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A novel inclusion of intermittent generation resources in long term energy auctions

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ABSTRACT

Long term energy auctions are positioning as a valuable tool in order to attract new investments into power systems, especially in Latin American countries where emergent economies characteristics and their correspondent risks are usually present.

Even though the focus of these auctions is the long term, there are short term issues involved which actual auction designs fail to include, resulting in an energy allocation that is not necessarily optimal for the system, a condition which becomes more evident in the presence of intermittent renewable technologies.

A novel mechanism is formulated to obtain the optimal allocation in long term energy auctions, considering short term generation profiles from both intermittent and conventional base load technologies, and also their risk aversions.

The proposed mechanism is developed and simulations are made for some scenarios in the Chilean power market, with different levels of renewable penetration. Significant cost savings are achieved for the final consumers in relation to energy purchases, in comparison with a mechanism that follows the demand profile.

As more renewable intermittent capacity enters the power system it is evident the need for changes in the energy auctions allocation mechanisms, including elements to exploit the synergies among participants in the short term.

1. Introduction

Latin America has been leading the effort worldwide to introduce long term electricity auctions as an instrument to promote competition in electricity procurement. Other countries such as Australia, Vietnam, Thailand and Philippines are also using actions to attract new capacity, the last three within single buyer schemes (Maurer and Barroso, 2011).

In essence, those are processes where contracts to provide a certain amount of energy in the long term are auctioned, so that the awardees can reduce their perceived risk when financing the projects that will be used to supply that energy.

The application of these auctions has developed well in Latin-American countries such as Brazil, Peru, Colombia, Chile and Panama, where emergent economies characteristics usually are present, like a strong but uncertain demand growth, low competition, and immaturity in certain market elements, which fail to reflect an accurate representation of the market conditions. Additionally, several of those countries have a considerable share of hydro generation, which contributes to the already volatile spot price inherent of those markets.

For these reasons, the classic elements of the peak load pricing theory (a spot market plus a capacity complement) have not been enough to attract an adequate level of new investments, required to supply the demand in an efficient way.

As mentioned, South East Asia has also carried out such auctions, with Vietnam, Thailand, Philippines and South Australia, in this last case specifically to attract new investments in some predetermined renewable technology.

In all the examples indicated there are various distinctions present in the auction designs, such as:

- They are carried out in a centralized or decentralized way (i.e. an entity represents a group of Load Serve Entities (LSE) versus each LSE implements their own process).
- Different time horizons are used for the auctioned contracts.
- Auctions consider specific technologies (e.g. one or more renewable technologies) or are technology neutral (e.g. any technology).

But the objective remains the same, to attract new investments into the system.

Abbreviations: ERNC, Spanish acronym for Non Conventional Renewable Energy

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Even though these auctions are designed to respond to long term energy requirements, they have to supply load as soon as contracts start. And there are short terms issues involved, even at the hourly level. In effect, the group of auction winners has to supply the actual aggregated load of the demanding entity, independent of the dispatch made by the Independent System Operator (ISO). In this sense, the hourly power obligation for an auction participant will determine a short term risk that it will have to face. In the actual auction designs, this issue has not been considered with enough detail in order to determine an optimum allocation.

For example, in the presence of renewables technologies among the auction participants, the approach that countries like Brazil and Peru have followed is to assign "production contracts" to the renewables, that is, to let those technologies fulfil their accorded energy whenever they produce it, leaving the conventional technologies to manage the increase in their short term risk that such decision leaves. On the other hand, trying to equate the treatment to all technologies, in the majority of auctions carried out in Chile, each auction winner (being conventional or renewable) has to supply an amount of the required hourly power proportional to its awarded energy. Being this required supply response a short term issue, auction design alternatives have failed to include some optimization in the auction design, coupling short term issues when the focus is long term.

In this work, a novel framework is proposed in order to design the auction, so that it considers a representation of the short term within the long term problem. Instead of a unique price and a quantity, auction bidders are required to provide both preferred short term supply profiles and indifference curves (price curves as functions of how much of the assigned energy is within or outside the provided supply profile).

An implementation of this framework is developed, where we consider that the short term supply profile provided by each bidder is an hourly profile of a typical day of the year. Simulations for this implementation are carried out for various levels of renewable penetration in the Chilean power system, showing that the proposed mechanism minimizes the expected payments from the demand and improves the allocation among the bidders.

2. Background

2.1. Auctions

As mentioned in (Maurer and Barroso, 2011), an auction is a selection process designed to distribute goods and services competitively; and in most of the cases in the electricity market, generation companies offer their products because they are interested in selling power contracts to large clients or distribution companies with a design that is focused on obtaining the best price (this is the so-called reverse auction).

Within the auctions oriented to attract new capacity, we can find ones that (i) include all types of technologies or technology neutral (direct competition among all technologies), (ii) only renewable energies, (iii) specific renewable technologies, (iv) specific projects (for example, to award a concession in a specific site) and (v) for demand resources.

Another distinction is the product that is auctioned as capacity per se (as in (Hobbs et al., 2005), (Hobbs et al., 2007), (Cramton, 2006), (Cramton and Stoft, 2005)), which normally correspond to short term auctions (annual, monthly) whose target is to keep the system reliability within certain margins in peak hours, or if the auctioned product is energy to be delivered within a certain period, which generally are long term contracts (up to 20 years) as in (Moreno et al., 2009), (Moreno et al., 2010) and (Chacon, 2013), among others.

These last types of auctions (where long term contracts for delivering energy are the products) are the ones that we are going to be referring for the rest of the article.

2.2. Renewable technologies in auctions

In the context of renewable energy, several countries have decided to foster the development of renewable technologies through exclusive auctions for one or more of those technologies, which necessarily implies a regulatory decision about the quantity of the demand intended for those kind of technologies. According to (Maurer and Barroso, 2011), these types of auctions have proven to be a viable alternative to the more traditional approaches like feed-in-tariff to attract renewable energy into the system. As the traditional auctions to attract new capacity, there are different combinations of target participants in these renewable auctions, being some of them: a) all types of renewable technologies, b) technology-specific or c) technology and site specific. In this context, (del Río and Linares, 2012) declare that there are mixed results in the implementations of such auctions, being one positive aspect the low level of subsidies in general. On the contrary, some of the negative elements include the low effectiveness to attract the expected renewable capacity, the low technological diversity, low innovation and high transaction costs.

On the other hand, technology neutral auctions are those where there are not restrictions on the types of technologies that can participate, being them renewables or conventional.

2.3. Short term issue of hourly power obligation

Clearly the long term is the main focus of the energy auctions, but also there are short terms issues involved, even at the hourly level. One of those issues is that the group of auction winners has to supply the actual aggregated load of the demanding entity, independent of the dispatch made by the ISO. The hourly power obligation will determine a short term risk that every auction participant will have to face in the case of winning. This issue becomes especially relevant as more renewable technologies enter the system, because unlike conventional base load technologies it is common for some renewable technologies to present several hours without generation, which raises the question of who has the obligation to supply the power on those hours.

2.3.1. Existing hourly assignments between auction winners

In most long term energy auctions, what has been done until now is to let the renewables fulfil their awarded energy supply according to a production logic (whenever they generate, their energy is recognized by the LSE until the awarded energy for the period is reached). This clearly imposes different conditions on conventional and renewables technologies, transferring risk among them. On the other hand, the Chilean energy market has been pioneer in implementing auctions where both kinds of technologies are treated equally. However, the implementation does not acknowledge that the dynamics of the generation technologies are different.

Until 2014, the Chilean electric market supply auctions considered that each generation company i that is awarded a supply contract must provide the awarded energy with a power profile that is equal to the demand in question.[1] In other words, in every hour h of the day it must provide P_i^h power equivalent to the Load Serving Entity demand at that time D_{LSE}^h multiplied by the percentage that represents its E_i awarded energy with respect to the total awarded E_{LSE}, as seen in the following equation.

$$P_i^h = D_{LSE}^h \cdot \frac{E_i}{E_{LSE}} \quad (1)$$

Moreover, the power system's economic dispatch is cost based (responds to the real audited costs associated to the units' generation, considering restrictions such as technical minimums and reserves). As

[1] The auction scheme was modified in 2014, allowing a small percentage of the energy to be auctioned at different time windows during the day.

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