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Aiming low and achieving it: A long-term analysis of a renewable policy in Chile

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ABSTRACT

We use an Integrated Resource Planning model to assess the costs of meeting a 70% renewables target by 2050 in Chile. This model is equivalent to a long-term equilibrium in electricity and renewable energy certificate (REC) markets under perfect competition. We consider different scenarios of demand growth, resource eligibility (e.g., large hydropower), and transmission system configuration. Our numerical results indicate that the sole characteristics of the available renewable resources in the country and reductions in technology costs will provide sufficient economic incentives for private investors to supply a fraction of renewables larger than 70% for a broad range of scenarios, meaning that the proposed target will likely remain a symbolic government effort. Increasing transmission capacity between the northern and central interconnected systems could reduce total system cost by $400 million per year and increase the equilibrium share of non-conventional renewable energy (NCRE) in the system from 45% to 52%, without the need for any additional policy incentive. Surprisingly, imposing a 70% of NCRE by 2050 results in a REC price lower than the noncompliance fine used for the current target of 20% of NCRE by 2025, the latter of which represents the country's maximum willingness to pay for the attributes of electricity supplied from NCRE resources.

1. Introduction

The Renewable Portfolio Standard (RPS) is one of the most widely used regulations around the world to promote generation from renewable energy resources. An RPS is an environmental policy that requires load-serving entities (LSEs) and electric utilities to provide a minimum fraction of their electricity using qualifiable renewable energy technologies within a compliance period. Some implementations allow LSEs and utilities to fulfill their obligations using Renewable Energy Certificates (RECs), which are financial instruments that represent the environmental attributes of the energy supplied from renewable resources and that can be traded separately from the electricity itself. Depending on the design of the policy, utilities can be allowed to comply with the renewable requirement using RECs that were generated using renewable resources outside of the control area of the RPS regulation.

There are several reasons why state and countries adopt RPS policies (Lyon and Yin, 2010). One of the most direct benefits that results from increasing the share of renewables in a power system is the displacement of greenhouse and air pollutant emissions from fossil-fueled power plants. Some countries, including Chile, also value the benefit of reducing their dependence on imported fossil fuels. It has been shown that renewables can also serve as physical hedges against price variability in a generation portfolio (Jenkin et al., 2013; Inzunza et al., 2016; Munoz et al., 2017. Additionally, RPS policies have also been supported to stimulate local employment, although there is little evidence of their effectiveness to accomplish this goal.

To date, more than 100 countries (REN21, 2015) and 49 states in the US (DSIRE, 2015) have created either binding or voluntary renewable targets. Despite their popularity, there are opposing views regarding the effectiveness of RPSs as mechanisms to support increasing investments in renewable energy technologies. Some empirical studies conclude that there is a positive correlation between regions with renewable targets and investments in renewable energy technologies (Lyon, 2016). They find that the magnitude of the correlation depends on the stringency of the policy, the enforcement of noncompliance penalties, the existence of flexibility measures (e.g., banking and borrowing of RECs), and the eligibility of RECs generated using resources outside of the control region (Wiser et al., 2007; Carley, 2009; Yin and Powers, 2010). Based on these factors, an RPS policy can be described as weak or strong, depending on how likely it is to support the proposed share of renewable generation.

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A good example of a weak RPS design was the 30% renewable target enacted in 1999 in the state of Maine (Lyon, 2016). Interestingly, at the time the policy was implemented, the share of generation from eligible renewable energy resources was already higher than 30%, leaving no incentives to local generation firms to increase their share of generation from renewables (Yin and Powers, 2010). The RPS in the state of Texas is another example of a policy implementation that has virtually no impact on the market. To date, there are more than 16 GW of wind capacity installed in the state (EIA-TX, 2016), which is 60% more than the state's 10 GW renewables target by 2025 (DSIRE, 2015). It has been argued that it was the federal production tax credit (PTC) of $23 per MWh and not the REC prices, which are currently traded at values below $1 per MWh, that drove these investments in renewables in the state (Trabish, 2015). Therefore, there is inconclusive evidence that RPS policies are responsible for investments in renewable energy technologies in the countries or regions where they have been implemented. Yet, they are gaining popularity outside of North America and Europe.

In South America, Chile was one of the first countries to enact a binding renewable target. The current RPS mandate requires generation firms to supply a minimum of 9% of their electricity from nonconventional renewable energy resources (NCRE) by 2017, with increasing requirements of approximately 1% per year, up to a final goal of 20% by 2025 (BNC, 2013). NCRE technologies include solar, wind, geothermal, biomass, tidal energy, and all hydroelectric power plants with an installed capacity smaller or equal to 20 MW. The restriction on the eligibility of hydropower aims at incentivizing investments in renewable energy technologies other than large hydro, which accounted for nearly 33% of the annual energy sales in 2015.

As shown in Fig. 1, the monthly amount of electricity generated from qualifying renewable energy resources from January 2012 until August 2016 has been far greater than the obligation. The effect of this oversupply of renewables with respect to the minimum amount required by the RPS policy has lead to a reduction of the average price of the RECs from $9.7 per MWh in 2010 to $4.5 per MWh in 2015. Thus, it is arguable that the renewable policy has had little or no impact on investment decisions given the small amount revenues that NCRE technologies can collect from the sales of RECs. Instead, it has been hypothesized that the increasing developments in new NCRE technologies in Chile from 2010 up to this date have been driven mainly by high electricity prices and important reductions in the capital costs of solar and wind generation.

The government recently released the 2050 energy roadmap (ME, 2015) that sets policy guidelines for the next three decades. One of the country's goals is extending the current RPS policy of a 20% share of NCRE by 2025 to a long-term goal of 70% of renewables by 2050. Although a 70% long-term goal of renewables might seem a large number, the proposed policy will be much less restrictive than the current RPS design, which only considers NCRE as eligible technologies. The 2050 energy roadmap proposes a 70% target that will allow all hydropower, both existing and new, to count as an eligible generation technology. To our best knowledge, there is no study that has quantified the feasibility of reaching such renewable target. Furthermore, it is not clear whether achieving this target will require a binding renewable policy or not given the large share of hydropower in the Chilean power system.

In this article we use an Integrated Resource Planning model to quantify the economic effects of a 70% RPS target in Chile by 2050. Under perfect competition this model is equivalent to the equilibrium of a set of private generation firms, which choose investments in conventional and renewable energy technologies to maximize profits for a representative year in the future. All firms that own eligible generation technologies can earn additional revenues from the sales of RECs, on top of the sales of electricity. Firms that only own non-eligible generation technologies (e.g., coal- and natural gas-fueled power plants) have to purchase RECs to fulfill the renewable policy. We consider different scenarios that could change the long-run market equilibrium, including demand growth, fuel prices, the configuration of the power system, and the policy design. For system configuration we focus on the potential scenario where the two main power systems in Chile, the Northern (SING) and Central (SIC) Interconnected Systems, remain separate, with no transmission capacity to exchange power between them. For policy design, we consider a potential scenario where the proposed RPS is made much more stringent and we assume that the 70% target by 2050 will incentivize only NCRE technologies, excluding all large hydropower.

We organize the rest of the paper as follows. In Section 2 we overview the relevant literature on equilibrium models of electricity and REC markets. In Section 3 we present an Integrated Resource Planning model that finds the optimal portfolio of investments considering demand requirements, a renewable target, renewable resource variability, and the flexibility of hydropower. In Section 4 we summarize the main characteristics of the two largest Chilean power systems, the SIC and SING. We also describe our assumptions regarding technology and fuel costs, resource variability, and system configuration. In Section 5 we present results from a series of numerical experiments. Here we estimate the annual cost of the renewable target in 2050, the value of large hydroelectric power plants to fulfill the policy, and the effect of a strong interconnection between the

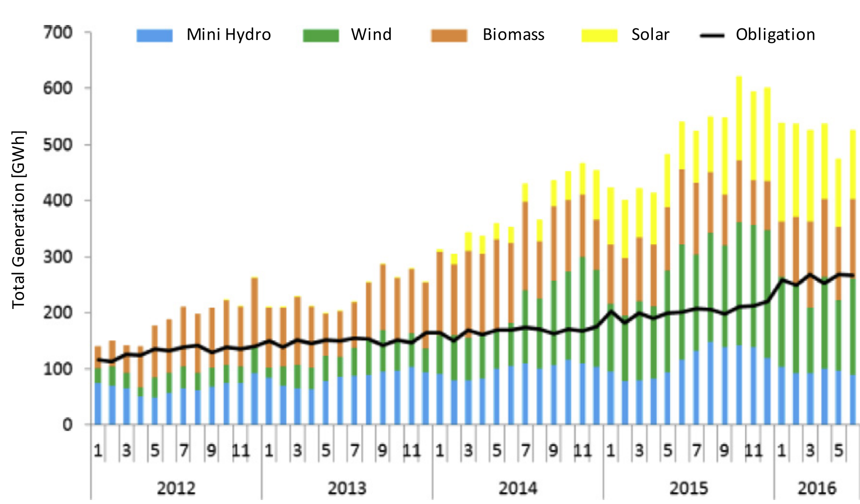

Fig. 1. Renewable obligation and generation from all eligible renewable energy technologies per month in Chile from January 2012 until August 2016. Adapted from Systep (2016).