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Innovative Concepts Applied to Recent Small Hydropower Plants

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Abstract

The goal to obtain acceptable economic features for small hydropower developments requires many thorough analyses. Thus, the river section selection, the conception of a general development scheme together with a detailed technical solution, the applied performance technology, the quality of operation tests and the structure of operation management represent the main steps that need to be carefully controlled.

The paper presents the innovative concepts and technical solutions that were applied on three small hydropower developments on Sebes River, Romania. The new concepts have been applied at: the hydraulic structures of the intakes; the diversion pipes; the features of power equipment. The good behavior in operation of the specified hydropower developments from the commissioning to the present and obtaining of the previewed main features of hydro developments certify the great influences of new concepts for new small hydro developments efficiency.

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Keywords: small hydropower; intake; innovative concepts; Romania

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1. Introduction

When referring to hydropower many authors say that it is a mature technology, which is true, having in mind the fact that water energy has been used since the Antiquity and the first hydropower plant appeared when the first house in the world started using electricity produced from hydropower in 1863, [1]. Nevertheless, the advancements and the development of the mathematical techniques and of the technology lead to the fact that today, efficiencies greater than 90% can be achieved for water diversion from the river to the turbine, no matter how difficult or long this diversion is.

Small hydropower plants (SHPPs) remain site specific, each development has to be designed for the real topographical and geological conditions of the site chosen for the intake, penstock, powerhouse and tailrace.

Taking into account as many as possible of these conditions, in [2] a software based on a stochastic evolutionary algorithm, which allows the determination of the most advantageous design alternatives for carrying out a small hydropower plant project, has been developed. There are scientific papers dedicated to the presentation of a review and the current situation of small hydropower developments schemes and technologies, [3, 4], showing the large diversity of possibilities to perform these developments.

There are papers dedicated to a certain device or equipment, as [5], which analyze problems related to the operation and maintenance of the SHPPs from the point of view of turbines. The authors present different types of turbines related to a large spectrum of operational problems such as: cavitation, erosion, fatigue and material defects. They also present suggestions for remedial measures.

Another paper, [6], draws up a comprehensive literature review on about 214 research papers, reports, guidelines and standards, having as subject research activities and practical experience in the area of refurbishment and uprating of hydropower plants. In this respect, the paper is announced by the authors as a real guide and reference for all the interested hydropower specialists.

The technologies that are used in South Africa for low head SHPPs were noted in [7]. The possibility to attach small hydropower plants to existing dams, irrigation systems, industrial and urban discharge, storm water systems, water distribution networks, not yet developed rivers, is also presented.

Innovative technologies that are to be applied in South Africa in order to enable SHPPs development in terms of costs and reliability, as a viable option for rural electrification are presented in [8]. As the survey of technologies has in view: penstocks, turbines, kinetic devices, generators and controllers; the authors have elaborated certain guidelines for selecting design and equipment that are adequate for certain developments.

Problems and strategies of the builders of the SHPP developments in Netherland are revealed in [9]. The authors have presented some case studies which addressed subjects as: the location, the fish passes, the interest of stakeholders, the political support and the public perception. They elaborate some kind of a roadmap suggesting solutions such as better collaboration between environmental, water, and energy authorities, developing the best practice of successful small-scale hydropower developments in environmentally sensitive areas.

Other papers, as [10], approach the problem of integrating a SHPP into a multi-purpose dam bridge, which represents examples on how to adapt the best hydropower technology to an existing situation.

A comprehensive study regarding the best practice for hydropower developments devices and equipment addressing: the technology, condition assessment, operations, and the best maintenance practices with the objective to maximize performance and reliability was presented in [11]. The authors show detailed presentations regarding the best practice for: trash racks and intakes, penstocks and tunnels, flumes and open channels, leakage and releases, Francis turbine, Kaplan/Propeller turbine, Pelton turbine, lubrication system, governor, shut-off valves, raw water system, generator, main power transformer, excitation system, instruments and controls for automation, machine condition monitoring, Francis turbine aeration.

At present in Romania there are about 400 SHPPs with an installed capacity of 585 MW and a mean annual production of electricity of around 2 TWh, [12]. Main part of these SHPPs was built before 1990 and the other small part represents SHPPs performed after 2000 year by private investors.

The SHPPs carried out before 1990 show an old conception for hydraulic structures and for power equipment, as well. In operation these SHPPs did not achieve their main features and they have many problems like: The intakes blockage with sand, wood pieces or different solid bodies; higher head losses through the diversion pipe than rated.