

Evolution of Chilean Electricity Market Design with Increasing Levels of Renewable Generation: Growing Need for Pricing of Frequency Regulation

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Overview

In recent years, electricity generation from intermittent and unpredicted nature of RETs like wind and solar energy has increased substantially in Latin American countries. These technologies have some unique characteristics compared to the traditional technologies that create challenges in design of power systems. Among the potential impacts, the emergence of high penetration rates of renewable energy sources in the energy mix of power systems can substantially increase the need for faster-ramping the resources participating in the frequency regulation services.

Considering the case of Chile, the rapid grow of renewable sources has resulted in some unintended consequences leading to significant distortions in the electricity market. Chile was a pioneer in Latin America with respect to electricity market reforms. Even though Chile's pioneering experience with the power sector privatization and liberalization created competition problems due to insufficient regulation, especially in transmission and vertical integration (Bitrán y Saavedra, 1993; Serra, 2002). In 1982 a new electricity law functionally separated generation, transmission and distribution, introduced mandatory marginal cost dispatch, opened access to transmission lines, created a contract-based generation market and formalized price cap regulation of distribution. More important for the purpose of this paper, it introduced regulated retailing: distributors purchase energy and capacity to generators under long-term, regulated contracts and resell it to residential and commercial customers at regulated prices. The two-product market (energy and capacity) has worked quite well, but this may now change with the fast and massive irruption of zero-operating-cost technologies, such as renewable energies. Over the past decade, the promotion of renewable energy in Chile, especially solar energy projects, has become increasingly important. As of the first quarter of 2016, electricity generation from RES (excluding large hydro) reached 15% of the total power capacity in the system and Chile has set a goal of lifting non-conventional renewables' share of the country's energy matrix to 70 percent by 2050. A large scale of renewable projects of about 20.300MW with environmental approval, most of them sidelined, is waiting to enter the grid, and projects for additional 9.000 MW are under evaluation. These numbers show that, entrance of large variable generation capacity from renewable sources to the grid might be real in the close future. In a market like this, with a high penetration of renewables, the lack of regulation capabilities from variable technologies generates a significant stress on conventional generators that need to provide frequency regulation to the system without the help of their renewable counterparts.

In 2012, for the first time Chilean market operator has introduced a new regulatory amendment to ancillary services to consider the cost of frequency in the system. These amendments set a fixed-compensation mechanism to the generators in the frequency regulation service where they need additional maintenance, fuel consumption and the investment to provide frequency regulation services. However, for the future development of market with a large share of renewables, it is necessary to develop market-based mechanisms for assignment and pricing of this important product. The paper studies the role of frequency regulation in an energy matrix with high penetration of renewables and examines the long term economic incentives for the main generation technologies in the power system. The aim is to quantify the profitability of different generation technologies under market-based mechanism and to study their future economic incentives to invest. In this way, it determines which mechanism is a better solution to the existing trade-off between the criteria of a fixed payment and a market-based mechanism for frequency regulation in the context of a high penetration of renewables.

The paper is organized as follows: After the introduction the second section gives a brief overview about the regulatory settings in the international market that are necessary to provide market-based frequency regulation services. The third section addresses the regulatory mechanisms for ancillary services in the case of Chile and market-based tools that have to be introduced to match well with the entrance of variable generations. In

section four we describe the conducted power system simulation and the results. In the final section policy implications are derived.

Method:

Economic Dispatch Model - Optimization of Unit commitment (UC) problem using Mixed-integer linear programming (MILP). The proposed mechanism is developed and simulations are carried out for some scenarios in the Chilean power market, with different levels of renewable penetration.

Results:

The study analyses the results from the four different scenarios and how they affect conventional and renewable technologies by applying two different remuneration methods (fixed payment and market based mechanisms) of frequency regulation. The results show that as more renewable capacity enters to the system, combined cycle natural gas plants are only technologies that are better off under market mechanism. In contrary, solar technologies are worse off compared to other technologies. The question regarding who should pay the frequency in the market stays open in Chile.

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