Allocation of firm-energy rights among hydro agents using cooperative game theory: an Aumann-Shapley approach

E. Faria, L.A. Barroso, R. Kelman, S. Granville, M. Pereira

Abstract— The firm energy of generation plants is a critical component in some electricity markets. It is usually calculated by the regulator and sets a cap to the amount a plant can trade in capacity markets (or auctions), in order to avoid free-riding behaviors. Firm energy is a systemic property and, in case of hydro plants, a synergy is observed whenever a cooperative operation occurs, i.e., the firm energy of a system is greater than the sum of the individual plants. This immediately raises the question of how to divide the system's firm energy among the individual hydro plants. The objective of this work is to investigate the application of different allocation methods of firm energy rights among hydro plants using a game-theoretic framework. It is shown that there is not an optimal and unique approach to make this allocation. The paper investigates the advantages and disadvantages of different methods, such as marginal allocation, average production during the critical period, incremental allocation, finally recommending the Aumann-Shapley as the allocation method. This method is tested for the Brazilian power system, which has around 100 hydro plants. The results obtained are compared with the current allocation adopted by the electricity regulatory agency of Brazil.

Index Terms— Aumann-Shapley, cost allocation methods, firm energy rights, hydropower, power system economics.

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