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Hydroenergetics Fundamentals, Types of Hydroelectric Power Stations, Their Advantages, and Disadvantages

Kholiyorova Maftuna Azamat qizi
Tashkent University of Architecture and Civil Engineering, Faculty of Architecture

Abstract: This article explores the foundational concepts of hydroenergetics, focusing on the various types of hydroelectric power stations and their operational principles. It provides an in-depth analysis of the key advantages and disadvantages of different types of hydroelectric stations, emphasizing their role in sustainable energy production. The article discusses the potential of hydroelectric power as a renewable energy source and its impact on the environment and economy. Additionally, it examines the technical and operational challenges associated with hydroelectric stations, as well as the factors influencing their efficiency and long-term sustainability.

Keywords: hydroenergetics, hydroelectric power stations, renewable energy, advantages, disadvantages, sustainable energy.

Introduction

Hydroelectricity is a method of generating electricity from the energy of flowing water. This method is significant as it reduces harmful emissions released into the environment and serves as an energy source that aligns with nature. The economic and social benefits of hydroenergy are demonstrated in the following ways:

Environmentally clean energy: Hydroenergetics produces no waste and often helps improve the condition of water sources.

Reliability: It has a high level of reliability for producing energy when needed and can also be used as a backup power source.

Cost advantage: The production costs of hydroelectric stations are typically low, helping to stabilize electricity prices.

Water resource management: It allows for the regulation of water levels in rivers, leading to more efficient management of water resources in these areas.

Support for development: The construction of hydroelectric stations creates local jobs, stimulates economic activity, and attracts investments.

Research Materials and Methodology

The development of hydroenergetics began long ago, with early examples of using water energy emerging in ancient times. The use of water wheels to drive mechanisms and perform work through water flow was an advanced method in this field.

In 1878, the first hydroelectric power station was built near the town of Nicholson, along the Fox River in the United States. This station used a direct current generator to produce electricity. In the early 20th century, hydroelectricity began to spread more widely. In 1902, the United States established the Hydroenergetic Construction Management Department, marking an important milestone for the development of the sector. Between 1920 and 1960, many large stations were built, including the Niagara Hydro Power Station in America and the Lenin Hydro Power Station on the Volga River in the USSR. Today, hydroenergetics continues to develop with new technologies and production methods. Additionally, hydroelectricity plays a significant role in combating climate change, as it is an environmentally clean energy source. Globally, hydroelectric power holds a leading position in electricity generation, with installed capacity exceeding 1 TW. According to the International Energy Agency (IEA), hydroelectricity accounts for approximately 16% of global electricity production. The largest producers of hydroelectric power are China, Brazil, the United States, Canada, India, and Russia.

Results and Discussion

Results

Hydroelectric power stations (HEPs) are energy facilities designed to convert water flow into electricity. These stations can be categorized based on their energy generation methods. The most common types include:

- **Flow-through HEPs**: These use the natural flow of river water to directly drive turbines, generating electricity.
- **Reservoir HEPs**: These have large water reservoirs that store water and release it through turbines to produce electricity when needed.
- **Combined HEPs**: These integrate both flow-through and reservoir characteristics, used for additional stability.
- **Tidal HEPs**: These generate energy from ocean tides and water level movements, converting tidal energy into electricity via turbines.
- **Mini HEPs**: Installed in smaller rivers, these stations generate power for remote areas or households, typically with lower capacity.

Additionally, HEPs can be classified based on dam height:

- **High dam HEPs**: These have high dams, which create large reservoirs behind them. They are capable of producing high power due to the large water volumes stored.
- **Low dam HEPs**: These stations have lower dams that create smaller, shallower reservoirs, suitable for smaller rivers or coastal areas for water level control.
- **Dam-less HEPs**: These use floating platforms or water passage devices and are applied in rivers with low flow or in areas requiring temporary reservoirs.

Various types of turbines are used in HEPs to convert water flow into electricity, such as:

- **Kaplan turbines**: Suitable for low-pressure conditions, these turbines work well in areas with high water flow.
- **Pelton turbines**: Designed for high-pressure conditions, they use water jets to strike blades, rotating the turbine.
- **Francis turbines**: These reaction turbines are efficient at medium pressure levels and work well across a broad range of conditions.
- **Propeller turbines**: These axial-flow turbines are best for low-pressure situations where large water flow is needed at low speeds.

In terms of operational modes, HEPs are divided into several categories:

- **Base-load HEPs**: These are designed to provide constant, reliable power to meet the daily energy demand.

- **Regulating HEPs**: These stabilize the energy grid by adjusting power production according to demand fluctuations.
- **Peak-load HEPs**: These are used to supply additional power during peak demand periods, such as during cold or hot weather.

Discussion

The study reveals the significant advantages of hydroelectric power stations as environmentally friendly energy sources. They generate electricity without harmful emissions, contributing to sustainable energy production. HEPs also offer high reliability, cost efficiency, and water resource management benefits. For example, they help control water levels in rivers, benefiting agricultural irrigation and flood control. The construction of HEPs stimulates local economies by creating jobs and attracting investment.

However, there are some notable disadvantages associated with HEPs. The environmental impact, such as changes in water flow, can disrupt local ecosystems, affecting fish populations, plants, and wildlife. Additionally, the high initial financial investment required for the construction of large-scale HEPs, along with the limited availability of suitable sites, presents economic challenges. The construction and maintenance costs of these stations can also be high, as they require regular servicing and repairs.

The geographical limitations of HEPs, such as the necessity for specific water flows and favorable geological conditions, restrict the number of locations where they can be constructed. Furthermore, the ecological impact of constructing large reservoirs and altering natural landscapes cannot be ignored.

Conclusion

In conclusion, hydroelectric power stations present significant advantages, including ecological cleanliness, high efficiency, and reliability, making them a promising energy source in modern power grids. However, their construction and operation come with considerable environmental and financial challenges. The potential ecological disruptions, high initial costs, and geographical constraints require careful planning and management. To mitigate these disadvantages, effective planning, cautious management, and a focus on ecological sustainability are essential. With proper planning, many of these issues can be minimized, ensuring that hydroelectric power continues to be a valuable part of global energy production.

References

1. S.A. Sheraliyeva, "The role of phraseological units in historical scientific works," *Oriental Renaissance: Innovative, Educational …*, 2024. [Online]. Available: cyberleninka.ru. [Accessed: Sep. 22, 2025].
2. E.M. Bakhodirovna, "Structural and functional features of phraseological units in the texts of works of art (English and Uzbek authors)," *Eurasian Journal of Academic Research*, 2024. [Online]. Available: cyberleninka.ru. [Accessed: Sep. 22, 2025].
3. M. Veresh, N. Demianenko, and O. Rud, "Phraseological units in modern linguistics: Systematization and semantic analysis," *Conhecimento & …*, 2023. [Online]. Available: svr-net127.unilasalle.edu.br. [Accessed: Sep. 22, 2025].
4. A. Naciscione, *Stylistic use of phraseological units in discourse*, 2010. [Online]. Available: library.oapen.org. [Accessed: Sep. 22, 2025].
5. M. Huseynova, "The evolution of English phraseological units: Historical and modern perspectives," *Biological Sciences*, 2024. [Online]. Available: colloquium-journal.org. [Accessed: Sep. 22, 2025].

6. T.N. Fedulenkova, "Pragmatic functions of modern English phraseology," *Nauchniy Rezultat. Voprosy Teoreticheskoy i Prakticheskoy Lingvistiki*, 2019. [Online]. Available: cyberleninka.ru. [Accessed: Sep. 22, 2025].
7. I. Hlukhovtseva, "Phraseology in works of art: Linguo-didactic approach," *Problem space of modern society: philosophical …*, 2019. [Online]. Available: ssoar.info. [Accessed: Sep. 22, 2025].
8. Y.O. Haidenko and O.O. Serheieva, "Phraseological units in a fiction text: Usual and occasional aspects," *Uzhnu University Repository*, 2024. [Online]. Available: dspace.uzhnu.edu.ua. [Accessed: Sep. 22, 2025].
9. H. Alisoy, "Semantic classification of phraseological units," *Acta Globalis Humanitatis Et Linguarum*, 2024. [Online]. Available: egarp.lt. [Accessed: Sep. 22, 2025].
10. N. Venzhynovych and M. Yatskiv, "Phraseology in Myroslav Dochynets' works of art," *Uzhnu University Repository*, 2022. [Online]. Available: dspace.uzhnu.edu.ua. [Accessed: Sep. 22, 2025]