Chapter 14
Implementation of an Integral Methodology for the Simulation of Renewable Energy Scenarios Applied to an Isolated Area

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ABSTRACT

This chapter provides an implementation of an integral methodology for the simulation of renewable energy scenarios applied to an isolated village situated in Democratic Republic of Congo. A specific area in Democratic Republic of Congo is selected as a case study in order to validate the methodology. In addition, this chapter includes the experimental validation of the HRES configuration, operating a scalable prototype in LabDER at UPV (Universitat Politècnica de València, Spain). Experimental tests conducted in the laboratory are described and main results and conclusions are discussed.

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1. INTRODUCTION

Energy Planning (EP) analyses the alternative paths for energy evolution of a region by studying different energy scenarios in three temporal ranges: short (1 to 10 years), medium (10 to approximately 30 years) and long term analysis (more than 30 years). Generally, it begins examining as a reference the actual scenario, named "Business As Usual (BAU)", and its evolution for the time span considered. Then, it compares the results from other different alternative scenarios under the same time span and demand constraints. Each energy scenario involves assessing and matching in an optimal manner the energy sources and their conversion with the energy requirements of different demand sectors (commercial, industrial, residential, etc.). Although, it may seem a simple idea, it becomes a complex problem in which various decisions and criteria converge, together with the existence of complex relationships between the different actors involved in the simulation process: generation, demand, emissions, economics, and technologies (Loken, 2007; Cárcel et al., 2018; Gómez et al., 2018; Peñalvo et al., 2019a; Peñalvo et al., 2019b). Models in energy planning are important in emerging communities and in developed urban areas, since they determine the energy path and goals for the next time period. Precise modelling requires large computational resources, thus a trade-off between exactness and resources needs to be balanced. In order to approximate reality with acceptable computational resources, models are based on certain hypothesis that tackle possible scenarios and casuistry, using estimations and assumptions which may or may not become valid under initial premises but that are unknown at the moment of modelling (Grubb, 1993).

Literature reviews show numerous tools for energy planningbased on HRES dimensioning. The applicability and benefits of these software tools, which facilitate calculations and reduce processing time, is widely demonstrated. Tools allow comparing different alternatives in order to assess the advantages and disadvantages of each solution, assisting in the evaluation of different HRES configurations and energy scenarios within a feasible time frame. Connolly et al. (Connolly, 2010) published a review of 37 computer tools for analysing the integration of renewable energy into various energy systems. Sinha and Chandel (Sinha & Chandel, 2014) provided also a description of different computer programs used for HRES dimensioning but did not focus on the combination of different renewable systems. Delgado-Antillón and Domínguez- Navarro (Delgado, 2018) used a genetic algorithm (GA) to optimize the capacity of a distributed system, minimising the storage capacity and power losses. Giallanza et al. (Giallanza, 2018) studied the probability of seasonal load loss ratio using an iterative method to design a standalone PV-wind-battery system. Rullo et al. (Rullo, 2019) proposed anoff-grid PV-wind-battery system dimensioning model based on active energy management to achieve the lowest operational cost. Dufo-López et al. (Dufo-López, 2016) presented a multi-objective evolutionary algorithm for optimizing off-grid HRESs by minimizing the total NPC, along with the maximization of HDI and job creation. Benavente et al. (Benavente, 2019) optimized the size of a stand-alone PV-battery system for three scenarios in Bolivia. The results provided a reference for the application of off-grid PV-battery systems in rural areas.

Also, Multicriteria Decision Methods applied to renewable energy planning are widely discussed in the literature. Pohekar´s analysis (Pohekar, 2004) (Polatidis, 2006) showed that Multi-Attribute Utility Theory (MAUT) (Wang, 2010)was the most common MCDM method used in energy planning bibliography, including Weighted Product Method (WPM) (Chang, 2001), Analytical Hierarchical Process (AHP)(Saaty, 1987), Analytic Network Process (ANP) (Saaty, 1996), MAUT, fuzzy methods and decision support systems (DSS), among others. The main objective of MADM is to select the alternative that has the highest score according to the set of evaluation criteria.

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