مركز البيان للدراسات والتخطيط
Al-Bayan Center for Planning and Studies

The construction of future electric power plants in Iraq with data of current and futurewater resources

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Al-Bayan Center Publications Series

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Dr. Karim Wahid Hassan*

1.Introduction

Approximately 68% of the Tigris River basin revenues and 97% of the Euphrates River revenues flow in from outside Iraq (Turkey, Syria and Iran). As a result of the evolution use of water in those countries (by irrigation and storage projects), with the absence of mutual agreements that determine each `ountry's share of the water and as Iraq is a downstream position leaves the country in an awkward position due to the negative effects this has on countries located in an upstream position and disturbs their procedures amidst the reality that illustrates that an approximation of only 55% to calculate the available water resources of the total requirements.

This shortfall necessitated reconsideration into the adoption of water resources for industrial purposes; including future construction of electrical energy steam power plants, as they mainly rely on river water to complete the cooling process. Additionally, future lower water levels in rivers below the average levels could influence the work of the recirculation pumps in the water outlet level, which ultimately leads to damaging the pumps because of the phenomenon of cavitation.

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The objective of this study:

•An assessment of the current phase of the plants producing energy.

•Setting indices for a plan to build energy production projects and in light of the water situation in Iraq.

•Proposing techniques that could be adopted in the future to address any problems.

2.The current situation and future of water in Iraq

The Tigris and Euphrates Rivers and their tributaries form the basis of Iraq's water resources. The annual average discharges of water to Iraq are as follows:

Tigris River and its tributaries (Great Zab, Little Zab, Diyala and Al-Authaim): 49.4 billion m³,

Euphrates River up to 1975: 30.3 billion m³; therefore an accumulation of 79.7 billion m³ annually.

After the completion of dam systems in both Syria and Turkey, the total revenue rate of the Euphrates River calculates to 19.6 billion m³ annually in recent years; reaching a revenue rate of the Tigris and Euphrates basin for 2008 up to 30 billion m³ per year. This decrease in flow of water is expected to increase in the coming years.

Figures (1), (2) and (3) display the needs of various sectors to the quantities of water, compared to income and the water shortage expected for 2015. For 2015, water shortage of total necessary water needed is expected at 33 billion m³ per year.

Figure (1)

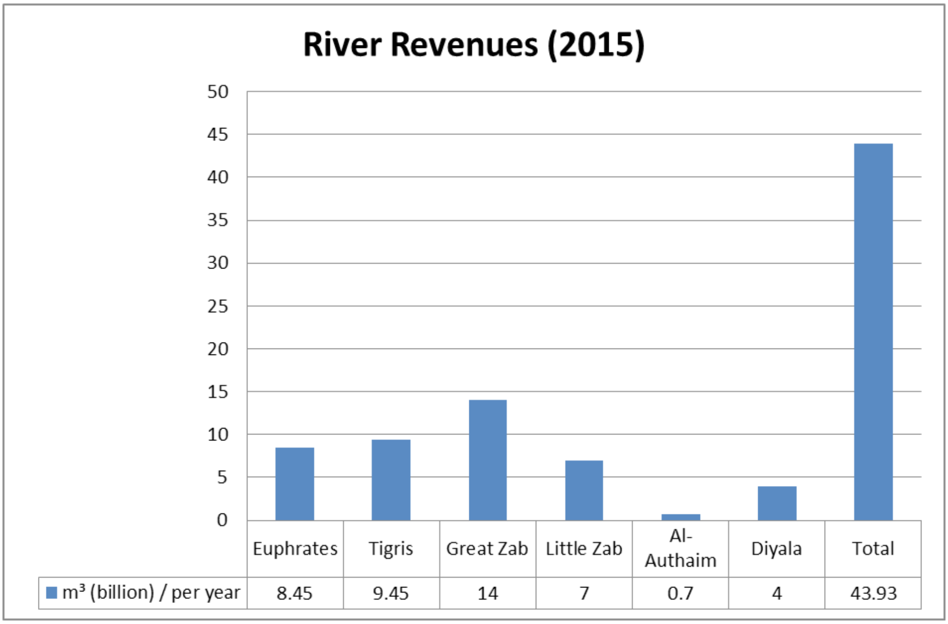


Figure (2)

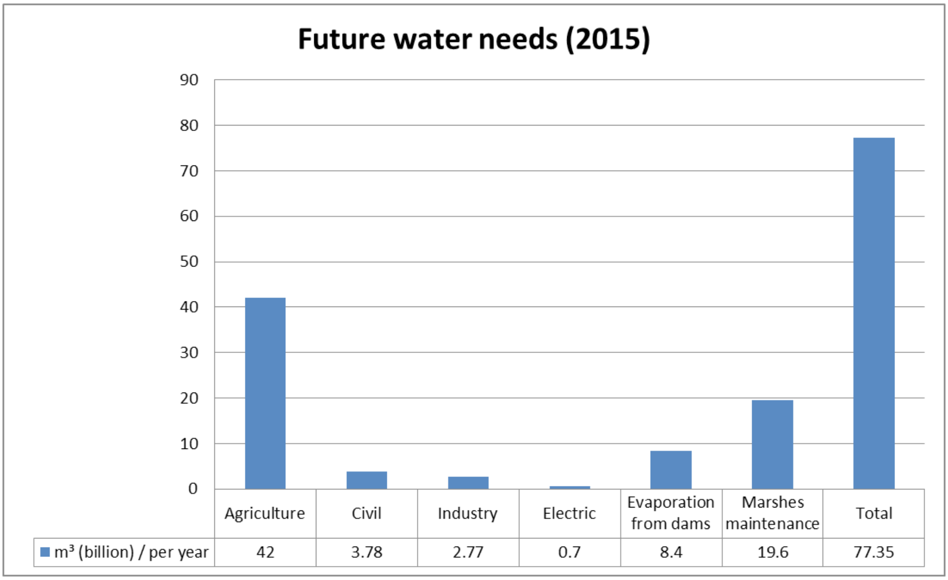
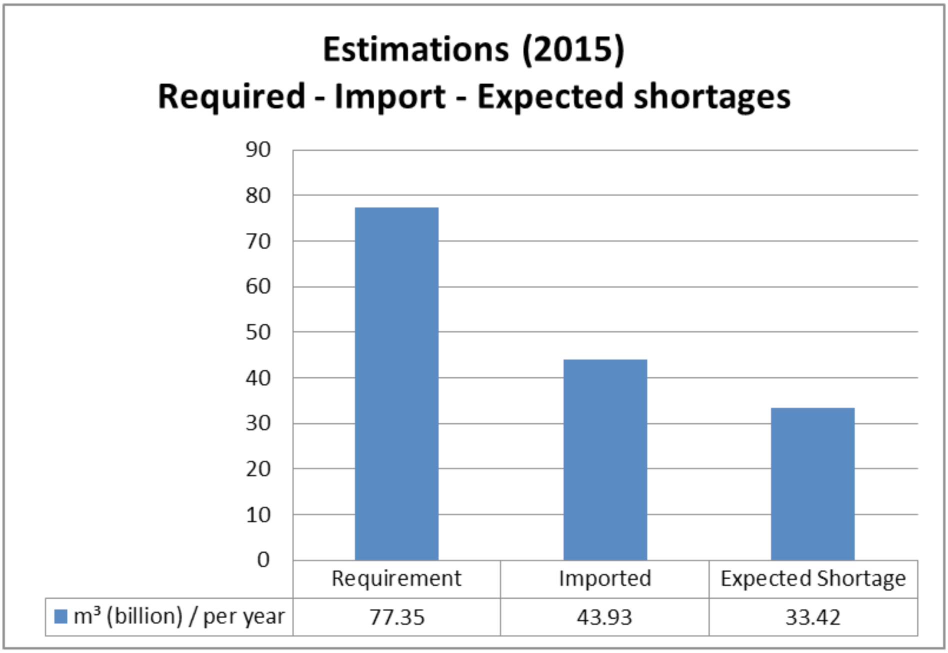


Figure (3)



3.Electrical energy production in Iraq 1990-2015

The electricity industry began in Iraq in 1917. Since, the following types of plants have been in use for the production of electrical energy:

- Steam stations
- Hydroelectric stations
- Gas stations
- Diesel stations

Since the beginning of the industry's establishment in Iraq and until the end of the 1970's, the industry focused on the establishment of steam stations. Thereon and through the 1980's, the focus shifted to the establishment of aquatic plants. However, the end of last century and the beginning of the 21st century marked an increase in the construction of gas stations.

Figure (4) illustrates the percentage of the participation of each type of energy production plants, as it is evident the increased participation of gas stations by 58%. This display of information demonstrates that there is a decrease in the production of hydraulic power stations because of the shortage of water resources, as the production of such plants depends on the flow in water rates and the level of water dams. The decline of water flow levels also affect the operation of steam plants and the production of energy due to the proximity of water levels in the rivers to the minimum operating limits for these stations. These stations mainly depend on the amount of water available to provide water needed to produce ionic steam and the provision of suitable systems for water cooling units.

Figure (5) shows how low drainage levels are through both Mosul and Haditha dams. It is evident from the figure that the conjugations of the Tigris River has decreased by up to 72% in 2008 than it was in 1995 and the percentage decline in the Euphrates River of up to 30% for the same period. In turn, Table (2) shows some of the requirements of steam stations in quantities of water to the rate of minimum flow. As demonstrated from the data, large amounts of water are necessary to ensure the proper operation of the stations. Steam stations estimated requirements of water calculate up to 180m^3 MW / per hour when energy efficiency is at its highest levels, and up to 250MW / h when less efficient. Thus, steam stations need 1000 MW to 50m^3 /per second in water capacity quantity; an amount considered relatively high to the current flow of the Tigris and Euphrates rivers.

Production of electrical energy in Iraq

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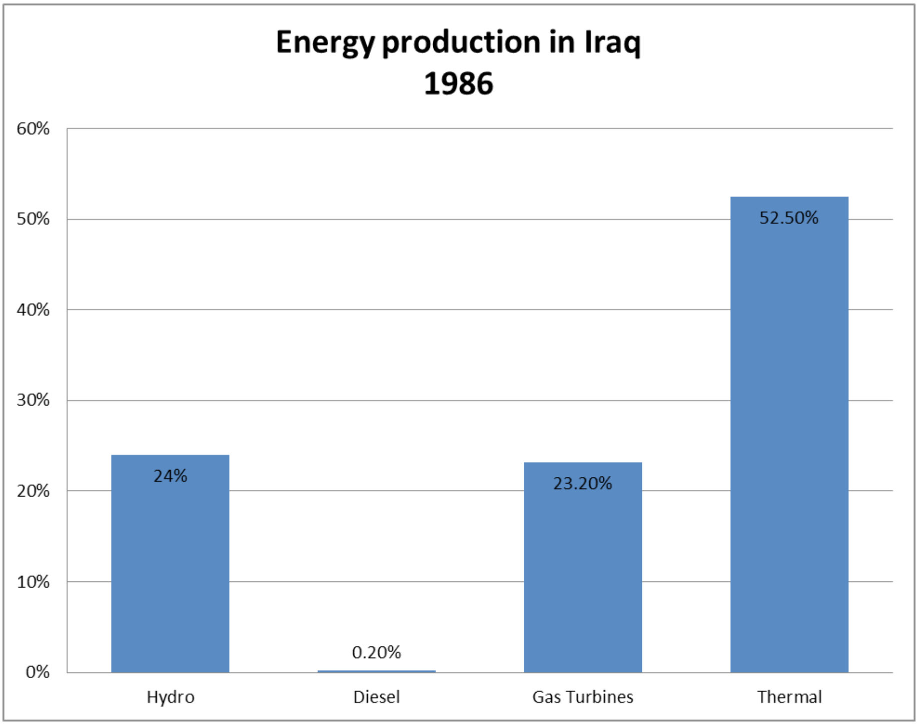


Figure (4)

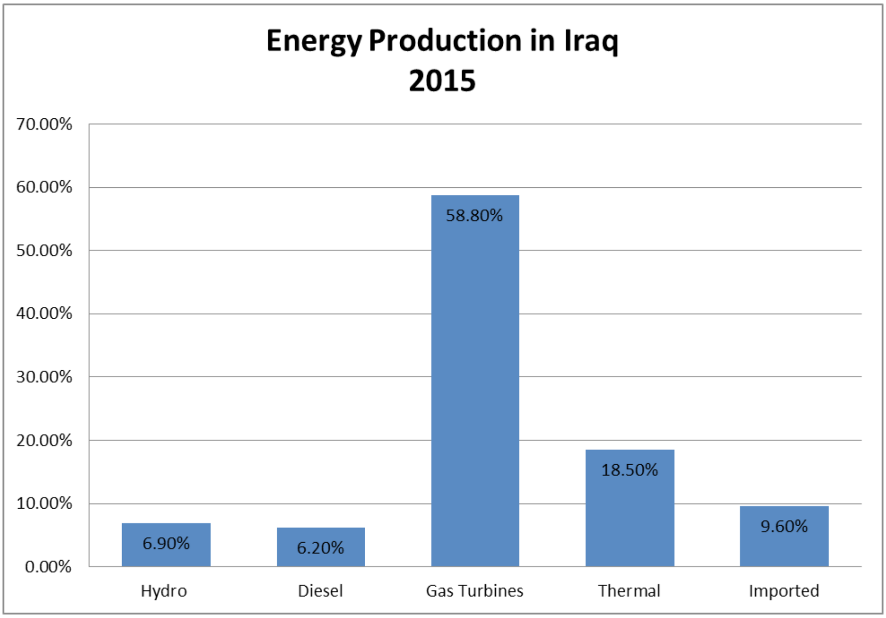
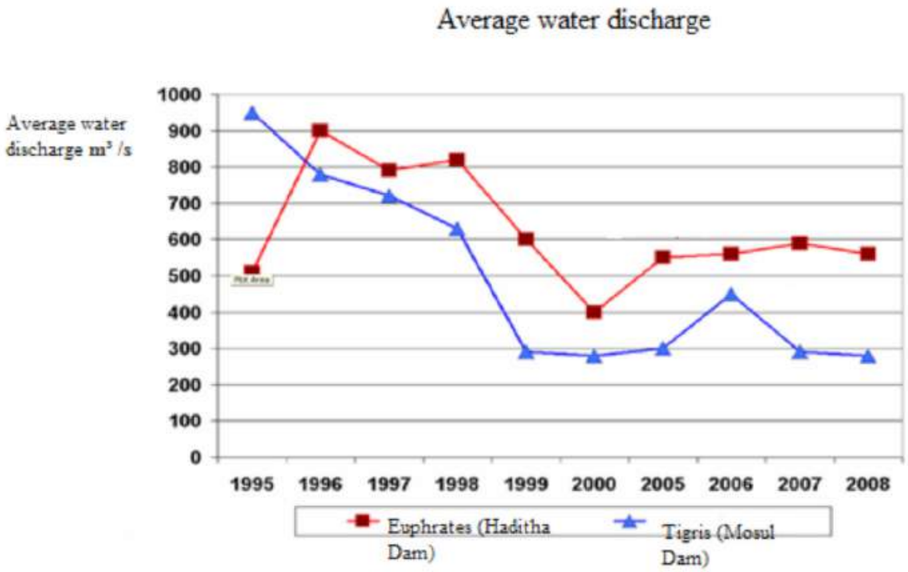


Table (1): Amounts of water needed for steam stations operation

Station	Capacity (MW)	Amount of water needed m³ / s	Amount of water withdrawn from the river m³ / s	Minimum flow rate required m³ / s	River
Al Musayab	4x300	108	67	327	Euphrates
Wasit	4x330	118	66	360	Tigris
Al Khayrat	4x300	108	60	327	Euphrates
Al Anbar	4x300	108	60	327	Euphrates
Al Nasriya	4x200	72	40	218	Euphrates
Al Doura	4x160	58	32	175	Tigris
Al Hartha	4x200	72	40	218	Shatt al Arab

Figure (5) Average water discharge



4.Future visions in building power producing plants

With indications of low water discharges in rivers Tigris and Euphrates and their tributaries now and in the future, require the adoption of future policy projects in electrical power production and depend on the following:

Firstly: expansion in the construction of high-volume gas stations.

Secondly: The use of alternative techniques to the current cooling systems in steam stations and in line with the Iraqi climate.

Thirdly: Taking new approaches towards constructed course techniques and the adoption of advanced cooling technology courses fit with the Iraqi climate.

Fourthly: Nuclear electromagnetic stations.

4. 1 - Practically expanding the use of gas units

During the past decades, the production of electrical power in Iraq has relied on steam stations as the Tigris and Euphrates provided the water resources. These stations contributed to approximately 52% of electrical power production (Figure 4) which is considered the largest type of power production and covering the heaviest load of production.

Alongside the steam stations, smaller and quick starting, connecting and portable gas units were operating to cover the peak loads. Because of the low levels of water and the evolution of gas stations technology, their high efficiency and evolution of operation, medium and large-sized gas stations were adopted in the 1990's and beginning of the 21st century (125, 260 MW) as the main energy producing stations, and not merely for the purposes of covering peak loads. As Figure (4) displays, there is an evident increase of gas units energy production contribution (MW/h) from 1990 - 2015 by up to 58%.

Gas units has become a suitable replacement for steam plants in terms of efficiency as well as significantly reduced quality costs and operating costs as well as the speed of performance. Table (3).

Table (3)

The technical and economic evaluation units produce electric power

Type	Capability of design ((MW	Qualitative costs (m/MW$)	Competence	Average temperature C/MW/h	Construction time Months
Gas SGT5-PAC2000F	164.9	0.85	(34-36%)	10470	(18-22)
Gas SGT5-PAC4000F	284.3	0.8	(34-36%)	9130	(18-22)
Gas PG9171E	127	0.85	(34-36%)	10770	(18-22)
Gas Combined Cycle	500	1.1	52%	6172	(20-24)
Open Steam Cooling System	4x350	1.25	(40-42%)	11200	(40-46)
Closed Steam Cool-ing System	4x350	1.5	(40-42%)	11400	(40-46)

Strategic gas stations adopted by the Ministry of Electricity Projects

General Electric (GE) units

Number of Units	MW per unit capacity	Qualitative price for each one when functioning on gas with ancillary systems	Qualitative price for each one when functioning on (4) kinds of fuels with ancillary systems	Total estimated cost Inc. additional equipment + operation	Estimated cost of MW
56	125	million $28	million $36	million $80	per $7,000 MW

Siemens units

Number of Units	**MW per unit capacity**	**Estimated qualitative cost for each one when functioning on gas**	**Estimated total cost inc. equipment and operation**	**Estimated cost of MW**	**Additional notes**
10	160	million $96	million $130	$700,000	Qualitative price includes the price of the turbine generator and electrical network equipment and control systems
6	265	million $158	million $210	$700,000	Functions on gas only

The Ministry of Electricity's work and plan to build power producing stations are compatible with this approach, as an additional 15,000 MW gas units are expected to operate from 2009-2013 to meet the shortfall in energy production and increased demand energy requirements.

4. 2 - Alternative cooling techniques of steam stations

i) Open Cycle cooling system

Every steam station used in the national system adopts an open cycle cooling system, where cooling water passes once through the condenser and on the condition that large and cheap amounts of cooling water are available. In Iraq, these amounts of waters usually source from rivers.

Advantages of this cooling system:

a) Low investment cost

b) No need for water treatment units by the condenser

c) Electrical energy required by recycling pumps is minimal

d) Minimal water waste

D isadvantages of this system:

a) Thermal pollution of the river

b) Erosion and pollution

c) Microscopic biological growth, which requires periodic maintenance operations and at a high pace

The use of this system requires large amounts of water, as mentioned in the preceding paragraphs (1,000 MW requires per 50 m^3 / s). With the continuing low water discharge in the Tigris and Euphrates levels, it has become necessary to study the possibility of using alternative cooling systems to cool the steam stations.

ii) Cooling Towers

A cooling tower is defined as a special heat exchanger; through which direct contact between air and water happens to complete the heat transfer process through an evaporative cooling process when touching a mass of water with a large surface area and a stream of air is saturated for a sufficient period of time to complete the heat transfer process. Evaporative cooling devices are classified into direct or indirect contact devices or both, between the water and air cooling devices.

The types of cooling towers are:

1.Natural Draft:

This type of cooling tower best functions in cold climates, where the difference in degree between the inside and outside of the tower helps with the formation of air and naturally stream helps to complete the cooling process. Therefore, this type of cooling tower is not suitable for use in Iraq, where the air temperature is high, especially in the summer.

2.Mechanical Draft:

To complete the process using this type of cooling tower, the water cools in upward air in hot climates. In Iraq, we have to use large-sized fans to push the air from the bottom upwards. There are several techniques for the use of these fans, from either the top or bottom of the tower.

A disadvantage in the use of this type of towers is its relatively large consumption of energy in the operation of these fans (1.5 - 2 MW). However, one of the best qualities of this type of cooling is the ability to control and lower the temperature of the water used for cooling temperature.

If cooling towers are used, economic costs of the components of the cooling system must be taken into consideration and as follows:

i) The primary cost for cooling towers, including the fans.

ii)The cost of pumps and piping system.

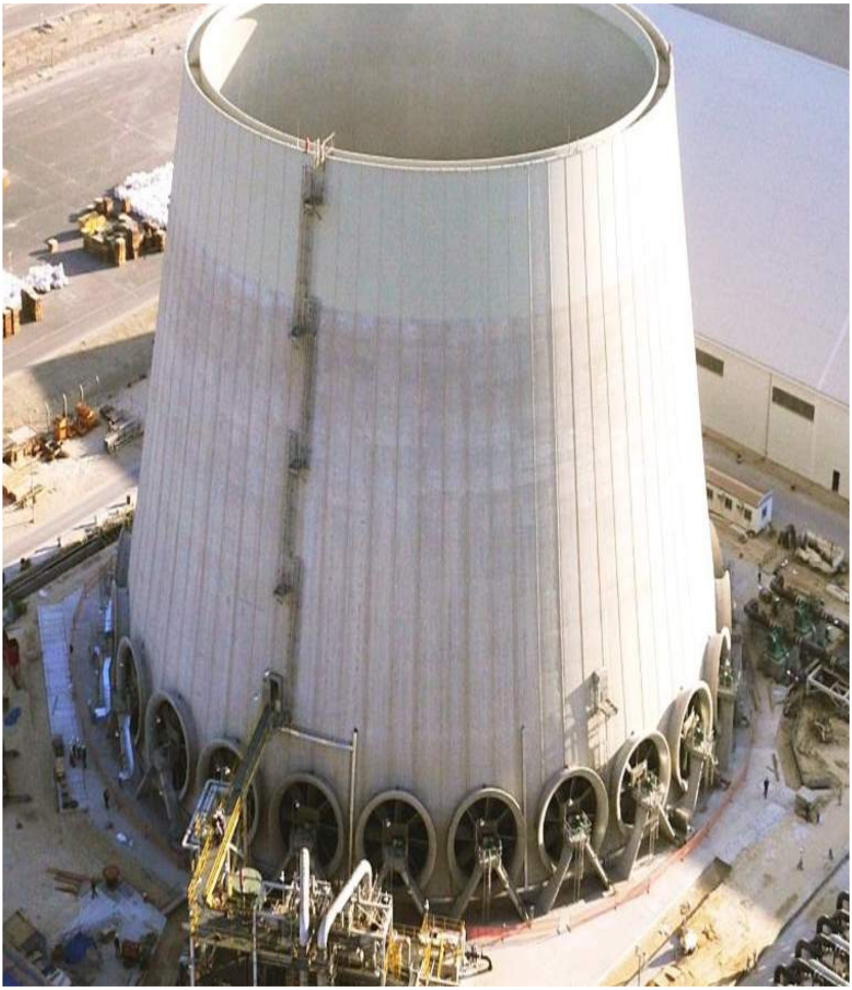
iii)The cost of aiding systems.

iv)The cost of the systems electricity consumption.

v)The cost of construction work.

Investment costs of mechanical draft cooling systems can be estimated at $500,000 –$600,000 per megawatt. In addition to this, there are operational and maintenance costs, which could reach up to three times the cost of operation and maintenance costs combined for Open Cycle cooling systems.

Natural cooling towers



Natural mechanical cooling towers

4. 3 - Stations with combined cycle

i) Introduction

With the significant progress achieved in the production of metals with great resistance to high temperatures and modern techniques in the (Hot path) field, especially in the first row of still and dynamic blades of the turbine in addition to the turbine's cooling method (between 1000 -1300 °C). Thus the heat emerging from the turbine's external gas is between the temperatures (450 to 600 °C). External gases generated from the turbine can be passed through a special vessel called the 'heat recovery steam generator'. As an energy recovery heat exchanger, this generator produces steam in large volumes in appropriate temperatures and pressures. The heat of the gas turbine's exhaust is used to generate steam by passing it through a heat recovery steam generator with a live steam temperature in a gas capacity unit called the combined cycle power plant (CCPP), otherwise known as gas turbine combined cycle (GTCC).

ii) Advantages of combined cycle units in comparison to single gas units

Combined cycle units are characterised by the overall thermal efficiency compared with the thermal efficiency of single gas units due to the balanced degree of heat inside gas turbines and lower external temperatures from the turbine's exhaust of combined cycle units than single gas units. This means the use of thermal energy and converting it into electrical energy is greater in combined cycle units. For comparison purposes, the following table shows the design capacity of thermal efficiency and heat rate for single gas unit in the same unit as combined cycle:

Type of unit	(Capacity (MW	efficiency %	Thermal average °C / kWh
ALSTOM GT 26 Single Cycle	**288.3**	**38.1**	**9,449**
ALSTOM GT 26 Combined Cycle	**424**	**58.3**	**6,172**

Single Cycle Gas Station

Combined Cycle Gas Station

4. 4 – Nuclear (electro) stations

Nuclear (electro) stations are considered an important energy source. Many countries rely on electrical energy production by nuclear power, including Sweden, France, United Kingdom, Pakistan and Japan among others. In 2009, the Ministry of Electricity began to communicate with some global institutions that have experience in the field of nuclear stations with a quest to outline initial steps of conducting feasibility studies for the selection of suitable sites for such plants in the future. The use of nuclear plants requires significant investment and the time could be extended to eight years to complete the construction of a plant, however, building nuclear plants remains essential with the aim of building an integrated energy strategy in Iraq, and not solely relying only on conventional fuel.

Conclusions and recommendations

1.Scarcity of water resources now and in the future and the shortage could reach 33 billion m³ / year in 2015, with low water discharges.

2.Increase in the demand for energy to reach the level of up to 25,000MW in 2018.

3.Reconsideration with the use of cooling systems, open cycle steam plants, and develop plans to adopt the use of mechanical cooling towers, after an in-depth feasibility studies.

4.Building large gas stations and relying on them for produce the larger load of energy.

5. Resorting to using combined cycle systems sessions in gas stations.

6.Initiate feasibility studies for nuclear station projects.