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Steady State price of Iran Capacity Certificate Market

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Original Article

Abstract. In Iran's electricity market, the energy market (with a price ceiling and ancillary services) and the capacity market are active separately. Meanwhile, the energy market price will cover the annual costs of the Peak-Load Power Plant, including the anniversary of the overhaul cost. The capacity market includes two sub-markets, the Energy Conversion Agreement (ECA) contract and the capacity certificate market, the total price of which should cover the initial investment cost of peak-load power plants. Naturally, over time, as the share of the capacity certificate price increases through competitive bidding, the share of the price of the guaranteed electricity purchase contract will decrease. The question is, if the share of the price of the guaranteed electricity purchase contract reaches zero, or if ECA is deleted, what would the price of the capacity certificate converge to? That is the subject of this paper.

The results indicate that before considering the consumption simultaneity coefficient (=0.4) of consumers' electricity, the long-term Capacity Certificate Price (CCP) should converge to peak-load power plant fixed costs and market excess demand, which evaluates to 1000 USD per kw in 2021.

Keywords: *Iran Electricity Market, Iran Capacity Certificate Market, Price Estimation, Electricity Market, Capacity Mechanism*

INTRODUCTION

The historical data on Iran’s electricity market indicates that power systems cannot create the effective conditions for optimal investment in generation capacity expansion physically or virtually by reducing energy demand and implementing energy efficiency projects (Heidarizadeh, 2018.), (Park, 2007), (Pérez-Arriaga, 2013).

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On the other hand, the economic consequences of power generation shortages have resulted in lost profits for exporting firms in this market. Thus, several incentives have been introduced to support investment in generation capacity (GC) (Bublitz, 2019), (Sener, 2013).

This situation is a result of the inherent characteristics of power systems, such as high construction costs and various risks to revenue and returns of capital, as well as the diversity of investors' viewpoints with the system operator (Department for Business, 2021), (Zucarato, 2012). In a restructured power system, maximizing profit is considered the main motivation for investors. However, the independent system operator seeks to minimize generation costs and maintain an acceptable level of reliability, which requires providing adequate GC (Briggs, 2013), (Rodilla, 2012).

Accordingly, a market designer may decide to intervene in the market to ensure adequate GC and the economic consequences of electricity shortages(Joskow, 2007).These mechanisms aim to keep existing generation capacities available and motivate investors to construct new generating units without imposing unnecessary costs on commercial customers (Kamalinia, 2010), (Conejo, 2016).

As part of the capacity payment mechanism, power plants are paid based on their available capacity, regardless of the amount of energy they produce (Batlle, 2008). Furthermore, by setting a price cap on the energy market, price spikes are prevented (Bublitz, 2019). The amount of capacity payment may vary depending on different hours and power plant technologies.

By conducting a case study in the Iranian electricity market, this study aims to estimate the long-term price of a 'Capacity Certificate' as a Generation Capacity Price in the Iranian power exchange.

In 2017, the concept of a capacity certificate was established in the Iranian electricity market. In the French electricity market, a capacity mechanism, known as the capacity certificate, is used to provide GC for peak hours. This certificate has a limited lifetime and is only valid for a specific year. It is also fundamentally different from the mechanism described in this paper.

The body of this paper is as follows. Section 2 introduces capacity mechanisms around the world. Sections 3 and 4 give a brief overview of the capacity certificate mechanism and modelling in the Iranian electricity market. Section 5 shows the results of the research. Finally, a conclusion is presented in the last section.

1. LITERATURE REVIEW OF CAPACITY MECHANISMS

Different types of capacity mechanisms have been proposed or implemented around the world.

1.1 Targeted

1.1.1 Volume-based

1.1.1.1 *Strategic reserve*

In this mechanism, a certain amount of capacity is held outside the market to be called upon in emergencies. Support is given only to the extra capacity required over that which was provided by the market without subsidies. Belgium, Poland, Sweden, and Germany use this mechanism.

1.1.1.2 *Tenders for new capacity*

In this mechanism, newly initiated investment projects get assistance corresponding to the available power capacity they can provide. This may be offered on the market or supported by a power purchase agreement. This mechanism is used in France.

1.1.2 Price-based

1.1.2.1 *Targeted capacity payments*

In this mechanism, administrative payments are made to a subset of the capacity on the market. Italy, Poland, Portugal, Spain, and Greece use this mechanism.

1.2 Market-wide

1.2.1 Volume-based

1.2.1.1 *Central buyer*

This mechanism supports all market participants (existing and new) to meet the required reliability standard. The total amount of required capacity is set centrally and procured by a central buyer through a central bidding process, in which potential capacity providers compete so that the market determines the price. This mechanism is planned to be used in Ireland, Italy, Poland, the UK, Greece, and USA (NE and PJM).

1.2.1.2 *De-Centralized obligation scheme*

With this mechanism, suppliers are obligated to make their arrangements to contract capacity and they are required to meet consumer demand. The market establishes the price for the required capacity. France plans to use this mechanism (hybrid with the central buyer mechanism).

1.2.2 Price-based

1.2.2.1 *Capacity payments*

All market participants are eligible for an administrative payment under this mechanism. This mechanism is used in Ireland (Cramton P. O., 2013), (Cramton P. S., 2005), (Hancher, 2015).

On the Iranian power exchange, Iran’s power plant capacity market mechanism is active. A power plant capacity owner without customers, or electricity demands, can offer a capacity certificate on the power exchange, equivalent to the capacity in hand. The purchaser will then buy their capacity certificate. The purpose of this paper is to determine the price of a capacity certificate for the long run (steady state), taking into account the above-mentioned market and the energy market with a price ceiling.

2. CAPACITY MECHANISMS (CAPACITY CERTIFICATE) ON THE IRANIAN ELECTRICITY MARKET

The capacity certificate mechanism is intended to motivate investors to invest in new GC (NGC) and to provide system adequacy on a competitive basis. The design of the capacity certificate mechanism is based on a two-sided market including supply and demand. Furthermore, power plants and customers can play on both sides of the market. The capacity certificate discussed in this paper is a tradable security that customers should purchase from the market (power exchange) according to the amount of capacity they need as a prerequisite for the grid connection. In this regard, customers ensure that the required equivalent capacity is provided without endangering the security of supply for existing customers when they connect to the grid. These securities are issued equivalent to the capacity of the new power plants that are connected to the grid each year. Although the price of a capacity certificate can be determined based on the agreement made between the buyer and seller, all exchanges of capacity certificates were made at a unique price in the present study. This price is fixed based on the total supply and demand in each year. Investors are reassured and motivated to invest in capacity expansion through this mechanism. In addition, it provides room for customers to participate in establishing a balance between generation and demand by releasing part of their demand. In fact, customers have recently been given a variety of technical options to reduce their peak load. The main challenge is the investment required to implement these options or the guarantee that the investment will be returned within a reasonable time frame. This challenge is easier to overcome with the capacity certificate mechanism since customers can sell the capacity certificate in proportion to the reduction in demand, and obtain the necessary resources accordingly. This is considered a distinctive feature of the capacity certificate mechanism. Thus, the main features of this mechanism are as follows:

- New customers must purchase capacity certificates in proportion to their demand.
- Existing customers are required to purchase capacity certificates if they are interested in increasing their demand.
- Investors will sell capacity certificates in proportion to the new capacity they add to the grid.
- Every year, the Capacity Certificate Price (CCP) is determined according to supply and demand, providing investors and customers with appropriate feedback to signal their actions.
- Trading capacity certificates could push traders' capital toward GC expansion. However, this study does not elaborate on this feature.
- Customers can sell capacity certificates in proportion to their releasable demand, which results in improved energy efficiency.
- Capacity certificate is consistent with market rules and the CCP is fixed through competition while the capacity payment is a direct manipulation of the market.

Despite the above-mentioned advantages, there are some challenges to implementing the capacity certificate mechanism, including:

- It is more complicated to implement capacity certificates compared to capacity payments. For example, it considers the legal aspects when a power plant sells capacity certificates but fails to generate electricity.
- If the certificates are dealt with as tradable security, there is a possibility of withholding which needs careful monitoring.
- Comparatively to capacity payments, investors face a higher level of risk, which is natural since competition and risk are two sides of the same coin.

Iran's Ministry of Energy presents the guidelines for implementing the capacity certificate on the Iranian electricity market. According to these guidelines, a capacity certificate is a tradable document which will be issued with the permission of the Ministry of Energy based on building up a new reliable power plant or reducing the demand of existing customers. The unit of the capacity certificate is kilowatt which represents the obligation to provide additional capacity equal to one kilowatt in an unlimited lifetime. As the lifetime of a power plant is considered unlimited, owners should accordingly build an NGC or purchase a capacity certificate to compensate for the reduction of power plant capacity due to ageing. Furthermore, new customers are forced to buy a capacity certificate based on their peak load since there is no control over the customer's load behaviour except the amount of maximum consumption. There is also the possibility that these peak loads occur simultaneously.

3. THEORY FRAMEWORK

Based on the Capital Asset Pricing Model framework, the cost of capital is given by the covariance of the asset's return (R_i) with the market portfolio's return (η). We will assume that random variables in the model belong to probability space (Demange and Rochet, 1992, Kreps, 1982). For an asset's random return, $R_i = \frac{\pi_i}{P}$, the CAPM equation states that: $E[R_i] = R_0 + \frac{cov(R_i,\eta)}{var(\eta)}(E[\eta] - R_0)$

With R_0, the risk-free return and the parameter $\frac{cov(R_i,\eta)}{var(\eta)}$, named the beta.

4. CAPACITY CERTIFICATE MARKET MODELLING

According to the CAPM theory framework, to calculate the capacity certificate price, we need to assume a given rate of return on investment in the construction of a new power plant in proportion to the level of risk. Also, it is assumed that the total expected load (TEL) has a fixed growth rate:

$$TEL_t = (1 + \alpha)TEL_{t-1} \quad (1)$$

The capacity certificate demand (CCD) equals the TEL. Thus:

$$CCD_t = \Delta TEL_t \quad (2)$$

The capacity certificates supply (CCS) is provided by NGC, which is the total new generation capacity (TNGC), and the decrease (shifted down) system Demand (DD). That is:

$$CCS_t = TNGC_t + DD_t \quad (3)$$

A high CCP motivates the customers to decrease (shifted down) a part of their actual demand and earn profit through selling capacity certificates for the decreased demand.

As an incentive to motivate investors, the capacity certificate should cover a part of their investment costs, which are not covered by profits from the Energy Conversion Agreement (ECA) and the energy market. Thus, the CCP is assumed to be given by (4), where the last item reflects the capacity certificate's market condition. If the demand for certificates is higher than the supply, the price will increase; and vice versa:

$$CCP = BCCP + \beta(CCD - CCS) \quad (4)$$

$$BCCP = NPV(Inv.Cost) - NPV(ECA) - NPV(En.Market) \quad (5)$$

Where:

BCCP	is the base capacity certificate price.
NPV (Inv. Cost)	is the net present value of fixed investment cost.
NPV (ECA)	is the net present value of energy conversion agreement income.
NPV (En. Market)	is the net present value of the energy market.
(CCD-CCS)	is the capacity certificate Excess demand.

$$NPV\ (Inv.Cost) = I_0 + (0.7)\ I_0 \sum_{n=0}^{\infty} \left(\frac{1+i}{1+r}\right)^{30*n} = (1.7)I_0 \left(\frac{1+r}{r-i}\right) \quad (6)$$

Where i and r are long-term inflation and discount rate, respectively.

When calculating the base price of the capacity certificate with infinite life, it is assumed that after the end of the useful life of the power plant, a new one will be built. Therefore, the lost money will be included in the financial flow infinitely for the duration of the power plant's life.

5. RESULTS

To calculate CCP for 2021, the following assumptions were made.

Table 1.Assumptions

Variable	value	Variable	value
30 years foreign inflation rate	60%	30 years domestic interest rate	20%
30 years foreign discount rate	300%	30 years domestic discount rate	35%
Investment cost of peak-load P.P	360 (Euro/kw)	Exchange rate	(250000 Rials = 1 USD)
ECA price	8350 (Rials/kWh)	Energy market	1100 (Rials/kWh)
Operation coefficient	0.85	Excess demand	5%
P.P lifetime	20 years	ECA period	7 years
Risk-free annual return	2.5%	P.P investment return	10%
CAPM-beta coefficient	0.6		

The calculation of equation (4) items for 2021 is shown in table (2):

Table 2. Results

CCP	NPV (Inv. Cost)	NPV (ECA)	NPV (En. Market)	Excess Demand value
Million Rials/kw				
25.1	255	190	33.7	6.2
β = 0.62				

The CCP value is the annual average (2021) of the capacity certificate in the Iranian Power Exchange, *before considering the consumption simultaneity coefficient (=0.4) of consumers' electricity*. The other results are calculated based on the descriptions in equations (4) and (5). The key point is the effect of the excess demand for capacity certificates on price. The results show that for every 1000 kilowatts of excess demand, the price of the capacity certificate will increase by 620 Rials (coefficient $\beta = 0.62$).

As shown, in 2021, the average price of the capacity certificate in the market is equal to the current value (in the infinite horizon) of investment costs minus the net present value of the income from the guaranteed purchase contract minus the net present value of the expected income in the energy market minus the current net value of the capacity certificate price due to excess demand in the 20-year horizon.

CONCLUSION

Designing suitable incentive mechanisms to motivate investors to invest in electricity generation capacity physically or virtually (demand reduction and energy efficiency projects), is essential in the electricity market as well as the Iranian power system based on load growth and the retirement of power plants. As a result, capacity and energy payment mechanisms were utilized to cover the fixed and variable components of annual costs, respectively. In addition, an Energy Conversion Agreement (ECA) design was used to recover fixed investment costs. Recently, there has been a new incentive introduced in parallel with ECA, called the ‘Capacity Certificate’ mechanism, which intends to solve the missing money problem in Iran’s electricity market. To demonstrate the efficiency of this incentive; we calculated the long-term power plant Capacity Certificate Price (CCP) and compared it to the market CCP.

Results show that the actual market CCP is close to the calculated CCP. Furthermore, the long-term price of capacity certificates in the Iranian Electricity Market in 2021 is 255 Million

Rials (1000 USD) per kw, which changes every year (*before considering the consumption simultaneity coefficient (=0.4) of consumers' electricity*). Additionally, the results indicate that for every 1000 kilowatts of excess demand, the price of the capacity certificate will increase by 620 Rials (coefficient $\beta = 0.62$).

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