
Management and Assessment of the Potential for Electricity Generation from Surface Water Sources in Non-Industrialized Areas Near Czestochowa

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Abstract:

Purpose: This article identifies the possibilities for constructing or reactivating small hydropower plants (at disused mills) in Częstochowa County. The vast majority of watercourses in Częstochowa County meet the conditions for the construction of such facilities. In the era of the energy transition, the key trends in the development of electricity generation from surface water sources include diversification of electricity sources, spatial decentralisation of generation sources, the use of modern grid solutions in the power sector, and the creation of local energy storage facilities.

Design/Methodology/Approach: This article proposes a concept for managing existing or potential local small hydropower plants. It has been examined and demonstrated that the quantitative parameters of the watercourses in the study area (although the data are several decades old) allow for the construction of such power plants, and that the soil quality (low permeability) is suitable for their development. This conceptual solution has not been presented elsewhere and is likely to be a novelty for which no equivalent has been found in the domestic or international literature.

Findingss: The majority of the data were sourced from documents dating from 2005 and the 1920s. This article does not present any new field measurements. It presents the author's preliminary research and is not a technical paper; therefore, it presents for the first time only the management concept for such small hydropower solutions.

Practical Implications: This article presents one of the ways of generating energy from renewable surface water sources in Częstochowa County. In the past, this energy was used in this area to power various types of watermills (e.g. grain mills, groat mills and steam mills). Today, hydropower is one of several alternatives to fossil fuels. Hydropower plants offer low operating costs and can be put into operation immediately; they can supplement other renewable energy sources considerably.

Originality/Value: The reactivation of disused mills and/or the construction of small hydropower plants could provide an alternative source of renewable energy.

Keywords: Surface water assessment, hydropower plants, energy production management.

JEL Codes: L9, R5, Q4.

Paper Type: Research article.

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1. Introduction

By 2030, Poland is required to generate at least 32% of its energy from renewable sources. This objective will be achieved by replacing the stable but harmful energy derived from hard coal and lignite. Hydropower plants, which are a renewable energy source, should be fully leveraged. In December 2025, Polish Waters presented a list of around 4,000 potential hydropower sites to investors. These state-owned sites are water-impounding structures such as weirs or control thresholds.

Investors must verify for themselves whether the proposed locations are suitable for such use. The energy potential of all the locations identified by Polish Waters is 655 MW of capacity and the potential for 4.86 TWh of annual electricity generation. This represents approx. 3% of electricity consumption in recent years, which has amounted to around 170 TWh per year (portal samorządowy 2026 <https://www.portalsamorzadowy.pl/polityka-i-spoleczenstwo/blisko...>; and portal samorządowy 2026.

(<https://www.portalsamorzadowy.pl/gospodarka-komunalna/wody-polskie-...>).

The aim of this study is to assess the feasibility of using state funds to establish a network of small hydropower plants in Czeŝochowa County, which would complement other sources of green electricity and could be managed centrally, for example, by the local power company, a specially established county consortium, or perhaps a consortium of local universities. If managed well, such power plants would also provide financial support for the activities of individual municipalities in the long term.

The research was limited to Czeŝochowa County, excluding the city of Czeŝochowa, and the acquired watercourse parameters concern virtually 90% of the municipalities in the county. It aims to explore the feasibility of an idea, not previously considered in any publication, namely the management of small hydropower plants across the voivodship, and to identify the economic operators best suited to managing such power plants.

The research methodology used to investigate the problem presented is quantitative and, to some extent, qualitative. The construction of small hydropower plants requires water, which is supplied in a specific quantity by watercourses; the quality of the site (low-permeability soil) is also important, as it enables these power plants to be built cost-effectively. Therefore, efforts were made to assess the feasibility of this project.

The specific research activities were carried out using information provided in studies and journals, as well as on the basis of literature reviews and source materials from the archives. It should also be noted that for most watercourses in Czeŝochowa County, neither their current parameters nor the areas where a small local hydropower plant could be built have been specified.

This is a significant drawback when it comes to determining the maximum capacity of a small hydropower plant and its location. The research focused primarily on studies of watercourses published between the 1920s and the 2020s. As shown (see tables), changes in the quantitative parameters of watercourses in Częstochowa County over the last century have been minor; however, the potential for constructing small hydropower plants has changed significantly due to the extensive development of residential and, to some extent, industrial buildings in these areas.

This paper proposes a method for managing a network of small hydropower plants in a specific area, which may be unknown or, alternatively, known but not yet in use. Once a small hydropower plant has been built and operated for several decades, it can also be controlled and managed using artificial intelligence; however, this requires the development of specific programmes to carry out multi-facility management involving at least several factors affecting the operation of the system. The material presents a solution that addresses two problems: the use of low-cost electricity generation, which is usually consumed in the immediate vicinity of where it is produced, and the potential to increase funding for the county's municipalities.

The production of widely accessible energy, which is both environmentally friendly and affordable, is currently a challenge facing humanity. The burning of hard coal, lignite, gas and oil is one of the main sources of environmental pollution. It introduces a range of harmful substances into the atmosphere, water and soil. Furthermore, the combustion of fossil fuels is responsible for greenhouse gas emissions, smog and acid rain.

The era of generating electricity from fossil fuels is likely coming to an end, albeit slowly, although in some quarters gas is mistakenly regarded as a non-polluting fuel. Electricity will be generated from air, water, the sun and other renewable sources. It is believed that low-cost electricity will be generated by nuclear power plants, although the disaster at the Chernobyl Nuclear Power Station has meant that the attitude towards nuclear power stations in Polish society is not entirely positive.

Energy obtained from biogas, biomass and biofuels, solar energy, wind energy, geothermal energy and energy from mine dewatering has been omitted. This article presents the energy potential of surface waters in Częstochowa County. It should also be added that energy from mine waters does not occur in Częstochowa County (Kopecki, 1976).

The key terms relating to this topic include energy management, renewable energy sources (RES), and small hydropower plants (SHPs). Energy management encompasses generation and distribution, including renewable energy sources (RES), and management thereof (Egemen, 2012; Breeze 2018). Energy is derived from renewable and non-renewable (conventional) sources. Renewable energy sources include geothermal, biomass, wind, solar and hydropower (Tomczyk, 2026). Non-renewable energy sources include hard coal and lignite, uranium and crude oil.

There is no official definition of small hydropower plants (SHPs) in Poland, but this category usually includes installations with a total capacity not exceeding 5 MW (<https://www.instytut.ioze.pl/pl/mala-..>; Karabegović and Doleček 2016; Rafique and Zhang, 2017). In many European countries, the upper limit for SHPS is 10 MW (Hannan *et al.*, 2018; Piwowar and Dzkuć 2022; Triviño-Madrid *et al.*, 2025; Janicka *et al.*, 2021).

This work mainly focuses on a selected/local area. It describes the use of surface water in Częstochowa County as an example of a renewable energy source, namely hydropower.

The non-industrial areas around Częstochowa (Częstochowa County) offer moderate conditions for the development of small-scale hydropower; nevertheless, all the existing water-impounding structures that have been surveyed are in reasonably good technical condition, which is relatively rare on a national scale and is mainly due to the high proportion of retention reservoirs, which tend to deteriorate less rapidly than other smaller structures (such as former mills).

Therefore, it appears important for county authorities to manage the efforts to bring these currently inactive and new small-scale electricity-generating facilities into operation and then, once they are operational, to transfer them by contractual arrangement to the executive boards of municipalities or even to private economic operators, on the understanding that the power plants will operate for the benefit of the local energy sector.

The specifics of managing the use of surface water in Częstochowa County require a tailored approach to assessing its potential. There are also old hydraulic structures in this area that could be put back into operation for energy generation. However, the lack of a comprehensive field assessment of specific local conditions, combined with the fact that the use of surface water is usually area-based and regional, means that it is not currently feasible to accurately determine the potential for managing these energy resources.

These measures have not yet led to a significant increase in the number of small hydropower plants in Poland. A government programme was intended to increase the number of small hydropower plants. Under this programme, small hydropower plants are defined as facilities with an installed capacity of between 1 MW and 10 MW, while smaller ones are classified as mini-power plants (301 kW–1 MW) and micro-power plants (<200 kW). Funding was available for investments, and grants can cover up to 50% of eligible costs (e.g. under the Environment, Energy and Climate Change programme).

This paper deals with one of the renewable sources of clean electricity, namely surface water. The energy balance for the area should be calculated taking into account all the energy sources available in that area (water, sun, wind). Poland

enjoys several months of favourable levels of sunshine each year (particularly during the summer holidays), but conditions are less favourable at other times.

However, their rational operation requires large areas, much larger than roof surfaces, and such areas may be difficult to find in land that has been used for agriculture for centuries. Surface water has been used for thousands of years; however, as late as the 19th century, many believed that a watermill could only operate for eight months of the year, as the watercourses were frozen over for the remaining months and the mill wheels would not turn.

Global warming has made it possible to generate electricity from surface water all year round. Consequently, in some areas, electricity generated from surface water may constitute the most significant component of the area's energy balance, ensuring that instantaneous demand and supply are balanced in that area.

2. An Assessment of Hydroelectric Potential in Poland during the Second Polish Republic (1918–1945) and Today

According to the *Mały Rocznik Statystyczny* (Small Statistical Yearbook 1935), the total estimated hydropower in 1935 in what was then Poland amounted to 3,700,000 hp, of which 2,200,000 hp was usable, whilst only 100,000 hp was actually utilised. These figures changed very slowly right until the end of the Second Polish Republic.

By the end of the 1930s, there were over 6,500 hydropower plants in operation in Poland, with a combined capacity of approximately 170 MW (assuming that 1 kW is 1.35962 hp), which corresponded to a capacity of approx. 231,000 hp and accounted for approx. 10% of the mechanical or electrical energy that could be generated.

In 1939, the largest hydropower plant in Poland was the Żur Power Plant on the Wda River, which took 1.5 years to build and was commissioned in December 1929. It was fitted with two Kaplan turbines, each with a capacity of 4.5 MW. Shortly before the war, a large 50 MW hydropower plant at the Rożnów reservoir on the Dunajec River was nearing completion (it was commissioned by the Germans in 1942).

Today, Poland's technical hydropower potential remains largely untapped and is estimated at approx. 137 TWh. There are just over 770 hydropower plants in operation, of which more than 760 are small hydropower plants with a capacity of less than 10 MW.

One of the impediments to the development of hydropower plants in Poland is the limited government support, as well as the lack of a comprehensive plan for managing the construction of hydropower plants, so that as much of the country's electricity as possible is generated from low-cost renewable sources utilising the power of surface water. At present, the largest pumped-storage hydropower plants are Żarnowiec (716 MW) and Porąbka-Żar (4x136 MW).

3. Problems with the Construction of Hydropower Plants and the Feasibility of Their Coordinated Management

The use of air (vertical-axis and horizontal-axis wind turbines) and the sun (primarily photovoltaic panels) is now widespread, whereas water (mill wheels, turbines and tidal energy) is used much less frequently in electricity generation. In the 19th and 20th centuries, weirs (both permanent and adjustable) were built across almost all watercourses throughout the country; these were constructed perpendicular to the direction of the water flow and served to dam up the water and maintain a constant water level, thereby enabling watermills to operate.

The area around Częstochowa was relatively rich in streams, small rivers and rivers, which had made it possible to build many watermills as far back as the Middle Ages. Most weirs and watermills have been decommissioned or destroyed since the mid-1940s, as a result of the country's widespread electrification, whereby electricity was generated in coal-fired power plants.

The key challenge in the construction of modern hydropower plants is determining the type of power plant the water drive is intended to power: a power plant operating in parallel with the local electricity grid (an asynchronous generator designed for continuous operation) or a separate grid (an AC generator designed to operate on a separate grid).

This study focuses on power plants operating in parallel with the local electricity grid, which enables the management of electricity generation across a relatively large area of Częstochowa County. It should also be noted that it is relatively straightforward to construct new buildings or, if necessary, adapt existing ones; however, the construction or refurbishment of water-impounding structures is more demanding, as technical guidelines require a minimum impoundment height of 0.7 m.

The second argument in favour of developing hydropower plants is their unique controllability, that is, the ability to start and stop power generation as needed. As recent years have shown, controllable power sources are essential for regulating power in the electricity grid, not only in the vicinity of Częstochowa but also across the country.

Therefore, it is essential to manage the operation of hydropower plants as a coordinated effort, which is currently restricted to a single county. The results of this study can be used to manage the operation of all hydropower plants in Poland (Łaski 1975; Michałowski and Plutecki 1975).

Work is currently underway on alternative concepts for the construction of energy storage facilities (both long- and short-term, known as energy storage systems, which enable the use of stored electricity in times of shortage). However, at this

stage of their development, costs are holding back large-scale construction of these facilities, as are energy losses resulting from energy storage and reuse. Some propose solving this issue through energy imports, which is costly and not always feasible.

4. Geographical Location of Częstochowa County and Its Division into Municipalities

According to the physico-geographical regionalisation of Poland, Częstochowa County is generally situated within the Polish Uplands province. The south-western part of the county is part of the Silesian–Kraków Upland province, encompassing the Woźniki–Wieluń Upland and the Kraków–Częstochowa Upland mesoregions.

Its north-eastern part lies within the Lesser Poland Upland subprovince, specifically within the Przedbórz Upland macroregion. Częstochowa County is located on the watershed dividing the Vistula and the Oder basins. The Pilica River and its tributary, the Białka, form part of the Vistula catchment, while the Warta River and its tributaries (including the Wiercica) belong to the Oder catchment.

Figure 1. Administrative division of Częstochowa County



Source: www.gminy.pl

Częstochowa County comprises five towns (Blachownia, Janów, Koniecpol, Olsztyn and Przysów), five urban–rural municipalities (Blachownia, Janów, Koniecpol, Olsztyn and Przysów), and eleven rural municipalities (Dąbrowa Zielona, Kamienica Polska, Kłomnice, Konopiska, Kruszyna, Lelów, Mstów, Mykanów, Poczesna, Rędziny and Starcza). Częstochowa County almost completely surrounds the city of Częstochowa along five-sixths of its borders.

5. Methodology for Estimating the Hydropower Potential of Watercourses and the Surface Water Energy Resources in Częstochowa County

The principal parameters used to estimate the hydropower potential of watercourses are the hydraulic head, expressed in metres [m], and the discharge, expressed in cubic metres per second [m³/s]. The average power output of a given watercourse is determined using the following relationships. For each watercourse, the theoretical potential for electricity generation (gross hydropower potential) is defined as the amount of energy that can be generated from a given river reach and is calculated as follows:

$$A_{avg} = 8760 \cdot P_{avg} \quad [\text{kWh}] \quad (1)$$

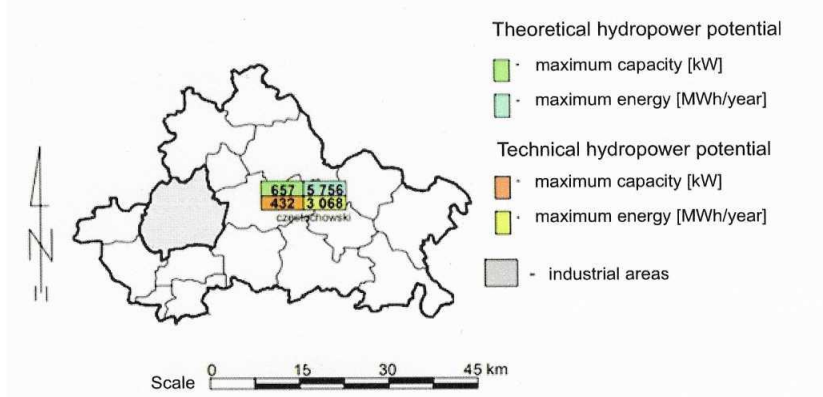
$$P_{avg} = 9.81 \cdot Q_{avg} \cdot H_{avg} \quad [\text{kW}] \quad (2)$$

where: P_{avg} [kW] – average power output, Q_{avg} [m³/s] – long-term average discharge, H_{avg} [m] – hydraulic head or river section. The technical (net) potential is the amount of energy that can be obtained using all feasible impounding structures and hydropower installations.

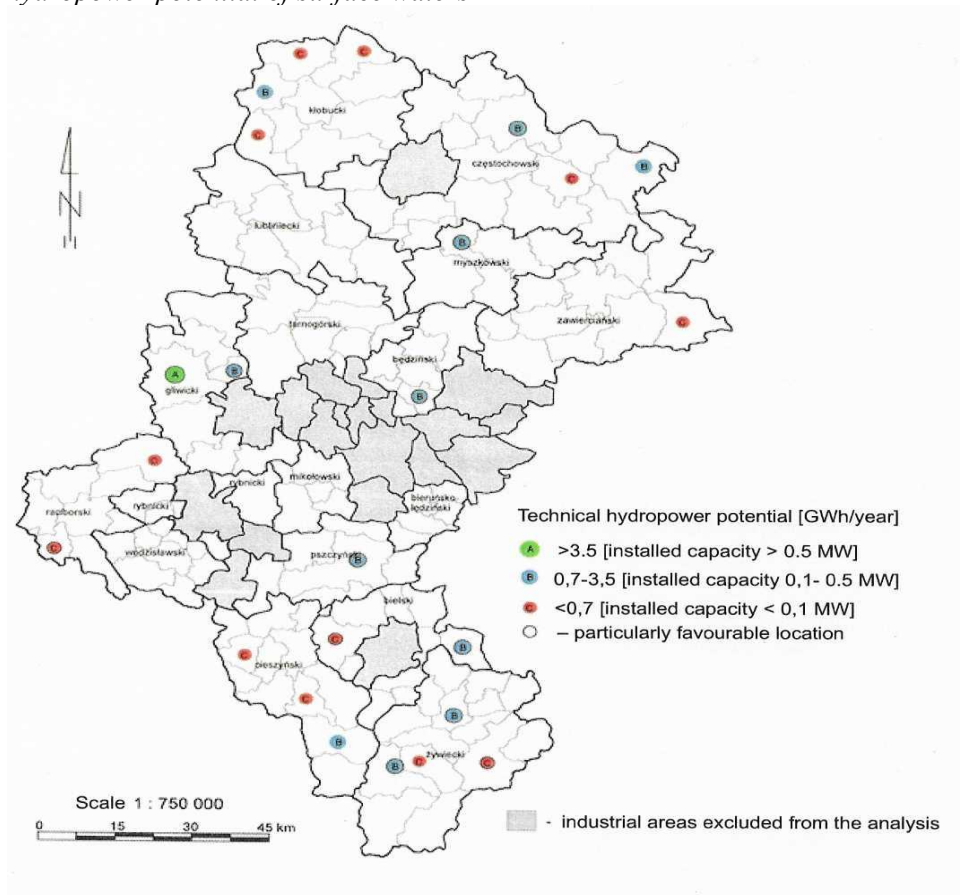
These include, among others, the natural variability of river discharge over time, seasonal fluctuations in hydraulic head (associated, for example, with flood flows), the efficiency of the equipment employed, consumptive water abstractions for non-energy purposes, and the requirement to maintain a minimum environmental flow downstream of the hydropower installation (also referred to as the ecological or instream flow). It is generally assumed that, in lowland areas, the technical hydropower potential amounts to approx. 20% of the theoretical potential (Łaski 1975; Michałowski and Plutecki, 1975).

The development of hydropower schemes is constrained by legal, siting, land-use and geomorphological conditions. Another important factor is the availability of investment capital, which may be supported through government funding. The construction of hydraulic structures used to impound water (such as weirs and dams) represents the largest capital cost, while buildings and associated technical infrastructure account for a smaller proportion of the investment. However, one of the principal advantages of hydropower plants is their very low operating and maintenance costs.

Within Częstochowa County, the maximum theoretical hydropower potential is estimated at 675 kW, corresponding to an annual electricity generation potential of approx. 5,756 MWh. The estimated technical hydropower potential is approx. 432 kW, enabling the generation of approx. 3,068 MWh of electricity per year (Opracowanie, 2005). Table 1 below presents the utilisation of surface hydropower in 2005.

Figure 2. Theoretical and technical hydropower potential of Częstochowa County

Source: Program ochrony środowiska dla powiatu częstochowskiego na lata 2024-2027 z perspektywą na lata 2028-2031 s. 45

Figure 3. Hydropower. Classification of municipalities according to the technical hydropower potential of surface waters

Source: Bujakowski W. (red), *Opracowanie metody programowania i modelowania systemów wykorzystania odnawialnych źródeł energii na terenach nieprzemysłowych województwa śląskiego, wraz z programem wykonawczym dla wybranych obszarów województwa, Część II Program wykorzystania odnawialnych źródeł energii na terenach nieprzemysłowych Województwa Śląskiego (Projekt), Polska Akademia Nauk, Instytut Gospodarki Surowcami Mineralnymi i Energia, Województwo Śląskie Wojewódzki Fundusz Ochrony Środowiska i Gospodarki Wodnej w Katowicach, Kraków-Katowice 2005, s. 125*

Table 1. Surface hydropower in Częstochowa County

No	Facility name Town/village Municipality	Location – river (catchment)	Type of facility	Hydropower parameters					
				Discharge	Hydraulic head	Theoretical potential		Technical potential	
						Capacity N kW	Energy A MWh/year	Capacity N kW	Energy A MWh/year
Częstochowa County						657,1	5756	432,4	3068,1
1.	Okołowice (Koniecpol)	Pilica (Wisła)	Impoundment for fish ponds	8,7	2,3	196,3	1719,6	140,1	993,9
2.	Koniecpol (Koniecpol)	Pilica (Wisła)	Mill (disused)	8,1	2,1	166,9	1461,8	119,1	844,9
3.	Rzeki Wielkie (Kłomnice)	Warta (Odra)	Factory powerhouse (out of operation)	7,1	3	209	1830,4	149,1	1058
4.	Smyków (Przyrów)	Wiercica (Warta)	Mill	1,5	2,3	33,8	296,5	24,2	171,4
5.	Zalesice (Janów)	Wiercica (Warta)	Recreational reservoir	1,4	2,5	34,3	300,8		
6.	Złoty Potok (Janów)	Wiercica (Warta)	Recreational reservoir	0,2	2,7	5,3	46,4		
7.	Złoty Potok (Janów)	Wiercica (Warta)	Mill (out of operation)	0,2	2,1	4,1	36,1		
8.	Błachownia (Błachownia)	Stradomka (Konopka)	Recreational reservoir	0,3	2,5	7,4	64,5		

Source: Bujakowski W. (red.) *Opracowanie metody programowania i modelowania systemów wykorzystania odnawialnych źródeł energii na terenach nieprzemysłowych Województwa Śląskiego, wraz z programem wykonawczym dla wybranych obszarów województwa, Część II Program wykorzystania odnawialnych źródeł energii na terenach nieprzemysłowych Województwa Śląskiego (Projekt), Polska Akademia Nauk, Instytut Gospodarki Surowcami Mineralnymi i Energia, Województwo Śląskie Wojewódzki Fundusz Ochrony Środowiska i Gospodarki Wodnej w Katowicach, Kraków-Katowice 2005, s.85i 86.*

As shown in Table 1, among the existing hydropower plants in Częstochowa County, the highest discharge is recorded on the Pilica River at Okołowice, near Koniecpol, where water is impounded to supply fish ponds. This is closely followed by the disused facility on the Pilica River in Koniecpol. The lowest discharges occur at two facilities on the Wiercica River in Złoty Potok, near Janów: a recreational reservoir and a disused mill.

The greatest hydraulic head is found at the hydropower site on the Wiercica River in Janów, near Złoty Potok. Slightly lower hydraulic heads occur at the hydropower

plants on the Stradomka River (more precisely, the Konopka River) within the administrative boundaries of Blachownia and at the reservoir on the Wiercica River in Zalesice, near Janów. The highest theoretical hydropower potential is associated with the Warta River at Rzeki Wielkie, near Kłomnice, at the site of a disused factory powerhouse.

A slightly lower theoretical potential is recorded at the fish pond impoundment on the Pilica River at Okołowice, near Koniecpol. This is reflected in the corresponding annual electricity generation potential. Overall, the greatest opportunities for hydropower development are offered by the Pilica River, a tributary of the Vistula, and the Warta River, which forms part of the Oder River basin.

In addition to the sites described above, only three small hydropower plants are currently in operation in Częstochowa County:

- “Megawat” small hydropower plant on the Warta River, located in Kłomnice,
- Warta hydropower plants, located in Kłomnice,
- Small hydropower plant on the Warta River, located in Kruszyna.

These installations are entered in the Register of Electricity Producers Operating Small Installations, maintained pursuant to Article 8(1) of the Renewable Energy Sources Act (Journal of Laws 2020, item 261, as amended). The register is maintained by the President of the Energy Regulatory Office (Urząd Regulacji Energetyki) in Warsaw.

Table 2. *Parameters of the Warta and Widawka Rivers, sections of which flow through Częstochowa County*

Rivers and their division into sections	Length of the river or its section	Gross head	Specific head	Catchment area	Average annual discharge	Average annual hydropower capacity	Specific hydropower capacity
	L km	H m	H:l Km2	F	Q M3/s	L KM	L:l KM/km
Warta River	676	372	-	30632	-	96471	-
From the source to Mrzygłód	16	98	61	80	0,22	216	13,5
From Mrzygłód to the mouth of the Kamieniczka River	31	47	1,5	540	1,71	804	25,9
From the mouth of the Kamieniczka River to the mouth of the Stradomka River	18	15	0,8	659	3,55	532	29,5
From the mouth of the Stradomka River to the mouth of the Wiercica River	45	33	0,7	1279	6,05	1996	44,4
From Wiercica to the mouth of the Radomka River	11	6	0,5	1917	10,13	608	55,2
From the mouth of the Radomka River to the mouth of the Liswarta River	38	18	0,5	2386	11,98	2155	56,7
From the mouth of the Liswarta River to the mouth of the Oleśnica River	83	42	0,5	4672	23,56	9895	119,2
From the mouth of the Oleśnica River to the mouth of the Widawka River	19	9	0,47	5447	29,62	2668	140,3
From the mouth of the Widawka River to	55	22	0,4	8572	41,12	9046	164,5

the mouth of the Sadówka River							
From the mouth of the Sadówka River to the mouth of the Ner River	43	20	0,46	9407	46,16	9232	214,7
From the mouth of the Ner River to the mouth of the Rgółka River	3	1	0,33	11418	56,97	570	190
From the mouth of the Rgółka River to the mouth of the Struga River	71	18	0,25	14357	65,99	11878	167,3
From the mouth of the Struga River to the mouth of the Prosna River	22	4	0,18	15532	76,46	3058	139
From the mouth of the Prosna River to the mouth of the Lutynia River	14	1	0,07	20494	90,01	900	64,3
From the mouth of the Lutynia River to the mouth of the Wełna River	131	24	0,18	25744	103,05	24732	188,8
From the mouth of the Wełna River to the mouth of Międzychód River	76	14	0,18	30632	129,86	18180	239,2
Widawka River	102,5	104	-	2428	-	3051	-
From the source to Gocławic	10,6	21	1,98	47	0,12	25	2,4
From Gocławic to Czyżowa	20,8	24	1,15	333	0,96	230	11,1
From Czyżów to the mouth of the Rakówka River	12,6	13,5	1,07	437	1,93	260	20,7
From the mouth of the Rakówka River to the mouth of the Pilsa River	21,8	20,5	0,94	760	3,4	697	32
From the mouth of the Pilsa River to the mouth of the Krasówka River	6,6	4,5	0,68	972	4,79	215	32,6
From the mouth of the Krasówka River to the mouth of the Chrzastówka River	10,9	9,5	0,87	1158	5,75	546	50,1
From the mouth of the Chrzastówka River to the mouth of the Niecierza River	6,6	5	0,75	2105	7,15	357	54,1
From the mouth of the Niecierza River to the Warta River	12,6	6	0,48	2428	12,02	721	57,2

Source: *Elektryfikacja Polski Zapotrzebowanie i produkcja energii elektrycznej Naturalne źródła energii Warszawa Tom I, Wydawnictwo Ministerstwa Robót Publicznych, Warszawa (około 1929 rok), Zeszyt III, Województwa Centralne i Wschodnie, s. 350 (tablica s. 261).*

Table 2 above provides the parameters of the Warta and Widawka rivers, sections of which flow through Częstochowa County. These are data from the 1920s, but the parameters of watercourses do not change rapidly (some claim that such changes amount to up to 10%).

Table 2 indicates that the greatest hydraulic head on the Warta River occurs between its source and the village of Mrzygłód, and a lower one between the mouth of the Liswarta River and the mouth of the Oleśnica River. On the Widawka River, the greatest hydraulic head occurs between the villages of Gocławice and Czyżów, while a slightly lower head is recorded between the river's source and Gocławice.

The greatest hydropower capacity on the Warta River can be generated on the sections from the mouth of the Lutynia River to the mouth of the Wełna River; the capacity is lower from the mouth of the Wełna River to the mouth of the Międzychód River. On the Widawka River, the greatest hydropower capacity can be obtained on the sections from the mouth of the Nieciecz River to the Warta River and from the mouth of the Krasówka River to the mouth of the Chrzastówka River.

Figure 4. Kolaczew Mill in Złoty Potok



Source: <https://orlegniazda.pl/culturalheritage/15794/mlyn-wodny-kolaczew-w-zlotym-potoku> odczyt 15.05.2026

In summary, Tables 1 and 2 indicate that small hydropower plants can be built in approx. 90% of the municipalities of Częstochowa County, and their construction is made possible by the numerous watercourses located within the county.

However, geological maps (which were not covered in this article) suggest that, throughout the area near these watercourses, there are vacant plots of land with low-grade soil and an impermeable subsoil, which could significantly reduce the construction costs of a small hydropower plant. If the municipalities do not own these areas, they will have to be purchased from private owners; however, given the low quality of the land, the purchase costs will likely be relatively low.

6. The Concept for Managing Electricity Generation Capacity from Surface Water Sources in Częstochowa County

The concept is grounded in the close cooperation between municipal authorities and the local electricity company in relation to energy generation by newly built small hydropower plants, taking into account existing power plants of this type (with new ones to be built at water impoundment sites). The concept for managing electricity generation capacity should be based on the following assumptions:

1. State funding is available for the construction of weirs and small hydropower plants.
2. These power plants are transferred to economic operators established by the municipalities.

3. A condition of the transfer of the power plant is consent for the county administrator to manage its operations, and for electricity to be supplied via the power grid to local entities in need (bypassing the national grid).
4. The energy supplied by each power plant is precisely determined (through accurate measurements) by the electricity network operator, and the revenue for the electricity generated is transferred to the administrator.
5. At regular intervals (monthly, quarterly), the costs incurred represent the total of payments received for the energy generated by all the power plants operated. For settlement purposes, these costs are allocated to individual hydropower plants in proportion to their installed electrical capacity, regardless of how long the power plant was in operation during the settlement period.
6. As the operating costs of hydropower plants are negligible, the profits generated by the municipal economic operators can boost the municipal financial resources.
7. Stable legal framework for small hydropower plants – the average service life is 60–70 years(<https://ungc.org.pl/wpcontent/...>). The generally accepted model is as follows:
 - Small hydropower plants operate within a specific, relatively small area, supported by the national grid and other electricity-generating facilities (e.g. wind turbines, photovoltaic systems and others).
 - These small hydropower plants serve two purposes:
 - Electricity supply to consumers in the local area,
 - Support of the national grid with electricity in the event of power shortages.
 - The operation of all power plants is managed by a management team responsible for the national electricity system. The management team receives real-time information on the volume of electricity generated at all power plants; however, due to local demand, these power plants sometimes operate at a lower capacity than is technically possible.
 - The aggregate data received by the management team enables an estimate of the value of the electricity generated and the collection of revenue for it.
 - This revenue is distributed periodically among the users (municipalities or groups of municipalities) of the individual hydropower plants, but according to the maximum generation capacity of each plant rather than its actual output.

This forward-looking concept concerns the management of a network of local small hydropower plants, whose number in the study area is currently difficult to estimate and cannot even be roughly determined. This also makes it impossible to carry out a cost-benefit analysis, as the benefits will accrue to the municipalities or a group of municipalities (depending on how the users of the hydropower plants are organised).

In Poland, approx. 2% of energy is generated by hydropower plants; the global average is 15%. Government measures should encourage the development of small hydropower plants (SHPs) or the reopening of old mills through a system of low-interest loans, preferential tax rates and stable legislation that encourages investment in hydropower.

Further development, which was initiated by Polish Waters' publication of a list of 4,000 potential small hydropower sites, depends on the involvement of local authorities, economic operators and individuals who can help to increase the amount of energy generated from small hydropower plants.

7. Conclusions

A major problem with surface waters in Częstochowa County, and indeed across the country, is their quality. The measures undertaken to protect waters in Częstochowa County are effective, as their condition has remained virtually unchanged for years. A major factor here is the implementation of measures to increase water retention: the maintenance and construction of impounding structures in river valleys and small water reservoirs, afforestation, and the preservation of wetlands. This applies in particular to droughts, floods and localised flooding.

Maintenance of watercourses and water infrastructure in Częstochowa County is carried out by the administrator, namely the State Water Holding Polish Waters and water companies. It is clear that the efficient use of water resources reduces the risk of water shortages, which are often linked to climate change. Given the increasing frequency of extreme weather events in recent years (and the predicted steady rise in their intensity), these events may occur more frequently and affect the operation of hydropower plants. The impact of these factors must be taken into account in the management of local and national hydropower.

Poland faces the challenge of increasing the share of renewable energy sources in its energy mix. Although surface water resources are limited, the hydropower potential remains untapped. It is estimated that the technical potential of hydropower plants in Poland stands at 13.7 TWh, and small hydropower plants could harness as much as 15% of this potential. According to Poland's draft National Energy and Climate Plan until 2030, the capacity of hydropower plants in Poland is set to rise to 1.0 GW over the next five years and reach 1.2 GW by 2040, with annual energy production of around 3 TWh. This means dynamic growth in Poland's hydropower market and new investment opportunities in this sector (https://bip.mos.gov.pl/fileadmin/user_upload...).

Every MWh generated by small hydropower plants results in a reduction in CO₂ emissions of 0.758 Mg. For a 1 MW power plant, this translates to a reduction of up to 1.5 million Mg of CO₂ per year, which provides tangible support for the climate targets of Poland and the European Union. The potential storage capacity of all

potential sites for small-scale hydropower is approx. 27 million m³, which is equivalent to the capacity of the Porąbka reservoir on the Soła River (<https://www.gov.pl/web/wody-polskie/...>).

It appears that, in the era of the energy transition, the key trends in the development of the electricity sector powered by surface water sources include:

- diversification of electricity sources;
- spatial decentralisation of generation sources;
- use of modern grid solutions in the power sector;
- creation of local energy storage facilities.

If the trends outlined above are put into practice, energy in non-industrial areas will be significantly cheaper than in industrial areas, where it will have to be transmitted via state-owned transmission lines. The spatial decentralisation of electricity generation from surface water resources is a long-term process of moving away from reliance on a limited number of large hydropower plants connected to the national grid (which should continue to be developed on rivers with very high discharges) towards a distributed system of hydropower plants located on small and medium-sized watercourses.

It should also be added that large pumped-storage hydropower plants stabilise the national electricity grids, and their energy balance is close to zero. This reflects the European Union's broader objective of increasing the number of electricity generation sources within the power system while reducing the installed capacity of individual generating units. This trend towards decentralisation has been facilitated by advances in power engineering technologies, which now appear to have reached a high level of technological maturity.

The implementation of modern smart grid solutions involves technical and technological improvements that enhance the operation of electricity networks, even within relatively small areas such as individual municipalities. These solutions enable the precise monitoring and balancing of electricity supply and demand at the local level. Applied in this way by local distribution system operators, and integrated with the management of local hydropower generation facilities, smart grid technologies make it possible to develop a reliable local electricity supply system (Kowalczyk-Juśko 2020).

At present, energy storage technologies represent one of the fastest-growing areas of the power sector; however, they are still at the research, demonstration and early deployment stage.

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