TECHNICAL SCIENCES

OBTAINING RENEWABLE ENERGY USING THE ARCHIMEDES SCREW TURBINE, FISH-FRIENDLYTURBINES

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Abstract

The current context, marked by a growing demand for electricity—especially clean energy from renewable sources—has driven the search for new production solutions. Unlike solar or wind power, the energy of flowing water has the advantage of being continuously available. A relatively recent technology introduced in micro-hydropower plants is the Archimedes screw turbine, which efficiently harnesses the energy potential of running water. This solution enables the use of low heads and variable flows, conditions under which Kaplan, Francis, Pelton, and similar turbines are no longer efficient. Moreover, a micro-hydropower plant equipped with Archimedes screw turbines is less expensive to build and operate, while having a significantly lower environmental impact compared to traditional hydropower systems. This article aims to present both the technical and ecological advantages of this technology, as well as the practical possibilities for implementing Archimedes screw turbines in Romania.

Keywords: Micro-hydropower plants, Archimedes screw turbines, Flow rate

Introduction

The In recent decades, the energy transition has become a global priority, driven by the need to reduce dependence on fossil fuels and greenhouse gas emissions [1], [2]. The European Union, through its sustainable development objectives and energy and climate legislative packages, encourages the expansion of renewable sources and the diversification of the energy mix [1]. In this context, hydropower, one of the oldest and most reliable renewable sources, continues to play a key role [3].

Although conventional hydroelectric power plants provide a significant share of energy production, they usually require high head of water and high flows, which limits their applicability in many regions [4]. Thus, small-scale hydropower resources, such as artificial weirs, irrigation canals or urban rivers with low head, remain underexploited. To capitalize on them, technologies adapted to local conditions are needed, which combine energy efficiency with a low environmental impact [5].

Archimedes screw turbine (AST) into this category of emerging technologies. Inspired by an ancient mechanism originally used to raise water, the modern turbine works by reversing the operating principle: water flows through the helical screw, causing it to rotate and, implicitly, produce electricity through a generator [6].

This technical solution presents a number of distinct advantages: optimal operation at low head (1–10 m), stable efficiency even with flow variations, low maintenance costs and, above all, compatibility with aquatic biodiversity, being considered a fish-friendly technology [3], [7]. In addition, Archimedes screw turbines are easily integrated into existing hydrotechnical infrastructure, which makes them attractive for community, agricultural and tourism projects.

In Romania, the hydropower context offers numerous opportunities for implementing this type of technology, especially on urbanized rivers, on irrigation canals in the south and east of the country and in mountainous areas with small dams [8]–[10]. Adapting international success stories to the national context can contribute to diversifying renewable energy sources and achieving energy efficiency and sustainability objectives [9], [10].

The general objective of this article is to analyze the potential of using Archimedes screw turbines in Romania, starting from the theoretical foundations and continuing with applied examples and case studies. The article aims to highlight both the technical and ecological benefits of this technology, as well as the real possibilities for implementation at a local and community scale [10].

Description of the Archimedes screw turbine

The Archimedes screw turbine (AST) is a modern hydrotechnical equipment derived from the ancient principle of Archimedes' screw, but used in reverse: instead of lifting water, as happened in Antiquity, the screw is driven by the flow of water and transforms the potential and kinetic energy of the water into mechanical energy, which is then converted into electrical energy by a generator [6], [7].

Figure 1shows a schematic representation of an Archimedes screw turbine.

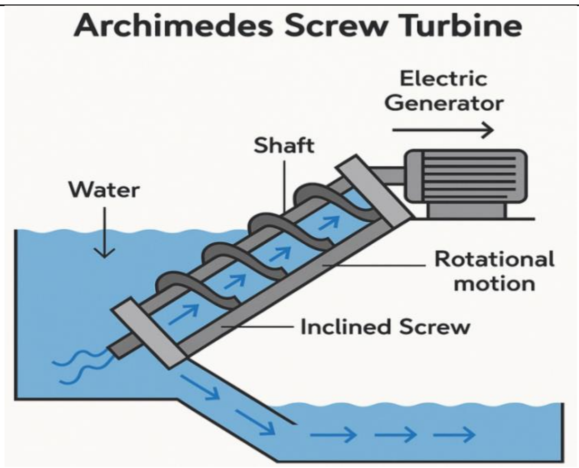

Figure 1. Schematic diagram of the Archimedes screw turbine

Operating principle

Water enters the upper part of the screw and, due to the water head (level difference), begins to move downwards, rotating the spiral propeller. The movement of the propeller is transmitted to the generator via a shaft and a gear system. Thus, the potential energy of the water is converted into mechanical and then electrical energy.

Scope

- Ideal for micro-hydropower plants at low heads of water (0.5–10 m).
- Flow rates: from a few liters/s to a few tens of cubic meters/s.
- Installed powers: from a few kW to hundreds of kW.

Advantages and limitations of Archimedes screw turbines

Technical advantages

Archimedes screw turbines (AST) have emerged in recent years as an efficient solution for harnessing the hydropower potential in areas with low head water [11], [12]. From a technical point of view, the main advantages are:

- Adaptability to low head water – operates efficiently at level differences of only 1–10 m, where classic turbines (Kaplan, Francis, Pelton) are no longer economically viable [13].
- Stable yield – they maintain high efficiency (60–80%) even under conditions of varying flow, which makes them suitable for rivers with fluctuating hydrological regime [14].
- Constructive simplicity – the screw has a robust geometry, with few moving parts, reducing the risk of failure [15].
- Long life span – the materials used (galvanized steel, stainless steel, composites) ensure high resistance to corrosion and wear, with a service life of over 20 years [16].
- Low maintenance – maintenance operations are minimal, compared to classic turbines, due to the simple design [17].

Ecological and social advantages

One of the main arguments in favor of implementing AST technology is its reduced ecological impact:

- Compatibility with aquatic fauna – thanks to its low rotational speed and the gaps between the blades, the screw allows fish and other organisms to pass through, being considered fish-friendly.
- Easy integration into the natural and urban environment – can be installed on existing infrastructure (small dams, locks, canals), avoiding massive new constructions [18].
- Educational and tourist value– due to the visibility and simplicity of the principle, ASTs become attractions for visitors, ecological centers and urban communities [19].
- Contribution to sustainability– promotes the use of green energy and increases public awareness of renewable resources.

Economic advantages

- Relatively low investment costs – especially in the case of projects that capitalize on existing hydro technical infrastructure [20].
- Profitability for low powers – allows for economic energy production even on a local scale (households, farms, small communities) [13].

Implementation of the Archimedes screw turbine

Relevant international examples of Archimedes screw turbines

Some international examples of Archimedes screw turbines that could adapt in Romania, where there are many rivers with low falls (1–10 m) and moderate flows, are presented below:

- *Reading Hydro – England (River Thames)*
  - Type: two screw turbines, each ~ 23 kW
  - Head: ~ 2.5 m
  - Flow: ~ 4 m^3/s
  - Production: ~ 320 MWh/year, enough for 90 homes
  - Financing: community society, crowdfunding investment.
  - Exemplary replicable in Romania: on medium-sized rivers (Someș, Olt, Bistrița), through community involvement.

Figure 2. Micro-hydropower on the River Thames at Caversham Weir (Reading, UK) [21]

- *Hydro Ness – Scotland (Inverness, River Ness)*
- Type: 92 kW screw
- Production: > 500,000 kWh/year
- Beneficiaries: powering the local sports center, the rest injected into the network
- Particular: included in the tourist and educational project (visitable).
- Exemplary replicable in Romania: in tourist areas (Prahova Valley, Bran, Apuseni) where green energy can be combined with ecotourism.

Figure 3. Image of the Hydro Ness project in Scotland on the River Ness [22]

- *Sandford Hydro – England (Oxfordshire, River Thames)*
- Type: three Archimedes screws, 450 kW total
- Head: ~ 3.5m
- Beneficiaries: energy for at least 500 households
- Particular: includes fish passage and eco-friendly design.
- In Romania, it can be replicated: on already existing small dams (secondary reservoirs on Olt or Argeș).

Figure 4. Sandford Hydro, the micro-hydropower plant located on the River Thames, in Oxfordshire, England [23]

- *Albert Canal – Belgium*
- At the Hasselt lock, unique Archimedes screws, ~30 m long, were installed in a hydraulic configuration with a switching valve ("jacket valve") that allows dual functions – pumping and generation.
- Type: large screws, up to 400 kW each
- Parameters: low head, high flows
- Beneficiaries: local energy + integration into the national grid.
- In Romania, it can be replicated: on irrigation canals or Danube diversions.

Figure 5. Combined hydropower-plant, pumping & turbine station on the Albertkanaal (Albert Canal) in Ham and Olen in Belgium [24]

- *Rochdale Interchange – England*
- Type: 21 kW, single screw
- Beneficiaries: energy for public infrastructure (train station and public buildings)
- Possible model to replicate in Romania: in urban areas with rivers and canals (Cluj – Someș, Timișoara – Bega, Bucharest – Dâmbovița).

Figure 6. The turbine house at the Rochdale hydropower scheme [25]

Examples of implementation of Archimedes screw turbines in Romania

- ***Zăvoiul Orbului micro-hydropower plant on the Argeș River***
- The Zăvoiul Orbului micro-hydropower project is a proposed project on the Argeș River, in Dâmbovița County, which includes the installation of 12 "fish-friendly" turbines, arranged in parallel on the right bank, in the area of the intake dam, each with an estimated power of 0.5 MW. These turbines are designed to operate efficiently at low flows and low head, making them suitable for mountainous areas and minimizing the impact on aquatic fauna.
- The configuration includes water intakes, supply and exhaust ducts, as well as specific equipment, as shown in the axonometric documentation.
- The implementation of this project could contribute to the production of renewable energy in the area, given that the Argeș River has a constant flow and a water fall suitable for such installations. The project could also support local economic development and represent an example of sustainable use of hydraulic resources.
- Stage: Planning / project

- ***Micro-hydropower plant on the Mureș River, in Noșlac commune, Alba county***
- A unit with 8 Archimedes screw turbines is planned, located directly in the riverbed, using an existing natural weir
- The project includes an inflatable dam to control the water level (increases the head by up to 1.65 m) and intakes built to capture the necessary flows.
- Status: Under construction / real project

- ***Micro-hydropower plant project on the Argeș River between Zeama-Rece and Catanele***

  - The technical documentation includes the Archimedes screw turbine, with capture at an elevation of 235 m and a 1.3 km long intake channel.
  - Designed to transform water energy into mechanical energy, subsequently transmitted to the electric generator
  - Stage: Study / documentation

Areas in Romania where Archimedes screw turbines can be used

The main rivers: Bistrița, Olt, Criș, Mureș, Someș, offer many sectors with head < 5 m → ideal for Archimedes screw turbines.

Rural areas: can supply villages or mountain guest houses → energy independence.

Urban areas: community projects (such as Reading Hydro) → energy for parks, street lighting or public buildings.

Agriculture: irrigation canals → additional energy for pumping stations.

Tourism: a project with Archimedes screw turbines visitable could be attractive in mountainous areas or near monasteries/dams.

Based on the typology of rivers and existing infrastructure, there are several places in Romania where Archimedes screw turbines could be installed efficiently.

- *Urban locations (for community/educational projects)*
  - Cluj-Napoca – Someșul Mic (thresholds and locks in the central area)
  - Timisoara – Bega Canal(existing locks and thresholds, controlled flow)
  - Bucharest – Dambovita (urban thresholds, demonstration/educational potential)
  - Oradea – Crișul Repede (central thresholds, easy access)
  - Arad – Mureș (small thresholds and dams, integration with the promenade area)
  - Sibiu – Cibin (urban thresholds, potential for tourist/educational microproject)
  - Pitesti – Arges (low thresholds that can power public lighting or public buildings)
- *Locations with small dams (low falls, stable flows)*
  - Olt River – secondary dams in the Călimănești – Râmnicu Vâlcea area
  - Bistrița River – downstream of microdams, Piatra Neamț area
  - Prut – downstream of the Stânca-Costești accumulation (spills and diversion channels)
- *Locations on irrigation canals*
  - Danube Meadow – Olt, Călărași, Ialomita counties (pumping stations and hydrotechnical nodes, controlled flows, small head of 1–3 m).
- *Locations on regulated rivers*
  - Siret – Tecuci / Tudor Vladimirescu (regulating works, low spillways).

Figure 7 shows a map of possible locations for the implementation of AST in Romania.

Figure 7. Locations in Romania where Archimedes screw turbines could be installed

The locations presented above are suitable for the implementation of Archimedes screw turbines because:

- have low head water (1–5 m), where Francis/Pelton turbines are not efficient.
- have relatively constant flows (urban, canals, secondary dams).
- have existing infrastructure (thresholds, locks, small dams) → low investment.
- they have opportunities for community and educational integration (public visibility).
- they are ecological solutions, friendly to fauna (fish can pass through)

Conclusions

The study on Archimedes screw turbines (AST) highlights the high potential of this technology in capitalizing on hydropower resources with low head water, which are currently insufficiently exploited in Romania.

From the analysis of the technical characteristics, it results that AST turbines offer significant advantages: stable efficiency even with flow variations, constructive simplicity and low maintenance costs, as well as a long lifespan. In addition, through their low rotation speed and design, they are friendly to aquatic fauna, which differentiates them from other hydropower solutions.

The versatility of AST turbines makes them suitable for a wide range of applications, from urban and rural communities to agriculture, tourism or local industry, offering a sustainable solution for producing electricity in conditions of variable flows and low head water.

The international examples analyzed show that AST turbines can be successfully implemented in community, agricultural, or urban projects, generating multiple benefits such as renewable energy production, local energy independence, and opportunities for educational and tourism integration. The case studies and calculations carried out confirm the economic and energy feasibility of these small- and medium-scale installations.

In Romania, the potential for implementation is considerable, due to the extensive network of rivers with rapids and small dams, as well as irrigation canals and urbanized watercourses. By capitalizing on these resources, AST turbines could contribute to diversifying the energy mix, reducing carbon emissions and increasing the energy resilience of communities.

Therefore, adapting successful international models to local conditions and stimulating investments in micro-hydropower plants with Archimedes' screw can represent a strategic direction for Romania in achieving the goals of energy sustainability and sustainable development.

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