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LONG TERM PLANNING TOOLS AND RELIABILITY NEEDS: *FOCUSING ON THE REUNION ISLAND*

Overview

The future of the energy industries have a number of challenges to overcome, in particular international constraints on carbon emission, the expected depletion of fossil fuels, the population densification and the tremendous growth in developing countries. At this point in time, the structure of the energy supplies is under questions and a number of studies suggest that high shares of renewable energy sources may become an essential feature of future electricity industry [1,2].

However, wide integration of renewable energy sources in the power system, in particular intermittent energy sources, raises several technical issues. An important issue to consider when evaluating the integration of renewable energy sources is that of a decrease in the reliability of the power system, defined as the ability of the electric system to withstand sudden disturbances [3]. It is therefore strongly recommended to consider reliability of the power system when evaluating building options for the integration of renewable energy sources.

For this task, we propose the use of Markal/TIMES models [4]. Markal/TIMES models are technological rich, long-term, partial-equilibrium models, that are used to evaluate and analyze investment alternatives and the future development of an energy sector. It evaluates investment in a large set of technologies and minimizes the total discounted cost of the energy system. The model is based on a bottom-up approach and considers aspects such as the current state of the power system, forecasted energy consumptions, supply of energy sources, political and technological constraints. In particular, the model evaluates the building options of the power system and offers an explicit representation of the production technologies, making it suitable to consider reliability requirements on the power system.

The aim of this paper is to discuss power systems provided by Markal/TIMES models in the light of reliability requirements and to study the reliability of supply for different shares of renewable energy sources. This is studied through the example of the Reunion Island, for which we perform a long-term analysis of the electricity sector. The Reunion Island is interesting to study as they aim to have in 2030 an energy consumption based to 100% on renewable energy sources [5]. As the current use of renewable energy sources is 36%, the energy system has to change substantial for reaching the electricity targets.

Methods

According to the UCTE handbook [3], the reliability of an electric system can be addressed by considering the adequacy and security of the system. The adequacy of the system is its ability to supply the electrical demand and energy requirements at all times, taking into account scheduled and reasonably expected unscheduled outages. The security of the system is its ability to withstand sudden disturbances such as electric short circuits and unanticipated loss of system elements.

To ensure these two features, power systems rely on frequency and voltage management [6]:

- Frequency and voltage are crucial quantities, whose deviations can lead to brownouts or power outages. This typically occurs when the system experiences transient states (e.g. lightning), or is recovering from production or load fluctuations.
- Maintaining voltage and frequency between appropriate limits depends respectively on the reactive power of the system and on the kinetic and spinning reserves. This emphasizes the need for reactive power and for appropriate reserves levels on power systems.
- Most renewable energy sources, and in particular intermittent ones, do not provide the required reserve levels as efficiently as conventional power units (for example thermal units and hydroelectricity) [7]. Furthermore, intermittent energy sources commonly induce frequent and high magnitude production fluctuations; further increasing the need for reliability of the electric system.

Then, the energy system of the Reunion Island is analyzed as a case study. The analyses are based on the MARKAL/Times family of models, which optimize the energy system utilizing an explicit and bottom-up representation of the available technologies. The model is based on a partial equilibrium approach in which the total discounted cost of the energy system is minimized. An advantage of the model is that the energy system can be optimized over a long time horizon, 50 – 100 years is common, divided into a set of time periods of variable length. The main decision variables are the activity and investment levels in the different technologies, while the constraints consider aspects such as the expected lifetime of the technologies, environmental and political constraint. The model considers the current state of the energy system and optimizes the investment and dismantling of the available technologies over the planning horizon. It thereby selects the most-suitable technologies for meeting the projected demand consumption.

For the case study of the Reunion Island, we cover the period 2008-2030 and assess the evolution of its electricity production sector. The main features of the electricity system of the Reunion are described as follow:

- In 2008, electricity consumption rose up to 2546 GWh, divided into 50% of coal, 14% of other fossil fuels and 36% of renewable sources (25% of hydroelectricity, 10% of biomass and others).
- The peaking capacity during 2008 was 408 MW, and the total installed capacities were around 800 MW.
- Since 1995, the growth rate of electricity demand has decreased from 6.7% to 2.8%. It is expected to continue decreasing and reach 2% or 1% in 2025 [8].
- The power system is small, weakly meshed and without interconnection, exacerbating the need for reliability of supply. As a matter of fact, the French government has put a legal limit of 30% on the level of intermittent capacities of its overseas territories (decree of April, 23th 2008), including the Reunion Island.

Furthermore, according to specialists additional potentials for energy supply are mainly renewable, namely: 130 GWh/year of biomass, 160 MW capacities of photovoltaic units and 70 MW capacities of hydroelectricity, plus 45 MW of hydraulic storage. Besides, in order to manage more efficiently intermittent sources, the island promotes the integration of storage capacities on the power system. Two examples are the installation of a 5 MW NaS battery on the power system, and the calls for tenders issued for 10 MW renewable energy farms with storage units.

Results

The work of this project is ongoing and results focus on the impacts of reliability requirements on wide integration of renewable energy sources. In particular, the analyses provide plausible shares of renewable energy sources in the Reunion Island depending on the level of reliability of supply.

Different scenarios allow us to compare the effect of reliability on several environmental and economic indicators, such as the CO_2 emissions levels over the years and total discounted costs of the energy systems. Finally, this study makes it possible to evaluate the feasibility and cost of reaching the target of 100% in 2030 of renewable electricity production.

Conclusions

In this paper, we have introduced the need to take reliability requirements into account for the design of future power systems. We discuss results provided by Markal/TIMES models in the light of reliability requirements and study the reliability of supply for different shares of renewable energy sources. It emphasizes the need to implement reliability requirements in long-term planning models. In fact, this work is a part of a larger project, which aim at integrating reliability in prospective studies and another aspect of this project is focused on the evaluation of the cost of reliability in future power systems.

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