Mechanism design and SWOT study of forward capacity market

Abstract

This study aimed to examine the strengths, weaknesses, opportunities, and challenges facing the design of a forward market of the capacity certificate, during which, in addition to preparing capacity certificate papers by consumers to contract with the network owner, investors will also be able to cover part of the fixed investment costs in the construction of the power plant by selling the trading securities. Also, with the transparent price of the securities in the market and the presence of various traders, the market will have sufficient liquidity and the investment process in this field will accelerate, leading to sufficient production in the long term. One of the strengths of the forward certificate is its readability and liquidity. This feature can become an opportunity to attract small capital. Electricity consumers, as the final buyers of capacity certificates, usually decide to supply the electricity in the last stages of setting up their consumption needs. If the buyers of this market are exclusive to this group of subscribers, funding the construction and operation of the power plant in the future will be difficult. Therefore, if the capacity certificate market is upgraded to the capacity certificate forward market based on electronic transactions, in addition to benefiting from high liquidity and financing, the cash capacity certificate will be updated, and the hoarded certificates will be offered in the current cash market.

Keywords: Forward market of capacity certificate, Investment in power production, Pricing

Introduction

The necessity to create competition through deregulation and privatization of various parts of the system to increase the efficiency of the equipment and ultimately optimal utilization are the reasons for changing the custom approach of the power operators to a reconstructed space. The key role of electricity in the economy and its significance from various aspects have forced the legislators to always prevent any shortage of electricity by applying laws and guaranteeing the sufficiency of production. Since the income from energy sales does not cover the fixed costs of power plant construction, studying methods to cover these costs is necessary. One of the ways to supply the deficit of financial resources and reduce the financial burden on the government budget is to use the potential of the private sector. The private sector creates occupation, transfers technical knowledge, increases economic mobility, and creates a basis for comparing and measuring the efficiency of similar power plants due to the better function of the private sector than the government and projects operating in a shorter time. In addition to profitability, the transparency of laws plays a fundamental role in order to create the basis for the participation of the private sector and attract new investors for the electricity industry. In this regard, the possibility of expanding independent power producers and independent power plant capacities is predicted in the country's development plan. In a situation where investors are not sure of covering their costs, they prefer to make investments less than the sufficiency level in order to receive more profit through the increase in energy prices. Therefore, a mechanism should be defined in which for confident investors in order to cover their costs concerning the network's proper capacity. At first, it was assumed that in privatization, the amount of investment needed to provide the production capacity would be provided. However, as this process progressed, concerns increased and the question arose whether the energy industry could only send investment signals to investors. In the restructured markets, electricity prices cannot sufficiently cover the costs of the investors and encourage them to ensure the system's adequacy. Also, the conditions of price jumps are decreased due to the demand decreases through expanding the participation of consumers in managing their demand when the current electricity prices increase. If there is no solution to encourage investors in order to ensure the system adequacy and construction of new power plants, demand-supply, and network security will be at risk due to the consumption increase. The energy market alone cannot guarantee production sufficiency, but the desired sufficiency can be provided by designing incentives. The capacity mechanism sends investment signals to investors to provide the required network capacity in the long term. In this regard, the physical capacity certificate market has been established to bond transactions under the monopoly of the Power Plant Holding Company. Since the only suppliers in the current industry are new power plants, this market does not have a financing function; because until the starting power plant is, the owner of the power plant does not have the capacity certificate to compensate part of the fixed costs by selling.

This study aimed to create a mechanism to provide a part of the investor's fixed costs for power plant construction by setting up a forward market of the capacity certificate. Since the main aim is to fund the ongoing project, the certificates are of the forward type and will be tradable until a certain usance. One of the strengths of forward bonds is their liquidity and tradibility, which can become an opportunity to attract small capital and not necessarily the final subscribers.

Investments are based on stimulants. These stimulants can create a profit, increase demand, operate the new, etc. Investing at the wrong time can lead to the loss of the investor's expected profit or the loss of network security and failure to demand-supply. The decision time to build a new unit is affected by several factors, including price forecast, capacity, and future profitability. Therefore, delay in investment is one of the causes of instability which can turn into an electricity supply crisis. In the current markets, sending the investment signal for the construction of new power plants is facing disruption due to the established laws. It is necessary to study and present a mechanism to remove the obstacles facing investment in this field. It is necessary to have a market for preparing the capacity certificate bonds according to the notification of the Minister of Energy to support the producers and facilitate the conditions for the preparation and presentation of capacity certificate bonds by the subscribers who have a network connection contract. Currently, the physical capacity certificate market is under the monopoly of the Power Plant Holding Company. It means that the capacity certificate is available in the market only to the extent of the newly installed capacity, and the owners of the new power plants are not willing to present it in the current market due to the lack of transparent pricing of the certificates. The acute conditions of this issue can be concluded from the bonds traded since the beginning of the cash capacity certificate

market until now, which is less than 2000 megawatts. The critical situation of investment in this area is obvious from the lack of capacity certificate documents, along with the requirement to develop electricity production capacity to the extent of 2500 megawatts per year. Since capacity certificates are issued exclusively by the owners of new power plants and depend on the new capacity installation, the investment process is disrupted and these bonds do not contribute to new investment in power plant construction and production capacity development. Therefore, the creation and development of the forward market of capacity certificate bonds based on electronic transactions seem necessary; in which consumers can prepare capacity certificate bonds in order to contract with the network owner before consuming electric energy, and investors will also be able to funding part of the fixed investment costs in the construction of the power plant by selling these bonds. Also, the market will have sufficient liquidity, and the investment process in this field will accelerate, leading to sufficient production in long term, through the transparent pricing of the bonds in the market with the presence of various traders.

Restructuring and its effect on the development of production capacity

After the restructuring of the power systems, each of the actors pursues its goals. The independent system operator seeks to minimize electricity supply costs while maintaining an acceptable level of reliability, which requires sufficient new production capacity in the network. On the other hand, investors and power plant owners seek to maximize their profits in the competitive environment of the electricity industry [1]. Although in perfect market, resolving such conflicts is handed to competition in the market. However, the unique characteristics of the electricity market have led to serious doubts about the adequacy of the energy market mechanism for production capacity development in power systems [2, 3]. The changes in the development of production capacity in competitive environments compared to the traditional environment can be summarized as follows [4]:

- In the traditional environment, the investor was often the government, or investors decided to invest by signing a contract to sell their electric power to the government. However, in a competitive environment, more investors are able to invest and sell their electricity in the market.
- The methods of solving the planning problem in the traditional environment are often the classic methods of operations research, whereas, in the competitive environment, methods based on learning and modeling the behavior of competitors are needed.
- Uncertainties of the traditional environment are less than the competitive environment.
- The decision to invest, in the traditional environment was made in a centralized manner with the aim of minimizing costs, whereas in the competitive environment it has been changed in a decentralized manner with different goals, such as maximizing the profit of each investor.
- The concern of the market regulator has changed from providing social welfare in the traditional environment to providing social welfare and attracting investors in a competitive environment.

Market barriers to energy-efficiency investments

investment at the right time is necessary to ensure the supply security of the power system. Meeting the concerns and risks of investors is necessary to attract suitable investment. Since the construction of a power plant requires a high investment, it is necessary to design solutions to provide a part of the required capital. One solution to motivate investors is to allow price jumps in the energy industry facing a capacity shortage when there is no other incentive mechanism in the market. This is the mechanism of energy only market. Defenders of the adequacy of the market mechanism believe that the market provides sufficient incentives for optimal and reliable investment for production capacity development and there is no need for a new mechanism. So, the only source of income for producers is received by selling energy. In this model, the widespread power cut is inventible due to the high price ceiling of the energy industry. On the other hand, theoretical studies and practical experiences of some countries have shown that competition-oriented mechanisms in the energy industry don't provide the necessary conditions for the proper development of production capacity due to the high costs of power plant construction and the various risks faced by investors and it will cause investment boom and bust [6]. So, there are serious doubts about the adequacy mechanism of energy only market to develop production capacity in power systems. Also, the sensitivity of electricity production and the widespread political and social consequences of the lack of capacity and power cuts have forced the majority of electricity market designers to intervene in the market and create mechanisms to ensure sufficient production

capacity in the network. These mechanisms are a set of applied policies in the electricity market to increase production capacities as well as create incentives for investors to develop new capacities [7].

The incentives used and their strengths and weaknesses

Incentive mechanisms, which are called capacity mechanisms, have been proposed to increase production capacities and motivate investment. The capacity mechanism, along with the energy market, is the main source of income for investors, as well as one of the main market regulating tools to ensure reliable product supply in the power system. The capacity mechanism can be considered a set of policies implemented by the electricity market legislator to increase the production capacity to ensure the system's required reliability and also creating incentives for investors to develop new capabilities in the long term. Several studies have investigated the impact of capacity mechanisms on investment development. Figure 1 shows the classification of capacity mechanisms.

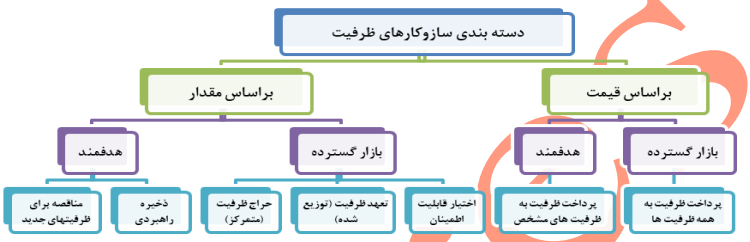

Figure 1) Classification of capacity mechanisms

In the category of price-based capacity mechanisms, the price of the capacity mechanism is specified and a payment is made for the capacity to all or some power plants. The required capacity is specified in the category of quantity-based capacity mechanisms and payment for capacity is calculated in different ways. In market-wide mode, all available capacities can participate in the capacity mechanism. The required capacity can be provided by an institution as a central buyer and an auction, or a supplier of each region provide the required demand of their region. Reliability is another market mechanism based on quantity. In the targeted mode, the price of the capacity mechanism is paid only to specific capacities based on various criteria such as new units, specific technologies, or specific capacities. In the strategic reserve mechanism, power plants that do not participate in the market and often have a long life should be used by signing a contract in times of capacity shortage and critical conditions. Also, the specifically required capacity can be provided by new power plants using the tender offer. In the following, the used mechanisms to ensure the production capacity are introduced.

Capacity payment

Among the different capacity mechanisms, capacity payment is more favored due to its simplicity in implementation. In this mechanism, a certain amount is paid to the power plants according to the standby capacity and regardless of the amount of energy production. There are various methods for capacity payment. One is that the same payment should be made to all existing and new power plants. This payment can change according to the system reserve. In the next method, capacity payment is not given to all power plants and only new or specific power plants benefit from this payment. The payment for different technologies can be the same or different. Considering the time-consuming return on investment in power plant construction projects, capacity payment creates little desire for investment, unless the capacity payment is high and increases the cost of system operating. On the other hand, paying the capacity to the power plants that have received the fixed cost of building their power plant, causes undirected the resources to the optimal aspect. In this mechanism, during a capacity deficiency, there will be a possibility of a price jump as high as the market price ceiling and a power cut for subscribers. Due to the uncertainty of creating a

suitable production capacity. The obvious manipulation in the market and the high cost imposed on the subscribers are the major weaknesses of the capacity payment mechanism [8].

Capacity auction

The high cost is one of the weaknesses of the capacity payment mechanism. The capacity auction mechanism has been introduced to reduce costs and create competition to provide the required capacity. This mechanism is one of the favored mechanisms of many prominent markets. In this mechanism, the independent operator of the system has predicted the required capacity between one and five years before the beginning of the year and provides the required production capacity by different auction methods. The participating power plants provide the lowest prices to be the winner of the auction. So, the auction settlement price is obtained by the price offer of new power plants. The exact estimation of the required capacity curve is one of the problems of this mechanism. In the markets based on the capacity auction, one institution is responsible for the system and market operating [9].

Capacity obligation

The capacity commitment mechanism is similar to the capacity auction with the difference that in the capacity commitment, demand is supplied decentralized by demand suppliers, and the risk of capacity deficiency will be shared between the load suppliers.

In this method, suppliers try to provide demands in three ways:

- Creation of new production capacity by demand suppliers.
- Purchasing capacity from other production capacities in the network in the form of a bilateral contract or auction.
- Using consumption management and cooperation of industries to use their capacity.

This mechanism has the shortcomings of the capacity auction mechanism. However, competition will be created between the participants because every demand supplier will start a capacity auction. On the other hand, the investors in the production capacity construction need to divide their large production capacity into several capacity auctions and provide competitive prices to secure their capital. The risk of providing capital and winning are among the challenges of this mechanism. There is no clear sign to encourage investment in this mechanism, which can be an obstacle to the entry of new producers [10].

Strategic Reserve

The strategic reserve mechanism is designed to provide the required capacity in capacity deficiency. In this method, during the lack of capacity, the independent operator of the network contracts with old units for production. The purpose of this method is to prevent the deactivation of old units and to use them during the lack of capacity. So, this method is especially suitable for maintaining the existing units in unusual conditions. However, this method is not proper for attracting investors. This method is used in markets with sufficient supply without growing demands in the future. This mechanism does not seek to solve missing money and create new production capacity, but only seeks to secure the system reserve by using existing power plants [11].

Reliability Option

The reliability option mechanism is similar to strategic reserve and a type of call option contract. In this mechanism, the demand supplier or the independent operator contract with the capacity supplier or suppliers. In such a way, demand suppliers provide the required energy while providing production capacity with an agreed price during the lack of capacity and increasing energy prices [12]. In this mechanism, if the obligations are not fulfilled, the capacity suppliers (power plants) will be fined.

In figure 2, you can see the different methods of the capacity mechanism used in the countries of the world.

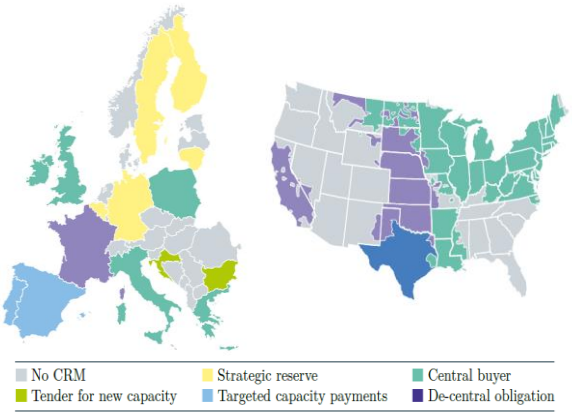

Figure 2) Different methods of capacity mechanism

Capacity mechanism in Iran's electricity market

After rapid development in early 1961, Iran's electricity network experienced blackouts in 1975, which led to significant investment in the construction of gas units. Due to the power cut caused by the lack of production capacity in the years after the end of the imposed war, investment in this industry was again taken into consideration in 1989. Subsequently, there was a decrease in the development of production capacity as the situation improved. After that, widespread power cut was experienced in 1996, 1997, 2003, 2004, and especially in 2008. Finally, power cuts and lack of capacity in the years 2017 to 2022 can be considered as the recent period of lack of production capacity. This situation shows an unstable investment for the development of electricity production capacity in Iran before and after the restructuring. In Iran's electricity market, like most electricity markets, changes in the price ceiling are caused by changes in fuel cost. The settlement of the energy market is based on offered payment, and the offering prices have a significant impact on the income of the power plants. A preparation cost is paid for every megawatt of production capacity expressed by the power plant units. The preparation rate in an hour is calculated by the product of the basic preparation rate and the coefficients for the considered hour. This cost is paid to the production unit regardless of whether the capacity expressed by the production unit is used or not in the market settlement process. The basis for determining the preparation rate by the Market Regulation Board is the construction, maintenance, and repair costs of the peak load of the power plant. The coefficients of the paid preparation price are determined and announced based on the network reserve forecast for each hour of the day in a year and the extra services provided by the power plant; so that it creates the necessary financial incentive for preparation during the lack of production reserves [13].

How do capacity markets solve the problem of resource sufficiency?

Since this study seeks to introduce a new mechanism for the optimal and appropriate development of production capacity, it is necessary to identify the characteristics of different mechanisms. Capacity support plans can be classified based on three general approaches:

Price-based mechanisms: These mechanisms encourage investment in generation capacity by recognizing producers' additional revenue other than what they could earn by participating in energy and ancillary services markets.

Price support schemes (known as capacity payment): It consists of a central entity that commits to setting a price for all available capacity. Capacity payment is widely accepted in European countries and differs only in calculating additional income. Capacity payment has been implemented since 1997 in Spain, from 2004 in Italy, and from 1990 to 2000 in the UK.

Quantity-based mechanisms: In these mechanisms, a specifically targeted capacity is determined by the system operator, which must be made available in a certain period in the future. The system operator determines the available capacity that the central unit is obligated to pay for, either directly or through load-supplying companies. This creates a demand for a product that generators can supply. The interaction between the demand specified by the system operator and the supply of available capacity determines the market settlement price for the available capacity. Quantity-

based mechanisms are usually classified based on how production capacity is traded. The third approach is to reserve a certain production capacity for use in shortage conditions as an alternative. Storage is the last solution, which includes a certain amount of production capacity from the electricity market, which enters the circuit during the detecting power shortage. This method is currently used in Sweden, Finland, and Norway. The system operator is responsible for purchasing strategic storage and determining the rules for providing production storage capacity in the market. Since in this method the system operator becomes a market agent, it can lead to significant distortion of price signals.

Development of the proposed method for Iran's electricity market

The electricity market regulator is an institution that pursues three aims in the field of energy supply:

A) System sustainable development;

b) System reliability;

c) Tolerable price.

In order to achieve these aims, the electricity market should create competition by creating financial incentives in a free and non-monopoly structure, monitoring the behavior of different market segments, and opening access to information for market players to provide profit signals to market players and encourage them to invest. In order to achieve this aim, the market regulator must ensure the security of the continued supply of electric energy. This issue includes fuel sufficiency, flexibility sufficiency between different types of electrical energy production technologies, the grid sufficiency for reliable electricity supply from producer to consumer, and the sufficiency of production capacity.

The methods of providing sufficient production capacity

In the structure of the energy-only market, it is assumed that the market alone is sufficient for production capacity development, and the investment and profit signals are provided through energy scarcity at different points of the network. Also, it assumed that part of the investment costs is compensated through price jumps during energy deficiencies. This structure is already used in the market of Australia, Texas, and Alberta. While in many markets of the world, it is believed that the structure of the energy-only market is not responsible for the adequacy of the production capacity and other solutions should be used. The main reasons for this issue are the high investment cost, relatively long time to build new capacity, and long waiting time for return on investment which leads to not encouraging investment in the production capacity development. Also, this leads to a delay in responding to the price signals and the boom and bust cycles in investment. In addition, the necessity of consumer needs, the impossibility of applying the reliability preferences of consumers, the lack of effective alternatives, and the impossibility of storing electricity are the other cases that have led to the inelasticity of electrical energy production. It is also not possible to temporarily supply severe shortages through electricity imports for a long time. The consumer also does not feel immediate price jumps and only these price jumps lead to an increase in the cost of electricity consumed in the medium term. So, according to the mentioned cases, the electricity market regulator concludes that a reliable mechanism is needed to ensure long-term production sufficiency. In energy-only markets, most of the time, the price drops to a short-run marginal cost of production, and the distance between the short-run marginal cost and the long-run average cost as lost money is a problem that cannot be solved by price jumps alone. The distance will be extended by applying policies such as determining price ceilings or not tolerating price jumps in the short term, even in countries with open economies, for providing services. This problem is more severe in our country with the structure of a subsidized economy and government management.

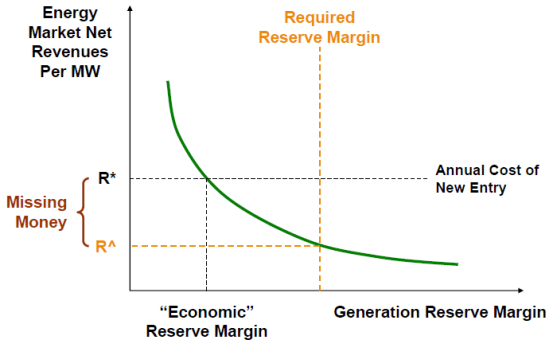

Figure 3) Why the structure of only energy market is not efficient.

Challenges of implementing the capacity certificate mechanism in Iran

Since the differences between the electricity industry in Iran and other countries, such as implementation methods, the absence of active consumers on the demand side, etc., there are many challenges in implementing a capacity assurance mechanism leading to sufficient investment and ensuring sufficient electric energy production capacity.

These challenges are categorized as follows:

Capacity certificate suppliers

The capacity certificate suppliers can be the producers who increased their capacity by optimizing the existing capacity using cooling systems in the thermal technologies of electricity generation. Also, producers who start constructing new capacities, are included in this category. Subscribers who reduce their demand can also receive a capacity certificate according to the reduced demand. The grid owners have led to an increase of the available capacity in the network by improving the transmission system and reducing losses, and receive a capacity certificate accordingly. Also, electricity importers during the peak period and energy savors can be other suppliers of the capacity certificate. In this regard, one of the challenges is separating the types of suppliers and interacting with them in the context of the capacity certificate market.

Capacity certificate applicants

New consumers and consumers who intend to extend their contractual power should purchase a capacity certificate accordingly. Also, producers who have faced a drop in capacity can be applicants for a capacity certificate. Capacity certificate traders, network owners with increased losses level, electricity exporters, and energy storage during peak load are other capacity certificate applicants.

Suppliable capacity certificate

The reliable capacity of a power plant as a capacity certificate can be obtained by monitoring the production capacity of the power plant or the energy produced during demand peak periods, which is specific hours throughout the year or a period such as June 15 to September 15. The production capability of the power plant is affected by many factors caused by the power plant or out of the responsibility of the power plant. These include breakdowns, repairs, access to the network, pollution, fuel restrictions, network incidents, etc., in each of which the impact on the production capacity must be measured and a reliable certificate should be supplied. Also, for power plants such as limited and renewable energy, whose production capacity cannot be calculated, the average energy produced in a period (daily, yearly, etc.) may be used.

Production capacity decreased due to wear and tear

Capacity reduction due to wear and tear is investigated in several cases. First is the differences between the annual capacity reduction level in different power plants, even in the same power plant and similar units. This problem becomes more complicated through different capacity losses of a unit in different periods. This issue can be caused by many different factors such as operation, repairs, the energy produced over a year, maintenance, type, and composition of the fuel, etc. Figure 4 shows the effective capacity of some old power plants in Iran. As can be seen in Figure 4, the

capacity drop did not necessarily have a regular trend, nor did the capacity necessarily drop. So, it is not possible to include a regular trend and announced to the power plants to purchase a certain capacity certificate every year. On the other hand, the commitment to compensate for the loss of capacity will lead to better maintenance and more accurate repairs, and ultimately more efficient operation of the power plants.

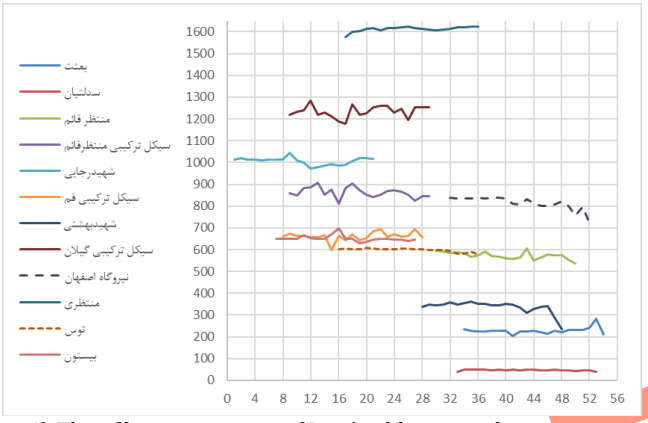

Figure 4) The effective capacity of Iran's old power plants over time

The question raised here is whether the current regulations deny the loss of power plant production capacity over time. The current regulations only indicate that the obligations resulting from receiving the capacity certificate do not adjust over time. One solution for this issue is that the government annually purchases the volume of capacity loss by guaranteed purchase contracts and reflects its cost in the bills of the subscribers. The challenges facing this solution are the heterogeneity of the capacity certificate, the dissimilarity of the capacity loss in different power plants, the incompatibility of the guaranteed purchase contract period with the life of the power plants, and the complexity of its implementation and application in the bills of the subscribers. Another solution is that the capacity certificate similar to the wear and tear of the power plant is the certificate of aging capacity. Named and anonymous capacity certificates can be used for this solution. In the named mode, the corresponding capacity certificate of that power plant should also decrease according to the capacity decrease of power plant (x), and the consumer who owns the relevant capacity certificate should compensate for the loss. In this case, the product capacity certificate is also heterogeneous, and validating the loss volume is impossible for the consumer, and they have to buy a product without any protection. In other countries, the power plants are responsible for loss of capacity; as in the PJM market, all power plants auction their guaranteed capacity every year for a period such as 2 or 5 years through annual capacity auctions. However, the capacity drop is practically hidden in the annual auctions and the power plants are responsible for it.

However, this method has a fundamental problem for Iran's electricity industry; in Iran, the return on investment should be fast to attract the industry and attract new investors. Also, this method requires active participation in the purchase of the annual capacity certificate, which also happens with the large presence of aggregators and retailers, which does not seem very practical in Iran at the moment.

The life span of the capacity certificate

In the current regulations, the lifetime of the capacity certificate can be longer than the life span of the power plant. This choice is since the commitments on the capacity side are not related to the life span of the power plant and as long as the consumers start to consume, they must have a reliable capacity. Since the lifetime of all power plants is different, if we assume that the lifetime of the capacity certificate is equal to the lifetime of the power plant, different certificates with various characteristics are created, which will lead to the heterogeneity of the capacity certificate market. These characteristics can include some factors such as the installation date of the power plant, the unit type, the fuel composition of the power plant, the type of technology upgrade, the use of

capacity increase systems, and even the unit's operation plan, such as the number of operating hours or the number of turning on and off of the units, etc. so this lead to the specific capacity certificate for each power plant. Therefore, there will be different types of capacity certificates with different characteristics, and different prices according to the number of power plants or even the number of units in operation, which the anonymity of the capacity certificate will be impaired, and its marketability will be reduced.

Requirements

The requirements of the capacity certificate must be met; For example, the price of the capacity certificate with an unlimited lifetime should be higher than the capacity certificate with a limited lifetime. Also, the complexity of the capacity certificate market should be low; because most of the applicant's capacity certificates are people whose fields of expertise are different from the electricity industry, and their connection link to this market is only their need for electricity consumption. So, the complexity of the market should be very low so that they can easily participate in the market and meet their needs. Finally, there should be minimal interventions in the market; because the interventions may lead to capital flight and the lack of significant capital for power plant construction.

Suggesting a solution for Iran's electricity industry

In this part, a solution suitable for the environment of Iran's electricity industry is provided, which in addition to persuading the current players and solving their concerns about the imposition of capacity loss compensation costs, it is also useful for attracting investment in the construction of new power plants. The proposed solution consists of three parts:

a) Annual auction of capacity certificate bonds with medium maturity (e.g. 5 years);

b) Secondary market of capacity certificate bonds with specific maturity;

c) Cash capacity certificate market;

a) In this solution, first, the auction of certificates of capacity is carried out as follows:

1) The government (Tavanir Company) predicts consumption growth in the next 5 years and determines the required capacity for construction for the next 5 years.

2) Forecasting the loss of the entire network capacity in one year corresponding to the next 5 years and also adding the new capacity required to repair the error in the prediction of consumption simultaneity coefficients.

3) The auction is organized as an invitation to tender and investors, after validating and qualifying the investment, announced their offer to the auction manager in the form of the minimum requested price to build a kilowatt of cycle thermal capacity and its operation for the next 5 years according to the secondary market rate of the previous maturity capacity certificate and other definite and uncertain economic parameters involved in the investment. The minimum acceptable price for covering the volume of megawatts desired by the auction manager is a price ceiling for construction and the winners will be awarded a forward capacity certificate according to the requested capacity.

4) Investors in the auction can include investors, who participate in the construction of new power plant capacities, optimizing consumption, reducing losses, etc.

5) The certificates offered in each maturity will be the same for all types of technologies in the auction. The additional payment will be included in the price of produced electricity for investors of more expensive technologies than thermal cycle technologies.

6) This auction is implemented every year with the forecast of the required total capacity for the next 5 years.

7) It is possible to define several corrective auctions in different intervals to reset the required capacity.

b) After implementing the mentioned auction, the secondary market of forward-certificate bonds will be formed as follows:

1) For each maturity in the auction, a secondary market is formed to trade accepted certificated. The market will be implemented as a separate board for each of the energy exchange maturities.

2) Applicants of bonds will be new consumers, retail and distribution companies on behalf of households, etc. which predict the grid connection or the consumption growth in the maturity date of the bonds and also other traders who play a significant role in extending market liquidity.

3) Bond sellers include bond issuers, consisting of investors of power plant units, optimizing or reducing losses, who have won the relevant maturity auction and are committed to creating or improving capacity on the delivery date, and also other traders who buy and sell bonds during the allowed trading period of this maturity.
4) The rate discovered in the market sends a signal of the required new capacities in the coming years to the annual auctions.
5) After the allowed trading period of a forward maturity, the unsold bonds will be transferred to the cash capacity certificate board and will be able to be sold to the final consumer only once.
c) The cash capacity certificate market, whose trading board is currently available in the Energy Exchange:
1)The required papers to compensate for the loss of the entire network's capacity will be supplied by Tawanir Company through the market every month. Papers purchased by Tawanir Company to compensate for the capacity deficiencies, will not be able to be resold and it only has the function of guaranteeing the electricity supply to the subscriber and the unlimitedness of the certificate owned by the consumer.
2) Bond applicants in this market are consumers who want to connect to the grid at the moment, whether they are general consumers or retailers and distribution companies, the Thermal Power Company to compensate for the loss of the entire network capacity, and the investors issuing capacity bonds in the forward market who have failed to fulfill all or part of their obligations in the construction of new capacity by the expiration of the delivery time.
3) Bond suppliers in this market are holders of maturity and unsold bonds in the forward market, other investors in construction or optimization who have succeeded in upgrading the network capacity without issuing bonds, and subscribers with a capacity reduction contract certificate.

Capacity dropping

If the capacity dropping in the capacity certificate is modeled as an unlimited capacity supply, it will lead to capital flight; because the action to compensate for the capacity dropping and equipment depreciation, like other fields of investment in various industries, should be at the disposal of the investor, and an investor should take steps to modify and improve the equipment by calculating the cost-benefit.
To solve the problem of capacity loss compensation, the following method is suggested:
1) If the capacity certificate is considered limited, it means that the installed capacity has been decreasing over time, and subsequently, the certificate purchased by the consumer will not have its initial value in terms of guaranteed consumption. Since the shared consumption power does not decrease over time, and there is no possibility to apply the dropping capacity certificate to the shared load, this capacity should be compensated by the consumer to receive electricity supply. For this purpose, and for purchasing the bonds based on the contractual strength and consumption simultaneity factor, the required cost for purchasing bonds will be added to the bills of subscribers who have been connected to the network in the last month.
2) Due to the different capacity dropping of power plants, an annual permitted capacity drop of the power plants is considered so that the power plants with better performance receive awards and power plants with poor performance receive penalties.
3) The total annual dropping of old power plants (with or without capacity certificate) and the permitted dropping off the power plants with sold capacity certificates should be considered in the process of compensating the dropping capacity by the consumers.
The effects of the above method can be expressed in the following cases:
- By paying the share of consumers of the capacity loss compensation, the capacity certificate in their possession will have an unlimited time. Whenever the consumers would like to reduce their contractual power, they can sell it at the daily price in the cash capacity certificate market, if they fulfilled the obligations related to compensation for the loss of capacity in the bills.
- Since the capacity dropping is generally calculated in the network and there is no connection between the type of production technology and different uses, all the consumers have committed to supply the capacity loss, and the capacity certificates will remain homogeneous.
- Since the capacity loss is calculated annually and does not depend on the life span of the power plant, as a result, the cost required to compensate for the capacity dropping has always been gradually received from the consumers and will not lead to the imposition of a heavy and one-time cost. So, including the costs in the monthly electricity bill helps easily receive the costs.

- Customers who have not bought capacity certificates for their electricity supply cannot sell bonds in the cash market due to reduced contractual power; because basically, they don't have any capacity certificate and the resources needed to construct capacity to supply their demand have already been provided by the government.
- The participation of this group of subscribers in compensating for the capacity dropping is to keep their capacity certificate at zero and try to be not negative.
- Reducing the contractual power of this group of subscribers will lead to the release of the capacity certificate in favor of the government to sell it in the cash capacity certificate market.

Executable capability

One of the challenges in implementing the unlimited capacity certificate is the requirement of producers to compensate for capacity dropping through the purchase of capacity certificate papers, which seems to lead to unattractive investment in this area.

In this section, we will examine the implementation framework proposed to solve this problem.

According to the statistics reported of Iran's electricity industry in 2022, about 32% of the consumed electrical energy was in the domestic sector and 36% in the industrial sector. The required capacity certificate for the equivalent of the total requested power is considered by 0.2 due to the consumption simultaneity factor suggested by Tawanir Company for subscribers connected to the weak pressure grid. So we calculated the share of a typical subscriber with a single-phase 25 amp home contract to supply the cost of purchasing a capacity certificate to compensate for the capacity dropping considering about 30 million household subscribers and assuming their same share in providing the capacity loss. The assumptions are as described in the table:

Table 1) Maximum monthly share of the household in compensating for the annual capacity dropping (Euro)

The cost of one kilowatt of cycle thermal capacity (Euro)	**Annual capacity loss of the entire network (percentage)**			
	0.5	0.1	1.5	0.2
550	0.23	0.46	0.69	0.92
650	0.27	0.54	0.81	1.08
750	0.31	0.63	0.94	1.25

As can be seen in table 1, assuming an average drop in production capacity of 1% per year of the entire network (this number is less than 1%; for example, the annual capacity loss of gas units is about 0.4% per year and the rest can be used to compensate for the prediction error in the consumption simultaneity coefficients) and the cost of 650 euros to build one kilowatt of thermal electricity production capacity, the cost imposed on household customers to compensate for the capacity lose with the free rate of Euro, is almost equal to 16 thousand tomans, which is not a significant cost for a month. If this cost depends on the consumption in addition to the contracted power, can be a source of saving electricity. It should also be noted that this cost for the construction of the power plant is owned by the government. If this cost is spent on the purchase of capacity certificates in the market leads to the construction of capacity by the private sector, and the cost of compensating for the capacity loss will be equal to a percentage of the obtained values; because the investors expect to cover only a part of their investment costs through the sale of capacity certificate bonds. A significant part of the cost of compensating for the capacity loss can be provided by imposing a small cost on the household consumers without imposing a huge cost on the owners of the power plants. A part of the annual need to build capacity can be secured in this way by choosing the appropriate percentage, which can be different from the actual capacity loss. Similar to domestic subscribers, the cost of capacity loss compensation has been obtained for an industrial subscriber with a contracted power of 100 megawatts connected to the high voltage network, whose coefficient is equal to 1. The average of this value is equal to 4650 rials per kilowatt hour in 200-2023. Assuming that the subscriber is in the circuit with its maximum power consumption of 80% of the time, the monthly energy consumption will be approximately equal to 268 billion Rials. Considering the assumptions of 1% annual capacity loss and the cost of 650 euros to build a kilowatt of thermal capacity, the cost of compensating for the loss of this subscriber's capacity will be approximately 16 billion rials per month, which is 6% of subscriber's energy cost. In another

way, if this cost is calculated based on each kilowatt-hour of energy consumed, the cost of compensating for the capacity loss will be equal to 425 rials per kilowatt hour based on the detailed production statistics of the year 2022-2023, taking into account 76000 megawatts of the total practical power of power plants, 350 billion kilowatt hours of energy consumption, 1% annual drop and the cost of 650 euros to capacity construction. By applying the mentioned changes, it is possible to compensate for the annual capacity loss and even more at a very low cost. In addition, if a subscriber has extra demand, by imposing additional costs, she/he is forced to cancel the demand or sell the certificate of added capacity, leading to the release of capacity by imposing additional costs. Also, this method has led to motivation for more production and as a result, maximum use of the available capacity to reduce the compensation share for the capacity loss from the monthly bill, and ultimately it will lead to the production optimization of industries and the timing of their expenses. Therefore, the basic problem of Iran's power plant industry, which is the low attractiveness of investment for creating new capacity, will be solved. The considerable reason for this problem is the energy price lower than its actual price, which leads to a longer return on investment. In a situation where Iran's economy is facing 40% and 50% inflation rates, the domestic rate of return with the current tariffs is very low and will not lead to a return on investment. Since there is no hope for a significant increase in electric energy rates based on the command pricing policies in Iran's economy. The mentioned method can bear a large part of the profitability of the power plant industry and lead to the attractiveness of investment in this field. Also, from the point of view of the mentioned approach, some problems can be solved such as being forced to compensate for the capacity loss and the unlimitedness of the supplied capacity certificate, which cannot be found in any other industry.

Conclusion

In the restructured markets, the electricity price cannot sufficiently cover the costs of the investor and encourage investors to ensure system adequacy. Also, price jumps are limited and happen less often by expanding the participation of consumers in managing their demand during the increase of current electricity prices, and also the application of the price ceiling by the regulatory bodies. If there is no solution to ensure system adequacy and encourage investors to build new power plants, the demand-supply is faced with a problem and the security of the network is at risk during the increase in consumption level. In this study, a method was proposed for Iran's electricity market after examining various capacity mechanisms. In this way, it was tried to reflect the current main problem of Iran's power plant industry, which is the lack of attractiveness of the industry for investors for various reasons such as the requirement to compensate for the capacity loss, the low price of electricity and difference with the real prices, the failure to compensate the investment cost in a reasonable period, etc. and provide solutions for them. It seems that the proposed method can provide enough capital while not effectively increasing the final price of electric energy, which is one of the policies of recent years. In this regard, some suggestions are provided:

The thermal power company stops the supply of the cash capacity certificate. The capacity certificate should be assigned to the power plant owner as a part of the payment for the ECA contract or to reduce the duration and volume of the capacity commitment until the elimination of the monopoly in the supply of cash capacity certificate occurs. The basic volume of the cash capacity certificate should be canceled so that its price can be increased in a short period and reach the real rate. The obligation of distribution companies to purchase capacity certificates on behalf of subscribers below 5 megawatts, as well as their obligation to contract with regional electricity companies, should be enforced.