RENEWABLE ENERGY SOURCES IN URBAN CONTEXT

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Abstract

The distribution of the RES potential is far from being even, individual regions of the world demonstrate relatively better conditions (than others) for development of specific renewable energy categories. The priorities of the comprehensively understood spatial policy should include not only energy safety guarantees and meeting the provisions of RES-related international treaties, but also, not less importantly, selecting the most advantageous renewable energy categories for given urbanized areas and limiting its adverse effects on landscapes and on valuable natural areas and species.

Renewable energy has many enthusiasts, who would like to maximize its potential. The overall idea is justified. But before we join in with them, let us put forward a question whether there is really nothing to lose in the process of the 'green' energy acquisition.

1. Introduction

In recent years the rapid socio-economic development of urban areas has resulted in an increased demand for utility power. Increasing environmental pollution and shrinking fossil fuel resources have triggered an interest in the possibilities of acquiring utility power from renewable energy sources (RES).

In the years to come renewable energy will account for a significant share of the energy balance of many countries around the world. In March 2007 at the EU Energy Summit the so-called climate and energy package referred to as "3x20" was endorsed, which is supposed to reduce the conventional power industry pressure on the environment. Poland, which I am here to represent, as a EU member state, has joined in to implement the strategic objectives of the package of measures, i.e. by the year 2020: to have achieved the level of 20% of renewable energy in the market energy supply, to have reduced the level of CO_2 emission by 20%, and to have reduced the unit utility power demand by 20%. These commitments require that the renewable energy sources production be considerably increased and they involve all settlements nets proportionately to their capacities and potentials.

In order to efficiently utilise the RES technical potential advantageous conditions are necessary to support its development, also increased outlays are needed for technological research and development and a system of subsidies for renewable energy projects should be put forward and disseminated. On many occasions the levels of RES capital investment required for such projects might result in considerably higher prices of the power generated with the use of renewables in comparison with the conventional fossil fuel sources.

From the point of view of power generation costs there are three RES technology categories:

• technologies whose power generation costs are lower or similar to the costs or prices of conventional energy carriers; including *inter alia*: air solar collectors, small manually operated wood- and straw-fired boilers, small automatic straw thermal power stations, small water power stations constructed on natural water drops, and waste dump gas installations;

• technologies whose power generation costs are higher than the domestic average ones, but which might be competitive should preferential loans or subsidies be provided; those include large power grid wind stations, automatic biomass thermal power stations, photovoltaic technologies;

• other technologies whose power generation costs are significantly higher than the conventional energy sources, provided the subsidies levels amount to even 50% of the project budget; those include water solar collectors, photovoltaic installations, small power grid stations, agricultural biogas plants, geothermal plants (Strategy, 2000).

In spite of the aforementioned economic differences between the individual RES technology categories, it is necessary to increase the levels of use of all energy sources, all the more so because there are many financial institutions assisting in overcoming economic problems connected with high capital investments. Such institutions provide preferential loans and subsidies that usually amount to not more than 50% of the project budget. There are many options for various enterprises to acquire financial assistance in the form of loans or subsidies for renewable energy industry development that are available for self-governments, research centres, businesses and physical persons.

The rational use of renewable energy sources, including *inter alia* the energy of rivers, wind, solar radiation, geothermal energy or the energy of biomass, has become one of the crucial components of sustainable development. The notable benefits of spatial planning incorporating the aforementioned aspects are not only such as: improved efficiency of energy sources utilization and economy, improved environmental quality through reduced air and water pollution and reduced levels of waste generation, but also: improvement of urban areas, and confinement of uncontrollable suburbanization. There are mutual relations between increasing demand for renewable energy sources and spatial planning, which considerably help reshape natural environment and landscape, and also introduce changes into the spatial structure of urban areas.

Every decision to utilize renewable energy sources has its spatial development repercussions. The utilization of RES in urban areas relies both on the potential of a given category of energy, and on the arrangement and level of protection of the existing environmental resources. However, the more important environmental protection and sustainable development become, the tighter restrictions are imposed on the possibilities of acquiring individual renewable energy sources. That is why the need for working out of methods that could help avoid such conflicts between RES and the environment is gaining in significance.

The way RES energy generation is effected may influence the layout and functions of settlement nets, the structure of cities at the local level, and the building development on the universal urban scale. On account of the importance of the spatial factor in individual renewable energy technologies, it might be essential to incorporate it in spatial planning at all the levels (table 1).

A potential increase of the renewable energy share in the national fuel-energy balance must not cause additional adverse environmental quality changes. For that reason it is necessary that one should talk not only about potential advantages, but also about RES disadvantages and also take the latter into consideration while planning such technologies' spatial arrangement.

Table 1: Possibilities of utilization of renewable energy sources in various spatial scales

	individual households	housing estate, residential district	town	city or urban agglomeration
Hydro power				
- large power station	—	—	+	++
- small power station	++	++	+	—
Solar power	++	+	—	—
Wind power	+	+	+	++
Biomass energy	+	+	+	++
Geothermal energy				
- high temp. natural	—	+	++	+
- post-mining	—	++	+	—
- heat pump	++	+	+	—
Other energy sources				
- heat tank	+	+	++	+

2. Hydro energy

Existing and planned large hydro power stations are usually situated outside urban areas, thus it is in an insignificant way that they influence the settlement net structure, whereas small hydro power stations do not require application of amended or irregular spatial planning principles, and their localization in the vicinity of energy customers allows for transmission losses minimization. Another advantage of hydro power stations is the fact that they produce neither sewage or exhaust gases, nor other pollutants; also water retention is an additional advantage which offers a possibility to regulate the local water conditions and add to the local flood control. An artificial reservoir may as well constitute an interesting landscape component.

Apart from the aforementioned advantages, hydro power stations also have disadvantages, such as hindering fish spawning migrations and fish fry development, reducing bird breeding sites through elevating the river water level and natural river bank erosion, and dying of reservoir water life as a result of silting and oxygen reduction in the water (Bochentyn, Riegel, 2006).

3. Solar power

The potential of the solar energy can be well described with the words of Prof. Pabis: "if one could accumulate all the energy of the fossil fuels of this planet, i.e. the energy of coal, wood, natural gas, petroleum, and then burn it all at 100 efficiency, then the amount of the output energy would equal the solar energy that the sun supplies the earth with in only four days". Unfortunately, the acquisition of the energy from the sun is still quite expensive, although it has its significant advantages. Singular solar collectors or photoelectric panels will not interfere with our perception of the urban landscape, however their technical requirements may force changes to the housing development in the urban scale. Although such panels can be integrated into the surface of roofs or walls, but on account of the recommended exposition time (for such photovoltaic elevations), it may be necessary to keep an appropriate screening distance from other urban development components (buildings, urban greenery, etc.), which in time may make urban development become less crowded. Furthermore, the utilization of solar power devices requires high air transparency, which considerably lowers their efficiency in intensely urbanized and highly polluted areas. The use of flat solar collectors contributing to the building heating systems or utility water heating may be significantly important in low-density housing (single-family or homestead development) and influence the local energy balance provided it is universally applied (fig.1).

Fig.1. Combination of solar collectors and roof windows

All in all it can be said that the solar energy acquisition does not come with negative environmental effects except one, which is connected with disposing of the panels containing heavy metals.

4. Wind power

The following three types can be singled out:

— small wind devices (miniturbines) installed on buildings (fig.2), on lampposts, etc. Further development of such devices will lead to their utilization in the way similar to that of photovoltaic panels (e.g. navigation illumination). Provided they are universally employed in cities, where they can amount to an interesting architectural element, it is necessary to set the standards of permissible sizes and the regulations as for the place and range of their use on account of their anticipated troublesomeness due to the noise, visual effects and electric shock hazards, etc.

Fig.2. Home wind power

— singular wind turbines of moderate capacities (moderate sizes), outside-the-power-grid standalone units, servicing individual homesteads or distant complexes (e.g. hostels) do not require introduction of new spatial settlement and environmental rules. It is necessary, however, to remember that even singular wind turbines may constitute a predominant landscape feature;

— wind farms generating up to several hundred (even up to 1,000) megawatts of power, occupying the area of up to several dozen sq. km connected to the power grid. The localization of such power generating farms requires: an appropriate undeveloped and unforested area (the so-called roughness coefficient conditions the wind power potential), and closeness to the power grid nodes (in order to connect the power stations to the power grid with the use of the shortest possible underground power lines). So, such a solution is strongly dependent on the infrastructure and development of the land. Such wind farms will require reservation of land plots in the vicinity of the power grid nodes in order to minimize transmission losses. A severe disadvantage of wind farms is the fact that they seriously devastate natural landscapes (fig. 3). Wind farms shouldn't be located at protected areas and recreational areas (more about it in distant part of the article).

Fig.3. Wind turbines in natural landscape of India

Moreover from anxiety about the good of inhabitants it isn't recommended to locate wind turbines in the immediate vicinity of human housing estates. As a protective zone is usually recognised a distance of 500 metres from the most immediate building development and 300 m from single homesteads. Wind turbines should be also in the distance of at least 500 m from composition lines, view lines or beauty spots (fig. 4). Because of the productivity of the wind turbines, distance of minimum 3000 m should separate the windward side from forests and the tower-block housing (fig. 5).

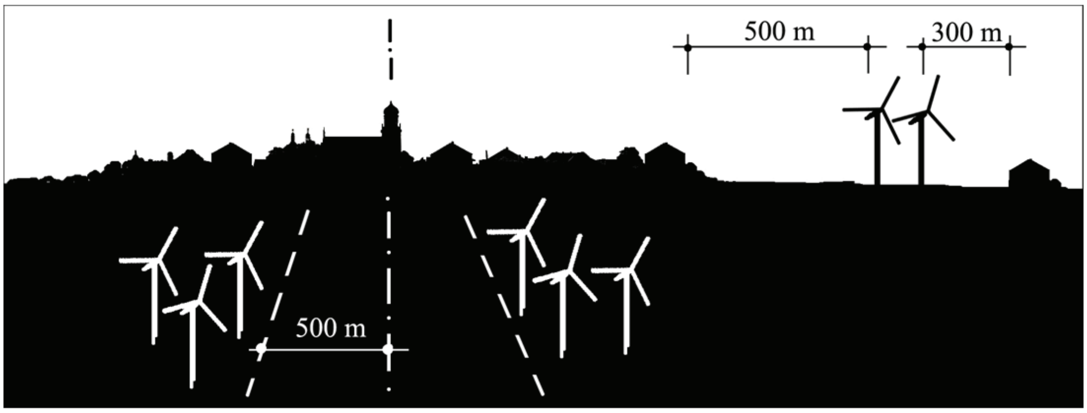

Fig.4. Recommended protective zones for wind turbines (author’s own study)

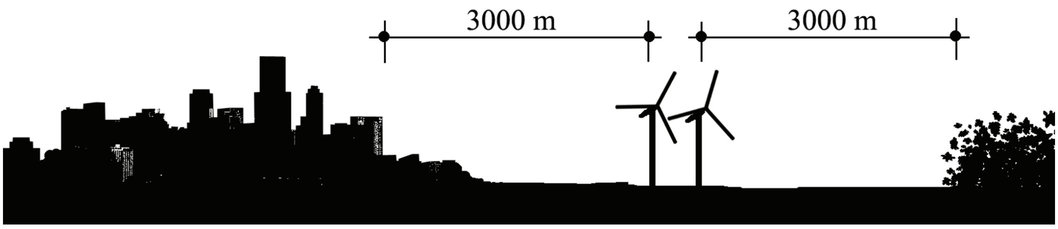

Fig.5. Recommended protective zones for wind turbines (author’s own study)

5. Geothermal energy

The use of geothermal energy may impact the function and structure of a given settlement unit depending on the type of employed energy:

- low temperature devices (heat pumps) supporting central heating systems may be significantly important for low density settlements (single-family or homestead development) and they may considerably influence the energy balance of a commune or township provided they are universally used. One of the adverse effects of heat pumps is limited possibilities of a building plot’s development with a horizontal installation and a reduction of numbers of trees in the vicinity (fig.6);
- high temperature devices can be economically used within a 6-km perimeter of a geothermal reservoir. Geothermal holes are usually localized in poorly urbanized areas. For economic reasons it is most efficient to use the existing exploratory boreholes. Since the capital investment outlays are significant it is necessary to only consider supplies of geothermal energy to

large customers, e.g. municipal heat power plants (for towns of at least 10,000 inhabitants), which in turn requires a localization of at least two geothermal holes of appropriate hydrogeological properties in the close vicinity of such a town (Macuda et al., 2001). In small centres (groups of villages, small towns) the utilization of geothermal energy will make the housing development concentrate round the reservoir and along the heat-pipes. On the other hand a geothermal reservoir situated near a city may make the housing development spread over a more extensive area. Such a geothermal reservoir may generate various functions such as: industrial, recreational, commercial etc., covered in thickening network of housing districts and communication routes;

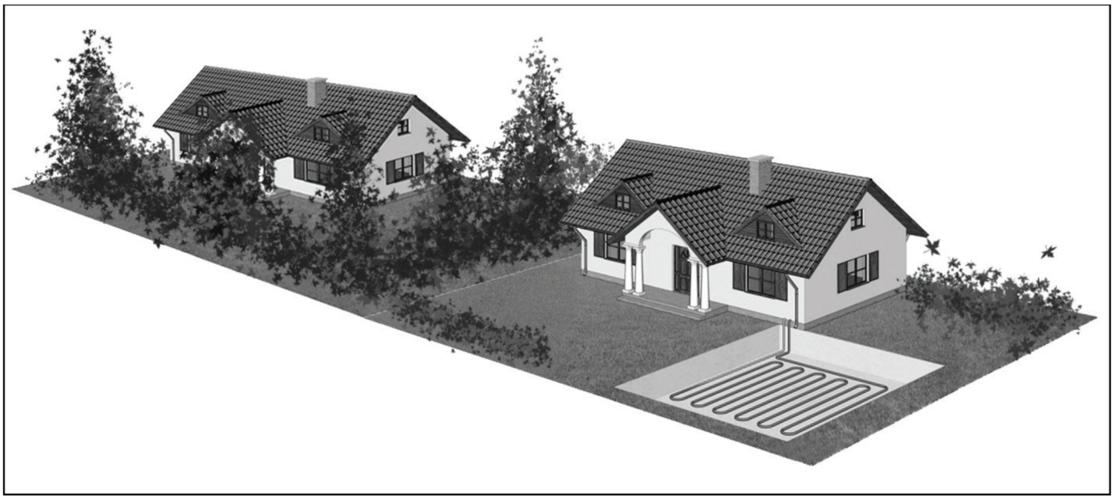

Fig.6. Heat pump with a horizontal installation and reduction of number of trees (author's own study)

- post-mining heat tanks in flooded mines are often situated in the vicinity of housing estates, for the mining areas in their times were settled over by mine workers. At present, the excavations have been converted into geothermal plants and they have become an additional factor accelerating revitalisation and improvement processes, and increasing the settlement density in the scope of its influence.

6. Biomass energy

In connection with the type of biomass used and the technology of energy acquisition the following can be singled out:

- biogas installations (waste dump gas, sludge gas, dung gas (animal waste)) – the accessibility of raw material, the devices and amounts of acquired energy are of local significance and they will not influence the settlement development, nor the environment, nor have they any influence on the layout of cities or urban development;

- solid biomass installations (wood- and straw-fired boilers) for direct burning are of local significance (local boilers) or they are used professionally (woodfired boilers), and they have no influence on the spatial development;

▪biomethane installations require extensive arable land areas for production of fermenting plants – in other words raw material acquisition is extensive. Optimally, fermentation substrates should be transported from a distance of about 5km (the maximum transport distance should not exceed 15 to 20km). A biogas installation farm is on average from 3 to 5 times larger than a typical farm, and the amount of electrical energy and gas generated often exceed the local needs, in such a case a bio electric power or biogas power plant should have a connection with the power grid or with a gas pipeline distribution network in order to dispose of a potential power surplus (Koch, 2007).

An undisturbed and economical utilization of such an installation requires appropriate undeveloped areas, which should be included in the spatial development plan. Introducing energy crops (e.g. rape or willow) allows for utilization of poor soils, wasteland, and contaminated soils. It is recommended that biomass crops should be introduced to at least 10-ha areas, because only such sizes render the utilization of the machinery and equipment economical. Approximately 17-18% of Poland's territory is in one way or another contaminated because of industrial, transport, power industry or agricultural factors. In effects such soils feature exceeded levels of acidity, salinity and alkalization, and water contamination, which renders production of high quality healthy food impossible.

Energy crops arable land planning requires thorough biological and landscape analyses in order to avoid unfavourable effects amounting to: monocultures, landscape monotony, reduction of biodiversity, as well as violation of protected natural areas. However, those are not all of the aspects to be considered carefully planning energy crops areas. Research results demonstrate that although 1ha can produce about 5,000 m^3 of biomethane, i.e. the amount comparable to a yearly demand for (Gasidlo et al., 2007):

▪natural gas for 15 people,

▪electric power for 7 people,

▪heat power for 6 people,

▪one should not forget that 1ha can also produce food for three people for one year.

So, in the case of individual cities deprived of extensive areas for food production, introducing biomass crops would mean less food for the city inhabitants. In conclusion, it is necessary to carry out thorough analyses preceding a potential decision to introduce renewable energy acquisition solutions, especially should spatial factors be of any significance.

The system of protected areas in a country consists of large areas, very often related to urban spaces and important to spatial development planning, conserved in the forms of: national parks, natural reserves, landscape parks and protected landscape areas. For example, in Poland all the protected area amounts to 32% of the whole territory. The Polish system includes: 23 national parks (i.e. 3,200 sq. km), 120 landscape parks (26,000 sq. km), 449 protected landscape areas (71,300 sq. km), and 1,395 natural reserves (1,700 sq. km) (Environmental Protection, 2006). Moreover, Poland, like many other countries, is included in numerous international programmes aiming at harmonization of conservation and economic objectives, as well as protection of cultural heritage connected with specific natural formations.

Considering the possibilities of putting such protected areas to renewable energy sources use, the following factors should not be overlooked (Gasidlo et al., 2007):

▪protected areas (national parks together with their protection zones, natural reserves), should be excluded from the possibilities of water, wind, solar, geothermal and biomass energy acquisition.

▪in the territory of landscape parks (together with existing protection zones) and in the protected landscape areas, where arable land and woodland and other land situated within those protected areas are left for economic use, it is possible to acquire forest and farming crops for the purpose of energy production, as well as to acquire solar, geothermal and wind energy on the local scale, without jeopardizing the local flora and fauna and the quality of the landscape and for the human recreational purposes. The possibilities of acquisition of the aforementioned types of energy should be registered, in accordance with the Law on environmental protection, in the statutory natural areas protection plans.

▪the areas under the Nature 2000 Programme (wherever they do not coincide with other forms of natural protection) should be excluded from the possibilities of RES acquisition on the regional scale. In those areas, both existing and planned, investment possibilities are limited. It is allowable however to invest there in case there are no alternative solutions, wherever such investments are in public interest, on condition that ecological compensation is provided.

▪both in the areas of the Nature 2000 Programme, where economic, farming, husbandry, game management or fishing activities are permitted, provided they do not violate the existing prohibitions, and in the areas of the National Ecological Network ECONET-PL (depending on individual conditions of ecological nodes and corridors), it is allowable to acquire biomass energy. What should, however, be considered is the necessity (in some cases) of preserving the existing structure and traditional management methods, and of protecting valuable natural (mosaics of natural and anthropogenic ecosystems) and cultural landscapes. This approach excludes utilization of extensive arable land for energy acquisition purposes (which promotes landscape unification), or large-scale acquisition of wood waste.

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مصادر الطاقة المتجددة في الإطار الحضري

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الملخص:

توزيع مصادر الطاقة المتجددة أبعد من أن يكون منتظم، فكل منطقة في العالم تشهد ظروف أفضل نسبيا (أكثر من غيرها) من أجل تنمية فئات محددة من الطاقة المتجددة. وأولويات السياسة الشاملة للمفهوم المكاني ينبغي أن تشمل ليس فقط الطاقة وضمانات السلامة والالتزام بأحكام المعاهدات الدولية ذات الصلة، ولكن أيضا، وهذا لا يقل أهمية، اختيار أنسب فئات الطاقة المتجددة للمناطق الحضرية المعينة، والحد من الآثار السلبية على المناظر والبيئة والخليقة الطبيعية.

وللطاقة المتجددة العديد من المتحمسين والذين يرغبون في تحقيق أقصى إمكاناتها. هذه الفكرة العامة لها ما يبررها، ولكن قبل أن نشارك معهم ، اسمحوا لنا طرح السؤال عما إذا كان هناك حقا لا شيئ نخسره في عملية اكتساب الطاقة "الخضراء".