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Iraqi Electricity Sector Overview



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Iraqi Electricity Sector Overview

Faisal Al-Saffar

Researcher, KAPITA

Safwa Salim

Professional Writer, KAPITA

Sarah Sallam

Translator, KAPITA

Mohammed Jamal

R&D Manager, KAPITA

m.jamal@kapita.iq



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info@kapita.iq



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Abbreviations

EIA	Energy Information Administration	KRG	Kurdistan Regional Government
EPC	Engineering, Procurement and Construction	kWh	Kilowatt-hour
GCC	Gulf Cooperation Council	LCOE	Levelized Cost of Electricity
GCCIA	Gulf Cooperation Council Interconnection Authority	MoE	Ministry of Electricity
GE	General Electric	MOU	Memorandum of Understanding
HFO	Heavy Fuel Oil	MW	Megawatt
IEA	International Energy Agency	PPA	Power Purchase Agreement
IEF	Iraq Energy Forum	PPP	Public-Private Partnership
IPP	Independent Power Producer	PV	Photovoltaic
IQD	Iraqi Dinar	UAE	United Arab Emirates
IMF	International Monetary Fund	USA	United States of America
		USD	United States Dollar

Related Definitions

- Electricity generation: is the process of producing electric energy by transforming other forms of energy; also, the amount of electric energy produced, expressed in kilowatt hours (kWh).¹
- Electric power distribution: the portion of the transmission and facilities of an electric system that is dedicated to delivering electric energy to an end-user.
- Electric power transmission: is the movement or transfer of electric energy over an interconnected group of lines and associated equipment between points of supply and points at which it is transformed for delivery to consumers or is delivered to other electric systems. transmission is considered to end when the energy is transformed for distribution to the consumer.
- Generation capacity: the amount of energy a power plant is able to produce, expressed in megawatts (MW). Mostly, generators do not operate at their full capacity all the time as the output varies according to many different factors and conditions.
- Grid: the layout of an electrical distribution system.
- Levelized cost of electricity: represents the average revenue per unit of electricity generated that would be required to recover the costs of building and operating a generating plant during an assumed financial life and duty cycle.
- Transmission network: a system of transmission or distribution lines so cross-connected and operated as to permit multiple power supply to any principal point.

Note: regarding the terms used in this report, Watt is the unit of power, and kWh is the unit of consumed power over time. To not dive into unnecessary technical details we can say almost M.V.A= MW.

¹ The definitions are retrieved from the glossary of the US Energy Information Administration (eia) : <https://www.eia.gov/tools/glossary/index.php?id=electricity>

Introduction

The electricity sector is an essential indicator of the development and the economic growth of a country. It is also a key player to promote the growth and the stability of the industrial sector (Burke et al., 2018). The Iraqi economy is known to be oil-dependent that lacks other developed sectors.

According to the International Monetary Fund, around 89% of government revenues in 2017 were from crude oil exports. The main focus of the government is on the petroleum industry which has led to the negligence of other sectors like the electrical and industrial sectors. The electrical sector has become highly dependent on the money generated from the oil revenues which are in turn proved to be unstable.

In this report, we will discuss the electrical sector from the state perspective, illustrate the role of the private sector, the latest developments, and highlight the possible ways to stabilize the fluctuating electrical grid.

Electricity supply is usually divided into three stages of the delivery process, it starts with the electricity generation, transmission, and distribution. The Ministry of Electricity follows this structure, where every stage of the delivery process is also segmented into regions, each region has a separate company. There are four regions: the south, the middle and upper Euphrates or midlands, Baghdad, and the north.

Historical Overview

- The earliest electrical connection in Iraq was established in 1917 in Khan Dala building in Baghdad.
- The areas that witnessed this first include Al-Rasheed Street, Bab Al Moatham, Karada Mariyam. The power was generated as direct current (DC) via diesel engines (archive of the Ministry of Electricity, 2008).
- Afterward, electricity was distributed to households and the demand started increasing which led to setting up a station with steam engines supplying alternating current (AC) and setting up a converter to supply consumers with direct current.
- Al-Sarafia station was opened in 1933.
- In 1955, Baghdad Light and Power limited company was nationalized.
- The general establishment of Baghdad distribution became a part of the Ministry of Industry and Minerals in 1987.
- The electricity system in Iraq suffered during the Gulf War in 1991 as many transmission lines and substations were damaged.
- In 1999, the Commission of Electricity was established as a separate entity from the Ministry of Industry and Minerals and the generating capacity reached 4,500 MW.
- The first Iraqi Ministry of Electricity was established in 2003.



One of the earliest electrical connections in Iraq in 1917.
(Al gardenia 2015)

Historical Overview

Following the war in 2003, the generation capacity was hindered, and citizens experienced long hours of power cuts. In the years to follow, the electricity sector continued to struggle affecting the economy negatively. The unstable situation, weak infrastructure, unreliable grid, subsidies policies, gas flaring, and mismanagement were and still are contributing to this issue.

In 2011, the grid electricity could meet only 55% of demand (IEA, 2012). The unreliable energy supply led to the widespread use of private diesel generators.

Natural gas provides economic advantages when used as a fuel for electricity generation. However, 60% of gas production was flared in Iraq in 2011 (IEA, 2012). The amount of gas flared in 2010 was 9 billion cubic meters, while it reached 16.8 billion cubic meters in 2018 (IEA, 2019).

The maximum grid supply was estimated at 16.4 GW in 2018 while the demand peak was 27.3 GW (IEA, 2019). The rehabilitation of the electrical grid is an important step in developing the country and promoting economic growth.



**AL-KHAIRAT 10 MODULES X125 MW SIMPLE CYCLE GAS
TURBINE POWER PLANT
(IDOM 2014)**

Electricity Supply by MoE

It is important to keep in mind as we delve into electricity generation that generated electricity is not interchangeably used as the capacity installed. Many factors determine the efficiency of electricity generation.

Iraq's generation capacity was lowered due to the imposed sanctions from 1990 until this day. In addition to the lack of spare parts and interruption of major maintenance cycles.

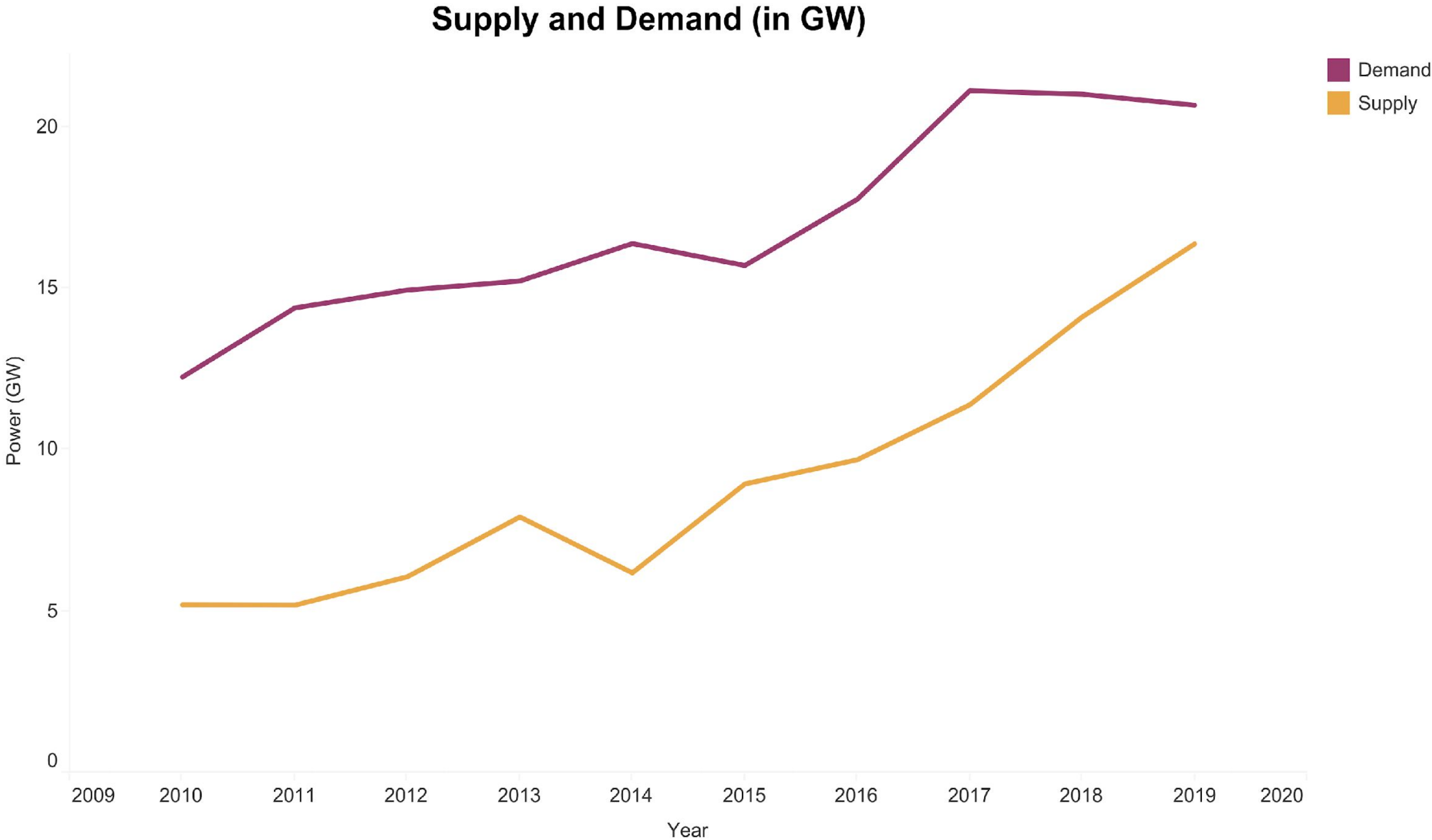
In 1990, Iraq had an installed capacity of 9,295 MW. However, one year later the capacity fell to 2,325 MW. By the end of 2002, the repaired units with limited resources reached 4,500 MW.

After 2003, the installed capacity was reduced again to 3,300 MW. While in 2008, the installed capacity reached 6,000 MW.

In 2008, the Minister of Electricity mentioned to Reuters that "The deals with GE, Siemens, and A third Company would be worth a total of \$7 billion to \$8 billion".

The three deals would enable Iraq to add around 10,000 MW-11,000 MW to installed capacity. However, in 2016 the installed capacity reached only 13000 MW.

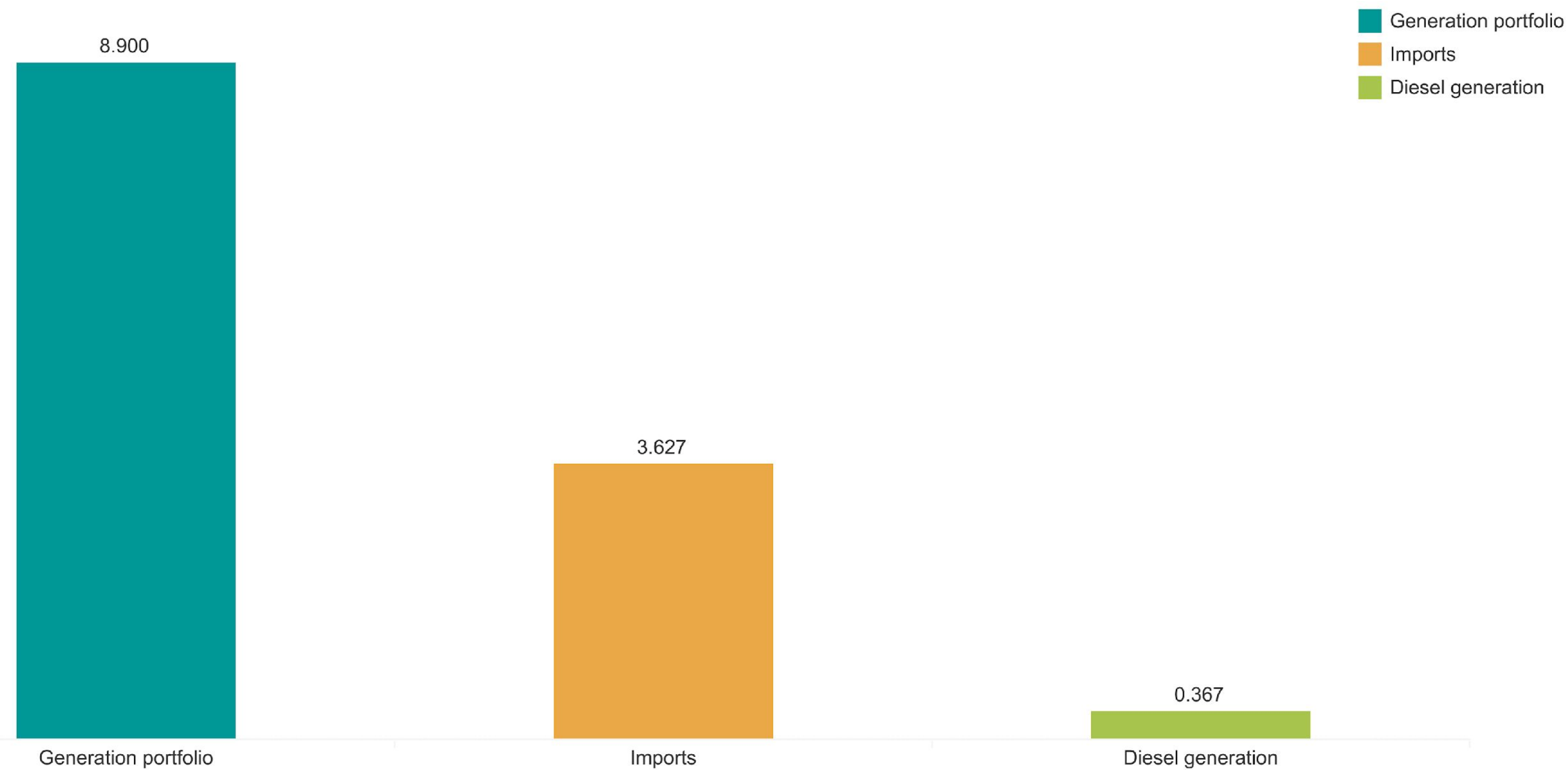
In 2010 the generation was supplying only 42% of the demand, while in 2013 the generation climbed up to 52%. It fell to 38% in 2014, and it reached up to 57% in 2015. In 2019, the generation exceeded 70%.



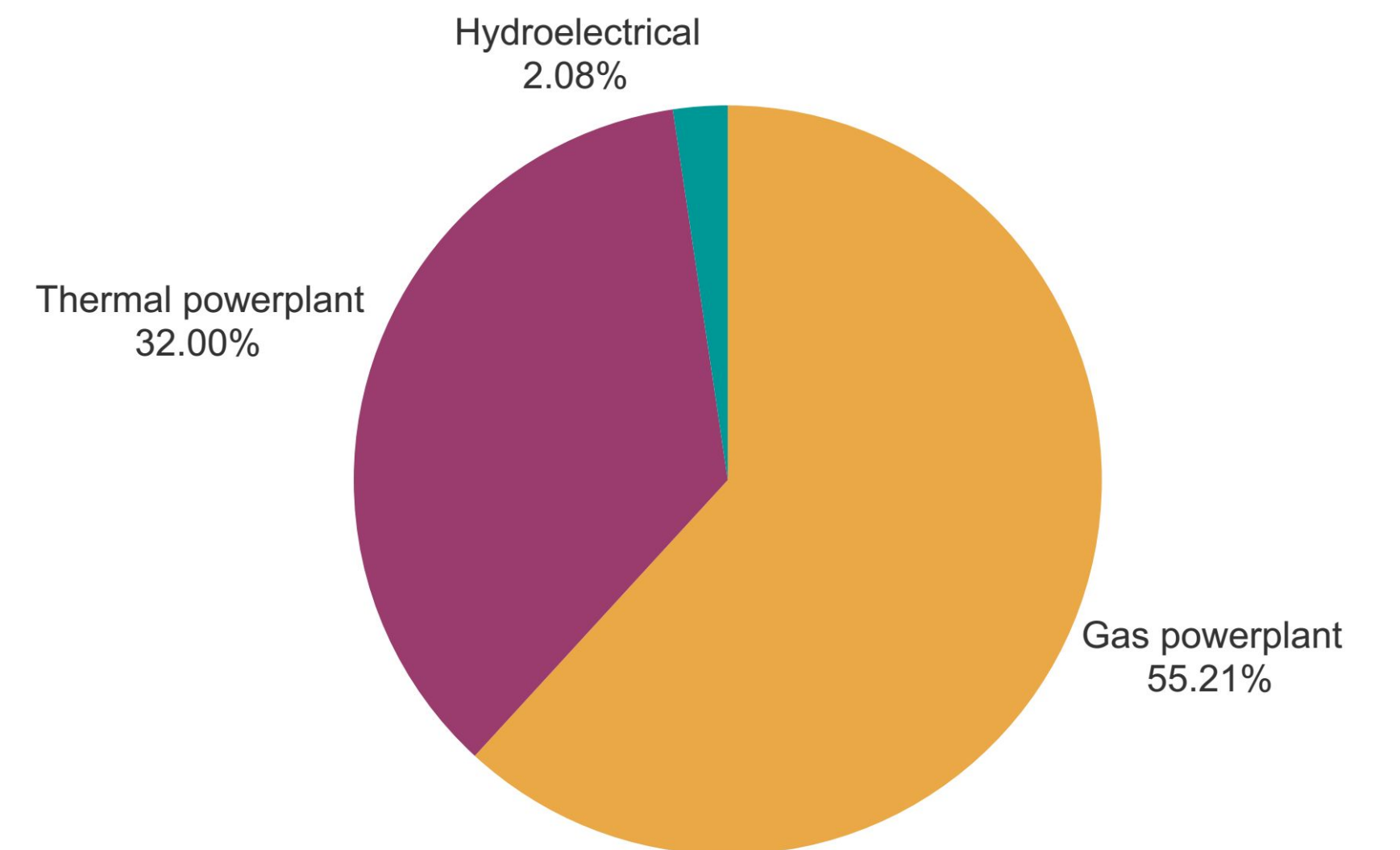
Electricity Supply by MoE - Generation Portfolio

The government provides electricity supply through multiple sources that include imports, diesel generation which is sourced by both MoE and the Iraqi Ministry of Oil, and MoE generation portfolio. The generation portfolio is composed of three different types of power plants. The majority of electricity supply is sourced by gas power plants, followed by thermal power plants, and hydroelectric power plants.

Supply Percentages



Percentage of Generation Portfolio



(Ministry of Electricity Annual Report, 2018)



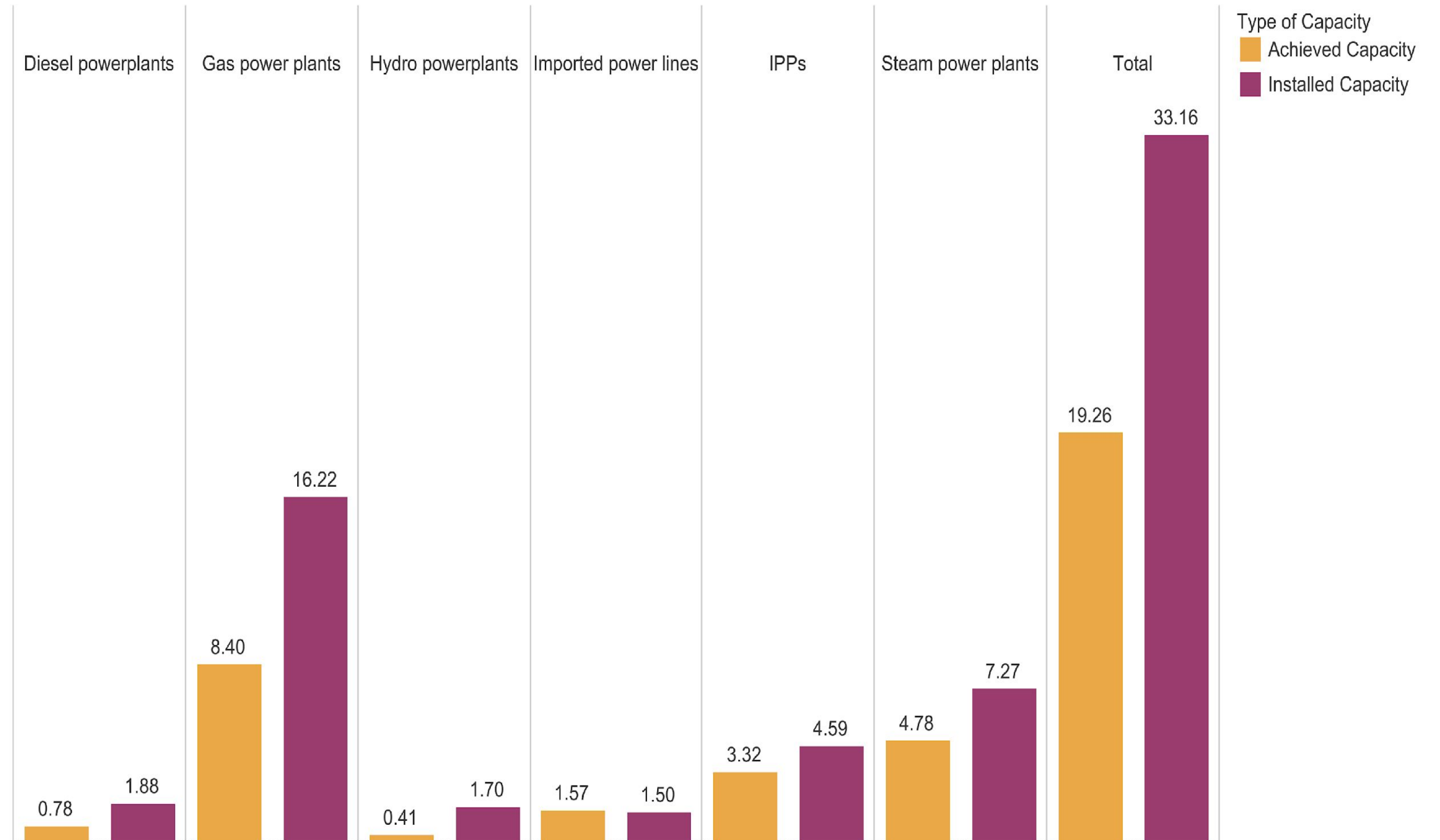
Electricity Supply by MoE - Generation Portfolio

This graph is based on the data presented by the Deputy Minister of Electricity in the Iraq Energy Forum (IEF) in 2019. Globally, the levelized cost of energy (LCOE) for gas power plants is higher than that of thermal power plants. In the case of Iraq, the cost of gas power plants is higher than that of steam power plants due to a set of factors including the type of fuel, which reduces the efficiency and increases the time and cost of maintenance.

Whereas steam power plants are more efficient and less costly. However, they can only supply the baseload power since they have a slower response time than that of gas power plants which are usually more rapid and used at peak loads.

The issue with the generation portfolio of the MoE is that the largest portion of the energy is generated with gas power plants instead of thermal power plants, which is less efficient and more costly.

Electricity Generation Capacity



Electricity Supply by MoE - Imports and Independent Power Producers (IPPS)

- Iraq imports electricity from Iran using four lines with a total capacity of 1,100 MW. It is also expected to purchase 300-400 MW of electricity from Turkey and 200 MW from Jordan.
- The first attempt was in 2003, despite tendering five projects and signing power purchase agreements (PPAs), the schemes proved impossible to finance due to security problems and disinterest among banks and other financiers in Iraqi infrastructure projects.
- Samawa Al Muthana cement Power Plant (owned by Shamara holding group) is an IPP plant based on 2 X G24 units for a total of 50 MW rated output.
- Enma' IPP: 64 MW, Shu'aiba IPP: 200 MW, Garmat Ali IPP:36 MW, and Hartha IPP: 120 MW. All of them are located in Basra.
- In 2017, Basmaya power plant (owned by Mass holding group) started to produce electricity to the national grid based on a PPA agreement with MoE to purchase 80-100% of the generation for 15 years at 3.2 cents per kWh. Now the total capacity is 3120 MW and they signed to increase it to 4500 MW with GE this year after the cabinet approval.
- Bazian power plant (owned by Qaiwan group) is located inside KRG in Sulimani, it is supplying KRI and federal Iraq as well.
- In May 2019, the MoE announced for investment licenses as IPPs to build seven PV farms in the southern region of Iraq with a total capacity of 755 MW.
- In 2019, the MoE signed an agreement with the GCCIA to connect Basra and purchase 500 MW.



**Besmaya Power Station in
Baghdad
(Mass Holding Group)**

Private Generators

Due to the shortage in the grid, people are left without electricity in the heat of the summer. Thus, people started to provide electricity in the neighborhoods using diesel private generators to satisfy their needs. People still rely on private generators to this day.

The ampere for 12 hours of the day costs on average 10,000 IQD per month which if the private operator operates all the time would cost the people 125 IQD per kWh. However, private generators only provide electricity supply half or three quarters at the worst times.

Private generators are no longer operating anymore in areas that were included in the PPP contracts. According to the International Energy Agency (IEA), the neighborhoods generators which we estimate provide 20% of the demand, charge a tariff that amounts to 600-1200 USD per megawatt. Subscriptions of 24 hours plan are more expensive than the conventional grid power supply.

Private generators charge around 20 USD per ampere of capacity. Therefore, a household looking to augment its grid supply with a neighborhood generator might pay over 300 USD per month for 15 amperes, it would need to power two air conditioning units, as well as a refrigerator and lights. In effect, neighborhood generators capture annual revenues of around 4 billion USD in 2018. This is equal to the amount allocated to the electricity sector in the federal budget for capital expenditure in 2019 (IEA, 2019).

Electrical Transmission Lines

- At the IEF in 2019, Nafa'a A. Ali, Deputy Minister of Electricity presented data about transmission lines, it stated that there are 65 lines of 400kV in comparison with the last detailed report of MoE in 2017, when there were 61 lines of 400kV but the length of the network has been shortened by 270 km, from 5,505 km to 5,235 km.
- While lower capacity transmission lines which are 132 kV, were 495 lines in 2017 and currently they increased to 548 lines with an increment in the length of the network from 11,882 km in 2017 to 13,876 km in 2019. In 2017, they were 18 stations for 400 kV transmission lines with a total capacity of 17,500 MVA, by 2019 they reached 41 stations with a total capacity of 29,500 MVA.
- For the lower voltage transmission lines of 132 kV, they were 234 stations with a total capacity of 32,717 MVA, by 2019 they have reached 247 stations with a total capacity of 38,333 MVA. In addition to 270 mobile stations with a total capacity of 6,556 MVA.

Interconnection with Neighboring Countries

- Iraq-Iran interconnections are the only interconnections operating now and provide the grid which consists of three transmission lines of 400 kV and one line of 132 kV.
- Iraq has an interconnection with Turkey consisting of two lines both are on hold, one is Mosul - Cizre which is not completed yet as the construction is on hold. The other is Zakho - Silopi which is operational on hold (constructed).
- In September 2019, MoE signed an agreement with GCCIA to construct a transmission line to interconnect Iraq with the GCC through Al Faw – Al Zour line.
- Also, MoE reached a final agreement about the technical requirements to interconnect Iraq with Jordan.
- These interconnections will benefit the grid as they add up more electric power to the grid without adding new power plants which will decrease the cost and emissions of the electricity delivery. Moreover, in case of emergency, if some power plants went off, it can still be possible to provide the grid with electricity bought from neighboring countries.
- Iraq will benefit from being a regional hub to transmit electric power between countries through Iraq transmission lines. In November 2019, the Iranian Minister of Energy stated that Iran would power Syria via Iraq in the future, which will increase the reliability of the transmission network not only on a domestic but also on a regional level.

Electricity Distribution

The distribution network suffered severely due to the losses in the network caused mainly by the trespassers on the network. In 2017, the total loss in the network reached 54% of the supplied electric power, in other words only 46% of the supplied power was sold to the customers and the rest was consumed by illegal connections on the network.

The substations and their capacities are the core and the valuable assets of the distribution network. In 2017, the number of 33/11 kV substations was 812 with a total capacity of 36,152 MVA. According to the 2018 MoE annual report, the capacity of medium voltage 33/11 kV was 37,859.5 MVA and low voltage 11/0.4 kV was 54,904 MVA. In 2019, the number of substations fell down to 743 with an increment in the capacity that reached 36,456 MVA. In addition to the 114 mobile substations with a total capacity of 2,180 MVA.

Although the distribution network capacity is developing, the problem is still persistent for the MoE. Thus, in 2016 the government started to award contracts of billing and services to the private sector companies, their duty was to protect the network from trespassers. However, they encountered other challenges due to the lack of expertise and communication with customers in the awarded companies.

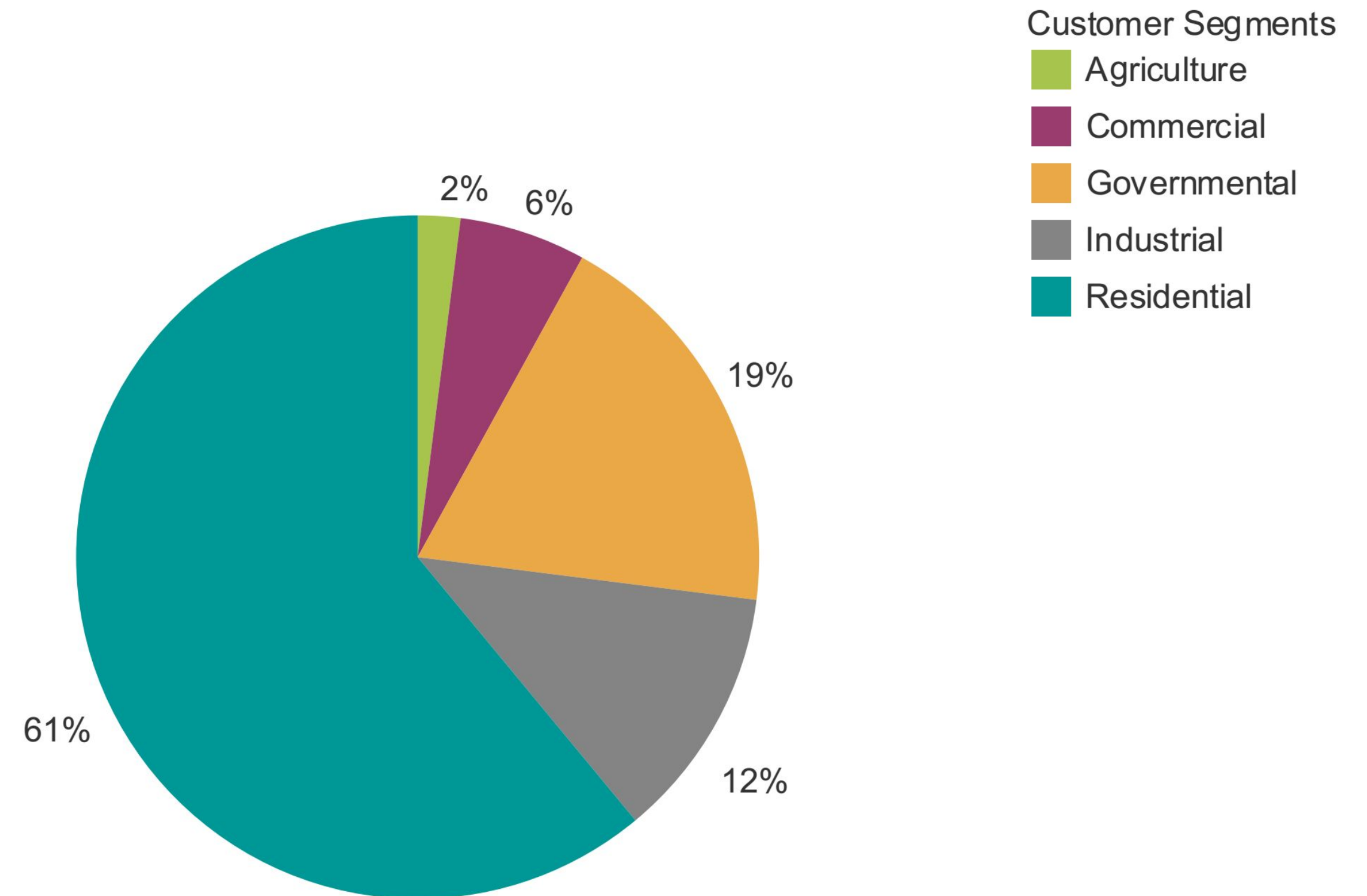
Customers

MoE segments customers into five segments: residential, governmental, commercial, industrial, and agricultural.

Residential customers consume the largest portion of 61%, followed by the governmental customers 19%, commercial customers 6%, the industrial 12%, and the agricultural customers consume 2%.

Tariffs in Iraq are low which explains the reason why consumption is growing at this rapid rate due to consumer behavior. The charged fee per kWh ranges from 10 to 120 IQD which is a low rate compared to the global price of 81 to 120 IQD per kWh.

Consumption Size of Customer Segments



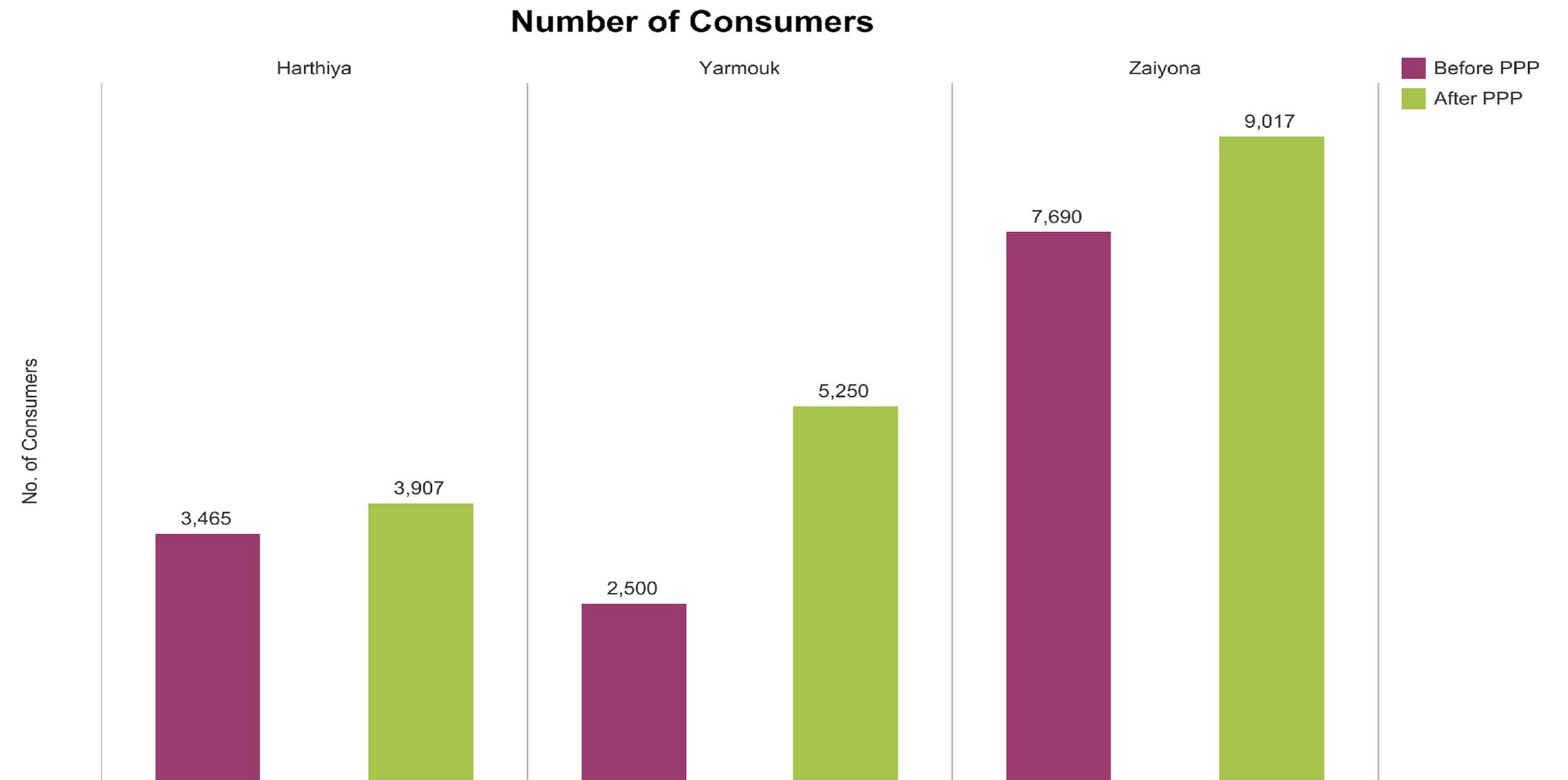
PPP Trial

The market model of electricity in Iraq has been a complete monopoly for the government until very recently. The PPP model started to appear in the form of IPPs license and service and billing contracts. PPP is expected to further grow as PPP contractors are performing better than the MoE.

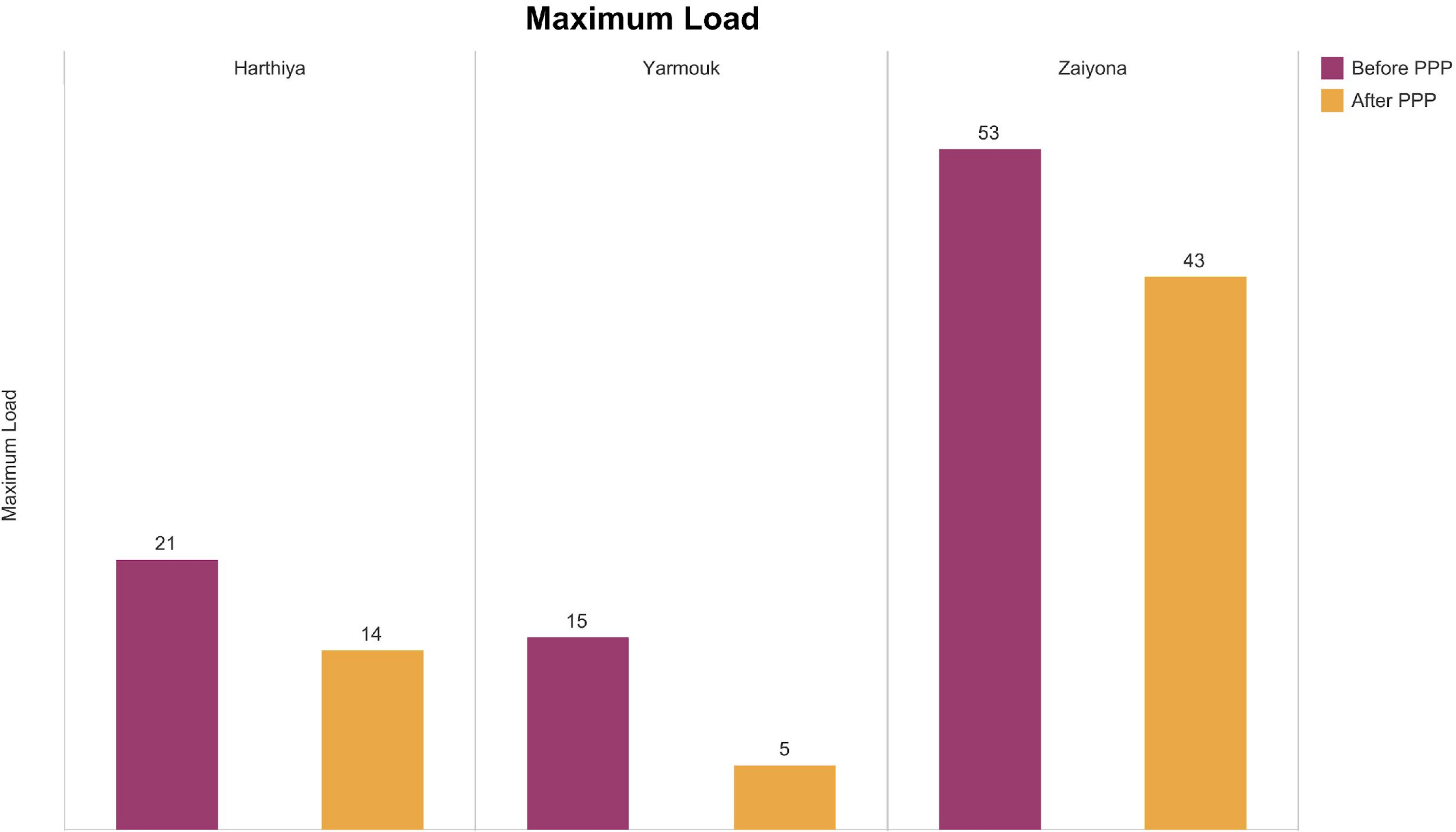
For example, Zaiyona, Yarmouk, and Harthiya were a part of a pilot project for the PPP contracts and the results show a decline in max loads from 89 MW to 62 MW and an increase in the number of consumers and collected bills from 13,655 consumers with total collected bills of 94 million IQD to 18,174 consumers with the total collected bills of 1.749 billion IQD.

However, the PPP model was not very welcomed by the public as the government was not quite transparent about this trial or the private companies who are managing this project.

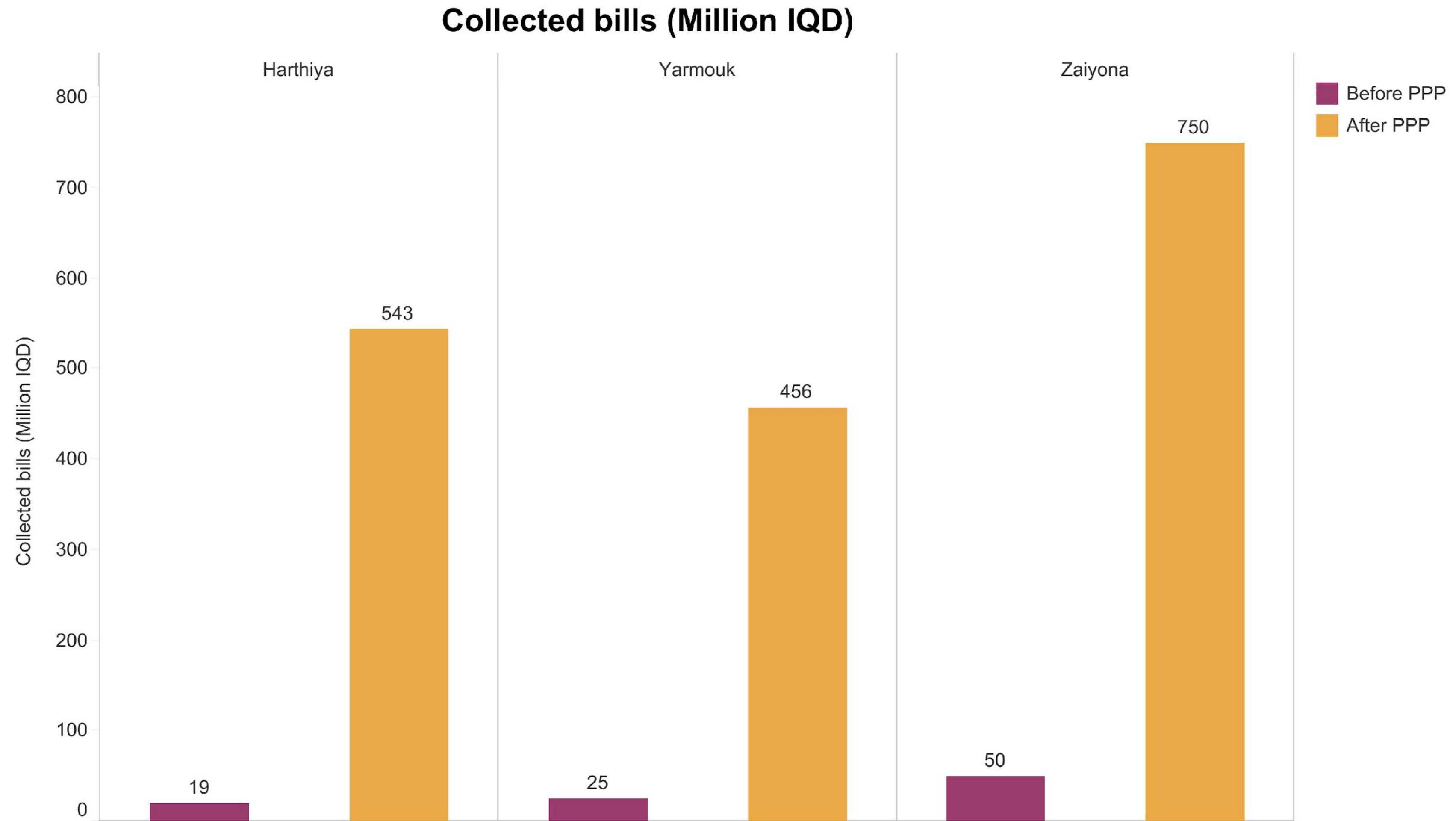
Different issues emerged, as the PPP trial did not focus mainly on providing citizens with uninterrupted electricity supply but rather on bills collection and increasing the electricity tariff to decrease the overall consumption. Furthermore, the trials were conducted in affluent areas where citizens might be able to afford to pay for these bills, while these trials would be not appropriate to apply in other areas. The PPP model is only handling one aspect of the electricity supply shortage which is the distribution and bills collection while disregarding the fact the MoE generation portfolio is not able to supply citizens with uninterrupted energy in the meantime.



PPP Trial



PPP Trial



Multinational Companies

Multinational companies such as GE and Siemens are playing a role in helping Iraq to recover and reform the electrical grid. In coordination with the MoE, they completed a package of contracts to reform the grid last year. They presented the document to the former cabinet “Roadmap For Repowering Iraq”, in addition to other EPC companies like Orascom Construction and Enka İnşaat.

➤ **Siemens:**

Siemens is a multinational company that was founded in 1847 in Germany; it operates in many sectors including energy, automation, mobility, digitization, and healthcare. Siemens, in cooperation with the Iraqi government, has built electrical infrastructure in Iraq in the 1930’s, and power plants in the 1970’s and 1980’s.

In April 2019, the Ministry of Electricity and Siemens signed the start of execution of the roadmap of Iraq. Phase one, short term, consisted of three contracts valued at 700 million euros. These contracts include the EPC construction of a 500 MW gas-fired power plant in Zubaidiya, the upgrade of 40 gas turbines with an upstream cooling system, and the installation of 13 of 132 kV substations along with 34 transformers across Iraq. They have added 700 MW to the grid. The beginning of phase two will include rebuilding Baiji 1 and Baiji 2 power plants in northern Iraq. These two have a total capacity of 1600 MW which will power the country’s largest refinery and thousands of households.

➤ **CMEC**

The China Machinery Engineering Corporation is a company that operates in the energy sector, construction, insurance, and real estate, which was founded in 1978. The company has been awarded a contract worth \$1.08 billion from the MoE to complete the thermal power plant in Salah Al Din province with a capacity of 1260 MW.

The Siemens logo consists of the word "SIEMENS" in a bold, teal, sans-serif font.

Multinational Companies

➤ General Electric (GE)

GE is an American multinational company, founded in 1892, and operates in multiple different fields like power, renewable energy, aviation, and many other sectors.

GE installed its first gas turbine in Iraq in 1965, and up until today, GE's technology is able to generate up to 55% of the country's electricity. In 2017, GE signed several new contracts worth a total of US \$1.4 billion with the Ministry of Electricity to add a further 2,000 MW to Iraq's grid. Under the agreements, GE would help supply turbines and other equipment as well as provide aid with engineering, procurement, and construction for a pair of new 750 MW power plants that were being built in Samawa and Thi Qar (GE, 2017). Phase 1 of the Samawa and Thi Qar power projects was completed and operational now. Also, GE has worked on rehabilitating Al Qayara power plant in Mosul.

Furthermore, GE signed a contract with Mass to upgrade the Basmaya power plant from 3120 MW to 4500 MW, by converting it from a simple cycle to a combined cycle adding 50% of the capacity without any use of extra fuel. Besides, GE's Renewable Grid Solutions landed a US \$727 million agreement with the Iraqi government to reinforce the transmission network and increase the grid's stability (GE, 2020).

In addition, GE has energized 5 new substations in 2020 in Baghdad and expects to develop another 9 substations by the end of 2021 across Iraq. Moreover, the Ministry of Finance, with the contribution of GE, has obtained loan agreements with various international financial institutions for energy sector projects that are worth more than US \$2.4 billion.



Iraqi Private Sector Companies

➤ Mass Group Holding

Mass Group Holding is a private company that was founded in 1994. It operates in three different sectors; electricity generation, cement production, and iron and steel manufacturing.

They established their first power plant in Kurdistan region in 2006. Their gas-fired power plants include Erbil power station and Sulaimaniya power station with a rated production capacity of 1500 MW each. In addition to Duhok power station which has a production capacity that can reach 1000 MW. They have also constructed the Basmaya power station in Baghdad. The combined cycle power plant has been equipped with 8 units of gas turbines type (9FA) and steam turbines type (7C) equipped by GE. The initial capacity of the plant is 3000 MW and will be further increased to 4500 MW.



➤ Qaiwan Group

Qaiwan Group is a private company that was founded in 1993. The company operates in many various sectors including energy, construction and real estate, hospitality, and education. The company has awarded ENKA for the construction of Bazian simple cycle power plant, which is equipped by 4 units of GE's 9E gas turbines. The total plant capacity reaches 500 MW and is expected to double with the expansion of the combined cycle project.



➤ KAR Group

KAR Group is a private company that was founded in 1999. It operates in the energy sector, construction and engineering, and cement industry. The company has constructed the Khurmala power plant with a capacity of 1000 MW, the power plant is located south of Erbil and utilizes the natural gas from the Khurmala oil field which is also owned by KAR group. The power plant is equipped by Siemens and cost around \$1 billion, the plant is expected to supply over 3 million people with reliable energy.



Iraqi Private Sector Companies

➤ Raban Al-Safina Group

Raban Al-Safina was founded in 1997 in Baghdad. They operate in the energy sector, construction, systems technology and automation, security services, trading, and other sectors. They own one of the largest factories in Najaf for products and equipment manufacturing. They have been licensed by Siemens to manufacture low and medium voltage distribution products. Furthermore, they supply solar energy equipment such as street lighting systems and charge controllers.



➤ AL-HANDASYA

AL-HANDASYA for Electrical Industries is a private company specialized in manufacturing and supplying electrical equipment. They are licensed by Schneider electric to produce MV switchgear 36 kV and 24 kV, kiosk substations, and low voltage switchboards. In January of 2020, they have supplied Basmaya city with a substation of 11/0.416 kV and they will install more kiosks in the future. Furthermore, they have assembled 3 mobile substations 33/11 kV for MoE with SCADA (supervisory control and data acquisition) system that has been equipped by Schneider.



Cost and Subsidy

The current amount of the electricity subsidy varies between 78.3%- 87.0% based on 61% of aggregate technical and commercial losses as shown in the table below (Iraq Energy Institute, 2020).²

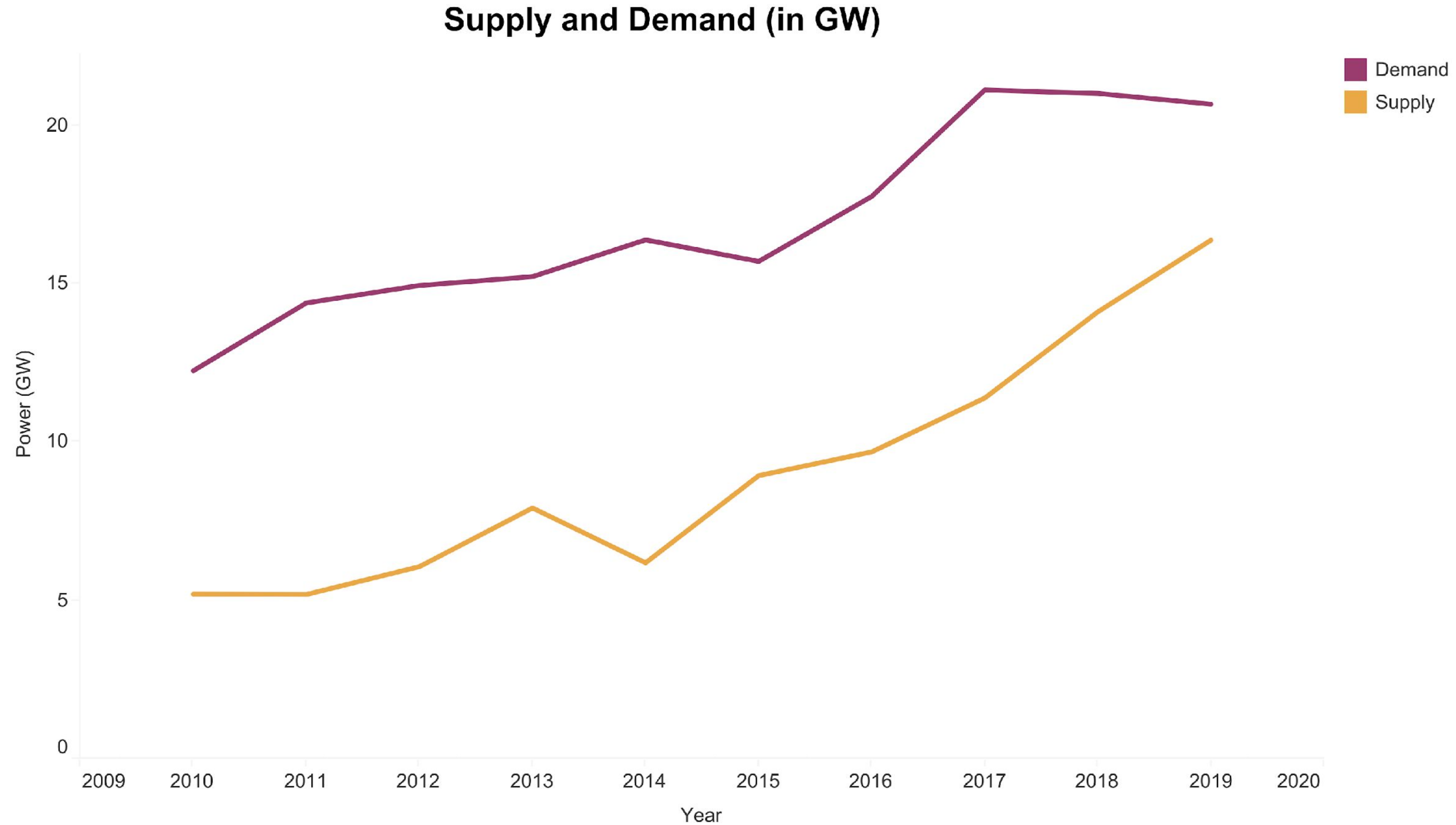
Subsidies amount with and without fuel subsidies (2018)

	With subsidized fuel	Without subsidized fuel
Total Actual Production without commercial losses (million MWh)	102.53	
Total cost of electricity production (billion IQD) [billion US\$]	7,218 [6.04]	12,032 [10.07]
Losses (%)	61%	
Electricity received after commercial losses (million MWh)	39.95	
Collected revenue (billion IQD) [billion US\$]	1,568 [1.31]	
Subsidies (billion IQD) [billion US\$]	5,650 [4.73]	10,464 [8.76]
Percentage of financial subsidies (%)	78.30%	87.00%

² The exchange rate in this table and throughout the report reflects the value used by the cited sources or the value at the time of data collection. Therefore, the exchange rate might vary slightly.

Issues of the Electricity Sector - Supply Shortage

Since 1990, Iraq has been suffering from supply shortage due to severe damage in the generation units. After 2003, all the added units were not sufficient for the demand growth due to the poor budget that was allocated for these projects. Corruption and misconduct have also contributed to this issue.



Issues of the Electricity Sector - Fuel Type

Iraq relies more on gas turbines than steam turbines, gas turbines (gas-fired) are suitable to use multiple fuel types but it would affect the production efficiency, operation cost, and maintenance cycle. Natural gas is the most efficient type of fuel to be used for these units. However, Iraq has relied on heavy crude oil for years to power the units until 2019 as Iraq switched to using natural gas in a few of the units and the number is increasing. This helped the MoE to increase the generation of these units by 10-20% and reduced the operation and maintenance cost.

Besides, the government imports natural gas for Basmaya power plant which is also a cost for the power purchased from this PPA. In case the price of buying the natural gas per kWh from Iran which is 7.5 US cents is added to the price of kWh from Basmaya 3.2 cent without other costs such as transportation, it would add up to 10.7 cents per kWh. While MoE sells the kWh to the consumers at a rate of 0.87-4.35 cents.

Even if we assume we cannot produce natural gas due to a variety of reasons such as security issues, lobbying, and corruption. Iraq flares the associated natural gas, even though sources like Akkas natural gas field exist and the company was awarded by the Ministry of Oil, however, KOGAS cannot operate there because of security issues.

On 10/12/2019 the Minister of electricity announced that the gas pipeline that imports our need for natural gas from Iran has stopped from 18th to 25th of November for maintenance on the Iranian side. After maintaining the pipeline, the imported quantity of the natural gas fell a quarter below our need which resulted in a shutdown and reduced production by using alternative fuel.

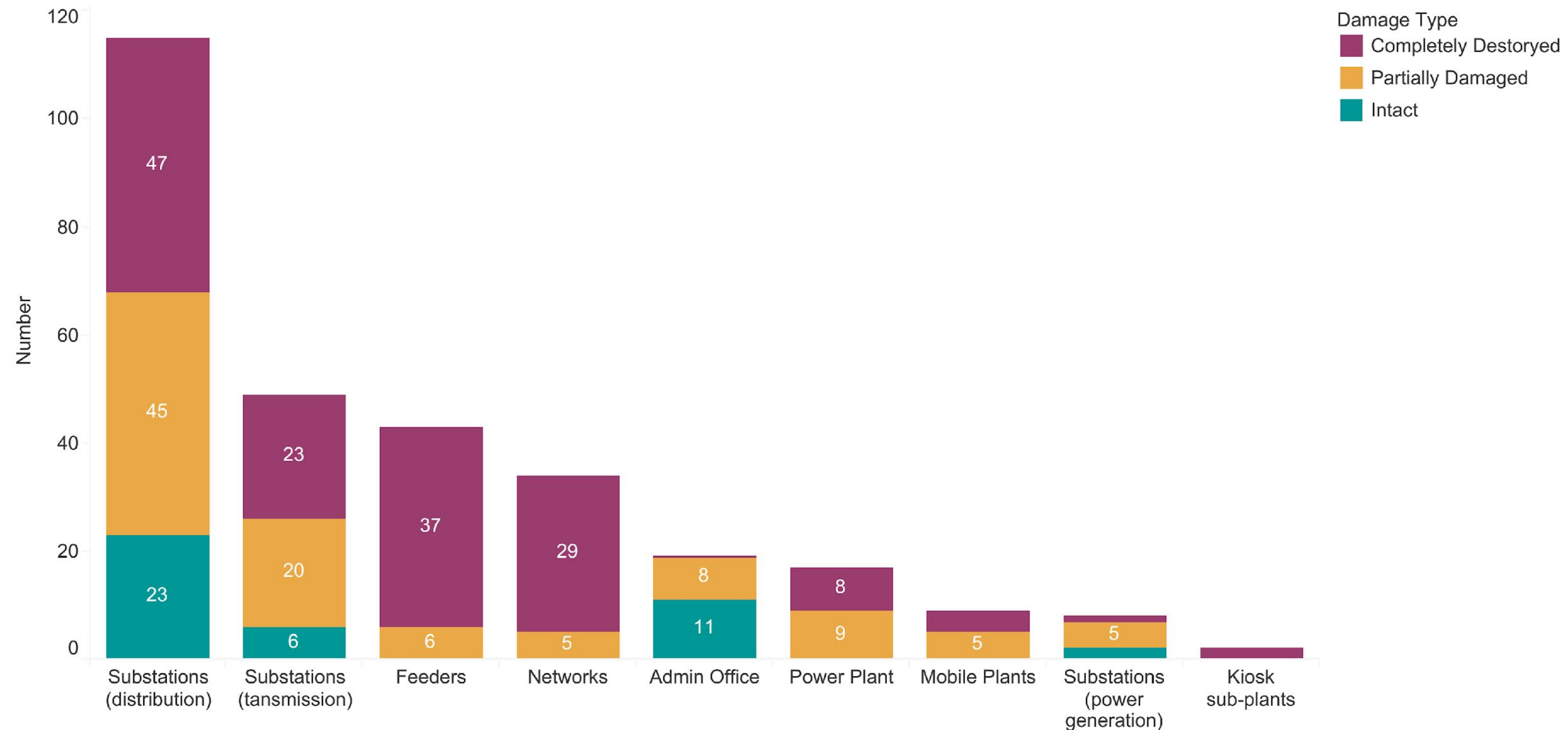
In conclusion, Iraq needs to put a stop to the flaring policies, reduce the reliance on imports, and start producing its need for natural gas to maintain the reliability of the grid.

Issues of the Electricity Sector - Conflict Affected Areas

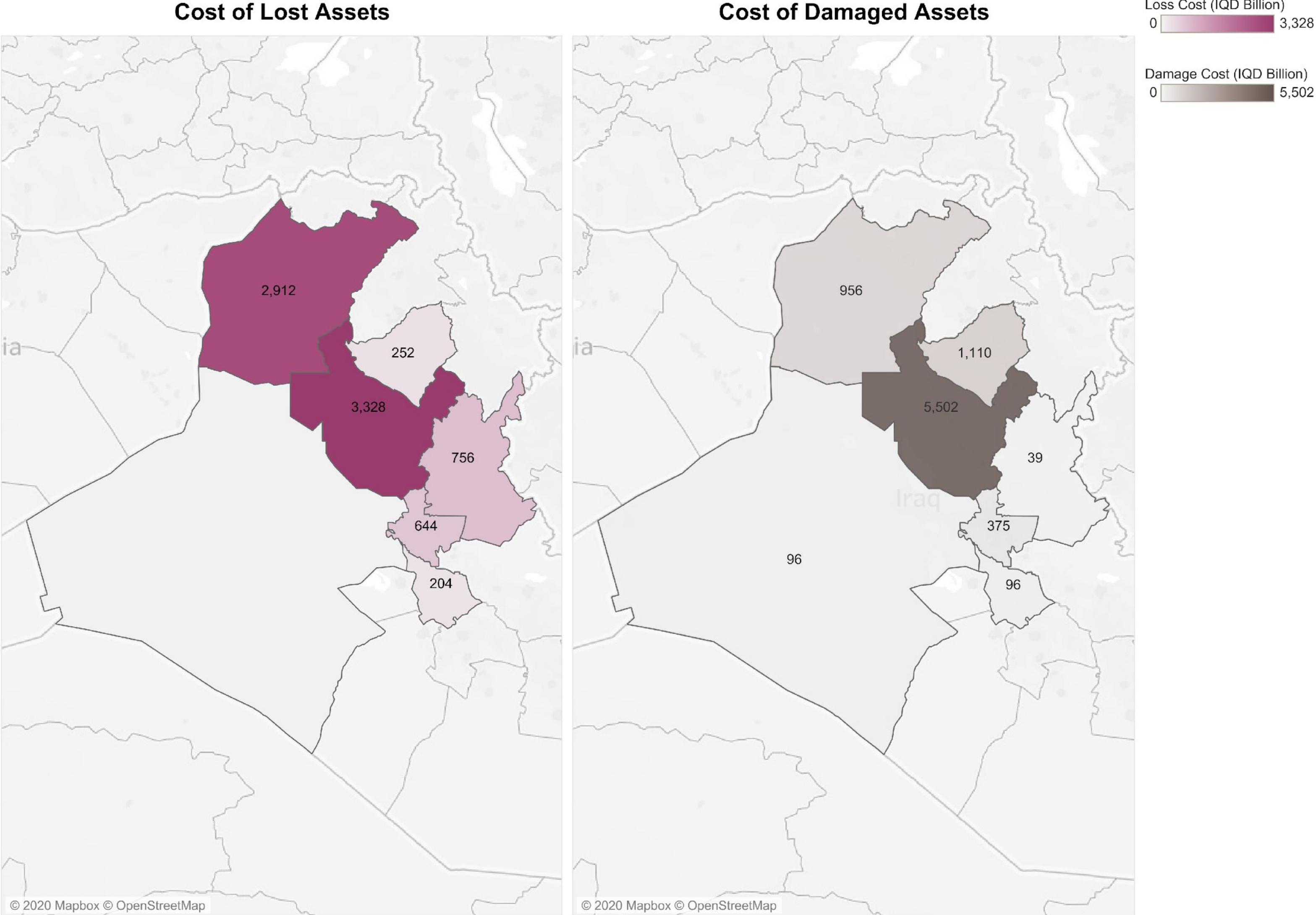
The ISIS crisis caused severe damages to the electrical grid estimated at 7 billion USD. Eight power plants were completely destroyed and twenty-five were damaged. Twenty-three transmission substations were destroyed and sixty-three were damaged. Forty-seven distribution substations were destroyed and one hundred thirty-seven were damaged. GE has signed contracts to help those areas recover (World Bank, 2018).

Number of Damaged Assets in Conflict-affected Areas

*The length of the bar represents the baseline number of assets



Issues of the Electricity Sector - Conflict Affected Areas



Issues of the Electricity Sector - Trespassing on the Electrical Grid

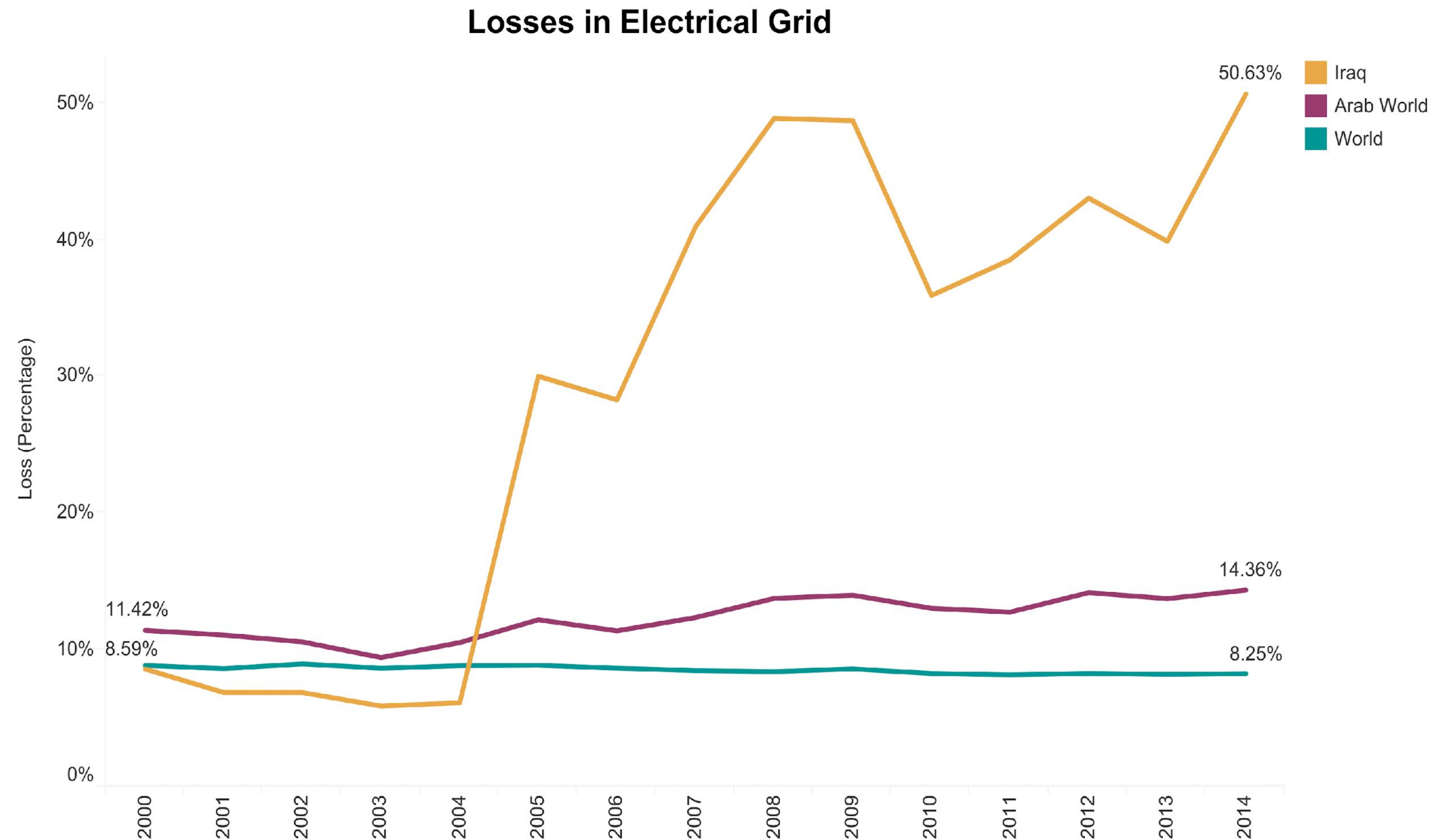
One of the main issues that cause losses in the electrical grid is the trespassing of consumers on the grid.

Many high power appliances are connected and consuming without being metered, while other low power appliances like light bulbs are connected to the line that is being metered by MoE.

This pattern of consumer behavior causes losses in the grid up to 54% of the supplied power which means only 46% of the supplied electricity is actually billed. Hence, not everyone is paying their real worth of usage bills. Thus, it is difficult to assume that the consumers paid 46% of the supply worth, it might be even less than 46%.

The PPP showed some results in the pilot project but Iraq still needs more professional, transparent, co-operative, and qualified infrastructure than the private companies that were awarded contracts of billing and service.

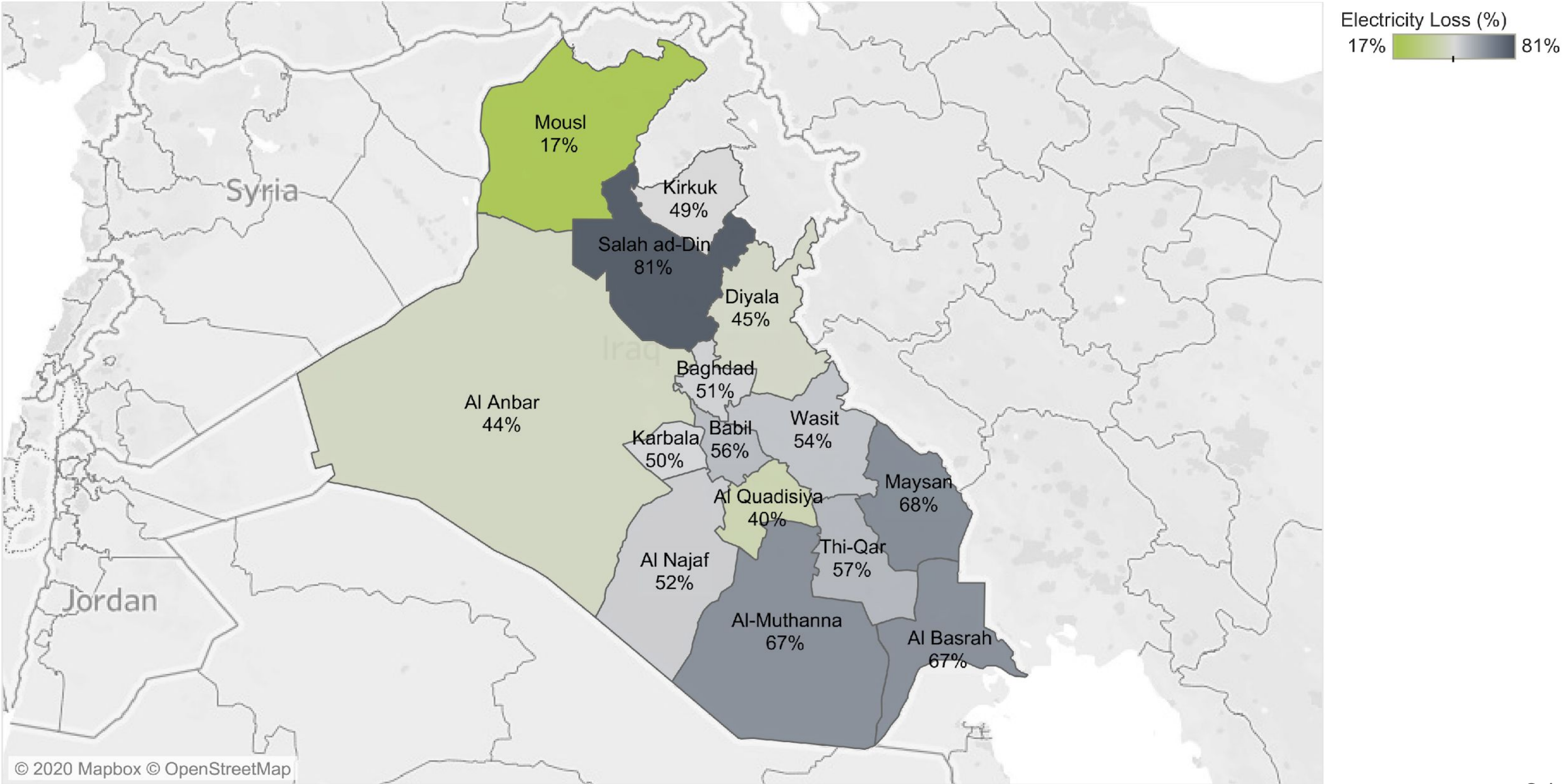
In addition to local electricians manipulation with mainboards of households which causes damage to the low-voltage distribution units due to the unequally distributed loads in regards to the specifications of the units.



Issues of the Electricity Sector - Trespassing on the Electrical Grid

As shown in the graph, the highest losses occur in areas with limited cultural background, like Saladin. While the lowest losses occur in the good cultural background areas, like Mosul.

Electrical Grid Losses by City



Issues of the Electricity Sector - Consumer Behavior

Electricity supply hours have declined specifically in Baghdad after 2003 due to the transition in the operation mechanism. The climate in Iraq is significantly hot especially during summer, people need electricity to operate fans, air conditioners, and air coolers. This leads to an increase in electricity demand.

Many people started buying diesel generators and selling electricity supply via monthly subscriptions for specific capacity measured by amperes to control it by a circuit breaker. It might be not the optimal solution but the huge electricity demand has started the trend of employing private generators in neighborhoods and making a profit out of them.

Since 1990 and even after 2003 for a while, people were not buying many household appliances due to the limited purchasing power and the limited supply of electricity. The population growth increased the electricity demand which was supplied mostly by the private generators.

Only the high power appliances were operating during the public electricity supply. Thus, people started to switch appliances on and off during the private generators supply hours due to the limited capacity they subscribed to as they did not want the electrical source to go off due to the circuit breaker. Besides, they switch on almost everything during the public electricity supply due to the limited hours of supply and the subsidized prices of electricity. However, some people do not pay their electricity bill even though the price is subsidized. Electricity subsidy costs the state 12 billion USD.

Issues of the Electricity Sector - Consumer Behavior

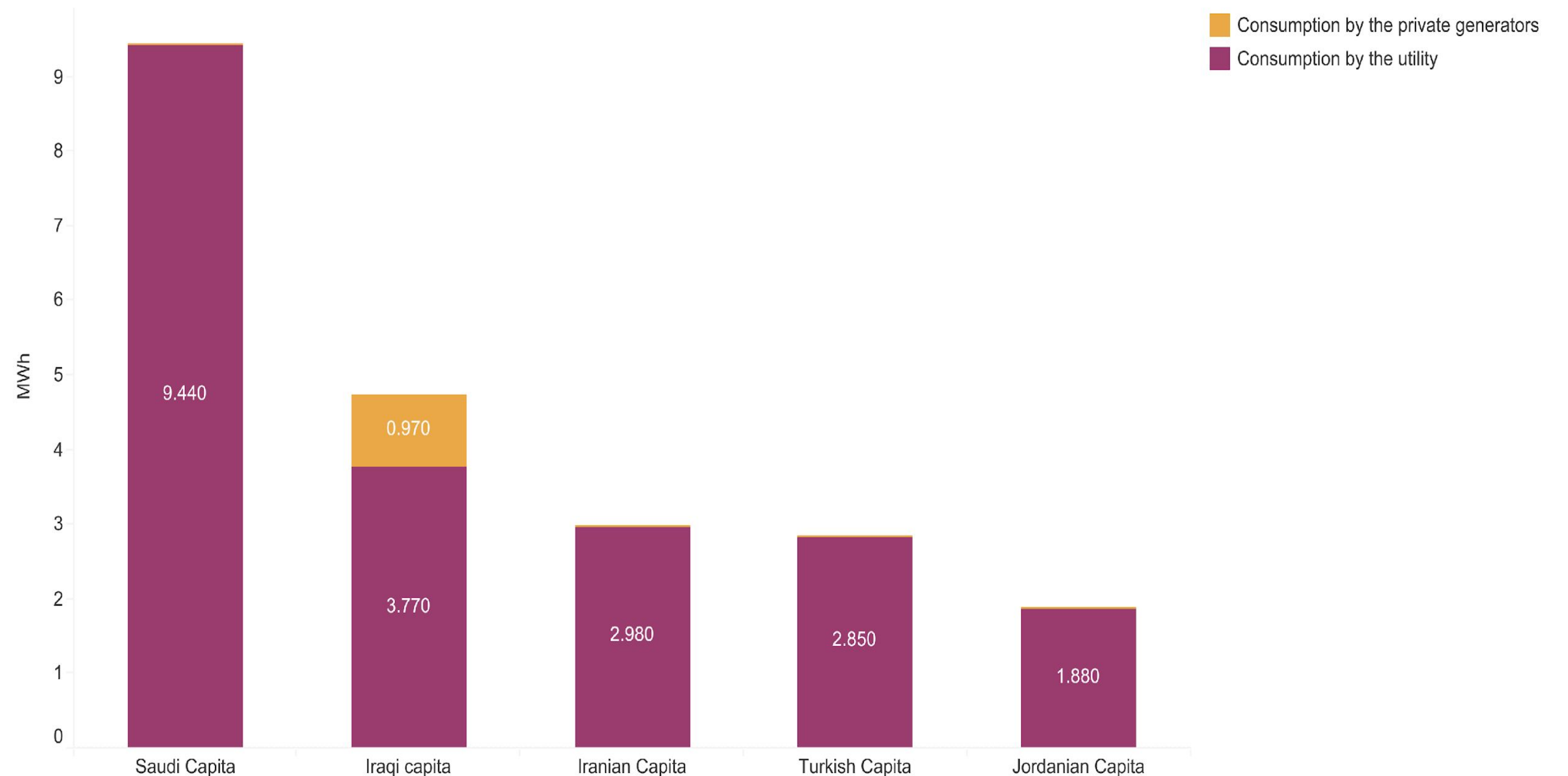
We calculated the electricity consumption annually per capita based on MoE data about the supply and demand In 2019. It is shown that the Iraqi citizen needs 4.74 MWh/year per capita. While the state only supplies 3.77 MWh/year per capita.

The remaining demand is supplied by private generators, people monitor their consumption during the private generator operation hours due to its cost and limited capacity which is measured by amperes. This shifted the consumers' mentality to care about the capacity needed instead of energy consumption.

Therefore, private generators charge very high per MWh. Private generators supply the shortage by monthly subscription fees that vary according to time and place but the average cost is 15,000 IQD per ampere, the majority of the households subscribe to 8 amperes which cost annually 1,800,000 IQD (1500 USD) but this also varies according to the household size.³

Hence, the shortage of the electric utility is 0.970 MWh/year per capita which costs 1,047,600 IQD (873 USD) based on the average of the MWh cost from private generators in Iraq from the IEA. While the demand that is supplied by the state costs 132,000 IQD (110 USD) annually based on the average of resident consumers' tariffs. In total, the cost of electricity annually is 1,179,600 IQD (983 USD) per capita.

Annual Electricity Consumption per Capita in MWh

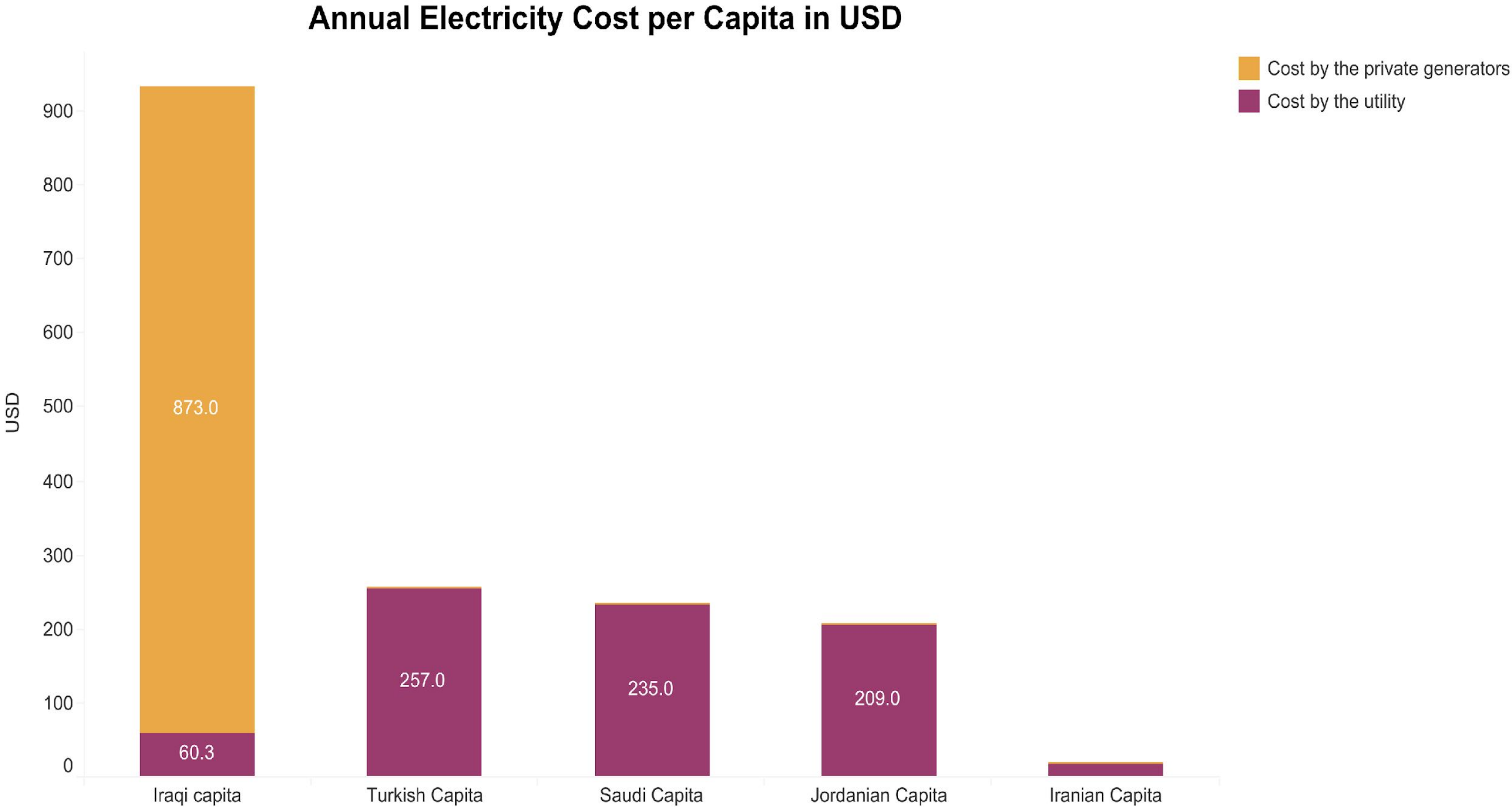


³ The exchange rate used throughout our calculations is assumed as 1 USD = 1200 IQD.



Issues of the Electricity Sector - Consumer Behavior

When comparing the electricity demand per capita considering the average tariff for households in each country we find that in Turkey the electricity demand is 2.85 MWh/year per capita and costs 257 USD. While in Iran it is 2.98 MWh/year per capita and costs 21 USD. In Jordan, the demand is 1.88 MWh/year per capita and costs 209 USD, and in Saudi Arabia 9.44 MWh/year per capita that costs 235 USD.



Issues of the Electricity Sector - Consumer Behavior

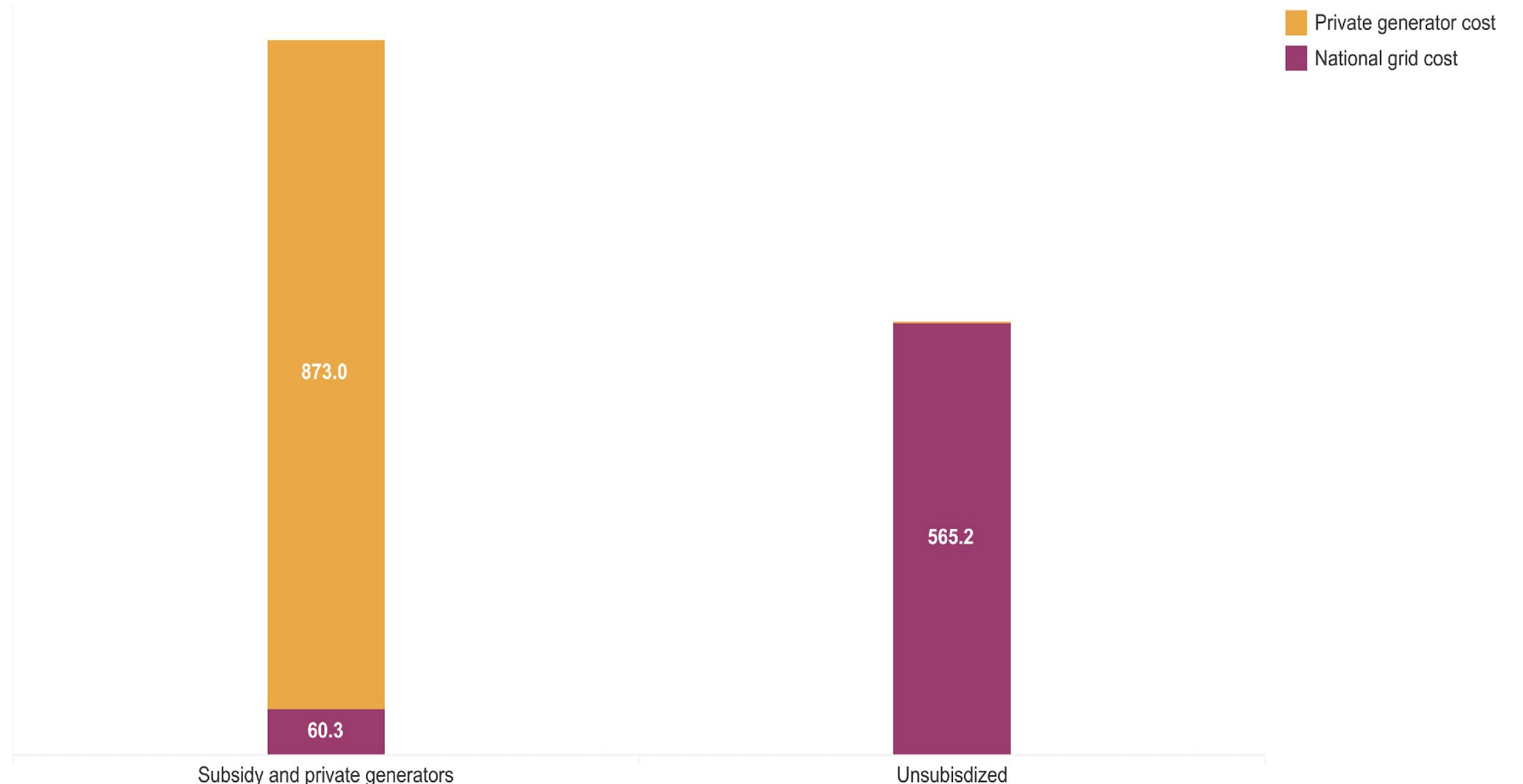
Reducing the consumers' demand and increasing the government's supply would help to bridge the gap and to reach 100% of the electricity supplied by the public utility, which makes it more reliable and affordable as it would cost 564,000 IQD (470 USD) annually when considering the same consumption rate in 2019 but at a higher state tariff of 120 IQD (0.1 USD) per kWh.

This would reduce the subsidies on the services provided for the residential consumers but more affordable and reliable in total. The difference would be to pay the state instead of private generators for electricity supply.

The average electricity generation in 2019 is 16500 MW. If this was charged at a rate of 120 IQD (0.1 USD) per kWh, in addition to fixing the losses caused by the trespassers on the grid excluding the technical losses and bills collection issues, it would generate revenues to the MoE that could reach 13 billion USD which would be exceeding the state subsidy for the electricity and the budget would be allocated for building and development programs.

If people started to consider efficient consumption seriously, it would help the grid to reduce the needed capacity. For example, changing only "one" economy loop bulb of 45 watts to LED bulb of 15 watts in every registered household in the grid would save more than 125 MW in capacity while The GE 9E.03 unit capacity is 132 MW.

Electricity Cost per Capita Entirely Reliant on Unsubsidized Grid vs. Subsidized Grid and Private Generators



Current Available Investment Public Projects

- According to the MoE renewable energy plan of 2017-2020, there were supposed to be 2695 MW of PV farms, As they have awarded the locations to some companies but no progress has been made yet.
- In 2019, the MoE announced investment opportunities for IPP using solar PV only with a total capacity of 755 MW. Also, in the upcoming period, they are planning to support poor residential users with small PV solar systems (3 kW) that cost a total of 15 million USD. Later in 2020, a tender was announced to provide solar systems in 6 provinces, but it was postponed due to the current financial situation.
- In July 2020, Najaf investment commission has announced an investment opportunity for a PV project in the Najaf desert, the assigned land covers a total area of 1807.2 Dunam (1 Dunam =2500 m²).

Conclusions and Recommendations

- The electrical grid of Iraq is highly subsidized which reduces investment potential for the private sector and international investors in most cases.
- Iraqi consumer pay doubles the cost that is needed to lift the subsidies on the electrical grid.
- if the electrical grid will lift the subsidy, electricity growth rates will decrease, and it will be much easier to track.
- Inefficient management of the electrical grid operations and maintenance due to outdated infrastructure for fuel supplies affects the whole generation portfolio efficiency.
- The annual growth of energy consumption is high and it is not fulfilled by supply, neither controlled by the tariffs.
- Iraq has a poorly designed portfolio, it relies on the usage of gas power plants (gas turbines) instead of thermal power plants (steam turbines) for about 73% of the generation supplying both the baseload and peaking load. Most of the time HFO is operating instead of natural gas which impacts efficiency, working hours, and increases operations and maintenance costs.
- Coming up with strategies to improve the process of bills collection will decrease the losses in the distribution networks and costs. This will also lead to decreasing demand and promoting efficient consumption.
- PPP plays a role in distribution networks, it helps decreasing demand and increasing both registered users and revenue.
- Demand management and shifting the customers' behavior towards more efficient consumption patterns would impact the peaks and average demand in considerable amounts.
- Encouraging households to distribute generation would reduce the load on the transmission and distribution since a percentage of the demand is supplied locally, by distributed generation we mean solar panel. Also, providing net-metering for consumers so citizens could use the grid as virtual storage and cut the high costs of energy storage.
- Initiatives to distribute electricity generation like community solar project, where members have access to energy supply from a solar farm, members can also own shares in the project which in return makes them gain benefits from the power produced and receive credits on their electricity bills.
- Increasing the percentage of renewables in the Iraqi power generation portfolio would reduce the greenhouse gases and the total cost of the bills since they would be self-sufficient in the day time.

Conclusions and Recommendations

- Energy tariffs reforms would be necessary to shift towards a time-based structure where the tariff amount increases during peak times like midday. Therefore reducing peaks and the transformers crashing possibility.
- Law No. 53 of the year 2017 as stated in the Official Gazette of the Iraqi Republic promotes partnerships between the public and the private sector when it comes to the generation and distribution processes. However, the legal framework does not include the transmission networks which limits the PPP projects.
- Improving PPP models in different aspects other than billing, like managing microgrids to reduce the costs of the operations and increase profitability.
- Incentivizing distributed generation for consumers using solar PV systems with a stable microgrid. In addition to promoting net-metering as virtual storage in solar systems that would reduce initial costs and periodical costs of storage replacement.
- The inclusion of distributed generation and distribution will help to bypass the transmission network bottlenecks.
- The electricity sector has many technical limitations in Iraq, empowering the private sector and the multinational companies to employ their platforms that support data analytics functionalities would overcome these limitations, unleash great potentials, limit fraud, and increase efficiency.
- Public energy subsidies are budget intensive and result in poor quality services. In addition to the shortage in providing these services. Energy subsidy reforms as suggested in the White Paper for Economic Reforms which has been released in October 2020, would stabilize the electricity sector, improve its performance and services, and decrease the debts.
- Energy subsidy reforms will overall decrease what citizens pay for electricity, as the need to subscribe to private generators would decrease due to a more stable electricity supply.
- Encouraging entrepreneurial initiatives and startups in the electricity sectors.

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