Renewable Energy Potential in the Pardubice Region as an Instrument of Public Safety

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Abstract: - The issue of energy supply sustainability is one of the most urgent problems in context of increasing energy consumption. The fundamental problem here does not lie only in the scarcity of non-renewable resources, but also in their unavailability due to political or economic reasons.
The paper discusses the estimation of technically available amount of renewable energy to supply the selected region. All the theoretically exploitable energy resources in the territory are considered. Maximal share (theoretic potential, in %) in total energy consumption within the region for different renewable resources were set based on the statistic data supplemented by qualified estimates.

Key-Words: - sustainability, renewable energy sources, theoretical potential, public safety, biomass, solar energy, wind and water energy.

1 Introduction

Mankind has certain needs and to meet the needs it uses the energy potential of available resources. Ways to convert energy into the necessary forms are different. In general it can be said that energy is obtained from the natural resources of the Earth, either from non-renewable resources or renewable resources [2].

Currently, in the world and the Czech Republic, the most frequent source of energy are fossil fuels. These fuels are among the natural resources, but they certainly cannot be considered inexhaustible. Current efforts to achieve sustainability reflect these problems in their approaches and propose solutions in the form of replacement of exhaustible resources by renewable sources.

This approach includes not only the economic and social dimension, but also safety benefits in terms of increased security in energy supply [7]. Unsuitable use of renewable energy sources can, however, result in increased exposure of the population to undesirable substances and thus create potential health risks.

The aim of this work is a comparative analysis of renewable energy potential in a selected region of Czech Republic and analysis of potential environmental burden caused by use of renewable energy. In this context, it is necessary to identify these sources first and to determine their potential in order to proceed to their analysis.

1.1 Energy Potentials and their Importance

The Pardubice region was chosen as the researched region because it represents in terms of its location and climatic conditions a typical sample of Central Europe. The potential of renewable energy sources is usually divided into four categories:

1) the theoretical global;
2) technically feasible,
3) economically achievable and
4) expected.

The theoretical global potential gives information about the theoretical global energy supply from the particular source.

Technically feasible potential is the potential of the renewable resources that can be obtained using available techniques with the use of the available area in appropriate locations.

It takes into account the possibility of distribution of energy obtained in such a way as well.

Economically achievable potential represents then the portion of technically achievable potential that is competitive in comparison with other exploited resources.

Categories awaited potential is then actually realized investment which has solved all

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administrational and economic problems associated, such as interest rates on loans, approval procedures etc.

Since the aim of this paper is to evaluate the theoretical achievable maximum, calculations will focus on technically achievable potential.

1.2 Possibilities of Using Renewable Energy Sources

Natural conditions in the Pardubice region are very diverse and have influence on the use of land and life in it. These properties are given, and define the regional potential. Firstly, we will concentrate on the solar energy potential.

1.2.1 Solar Energy

At the beginning, it is necessary to calculate and determine the intensity of solar radiation in the region. The map shows the global solar radiation falling on a horizontal surface of 1 m2 per year and provides information on the amount of usable solar energy in terms of Czech republic [1].

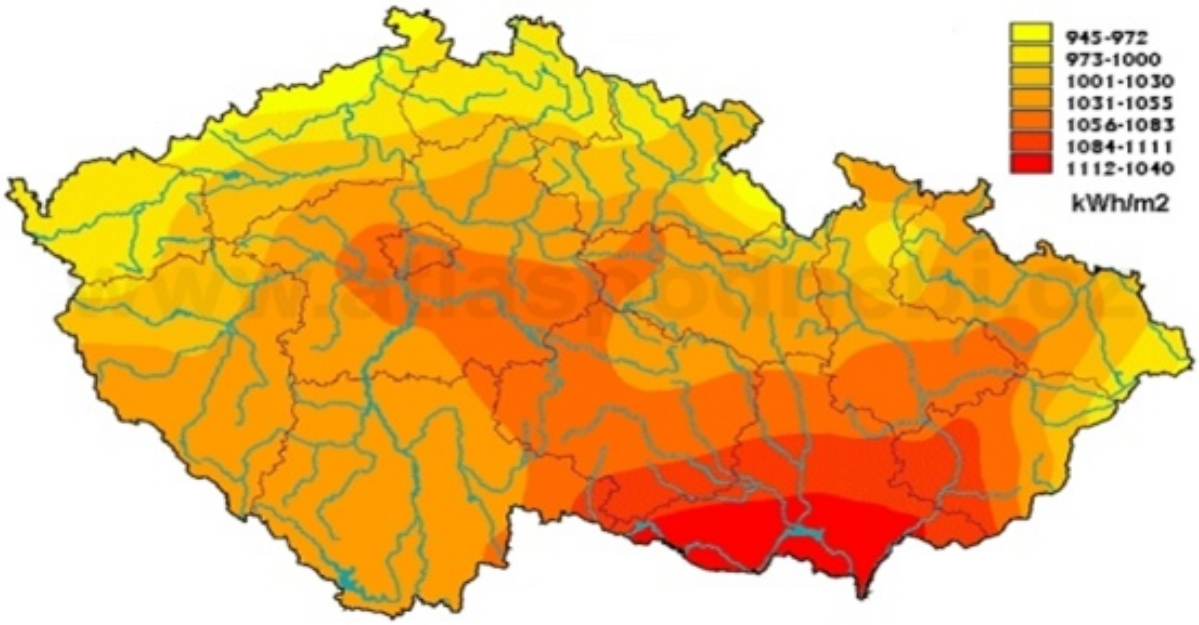

Fig.1: The annual total global radiation

Source: [11]

We see that in the Pardubice Region, the intensity of solar radiation varies in average between 1031-1055 KWh.m-2.a-1. From this information technically exploitable potential for the region can be theoretically calculated. To calculate the technically exploitable potential for photovoltaic systems it is necessary to know:

- area of the region F, which equals in the Pardubice Region to 4 519 km^2 = 4 519 000 000m^2.
- the intensity of solar radiation, which is in the Pardubice region around 1040 $kWh/m^{-2}.a^{-1}$
- efficiency η of photovoltaic panels, which hovers after taking into account the losses trough transformation and distribution around 10%
- Usable part of the region's total area of F_r. This number is estimated at 1% (as long as it should not lead to competition in agricultural land use.). One percent of the area usually corresponds to the area of roofs.

Technically exploitable potential can be calculated by the formula:

$$E_s = F \times S \times \eta \times F_r \qquad (1.1)$$

After substitution:

4 519 000 000 * 1 040 * 0,10 * 0,01 = 4 699 760 000 $kWh.a^{-1}$ = 4 699 $GWh.a^{-1}$

It is interesting to compare the theoretical calculation with the real situation. According [3] was the solar energy produced by photovoltaic plants in 2012 in Pardubice region about 93,9 GWh. This value, which is still quite far from the technically exploitable potential, has been achieved

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through considerable occupation of agricultural usable land.

1.2.2 Wind Energy

The use of wind energy has to deal with completely different problems.The wind energy potential depends on the prevailing wind speed in accessible locations. It could be estimated as follows:

The weather conditions in the Czech Republic allow for economical use of wind energy, mainly in the mountainous areas (see fig. 2), while the use is limited by the development of standards for the nature protection and weather conditions that severely restrict the operation of power plants in the windiest time of the year [4].

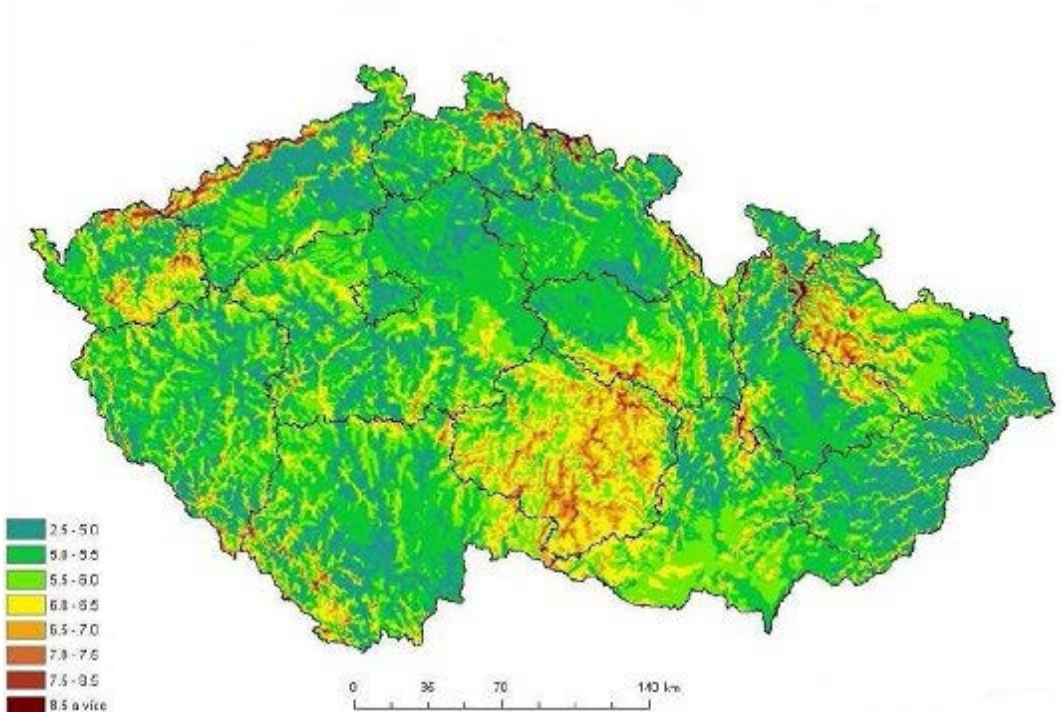

Fig. 2: Average wind speed in m/s

Source: [12]

The average potential includes the border highlands of the Czech Republic and scattered locations in the eastern part of the region. Highlands: Extremely high technical potential will undoubtedly be utilized only in a small part, mainly because of the limited possibilities of power distribution channels and landscape protection. Based on the information from the Institute of Atmospheric Physics (AV CR) the exploitable wind energy potential has been identified. These values are theoretical and are rather indicative. Technically qualified estimate of the total exploitable wind energy potential for the Pardubice region could be approximately 65 $MWh.a^{-1}$. Due to unsuitable conditions, the wind power is an insignificant source in the Czech Republic.

Hydropower has been used as a power source for a long time. The most common method of using the water flow energy is through conversion into electric energy [1]. The water power is the third researched energy source.

1.2.3 Water Power

New opportunities are opening through the development of micro hydro-plants that can be used for exploitation of minor streams unusable till now.

In the Pardubice region (all over the country - the watershed area) the natural conditions for the construction of water power works are not perfect. Rivers do not have adequate or sufficient drop of water. Therefore, the share of electricity from hydropower in the total production in the Czech Republic is low, especially in comparison with coal burning power production. The Pardubice Region is maximized in terms of hydropower, and, therefore, the base of technically exploitable potential of this region can be calculated with the help of actual installed capacity, listed in table 1.

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Table1: The total installed capacity of hydroelectric power stations in the Pardubice Region

Hydroelectric power plantsin the Pardubice Region	
Locality	Installed capacity**(MW)**
Trnávka	0,186
Přelouč	2,340
Pastviny	3,000
Pardubice	1,960
Srnojedy	1,960
Seč	3,120
Total	**12,566**

As the micro power plants enable the utilization of otherwise unsuitable streams, we expect the growth of this potential to a double of the current potential.

From the point of view of the list of watercourses in terms of energy use revealed, that approximately 2/3 of river flows are occupied. [10] According to the Ministry of Industry and Trade the technically exploitable potential of rivers in the Czech Republic is 3 380 GWh.a^{-1}.[1]. After the conversion of installed capacity 12,566 MW to the annual output we get 8760 x 12,566 =110078,16 MWh.a^{-1} = 110 GWh.a^{-1}. Technically exploitable potential value is increased by 1/3, (110/3) x 4 = 146,6 GWh.a^{-1}. Using water micro power plants therefore leads to 293,2 GWh.a^{-1}

The fourth researched source is the energy obtained from biomass.

1.2.4 Energy of Biomass

To calculate the technically exploitable potential of biomass for the reference region, it is needed to know the size of fields and forests. The following considerations include only forest area in the region and forestry waste generated from it. This is to prevent problematic competition with food production for growing of energy crops. The Czech Statistical Office found that the forests cover 130 000 ha of the region area. Using bio-waste that constantly arises in the forests, we can get 1500 l biodiesel[2] every year from one hectare of forest. It is bio-diesel produced by Fischer-Tropsch method, which, unlike in the case of the use of biodiesel based on rapeseed oil methyl ester, causes no problems when commonly used as diesel fuel in car engines.

By multiplying the available energy by the area we can get the full potential.

130 000 * 1500 = 195 000 000 biodiesel.a^{-1}

The calorific value of the expected 41MJ/Kg [5] and density 0,85 kg/l [9] leads to the assumption the from that area it can theoretically be obtained 195 000 000 x 0,85 = 165 750 000 Kg in form of biofuel and equivalent energy of 7 060 950 000 Mj = ca. 1961 GWh.a^{-1} by calorific value of 42.6 MJ/kg. The above calculation shows that just this energy from unused biomass could cover approx. 2/3 of electricity consumption in the region. Even taking into account the normally achieved efficiency of its transformation, which is, according to the type of device, between 95-35%, there remains huge reserve of energy. Another part of the untapped energy potential, which is not included here, is represented by the use of agricultural waste, sewage sludge and so on. The renewable energy sources in the Czech Republic currently provide about 9% of primary sources. The theoretical potential of renewable resources offers much more than current consumption. [8].

The total available potential of renewable sources of the Pardubice region can, therefore, be calculated as follows:

- 4 699 GWh of solar energy
- 0,065 GWh of wind energy
- 293,2 GWh of water energy
- 1961 GWh of forest-waste-biomass energy.

The total potential available then reaches to 6953,265 GWh.a^{-1}

3 Comparison of Identified Potential and Consumption

1 http://www.mpo.cz/dokument25358.html

2 http://www.eee-info.net/cms/

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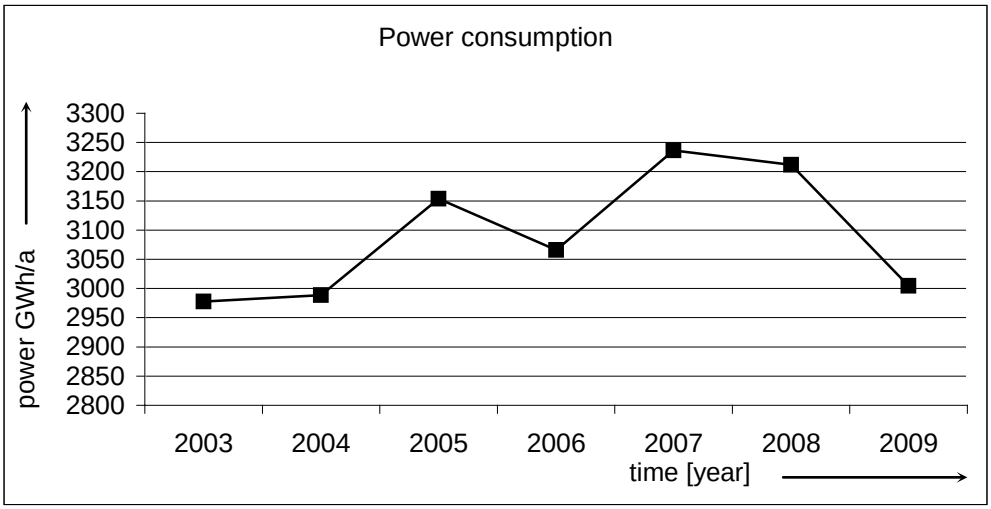
The electricity consumption in the Pardubice region grew slower in 2003 to 2006 than in the whole Czech Republic. After the increase in the consumption in 2007 in the region by 5.6% (caused by increasing electricity production in lignite power plants and thus increase energy consumption for energy) and a slight decline in consumption in 2008 (-0.8%) allowed to decrease consumption in 2009 by 6.5% to the level of electricity consumption in the region in 2003. Details are shown in Fig. 3.

Fig.3: Electricity consumption in the Pardubice Region in 2003 - 2009



Source: [6]

This consumption was covered by 98% from non-renewable resources [6]. While the average electricity consumption in the Pardubice region is 3004,5 GWh pro year, the comparison to the total technically exploitable potential of renewable energy sources shows that renewable resources can cover this need with a great reserve and without any additional pressure on energy crops. This can be achieved, however, only by moving to the next stage and by using previously unused, but available resources. This result also confirms the functionality of the model used in the Austrian city of Güssing.

4 Conclusion

The paper analyzed the technically exploitable potential of selected renewable energy sources focusing on the monitored region. The work focuses on the technical potential and the potential usable technologies available in the defined area of the selected region.

Energy consumption in the Pardubice region was used as the basis for the comparison. This has significant impact on the result as it was calculated with photovoltaic conversion efficiency of 10% opposed to the thermal energy , where can be counted with efficiency around 70%. Despite this, after screening of the needed energy composition it would be possible to reach a clear conclusion in order to provide demanded composition of electricity and other forms of energy demanded by the region with the further added utilization of the dominant energy potential of biomass. It is obvious that due to the fact, that in the case of renewable energy they are usually a low inertia systems, has to be considered as additional and sizeable increase in land use for obtaining this renewable energy.

Compared with conventional, renewable sources, however, show a higher degree of reliability, because their properties are well known and eliminates the risks associated with obtaining energy carriers from politically unstable regions.

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