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Electricity industry restructuring in Iran

G.Reza Yousefi[a,*], Sajjad Makhdoomi Kaviri[a], Mohammad Amin Latify[a], Iman Rahmati[b]

[a] Department of Electrical and Computer Engineering, Isfahan University of Technology, Isfahan 84156-83111, Iran
[b] Iran Grid Management Company, Tehran, Iran

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ABSTRACT

Iran, as a developing country with a growing population, has an increasing energy consumption. In particular, the electricity consumption with the average annual growth rate of 7.24% has been increasing considerably over the past two decades.

In step with the changes in the world electricity industry, initial steps towards restructuring in Iran's electricity industry were taken during the 1990s, resulting in the launching of Iranian wholesale electricity market in November 2003. Achieving long-term security of supply, clarification of the electricity price and the attraction of the private investments are some of the main goals of the electricity industry restructuring in Iran. The privatization and breaking of the governmental monopoly was officially started in 2000 with the beginning of the third development plan, which led to the 48.05% contribution of the private sector in the annual energy generation in 2015.

This paper investigates the process of restructuring in Iranian electricity industry comprehensively. The current situation and the history of Iran's electricity industry, as well as the operating principles of Iran's electricity market and its prominent characteristics including its regulations, entities and administrative process, are discussed in this paper. Moreover, some of the results including privatization process and the changes in the electricity price are investigated in this paper.

1. Introduction

Over the past two decades, electricity industry has gone through restructuring in many countries around the world. In this regard the governments' attitudes toward ownership, management, operation, and planning of power systems have changed dramatically in recent years and improving the economic efficiency has been claimed as the main goal in these domains. This process has brought on the separation of sectors with different tasks, raising competition at wholesale and retail markets alike. The study and analysis of different countries restructuring process, as practical patterns, can be helpful for decision-makers in this area. Therefore this area of study has gained a large attention as (Danias et al., 2013; Mustafa Durakoğlu, 2011; Du et al., 2009; Ngan, 2010; Knaut et al., 2016; Nelson and Orton, 2016; Nepal and Foster, 2015). In (Danias et al., 2013) the evolution of the Greek electricity market since the beginning of the liberalization process is investigated. In addition, the remaining key deficiencies in the policies, which need to be resolved, are discussed in (Danias et al., 2013). In (Mustafa Durakoğlu, 2011) the political and economic endowments of the electricity market in Turkey are analyzed. The impact of the regulatory reforms on electricity generation plants in China is estimated in (Du et al., 2009). Moreover, the main three stages of the reform in the electricity industry of China until 2011 (e.g. electricity energy investment financing, the separation between government and power enterprises, and the division between the power grids and the power generation firms) are reviewed in (Ngan, 2010). An overview of the energy legislations passed in 2010 by the German government and the German Energy Reference Forecast and in accordance with the investment and dispatch model for the European electricity sector over the planning horizon up to 2050, is presented in (Knaut et al., 2016).

Abbreviations: AEP, Average Electricity Price; AHEP, Average Hourly Electricity Price; ASP, Ancillary Services Procurement; AVC, Average Variable Cost; BAP, Base Availability Price; BOO, Build-Operate-Own; BOT, Build-Operate-Transfer; CHP, Combined Heat and Power; DAM, Day Ahead Market; DG, Distributed Generation; DISCO, Distribution Company; ECA, Energy Conversion Agreement; EC, Electricity Cost; FERC, Federal Energy Regulatory Commission; GENCO, Generation Company; HEP, Hourly Energy Price; IEE, Iranian Energy Exchange; IEM, Iranian Electricity Market; IEMRB, Iran Electricity Market Regulatory Board; IGMC, Iran Grid Management Company; IGOMC, Iran Grid Operation & Monitoring Center; IOEP, Iran Organization for Electric Power Affairs; IPP, Independent Power Producer; ISO, Independent System Operator; MCP, Market Clearing Price; MO, Market Operator; MOE, Ministry of Energy; OR, Operational Reserve; PAB, Pay-as-Bid; PBM, Pool-Based Market; PCMEI, Privatization Council in Ministry of Energy of Iran; PFC, Primary Frequency Control; PGMC, Power Generation Management Company; PPA, Power Purchase Agreement; REC, Regional Electric Company; WAP, Weighted Average Price

* Corresponding author.
E-mail address: yousefi@cc.iut.ac.ir (G.R. Yousefi).

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The dynamics of the electricity market in South Australian is studied in (Nelson and Orton, 2016). Based on the results presented in (Nelson and Orton, 2016) a review of the energy market frameworks is suggested due to failure to achieve the decarbonization-related objectives in the existing market. In (Nepal and Foster, 2015) the economic performance of the private and state-owned electricity networks in Australia is modeled and compared in term of prices, quality and investment. The study results show the superior performance of the privately owned networks in comparison with the state-owned networks.

Iran, as a developing country, has adapted to the changes in the world electricity industry. Some initial steps towards restructuring were taken during the 1990s which eventually resulted in the launching of Iranian wholesale electricity market in November 2003. Achieving long-term security of supply, clarification of the electricity price and absorption of private investment as well as business growth are the main goals of electricity industry restructuring in Iran (Karim and Reza, 2009).

Iran is a middle-eastern country with the total area of 1648195 square kilometers. According to the 2011 census, Iran has a population of around 75 million people. To the north, it neighbors Azerbaijan Republic, Armenia, and Turkmenistan, to the east, Afghanistan, and Pakistan and to the west, Turkey and Iraq. Iran borders the Caspian Sea to the north and the Persian Gulf and Oman Sea to the south (Wikipedia, 2015; Statistical center of Iran, 2015).

Iranian electricity industry started its activity in 1903 when a few generators were imported into Iran. The electricity industry in Iran has undergone several changes in early years; one of which was the result of the implementation of five development plans from 1936 to 1977 that resulted in the improvement of indices such as installed capacity, reduction of costs, development of grid and public electrification (Bankian Mohammad, 2007).

In the course of the war with Iraq, from 1980 to 1988, and the years that followed, electricity industry focused on reconstruction the damages of the war. The development of electricity industry was restarted and speeded up by implementation of five new social, cultural and economic development plans since 1989 (Bankian Mohammad, 2004). Iran's Ministry of Energy (MOE) began restructuring the electricity industry in the early 1990s. The purpose was to secure electricity supply, attract investment from private sector and accelerate the business growth in Iran's electricity industry. Gradually, different parts of electricity industry went through different changes (e.g., unbundling the vertically integrated utilities, privatization, and the introduction of Energy Conversion Agreements (ECA) to buy electricity produced by Independent Power Producers (IPPs)). This resulted in the launching of Iranian (wholesale) Electricity Market (IEM) as one of the foundations of the restructuring. Shortly after, Iran Grid Management Company (IGMC) was established in November 2004 as the main entity in electricity market operation. At the same time, Iran Electricity Market Regulatory Board (IEMRB) was founded to fulfill its role as the main legislative body of IEM (Heidary, 2003). Along with restructuring, the private sector started to provide limited services (e.g. power plant operation and maintenance), and in the late 1990s, the private sectors were allowed to participate in the ownership of power plants' assets.

This paper presents an overview of the Iranian electricity industry, the structure of IEM, and some of its important aspects such as generation and consumption characteristics, geographical spread, and the changes that have happened during the restructuring of the industry. General specifications of Iran electricity grid such as the price of electricity consumption for different categories of consumers (residential, public, industrial, agricultural, and commercial consumers), and the rate of load growth and foreign imports and exports are discussed in this paper. The history of the restructuring of Iranian electricity industry, the rules and entities established, and the progress made in privatization are discussed in more detail. Also, the operation and clearing process of IEM and the procurement of ancillary and transmission services are discussed. Finally, to study the economical indices of Iranian electricity industry, wholesale and retail prices in the past six years are analyzed.

This paper is organized as follows: In Section 2, the current situation of the electricity industry in Iran is briefly discussed. The history of the Iranian electricity industry development, as well as important events in a chronological order, are given in Section 3. The administrative process of the electricity market in Iran is discussed in Section 4. In Section 5, energy prices in the last eight years are analyzed. Finally, the plans implemented to improve the IEM as well as the required plans for future are discussed in Section 6. The paper is concluded in Section 7. Appendix A summarizes the process of privatization of Iranian electricity industry and in Appendix B, rules and entities established for this purpose are reviewed. Timing, fiscal logic, and clearing process in energy and reserve market are also addressed in Appendix C and D. Ancillary services and their procurement methods are dealt with in Appendix E. We further elaborate on Iranian Electricity Exchange (IEE) and the way it is operated in Appendix F.

2. Electricity industry in Iran

2.1. The structure of ownership and regulation

The main agent in Iranian electricity industry is the MOE. In the electricity sector, towards sustainable development, the mission of the MOE is to ensure and promote the security of electricity supply and to ensure and promote the quality of services. MOE is in charge of making strategic energy policies to execute its missions. Iran Power Transmission, Generation and Distribution Company (Tavanir), is responsible for generation and transmission expansions and wholesaling the electricity all over the country. Tavanir, as a governmental company, is supervised by the MOE and is considered to be the executive branch of the MOE. Tavanir puts all the decisions made regarding the use and development of electricity industry into practice. This organization also helps the MOE in plan-making and supervision tasks (Heidary, 2003).

Presently (2016) the main active companies in Iran's electricity industry can be classified as: 16 Regional Electric Companies (RECs), 39 Power Generation Management Companies (PGMCs), 39 Distribution Companies (DISCOs), some Generation Companies (GENCOs), and some other active companies including IGMC, that are under supervision of MOE and IEMRB (Heidary, 2003; Management of information technology and statics office of Tavanir, 2015a). RECs have a managing role in their geographical area. They also monitor subordinate companies and are responsible for transmission, and selling of electricity in the transmission level. Each REC owns the governmental power plants in its region so they also have a GENCO's role too. In every region, RECs are in possession of transmission equipment. Based on articles of the establishment of RECs, Tavanir holds all of the shares of these companies. Fig. 1 shows the locations of RECs and cross-border exchanges of electricity (FTP site of regional electricity companies, 2010).

Each DISCO is responsible for the development, maintenance, and operation of the distribution grid, as well as ensuring the quality of provided electricity in its geographical area (province or city). Presently, 40% of shares of each DISCO belongs to Tavanir and the remaining 60% is controlled by SABA Company. SABA Company was established in 2004, with both public and private shares, for the purpose of constructing and operating non-governmental power plants. With the purpose of restructuring the electricity industry, Iranian parliament passed a law enforcing the independency of DISCOs. As a result, as of 2005, these companies are no longer subdivisions of RECs and act independently.

PGMCs, founded as non-governmental companies (with joint

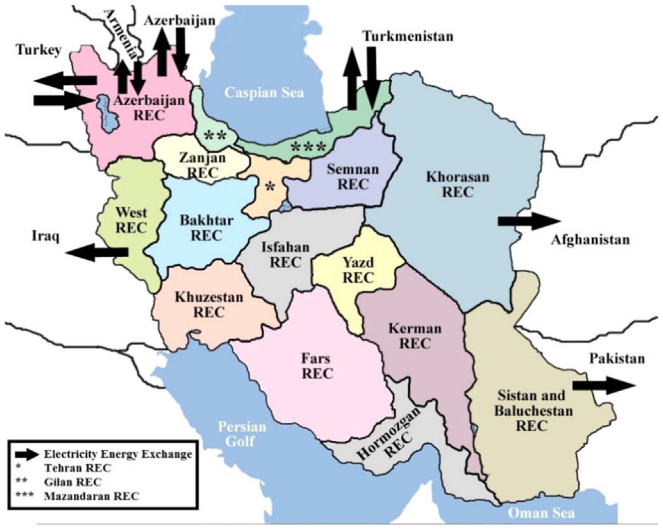

Fig. 1. Geographical locations of RECs and across border exchanges of electricity in Iranian electricity industry (FTP site of regional electricity companies, 2010).

stock), are in charge of operating the power plants. Presently, these companies, based on their contracts with RECs, are employed as contractors. 40% of the shares of PGMCs belongs to Tavanir, 40% belongs to the MOE, and the remaining 20% is held by individuals or official bodies (Heidary, 2003).

Before the beginning of the Forth (National) Development Plan (in 2005), thermal and hydro power plants were owned by RECs and Regional Water Companies (RWCs) respectively. Since the initialization of this program, the private sector has constructed a number of power plants. Also since then, 22 governmental power plants with a total nominal capacity of 20708 MW have become independent from their respective RECs and were transferred to the private sector. As a result, by April 2015, the total private nominal generating capacity reached around 32365 MW (44% of the total nominal capacity) (Management of information technology and statics office of Tavanir, 2015a). Fig. 2 depicts the structure of ownership and supervision in Iranian electricity industry.

2.2. Statistics of Iranian electricity industry

The demand for electricity has been growing in recent years due to various reasons. Some of these reasons can be classified as: population growth, increasing rate of urbanization, increased demand on social welfare, governmental tariffs, climate changes and development of industries and businesses. Table 1 shows the energy consumption statistics during the years 2000, 2007, and 2014 based on the type of users (Deputy of Power and Energy, 2015a; Management of information technology and statics office of Tavanir, 2015b, 2014). Table 2 shows the gross power generation (the total energy production over a given time period (e.g. one year)) as measured in kWh or MWh on the generator's terminal) during the aforementioned years and in terms of the type of primary source of energy (Management of information technology and statics office of Tavanir, 2014, 2015c).

As can be seen in Table 1, energy consumption in Iran has grown from 90366 GWh in 2000 to 219653 GWh in 2014, showing 7.4%

Table 1
Electrical energy Consumption in 2000, 2007 and 2014, based on the type of users (Deputy of Power and Energy, 2015a; Management of information technology and statics office of Tavanir, 2015b, 2014).

	2000		2007		2014	
	GWh	%	GWh	%	GWh	%
Domestic	31266	34.5	50777	33.3	71163	32.3
Public	11271	12.4	19648	12.9	19767	8.9
Industrial	28937	32.0	49772	32.7	74294	33.9
Passages Lighting	3754	4.15	4510	2.9	3837	1.7
Agriculture	9147	10.1	17670	11.6	35188	16.1
Other	5991	5.5	9953	6.6	15404	7.1
Total	90366	100	152330	100	219653	100

Table 2
Gross power generation in 2000, 2007 and 2014, based on the type of generation (Management of information technology and statics office of Tavanir, 2014, 2015c).

	2000		2007		2014	
	GWh	%	GWh	%	GWh	%
Thermal	80710	68.1	94228	46.2	85624	31.2
Gas	20865	17.6	37604	18.4	73340	26.7
Combined Cycle	12855	10.9	53796	26.4	96823	35.3
Diesel	361	0.3	225	0.13	74	0.03
Hydro-electric	3650	3.1	17987	8.8	13862	5.1
Renewable & Nuclear	0	0	141	0.07	4756	1.67
Total	118441	100	203981	100	274479	100

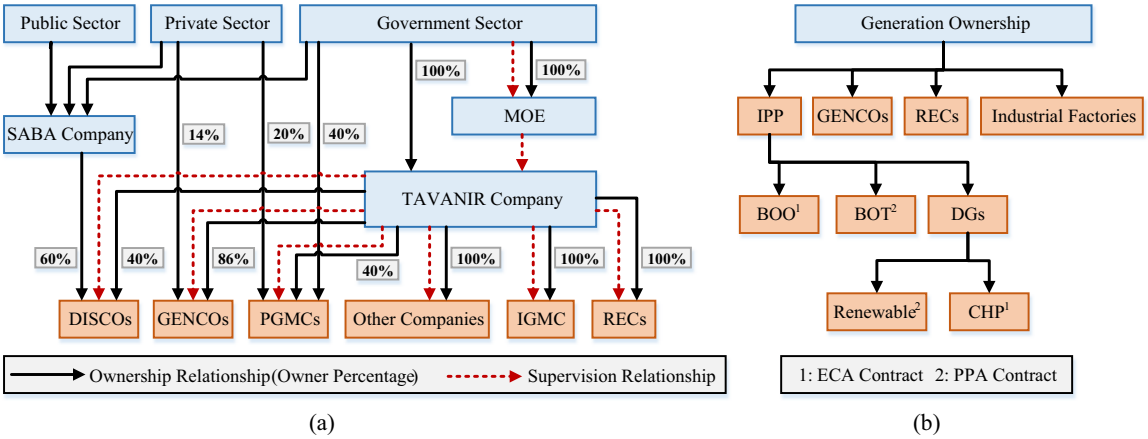

Fig. 2. Iranian electricity industry: (a) Ownership and supervision structure, (b) Generation ownership structure.

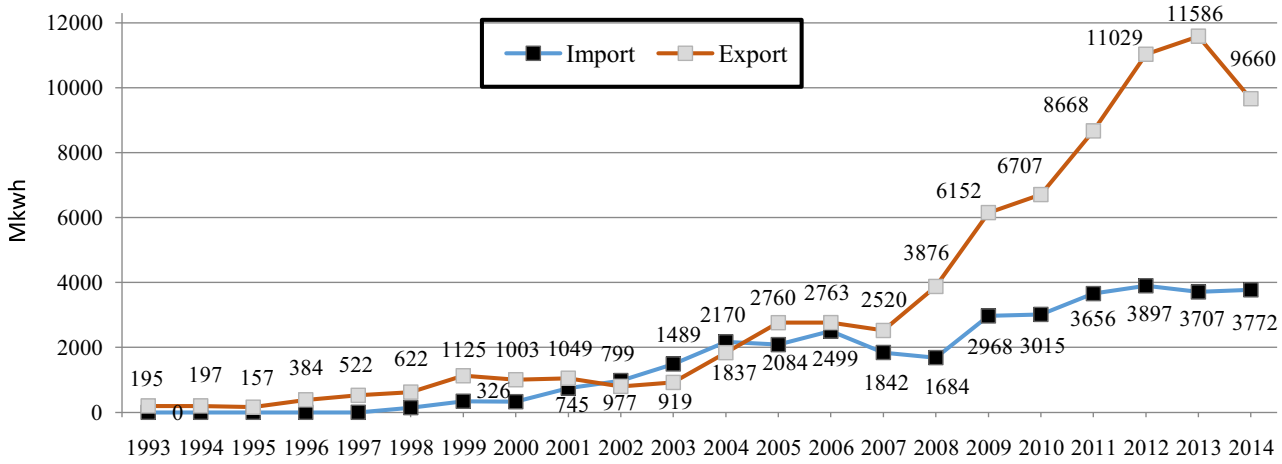

Fig. 3. The Total electricity energy trading with neighboring countries (Management of information technology and statics office of Tavanir, 2015a).

average annual growth rate (Management of information technology and statics office of Tavanir, 2014). Based on the studies done in the MOE, the peak demand of energy for 2020 is expected to be around 73500 MW. Compared with the peak of 40239 MW in 2010, the expected demand for 2020 demonstrates an annual growth of 8.6% in energy consumption in Iran (Management of information technology and statics office of Tavanir, 2011a; Tavanir statistic reports, 2012).

From 2000–2014, domestic, industrial, agricultural and public users have been the major consumers of energy. Over the same period, we observe a decrease of 2.2% and 3.5% in domestic and public consumption, respectively, while there has been an increase of 1.9% and 6% for industrial and agricultural consumptions, respectively.

In recent years (from 1993), there have been active electrical tie lines between Iran and its neighboring countries; Turkey, Republic of Azerbaijan, Armenia, Turkmenistan, Pakistan, Afghanistan, and Iraq. Information related to the electrical trading between Iran and its neighbors is presented in Fig. 3. This figure shows an increasing volume of energy exchanges in recent years except 2014 (due to the war in Iraq and the lack of precipitation in 2014). These exchanges are mostly resulted by the incoherent peak demand in the aforementioned countries (Management of information technology and statics office of Tavanir, 2015a, 2015b). Since 2015, private GENCOs have been allowed to export a part of their generated energy (up to 50%) to other countries, under the supervision of Tavanir. This option is a good incentive for private sector to increase its investment in electricity generation sector and can lead to increase in the export of electricity in the coming years.

Among different power plant technologies, thermal, combined cycle, and gas power plants have had the highest contribution in providing energy. While most of the attentions in IEM have been focused on developing the wind power energy, the renewable energy sources have had a low contribution in recent years from 2000 to 2014 (6.77% in 2014, including nuclear and hydro-electric generation) (Management of information technology and statics office of Tavanir, 2014). Natural gas, petroleum, and diesel, as the most used fuels, have had a contribution of 71.8, 15.6, and 12.6% in 2014 (Management of information technology and statics office of Tavanir, 2015c). Table 3 summarizes the conditions of Iranian electricity industry in generation, transmission, and distribution at the beginning of February 2016 (Tavanir statistic reports, 2016).

3. The history of development of Iranian electricity industry

The history of the electricity industry in Iran can be divided into five periods as follows:

3.1. Private sector activities (1885–1936)

The first generator was brought to Iran three years after the establishment of Thomas Edison Electricity Institute (1885). This generator, with a capacity of 3 kW, was installed for Shah's Court illumination. In 1903, two generators with a total capacity of 27.6 kW were installed for illumination of *Imam Reza's Holy Shrine* in Mashhad (Bankian Mohammad, 2007).

During this period, the private sector was active and mainly focused on buying small generators from Russia and Germany to provide public illumination. The first official measure for the electricity generation was taken in 1906 when the Office of Lighting was established to provide illumination for a part of the city of Tehran. The office used a three phase generator with a capacity of 400 kW and an output voltage of 380 V. The electricity was transferred to a low voltage grid that stretched 800 m around the power plant (Bankian Mohammad, 2004).

By early 1920, as electricity industry was becoming attractive for the private sector, some infrastructures were built in small and big cities of Iran. These activities were in small-scale, quite limited and independent from each other. Electricity power plants were managed by the private sector and the price of electricity was set unilaterally. Due to the high cost of fuel, undeveloped technology, and the low efficiency, the electricity price was high. At the same time, some of the newly-built factories were equipped with electricity generators and were signing contracts with urban electricity entities to sell their extra generated energy. At the end of this period (in 1936), due to the need of the newly established bureaus to electricity, and cities need for illumination, municipalities were in charge of providing electricity for light (Bankian Mohammad, 2007, 2004; Hamed and Habibi, 1998; Ministry of Energy, 1976).

3.2. Parallel activities of private and public sector (1936–1962)

During this period, public and private sector were active simultaneously, so that in 1962, just before the establishment of Iran Electricity Organization law, there were 32 active private electricity generation companies in Tehran. Except for issues related to public illumination, during that time the government didn't intervene in the activities of private companies. In 1936, upon the agreement of Association of Articles of Tehran Municipality Electric Organization, municipality's office of Lighting was turned into Electric Organization of Tehran. It operated as an independent organization under the supervision of the municipality; performing a number of tasks such as setting the electricity tariffs, carrying out supervisory control, and making contracts with factories and organizations for selling electricity (Bankian Mohammad, 2004).

Table 3
Status of Iranian electricity industry in generation, transmission and distribution in February 2016 (Tavanir statistic reports, 2016).

Generation	Installed Capacity (MW)	Thermal		15829
		Gas		25772
		Combined Cycle		18494
		Diesel		439
		Nuclear		1020
		Hydro-electric		11206
		Renewable sources		232
		Distributed Generation		766
		Total		73758
Transmission and Sub-transmission	The Length of transmission and sub-transmission lines (km)	400 kV	Overhead	20003
			Underground	0
			Total	20003
		230 kV	Overhead	31007
			Underground	31
			Total	31038
		132 kV	Overhead	22982
			Underground	32
			Total	23014
		66/63 kV	Overhead	45922
			Underground	1530
			Total	47452
	Substations Installed capacity (MVA)	400 kV		57973
		230 kV		76302
		132 kV		29598
		66/63 kV		66328
Distribution	Lines length (km)	11, 20, 33 KV		403000
		Low voltage grid		343000
	Total capacity of transformers (MVA)			108114

One of the most important events during this period was the implementation of 2 seven-year Development Plans in the electricity industry. In the first one (1948–1955), the purpose was to meet the residential necessities. To-do so, a few small diesel generators (50, 100, and 150 kW) were imported from abroad (mostly from Germany) by Iranian merchants and sold to private companies and municipalities. At the end of the first plan, the total installed nominal capacity was 40 MW and the annual energy generated was 200 million kWh.

The second seven-year Development Plan was implemented from 1955 to 1962. Its main purpose was to increase the generation capacity, reduce the electricity costs, and decrease the tariffs. Construction of the first hydro-electric power plants in the country, such as *Dez* Dam (with an initial capacity of 130 MW), *Karaj* Dam (91 MW), *Sefidrood* Dam (35 MW), as well as *Tarasht* thermal power plant (50 MW), were other achievements during this period (Bankian Mohammad, 2007, 2004; Hamed and Habibi, 1998; Ministry of Energy, 1976).

By the end of the second plan (1962), there was no predetermined policy regarding generation, transmission, and distribution of electricity. In most cities, municipalities or private companies were producing electricity with low investments and had to impose high demand tariffs on the consumers (the price of electricity was 8–9 cents/kWh[1]) (Hamed and Habibi, 1998).

3.3. Centralization and monopolization of the public sector (1962–1986)

One of the most important proceedings during this period was the implementation of three Development Plans; from the third in 1962 to the fifth in 1977. These three plans were concerned with supplying electricity to cities, constructing the transmission lines, establishing relatively big hydro and thermal power plants, and general development of the electricity industry in Iran. At the end of the fifth plan, total installed capacity reached 7105 MW with an annual growth rate of 16.2%; and the annual energy generated was 18984 million kWh which showed a 14.7% annual growth rate (Management of information technology and statics office of Tavanir, 2011b).

Considering the aforementioned Development Plans and the prospect of the country's growing need for electricity (as an important energy source for the growth of industry), nationalization of electricity industry appeared to be the only way to achieve these goals, as the needed investment was beyond what the private sector could afford. Furthermore, the construction of a national transmission grid and a distribution system was only possible through the direct intervention of the government (Ministry of Energy, 1976).

Until 1962, there was no specific organization to manage electricity industry in Iran and major decisions were made by the Interior Ministry and the Budget and Planning Organization and announced to municipalities and private organizations. To tackle this problem, the Iran organization for electric power affairs (IOEP) was founded to handle the generation expansion plans and establishment of genera-

[1] - One *USD* was 76.5 *Rials* (Iran's Currency) in 1962

tion, transmission, and distribution management companies as well as managing the investments (Karim and Reza, 2009).

Board of Ministers approved IOEP establishment act on June 3rd, 1963, and the organization started its activities in August 1963. According to its articles of association, IOEP was responsible for designing and implementing of generation expansion plans as well as constructing distribution network, setting tariffs and founding RECs through integrating the electricity entities in each area.

As the IOEP activities were not covering all the country and necessity of electricity industry development, the law related to the establishment of Ministry of Water and Power was agreed by the board of Ministers on March 1964 to unify and integrate all the electricity industry activities. The mentioned Ministry started to work on March 1964. According to its articles of association, all activities including operation, monitoring, and expansion of generation, transmission and distribution facilities were entrusted to this Ministry (Vatanian, 1971).

Based on the article 50 of the Country Whole Budget Law in 1965, the IOEP was dissolved in the Ministry of Water and Power as the Electricity Department. All responsibilities of this organization were assigned to the Ministry of Water and Power. In the same year, articles of associations for RECs were prepared and ten RECs were established. The mission of RECs was to generate, transmit, distribute, purchase and sell electricity in their region.

Following the establishment of the Ministry of Water and Power in 1964, all requisites were prepared for nationalizing the electricity industry in Iran. This was realized by passing the law of development of non-governmental electricity organizations by the Parliament in 1965. Accordingly, Ministry of Water and Power was able to buy those organizations and companies which belonged to the private sector and were not able to comply with the new regulations and technical requirements (determined by Ministry of Water and Power). Based on the new law, electrical entities, private and public entities, were given 3 months to announce their financial and technological readiness and their commitment to follow the program. In effect, none of the entities (including private ones and those under the control of municipalities) were able to comply with the new regulations and technical requirements. Therefore, all infrastructures in small and big cities became the property of the government and operated by the RECs. By the end of 1972, ninety-eight percent of all public infrastructures became the property of the government (Vatanian, 1971).

In order to move toward enhanced operation and energy exchange with RECs, The Iranian Power Generation and Transmission Company (Tavanir) started its mission in 1969. Based on its articles of association Tavanir was responsible for generation and transmission expansions and wholesaling the electricity all over the country. In 1974, the Ministry of Water and Power was renamed to the Ministry of Energy (MOE) after being assigned to the task of comprehensive planning and the related activities, (Ministry of Energy report, 1976).

The most notable events during this period were the victory of Islamic Revolution in 1979 and the beginning of the 8-year war with Iraq in 1981 that resulted in serious destruction of electricity infrastructure and reduction of 2210 MW of the installed capacity.

From 1978–1986, one of the priorities was bringing electricity to villages. Thus by the end of 1986, the number of villages with electricity increased from 4327 (in 1978) to 22,541 (Bankian Mohammad, 2007, 2004; Hamed and Habibi, 1998; Ministry of Energy, 1976). At the end of this period, the installed capacity reached 13,011 MW and the annual consumption was 32,619 million kWh. Also, the total length of transmission and distribution lines reached 21,3072 km (Management of information technology and statics office of Tavanir, 2011b).

It has been argued that the enactment of Article 12 of the IOEP law in 1985 was the first step toward establishing a wholesale market of electricity in Iran. According to this article, all the public and private entities had to obey the decisions made by the MOE regarding generation, transmission, and distribution of electricity and provide the ministry with the necessary information.

3.4. The tendency toward decentralization, structure renovation, and attraction of the private sector (1986–2002)

Due to the serious damage caused by the imposed war with Iraq, the focus of electricity industry from 1988 to 1991 was rebuilding the infrastructure and restoring the 2210 MW capacity lost during the war. By the end of 1999, following the implementation of two other five-year Development Plans (the new Development Plans started after the Islamic Revolution in 1979), the installed capacity reached 23,258 MW (with a 6.1% annual growth rate) and the annual consumption reached 73,880 million kWh (an 8.3% annual growth). The major goals of the two new Development Plans in the electricity industry were rebuilding the damage and meeting the country's need for electricity through increasing the generating capacity, increasing the efficiency, and lowering government's intervention by means of privatization plans. Accordingly, following the approval of the Board of Ministers in June 1991, 397 governmental companies were privatized (Karim and Reza, 2009).

According to the policies enforced by the Development Plans, researches about the restructuring of the Iranian electricity industry started in the 1990s which aimed to improve efficiency, strengthen private sector participation and provide the required resources through the governmental and private investment (in compliance with the growth rate of electricity consumption). The result was a proposal for separation of generation, transmission, and distribution sectors in favor of electricity industry privatization (Kashef bahrami, 2012).

Furthermore, some measures were taken to create legal personalities to perform business transactions in generation, transmission, and distribution sectors, hence PGMCs and DISCOs were founded in 1997 (as sub-divisions of Tavanir). RECs (as the owners of electrical facilities) contracted these companies for operation and maintenance of the distribution grids and power plants (Bankian Mohammad, 2007, 2004).

In the year 2000, at the end of this period, the third new Development Plan, which had been legislated by the Parliament, started. For the first time, the necessity for the separation of the vertically integrated power industry was emphasized by the law (articles 4, 35, and specification d of the article 122) and the government was obliged to perform necessary legal activities for breaking the monopoly within one year after the legislation. Also, it was made possible to grant, annul, or integrate governmental companies for the sake of restructuring. According to specification c of article 122 of the law, it became possible to support IPPs through guaranteed purchase of their produced electricity. Also, by the specification b of article 22 of the law, the required preparations were considered for the contribution of the private sector in the construction of new power plants (Islamic Republic of Iran third economic, 2014).

With the beginning of the third round of five-year Development Plans in 2000, the necessary conditions for restructuring the electricity industry were provided. Therefore, in 2001, with the support of the Minister of Energy and the use of all potentials and the experts, the road map for the restructuring of Iranian electricity industry from 2001 to 2003 was planned. The most important measures taken for the implementation of restructuring plans were:

1. Issuing the proposal for establishing an electricity market regulatory board for the purpose of investigating the methods and models of restructuring as well as centralization of diverse measures in this regard.
2. Conducting initial studies and designing the structure of Iranian electricity industry as well as preparing the legal basis for the successful realization of the restructuring.
3. Creating a competitive environment in the electricity industry and initializing market researches (Ghazizadeh et al., 2014).

The first major pragmatic step toward the restructuring of the

electricity industry was taken in 2002 when the industry was vertically integrated and RECs were in charge of generation, transmission, and distribution at the same time. As can be derived from the above passages, all the attempts were concentrated on attracting private sector investment in the generation sector, without changing the general structure of the electricity industry. In other words, electricity was still a public commodity which could be owned solely by the governmental companies. Even the newly invested power plants were forced to sell their total production to the governmental companies.

In such environment and before the establishment of the IEM, Tavanir enacted a new rule based on which RECs were obliged to register the power transaction from the generation sector to the distribution sector as a trade. Since Tavanir was the sole shareholder of RECs, this rule passed through them and brought about an effective basis for restructuring and for the first time the electrical energy was considered as a tradable good.

According to the statistics, at the end of this period, the installed generation capacity, the total energy consumption, and the total length of transmission and sub-transmission lines were 31,518 MW, 105,076 million kWh, and 73,912 km respectively. Furthermore, in 2002, the number of villages with electricity reached 46,235, showing an average annual growth of 3.8% (Management of information technology and statics office of Tavanir, 2011b).

3.5. The development of electricity market (2002-present)

After accepting the initial principles of restructuring in the last period, restructuring of the electricity industry entered a new stage which involved more execution. The urgent need for network management and independent run of market operation was felt. As mentioned in Section 3.3, the first steps toward the development of IEM were taken upon the enactment of article 12 of the IOEP Law in 1985. Accordingly, the formation of such entities as IEMRB for regulation, and IGMC as Independent System Operator (ISO) was considered (Ministry of Energy, 2007).

In 2002, in accordance with the restructuring of the Iranian electricity industry, the management structure of the interrelated companies in charge of electricity industry was changed into a specialized holding company (Tavanir Co) and its subordinate companies. Articles of association of these companies were revised to adapt them to the restructuring process. According to part 6 of article 7 in the new articles of association (agreed upon in 2000), the necessary environment for the development of competition in generation, purchasing and selling of electricity were prepared (e.g. through the development of electricity exchange) (Ghazizadeh et al., 2014).

Later, following the legislation of part d of note 12 in 2003 Budget Law by the Parliament, an attempt was made to create a safe environment for economic activities in different parts of electricity industry as well as decoupling the vertically integrated monopoly. Other measures were taken; such as designing wholesale electricity market, codifying articles of association of IGMC (as an ISO and Market Operator (MO)), and establishing IEMRB (as the regulatory body) (Ministry of Energy, 2007).

Furthermore, at the beginning of 2003, the Board of Ministers agreed upon provision of article 7 of RECs' articles of association, in order to create a competitive environment through providing open access to the grid for all participants. A year later, regulations regarding tariffs and conditions of procurement of transmission ancillary service were made.

MOE legislated the first structural revision of electricity wholesaling act under the title of 'Regulation on the purchase and sale of electricity and its conditions' in 2003; based on which IEM officially started to work in November of the same year. In the September of that year, 'IEMRB', which was in charge of directing and super-visioning the electricity market, was established as the regulatory body. 'IGMC', as a governmental company, was established in 2004 to manage the network, performing power and business transactions, and creating the electricity market. Also in 2006, the national dispatching center, with a revision in its articles of association, was included in IGMC and renamed as Iranian Grid Operation & Monitoring Center (IGOMC), in order to manage the grid, insure the operation, and control the power transactions (Ghazizadeh et al., 2014).

According to the 'Regulation on the purchase and sale of electricity and its conditions', IEMRB consists of 7 members, designated by the Minister of Energy for a period of two years. The major responsibilities of this board are: codifying and making executive rules as well as supervising them, annulling and/or issuing certificates for participants in the electricity market, defining the indices of efficiency, and monitoring the market to ensure its normal operation (Jahanbin and Elahi, 2014).

Once again at this stage of the development of the Iranian electricity industry, the private sector was considered seriously and different laws were adopted in this regard such as: Article 62 of the 2002 Budget Law, part C of note 12 in the 2003 Budget Law, and part 6 in article 7 of RECs' articles of association (passed in 2003), to establish guaranteed purchase tariffs for electricity bought from independent producers, to transfer governmental power plants to the private sector, and to provide transmission ancillary services from private companies, respectively. For this purpose, the law regarding the fourth Development Plan was agreed upon in the second half of the year 2004 with the goal of continuation of privatization and empowering the private sector. This plan was implemented at the beginning of the year 2005. Part B of article 25 of this law determined the guaranteed conditions under which electricity could be bought from IPPs.

IEM entered a new stage by enactment of the new laws such as the law related to the constitution of generating companies that made it possible for them to transfer their shares in the stocks at the beginning of 2005 and the law related to the independency of DISCOs that committed them to buy electricity from electricity market at the end of the same year (Ghazizadeh et al., 2014).

One of the most important events during this stage was the declaration of general policies regarding Principle 44 of the Constitution (including five parts) in 2005 and 2006. According to this principle, areas such as electricity power supply were no longer under the monopoly of the government. Therefore, the development of non-governmental sectors, through transferring the governmental entities to the private sector, was more seriously considered than third and fourth Development Plans. Moreover, in order to manage private sector's activities and implement the Principle 44 in the electricity industry, the formation of the Privatization Bureau in Ministry of Energy of Iran (PCMEI) became part of the agenda and this council officially started its work in late 2005 (Manzour and Askariazad, 2009). The comprehensive review of the privatization process in Iran electricity industry is presented in Appendix A.

Another major event that directly influenced the restructuring of electricity industry was the economic reform carried out in compliance with the new 'Subsidies Reform' law in January 2010. According to the new law, the government is obliged to omit the subsidies from electricity industry by 2014 and to increase the efficiency in transmission and generation sectors (Working group for economic reforms, 2014).

A brief review of entities and legal basis of IEM is presented in Appendix B.

Fig. 4 summarizes different development stages in Iranian electricity industry along with related statistics at the end of each period, the created entities, and the important completed tasks in each stage.

4. Physical energy and operational reserve market

According to the 'Regulation on the purchase and sale of electricity and its conditions', IEM consists of Day Ahead Wholesaling Market (DAM), Ancillary Services Procurement (ASP), and Bilateral

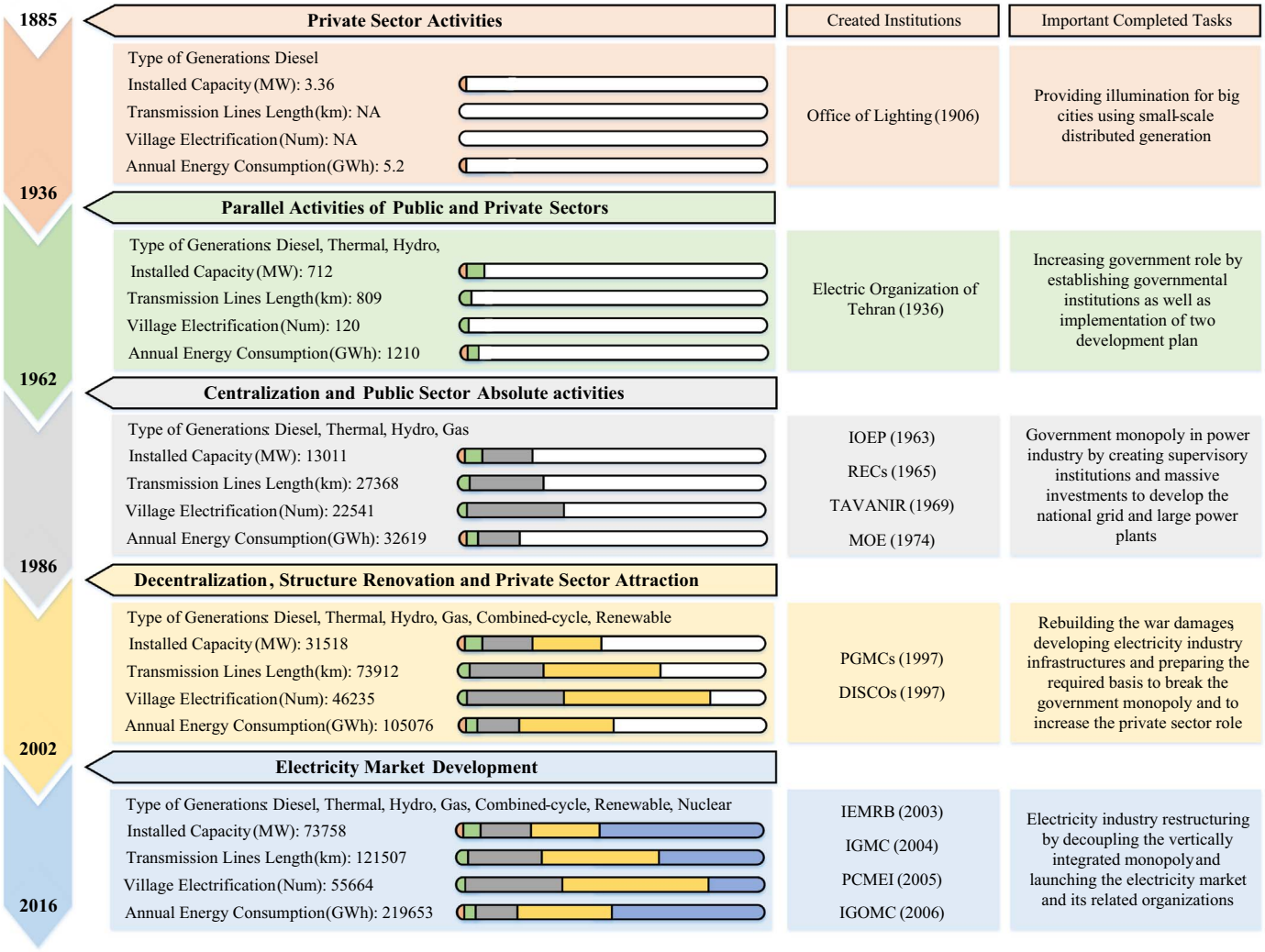

Fig. 4. Time diagram of development stages in Iranian electricity industry along with related statistics at the end of each period, the created entities, and the important competed tasks in each stage.

Transactions. IGMC is responsible for holding the wholesaling market, issuing certificates of bilateral transactions, and operating the national grid. IEMRB is the regulator entity that monitors the law enforcement and acts as the market referee (Heidary, 2003).

IEM was started in August 2003. In the beginning, RECs, as the owners of power plants, were responsible for selling electricity. Moreover, as owners of DISCOs, they were also responsible for purchasing electricity and procuring transmission services. Following the legislation passed in March 2006 that allowed the DISCOs to be independent of RECs, the responsibility of purchasing electricity has been delegated to DISCOS since the beginning of 2008 (Karim and Reza, 2009).

Currently,[2] IEM is a pool-based day-ahead market. Issuing Bilateral Contracts are possible and their regulations are under development. The settlement is based on the Pay as Bid (PAB) method. In IEM, the competition is in generation side and GENCOs should provide energy curves in rising steps with a maximum of ten steps and a cap price limit (13.7[3] $/MWh in 2016 (Iran grid Management Company, 2015)). Upon the acceptance of these prices in the electricity market, the fee is paid based on bids (Setayesh nazar et al., 2007). The buying rate is always determined according to the Market Average Price (MAP) which is announced at 5 p.m. of one day ahead. Fig. 5 shows the overall structure of IEM (Karim and Reza, 2009; Setayesh nazar et al., 2007; Ghazizadeh et al., 2007). Further details on timing, fiscal legislations, and clearing process in DAM have been provided in Appendix C.

The active agents in IEM are sellers, buyers, market manager, and regulatory board of market. The active organizations in IEM are shown in Fig. 5. The electricity market deputy of the IGMC acts as the market manager in IEM and organizes the exchange of information and market operation. According to the structure shown in Fig. 5, RECs, Tavanir, private power plants, and power plants outside the management of the MOE (which mostly includes power plants of major industries that sell their extra electricity according to the guaranteed price) act as sellers. While DISCOs, RECs, Tavanir, and independent consumers act as buyers who can either purchase the electricity they need directly from the market manager or make a direct contract with the seller. DISCOs are the providers of electricity in their local distribution networks (Ministry of Energy, 2007).

According to Fig. 5, it is possible to make bilateral contracts in IEM. Bilateral contracts have been possible since the beginning of IEM and the necessary legislation has been passed, but due to lack of required infrastructure, these contracts have been restricted to a limited case since 2014 and are still in a pilot phase. Moreover, in order to

[2] - Feb 2017

[3] - Calculations have done based on the reference rate for the dollar (1$=30337 *Rials*) at the Central Bank of Iran on 1/2/2016.

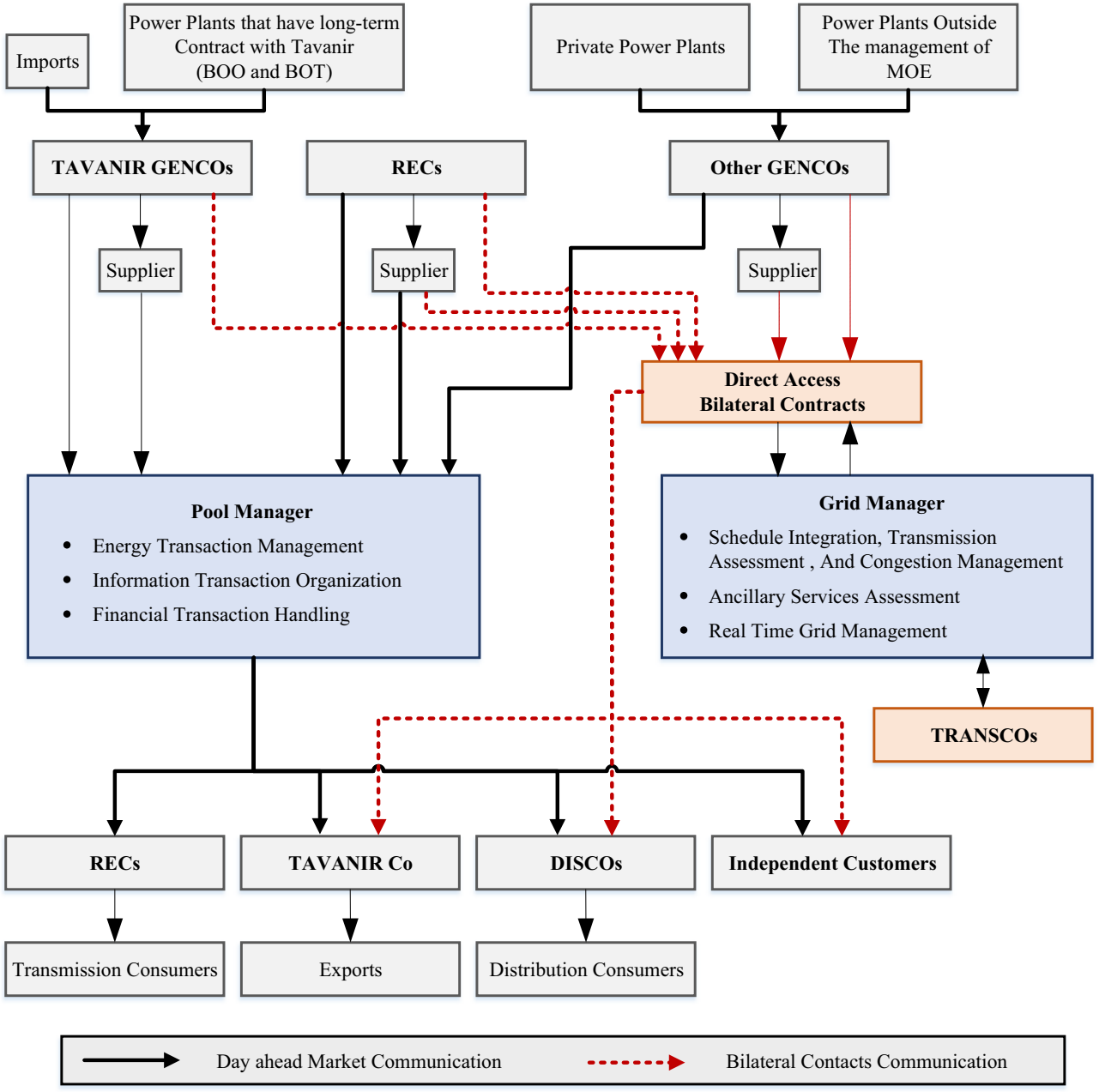

Fig. 5. The structure of IEM (Karim and Reza, 2009; Ghazizadeh et al., 2007).

implement the bilateral contracts market completely, new laws are being discussed; further details are covered in Appendix F.

Bilateral contracts, in their present form, are carried out electronically from 8 A.M until 2 P.M every weekday in the energy exchange market. Suppliers and buyers submit their proposed packages including all necessary details (amount, bid, time period and delivery node) using the market website. These are energy packages with a specific time period in which these should be bought or sold according to the contract. Proposing to sell or buy a package implies the readiness to receive the package at any time during the period specified. In terms of variety, these packages could be delivered on a daily, monthly, or seasonally basis (IRAN electricity market regulatory board, 2009).

The transacted package has an agreed price which is the cost for issuing the bill and settlement. The supplier should pay transit fees as well as the cost of the transmission losses to the market manager of bilateral transactions. At the end of each working day, the schedule of transactions for the next two days is given to the market manager to be considered in generation dispatch. Also, the obligations of the contract parties are announced electronically. The deputy of the IEM is responsible for such transactions until this task could be delegated to IEE (IRAN electricity market regulatory board, 2009).

Across-border transactions provided the IEM with the ability to purchase electricity from overseas and deliver it to the national grid or purchas electricity from the grid and sell it overseas. As of 2015, all these transactions are exclusively carried out by Tavanir. The amounts of such transactions are determined through IGMC approval and according to the possibility of energy supplying considering the national grid standards and reliability. In all across-border transactions, regulations and fees similar to a domestic agent for both purchasing and selling electricity should be followed (IRAN electricity market regulatory board, 2005).

As mentioned in the beginning of this section, IEM also includes an Operational Reserve (OR) market that is meant to ensure grid security and compensate the possible outage in the generation and load. The

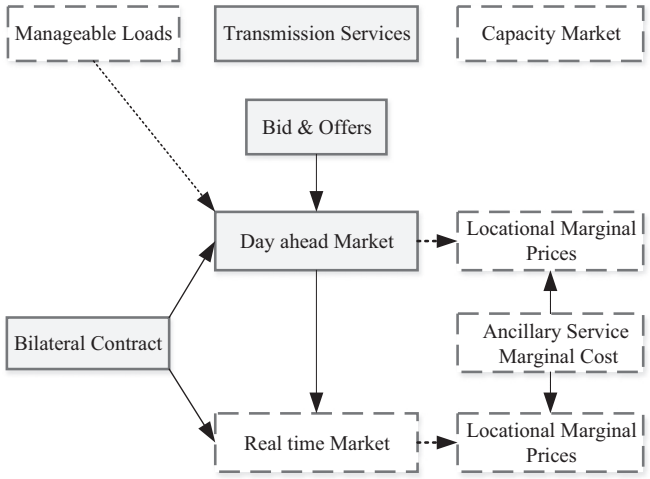

Fig. 6. IEM model in comparison with standard market from the viewpoint of FERC (the dotted connections have not been established yet).

required amount of reserve in this market is provided from two major sources: the power plants participating in this market (in and out of service), and manageable loads (interruptible loads). OR market is held regionally, based on the limits in operating and power transmission in the grid. The regions are selected by the IGOMC according to the bottlenecks of the grid (IRAN electricity market regulatory board, 2011).

It must be noted that there are two methods for providing OR in IEM. The first method is providing the required OR through the OR market. The laws related to this market have been passed, but the operational and executive stages have not started yet. In the second method, which is currently being used in the DAM, providing the reserve is considered as a part of the AS and is handled by the market manager through paying fixed fees to all units which participate in providing the service. Due to the importance of the first method and its imminent implementation, which is set to replace with the second method, the details of its execution, as well as its timing, will be discussed in the Appendix C. The second method is also addressed in Appendix E.

Tavanir, as the government agent in the electricity industry, possesses all the RECs, and, indirectly, possess transmission and a large part of distribution sections (in spite of the commencement of privatization process in DISCOs in 2006, the shares of these companies, for the most part, are held by the government). The transmission section still has a monopoly structure, while privatization of the generation and distribution sections have created competition in these levels (Management of information technology and statics office of Tavanir, 2011a). Therefore, the structure of IEM can be summarized as competition in generation and distribution sectors along with privatization in them and monopoly in transmission sector.

Fig. 6 summarizes the active markets in IEM (2016) and the pilot markets (shown with dots) required to reach a standard market (from view point of FERC (Sam, 2003)).

5. Evaluation of energy and ancillary services prices in IEM

In general, the prices in IEM can be categorized into three groups: 1- the wholesaling price, which is the hourly DAM clearing price, 2- transmission ancillary services prices, and 3- retailing prices or electricity rates that apply to the consumers connected to the distribution grid. Each price group has been described in the following.

5.1. Wholesaling price

As stated in Section 4, all generating units are required to submit their offer price curves for each hour of the following day by 10:00A.M. Offer price curves may include 10 increasing steps at most while, all offered prices are limited to the regulated energy cap-price. Since the market is single-sided, Market Operator (IGMC in IEM) is supposed to find the optimum generation schedule for the next day that minimizes the total daily cost (including energy cost, opportunity cost, and fuel price-difference cost), yet satisfies all the network, generation and reliability constraints.

For each hour, each accepted generating unit receives its offered price for its accepted energy production level. The *must run* units, that have to generate at a specific minimum level according to their operational constraints, only receive their Average Variable Cost (AVC) in case they are not accepted in the market. On the other hand, the unaccepted generation units that are rejected because of the operational limitations of another generating unit or transmission network constraints, not because of their high offered price, are subjected to receive opportunity cost which is generally equal to their offered prices minus their AVC. AVCs are validated daily by a third party independent technical expert division.

In addition, all generating units receive capacity payment for their whole available capacity at each hour, regardless of their accepted energy production level. Further details on energy and operational reserve markets mechanisms including timing, fiscal legislations, and price determination process, are covered in Appendix C.1 to C.3 respectively.

In order to comply with the changes in the competition environment, energy cap-price and Base Availability Price (BAP) are generally revised annually by the Regulatory Board. Since the market was lunched 13 years ago, with the aim of boosting the competition level, Regulatory Board has been decreasing the share of capacity payment in

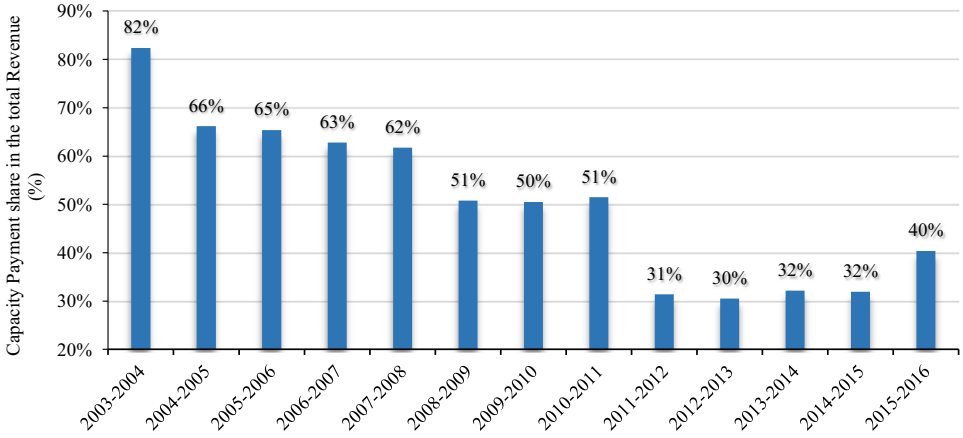

Fig. 7. The share of capacity payment in the total revenue of the generation sector in IEM from 2003 to 2016.

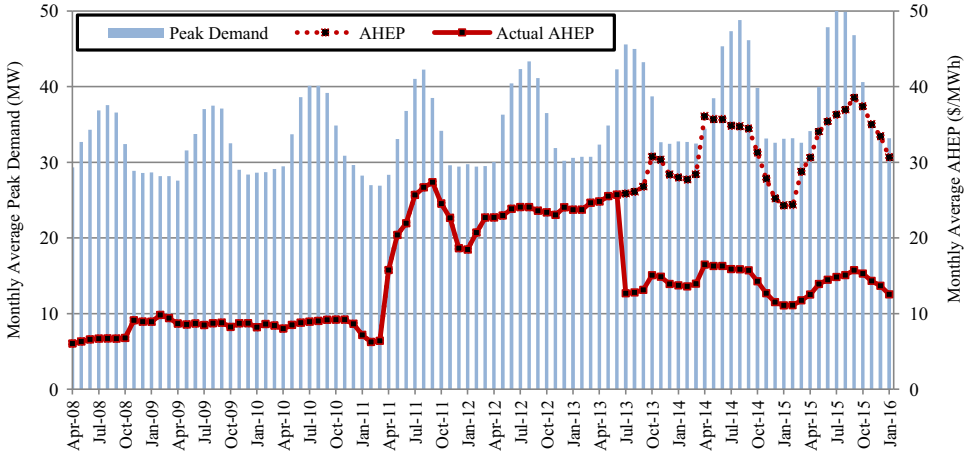

Fig. 8. Monthly AHEP averages and peak demands, 2008–2014.

the total revenue of the generation sector. Fig. 7 depicts this trend.

The Average Hourly Energy Price (AHEP) and the monthly average peak demand in IEM from Apr 2008 to Feb 2016 are shown in Fig. 8 (National grid peak, 2016; Monthly reports of Iran's electricity market, 2016). Due to the use of gas for heating purposes in Iran, the peaks occur in summers when the cooling systems are in use. According to Fig. 8, the maximum peak occurred in August 2015 (50.177 MW) due to the extreme summer heat. The insignificant role of private power plants compared to the government-owned units and the strict cap price in IEM were the most significant reasons that kept the price fluctuation of AHEP in a limited range from 2008 to 2010. In addition, the use of governmental subsidies for providing power plants with the fixed-price fuel is another reason why AHEP and wholesale prices have been almost constant during this period.

By implementation of the law of "Subsidy Reform" in the beginning of 2011, which led to the reduction of power plants' fuel subsidies[4] and change in the cap price (such as March 2011 and 2014) in IEM, a considerable fluctuation of AHEP occurred in IEM in March 2011 and 2014. The trend of gas price tariff for energy production is depicted in Fig. 9. As can be seen in Fig. 8 and Fig. 9, the subsidy reform in 2011 and the spike in natural gas tariff caused a noticeable increase in the wholesale electricity price. Moreover, due to a demand increase in summer 2011, AHEP increased significantly compared to preceding years. But because of the incomplete elimination of subsidies, still, there is a significant difference between AHEP and the real price of electricity (price without the aid of subsidized fuel) in IEM (real prices were 96.8 and 101.3 $/MWh in 2011 and 2012 respectively) (Deputy of Power and Energy, 2011a).

As can be seen in Fig. 8, a considerable decrease in prices occurred in July 2013 which is due to the change of the official exchange rate of Iran's currency (Rial) to US dollar.[5] Therefore in order to provide a more comprehensive comparison of prices, both actual AHEP (prices based on the real exchange rate of central bank of Iran[6]) and AHEP (prices based on the constant exchange rate of 1$=12260 Rials) are provided here. As can be seen in Fig. 8, apart from the dramatical decrease of prices in Jul 2013 (which is related to the dollar rate not the actual price of energy in IEM), the AHEP has been increased during Jan 2012 to Feb 2016. The gradual elimination of power plants' fuel subsidies and the cap price changing are considered as the main stimulants to increase the electricity price in IEM during this period.

It is worthy of note that the large-scale customers can directly participate in the IEM and purchase their energy from there. These customers are shown in Fig. 5 (Section 4) as independent customers. For each hour, the total market cost consists of generation cost (capacity, energy, and ancillary services), and transmission cost (availability cost and energy-flow cost) are prorated among all the market buyers based on their hourly consumptions. It is also possible to make bilateral contracts with such customers based on which the exchange energy price is determined by an agreement between the two parties. The price for other customers is determined by electricity retail tariffs.

The export and import energy prices are determined based on AHEP and the price of unsubsidized fuel at each hour.

5.2. Transmission ancillary services prices

Currently, three categories of ancillary services are defined by Regulatory Board in IEM, namely Primary Frequency Control (PFC), Reactive Power support, and Black-start services. As stated in Section 4, at the present time these services are procured by means of non-competitive mechanisms and the payments are based on the regulated tariffs determined by the Regulatory Board. Generally, these tariffs are determined as a fraction of BAP. Further details on ancillary services procurement mechanisms including eligible participants, fiscal logic, tariffs, and price determination process, are explained in Appendix E.

The share of each aforementioned category of ancillary services in annual ancillary services cost in 2016 is shown in Fig. 10(a). The share of total annual ancillary services cost in the annual generation cost in 2016 has also been depicted in Fig. 10(b). The Fig. 10(a) implies that most of the ancillary services cost is dedicated to reactive and voltage support. However, due to the intensified concerns about the frequency deviation and system stability, Regulatory Board recently legislated a new instruction for the procurement of PFC to motivate the generation companies to take a more proactive role in delivering PFC service. It is predicted that the new mechanism will increase the PFC payment noticeably (about 1800%).

Transmission sector in IEM is totally state-owned and regulated. The apparatus in the transmission grid, receive Availability payment (proportional to their Total Transmission Capability) and energy-flow payment. Based on the voltage level, the availability rate ($/MW/km) and the energy-flow rate ($/MWh/km) are legislated by the minister of energy. According to "Base policies regarding Article 44 of constitution law", the bulk power grid is not going to be privatized. Thus the policy of Regulatory Board regarding transmission grid is to provide sufficient revenue for the transmission companies in order to operate, renew and expand the transmission grid, but the profit margin for the transmis-

[4] - Before the implementation of the subsidy reform (March 2011), fuel (natural gas) was delivered to power plants with the low price of 0.4 cents per cubic meter. But after the implementation of the reform, the mentioned price has increased to the 5.8 cents for every cubic meter of gas in April 2011.

[5] - At July 2013 the exchange rate of Rial to US dollar has changed from 1$=12260 Rials to 1$=24480 Rials.

[6] - From July 2013 to March 2014, 1$=24480 Rials, and from March 2014 to March 2015, 1$=26880 Rials, and from March 2015 until now, 1$=30300 Rials.

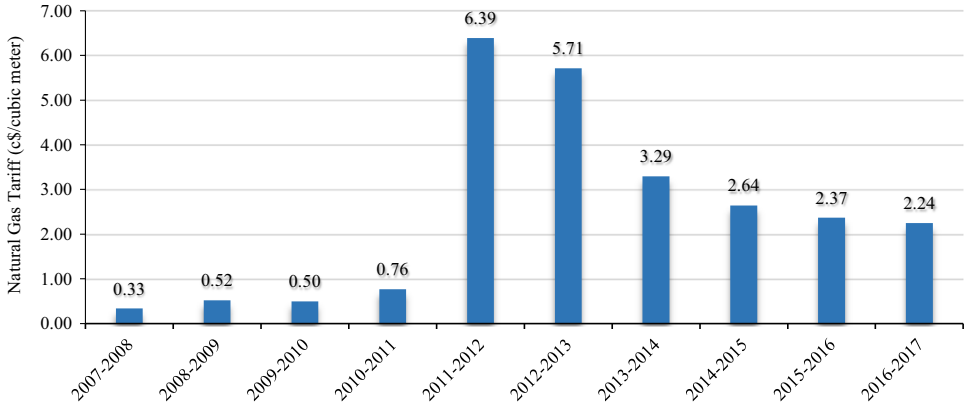

Fig. 9. The trend of gas price tariff for energy production during 2007–2017 in IEM.

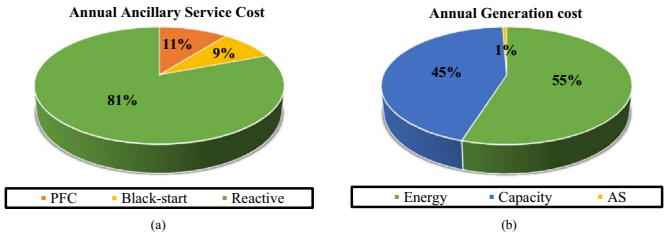

Fig. 10. a) The share of each ancillary service in total cost of the annual ancillary services in 2016, b) The share of total annual ancillary services cost in annual generation cost in 2016.

Table 4
Transmission tariff changes during 2004–2016 in IEM.

		Voltage Level					
		230 kV and above			132 kV and below		
		2004	2010	2014	2004	2010	2014
Availability Rate (Cent/MW/km)	Line	0.08	0.2	0.42	0.24	0.57	1.2
	Transformer	8.2	12.4	25.8	14.6	19.5	40.7
Energy-flow Rate (Cent/MWh/km)	Line	0.08	0.2	0.42	0.24	0.57	1.2
	Transformer	9.7	14.9	31.1	12.2	16.2	33.9

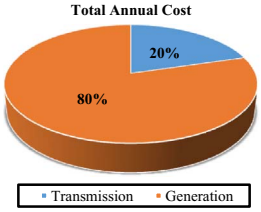

Fig. 11. Share of transmission and generation sectors in the total annual cost of market in 2015–2016 fiscal year.

sion owners is kept low intentionally. The transmission tariffs are not revised annually and in fact there is no specific frequency for revising these rates. The transmission tariff changes, during 2004–2016, have been included in Table 4.[7] The share of the transmission and generation sectors in the total annual cost of the IEM market in 2015–2016 fiscal year are shown in Fig. 11.

5.3. Electricity rates

On the basis of the provisions of principle 44,[8] the government is obliged to pay the difference between the retailing tariffs and the real price of electricity to the electricity industry. Therefore, the payments made by the customers are not based on the real prices. They are made according to the tariffs determined by the model offered by the Board of the Ministers each year. In this model, various factors such as economic, social and political factors are considered to calculate tariffs. Electricity tariffs are classified according to the nature of activity and usage. This classification includes five categories including residential, public, industrial, agricultural, and commercial rates. These rates vary as a function of season and region. For example, in summer, when the demand for electricity is rising, the price for all categories is increasing as well (Deputy of Power and Energy, 2012). Fig. 12 shows the Average Electricity Price (AEP) (based on retailing tariffs) in comparison to the real price (prices without considering subsidies) in different categories, from 2004 to 2015 (Management of information technology and statics office of Tavanir, 2015a; Deputy of Power and Energy, 2015a, 2012).

According to Fig. 12, in 2011 and 2014, the average price for one

[7] - All Calculations have done based on the reference rate for the dollar (1$=12260 *Rials*)

[8] - Please refer to Section 3.5 for more detail about the principle 44.

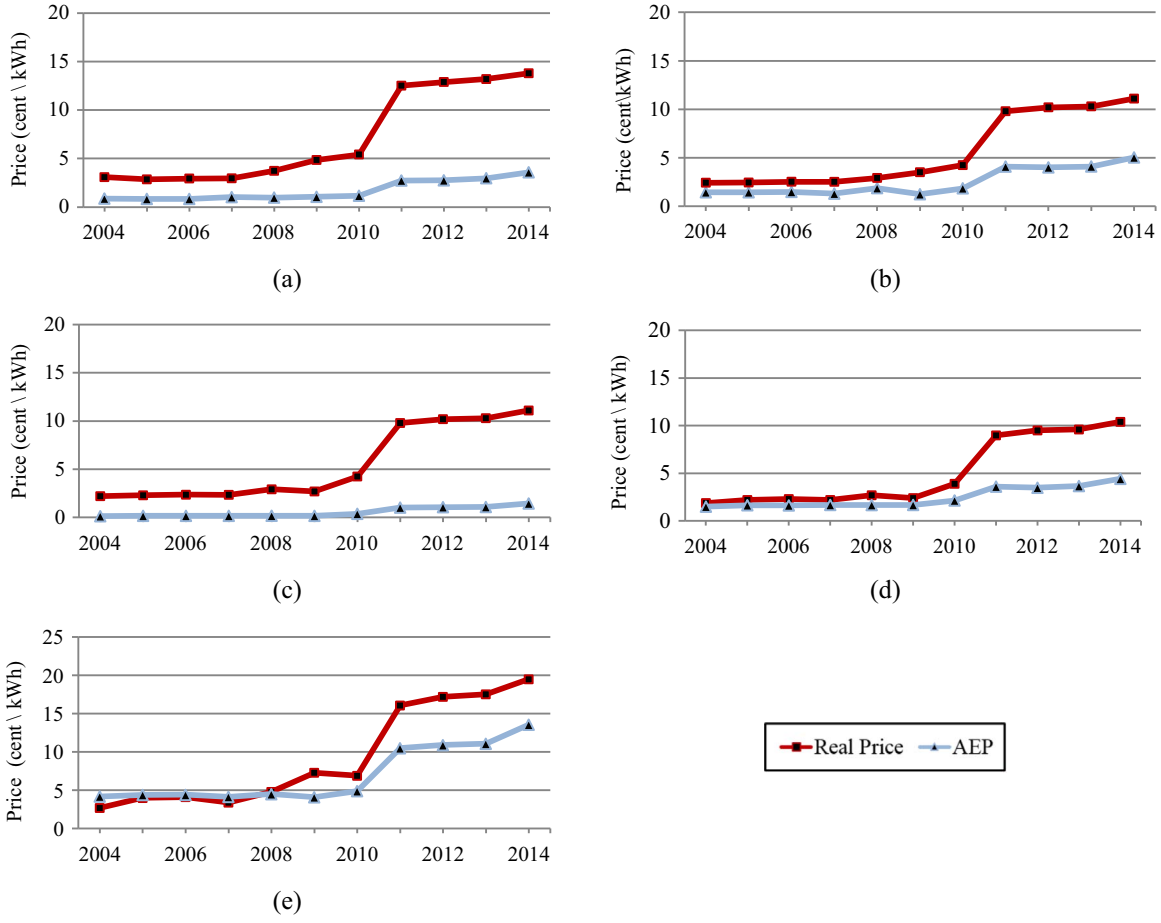

Fig. 12. Comparison of AEP with the energy real price in (a): residential, (b): public, (c): agricultural, (d): industrial, and (e): commercial categories. Calculations have done based on the reference rate for the dollar (1$=12260 Rials) at the Central Bank of Iran.

kWh of electricity in IEM was 3.34 and 3.38 cents and 10.3 and 12.5 cents using subsidized fuel and without it, respectively. Comparison of the real prices and AEPs reveals the highest subsidy rate (the residential section with 10.22 cents/kWh) and the lowest (the commercial sector with 5.93 cents/kWh) in 2014 (Deputy of Power and Energy, 2015b).

In the hope of closing the gap between AEP and the real price, the law of "Subsidy Reform" was passed on December 19th, 2010. Accordingly, new tariffs were announced to electricity companies (Deputy of Power and Energy, 2015a). In 2011, with the new tariffs in place, the average price of electricity for residential, public, agricultural, industrial, and commercial sectors became 2.73, 4.091, 1.025, 3.604, and 10.5 cents/kWh respectively. These new tariffs show the governmental support of the agricultural and industrial sectors as well as the gradual removal of subsidies in the public and commercial sectors (Deputy of Power and Energy, 2015b). It must be mentioned that according to part F of article one in the law of "Subsidy Reform" plan, the average electricity tariffs or AEPs, should be gradually increased to eliminate the gap between AEPs and real prices by the end of the fifth economic, social, and cultural Development Plan (2015), which has not been achieved according to Fig. 12.

6. Practical plans for improving IEM

As the primary goals, Iran electricity restructuring took place to track three major goals: financial clarity, improve economic performance, and reduce political interference. For quite a long time, electricity has been defined as a highly subsidized public service, that should be provided by the government regardless the economic value of the process. There was a unanimous belief that the state-owned total monopoly is the prominent reason for the low economic performance. The engineering part of the industry claimed that being a totally state-owned industry have had a negative influence on the decision making process and some political relationships were shadowed the economic and engineering complexity.

It was construed that restructuring may bring about a profound change. Therefore, the restructuring process started in four phases:

1. Unbundling the monopoly structure in which the generation, transmission, and distribution sectors were separated, while they still owned by the state-owned holding company Tavanir.
2. Privatization, that started by deregulating the ownership restrictions, allowing the private sector to own the generation facilities by means of build–own–operate (BOO) and build–own–transfer (BOT) contract models. But they had to sell their generated energy solely to the government, based on the predetermined tariffs. There was no competition and no option for choosing the buyers.
3. Providing competitive environment: by implementing the second restructuring phase, the governmental bodies were worried about losing their controlling power, the 3rd phase was lunched by the establishment of the wholesale electricity market in a single buyer pool market model in which all the producers had to sell their electricity solely into that market.
4. Make the electricity publicly tradable: this phase is still in process. In this phase, the private generation companies became eligible to sell their electricity in bilateral contracts. Unlike all the predictions, this new mechanism did not become active until several years later. Up to this point, issuing bilateral contracts are possible and their

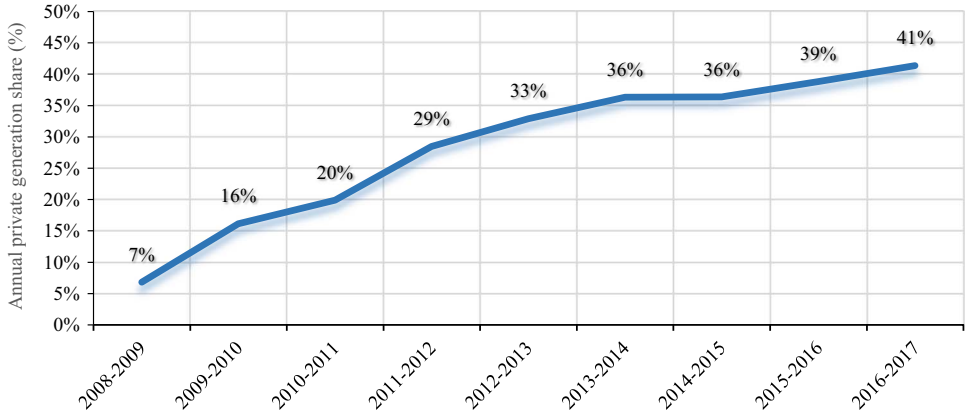

Fig. 13. The annual private generation share in the total annual generation in IEM from 2008 to 2017.

regulations are under development.

In the recent years, the privatization process of the state-owned power plants decelerated. Although because of the addition of new private power plants, the share of private sector in an annual generation has been getting higher persistently. Fig. 13 depicts the annual private generation share in a total annual generation in IEM from 2008 to 2017.

After around 13 years, now IEM is mainly focused on increasing the share of bilateral contracts (especially among industrial consumers that consume roughly 30% of total annual consumption), as well as energy trades within the energy exchange center. As a preliminary step toward making the electricity industry subsidy-free, the retail market has been proposed. To realize this step, an act has been issued by the prime minister in 2016, which makes all the consumers (with a consumption rating higher than 5 MW) eligible to procure their electricity via bilateral contracts, instead of distribution companies.

In the scope of spot electricity market, with the aim of making the market more efficient, the establishment of a real-time energy market (more specifically intra-day market) is currently under study. It is expected that having a real-time or intra-day market may help the dispatching center to manage the inevitable changes in the day-ahead schedule in a more efficient manner.

As well as the real-time energy market, the competitive procurement of Available Capacity market, instead of paying the regulated capacity payment fee to all the available generating units, has been investigated and it will be lunched in Summer 2017. It is estimated that using a competitive mechanism for capacity payment, will decrease the capacity revenue percentage even more than the current method.

Moreover, a separate market for the procurement of operating spinning reserve capacity has been proposed, but due to the lack of technical requirements, it is not going to be activated in near future.

Currently, there is no direct consideration of the start up/shut down costs of the generating units. Even when the dispatcher increases the number of shut downs of generating units, the excess cost relating to the excess shutdowns are not compensated. In order to overcome with this conceptual draw back, Regulatory Board has legislated a new mechanism which is going to become activated in April 2017. This new mechanism emphasizes that Market Operator should compensate the excess cost of start-up imposed by the dispatching center, based on the rates predetermined by the independent third party expert agency. For each thermal generating unit there will be three different start-up rate (cold, warm, hot) based on the number of hours that the unit was turned off. Furthermore, the recently issued mechanism implies that the excess payment can be negative if dispatching center reduces the number of start-ups of a generating unit. Regulatory Board expects that the new mechanism for start-up cost will boost the competition level in the market and will reduce the gap between market day-ahead schedule and actual schedule mandated by the dispatching center.

7. Conclusion

In this paper, restructuring in the electricity industry in Iran has been investigated. In addition, the history of the electricity market in Iran along with its executive process were discussed. Throughout this study, the important features in electricity industry like price changes and privatization were discussed. The process of restructuring in Iranian electricity industry started in the 1970s that eventually reached its targets in 2003 when the IEM was formed. IGMC (as the main market operator) and IEMRB (as the main rule-making body) along with other relevant bodies are responsible for IEM operation. IEM includes several sub-markets such as the DAM, OR and the ASP, which can ensure the security and stability of grid operation.

Energy pricing in IEM at the wholesaling stage is based on PAB and MCP while providing electricity for small customers is based on fixed tariffs determined by the Board of Ministers every year. The implementation of the law of 'Subsidy Reform' in 2011 and the gradual removal of government subsidies in electricity sector resulted in a more realistic price of electricity in IEM, while prior to this, because of government subsidies and the limited participation of private power plants, there had been limited and unrealistic changes in the price of electricity over the years. In spite of starting the privatization of electricity industry since 2005 in Iran, the government still has a monopoly over the transmission and distribution sectors. Implementation of IEE and the increasing the incentives for the private sector (by enacting the supportive regulations) in the recent decade, can hopefully lead to a more noticeable presence of private sector in the Iranian electricity industry.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.enpol.2017.05.018.

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