



Identification and application of indicators for the assessment of pumped hydro storage projects with renewable energy generation

JALON



Natalia Naval¹, María del Pilar Martínez² and José M. Yusta¹

¹ Department of Electrical Engineering, Zaragoza University, e-mail: naval@unizar.es, jmyusta@unizar.es

² Atalaya Generación, Zaragoza (Spain), e-mail: pilarmartinez@atalaya.eu



Universidad
Zaragoza



BACKGROUND



The energy sector is undergoing a profound transformation driven by climate change reduction and the efficient use of natural resources. By 2050, Spain must achieve climate neutrality and the electricity system must be based exclusively on renewable sources [1]. Today, these objectives can be difficult to reach for several reasons. First, large amount of the energy generated by renewable sources is rejected as a result of grid constraints and technical reasons associated with the security of electricity systems. Secondly, most renewable energy sources depend on weather conditions, i.e., they are uncertain and uncontrollable, producing imbalances in the grid. Therefore, to overcome these drawbacks, **the combination of wind and photovoltaic generation together with pumped hydro energy storage is growing.**

It should be noted that this type of storage is the most mature and viable technology on a **large scale**. PHES has a **fast response time**, which is ideal for load leveling applications, and the use of variable speed machines allows for **frequency regulation** in both pumping and generating modes. Thus, PHES systems **improve their efficiency** by approximately 3% and extend the lifespan of the system [2], [3]. However, despite the many advantages presented, pumped hydro storage plants have some drawbacks, such as their **dependence on specific geological formations** due to the construction of two large reservoirs with sufficient height between them, **difficult access for electrical connection**, **high investment costs** and the construction of dams could cause an **environmental impact** high.

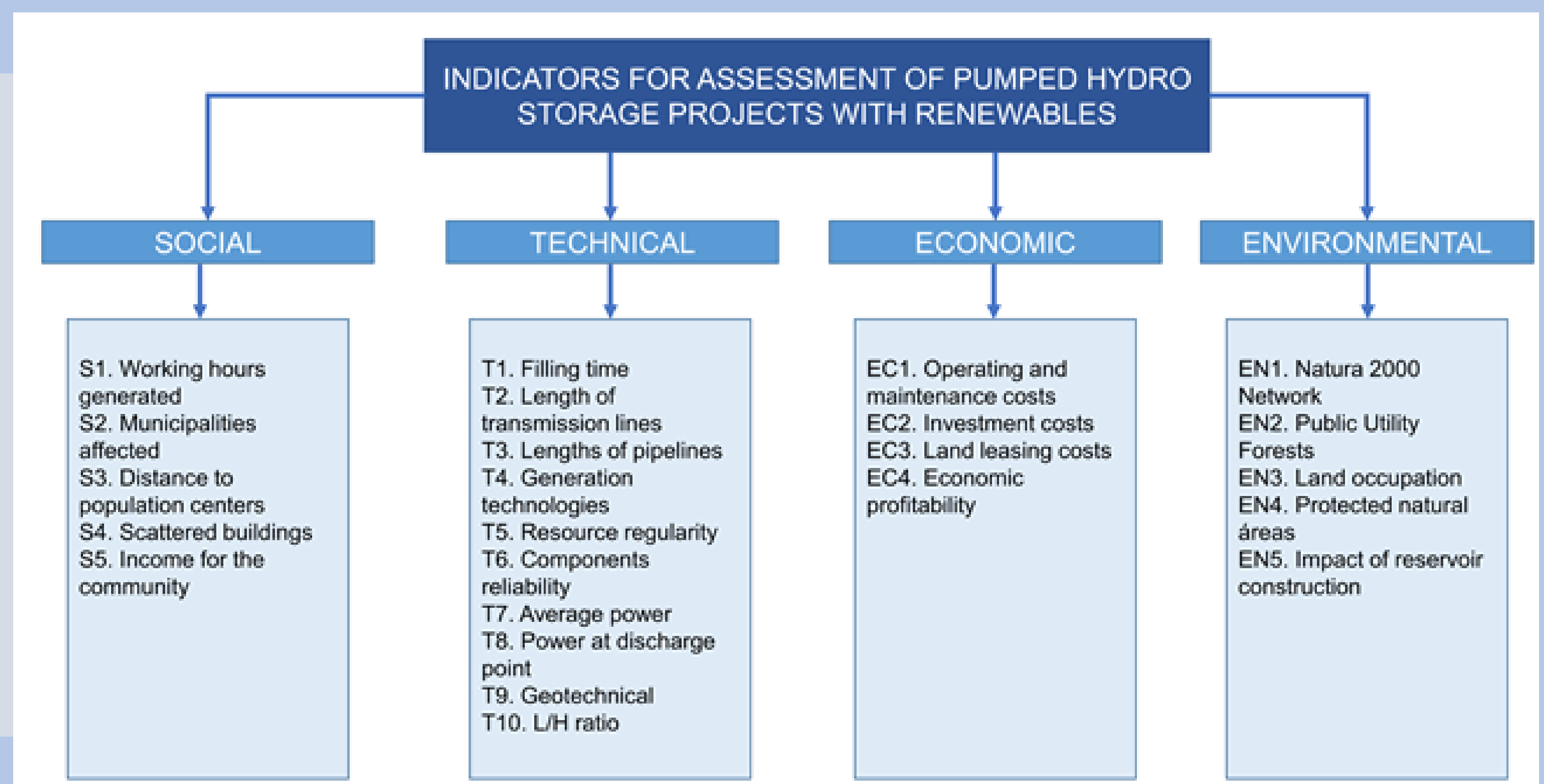
OBJECTIVE

This article aims to **identify and calculate criteria and sub-criteria** that can provide the most complete view possible of the **real impact of pumped hydro storage projects with integration of renewable energy**, by incorporating the most relevant aspects in the assessment of these large-scale storage projects.

- Social
- Technical
- Economic
- Environmental

CRITERIA

In total 24 sub-criteria have been identified,



APPLICATION

The selected indicators have been calculated for the case of a real project of renewable energy production facilities that also incorporates a reversible pumped storage facility. The project consists of **1209 MW of photovoltaic power, 702 MW of wind power and 396 MW of pumping.**

When developing a pumped hydro storage project, there are several aspects to take into account, such as the **availability of the water resource, access to the grid connection, the difference in level between the reservoirs**, among others. Therefore, there must be a balance between all these factors.

The project analyzed with the indicators proposed in this paper should **minimize environmental impact and avoid special protection zones for birds**. The project presents good conditions for the hybridization of storage with photovoltaic and wind generation plants.

Regarding the water resource, the catchment point for this project has a **high water flow rate** and, therefore, the time required to **fill the reservoirs** would be **reduced**. The difference in elevation between the lower and upper reservoir of the facility is more than **320 meters**.



CONCLUSION

The combination of **renewable generation plants with pumped hydro storage** is one of the alternatives most widely used on a large scale in order to **manage grid imbalances**, due to the high uncertainty of renewable production, and to meet the energy targets set by Spanish and European regulations.

Renewable energy projects in rural areas focus on minimizing the environmental impacts caused by renewables facilities, without considering the other criteria: social, technical and economic. **The identification and application of indicators of different categories** in this article provides an adequate tool to **assess the real impact of pumped hydro storage projects**, and in further research, these indicators can be used to **prioritize different economic investment and energy generation alternatives** over others and make a more robust defense of the best option to implement.

INDICATORS
CALCULATION



SCAN ME

REFERENCES



SCAN ME