Regional strategy of energy and CO_2 emissions management – base study on the example of Gliwice region

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Abstract. The European Union has set the requirements for year 2030, aimed to increase the energy production from the renewable sources and to lower the CO_2 emissions. Currently the percentage of renewable energy production in Poland is too low. The actual data of Gliwice County from Study of Conditions and Directions of Spatial Development (SUIKZP), Plan of Low-Emission Management (PONE/PGN) and Predictions of Impact on the Environment (POŚ) documents was used to calculate the regional energy consumption for heating and electricity. The data has been used in the simulation of the energy consumption and the CO_2 emission for year 2030, including the production of the energy using region's potential renewable resources. Based on that, the authors have calculated how much more energy must be produced from the renewable sources to meet the European Union requirements. The analysis includes the investment cost in the new energy sources and its comparison to the financial penalties the region would have to pay for not meeting the requirements.

1 Introduction

Powering buildings in electricity and heating states for 40% of global energy consumption and 30% of CO_2 emission. In central and northern Europe 80% of total energy for buildings is used for heating. High level of heating energy is caused by low insulation standard of majority of buildings [1]. Most of Poland's energy is produced from fossil fuels, hard and brown coal in particular. Rising mining costs, emission problems, European regulations are making conventional energy sources more and more expensive and cumbersome. On the other hand the potential for renewable and sustainable energy sources is very big. It is speculated that by year 2020 emissions will be reduced by 20% and by year 2050 all of the buildings will be neutral to the environment, due to the usage of renewable resources in 100% [1]. Poland stands behind western countries in climate matter, but there is possibility to catch up and increase the usage of clean energy. Gliwice region is popular for its great coal potential, and it stands for 82% of its energy demand [4]. Although the region has also very great potential for renewable technologies. The investment cost in new energy sources is big, but the costs of waste emissions is also big, and will rise in the future, and soon the local

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authorities will not be able to pay for it. The main point of this article is to calculate the costs of new energy sources including actual region's potential and comparison to emission penalties.

2 Methodology

All of the data used for this study was collected from Gierałtowice, Knurów, Pilchowice, Pyskowice, Rudziniec, Sośnicowice, Toszek, Wielowieś documents of: Study of Conditions and Directions of Spatial Development (SUIKZP) [2], Plan of Low-Emission Management (PONE/PGN) [3] and Predictions of Impact on the Environment (POŚ) [4]. The data contains actual energy consumption for buildings of all sectors (residential, commercial, industrial, public utilities) and energy sources. Based on that and the specification of the region the simulation for 2030 was made including various new, renewable and sustainable energy sources in an exact number to reduce the CO_2 emissions by 30% to current level. The European Councils decision demands reducing emission by 40% below 1990 by 2030 [6]. Due to lack of data from that period the emission condition was changed. The investment cost was evaluated using the referenced prices established by the Ministry of Energy [7]. In the end the combined costs were compared to the value of penalties the region will pay for emissions, if they would keep the current level by 2030.

3 Region's specification

The energy distribution by sector is almost balanced in the region as shown in figure 1. The majority of energy is used in residential (40%) and industrial (35%) sectors. The minor part is commercial (15%) and public utilities (10%) sectors. Most of the residential buildings in the region are single-family and small multi-family buildings, the only exception is the city of Knurów, where majority of buildings are blocks of flats. Commercial and public utilities sector are both well insulated buildings powered by regulations-fulfilling energy sources. Industrial sector is consist mainly of mines, coal processing facilities, woodworking, farming and food production.

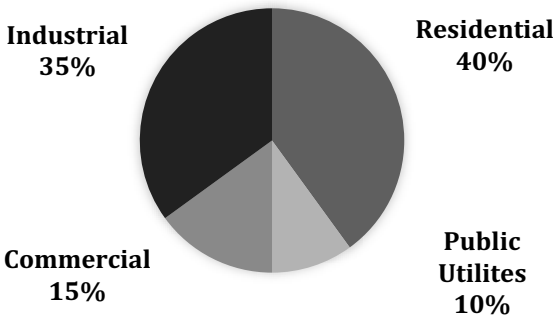

Fig. 1. Energy consumption percentage distribution by building sectors [2].

Figure 2 shows 3 maps defining the regions energy and emission specification basing on actual data. The firs shows the imbalance of energy usage for heating (pink) and electricity (red). The reason for this is poor insulation of old buildings in the village parts of the region. The imbalance is the smallest in Knurów and Gierałtowice, because of recent building insulation programmes, which eliminated the problem in all sectors except for industrial.

Most of industrial sector in Knurów are mines, coal processing and water treatment buildings that are not insulated at all. On the second map energy sources are shown. Energy mainly comes from coal (grey), and depending on local politics they are also other sources such as natural gas (yellow) and renewable (teal). Cities of Knurów and Pyskowice are the only parts of the region with heat network powered by cogeneration (pink) and providing 1/3 of needed heat energy. The last map shows emission level, which is the biggest in Knurów, because of concentration of majority of region's industry, mining facilities and power plants.

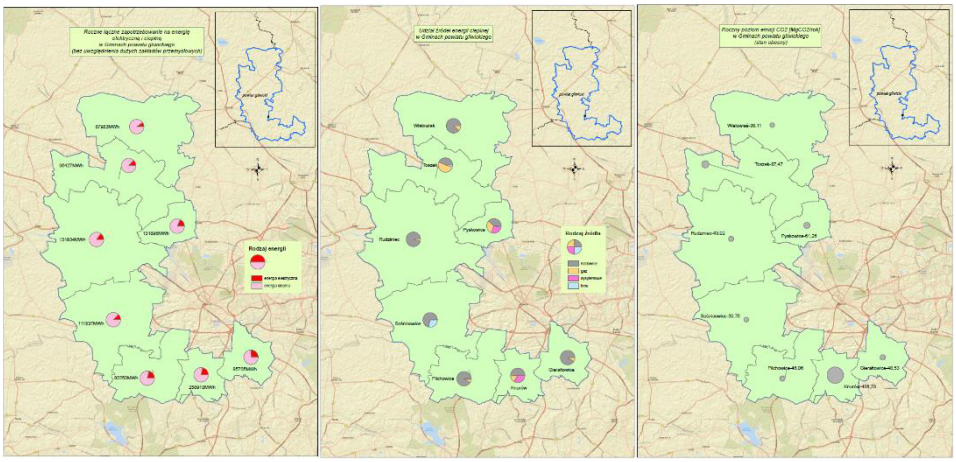

Fig. 2. Region's energy consumption, energy sources and CO_2 emission [4].

4 Energy production

4.1 Current energy production

Currently the region's power safety lies in coal industry. Renewable energy stands for 4.20% of energy production, while coal (heating + electricity) stands for 72.65% of total 996 630 MWh energy produced in 2018. Figure 3 shows shares of energy production by source. Coal column on the chart shows the usage for heating, while electricity was separated. Domination of coal is determined by region's traditions, local mines and high number of old buildings. Natural gas and cogeneration heat networks are built only in more populated parts of region, thus its share is overall small and cannot be applied in all of the region. Renewable energy consists of solar panels used in residential sector and heat pumps, used mostly in commercial and public utilities buildings.

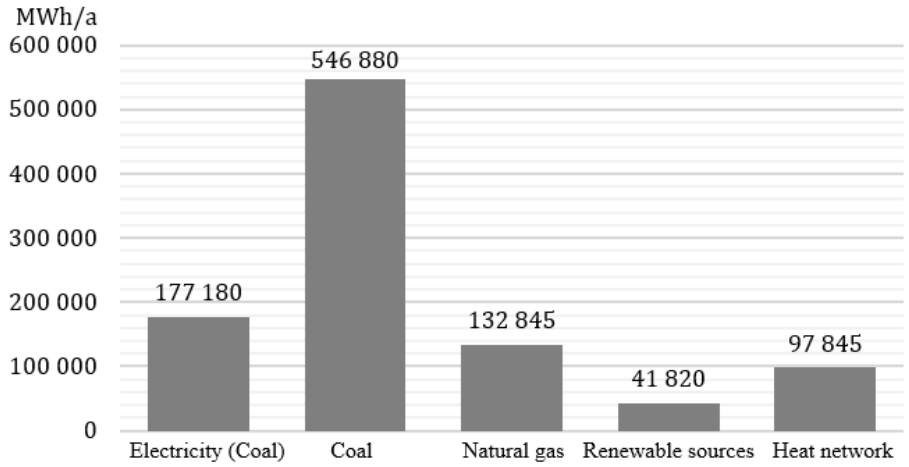

Fig. 3. Current energy production by sources [2].

4.2 Renewable and sustainable energy potential in the region

The region has many buildings appropriate for installing photovoltaic installations and a lot of unused land around its dense road network for photovoltaic or solar power plants. Especially Wielowieś, which declare willingness for such energy source in its development plans. Farming and food production facilities cover 52% of region's surface and produce tons of biological waste, which is currently not used, or used inefficiently. This makes a great source for biogas plant and biomass power plants. More settlements are ready for connection to natural gas or cogeneration heat networks. Buildings in less populated areas can be powered in heat by air heat pumps, because although Gliwice region lies in a 3rd climate zone of Poland, with temperatures reaching -18 Celsius degrees, in last 30 years winters are less harsh, and temperatures drop below 10 Celsius degrees less than 100 hours a year. Such temperature regime is optimal for air heat pumps and rarely require additional electrical heating. The region is also rich in rivers, moist soil, abandoned mining shafts. These can be effectively used as source for ground and water heat pumps for adjacent areas and buildings.

4.3 Predicted energy production in 2030

Considered actions to reduce usage of coal and conventional energy sources were based on the regions unused potential and technologies that would bring the biggest result, with the lowest cost. Main objective is to reduce CO2 emissions by 30% and raise renewable sources usage to 30% (287 805 MWh in 2030) of total 959 350 MWh used speculated required energy. In case analysis following in-vestments were used, separately for all sectors:

- Residential (32.8% of total renewable energy): heat pumps, photovoltaics, solar panels
- Commercial (18.4%): heat pumps, photovoltaics, solar panels
- Industrial (42.5%): heat pumps, photovoltaics, solar panels, biogas
- Public utilities (6.3%): heat pumps, photovoltaics, solar panels

Figure 4 shows the energy production profile in 2030 with applied new investments and technologies, cutting off the coal usage.

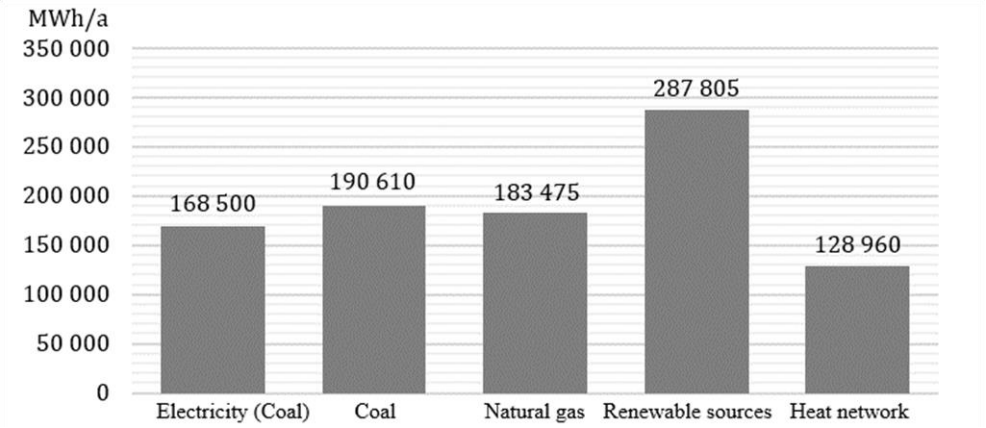

Fig. 4. Speculated 2030 energy production by sources.

In order to fulfil renewability and emissions requirements the analysis adopted changes that included: decentralisation of energy sources, reducing of coal usage, expansion of natural gas and cogeneration heat networks, biogas production and various renewable energy sources appropriate for the region.

5 CO_2 emission

Actual emission level is very high in the region. However usage of different than coal energy sources in this simulation makes it possible to lower CO2 emissions by 30%.

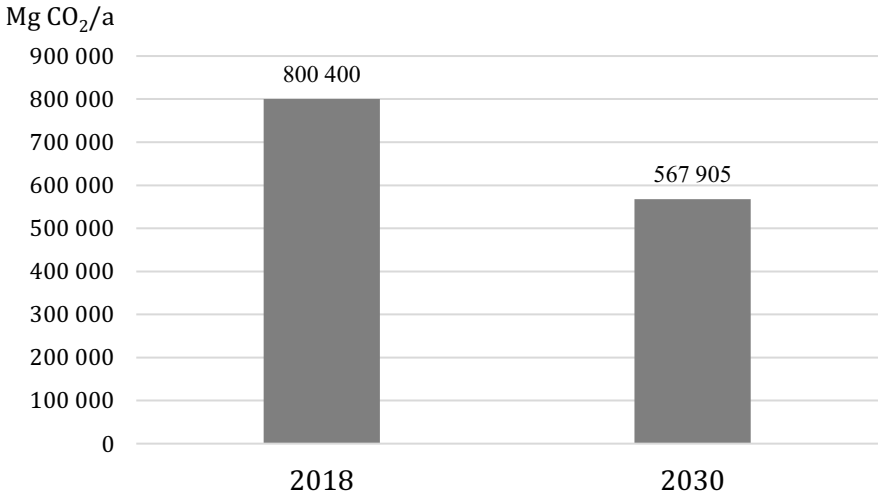

Fig. 5. CO_2 emission comparison.

6 Financial case

Investing in new, environmental energy sources is not cheap. But in a long-term view it will be not only more ecologic for the region but also more profitable. It's because the financial penalties that the region will have to pay every year for emissions higher than those accepted by European Union. Calculated cost of the new energy sources in the analysis would be 125 million PLN, according to reference prices. However the emission penalties would reach

297 million PLN if the emission level would not change by 2030. The penalties can be even higher, because the analysis is based only on CO2 emissions, and penalties can be applied to other pollution too.

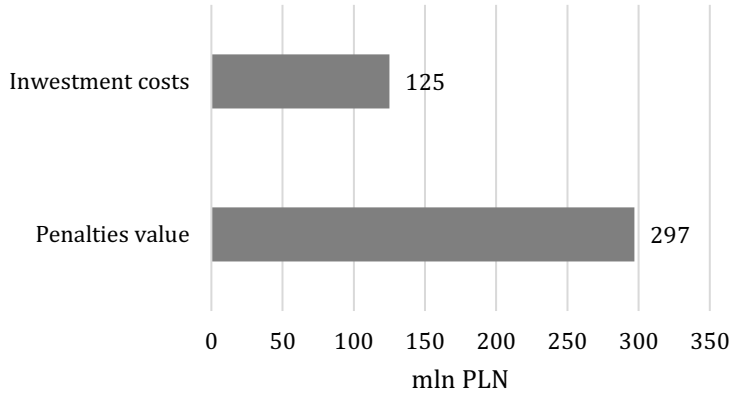

Fig. 6. Investment costs and CO2 emission penalties comparison.

7 Conclusions

It is not an easy task to meet up with requirements of European Union for countries like Poland, with its energy economy centralised around coal. The Gliwice region has serious problem with current emissions level. Basing on the newest technologies and complex, actual data of buildings energy experts are creating a program of funding new energy sources in the whole region. The program will include all sectors and will be used as an example for the rest of Poland. It shows that there is still possibility and desire for executing European requirements. Lowering the emissions by 30% and increasing the usage of renewable resources by 30% is the first step that the region, as well as all of Poland, needs to make to eventually decrease energy production emissions to 0% and make buildings neutral to environment by 2050 (or later in the future). Every year of delay will result in higher emission penalties and local environment degradation. It is crucial to make a difference, because the more outdated and conventional energy sources will be, the more costly requiring the modernizations will be.

References

1. E. Ursula, *Enegry Efficient Buildings with Solar and Geothermal Resources* (Wiley, Chichester, 2014)
2. Studium uwarunkowań i kierunków zagospodarowania przestrzennego gmin: Gierałtowice, Knurów, Pilchowice, Pyskowice, Rudziniec, Sośnicowice, Toszek, Wielowieś
3. Plan gospodarki niskoemisyjnej gmin: Gierałtowice, Knurów, Pilchowice, Pyskowice, Rudziniec, Sośnicowice, Toszek, Wielowieś
4. Prognoza oddziaływań na środowisko gmin: Gierałtowice, Knurów, Pilchowice, Pyskowice, Rudziniec, Sośnicowice, Toszek, Wielowieś

5. Dz.U. 2002 nr 75 poz. 690, Rozporządzenie Ministra Infrastruktury z dnia 12 kwietnia 2002 r. w sprawie warunków technicznych, jakim powinny odpowiadać budynki i ich usytuowanie.
6. Directive of the European Parliament and of the Concil amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments and Decision (EU) 2015/1814
7. Reference prices for renewable and sustainable energy sources established by the Ministry of Energy, http://gramwzielone.pl/trendy/25180/ceny-referencyjne-w-aukcjach-dla-oze-na-2017-r