Economic Determinants for the Development of Hydropower in the Czech Republic and Poland

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Abstract: The Czech Republic and Poland face serious challenges related to the further development of renewable energy sources and the continuation of the energy transformation. It should be noticed that the analysed renewable energy source can be particularly easily implemented in rural areas. This is related to the dispersed potential of locating hydropower installations. It should be emphasized that both the Czech Republic and Poland do not fully use the potential of hydropower in rural areas. The aim of the article is to analyse the development of hydropower in the Czech Republic and Poland. The article also demonstrates conditions related to relieving energy transmission networks due to the reduced importance of large coal-fired power plants in Poland and the Czech Republic. Moreover, the article indicates the positive impact of using some hydropower plants as energy storage, which may improve the stability of the energy system locally.

Keywords: renewable energy sources; economy; hydropower; Czech Republic; Poland

JEL Classification: O11; Q28; Q56

1. Introduction

The development of renewable energy in the Czech Republic and Poland is, among other things, an element of improving the quality of the natural environment, a solution supporting the reduction of the use of fossil fuels and a response to the growing pressure from the European Union authorities and European residents to improve the quality of life (European Commission, 2023; Zarębska & Dzikuć, 2013). It should be emphasized that air quality is particularly bad in Poland; according to data from the European Environment Agency prepared by Toute l'Europe, Poland has 7 out of 10 most polluted cities in the EU. The remaining 3 cities are located in Croatia (one city) and Italy (two cities). It should be underlined that Poland is still a country largely dependent on coal. Polish energy industry currently relies on approximately 70% of hard coal and brown coal, which emits huge amounts of suspended dust and other harmful substances when burned. One of the important elements of improving environmental quality is reducing the share of fossil fuels through the development of renewable energy sources, including hydropower (Olczak, 2022; Rokicki et al., 2022). The Czech energy sector is much less reliant on coal due to the two nuclear power plants in operation, which in 2020 accounted for 36.7% of the energy produced (Energetický Regulační Úřad, 2023). The Czech Republic and Poland are not among the leaders in renewable energy in

the EU. The share of RES in both countries is below the EU average (Fig. 1). Additionally, hydropower plays an important role in the energy mix of EU countries. The share of hydropower in the EU-27 was relatively high, accounting for 13.8% of the total net electricity production in 2020 (Eurostat, 2023).

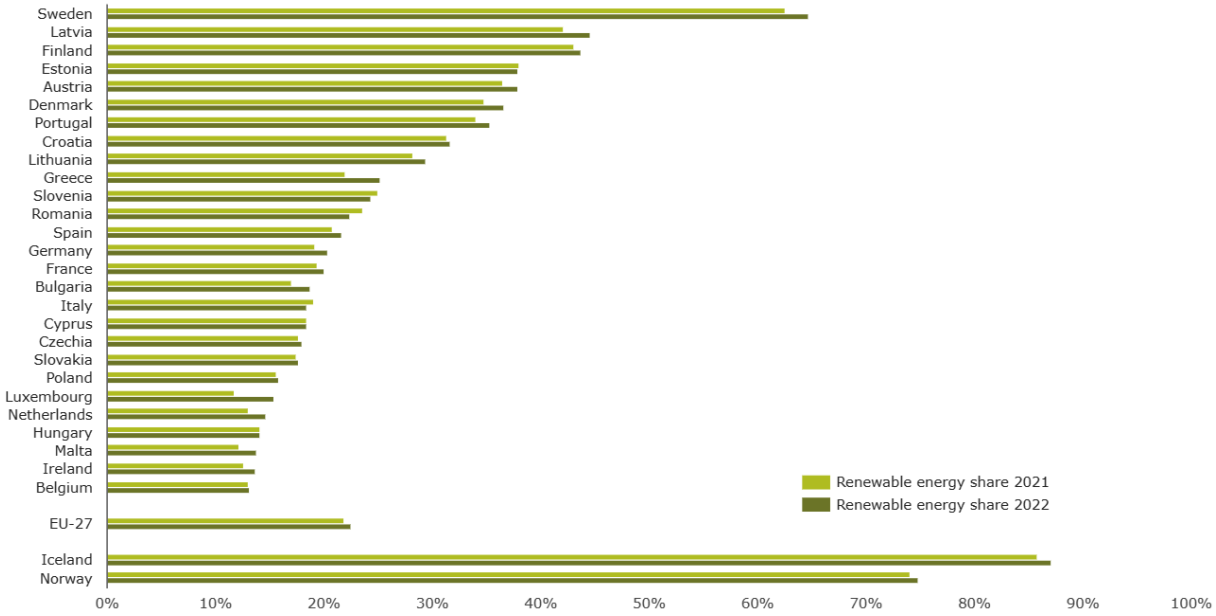

Figure 1. Share of energy from renewable sources, by country (European Environment Agency, 2023)

2. Methodology

The aim of the article is to analyse the development of hydropower in the Czech Republic and Poland. The article also demonstrates conditions related to relieving energy transmission networks due to the reduced importance of large coal-fired power plants in Poland and the Czech Republic (Yan et al., 2021; Raczkowski et al., 2022; Urban & Dzikuć, 2013). Moreover, the article indicates the positive impact of using some hydropower plants as energy storage, which may improve the stability of the energy system locally (Chu et al., 2022).

The methodology of the research conducted in the article is related to the purpose of the analyses. The indicated research goal was a contribution to the use of methods typical of social sciences (Poór et al., 2015). In order to effectively achieve the assumed research objectives, several research methods were used:

- analysis of the subject literature,
- tabular and descriptive charts
- methods of descriptive and mathematical statistics,
- deductive method,
- analysis of source documents.

The collected data was helpful in carrying out analyses of the potential development of hydropower in the Czech Republic and Poland. The analyses performed were used to determine the development potential of hydropower in the coming years. The research used secondary data obtained from central and local government authorities of individual countries. The paper carried out analyses based on statistical data and other information related to the operation and development of hydropower. The research methods and techniques used in the

article allowed achieving the assumed goal. Statistical data and other important information used during the analyses constituted the basis for drawing conclusions regarding the analysed renewable energy source, i.e. hydropower.

3. Results

It should be noted that the development potential of hydropower in the Czech Republic and Poland is limited. However, it is important to analyze the environmental and economic possibilities of developing this renewable energy source. Greater use of the technical potential of hydropower may be an important element in the gradual reduction of the use of conventional fuels. This may be an important element in the development of renewable energy in rural and less urbanized areas (Azarinfar et al., 2024; Heidari et al., 2024).

In Poland, the share of hydropower in total production was much lower than in the EU. However, the share of hydropower production in 2020 in the Czech Republic was higher than in Poland and closer to the EU average, even though in all analysed years the sum of hydropower-based production was lower than in Poland (Table 1). However, due to the much lower total electricity production in the Czech Republic compared to Poland, Czech hydroelectric power plants had a larger share in the total energy production.

The Czech Republic and Poland are located in Central and Eastern Europe with a similar climate. Poland covers an area almost four times larger (312.7 thousand km^2) than the Czech Republic (79.9 thousand km^2) and is also inhabited by many more people (over 38 million) than the Czech Republic (less than 11 million). However, in the Czech Republic the average population density is higher (135.5 people per km^2) than in Poland (122.7 people per km^2). Most of the Czech Republic is located on the Bohemian Plateau and is surrounded by mountain ranges. Poland, on the other hand, is a lowland country with mountain ranges in its southern part. Most of Poland is below 300 m above sea level. The climate of the Czech Republic is mild and depends on the altitude above sea level. In turn, the border between the temperate and subarctic as well as the continental and oceanic climate zones runs through Poland. This causes significant weather variability, especially severe in recent years (e.g. periods of drought).

In the Czech Republic and Poland, most of the rainfall falls in the summer months. However, in winter there is the least rainfall and it occurs mainly in the mountains. The average rainfall in the Czech Republic ranges from 600 mm to 800 mm. However, in Poland the average rainfall is approximately 600 mm with possible significant deviations from the indicated values in both countries. But, similarly to the Czech Republic, Poland also records higher annual rainfall in mountainous areas. The main water divide in Europe is located in the Czech Republic, separating the basins of the Baltic, Black and North Seas. One of the country's main rivers is the Elbe, which flows into the North Sea. The Morava River, in turn, flows into the Danube. The last major river, the Odra, flows into the Baltic Sea. However, approximately 99.7% of Poland's area belongs to the Baltic Sea catchment area, which consists mainly of the Vistula and Odra river basins (nearly 90%) and, to a small extent, the Neman river basin (less than 1%). The rest (just over 9%) constitutes the direct basin of the Baltic Sea.

Table 1. Hydropower electricity production capacities in EU countries - in MW

Specification	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
European Union—27 countries	142,433.708	143,073.780	144,156.131	144,329.264	146,291.976	147,816.738	148,584.348	148,613.314	148,996.193	148,982.176
Belgium	1,426.000	1,427.000	1,429.000	1,431.000	1,422.000	1,419.100	1,417.100	1,417.800	1,414.100	1,415.800
Bulgaria	3,108.000	3,181.000	3,203.000	3,219.000	3,219.000	3,223.000	3,371.550	3,379.000	3,378.350	3,376.456
Czechia	2,023.000	2,029.000	2,064.000	2,062.000	2,069.000	2,071.000	2,080.890	2,080.598	2,080.955	2,081.012
Denmark	9.000	9.000	9.000	9.000	6.878	9.267	7.153	7.153	7.263	7.263
Germany	11,367.000	11,185.000	11,197.000	11,190.000	11,212.000	11,164.000	11,078.000	10,652.000	10,698.000	10,757.000
Estonia	5.000	8.000	8.000	5.000	6.000	6.000	7.300	7.300	6.000	8.000
Ireland	237.000	529.000	529.000	529.000	529.000	529.000	529.000	529.000	529.000	529.000
Greece	3,224.000	3,236.000	3,238.000	3,389.000	3,392.000	3,392.000	3392.000	3,409.000	3,412.000	3,417.000
Spain	18,197.000	18,207.000	18,818.000	18,856.000	19,686.000	19,711.000	19,710.000	19,710.572	19,744.667	19,747.592
France	25,454.181	25,469.754	25,458.073	25,398.027	25,368.096	25,435.177	25,517.417	25,542.147	25,674.256	25,496.113
Croatia	2,127.000	2,127.000	2,176.000	2,178.100	2,192.100	2,189.100	2190.300	2,196.800	2,197.000	2,197.200
Italy	21,568.000	21,752.000	21,890.000	21,979.000	22,099.000	22,181.000	22,307.160	22,393.119	22,434.666	22,604.426
Cyprus	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Latvia	1,571.000	1,573.000	1,585.525	1,586.748	1,586.693	1,563.196	1,563.260	1,563.339	1,585.204	1,584.755
Lithuania	876.000	876.000	876.000	877.000	877.000	877.000	877.000	877.000	877.000	877.000
Luxembourg	1,132.300	1,132.300	1,132.300	1,328.300	1,328.300	1,328.300	1,328.580	1,328.508	1,328.508	1,328.508
Hungary	55.000	56.000	57.000	57.000	57.000	57.000	57.000	57.000	58.000	58.000
Malta	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Netherlands	37.000	37.000	37.000	37.000	37.000	37.000	37.000	37.000	37.000	37.000
Austria	12,642.227	12,773.726	12,848.233	12,997.089	13,112.909	13,570.598	13,717.985	14,088.138	14,162.000	14,169.295
Poland	2,345.000	2,350.000	2,354.000	2,363.000	2,369.000	2,385.000	2,389.559	2,390.768	2,396.512	2,399.102
Portugal	5,529.000	5,706.000	5,655.000	5,709.000	6,162.000	6,954.000	7,219.731	7,229.642	7,255.885	7,234.706
Romania	6,411.000	6,455.000	6,509.000	6,523.000	6,619.000	6,644.000	6,610.437	6,617.714	6,602.737	6,565.675
Slovenia	1,137.000	1,138.000	1,183.000	1,180.000	1,179.000	1,177.000	1,230.926	1,227.716	1,230.090	1,230.273
Slovakia	2,494.000	2,493.000	2,493.000	2,493.000	2,495.000	2,493.000	2,493.000	2,496.000	2,494.000	2,496.000
Finland	2,885.000	2,913.000	2,922.000	2,946.000	2,947.000	2,947.000	2,968.000	2,963.000	2,949.000	2,959.000
Sweden	16,574.000	16,411.000	16,485.000	15,987.000	16,321.000	16,454.000	16,484.000	16,413.000	16,444.000	16,406.000

Source: Eurostat (2023)

Both Poland and the Czech Republic have a rich history of using water energy in economic processes. Originally, it was used in water mills, and the first of them operated in Poland and Czech Republic in the 12th century (Piwowar & Dzikuć, 2022; Havlíček et al., 2022). Its use corresponds to the Pan-European trends (Štěpán & Křivanová, 2000). Its use corresponds to the Pan-European trends. Hydropower systems, including primary ones using the energy of flowing water in the form of a mill, are perceived as basic elements of economic and social development processes, including in rural areas (Szatten et al., 2023). In both Poland and the Czech Republic, and more broadly in Central and Eastern Europe, there have been periods of increased interest and development in hydropower, as well as periods of lack of interest and significant environmental constraints in expanding existing hydropower facilities (Kałuża et al., 2022; Steller et al., 2018).

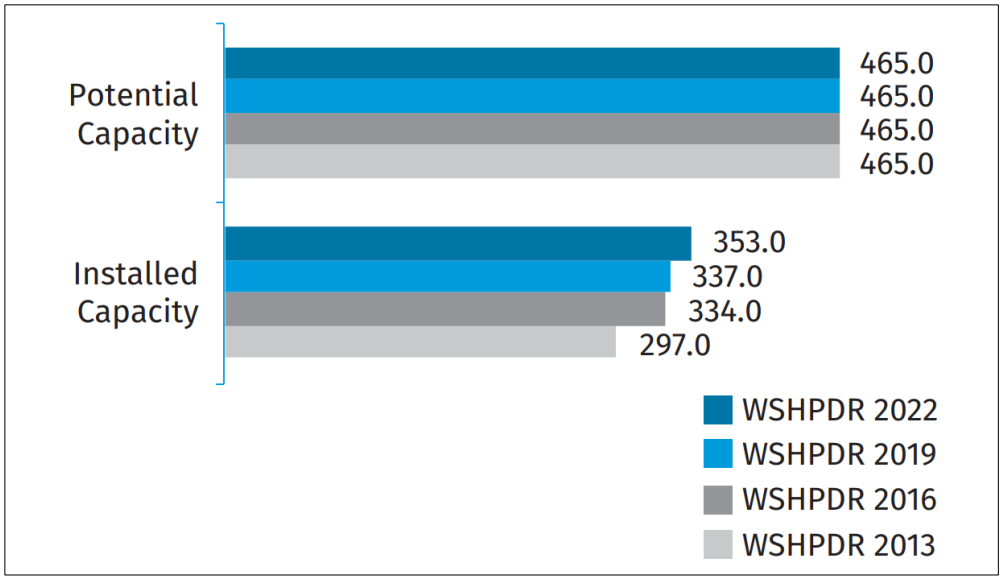

Figure 2. Small hydropower capacities in the WSHPDR 2013/2016/2019/2022 in the Czech Republic (MW) (UNIDO, ICSHP 2022)

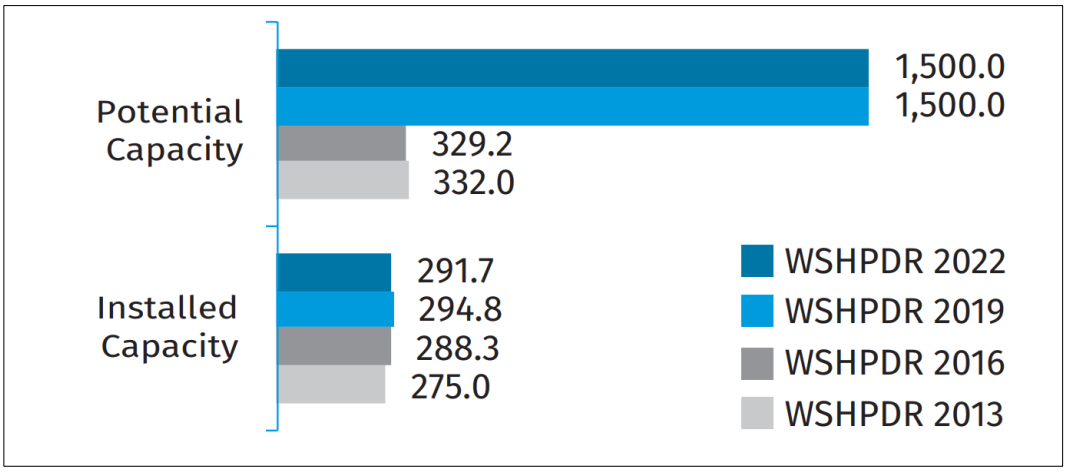

Figure 3. Small hydropower capacities in the WSHPDR 2013/2016/2019/2022 in Poland (MW) (UNIDO, ICSHP 2022)

According to data from World Small Hydropower Development, both the Czech Republic and Poland are currently not using the technical potential of hydropower (Figure 2 and 3). This applies in particular to the possibility of generating energy based on small hydroelectric power plants, which, from the point of view of investment, are less complicated during implementation and have a smaller impact on the natural environment (Dzikuć & Tomaszewski, 2016). This problem is particularly visible in Poland, where about one fifth of the hydropower potential is used (UNIDO, ICSHP 2022).

4. Discussion

It should be emphasized that both the Czech Republic and Poland do not fully use the potential of hydropower in rural areas. The possibilities for dynamic development of hydropower in the Czech Republic are limited because the vast majority of this potential has already been utilized. Nevertheless, the literature indicates, for example, the advantages of natural conditions in the Moravica basin, along the Moravica River, which may be the basis for the creation of new or renovation of old infrastructure for hydropower plants (Havlíček et al., 2022; Duchan et al., 2020; Gono et al., 2012). The situation is completely different in Poland, where there are a large number of potential locations to be developed where hydrotechnical facilities can be built or restored. This is often a relatively easy task because most potential locations for this type of investment remain undeveloped.

An additional benefit may be at least partial use of a hydroelectric power plant as an energy storage facility. This is important because currently in Poland the problem of using energy generated from renewable energy sources, which is periodically produced in excess, has not been solved. This mainly applies to sunny summer days, which are also days off from work. A large number of small hydropower plants could, at least partially, solve this problem. The problem of periodic increases in energy production will intensify in Czech Republic and Poland due to the energy transformation plans, which assume dynamic development of renewable energy sources. Nevertheless, renewable energy sources, at the current state of technology development, do not have the potential to completely replace the power of coal-fired power plants (in Poland) or coal-fired and nuclear power plants (in the Czech Republic) (Charvat et al., 2020). There is currently an ongoing discussion in Poland that nuclear energy should be a large-scale, proven alternative to coal. This is important for the stability of the energy system in Poland and requires many challenges in the technological, logistic and social areas.

5. Conclusions

The analyses carried out in the article demonstrate a significant potential for the development of hydropower, especially in Poland, where the vast majority of locations favourable for this renewable energy remain undeveloped. Although hydropower will not be the dominant renewable energy source in the Czech Republic and Poland in the future, a detailed economic, environmental and technical analysis should be carried out in order to increase the use of the potential of hydropower, which, additionally with certain modifications to the installation, in some cases can also be used as an energy storage facility.

Such actions may, to some extent, reduce the need to expand energy transmission networks and contribute to faster and more effective development of distributed energy.

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Conflicts of Interest: none.

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