Do the Polish Energy Clusters Have a Chance to Become Units Independent from External Energy Supplies and Can They Operate as Self-Financing Bodies?

Anna WIKTOR-SUŁKOWSKA[1)]

[1)] Ph. D. Eng.; AGH University of Science and Technology in Kraków

http://doi.org/10.29227/IM-2018-02-16

Abstract

The Kyoto Protocol, the 3x20 Energy Package, Paris Agreement and the Winter Package are regulations which have imposed a requirement for their signatories to reduce CO2 emissions, through a reduction in energy production from conventional sources in favour of production utilising renewable energy sources (RES) and increasing energy efficiency. One of the ideas to meet these requirements is to create energy clusters that would serve as local power generators, where energy production is mainly based on RES. The idea is to build energy clusters which will become self-supporting bodies independent from external energy supplies and funding sources.

In this article, the author illustrates the current situation of energy clusters in Poland and, using analytical calculations, presents the premise underlying the expected synergy effect in clusters. Finally, the author attempts to answer the question of whether it is possible to build ideal energy clusters, which will become self-supporting bodies independent from external energy supplies and funding sources.

Keywords: energy clusters, synergy effect, sustainable development, energy prices

Submission date: 13-09-2018 | Review date: 20-10-2018

Introduction

The Kyoto Protocol and the 3x20 Energy Package are instruments which have imposed a requirement for signatories of these agreements to reduce the levels of energy production from conventional sources in favour of production utilising renewable energy sources (RES). In 2016, the so-called "Winter Package" was published, being a set of regulations which further reinforce the objectives of the 3x20 Package. [1] The EU Member States have committed to reduce by 2030 their internal greenhouse gas emissions by a minimum of 40% [40% is the average value; emissions are expected to be reduced by 43% in the emission-trading sector and by 30% in units outside this sector.] (from the 1990 level), increase the RES energy output by at least 27%, and improve energy efficiency also by a minimum of 27%. Accordingly, Poland decided to comply with the objectives of the climate policy by, inter alia, adopting the concept of distributed energy generation which stipulates the building of local energy clusters. [2]

In this article, the author briefly outlines the current situation of the Polish energy cluster sector, uses analytical calculations to present the premise underlying the expected synergy effect in clusters, and attempts to answer the question of whether clusters are capable of becoming self-supporting bodies independent from external energy supplies and funding sources.

Energy cluster

The concept of 'cluster' understood as the merging of units aimed to attain the effect of synergy has been a relatively recent (from 2008) topic in the Polish literature. As regards the term 'energy cluster' itself, it was introduced to the Polish legal order in 2016 along with the amendment to the Act on renewable energy sources [3]. The Act defines 'energy cluster' as a civil-law agreement, the parties to which may include natural persons, legal persons, scientific units, research institutes and local-government units. The agreement concerns the production and the balancing of demand, distribution of or trade in energy from renewable sources or other sources or fuels, within a distribution network with a rated voltage of less than 110 kV. An energy cluster should operate across an area not exceeding the borders of one district (powiat) or five communes (gminas).

Energy clusters are to serve as a tool aiding the development of the distributed energy generation concept which in turn is designed to safeguard the energy security of small areas and hence, ultimately, contribute to the growth of local economies. By definition, energy clusters are to be environment-friendly by creating optimum organisational, legal and financial conditions that will enable the deployment of the latest technologies, while accounting for the availability of local resources and the potential of the national energy industry. [4] [5] [6]

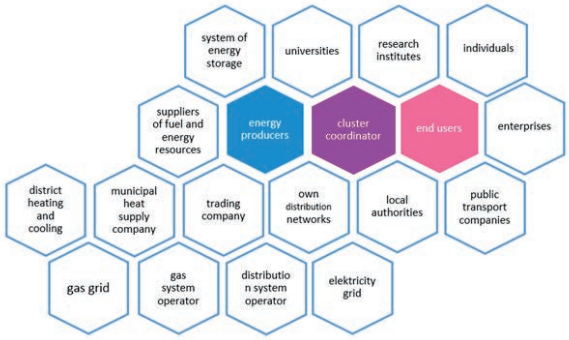

Fig. 1. Detailed diagram of an energy cluster. Source: own elaboration
Rys. 1. Rozbudowany schemat klastra energii

Furthermore, clusters are to foster the emergence of regions that will be self-sufficient in respect of energy production and provided with efficient networks and low prices of energy and distribution. Clusters will also promote the growth of RES and hence contribute to improved quality of environmental compartments at the regional and national levels. Finally, they are to help local economies develop by encouraging investors to put in their money and, as a result, stimulate the growth of technologies and new jobs.

Energy clusters in Poland

Although energy clusters have been present in Poland for some time, it was not until four years ago that they assumed a more prominent role. In May 2018, the Ministry of Energy awarded pilot cluster certificates to 33 concepts (out of 115). The title of leader in this field went to the Czorsztyn Reservoir Energy Cluster. The following ten projects earned special distinctions: the Białogard Energy Cluster, energyREGION Michałowo, the Karkonosze Energy Cluster, the "Żywiec Energy of the Future" Cluster, the Serce Podhala Cluster, the "Zielone Olecko" Renewable Electric and Thermal Energy, the Siemiatycze Energy Cluster, the Słupsk Bioenergy Cluster, and the Zgorzelec Cluster for the Development of Renewable Energy Sources and Energy Efficiency [The list of projects is available on the website of the Ministry of Energy [4]]. With a certificate from the Ministry of Energy, clusters can apply for funding in competitions organised specifically for them under the "Infrastructure and Environment" Operational Programme.

Some of the clusters have already been launched, while others are still being built or expanded. Every cluster is different in terms of cooperating units, territorial coverage and energy generation methods. The legislator has intended for energy clusters to utilise RES-based energy, and this indeed is the case, e.g.:

- the Czorsztyn Reservoir Energy Cluster uses a hydroelectric power plant as its primary source of operation;
- the Białogard Energy Cluster is to produce electricity with the aid of a wind power plant, photovoltaic panels, a biogas plant, and highly-efficient cogeneration facilities utilising natural gas from local extraction;
- the "Serce Podhala" Energy Cluster generates energy from geothermal sources;
- energyREGION Michałowo – photovoltaic panels;
- the Karkonosze Energy Cluster – geothermal sources and photovoltaic panels;
- the Słupsk Bioenergy Cluster – a wind power plant, photovoltaic panels, and a biogas plant.

The synergy effect in energy clusters

In this chapter, on the basis of The concept of operation of energy clusters in Poland [7], we will first analyse the energy balance of a sample cluster and then discuss the synergy effect. For the purposes of this paper, we have discussed a cluster which uses three hydroelectric power plants (installed capacity of 820 KW) to produce energy. At this point, it will suffice for the author to refer to only one variant of the cluster, because the aim of that part of the article is presentation of the processes, which make up the synergy effect.

Energy balance

The chart above (Chart 1) presents energy balance in a cluster. Demand for energy rises in the winter and autumn months to drop again during spring and summer. As was already mentioned, in this scenario we are analysing a cluster which produces energy via a hydroelectric power plant. Hence, the highest demand for energy is recorded between February and June, a season with the most intense precipitation. If energy shortages are expected, energy will be purchased on the balancing market; any excess energy will be resold back to the same market. Based on the chart above, it can be presumed that the cluster in the period from February to June would be capable of producing enough energy for its own needs. Even so, however, such a cluster could

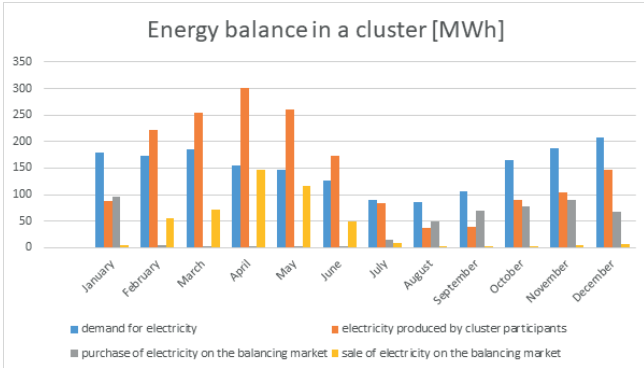

Chart 1. Energy balance in a cluster. Source: own elaboration on the basis of data [7]
Wyk. 1. Bilans energetyczny w obrębie klastra

not operate as a self-sufficient body due to a negative balance of the purchase and sale of energy on the balancing market.

Synergy effect

The calculations assumed a 1000-member sample of end users, all in the G11 tariff group, with 1806.29 MWh of annual demand for electricity. Electricity generated by prosumers outside the cluster is sold at PLN 167.36/MWh; electricity generated by the cluster members is sold to the cluster coordinator at the 'reference price' of PLN 204.94/MWh which is the arithmetic mean of the purchase price paid by the end user for electricity outside the cluster within a tariff or the seller's price list, and the competitive market price published in quarterly intervals for the most recent interval by the President of the Energy Regulatory Office. The coordinator then sells electricity to end users in the cluster for the price of PLN 327.4/MWh.

The perspective of energy producers

It was assumed that the producers would be able to generate 1801.43 MWh. If they sold this amount of electricity outside the cluster, their yearly revenue would equal

*1801.43 MWh * PLN 167.36/MWh = PLN 301,487.32*

if they sell the same amount in the cluster at the reference price, their revenue will be

*1801.43 MWh * PLN 204.94/MWh = PLN 369,185.06*

As a result, by selling electricity in the cluster, they will earn an extra PLN 67,697.32

Coordinator

The coordinator purchases electricity from its producers at the reference price of PLN 204.94/MWh and sells it to end users for the price of PLN 327.4/MWh

*1806 MWh * PLN 327.40/MWh – 1801.43 MWh * PLN 204.94/MWh = PLN 222,099.33*

This will be the profit once the supply-demand needs are balanced within the cluster.

Including the purchase of missing energy on the balancing market, valued at PLN 16,697.20, the coordinator will make a profit of PLN 205,402.13.

End users

For electricity alone, end users in the cluster will pay more. Outside the cluster they would pay

*1806.29 MWh *PLN 271.12/MWh = PLN 489,721.34*

as compared to PLN 591,379.35 in the cluster. In this case they will incur a loss of PLN 101,658. The price of energy, however, is not made up solely of the price of electricity, but also of distribution.

$$D = S_{st} * L + S_{zm} * E + Sj * E + So * L + SOZE * E + O \quad (1)$$

S_{st}	– fixed component	PLN/month	5.34
S_{zm}	– variable component	PLN/MWh	181.5
Sj	– qualitative rate	PLN/MWh	15.4
Sp	– transitory fee	PLN/month	8
Soze	– RES fee	PLN/MWh	0
O	– subscription fee	PLN/month	0.47
L	– number of months		12

*D = PLN 5.34/month*1000*12 months +PLN 181.5/MWh *1806.29 MWh +PLN 15.4/MWh *1806.49 MWh +PLN 8/month *1000*12 months +PLN 0.47/month *1000*12 months = PLN 521,379*

End users in the cluster will also have to incur the costs of electricity distribution by being charged two fees [This fee will be listed on electricity bills no sooner than in 2021; here, its estimated value is provided in accordance with [7]]: 'power' fee of PLN 42,217.47 and transitory fee of PLN 96,000. The total cost of dis-

Tab. 1. An example of base financial assumptions for the analysed technologies, expressed as 1 MW of installed capacity
Wyk. 1. Bilans energetyczny w obrębie klastra

Technology	Investment outlays (PLN thous.)	Residual value after 15 years (%)	Cost of fuel (PLN thous./year)	Cost of commercial balancing (PLN thous./year)	Other operating costs (PLN thous./year)
Agricultural biogas plant <1 MW	14 500	15	1 700	25	500
Wind power plant < 5 MW	6 500	15	0	35	110
Hydroelectric power plant < 5 MW	14 500	40	0	35	350
PV installation < 2 MW	4 000	20	0	10	85
Geothermal heating plant	4 650	20	0	0	0
Solar collectors < 2MW	2 000	15	0	0	11

Source: [7]

tribution will amount to PLN 138,217.47. The end user will save PLN 383,161.53 on the distribution of electricity. Taking into account the final financial result for the end users of electricity, membership in the cluster will bring them savings of PLN 281 503.53 over a period of one year.

All in all, this brings about gains for every member of the cluster. Producers can sell their energy for prices over 20% higher than the prices outside the cluster. In this scenario, the coordinator, as the body appointed specifically for cluster-related purposes, gains PLN 205,402.13 annually. End users receive energy cheaper by more than 27%.

Costs related to the operation of energy clusters

The calculations above demonstrate the internal mechanisms of the cluster, but they do not count in the costs of initial capital and the operating costs associated with the maintenance of the entire cluster infrastructure. Table 1 shows the estimated values of investment outlays and operating costs.

The data shown in the table suggest that the launching of each of the energy-generating sources requires substantial investment outlays. These outlays can be partially covered by subsidies. For this year, the Polish government has planned to earmark EU subsidies (loans – A loan to cover up to 85% of eligible costs. The interest rate is 0%. It will also be possible to have the debt remitted up to 50% of eligible costs.) for such projects under the National Fund for Environmental Protection and Water Management, the Infrastructure and Environment Operational Programme, Sub-measure 1.1.1. "Support for projects in the field of renewable source energy production and the connecting of such sources to distribution/transmission networks" (competition POIS.01.01.01-IW.03-00-004/18). The funding will be granted for the construction or expansion of RES-based electric or thermal energy cogeneration facilities and the connecting of such sources to a distribution or transmission network offering the highest potential for the reduction of CO_2 emissions. The total amount to be allocated for energy clusters which received the Energy Cluster Certificate from the Ministry of Energy is PLN 50 million.

For clusters recording higher operating costs as agricultural biogas plant, wind power plant and hydroelectric power plant external continous funding will be needed as the profit generated by the coordinator will not be sufficient to cover these costs. In this case, another option to consider in biofuel-based facilities would be the recovery of thermal energy. Also worth considering is the question of how electricity should be distributed, i.e. by means of one's own infrastructure or existing infrastructure, the latter subject to price negotiations.

Conclusion

The very idea of distributed energy generation is an interesting concept which merits attention in light of the laws currently in force and those yet to be enacted. Clusters offer many advantages. They will drive the growth of local economies based on the effect of synergy for the local market actors. Producers will be able to yield higher revenues from the sale of electricity and end users, despite prices higher than on the regular market, will ultimately pay less due to distribution costs being markedly lower than those on the market. The cluster will also feature a cluster coordinator to act as an agent in the trade in electricity between producers and end users. This trade will bring profits also to the coordinator. As of now, the concept of clusters will continue to require attention, because even though the availability of various subsidies to cover investment outlays is already known, it still remains unclear who should cover high operating costs arising from the operation of the cluster. “The concept of operation of energy clusters in Poland” suggests that this task could be taken on by territorial local governments, since the generation of ‘clean energy’ and the resulting improvement in the quality of local environmental components should be matters of concern for them. Clusters, where energy production is based on geothermal, photovoltaic or solar collectors, would be able to cover their operating costs, because they would not be too high. However, one question remains to be answered. Could energy clusters become independent from external energy supplies? The article uses only one example – a cluster producing energy based on a hydroelectric power plant – here it has been shown that there are periods of electricity overproduction throughout the year, but also periods when energy volume is too low to meet the needs of the local population. Each cluster operating on the basis of RES will be an unstable energy source, because wind sometimes does not blow, the sun sometimes does not shine, and, depending on the season, biomass can be missing. Therefore, clusters must have security in conventional energy.

Literatura – References

1. Dąbrowski W., " Winter Package " hits into development of the Polish energy sector," https://www.cire.pl, 09 wrzesień 2018. [Online].
2. Wiktor-Sułkowska A., "Renewable energy sources (RES): Alternative possibilities, which could be implemented in Poland," in 1st international conference on the Sustainable Energy and Environment Development, Cracow, 2016.
3. Act on renewable energy sources 20th of Febuary 2015, OJ 2015 pos. 478 (OJ pos. 925)
4. The Ministry of Energy, „https://www.gov.pl/energia/klastry-energii," 08th of September 2018. [Online]
5. Zhanga X. , Lovatib M. , Vignab I. and others, "A review of urban energy systems at building cluster level incorporating," vol. 230, pp. 1034-1056, 15 November 2018.
6. Howell S., Rezgui Y., Hippolyte J., "Towards the next generation of smart grids: Semantic and holonic multi-agent management of distributed energy resources," vol. 77, pp. 193-214, September 2017.
7. KAPA, WiseEuropa, Atmoterm S.A., KIER, " The concept of operation of energy clusters in Poland 2016. [Online]. Available: file:///C:/Users/Ania/Downloads/3164-koncepcja-funkcjonowania-klastrow-energii-w-polsce.pdf.
8. European Commission, "DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC," European Commission, 23 April 2009.

Czy polskie klastry energetyczne mają szansę stać się jednostkami niezależnymi od zewnętrznych dostaw energii oraz czy mogą stanowić organizmy samofinansujące?

Protokół z Kioto, Pakiet 3x20 oraz Pakiet klimatyczny, są to regulacje które kładą nacisk między innymi na ograniczanie emisji CO2, na zwiększenie udziału OZE w produkcji prądu oraz na zwiększenie efektywności energetycznej. Jednym z pomysłów na wypełnienie tych wymogów jest tworzenie klastrów energetycznych, które miałyby stanowić lokalne spółdzielnie prądotwórcze, gdzie prąd wytwarza się głównie w oparciu o OZE. Klastry energii docelowo miałyby stać się jednostkami niezalenym od zewnętrznych dostaw energii oraz samofinansującymi się.

W niniejszymi artykule autor zobrazował sytuację klastrów energii w Polsce, na podstawie obliczeń analitycznych ukazał zasadę synergii w klastrze, a także spróbował udzielić odpowiedzi na pytanie, czy klastry energetyczne mogą stanowić organizmy samodzielne, niezależne od zewnętrznych dostaw energii oraz niezależne od zewnętrznych źródeł finansowania.

Słowa kluczowe: klastry energetyczne, efekt synergii, zrównoważony rozwój, ceny energii