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Reliability payments to generation capacity in electricity markets

Fernando Olsina [a,b,*], Rolando Pringles [a,b], Carlos Larisson [b], Francisco Garcés [a,b]

[a] National Scientific and Technical Research Council (CONICET), Argentina
[b] Institute of Electrical Energy (IEE), National University of San Juan (UNSJ), Av. Lib. Gral. San Martín 1109(O), J5400ARL San Juan, Argentina

HIGHLIGHTS

- A new approach for remunerating supply reliability provided by generation units is proposed.
- The contribution of each generating unit to lessen power shortfalls is determined by simulations.
- Efficiency, fairness and incentive compatibility of the proposed reliability payment are assessed.

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ABSTRACT

Electric power is a critical input to modern economies. Generation adequacy and security of supply in power systems running under competition are currently topics of high concern for consumers, regulators and governments. In a market setting, generation investments and adequacy can only be achieved by an appropriate regulatory framework that sets efficient remuneration to power capacity. Theoretically, energy-only electricity markets are efficient and no additional mechanism is needed. Nonetheless, the energy-only market design suffers from serious drawbacks. Therefore, jointly with the evolution of electricity markets, many remunerating mechanisms for generation capacity have been proposed. Explicit capacity payment was the first remunerating approach implemented and perhaps still the most applied. However, this price-based regulation has been applied no without severe difficulties and criticism. In this paper, a new reliability payment mechanism is envisioned. Capacity of each generating unit is paid according to its effective contribution to overall system reliability. The proposed scheme has many attractive features and preserves the theoretical efficiency properties of energy-only markets. Fairness, incentive compatibility, market power mitigation and settlement rules are investigated in this work. The article also examines the requirements for system data and models in order to implement the proposed capacity mechanism. A numerical example on a real hydrothermal system serves for illustrating the practicability of the proposed approach and the resulting reliability payments to the generation units.

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1. Introduction

Modern societies have developed a critical dependence on continuous delivery of electric power. Because of the vast impact—and potentially indeterminate reach—of power rationing events, supply reliability and generation adequacy (NERC, 1997) are matters of utmost concern for consumers and are deemed strategic by government bodies such as policymakers, regulatory authorities and agencies overseeing homeland security.

After restructuring of the electricity industry, centralized generation expansion planning has been replaced by decentralized investment decision-making following price (coordinating) signals and expectations on future returns. Capital allocation in generation capacity is now decided by multiple agents who aim at maximizing own profits while protecting themselves from risks. Since the very beginning of power markets, regulators and market designers have been reluctant to leave the market alone to warrant security of supply. Indeed, the pioneering electricity markets in Chile, UK and Argentina considered special mechanisms and provisions aimed at attracting timely investments in power capacity and sustaining supply reliability.

The rules governing electricity markets and their payment mechanisms should generate signals that produce efficient investments in terms of amount of installed capacity, mix of generation technology, and timing for being online. The power capacity that maximizes social welfare is regarded as the optimal adequacy level. However, determination of the optimal generation capacity

* Corresponding author at: Institute of Electrical Energy (IEE), National University of San Juan (UNSJ), Av. Lib. Gral. San Martín 1109(O), J5400ARL San Juan, Argentina. Tel.: +54 264 4226444; fax: +54 264 4210299.
E-mail address: olsina@iee.unsj.edu.ar (F. Olsina).

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is not an easy task as requires an accurate estimate of the Value of Lost Load (VOLL).

The heart of the current debate regards the proper regulatory framework that sets efficient remuneration to generation capacity. The selection of the right capacity mechanism is perhaps the most contentious issue in the design of electricity markets. As in other fields of economics, most regulatory proposals for capacity remuneration can be classified as either price-based or quantity-based. Sometimes, these dichotomous regulatory views are misrepresented as interventionist or market-friendly, when actually both approaches rest on administratively setting key design parameters. Currently, there is a lack of ample consensus regarding the superiority of some approaches with respect to others, as well as towards which mechanism is better suited for a particular organization in a given electricity market and the characteristic of its underlying power system. Unfortunately, the presently available theoretical and empirical evidence on these matters is at best spare and ambiguous. Under these circumstances, advocacy and opposition to the different approaches have often followed ideological lines of discussion.

Despite the weaknesses pointed out in the literature, price-based regulation to remunerate peak and reserve generation capacity by explicitly setting administrative payments is still one of the preferred schemes by regulators in many countries. This fact can probably be explained by the mechanism's success in addressing the challenge of attracting continuous capital investment flows in power generation to keep track of high load growth rates in fast expanding economies. Many markets also rely on explicit capacity payments in order to deliver proper supply reliability in hydro-dominated power systems, which are much more risky and challenging than thermal-only generation systems.

Most of the implementations of the capacity payment approach have shown a number of drawbacks. First, capacity payments are often fixed and do not reflect the prevailing adequacy of the generation system. Second, objective procedures for establishing the administrative value of the capacity price are generally missing or overly simplistic. Third, the capacity product to be exchanged for these payments is commonly loosely defined. In fact, the product is usually defined in terms of the generator´s "firm capacity", which is normally estimated by means of very arguable procedures. Consequently, payments resulting from such methods often do not necessarily correlate with actual contributions of generating units to system reliability and its ability to deliver energy during scarcity. This leads to inefficiencies such as the misallocation of payments, the distortion of investment signals, and unfairness.

The aim of this paper is to present a methodological contribution to improve the way capacity payments are currently established in order to overcome most of its pitfalls. To this purpose, a reliability-based approach for determining the payments that should be awarded to each individual generating unit has been developed. The proposed reliability payments intend to reward the real contribution of each generation unit in regards to overall system reliability. The method presents attractive properties regarding efficiency and fairness.

The reminder of the article is organized as follows. Section 1.1 briefly revisits the most relevant issues about adequacy in electricity markets; Section 1.2 reviews each existing capacity mechanism aimed at supply adequacy and discusses in detail the shortcomings of several existing approaches for setting capacity payments, our main focus. Section 2 presents the proposed reliability payment, and includes data and models required for practical implementation of the new remuneration method. Detailed results of the proposed methodology for a real power system are illustrated in Section 3 jointly with an in-depth discussion of the policy implications. Section 4 closes with the conclusions.

1.1. Generation adequacy in electricity markets

It has been proven theoretically that electricity spot markets operating under perfect competition provide the right incentives to deliver optimal investments regarding capacity level and generation technology mix to supply power and energy demand at minimal cost (Stoft, 2002; Schweppe et al., 1988; Caramanis, 1982). Under these conditions, price spikes during rationing periods lead to scarcity revenues sufficient enough to attract the needed investments in peak generation (Olsina et al., 2006; Oren, 2000).

However, several problems in real settings must be considered. First, electricity demand is nearly inelastic and can lead to sharp albeit infrequent price spikes, which may be seen by both customers and regulators as a legitimate signal of system inadequacy. Second, scarcity creates favorable conditions for exercising market power in small or concentrated markets. It can be very difficult to distinguish legitimate high prices due to scarcity from those artificially elevated by the exercise of market power.

Although scarcity rents can be very significant, they are sporadic, erratic and unpredictable by their very nature. As a consequence of the extreme volatility of scarcity revenues, risk-averse investors delay or simply abandon investment plans in peak capacity necessary to guarantee long-term adequacy, causing a lower than optimal adequacy level and eventually capacity shortfall conditions. This situation can drastically deteriorate depending on if regulators administratively limit the market prices below the VOLL, e.g. by introducing price caps, or even if market participants believe the regulator would do it in the future, when scarcity events arise, in order to protect the demand from paying politically inacceptable prices. Because of the rather lengthy lead construction times, such situations may take considerable time to overcome.

1.2. Market designs for generation adequacy

The problems of finding the optimal production capacity and pricing of non-storable commodities, like electrical energy, have long been an important problem and have received extensive treatment in economic literature during decades. After the seminal article by Boiteux (1949), classical works on this topic, often referred in the literature as "peak load pricing", were published (Kleindorfer and Fernando, 1993; Chao, 1983; Crew and Kleindorfer, 1976). Reviews of economic literature on different features and approaches to this problem can be found in Crew et al. (1995) and Joskow (1976).

The most important findings of these works show that under the hypothesis of risk neutrality and maximization of social welfare under uncertainty, the optimal generation capacity is that for which the marginal cost of an additional unit of capacity equals the expected marginal cost of the unserved energy. Although these results suggest that no further payment for capacity are needed, further research and empirical evidence show that some form of capacity remuneration is necessary in order to ensure that enough generation capacity be timely built. Several proposals for complementary payments for power capacity are reviewed by Batlle and Rodilla (2010), Baldick et al. (2005), Wen et al. (2004) and Vázquez et al. (2002).

Table I summarizes four different approaches to market design for generation adequacy, includes their relevant features and attributes, and mentions systems in which they have been applied. Comparative studies of different capacity mechanisms based on dynamic simulation models show that fixed capacity payments perform nearly as well as reliability options and long-term forward markets (de Vries and Heijnen, 2008).

However, implementing capacity payments is not exempt from notable difficulties. Here, a key issue is determining the payment level that yields the right capacity. If capacity price is settled too low, adequacy will deteriorate and conversely, if fixed too high, overcapacity will likely arise. Often, obscure (or plainly discretionary)

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