



Multistage expansion planning of generation and interconnections with sustainable energy development criteria: A multiobjective model

Clodomiro Unsuhuay-Vila^{a,*}, J.W. Marangon-Lima^b, A.C. Zambroni de Souza^b, I.J. Perez-Arriaga^c

^a Department of Electrical Engineering, Federal University of Paraná, Curitiba, Brazil

^b Electrical and Energy Systems Institute, Federal University at Itajubá, Itajubá, Brazil

^c Institute for Technological Research, Comillas Pontifical University, Madrid, Spain

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ABSTRACT

A novel multiobjective, multiarea and multistage model to long-term expansion planning of integrated generation and transmission corridors incorporating sustainable energy developing is presented in this paper. The proposed MESEDES model is a “bottom-up” energy model which considers the electricity generation/transmission value-chain, i.e., power generation alternatives including renewables, nuclear and traditional thermal generation along with transmission corridors. The model decides the optimal location and timing of the electricity generation/transmission abroad the multistage planning horizon. The proposed model considers three objectives belonging to sustainable energy development criteria such as: (a) the minimization of investments and operation costs of power generation, transmission corridors, energy efficiency (demand side management (DSM) programs) considering CO₂ capture technologies; (b) minimization of Life-Cycle Greenhouse Gas Emissions (GHG); and (c) maximization of the diversification of electricity generation mix. The proposed model consider aspects of the carbon abatement policy under the CDM – Clean Development Mechanism or European Union Greenhouse Gas Emission Trading Scheme. A case study is used to illustrate the proposed framework.

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1. Introduction

The energy policy and planning are changing worldwide due to the increasing concern about the world environment. The sustainable energy development has gained much attention of all governments on finding a trade-off between the economic development and the environmental constraints. One example is the current discussion about the global warming which is the top concern of most politicians and decision makers [1–3].

Several studies using different approaches and different perspectives [4,5] share the conclusion that the current world energy model (particularly the one of developed countries) is unsustainable on economic, social and environmental terms. Considering the current economic growth and the equalization in energy access to the world population, a serious environmental impact is expected. There is a broad consensus on sustainability challenges of the current energy model and on the general strategies required to face them [1–7]. The major aspects that the electricity/energy supply model should focus are: (a) the universal access to electricity; (b) the energy efficiency and savings; (c) the GHG Emission (global climate warning) and air pollutions; (d) the security of

supply which means the dependence on energy imports and diversity of supply.

The traditional generation/transmission expansion planning of electricity is defined as the problem of determining *which*, *where*, and *when* new generation/transmission installations should be constructed over a long range planning horizon. The main objective of this traditional approach is to minimize the total investment and operating costs in order to supply the electricity demand following a set of technical criteria. In many countries the expansion planning of the electricity generation and transmission is done in a centralized way. Particularly in Brazil, the generation and transmission plan is made by the government. As for the generation, it is indicative whereas for transmission it is determinative. However, in countries such as Spain, the power generation/transmission expansion is an outcome of the market, i.e., it is driven by the economic signals generated in the market.

Additionally, Refs. [1–3] argue that, although markets are adequate instruments to achieve an efficient allocation of resources and to promote private initiative, the resolution of the sustainability cannot be left only to market forces. It requires other complementary instruments, such as carbon markets for a decentralized form, an indicative plan with incentives to follow its guidelines or a determinative plan.

Optimal expansion planning in energy systems with multiple energy carriers is currently dominated by those bottom-up large-

* Corresponding author. Universidade Federal de Paraná, Departamento de Engenharia Elétrica, Centro Politécnico – Jardim das Américas, Curitiba Paraná CEP: 81531-990, Brazil. Tel.: +5541 361 3229.

E-mail address: clodomiro@eletrica.ufpr.br (C. Unsuhuay-Vila).