introduction

The policy of rational management of heat and electricity, which is coupled with cooperation with all the subjects of the local energy market and focusing on securing heat,

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electricity and natural gas supplies, forms an important task facing the operation of a commune. In this respect, it is particularly important to note the joint enterprises focusing on energy production from renewable energy sources (RES), as the successful implementation of such activities guarantee the economic development of a commune, combined with independence of energy supplies.

The implementation of the construct associated with the energy autonomy by application of the locally available energy resources is feasible at the local level on the scale of a province, county, commune and even town; yet with the option of reducing the concept to housing areas and individual houses.

The meeting of the local energy demand based on renewable resources involves the following activities (Sorrell S., 2015:74-82; Leal V.M, et al. 2016: 421-428):

- a decrease in the dependence on energy supply from external sources,
- reduction of the use of conventional energy carriers,
- an increase in the local added value,
- reduction of the pollutant emission into the environment.

The implementation of the energy concept based on decentralized management systems in the power industry is only possible as a result of the close cooperation between local authorities, distribution companies, local businesses and even individual consumers and home owners, the so-called prosumers. An undoubtedly important and key role in the decentralization of the energy system needs to be played by the policy issues and legislation, as these aspects can promote fast transformation or lead to a decrease in its pace. This converts well into the introduction of the support systems by means of government grants, concessionary credits, subsidies, as well as incentive systems (price system and quota system), which form important considerations affecting the development of the sector of renewable energy.

The idea of the decentralized energy management requires that a local energy and fuel market needs to be constantly developed; hence, local centers are initiated with the purpose of management in the energy sector, along with energy communities and energy associations, whose task is to coordinate the production and distribution of energy derived from various types of renewable sources. The activity of these subjects also involves local businesses, environment institutions, economic chambers, energy clusters and scientific units so as to develop the most applicable solutions promoting the innovative development of the local energy infrastructure.

The challenge concerned with the sustainable energy policy needs to involve a comprehensive, integrated and long-term actions. This task also needs to involve the commitment of all stakeholders in the energy policy, development of the conditions for

a successful compromise and cooperation as well as the application of the effective technical solutions that fulfill the condition of environmental friendliness. At the same time, such a task forms necessarily in the dynamically developing energy market nowadays.

The objective of this paper is to discuss and demonstrate the possibilities for local actions, approaches aimed at involving various communities with the purpose of the development of renewable energy sector and indication of the so-called good practices in this area throughout their adaptation to the local conditions in Poland.

2. Local activities undertaken with the purpose of promoting energy security

The plan for supplying a commune with heat, electricity and gas fuels forms one of the key documents for the local authorities. This is due to various aspects and primarily aims at securing the energy supplies to the inhabitants of the commune, provide supervision over the development of the companies in the energy sector and stimulate the perspective of rationalizing the development of energy systems.

Both towns and communes implement the functions which are associated with the production and supply of energy by taking actions in the following areas (IEA, 2011; Bazmi A.A., et al., 2011: 3480-3500):

- heat and electricity production (and sometimes thermal energy production for cooling purposes),
- use of renewable energy sources,
- application of solid communal waste as a fuel for energy production,
- transmission and distribution of energy to consumers.

By realization of the guidelines found in the Act of Energy Law (Energy Law, 1997) that is concerned with the plan for supplying the commune with heat, electricity and gas fuels, each commune is obliged to account for the local potential of renewable energy resources (Ministry of Economy, 2009).

It is commonly recognized that in contrast to conventional fuels, RES have a beneficial impact on the environment and are considered to be accessible and inexhaustible, and can have a considerable share in the overall energy balance of the country. Hence, they can form crucial contributions to the pillars of sustainable energy policy.

In Polish conditions, biomass forms the most popular source of renewable energy. In the form of lumps or processed form (pellets), it is applied for combustion in boilers for the purposes of central heating and domestic hot water so as to provide adequate supply in a single

installation or a group of buildings. Very often even small energy production facilities, such as a local heat and power plants apply on-site co-generation (i.e. a small capacity system installed in a close vicinity of energy consumers).

The application of local renewables such as geothermal, wind and water energy depends on the local accessibility to them and for the case of solar energy the issue is concerned with its availability only in the summer season. Recently, we are facing a development in terms of the use of solar energy (Banos et.al., 2011: 1753–1766). Although solar cells are most effective in the conditions of considerable insolation, the greatest solar capacity is installed in Germany, where the weather conditions are similar to those in Poland. The current incentive system projects the extensive use of photovoltaics, and it is believed that the solar installations will have had a satisfactory economic effectiveness without the existing subsidies by the end of this decade.

A rational and effective measure aimed at an increase in the efficiency of a sustainable energy system operating in the given climate conditions can be associated with the concurrent use of a few locally accessible sources of renewable energy. Such installations are called a hybrid or combined system (Piotrowski et al., 2007: 2). A typical hybrid system applying only renewable resources includes such a layout that applies solar, wind and water energy, and some systems also involve RES technologies that are coupled with conventional technologies of electricity and heat production. In this context, an interesting example is given by the system in Fig. 1, which combines various renewable technologies, and offers the development of the so-called local energy island. In hybrid systems (Fig. 1.) *smart grids* integrate the activities of all participants in generation, transmission, distribution to provide energy in a reliable, safe and economical way, taking into account environmental protection requirements. Energy storage technologies play a crucial role in those systems. Currently, the cheapest and most available are energy storage technologies in hot water (storage tanks/individual boilers in residential houses allowing for energy storage in daily cycles, land heat storage and the so-called district heating, land heat storage for seasonal storage).

The application of RES provides a self-sufficient local energy island located in the areas of remote rural and mountain communities, where the high cost and potential impact of the traditional energy systems create an ideal environment for RES so as to realize projects aimed to create a more sustainable energy economy. However, it is also possible to achieve energy autonomy in cities as well as individual housing areas.

In Europe, there are already thousands of local communities using RES for useful energy production. However, Germany has taken on the role of a leader in this respect. Across

this country, around 15% of households derive energy demand from local networks, which are capable of processing the locally available biomass.

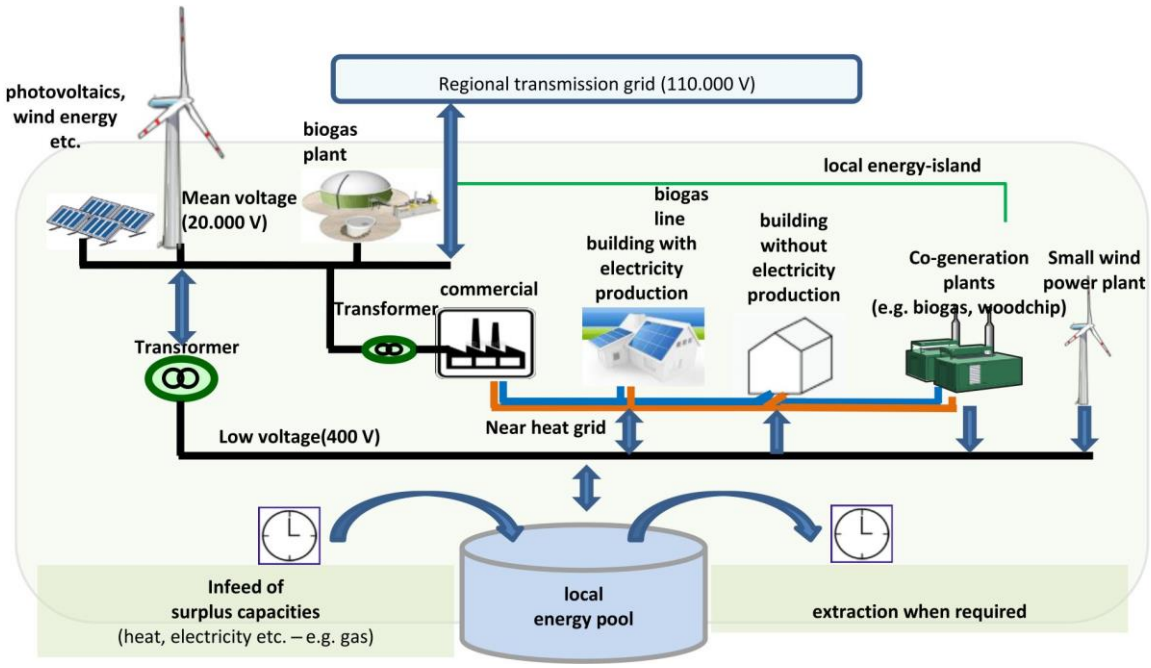

Figure 1. Local energy island
Source: Energiewende GmbH

An example of the existing solutions includes the country of Wettesingen, close to Kessel, with a population of around 1,300, which is capable of almost completely meeting the demand of the population for energy from the local solutions applying RES. Another good example is Feldheim in Brandenburg, Germany – a commune that has achieved a complete independence in terms of energy supply. This commune with a population of 130 inhabitants living in 37 houses has installed 47 wind mills with the total production of energy from wind turbines that can produce more than 175.1 million kWh in a year, and in addition it owns a biogas plant and a heat and power plant that derives energy from wood from the local forest (as an addition al heat source applied in the heating season) (Kang L., 2014: 3). Moreover, this commune has a solar farm comprising 9844 photovoltaic panels (with the annual output of 2748 MWp) (www.nef-feldheim.info). Only 1% of the energy produced in this manner is utilized locally by the community, the rest is sold to the energy market (Hejna-Modi, 2014). Still another example is provided by Jühnde commune (200 houses) in the Göttingen district, also located in Germany. In this location, the greatest proportion of energy production occurs on the basis of biomass obtained from biomass processing in a methane fermentation process. The energy derived in such a way is delivered to the local electricity network and heat is used for heating homes through a local heat distribution network. In the period corresponding to the greater heat

demand, the on-site thermal plant burns wood chips. The commune of Jühnde is cable of producing around 4 million kWh per year, which approximately corresponds to two times the local demand for energy. The revenues from the sales of energy surplus amount to around Euro 600,000 per year. In consequence, each household saves as a result of the use of renewable energy and savings are equal to around Euro 750 per year (www.bioenergiedorf.de).

The development of such communes with self-sufficient energy supply was possible not only as a result of the involvement of its inhabitants, but also as a consequence of the central government policy called *Energiewende* (energy transformation).

In the conditions of Poland, attempts to create self-sufficient villages in terms of energy supply were initiated in the Districts of Daszyn and Uniejów in Łódzkie Province. An investment is under way in Daszyn District, which involve the construction of a heat and power plant beside the existing heating biomass-fired boiler plant. This local investment also includes the installation of 217 photovoltaic panels in individual houses, 146 photovoltaic lamps in the commune and solar collectors in the local primary school (www.globenergia.pl).

Concurrently, in Uniejów District, a hybrid heat and power plant is being built applying biomass and geothermal resources. The thermal energy and electricity that will be produced in Uniejów will satisfy the demand of the buildings managed by the commune and the companies working for the municipality. A similar situation has taken place in Łapy District (Podlaskie Province), where one of the villages should gain independence in terms of thermal energy and electricity supply as a result of the use of biomass. Other projects include Tuczępy District in Świętokrzyskie Province, which projects the development of a biomass-fired power plant (with the capacity of 9.6 MW), solar power plant (10 MW), wind turbines (18 MW) and a water mill (20-30 kW) combined in a Renewable Energy Source Park (www.globenergia.pl; www.ecouniejow.pl).

3. Citizen's energy industry – involvement of local community in the energy policy

A sustainable energy policy needs to be primarily based on the involvement of society. In the era of knowledge-based society, the application of knowledge and information available for the local community forms the key element in the development of innovation introduced with the purpose of strengthening the local development.

The first step needs raising the ecological and energy awareness in the community. The awareness of the local potential in terms of RES, the benefits and drawbacks associated with the use of various types of sources (both renewable and non-renewable) promotes the

development of society that is conscious with regard to energy and aids local authorities in the implementation of innovative energy plans.

One of the important tasks undertaken at a local level could be based on the involvement of the community members in the decision-taking processes as well as gaining progress in various types of projects. This brings tangible effects for the entire commune since without the social support and approval of the course of the adopted solutions it is not possible to implement changes in the local energy policy.

Another important aspect is related to awareness of the citizens with regard to their economic interests, which encourages the involvement in the energy-related ventures of the investors living in the area (who also play the role of the players in the energy market) without involving external investors, development of a local energy market by contributing to vocation activation of the local community. This type of activity leads to the possibility of investing the generated profits in the region, thus offering an increase in the local added value.

An interesting solution is associated with the involvement of the local community as participants and shareholders of the local energy market (Energiewende GmbH). Such solutions have been applied in the energy market in Germany for a long time. In this respect, an interesting example is provided by the Herten Fund, through which the citizens of Herten were offered to purchase stakes in the communal energy enterprise. Around 1000 citizens used this possibility, which was converted into an equity value of above Euro 10 million. The resources in the Herten Fund are allocated solely in the projects involved with the development of RES (www.urbangreenbluegrids.com)

Feldheim commune offers an example of cooperation operating at various levels of the administration and private capital. In this case, the development of bio-energy village was supported by finance of the federal government, the mentioned herein Feldheim commune, the Ministry of Agriculture and private capital. The energy matters are managed by the company called Feldheim Energie, whose stakeholders are formed by the citizens of the commune on condition that they are ready to invest Euro 3000 (Tusińska M., 2015:29-32). In the village called Jühnde, the operation biogas plant is administered by the co-operative society named Bioenergiedorf Jühnde eG, whose members are local citizens. In this case, the minimum stake in the investment set for the citizens was set at Euro 1500 (www.bioenergiedorf.de).

In the Polish conditions, the existing legislation promotes the development of microinstallations by individuals (called prosumers), the purpose of which is to produce energy from renewable sources at homes and connection of these installations into the electrical grid. However, the development of this sector is relative to a number of factors, such as the possibility

of gaining financial support and conditions that are related to details of the legislation. In Germany, due to the existence of a five-million prosumer group (comprising two-million producing electricity and three-million producing heat), it was possible to increase the energy security and stability of supplies as well as obtain independence of the imported energy carriers (www.urbangreenbluegrids.com).

The social participation in the local energy enterprises, cooperation with the business environment leads to the development of the citizens' awareness in the fact that the energy policy conducted by a commune forms an important part of everyday life of a local community.

4. Implementation of sustainable energy systems on a local scale

A number of models and concepts have been developed with the purpose of implementing the idea of sustainable energy systems on a local scale.

One of such concepts is called *Smart City*, whose operation is determined by the idea of development of cities in the direction of sustainable well-being of the citizens living in the conditions of environmental comfort and being self-sufficient in selected aspects, including, e.g. energy and food production, waste disposal (www.smart-cities.eu). This goal can only be achieved as a result of realizing adequate procedures associated with the procedures applied for management in the city, and based on the active involvement of the local community and local businesses.

Another idea is called *Green City Building*, and it originated with the purpose of creating a model of managing urban systems accounting for the policy of sustainability. As part of this project, a local strategy was developed for the purpose of implementing sustainable building engineering and set of rules to be applied for the issue of *Green City Building Certificate* that can be granted to cities, in which urban development occurs in accordance with the principles of the sustainability (Jarzemska et al., 2010: 11).

The implementation of the vision of the sustainable energy supply that is based on the economic, social and ecological aspects needs to involve steps aimed at the integration and comprehensive approach to these types of ventures, and the achievement of the projected goals requires realization of long-term and staged tasks.

The development of the concept, implementation and monitoring of activities by communes can be aided by the specialized subjects, whose role is concerned with the energy consultancy and consortiums and energy associations created with such a purpose.

For purpose of illustration, the schedule of activities of the energy consultancy firm *Energiewende* throughout implementing a sustainable energy system in a commune is presented

in Fig. 2. The first phase of the project – an analysis of the electricity and thermal energy demand – is undertaken, coupled with the potential energy resources and real possibilities for using them in a commune. This is followed by the development of an individual concept with regard to the development of the local energy policy that is adapted to the requirements of the commune and largely based on the locally accessible RES.

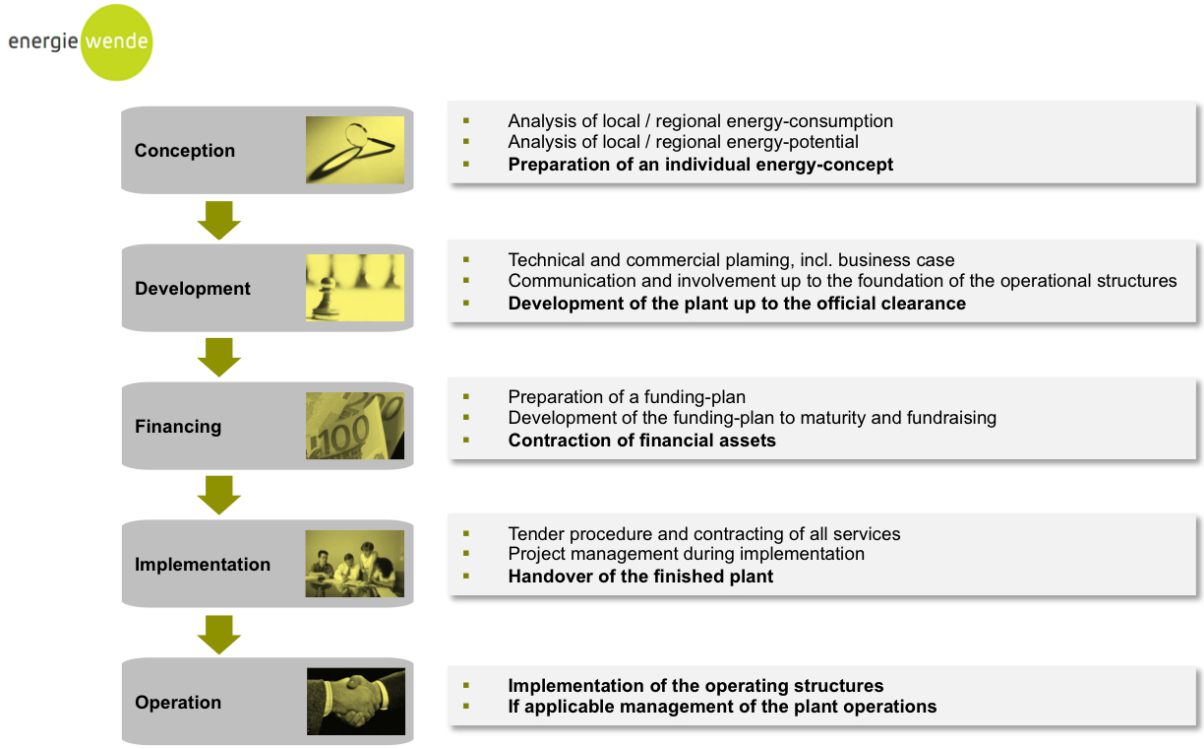

Figure 2. Schedule of actions followed throughout the implementation of the concept of sustainable energy economy on a local level in accordance with standards of *Energiewende*

Source: Energiewende GmbH

The realization of the activities is undertaken so as to improve the energy efficiency and to apply new solutions in terms of the use of technology.

The task of coordinating the realization of such a venture, it is indispensable to establish an adequate organization structure with the purpose of an effective management of the overall system not only at the stages of the design and implementation, but also throughout the normal operation of the system.

For these purposes, energy communities are established (Zdravko et al., 2010: 26), along with the centers, whose purpose is to manage energy (Energiewende GmbH) or, alternatively, energy associations are formed, through which local authorities, non-governmental organizations, investors, business people and members of the local community can cooperate with the purpose of developing a sustainable energy policy of an individual commune.

It is also recommended to include local scientific units in such activities with the purpose of gaining support with regard to the selection of technology solutions and application of new technologies.

An important aspect in the realization of this type of enterprise is associated with the possibility of exchange of experience and know-how in the area of the effective energy use of environmental protection as well as dissemination of good practices in this area. This type of cooperation can be realized on a level of communes, national and world communities, whose examples include actions aiming at the diffusion in the initiative of sustainable development.

It is also noteworthy to mention the *Covenant of Mayors* initiative (an agreement of city mayors) (www.eumayors.eu), which is an idea that involves towns and cities across Europe followed with the purpose of conserving the climate, and the *City_SEC* project (City – Sustainable Energy Communities) (www.citysec.eu), whose aim is to support the authorities on the local and district level with regard to the sustainable energy economy, with regard to companies and institutions as well as on the level of individual households.

Other activities in this regard include the *MODEL* and *Energy Cities* projects. The addressees include new EU member states, western Balkan countries and Ukraine and are intended with the purpose of narrowing the gap in the development of the energy sector that separates them from the original members of the EU. The *Energy Cities* project now includes 1000 members from 30 countries located across the world, along with the local energy companies and associations and energy companies owned by commune authorities (http://www.citysec.eu). In Poland, the access to the project was initiated by the town of Bielsko-Biała and the Association of Municipalities Polish Network *Energie Cités* grouping together 29 towns across the country (www.pnec.org.pl).

Local energy forums are organized with the objective of the experience exchange and implementation of Sustainable Energy Action Plan (SEAP). They are organized with the aid of the Association of Municipalities Polish Network *Energie Cités* in 6 communes (Niepołomice, Dzierżoniów, Bielawa, Raciechowice, Władysławowo i Ełk) as these localities are involved in the realization of the *Energy for Mayors* project. The scope of actions followed in the particular initiatives, a list of good practices was developed so as to promote the implementation of the idea of a sustainable city.

5. Conclusions

The development of energy management systems forms a considerable challenge in the context of sustainable development over the next decades in terms of the technical, social and

economic aspects. The implementation of such systems will be possible as only a result of the use of locally accessible energy sources.

The social awareness regarding renewable energy sources constantly increases in the Polish society. Nevertheless, it is necessary to develop measures so as to ensure that people can participate in the benefits as well as see the savings and profit potential resulting from the use of the local energy sources. This is particularly relevant for the development of rural areas which form small communities as the energy trade in them can contribute to the local added value. This aspect needs to attract financial support and ensure law stability in a process in a legal and institutional frameworks for disperse energy generation in Poland. We can note the progress potential of the funding offered within the framework of national financial support programs, as well as local support initiatives such as Rural Development Programs.

An important role in the propagation of the idea of energy autonomy is played by the experience exchange forums forming energy clusters and created so as to promote innovative solutions. Good practices in this field are implemented as a result of the synergy effect achieved by the involvement of local businesses, business environment institutions, local authorities and research centers. These projects are usually connected with the implementation of projects conducted with the purpose of developing local energy infrastructure, such as creating energy villages and local energy islands. These initiatives can demonstrate clearly to the inhabitants and local authorities the benefits which are offered by successful solutions.

Recently, we have been facing a dynamic development of energy clusters in Poland as the country already has 50 entities of this kind. This process can contribute to the progress of local autonomous solutions in the energy sector that are not limited to energy villages, but extend to projects involving areas such as towns, communes and even residential districts.

We have to face the fact that decentralization of the energy sector forms a long-term process and its driving force is based on the stability and transparency of the legal environment strengthened by the adequate financial support systems. Nowadays we can note that the promotion of the local sustainable development in the energy sector can lead to the improvement of the energy self-sufficiency and promote the activation of local communities, institutions and businesses.

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ROLA ODNAWIALNYCH ŹRÓDEŁ ENERGII W ROZWOJU ZRÓWNOWAŻONEJ GOSPODARKI ENERGETYCZNEJ NA POZIOMIE LOKALNYM

Streszczenie

W pracy omówiono innowacyjne rozwiązania w zakresie lokalnej gospodarki energetycznej opartej na aspektach ekonomicznych, społecznych i ekologicznych.

Przeanalizowano główne elementy zrównoważonego gospodarowania energią, w tym możliwości rozwoju lokalnej infrastruktury energetycznej ze szczególnym uwzględnieniem wykorzystania odnawialnych źródeł energii. Omówiono innowacyjne rozwiązania energetyki lokalnej w aspekcie ich możliwości adaptacyjnych do adaptacji do warunków polskich. Omówione zostały czynniki wpływające na rozwój lokalnej energetyki. Szczególną uwagę poświęcono inicjatywom angażującym lokalną społeczność w rozwój energetyki odnawialnej oraz sposoby implementacji rozwiązań na przykładzie rozwiązań istniejących w Europie.

Słowa kluczowe: zrównoważona energetyka, odnawialne źródła energii, energetyka lokalna.

Kody JEL: P18, Q42, Q55

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