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Analysis of the problems of electricity in Iraq and recommendations of methods of overcoming them

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ABSTRACT

The Iraqi power sector is at a critical stage that requires urgent reforms. Concerns regarding the ability of the system to provide steady power and its operational inefficiencies, in general, have been expressed by the industry and academia. Currently, the power industry is experiencing one of the highest demand growth in the world, and given that it is capital intensive, it takes up a large share of Iraq's government capital investment program. More so, there is a huge increase in the financial burden of the Iraqi electricity supply industry due to the high subsidies required for the coverage of the recurrent expenditure. This subsidy is regarded as one of the highest in the world, given the extremely low traffic which does not cover up to 20% of the periodic expenditure. Apart from the huge subsidy in electricity tariff, another major and indirect socioeconomic subsidy is the fact that the industry is over-staffed with over 50,000 employees which under normal circumstances should not be more than 15,000. The estimated annual cost of the aforementioned inefficiencies and insufficient power supply is about $3 to 4 billion. In 2013, about 70% of the generated electricity was lost, and this loss is in three areas, including commercial, technical, and administrative losses. Therefore, there is a need for massive reforms that are targeted at addressing the entire issue. This can be achieved through the engagement of the private sector, higher competition, and the introduction of novel regulatory and legislative frameworks. In addition to that, the available sources of energy in Iraq need to be optimized alongside gas usage related to oil extraction, while solar energy in Iraq is explored and the solar hybridization of the current power stations.

Keywords: reform, Iraqi power system, generation, distribution, metering, solar hybridization.

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1. Introduction

Starting from the 1990s, Iraq began to experience a shortage in the supply of electricity. The 1991 Gulf War led to the destruction of almost 90% of the electricity generation and distribution infrastructures, and after that time, it has been difficult to achieve total rehabilitation of the damaged systems. However, almost 50% of the systems have been recovered. Regardless of this, in the post-war period (2003 to 2013), the Iraqi power sector was unable to generate and supply adequate power, due to reduced capacity in terms of energy generation and distribution. This means that the domestic, industrial, and commercial electricity needs could not be met by the power sector. This issue has not been addressed but has rather escalated, resulting in a drastic increase in electricity demand since the year 2003. The problem has been worsened by problems like sabotage, vandalism, military actions, and corrupt practices. The annual cost of the shortage in power supply in Iraq is estimated at 3 to 4 billion US Dollars. The direct consequence of this is seen in the economic growth, which is negatively affected by the shortage in power supply, and this, in turn, causes hardship on the citizen. The three components of the value chain (generation, transmission, and distribution) have been left in a critical situation as a result of

a lack of maintenance and funding. Reports from numerous sources reveal that about 90% of the households in Iraq augment the public electricity with costly private auto-generators that are energy inefficient, and rely on petrol and diesel. More so, it is estimated that almost 23% of the households in Iraq depend on self-generators as their major source of power supply. As reported by [1], the total number of private units in use was in the range of 60,000 to 85,000, with an estimated capacity of around 8,000MW [1]. In the year 2013, a slight improvement was recorded with the net capacity reaching up to 9,000 MW. This is still not up to the needed capacity of 15,000 MW, meaning that there is a need for an increase to 70% amounting to 6,000 MW [2]. The increased need for power for domestic and industrial use in Iraq has resulted in this higher rate of electricity demand. Also, the affordability of electric appliances, particularly air conditioners during the summer period and heating appliances during the winter season has led to the increased demand for electricity, thereby resulting in the electric supply gap. Increasingly, these problems increase the unreliability rate of electricity in Iraq.

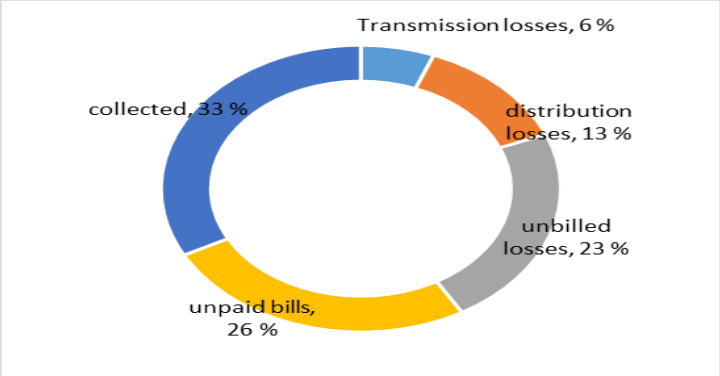

Figure 1. Percentage of losses for different components

In 2013, about 70% of the total electricity that was generated was lost, and the losses have been documented in three different areas, including commercial, technical, and administrative losses. Out of 70% of the losses, 6% of the losses were recorded for transmission, 13% for distribution, 26% non-collected, and 23% for theft and non-billed, while the remaining 33% was recorded for collected. More than 90% of the losses are in the distribution network of which 79% are non-technical losses (theft, non-billed and non-collected) [3-6]. In Iraq, the metering system, especially for end-users is epileptic, as it is characterized by malfunctioning or obsolete meters, as well as the widespread theft of electricity coupled with the presence of unmetered connections. It has been estimated that about 23% of the total power generated is stolen through illegal unmetered connections to the distribution system. More so, about 80% of the meters used by end-users are outdated, dating to as far back as 30 years, without any recalibration. Apart from the poor end-user metering, the collection and billing procedures and systems are ineffective, thereby resulting in increased thefts, non-billing, and payments. Out of the total estimated losses recorded in the system, it has been noted that 50% of the losses are associated with non-technical losses. The estimated average cost of generating power is about US$13.0 compared to the average tariff of about US$2.50. As a result of the challenges, the Iraqi power industry has continued to experience dramatically low recovery of cost, and it has also been estimated that collected revenues only constitute 10% of the operational costs [3, 7]. Reports have shown that in June 2012, the gas produced was about 2 billion cubic meters (bcm), with about 55% coming from southern oilfields in Iraq. It is assumed that over 50% of the gas generated was flared as the industry cannot process the gas generated. There is consistency between the monthly estimate and that of 2011, which showed that about 20 billion cubic meters of gas were produced, but sadly, 12 bcm was flared. Flaring is an activity that causes waste of resources, considering that the generated gas can be used to generate power; it also has adverse environmental effects [8-12]. To this end, there is a need for massive reformations in the power industry, because, through the reforms, economic growth can be further stimulated while the electricity-related problems can be addressed. The reforms must be planned with long-term goals that are aimed at transforming the entire power industry and promoting structural development, especially in the area of distribution.

2. Status of power generation

The total capacity of installed generation is more than 16,800 MW (2012) and consists of 478 generation units ranging from 1.7 to 300 MW per unit. The generation units are distributed across 8 hydro-based stations with a total capacity of over 2,500 MW, while the combined capacity of the 8 thermal stations is estimated at almost

5,500 MW. Also, the generation units are characterized by 28 gas turbine stations that have an estimated combined capacity of 8,700 MW and 15 diesel engine stations with a total capacity of about 1,600 MW alongside over 100 small diesel generators that have been specifically designed for peak loads [3]. Based on the Energy Master Plan of Iraq, an additional 24,400 MW should have been achieved between 2012 and 2019, out of which 13,000 MW should be gas-fired capacity, 7,000 MW should be thermal power capacity, while 400 MW of renewable energy should be achieved by the year 2015. Unfortunately, this has not been realized. Consequently, 14 hours of power is enjoyed by Iraq daily. Gas turbines constitute 61% of installed generation capacity; steam 28%; diesel 3%; hydro 8% as shown in figure (1). In 2017, the government proposed a total of 28,680 MW capacity, however, only 24,020 MW was achieved, and this is inclusive of 2 GW of imports and barges.

Another factor that impeded the generation of power in Iraq is the war against ISIS in Baiji and Mosul hydro plants. The situation has been worsened by the 7% average yearly increase in demand for electricity [13-15].

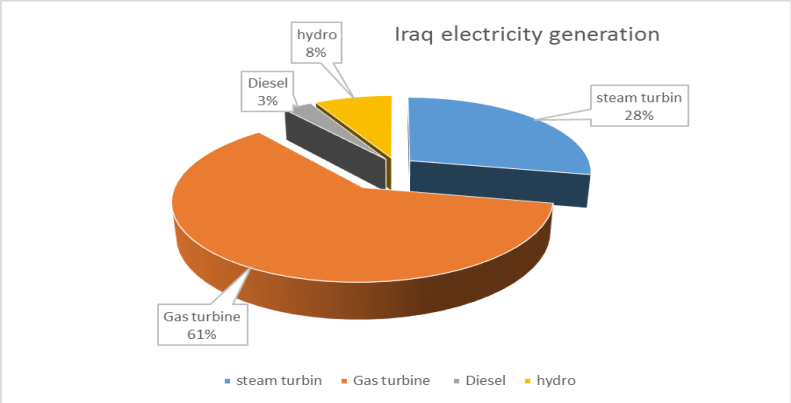

Figure 2. Iraq electricity generation

Based on the Iraqi government's plan to generate an additional 8,000 MW to make the total capacity 20,000 MW, by May 2014, Iraqis will enjoy 24 hours. Unfortunately, with the emergence of IS, grid losses of over 8,000 MW were recorded and announced by the Ministry of Electricity. As a result of these losses, Iraqis enjoy only 5 to 8 hours of electricity daily, despite the promises made by the government to increase the generated electricity by summer in 2015. The yearly losses caused by this unending conflict between the demand and supply of electricity have had gross negative effects on the economy of Iraq, amounting to $40 billion every year. One of the ways through which the problem of the deficiency of the public grid has been addressed by Iraqis is the use of other kinds of generators that work at the zone level. These generators are often owned by private investors who generate electricity and sell it to communities within particular zones. To a certain extent, the short supply of electricity caused by public network deficiencies is augmented by the generators. However, the cost of electricity sold by the private investors is higher than the grid electricity, which costs around US$ 3/kWh [2]. The monthly cost of electricity from the generators is around $40 per Ampere, which is quite expensive for consumers that are below average. Thus, an agreement was reached by the Ministry of Oil (MoO) to make provision for a limited amount of subsidized fuel to owners of off-grid self-generators to minimize the effect of the high cost of their electricity; a minimum of 10 hours of electricity is provided by the owners of such generators daily. This subsidization of fuel has made the price of the electricity generated by the private generator owners has caused a fall in the price of electricity sold to residential consumers. Presently, the price range of the electricity is between $4 and $8 per ampere monthly at 220 Volts as compared to 8-17/kWh [16].

3. Status of transmission and distribution

In terms of the transmission of electricity, five directorates are located at different geographic locations, including Upper Euphrates transmission, central transmission, north transmission, central Euphrates transmission, and south transmission. The five directorates are responsible for transmitting 400kV to 16,429 km alongside 132 kV high-voltage transmission lines and 232 primary and secondary substations with a total capacity of 44,000 MVA. More so, it is the sole responsibility of the five directorates to operate and maintain the transmission lines and sub-stations within the whole country, except for the Kurdistan region governorate (KRG). The distribution of electricity is carried out by the ministry through the seven directorates that were

established based on geographical locations. The directorates include, Tawzia al-Furat al Wasat, Tawzia al-Karkh, Tawzia al-Risafa, Tawzia al-Wasat, Tawzia tawzia al-Sadr, Tawzia al-janub, al-shimal) [9, 2].
Through the aforementioned directorates, 3,275,000 end-users within 15 governorates are served, while another 663,266 users are served through the three KRG Governorates [17]. Generally, a critical look at the system of electricity distribution in Iraq, shows that the system is in a deplorable condition even though it is one of the critical components of electricity supply. The current state of the distribution system is due to administrative inefficiencies and little or no funding for the development of the system. More so, the system has suffered from a high rate of both technical and non-technical losses due to unplanned and unregulated expansions coupled with the use of the obsolete network, which has also over-burdened the system. For instance, a key source of system losses is the distribution lines that convey a limited amount of power over short distances. Almost 40 to 50% of system losses that occur in the power sector of Iraq are attributed to transmission and distribution losses, with a higher rate of losses coming from the distribution sector (i.e., 80-90% of the total transmission and distribution losses). The inefficiency in managing and running the affairs of the distribution sector has resulted in the aforementioned issues. Some of the inefficiencies are in the areas of metering, billing, customer service, as well as inability to improve the performance of the system. In the same vein, despite the equal distribution of substations across Iraq, statistical reports have shown that about 17% of the total capacity of the substations is lost due to vandalization, theft, and conflict of interests. The reliability and efficiency of the entire power system have suffered great adverse effects of these problems. For example, accidents (such as the damage of the Fallujah 132/33kV and 33/11kV Air Insulated Substation caused by a fire outbreak in the year 2006) have occurred at some substations, leading to reduced performance [2, 18, 19]. The increase in these problems has been triggered by the high number of unmetered customers, the absence of an efficient and effective system of billing, resulting in widespread illegal electrical connections that are unpaid. Another issue is that of the high rate of non- or under-collection of billed electricity, which in turn escalates the associated problems. Also, increased electricity supply-demand is a leading cause of power supply problems in Iraq. The Ministry of Electricity has estimated that the average increase rate of national peak load is 7.9% annually. Domestic consumers constitute 80% of the Iraqi electricity customer base, with these customers having more demand for electricity to power their heaters during winter and air conditioners during summer. As of 2013, an average of 8 hours of electricity was supplied to households in Iraq daily through the public power network [2, 20, 21]. While some households have access to alternative sources of power, about a quarter of the total number of customers has no alternative source. Residents of most governorates receive less than 18 hours of electricity daily, regardless of the presence of costly private and communal generates. More disturbing is the condition of 37% of Iraqi IDPs who receive less than 4 hours of electricity supply daily [22].

4. Main challenges facing the power sector of Iraq

Given the technically vertical nature of the electricity integrated system and the institutional decentralization, the development of an all-encompassing policy framework is needed for the whole value chain, which is inclusive of power generation, transmission, and distribution. The electric power sector is very capital intensive but has the potential of producing huge revenues when properly managed and operated. The Government of Iraq has clearly understood that it cannot bear all the financial burdens of the developments required in the power sector due to its other financial burdens in other sectors of the Iraqi economy. For this reason, it has become important to reform the sector in a manner that addresses the impeding issues mentioned in this paper. Such reforms can increase the financial performance and efficiency of the system since these are the major concerns of the Iraqi Government. More so, the reforms should be carried out in a manner that: Attracts and supports the engagement of the private sector in the operations and management of the Electricity Supply Industry (ESI); Attracts capital funds outside of the public and development finance sectors so that the expansion of electricity industry can be adequately financed, while the industry is upgraded. The Iraqi Electrical Supply Industry is faced with the following challenges:

1- The generation of electricity is heavily dependent on the use of simple cycle technology as well as heavy fuel oil (HFO), and gas flaring.
2- Low capacity of generating energy and inadequate units of energy generation.
3- Overloading of the different transmission and distribution components.
4- High technical and administrative transmission and distribution losses.
5- Absence of routine servicing and preventive practices across the value chain of ESI.
6- Insufficient distribution networks that are unable to meet the increasing needs of electricity consumers.
7- lack of efficient end-user metering system.

8- Electricity theft due to the high rate of illegal connections to the grid.
9- Low tariff coupled with deficiencies in billing and collection.

5. Reforms generation sector

In this paper, recommendations aimed at addressing the challenges of the electricity generation sector are proposed. These recommendations are concerned with the rehabilitation of extant plants, the addition of new units, and the replacement of obsolete infrastructure, beginning with the transmission and distribution facilities. More so, there is a need for more investments to be made in the areas of additional generation capacity as well as in the transmission and distribution sectors of the system so that the epileptic generation will not be further stranded.

The electricity generation system relies on thermal power plants that are run on natural gas and oil. Consequently, about 16% of the energy produced is generated by hydroelectric power. Despite this, a continuous decrease is observed in hydro share because of drought and increased upstream usage by other countries coupled with thermal power plants' expansion. The shortage of natural gas and fuel oil, as well as the banning of gas flaring in Iraq, has hampered on the reliability of fuel supply to generation plants. The majority of the older generation plants have been powered by crude oil and heavy fuel oil (HFO). The HFO produced in Iraq is insufficient and as such, it relies on the importation of costly finished products for power generation. It is impossible to resolve the electricity crises without sufficient feedstock for the thermal generation plants. To this end, it is recommended that the government design a strategy that ensures that most of the new generation plants are powered by natural gas; it is important to note that such plants are normally single-cycle plants. Another approach is the conversion of HFO-powered plants to natural gas-powered plants, as well as the conversion of open-cycle plants to combined-cycle gas turbines (CCGT) and hybridization with solar energy [23]. Presently, it is estimated that based on the advancement of natural gas generation plants, the daily need for natural gas will be 7-10 million metric tonnes. The production of this quantity can be achieved by Iraq if more potentials of gas are exploited alongside and gas flaring is banned. Measures that can enable the reforms in the power sector, especially the area of power generation are summarized as follows:

1- Conversion of fuel from heavy fuel oil to natural gas as well as CCGT. This means that the generation plants should begin using natural gas combined with solar energy so that new hybrid power plants such as integrated solar combined – cycle (ISCC) can emerge [22, 24].
2- the direct usage of renewable energy such as wind and solar or through hybridization with fossil fuel.
3- Outdated generation units should be phased out, revamped, or new ones are purchased.
4- The introduction of a generation expansion plan that is centered on the Natural Gas combined cycle and integrated solar combined cycle (ISCC).
5- As part of the generation expansion plan, the government should introduce private sector Independent Power Producers, targeting Natural Gas Open Cycles with place for a CCGT.

6. Reformation of the transmission and distribution systems

Given the increased generation capacity, it is evident that the limited transmission network is not sufficient enough to cater to the increased load which the network is overburdened with. This has led to unending unstable conditions of the system. In addition to this, the problem of high voltage exists, particularly close to clusters of power plants that are located in the central, Nothern, and Southern parts of the country. More so, the central area, particularly Baghdad is overburdened with high loads, which is an additional limitation to the transmission capacity of the systems. It is recommended that the Ministry of Electricity focus more on improving and expanding the capacity of the transmission system. With the present situation of things in the power sector of Iraq, there is a need for overhauling of the entire system, focusing on enhancing transmission infrastructure while reinforcing action. More so, more high voltage lines should be purchased so that the high electricity demand can be met.

Table 1. Transmission and distribution in Iraq [2]

Type	**2015**	**2017**	**Plan for 2022**
400 kV substations	29	52	82
400 kV overhead lines	5100 km	6000 km	9200 km

132 kV substations	219	283	391
132 kV overhead lines	12600 km	16000 km	20000 km

The Transmission Sector Reform procedures are summarized as follows: construction of new 400 kV transmission lines, construction of new 132 kV transmission lines, building new 400/132 kV substations, construction of new 132/33/11 kV substations, revamping of 400/132 kV substations, revamping of 132/33/11 kV substations, interconnection with power stations of neighboring countries, including Saudi Arabia, Turkey, and Iran, use of grid metering system, and enhancement of operational capabilities of the power system, including SCADA and dispatch control. The implementation of the reforms in terms of generating and transmitting electricity has great implications for the distribution sector due to the nature of the electricity production systems that are vertically technically integrated. Therefore, the reforms must be planned and well-coordinated so that the benefits of the reforms can be derived. Huge capital investment in distribution is required for new installed capacity in both generation and transmission sectors. Without a distribution bottleneck, this strategy will produce the needed results. To have a financially sustainable system, the distribution sector must gain economic sustainability as a matter of urgency. Presently, the consumer metering system is almost non-existent, as what is available is a cocktail of obsolete and ineffective meters alongside widespread electricity theft or illegal and unmetered connections. The MoE estimated the total number of unmetered connections at over 160,000, even though these connections are legal or with obsolete faulty meters. It is also recommended that strategic investment plans should be designed by the Ministry of Electricity so that the large physical asset components of the sector can be revived. These strategies should focus on replacing and expanding switch gears and substations, providing long 11kV feeders, fortifying and revamping the network, and expanding the critical communication infrastructure. Both regulatory and legislative policies must be made to facilitate the horizontal and vertical decentralization of the power sector and to incorporate service delivery from profit-oriented companies. These policies should allow private agents to control 70% of the activities of the generation and distribution sector. More so, there should be a 50% reduction of average technical commercial and collection losses so that the sector can be financially stable. If such policies are put in place, the electricity will be delivered to customers through modern and functional meters. More so, the revenue-grade interface between generation and transmission, transmission and distribution, and the border should be installed alongside the deployment of a multi-year tariff system. Furthermore, there should be provisions for lifeline tafiff, and transmission and retail tariff so that the needs of underprivileged and deserving consumers can be met. Also, to achieve total reformation of the power sector, provisions must be made for the Independent System Operator (ISP) to be a legal entity whose operations are independent of the interference of the Transmission Service Provider (TSP). More so, there should be structures and policies for contracts, particularly in terms of PPAs and Vesting contracts or bulk supply agreements between the single buyer and the distribution companies [12-16].

7. Conclusion

In general, the Iraqi power sector has suffered low performance, particularly in the areas of electricity generation, transmission, and distribution. These issues have emerged as a result of operational and administrative inefficiencies and negligence. Consequently, a lot of technical and non-technical losses have been incurred, amounting to 30-40 billion USD annually. The problems are also attributed to unplanned and unregulated expansions coupled with the use of an obsolete network, which has also over-burdened the system. Specifically, the problems that exist in the power sector include poor billing systems, ineffective metering, lower rate of revenue generation, inadequate funding, and poor management. Thus, this paper provides an analysis of the problems and presents some recommendations that can be deployed in improving the efficiency of the power sector. Most importantly, the paper suggests the total revamping of the power sector, which should be focusing on improving the billing and metering system, using legislative and regulatory provisions that allow the unbundling of the power sector, and engaging private agents in the three processes (generation, transmission, and distribution) of the power sector to enhance the performance of the sector, especially in terms of meeting the electricity demand of the populace. The reforms suggested in this paper have the potential to reduce the extremely high commercial and technical losses, improve the billing and revenue collection, as well the overall performance of the power sector.

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