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Multi-Objective Optimization of Run-of-River Small-Hydropower Plants Considering Both Investment Cost and Annual Energy Generation

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Abstract : This paper presents the techno-economic evaluation of run-of-river small-hydropower plants. In this regard, a multi-objective optimization procedure is proposed for the optimal sizing of the hydropower plants, and NSGAII is employed as the optimization algorithm. Annual generated energy and investment cost are considered as the objective functions, and number of generator units (n) and nominal turbine flow rate (Q_T) constitute the decision variables. Site of Yeripao in Benin is considered as the case study. We have categorized the river of this site using its environmental characteristics: gross head, and first quartile, median, third quartile and mean of flow. Effects of each decision variable on the objective functions are analysed. The results gave Pareto Front which represents the trade-offs between annual energy generation and the investment cost of hydropower plants, as well as the recommended optimal solutions. We noted that with the increase of the annual energy generation, the investment cost rises. Thus, maximizing energy generation is contradictory with minimizing the investment cost. Moreover, we have noted that the solutions of Pareto Front are grouped according to the number of generator units (n). The results also illustrate that the costs per kWh are grouped according to the n and rise with the increase of the nominal turbine flow rate. The lowest investment costs per kWh are obtained for n equal to one and are between 0.065 and 0.180 €/kWh. Following the values of n (equal to 1, 2, 3 or 4), the investment cost and investment cost per kWh increase almost linearly with increasing the nominal turbine flowrate while annual generated. Energy increases logarithmically with increasing of the nominal turbine flowrate. This study made for the Yeripao river can be applied to other rivers with their own characteristics.

Keywords : hydropower plant, investment cost, multi-objective optimization, number of generator units
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