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Technical and Economic Perspective for Repowering of Micro Hydro Power Plants: a Case Study of an Early XX Century Power Plant

A. Gagliano[a], G. M. Tina[b], F. Nocera[a] , F. Patania[a]

[a]*University of Catania, DII, viale Andrea Doria 6, Catania 95125, Italy*
[b]*University of Catania, DIEEI, viale Andrea Doria 6, Catania 95125, Italy*

Abstract

Nowadays many countries have dramatically cut the incentives for solar photovoltaic and wind farms; consequently many new investors and entrepreneurs pay more attention to small and mini hydro power plants. Hydropower currently respect to other renewable sources has not negligible benefits as lower cost of installation to equal installed capacity, higher reliability, higher energy production and more intensity and consistency over time. Many aspects as well as the sensibility to environmental issues related to civil works and the introduction of incentives for the production of renewable energy from small plants (< 1 MW) drive the attention to small Hydro Power Plants (HPPs). The thousands of historic mills, water wheels, inoperative hydropower stations or unrealized potential offer an interesting opportunity for small and micro hydropower generation.

This article evaluates technical and economic feasibility of the repowering of one of the oldest Sicilian hydro power plant currently abandoned and disused. The reactivation of the Catarrate hydropower plant allows producing energy from renewable source contributing to the energy independence of the local community, with an energy yearly production of about 220 MW. Moreover, this study demonstrates the attractiveness of small hydropower as a local investment vehicle and at same time an occasion to preserve the historical industrial heritage of disused hydro plants.

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Keywords: micro-hydro power, renewable energy, repowering, economic analysis

1. Introduction

Hydroelectricity is one of the most mature forms of renewable energy, providing more than 16% of the world's electricity consumption from both large and small power plants [1].

* Corresponding author. Tel.: + 39-320-433-2228; fax: +39-095-738-2496.
E-mail address: agagliano@dii.unict.it

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The hydropower plants can be classified in function of different parameters [2],[3]:

• head: low (less than 50 m); medium (between 50 and 250 m); high (greater than 250 m);

• exploitation and storage: with daily (or seasonal) flow regulation (reservoir type); without flow regulation (run-of-the-river type);

• conveyance system: pressurized (penstock); mixed circuit (canal and penstock);

• powerhouse site: dam or diversion scheme;

• energy conversion mode: turbining or reversible pumping-turbining;

• type of turbines: impulse, reaction and reversible;

• installed power: pico (Pt < 5 kW; micro (5 ≤ Pt < 100 kW); small (100 ≤ Pt < 1MW); medium (1 ≤ Pt < 10 MW).

Hydroelectric facilities are typically older and operate with a mismatched assortment of hardware and controls, which are not optimized to work as a unified system. The median age of hydroelectric capacities in Europe is 41 years. This and barriers to new builds explain why electric utilities in Europe tend to focus on the repowering of existing plants with modern turbines and equipment rather than greenfield projects. Many aspects as well as the sensibility to environmental issues related to civil works and the introduction of incentives for the production of renewable energy from small plants (< 1 MW) drive the attention to small HPPs (S-HPPs). Moreover, the dramatically cut off the incentives for solar and wind farms might attract many new investors and entrepreneurs to pay more attention to small hydro. With approximately 13 GW [3], small hydro represents a significant renewable energy resource. The renewed interest for HPPs is witnessed by several projects co-financed by the European Commission under the Intelligent Energy Europe programme, i.e the Renewable Energy Sources Transforming Our Regions (RESTOR) Hydro, or Hydro Data Initiative (HYDI), which provides statistics and information on energy, market and policy data covering the entire Hydropower sector in EU-27 Member States. Access to the database is free of charge. Several studies demonstrate that the potential for future S-HPPs development, both in terms of upgrading the oldest existing plants and building new sites [3],[4],[5]. The annual electricity production exploitable through the reinstalling or upgrading existing underdeveloped plants was estimated in of about 4500 GWh [6]. The aim of this study is twofold: firstly the assessment of the economic perspectives of mini-hydro in Italy is performed (section 2), therefore the perspectives of the repowering of an old micro hydropower plant located in the territory of Petralia Sottana (Sicily) is presented (section 3,4 and 5), finally some conclusions are drawn..

2. Economic perspective of mini-hydro power plants in Italy

Italy is one of the leading countries in Europe referring to hydroelectric power generation, where many historic mills, water wheels, inoperative hydropower stations, weirs and other lateral structures in rivers, which constitute an unrealized potential for small and micro hydropower generation exist. The exploitation of water energy through hydraulic wheels occurred between XII and XIII centuries, while of the invention of water turbine (1827) led to development and spread of modern hydro power stations in Europe. The first run-of-river water hydropower, called “Tusciano”, was built in Italy in the late nineteenth century (1890). At that time, the hydro source was the most favorable energy source and it was called "white coal". Until the 60s, electric energy demand was almost entirely satisfied by hydraulic energy resource, certainly the most efficient of the renewable sources. For example, the annual electric production in Italy in 1960 was of around 56 TWh, of which 82% hydroelectric. Many small HPPs were abandoned and disarmed during the nationalization of the electric energy (1962) and many of them could be reactivated today in Italy.