Microinstallations Based on Renewable Energy Sources in the Construction Sector

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Abstract. The focus of this paper is on the status and prognoses of the use of microinstallations based on renewable energy sources to supply heat and power. The technologies that have been important in Europe and Poland for microgeneration of electricity include photovoltaic systems, micro wind turbines and co-generation systems. Solar collectors, heat pumps and biomass have also been used to generate heat. Microinstallations for renewable energy sources represent the initial point and the foundation for the development of micro networks, intelligent networks and the whole prosumer energy sector.

1. Introduction
The concept of microinstallations for renewable energy and the related definition of the prosumer have become the focus of explorations of producers and consumers in the European Union and Poland, especially in the last years.

According to the Polish standards, microinstallation is a renewable energy source with the installed electrical capacity not exceeding 40 kW and in case of heat the boundary is 200kW. Prosumer is a natural or legal person, or an organizational entity without legal personality and being an energy producer in the microinstallation used to consume it for internal needs or for sale.

With the whole array of technological solutions present in the market, there is no household, agricultural farm or a small business that would be unable to use at least one type of microinstallation of renewable energy sources. Development of microinstallations and prosumer energy is inherent in the construction sector. Especially in the new model of the energy sector, buildings can be transformed into heat installations, combined heat and power plants and green power plants. Widespread implementation of energy technologies in the field of distributed energy sectors with other subsystems will allow for creation of local electrical power systems, which will translate into the reform in the whole electric power sector and popularization of its prosumer character. Initial analyses have demonstrated that development of distributed generation should contribute to the development of local communities (greater role of local governments, new workplaces etc.) [1, 2].

2. Renewable energy in civil engineering
The construction sector is the biggest industrial employer in the EU that generates 20% of the GDP and 40% of consumed final energy according to Eurostat [2, 3, 4]. There are over 190 million buildings in the EU that represent candidates for transformation into micro power plants. Analyses performed in e.g.
the photovoltaic energy sector showed that 15% of roofs and façades in the EU can be directly equipped in photovoltaic cells and PV modules. Consequently, the capacity of the PV systems installed on the buildings in the EU would reach 1.5 TW and would allow for nearly 40% of total demand for electricity in the EU. The costs of construction are significantly determined by energy consumption and costs of its generation. Therefore, one of the major tasks at individual stages of construction of buildings is reduction in consumption and searching and utilization of the cheapest and most environmentally-friendly sources [3, 4].

The energy consumed in the building is divided into:

- embodied energy i.e. energy accumulated in the building during its construction in the form of energy consumed for production of materials, transport, embodying processes and energy needed for repairs and maintenance,
- operational energy, i.e. energy consumed during the use for heating, ventilation, air conditioning, lighting and energy consumed to prepare meals,
- processed energy, that is, energy needed for the demolition of buildings and waste management.

![Figure 1](image)

**Figure 1.** Structure of energy consumption in the technological life cycle of the building, author's own elaboration based on [3, 4]

Figure 1, which illustrates the structure of the energy consumption balance in the building life cycle, reveals that the most important type of energy is the energy connected with using the building, representing 83% of total energy. The embodied energy, which concerns manufacturing of materials, transport, construction and repairs accounts for 15.7%. With the level of 0.4%, the energy balance is closed by the energy connected with using the building at the end of building life [3, 4].

3. Evolution of the development of microinstallations of renewable energy sources

Microinstallations of renewable energy sources represent the initial point and the foundation for the development of microgrids, smart grids and broadly understood prosumer energy sector. Prosumer energy sector requires a period of incubation and is implemented into the energy systems with stages.
These stages, being the steps to popularize prosumer energy using intelligent energy environment, can be formulated in the following manner:

1) development of technologies that utilize renewable energy sources,

2) transformation of building owners into prosumers and transformation of buildings into micro power plants with microinstallations,

3) development of new technologies for periodical storage of energy and using them in microinstallations,

4) utilization of internet technologies i.e. energy internet, for exchange of energy between prosumers (buildings) and sharing the surplus energy,

5) popularization of intelligent networks of supplying power to buildings.

Figure 2. Evolution of consumers into prosumers using microinstallations of renewable energy sources and their use in intelligent management of energy supply [2]

Figure 2 presents the role of microinstallations based on renewable energy sources in broader technological and market environment and their evolution with technological advances that take into consideration social expectations. It is hard to imagine construction and development of intelligent energy systems and prosumer energy sector without these installations. However, on the other hand, the most of microinstallations cannot be developed to a larger scale, nor go beyond individual applications without friendly social environment (civil energy sector), technological advances in the field of energy grids and proper model of the energy market with the space for prosumer energy sector.

4. Renewable energy in the EU

One of the most important components of the energy and environmental policies of the EU, with Poland being its member, is to improve energy efficiency and increase the contribution of renewable sources of energy to its total use. The European Council (including the representatives of Poland) adopted new objectives in March 2007. This policy was reflected by the climate and energy package and 20-20-20 plan. Within the internal market and compared to 2005, the European Union agreed to meet the following targets by 2020:

- reduce CO₂ emissions by at least 20% or 30% if other countries of the world join this obligation,
• increase production of energy from renewable sources to 20% in the primary energy balance and increase biofuel contribution to 10%,

• limit energy consumption by 20%.

Percentage energy contribution in total energy consumption in the European Union countries is planned to be reached by 2020 (light stripes) and those achieved in 2015 (dark stripes) are presented in figure 3, [5]. It can be noticed that these levels differ significantly. The figure shows that the adopted levels of obligations in 2020 range from 10% for Malta to 49% for Sweden. In this comparison, Poland, with its obligation of 15%, is situated in the middle of the EU countries. The obligations adopted by the European Union result from the analyses and negotiations concerning previous contribution of renewable energy to its consumption in individual countries. Furthermore, during determination of the obligations, the resources and availability of individual renewable sources, and potential and status of socioeconomic development of individual EU countries were taken into account.

The chart concerns all 28 EU countries. Level of goal achievement in 2015 by individual countries is marked by the dark stripes. For example, the contribution of the renewable energy in the Netherlands and UK in energy consumption was 5.8% and 8.2%, respectively. The opposite places of the ranking were taken by Finland (39.3%) and Sweden (53.9%). This contribution for the whole European Union was 16.7%.

Figure 3. The percentage contribution of renewable energy in gross energy consumption in the EU countries in 2015 and the obligations adopted for the year 2020 [%], author's own elaboration according to [5]

With the new system, development of the utilization of renewable energy sources was accelerated in the EU countries. Analysis of annual increases in the energy from renewable sources reveals that most of the countries meet the obligations adopted for the year 2020. As a whole, the European Union will reach the adopted level of 20% and the obligations not met by certain countries will be compensated by those exceeding the limits, such as Sweden or Finland.
5. Microinstallations based on renewable energy sources in Poland by 2030.

As a separate market segment, the microinstallations based on renewable energy sources have become an element of the national energy strategy when the National Action Plan on Renewable Energy Sources was adopted by the Polish government. The National Action Plan stipulates the technological path of development of renewable energy sources by 2020. To this date, this plan represents the only formal basis for planning of the development of the market of microinstallations in Poland as a component of the renewable energy. The National Action Plan defines that by 2020, contribution of energy from renewable sources to final gross energy in Poland should increase to at least to 15% [6]. The document also defines indirect and sector-based objectives for power engineering (19%), heat and cooling sector (17%) and transport (11%).

In 2015 in Poland, around 300,000 people (termed prosumers) produced energy using the microinstallations of renewable energy sources. These were mostly facilities used for heat generation, but microsources for electricity generation are becoming more and more popular. However, the group is too small to counterbalance the large-scale sources based on fossil fuels. Different pattern is observed in the OECD countries. Development of microsources represents the opportunity for growth of the economy and civilization, creation of new workplaces, local entrepreneurship, generation of regional and global incomes or development of the national database of equipment manufacturers.

In Poland, the Institute for Renewable Energy developed “The National Plan for Development of Microinstallations of Renewable Energy Sources by 2030” [7]. This plan focuses on highlighting the opportunities for the use of home microinstallations of renewable energy sources with real path for dynamic development by 2030 based on realistic technological and economic background.

The study also formulates the national technological roadmap for microinstallations of the renewable energy sources that take into consideration small-scale home sources of electricity and heat. It also represents the attempt to extend multi-threaded concepts of development with microinstallations, mainly through inclusion of microsources of renewable energy sources into the priorities for energy, environmental, agricultural and socio-economic policies. Furthermore, the development of microinstallations that ensure the synergistic effect with other modernization programs (e.g. thermomodernization, liquidation of low emissions or reduction in greenhouse gases) was emphasized.

The study [7] discussed the technologies based on the division into sources of electricity, heat and co-generation, with the following abbreviations of the names used for further presentation of the results:

- SWPP – small wind power plants (micro wind turbines),
- PV – photovoltaic microsystems,
- SC – solar collectors,
- HP – heat pumps (including geothermal)
- BB – dedicated automated biomass boilers,
- mB and mCHP – cogeneration microsystems using biomass and biofuels (to fuel electricity generation with different external combustion generators)

Selected results of the scenario [7] are presented in Figures 4 to 7.
Figure 4. Structure of the number of prosumers in the market of microinstallations of renewable energy sources in 2015 [7]

Figure 5. Structure of the number of prosumers in the market of microinstallations of renewable energy sources in 2030 [7]

Figure 6. Prognosis of the market potential for microinstallations of the renewable energy sources by 2030 with the division into technologies expressed in the number of installations (dark bars: electricity, light bars: heat), [7]

Figure 7. Prognosis of the market potential for microinstallations of the renewable energy sources by 2030 with division into technologies in [MW] installations (dark bars: electricity, light bars: heat), [7]

Figure 5 shows the changes in the structure of microinstallations of renewable energy sources by 2030 compared to the status from 2015 presented in Figure 4. It is estimated that, compared to current situation, the number of investors in electricity microinstallations (PV, SWPP) will be more noticeable. The percentage of electricity microinstallations in the whole microinstallation segment will increase to 50% compared to ca. 1%. In 2030, the number of prosumers will have increased over 10 times, from 0.3 million to 3.6 million of microinstallations in renewable energy sources (see Figure 6). The scenario indicates that the most of new investors can be expected in the case of solar installations (PV and SC). It should be also noted that the contribution of solar collectors (SC) to the structure of microinstallations of renewable energy sources in 2030 will not be as dominant as now, with 61% of all microinstallations (Figure 4).
Total market potential of the development of microinstallations that generate electricity by 2030 in Poland is over 1.8 million of installations (Figure 6) with total installed capacity (SWPP and PV) of 16 GW. Additional 0.5 GW of microgenerations can be installed in rural areas (mB, mCHP) (see Figure 7). The most important installations in heat power microgeneration in 2030 will be biomass boilers (BB) and solar collectors (SC). The above prognoses should be considered as material for further analyses, with their implementation depending on many external factors such as international conditions.

With the most popular underestimation of the importance of prosumer energy, the results should be discussed and confronted with the prognoses for other countries. Micropower Europe predicts in its "moderate" scenario [8] that the number of microinstallations will have increased to 50 million by 2020. The prognoses by the experts working at the request of the UK’s government showed [9] the number of installations by 2020 reaching 13 million. Even more optimistic scenarios for the development of microinstallations are presented in the USA. Rocky Mountain Institute (RMI) estimates in their long-term energy prognosis [10] that the installed capacity in the distributed power sector in the USA will reach ca. 1000 GW by 2050, with 700 GW in home (roof) PV microinstallations and 250 GW in distributed wind power sector.

6. Opportunities and threats for new microinstallations

Widespread implementation of energy technologies in the field of distributed energy sectors with other subsystems will allow for creation of local electrical power systems, which will translate into the reform in the whole electric power sector and popularization of its prosumer character. Initial analyses have demonstrated that development of distributed generation should contribute to the development of local communities (greater role of local governments, new workplaces etc.). Among potential benefits are [1, 2, 3, 7]:

- use of the technologies based on renewable energy sources;
- use of ecological sources and easily available sources;
- reduction of the effect of bigger system failures;
- development of local energy policies;
- creation and development of local energy markets, development of local governments;
- improvement in quality parameters of electric energy and, consequently, improvement in level of services for final consumers;
- avoiding or postponing the modernization or extension of power transmission lines;
- reinforcement of ties between science and industry: the need for development and implementation of new innovative technological solutions and education of modern and competent engineering staffs (transfer of technology and knowledge);
- stimulation of development of new sector of the economy (power microgrids with organizational and technological facilities);
- achievement of the goals of 20-20-20 policy and other energy and environmental directives in the European Union;
- active participation of the recipient in the energy market.

The above presented benefits show that development of distributed generation might facilitate functioning of individual regions of Poland not only from technical but also from social point of view and, consequently, translate into improved level of living of Polish society. Distributed generation allows for implementation of the basic principles which are a priority for the economic development of each country, with particular focus on the energy policy, including energy independence, which has become a key problem today.
However, there are a number of barriers of economic, technological, organizational and legal nature that inhibit development of distributed supply of energy to consumers-prosumers. The key problems include [1,2,3,7]:

- insufficient technological and economic maturity of renewable and alternative manufacturing technologies;
- risk of destabilization of the energy system assuming high share in energy balance of unstable energy sources;
- lack of detailed guidelines concerning inclusion of small manufacturing units to low voltage grids;
- strong dependency on foreign technologies;
- insufficient share of public resources in financing science, including distribution of public funds (EU) for projects and implementations;
- lack of legal regulations that allow for creation of local energy markets, including the lack of a dynamic system of tariffs;
- insufficient social education in terms of ecology and technology;
- no strong relationships between science and business, without which reconstruction of the national energy sector is impossible;
- reluctance to changes;
- reluctance to reform the energy sector among big manufacturers.

Obviously, this list does not contain all the problems. However, the list shows clearly that the energy revolution is coming, with energy consumers becoming also the producers.

7. Conclusion
In the upcoming years, microinstallations based on renewable energy sources will start playing an important role in the development of the Polish energy sector. The particular importance will be from supplying of electric energy and heat to detached houses located far from big networks of distribution of energy generated in conventional ways. Market barriers, institutional barriers and geographical factors will only delay, for several years, the achievement of full market competitiveness by distributed technologies.

Appearance of great number of prosumers will substantially affect the sector of conventional energy which will be shrinking, whereas investments in distributed sources will become attractive.

The prosumer model, which is becoming competitive for current big manufacturers, creates new business opportunities. Not only production of installations for distributed generation of energy but also their construction and customer service might be the chance for development of local economy and national industry. Prosumers also stimulate development of sustainable energy economy, reduce the dependency on consumption of fossil fuels which are harmful for human health and the environment and make the energy sector independent of the centralized manufacturing, exposed to big failures of the whole system.

The serious challenge for the state is to prepare legal regulations to ensure harmonious development of prosumer energy sector and its coexistence in common centralized European market. The role of non-government organizations and analytical centres should be to increase social awareness of potential of prosumer energy and stimulate the debate among decision-makers and society about the role of prosumers in sustainable economy of the future.
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