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Chapter 7
Indicators characterizing local energy systems in naturally valuable areas in the light of the requirements of sustainable development

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Abstract: The purpose of the article is to select and define values the analysis of which would enable an assessment of the direction in which changes in a local energy system in the naturally valuable areas would take place. The analysis was taken from the perspective of the principles of sustainable development. There were suggested indicators that refer to the social, environmental and economic sphere of the analyzed area. Some of the discussed values refer in the same way to all local energy systems, whereas others are essential only for energy systems that function in naturally valuable areas.

Keywords: sustainable development, indicators, local energy systems, naturally valuable areas

Introduction

Sustainable development is presently, at least in the sphere of declarations, the subject of interest for a majority of decision makers on the international, national and local level. However, in order to introduce in practice the principles ensuing from the premises of sustainable development, it is essential to make decisions on the basis of concrete knowledge and reliable information. Such information is ensured by indicators that are elaborated for monitoring changes in various spheres of man's activity. While analyzing the possibilities of realizing sustainable development policy, one needs to remember that the realization of great national goals requires progress in the realization of small local goals. Therefore, the implementation of the principles of sustainable development on the general national and local level ought to be treated on equal terms. Of utmost importance is this requirement in relation to areas with certain characteristic properties which distinguish them from others that are governed by general principles. Such areas include among others municipalities or counties in the regions with naturally valuable areas which constitute a considerable part of the entity's total area. In most

cases the indicators describing changes in energy systems, as regards sustainable development, are elaborated and prepared on the national level. What is overlooked is the analysis of energy systems on the local level, which may lead to taking little notice of those aspects of development sustaining that are important for the local community. A center-oriented approach is in opposition to the premises of Agenda 21, which gives priority to local involvement and pays less attention to the central planning and also demands that local communities ought to be given the possibility to formulate such a policy of sustainable development that is adjusted to the regional expectations [1].

Indicators characterizing local energy systems

It needs emphasizing that depending on the level of socio-economic development of the country in relation to the activities that are conducted in its area on the local level and lead to sustaining development, there arise various expectations and values that will describe these expectations. This requirement also regards the local energy system, which is perceived as a crucial element of sustainable development that is directly related to each of the three basic orders of sustainable development: social, economic and environmental (Fig. 7.1).

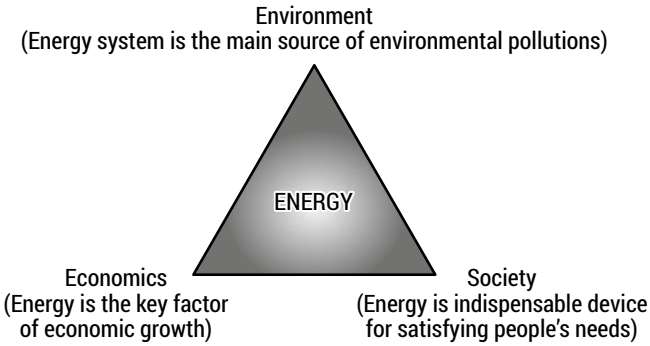

FIGURE 7.1. Relations between energy and sustainable development [2]

It means that while the indicators that are elaborated for national energy systems can be considered as universal on the global level and as capable of describing energy systems of countries on various levels of development and in various social and environmental conditions; the values that describe energy system on the local level require a more individual approach and adjustment to the local needs and requirements. The observations regarding the usage of indicators describing the changes concerning sustainable development show that local communities are not eager to invest in the accumulation of data serving elaboration of indicators as long as they do not

sense the relation between the determination of an indicator as the meter of changes that take place on the local scale and yield noticeable advantages. This gives rise to drawing of the following conclusion: local communities ought to participate at all stages of planning, realizing and supervising of a project, including monitoring of the directions of changes that will take place as the consequence of realizing these projects. In other words, all indicators that are prepared for local needs must be combined with local conditions and need to ensure the possibility of participating in the processes that constitute local inhabitants' reaction to these values. Furthermore, the values that are taken into consideration need to reflect the changes that take place in local environmental and economic conditions. Owing to this, the indicators of development sustaining at the local level can be not only simple meters of advancement but they can also stimulate the processes that lead to the better understanding of environmental, social and economic phenomena[1]. This also concerns the local energy system, which is closely related to economy, environment and local social development.

The aim of this article is to analyze the values that could constitute indicators of development of a local energy system in naturally valuable areas (NVAs) from the point of view of sustainable development. This purpose will be realized through the analysis of those indicators that have been suggested for energy systems until now, by checking their usefulness for the local level and by means of selecting special values characterizing energy systems in naturally valuable areas.

The values selected for the description of both the state and changes in the local energy system ought to be characterized by the following features:

- the data used for determining them needs to be relatively easily available and it has to be obtained from the set of conventionally collected statistical data or collected directly, among others, by means of surveys conducted among the group of energy customers selected in an appropriate statistical way;
- the way of collecting data for determining these values must guarantee their correctness;
- data is simple to interpret;
- data is specified in a relatively uncomplicated way;
- data reflects the main problems of energy systems in naturally valuable areas.

The suggested values that are supposed to indicate the state of a local energy system in the context of the requirements of sustainable development can be divided into three groups, i.e. just as it is done in many publications concerning this issue.

The first group comprises values that describe the relation: energy system – local community. This group must comprise:

1) the number of recorded accidents connected with the functioning of the energy system (measured on the basis of the number of recorded incidents);
2) the total number of hours during which there were interruptions in the supply of water for the reasons depending on suppliers, with division into heat energy and electrical energy (measured on the basis of the number of hours/year);

3) the usage of energy per person and the usage of energy per person in a group of households with the lowest incomes (measured on the basis of the value kWh/year).

The first value among the aforementioned refers to the key concept from the social point of view: safety of service and usage of the local energy system. While analyzing this issue, the value describing the state of energy system ought to be divided into two elements:

- the number of accidents per year during service of energy systems (heat energy and electrical energy) related to the number of workers in energy companies in the departments of service and exploitation (workers directly involved in the exploitation and conservation of devices) (measured on the basis of the number of accidents/worker/year);
- the number of accidents per year among the users of heat and electrical energy systems (that result from their usage) in relation to the number of inhabitants (measured on the basis of the number of accidents/inhabitant/year).

Statistics on the national level usually take into consideration fatal accidents, chiefly for practical reasons. However, the safety of service and usage of energy equipment is influenced mainly by external factors that can reduce the hazard despite the fact that the state of energy devices has not changed[1]. Therefore, the safety state of energy systems is best defined by the total number of accidents. Unfortunately, less serious accidents that do not require a physician's intervention are usually neither reported nor recorded. In opposition to the situation on the national scale, in smaller areas it is much easier to obtain information about all the incidents that require a physician's intervention, which can give a better and more realistic view of the safety of service and of the way the local energy system is used. In the energy system the accidents include mostly scald and electric shock, whereas in Poland there are also frequent cases of carbon monoxide poisoning.

The first factor that has an influence on the safety of service of energy systems is knowledge that workers of energy companies have about the safety principles related to the conservation and exploitation of energy devices and also about the compliance with the accepted procedures of conduct. The second group of factors includes technical factors which, in case of the energy system, include the quality of protection equipment. In case of safety of using energy system the division of factors is generally similar. The first important issue is the users' awareness of the existence of potential hazards and familiarity with the ways of avoiding them. The second essential issue is the technical state of networks and installations as well as the protection equipment existing there. All new installations are made in accordance with the bequests

[1] For example, changing the surface from reinforced concrete to wood surface can reduce the possibility of death in case of electric shock. A change of the surface can cause less serious consequences of an accident, but does not improve the quality of the system itself.

of norms, which ensures the acceptable level of usage safety. There remains the problem of old energy installations which were constructed in compliance with the requirements from the time period in which they were made, owing to which they frequently differ from the modern ones and often require careful and regular conservation and repairs that enable restoring or preserving their good technical state.

An essential element from both the social and economic point of view is reliability of supplying energy for customers. In technical calculations there is a number of statistically determined values that describe unreliability of particular elements of the energy system. There were elaborated also detailed algorithms of theoretical estimation of fallibility of the energy system that are based on the analysis of the system structure. However, these methods are too complex to be universally used with reference to all customers in the local system. It would be better to use such algorithms that enable easier estimation and obtainment of data and at the same time that show what is the essence of the issue of value. Thus, it is recommended to use:

- the number of interruptions within a year per customer or equivalent of this value, calculated as the relation between the number of customer interruptions within a year to the total number of customers (*Customer Interruption*),

or

- duration of the time period within which energy was not supplied per customer, or in other words the relation between the duration of interruptions in the supplies within a year (in minutes) and the number of customers (*Customer Minutes Lost*).

Some customers are more sensitive to interruptions in the supply of energy, however, the division of customers into groups depending on their sensitivity to lack of energy and the determination of the aforementioned values separately for each of these groups considerably complicates the practical usage and interpretation of these values and brings additional difficulties related to the formation of groups and to the classification of customers into each of them. Furthermore, the collection of data is becoming more complicated. From the point of view of supervision of the improvement of the reliability of supplying customers with energy, when it comes to customers on the local level, both the aforementioned values meet the expectations of the analysis of work of the local energy system.

In fact, in all the elaborations concerning the values describing the state of the energy system in the light of the requirements of sustainable development into consideration is given to the participation of expenditure on energy in the incomes of households, which is perceived as the measuring instrument of access to energy and energy services[2]. This value is usually analyzed as the average value for all households in the analyzed area and for a certain group of the poorest households.

[2] Energy service – effect that is achieved thanks to the usage of energy and that serves satisfaction of various human needs. Energy service can be exemplified by the fact that everyone likes to feel warmth at home, and in order to achieve this aim and to make radiators warm, gas is combusted in the central heating furnace. In this case energy service is described as the expected temperature

Two of the aforementioned values have their equivalents in sets of indicators of sustainable development elaborated by international scientific organizations.[3] The values which are suggested as measures of reliability of supplying customers with energy, to a certain degree that does not take into consideration fallibility of the intermission of energy, are reflected for the national level by means of indicators regarding primary energy[4]. These values are modeled in the set of indicators for the energy system in a very wide range and in various configurations, whereas the safety of the functioning of the energy system at the national level from the point of view of hazard to health and life of people is described by means of the indicator defined as the number of fatal accidents in the production chain of energy. Unfortunately, this value does not take into consideration accidents among people who are not workers of energy companies, but are only users of the system.

The second group of values describing the state of a local energy system comprises indicators related to the so-called economic order. It is suggested that the group of these values ought to include:

1) the number of working places existing thanks to the functioning of the energy system in a certain area (measured on the basis of the number of working places/year);
2) participation of the area of energy cultivation in the area with soils of V and VI bonitation level (measured in %);
3) participation of local resources of energy in the total amount of used primary energy (measured in %);
4) usage of energy per capita in relation to the average amount of energy used per inhabitant in the country (measured in %);
5) efficiency of the local energy system (measured in %);
6) participation of energy produced from renewable primary energy in the total amount of energy used in the local energy system (measured in %);
7) participation of energy fraction of wastes used for energy-related purposes (measured in %);
8) participation of disposed wastes in the entirety of produced hearth wastes (measured in %);
9) participation of centralized energy systems in the production of heat energy (measured in %);
10) energy consumption in economy (measured in kWh/PLN);
11) average unit cost of electrical energy (measured in PLN/kWh) and heat energy (measured in PLN/GJ).

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in the building. Usually this temperature is approx. 20°, which is satisfactory for a man to feel comfort in terms of warmth. Another example is the possibility of watching television thanks to supplying electrical energy to the TV set.

[3] International Atomic Energy Agency, United Nations Department of Economic and Social Affairs, International Energy Agency, Eurostat, European Environment Agency. Energy indicators for sustainable development: guidelines and methodologies. Vienna: IAEA; 2005

[4] Primary energy – energy in the form not transformed by man, e.g. chemical energy of coal, chemical energy of biomass in natural form not transformed into bio-fuel, energy of water stream, etc.

The value which has a considerable impact on the vision of economic life in the analyzed area is the number of working places generated by the energy system. This value can be considered by the division of it into two elements. One of the elements is the number of workplaces found directly in companies related to the energy system, i.e. in plants that produce energy, distribute it, in companies that sell fuels and energy, produce energy devices and transport fuels, etc. The second element concerns the workplaces that exist thanks to the functioning of the energy system, in companies that are not directly related to this system, i.e. in banks, which provide services for companies of the energy sector, in insurance companies and in inland revenues, etc. This value is to a large degree dependent on the structure of the energy system in the analyzed area. If the analyzed values refer to systems in naturally valuable areas (NVAs), where naturally there are no large companies producing energy, the number of workplaces related to the energy system is affected mainly by the structure of produced energy, and especially by the structure of renewable energy. This value will have a greater value if, for example, higher participation in the production of energy will be seized upon by the production of energy using biomass, whereas smaller participation in the local production of energy will be assumed by the wind power station.

In the indicators that were presented in literature with reference to the energy system at the national level, the role of the energy system as the 'generator' of workplaces was not taken into consideration, which is especially important in the regions with areas protected by law. It implies limitations in running economic activity and thus increases a potential threat of unemployment.

Another value describes the impact of the energy system on agriculture management and concerns the area of energetic cultivation. A local energy system which makes use chiefly of biomass could contribute to the increase in the potential of local agriculture. In general, energetic cultivations are of extensive type – i.e. they do not use large amounts of fertilizers because chemical substances included in the process of energetic combustion of plants would create exhaust fumes and these would pollute the environment. On the one hand, such agriculture would reduce the demand for forest biomass, and on the other hand, it would give the possibility of farming production that yields profits and ensures local development of industry related to the production of various types of biofuels. However, it needs emphasizing that the cultivation of energetic plants ought to take place on soils of low bonitation level. Plantations of energetic plants on soils which would guarantee good harvests of products serving consumption by people would be in opposition to the principles of sustainable development.

Participation of local resources of primary energy, measured in per cents, in the total amount of primary energy used within a year describes the potential and state of using local energy resources. An alternative for an indicator formulated in this way would be the simultaneous usage of two other values:

- amount of primary energy obtained from the outside of the analyzed area in relation to the total amount of primary energy used within a year (measured in %);

- amount of energy produced on the basis of local energy resources in relation to the technical estimates of local energy resources (measured in %)[5].

An advantage of the suggested first version of indicator is the presentation of the issue using one value, whereas the drawback is that the value of the indicator depends on natural energy resources in a certain area, which is not directly reflected in the indicator, whereas energy potential in terms of primary energy does not depend on the adopted energy policy. The usage of the two aforementioned values enables to describe the situation in a more precise way, but also increases the number of values which also need to be analyzed, which makes it slightly more difficult to use them in practice.

The amount of energy used annually per 1 inhabitant (kWh/inhabitant/year) is the universally used value that describes the level of economic growth. In the suggested set of values this indicator was modified and the average amount of energy used per 1 inhabitant in the analyzed area was referred to the average amount of energy that was used per 1 inhabitant in the country. While analyzing this coefficient, it is necessary to become aware of the fact that the value that is lower than 1 does not necessarily mean a worse level of economic growth. In the present level of global economy development it frequently means that in the analyzed area there are used modern technologies in which the added value is created by the technical idea, and not by the energy placed in the product.

A definition needs to be formed for the value that is termed as the efficiency of the local energy system. It is defined as the relation between the energy used by the energy customer to the primary energy introduced into the system (in the form of an abstract fraction or in per cents). The efficiency of the local energy system is affected by the following factors: the degree of energy consumption of the processes of transforming primary energy into fuels; the efficiency of transforming fuels into heat or electrical energy; and the efficiency of sending energy to customers. From the point of view of a sustainable energy system, it would be more beneficial if the numerator of this coefficient included a certain amount of useful energy used by energy customers that would transform it into energy services, which would require knowledge of what is the efficiency of receiving devices functioning in the system. Unfortunately, it appears that in case of statistical information that is presently available, the calculation of an indicator formulated in this way is virtually impossible.

The essence of why the efficiency of the energy system is so essential from the point of view of sustainable development results, among others, from the fact that greater energy efficiency of a system, on the one hand, implies lower usage of non-renewable primary energy, and lower short-term marginal costs of supplying energy to customers,

[5] Technical local energy resources – energy resources that can be used with aid of available technologies of obtaining and transforming them.

which at the same time constitutes a recommendation to set lower prices of energy. On the other hand, higher efficiency of the energy system also implies lower influence on the environment, especially in the subsystem of producing energy.

The expressed in per cents participation of energy produced from renewable primary energy in the total amount of energy used in a local energy system in principle does not require any comment owing to the fact that this value is used almost in all elaborations concerning indicators of sustainable energy systems. However, the value that requires explanation is the participation of the energy fraction of waste that is used for energy-related purposes (%). One needs to take into consideration both industrial and municipal wastes which are not subject to recycling. In general, there remains the problem of energy management of municipal wastes that contain: fraction of bio-degradable biomass, fraction of plastic and part in the form of glass, rubble, scrap metal, sand and ash as well as water. The first two fractions are flammable substances that decide upon the possibility of thermal transformation of wastes. This issue has been underestimated so far and the energy fraction of municipal wastes is placed on waste heaps. Hence, this problem has an important economic, social and environmental aspect. Naturally, it needs to be solved on a local scale and is directly related to sustainable development of the local energy system. It was included in the group of values of influence on the economic system because the management of energy fraction of municipal waste is connected with the obligation to make considerable investments related to both the selection of some wastes that can be used for energy-related purposes, and to the establishment of plants serving transformation, etc. Furthermore, the plants of thermal conversion of wastes which use the most advanced technologies, e.g. gasification and finally gas combustion, can become environmentally-friendly objects and constitute an essential element of animating the local economic life.

The universally used indicator of sustainable development of energy systems on the national scale is the per cent participation of properly secured solid waste of the energy system. In this case, solid wastes are considered all the wastes in the fuel chain, starting from the wastes created in the processes of extracting fuels, transforming them and ending with the wastes created in the process of combustion. In case of local energy systems in NVAs there are only wastes in the processes of fuel combustion. There is an attempt to define the indicator describing management of these wastes as participation of properly used or secured solid wastes in the entire amount of wastes created in the local energy system. An essential word in this definition is "used", which means that storing of hearth wastes cannot be perceived as the process that is inextricably linked with the creation of energy because there are such branches of economy in which the material created in the processes of combustion can be only a raw material.

Countries that import coal (Denmark, Finland, the Netherlands) use ashes almost in 100% as the substitute of sand and gravel for building roads, surfaces, parking lots, construction embankments for bedding under pipelines and for filling excavations.

On the other hand, when hearth wastes are not used by economic entities, they become stored in waste heaps where they occupy large parts of the area that is later excluded from farming or forest activity.

The value that was shown in the aforementioned set of values for the local energy system as energy consumption of the economy is defined using the following relation: the amount of energy in kWh to the value of production in PLN. It enables the evaluation of energy processes in economy and the analysis of the trends of changes in the energy consumption of the applied technologies, and of changes in the structure of economy. In the elaborations concerning the indicators of sustainable development of local energy systems, an equivalent of the indicator formulated in this way is the efficiency of particular main sectors of economy, i.e. industry, agriculture, trade and services, and it is set as the amount of energy used per unit of the added value created in each sector. At the local level, owing to a lack of data, the indicator formulated in this way would be hard to obtain.

Improvement of energy efficiency of economy (in other words: reduction in the absorbency of energy) has a multidirectional influence on both the economy and the environment. Lower energy consumption directly results in a lower total value of produced energy, and thus it leads to the lower usage of primary energy (including fossil fuels) and a smaller impact of the energy system on the environment. Still, the achievement of lower energy consumption is most frequently related to the necessity to increase outlays on new technologies and modernizations in economy.

Another indicator, i.e. the price of heat and electric energy for target customers in the suggested set of indicators for local energy systems in naturally valuable areas has a classical form and is defined as the average price of energy for the target consumer (in PLN/kWh for electric energy or PLN/GJ for heat energy or energy included in fuels). The problem with the calculation and interpretation of this indicator is that the prices vary depending on the customer in particular groups (e.g. they are different for industrial customers than for municipal and existential customers). This results in the necessity to observe prices for selected types of customers.[6]

Energy prices constitute a stimulus for increasing consumption, or adversely, they may become an inspiration to save energy. Prices are also the factor that decides upon the availability of energy, and to a large degree affects the cost of production, and, as a consequence, has an impact on the competitiveness on the market. Another form of this indicator for the local energy system would be the relation between the prices of energy in the analyzed area and the average price of energy in the country. The analysis conducted on the basis of such a factor could become a stimulus for the highest possible development of the energy system based on local energy

[6] The issue of energy prices viewed as the indicator of sustainable development of energy systems has at least several aspects that would require explanation. However, this problem is too complex to explain it to a satisfactory degree in this publication.

resources. Prices that are either higher than the country's average or lower than the average in the country can become a factor that hinders socio-economic development in the areas that are characterized by unique natural amenities.

From the perspective of areas that are characterized by unique natural amenities, the participation of centralized systems in the production of energy is particularly crucial because these areas usually comprise villages and small towns, where the participation of individual sources of heat energy is very essential. On the one hand, the percentage of the energy produced in centralized sources is related to the influence that the local energy system has on the economy. On the other hand, it affects the influence that this system has on the local environment. The impact on the economy can be seen in the fact that there exists an industrial company that runs economic activity and sells goods in the form of energy. This company must submit various tasks to other economic entities, needs services in offices, banks, insurance companies, pays taxes in which also local budgets take part. A bulk of the economy's influence does not exist when energy is produced directly by customers in their individual appliances.

During the analysis of the influence of the local energy system on the environment in the naturally valuable areas of significance are such features that are not taken into consideration at the national level. Still, the values that are included in the set of indicators of sustainable development of energy systems at the national level in case of naturally valuable areas are frequently either insignificant or impossible to set on the basis of data that is either available or easy to prepare. Therefore, in the suggested set of values for local energy systems in NVAs there are no values that refer to typical systemic issues at a general national level, i.e. the ones concerning the nuclear energy system. There were suggested values that are related to the structure of the energy system and present their influence on nature in a certain area. Such values are essential in Polish conditions because local energy systems in NVAs might have difficulty in the unification of such values on the global scale. The types of problems related to energy in areas that are characterized by high natural value vary from country to country, and in Poland they vary from those, for example, in Finland, whereas completely different problems will be encountered in African countries. There will be differences in conditions, and thus also in the values describing the energy system, for example, in naturally valuable areas and in industrialized areas.

The suggested values that characterize the local energy system within the framework of an environmental order of sustainable development include:

1) participation of wood biomass not obtained from plantation in the entirety of the primary energy obtained from vegetal biomass used for energy-related purposes (measured in % of energetic value (i.e. GJ/GJx100%);
2) amount of created hearth wastes per unit of energy (measured in kg/kWh);
3) amount of emitted air pollutions in relation to created energy (kg/kWh);
4) area of clearings in forests in which power lines are placed in relation to the length of power lines (measured in ha/100km) (or another mechanical intrusion in the environment that is related to the construction and exploitation of energy devices);

5) difference in the level of pollutions in selected neuralgic spots in the summer and winter season in relation to the total consumption of primary energy in the given area (measured in kg/GJ).

The expressed in per cents participation of wood biomass not obtained from plantation in the entirety of primary energy obtained from vegetal biomass used for energy-related purposes is essential owing to the fact that in Poland in the areas where forest wood is accessible, it is used chiefly as fire-wood, which, from the perspective of the renewable energy system, meets the expectations regarding the participation of renewable energy, whereas from the point of view of natural protection, it is in opposition to the expectations. Additionally, part of biomass from forests is obtained in the form of illegal collecting. However, this problem is not as serious as in other countries, for example in South-Eastern Europe or in other relatively poor countries [4]. The greater the participation of forest biomass in primary energy, the less rational, from the point of view of sustainable development of NVAs, is the management of primary energy in this area.

Two other values referring to the relation between the energy system and the environment are listed in many other elaborations concerning this issue in the form of the absolute amount of created pollutions. As suggested in this elaboration, the creation of air pollutions means successively the amount of sulphur dioxide, nitric oxides, carbon dioxide and suspended dust created during the production of an energy unit. Similarly, a frequently used and almost typical value describing the relation between the energy system and the environment is the amount of created wastes per unit of created energy.[7]

A special value which is practically not used in any other sets of values describing the energy system from the point of view of sustainable development and which is essential for the areas of unique natural value is the area of forest clearings in relation to 100 km of power lines. Energetic lines are frequently in forest areas. They are usually of low and medium voltage. The area of clearings caused by the formation of lines in these areas depends on the length of lines in these areas and on the technology of the line, i.e. on the type of sloops and types of wire.

The difference in the level of pollution in selected neuralgic spots in the summer and winter season in relation to the total usage of primary energy in a certain area presents what is the scale of air pollutions emitted by the local energy system because considerable amount of energy in local energy systems is produced as heat energy for the purpose of heating, frequently in individual furnaces that do not have any environmental protection systems. The indicator showing the participation of individual heating systems in the total amount of energy used in a given area shows what is the scale of the phenomenon, whereas the indicator evaluating the difference between the concentration of air pollution in the winter and summer season assesses the quality of these systems. The indicator in the form of such a difference

[7] International Atomic Energy Agency, United Nations Department of Economic and Social Affairs

well describes the state of the heating system in a certain area, especially in the country where the electrical energy system is largely centralized and the local production of electrical energy is marginal.

The analysis of suggested values shows that it is frequently difficult to unequivocally classify particular values into three basic areas analyzed with reference to sustainable development. The issues related to social and economic development as well as environmental issues are linked with each other and depend on one another. For example, reliability of supplying customers with energy is the issue that concerns both the social and economic sphere. If energy is not supplied to the customers of service and trade branches or to the industrial customer, without energy these customers will incur losses which not always can be retrieved, and there will be losses in energy companies due to smaller sales of goods that they produce, send and sell. On the other hand, there may be losses ensuing from the provisions of contracts signed with consumers as regards the expected infallibility level of supply and penalties resulting from defaulting on contract provisions. In situations where energy is not supplied to municipal and existential consumers, suppliers are not burdened with any contractual penalties; the only consequence is that companies lose incomes due to the reduction in sale, whereas consumers are deprived of the possibility to use energy-related services. In Polish conditions this problem concerns especially urban and rural areas, which are predominant in NVAs, in which there are mainly electrical energy overhead lines characterized by a noticeable relation between the reliability of their work and atmospheric conditions. Frequent interruptions in the supplies of energy constitute a considerable burden for the existence in the contemporary world. Consumers are forced to change their daily habits and face forced and uncomfortable situations. Energy shortages at home result in inactivity as well as in worsening of the conditions of having a recess, and frequently lead to the situations where rooms cannot be heated or air-conditioned, and especially when there is no water, etc. Attempts were made to evaluate the interruptions for both the industry and the municipal consumer by means of determination of the readiness to make payments [3]. As the results of the research show, individual municipal consumers were much more interested in the subject than industrial consumers (greater amount of filled in and submitted surveys). On this basis the following conclusion can be drawn: interruptions in the supplies of energy are more burdensome for individual municipal consumers than for the other groups of customers. Furthermore, in terms of quantity they constitute a vast majority. Naturally, it is possible to divide the value describing the reliability of supplying customers with energy into two elements:

- concerning individual customers;
- concerning industrial customers as well as trade and services;

and to qualify the first among them into the sphere of social issues, whereas the second one to economic issues. However, this would complicate the transparency of the values that constitute the basis for assessing the state of the local energy system.

Another example of value that in fact could be classified into the economic, environmental and social order as well is the per cent participation of energy fraction of wastes used for energy-related purposes. The economic aspect was presented in the shortened form above. In this case environmental issues are quite essential and rather clear. On the one hand, the usage of wastes for energy-related purposes contributes to a smaller amount of stored wastes and environmental hazards related to it, whereas on the other hand there emerges a potential hazard (which can be considerably eliminated thanks to the selection of appropriate technology) that is related to the processes of thermal transformation of wastes and emissions into the air as well as to the hazards concerning storing of hearth wastes of these processes. In case of this value there is also a crucial social aspect. It is clear that the thermal transformation of wastes in almost any technology and in every place, irrespective of the character of the area in which such plants could be established, raise serious social resistance. To a large degree they ensue from the lack of knowledge concerning modern technologies.

Similarly, participation of wood biomass not obtained from plantation in the entirety of primary energy obtained from wood biomass can be perceived as equivocal in terms of classification into orders of sustainable development. On the one hand, there can be an easily observed environmental aspect. The greater the participation of biomass from plantation, the less trees are cut down (environmental aspect). On the other hand, this value can be looked at from the economic perspective, i.e. the greater the value of this indicator, the greater influence the local energy system has on the functioning of agriculture (economic aspect).

Conclusions

There are numerous publications concerning indicators of sustainable development, including indicators for energy systems at the national level. However, it is difficult to find elaborations that would raise these issues with regard to local energy systems, let alone local energy systems in such unique areas as naturally valuable areas. It needs emphasizing that the requirements towards energy systems in these areas are special owing to the fact that on the one hand there are required higher standards with regard to environmental protection, and on the other hand due to more difficult conditions of management because of limitations connected with the existence of areas protected by law. Indicators of sustainable development of energy systems in these areas ought to reflect these unique conditions of management and special conditions related to natural protection. Simultaneously, in order to be clear for local decision makers the indicators must have a relatively simple structure. A great number of indicators (both with regard to sustainable development of local energy systems and in general a great amount of dispersed data being the basis for making any decisions) leads to the situation in which their informative role is lost and decision

makers are completely unable to make decisions that would use information carried by very complex set of indicators. This elaboration presents 18 such values with traditional division into the values related to social, environmental and economic order. However, it should be highlighted that this division is to a large degree conventional because many indicators directly or indirectly concern more than one of the aforementioned orders.

It is believed that the basic feature that indicators of sustainable development need to have are comparability to other areas (for example, for general national indicators – the possibility of being used by various countries), whereas for naturally valuable areas in the entire world it is essential to take into consideration the specific character of energy systems in various conditions of climate and economy, and also to take into account the conditions in naturally valuable areas that are specific for particular climatic and economic conditions. If there was constructed a system of indicators that would take into consideration all requirements for such areas, the vast majority of indicators for particular areas would be dead because of not being adjusted to the conditions existing there. The indicators presented in this article satisfy the needs regarding the assessment of the relation between the economic-environmental-societal and the energy system in Poland and in other countries of Eastern Europe as well as in countries with similar type of problems regarding the relations between particular elements mentioned above. This paper may become an inspiration for other researchers in various parts of the world, who would wish to supplement the presented set of indicators with other indicators which would show the specific character of naturally valuable areas in other regions of the world.

The indicators presented in this paper can be used for the assessment of energy systems and would equip local decision makers with knowledge concerning the changes that will take place with regard to their local energy-related policies, and also for the assessment of changes that have already taken place. They ought to enable evaluation whether changes in the energy system are in accordance with the premises and requirements of local sustainable development.

Streszczenie: Celem artykułu jest wyselekcjonowanie i zdefiniowanie wielkości, których analiza pozwoliłaby na ocenę kierunku zmian w lokalnym systemie energetycznym na obszarach przyrodniczo cennych z punktu widzenia zasad zrównoważonego rozwoju. Zaproponowano wskaźniki, odnoszące się zarówno do sfery społecznej jak i środowiskowej i ekonomicznej analizowanego obszaru. Niektóre z omawianych wielkości, w jednakowy sposób odnoszą się do wszystkich lokalnych systemów energetycznych, niektóre natomiast są istotne jedynie dla systemów energetycznych funkcjonujących na obszarach przyrodniczo cennych.

Słowa kluczowe: rozwój zrównoważony, wskaźniki, lokalny system energetyczny, obszary cenne przyrodniczo.

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