

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

وَيَسْأَلُونَكَ عَنِ الرُّوحِ <sup>صَلُّوا</sup> قُلِ الرُّوحُ مِنْ أَمْرِ رَبِّي وَمَا أُوتِيتُمْ مِنَ  
الْعِلْمِ إِلَّا قَلِيلًا

صدق الله العلي العظيم

الأسراء- الآية 85

# PROSPECTS OF ELECTRICAL POWER GENERATION IN IRAQ

- Prof Haroun A.K. Shahad
- Department of Mechanical Engineering
  - College of Engineering
  - University of Babylon

Al-Mustaqbal University College  
22-24 Oct. 2022

# Tracks of this Lecture

- 1-Energy Resources in IRAQ.
- 2- Energy Consumption in IRAQ
- 3-Energy Production in IRAQ
- 4-Impact of Using Fossil Fuel on Environment

Al-Mustaqbal University College

• 22Oct. 2022

# AVAILABLE ENERGY RESOURCES TO PRODUCE ELECTRICAL POWER IN IRAQ

- 1- Fossil fuel
- 2-Biomass or Bioenergy
- 3-Solar energy
- 4-Hydro energy

# Fossil Fuel in IRAQ

Fossil fuel or hydrocarbon fuel includes:

1-Crude oil

2-Natural gas

3-Liquefied petroleum gas

Proven crude oil reserves 150-200 bbl

Proven natural gas reserves (**trillion cubic feet**) 132

Crude oil production (1,000 b/d) 3,971

Natural gas production 378 bcf

# Biomass

- In Iraq, the most important sources of biomass are municipal solid waste, agricultural waste (date palm, wheat straw, barley straw, rice straw, sorghum straw), and animal waste.
- Agricultural Crop,
- Dates. Corn, Sun flower



The most important species of dates in Iraq is Alzahdi. It accumulates to 70% of Iraq production. It has the maximum sugar content. It can be used to produce bio-ethanol. In research carried out at college of engineering/University of Babylon, 300 L of bio-ethanol was produced from one ton of dates with a price of \$1/L



الانتاج (طن)	السنة
39000	1985
545000	1990
880000	1995
1023000	2000
438000	2005
350000	2008
645000	2009

www.tawyccert.com

- According to the Baghdad municipality statistics, an estimate of 10,000–11,000 tons of solid wastes produced daily in Baghdad. About 7000 tons of wastes are deposited per day in landfills.
- The solid waste produced in Iraq is about 20000 ton per day.
- (each person produces 0.5 kg of solid waste per day)





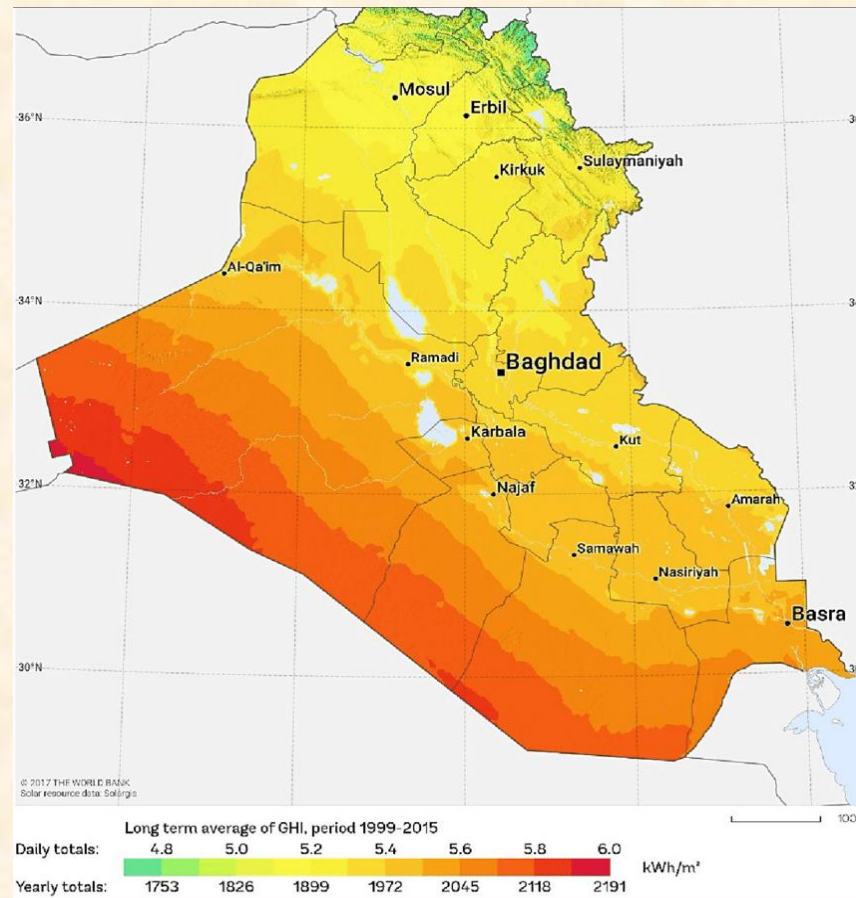
- **Biofuel**
- Biofuel is produced from agricultural crops and solid waste.
- Bio-ethanol and bio-diesel are produced from agricultural crops.
- Bio-ethanol is produced in the labs of the Mechanical Engineering Department/ Babylon University from dates specially the Zahdi .
- The yield of the Zahdi dates in Iraq is about 450 ton.
- Each ton yields about 300 L of bio-ethanol at a cost about one dollar per liter.

- Bio-methane is produced from solid waste. About 15-300 L of bio-methane per kg of solid waste depending on its quality.
- For the lowest yield it is equivalent to 7.7 kg of methane per ton solid waste
- BY simple mathematical calculations the methane produced from solid waste in Iraq can run a gas turbine power station with a capacity of electrical power production of about 50 MW.
- **ALL POWER STATION IN IRAQ RUN ON FOSSIL FUEL. ALTHOUGH SOLAR ENERGY IS USED ON SMALL SCALE IN SOME RESIDENTIAL APPLICATION**



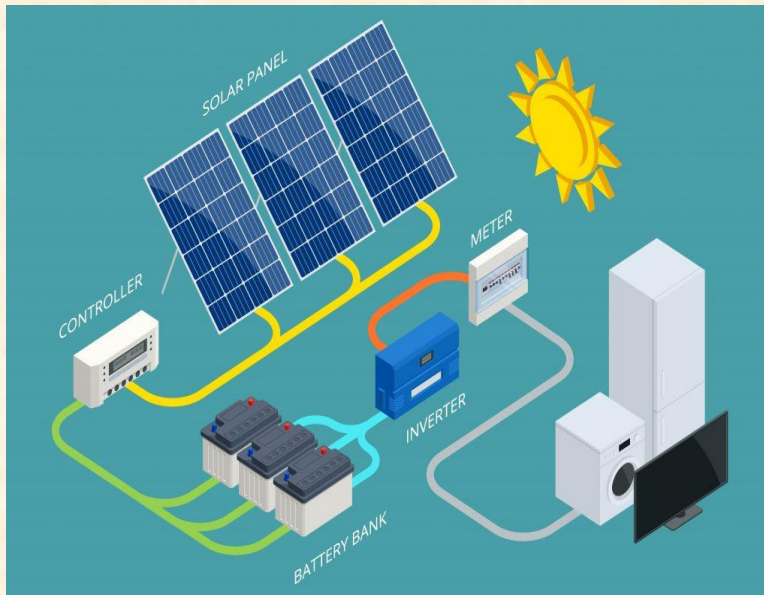
# SOLAR RADIATION IN IRAQ

- Iraq has a very good potential of using solar energy to generate electrical power since through out the year there are 300 sunny days.
- The average daily solar radiation is about **(5-5.5) kW/m<sup>2</sup>/day**.
- Therefore there is a very good potential of using solar energy in Iraq to generate electrical power.



# Solar energy Conversion Techniques

- Two techniques are available to harvest solar energy, namely photovoltaic cells and solar collectors.



- In photovoltaic technique the solar energy is converted directly to electrical energy with a conversion efficiency of about 15%.
- In the collector technique the solar energy is converted to thermal energy first to produce either hot water for heating or to produce vapor for electrical power generation.
- There are different types of collector such as:
  - 1-Evacuated Tube collector
  - 2-Flat Plate Collector.
  - 3-Parabolic Trough Collector
  - 4-Compound Parabolic Concentrator
  - 5-Parabolic Dish
  - 6-Heliostat

# Heliostat

- Heliostat is a large number of reflectors that reflect the solar radiation on a focal point. At the focal point the working fluid is evaporated and the vapor is supplied to a turbine to generate electrical power



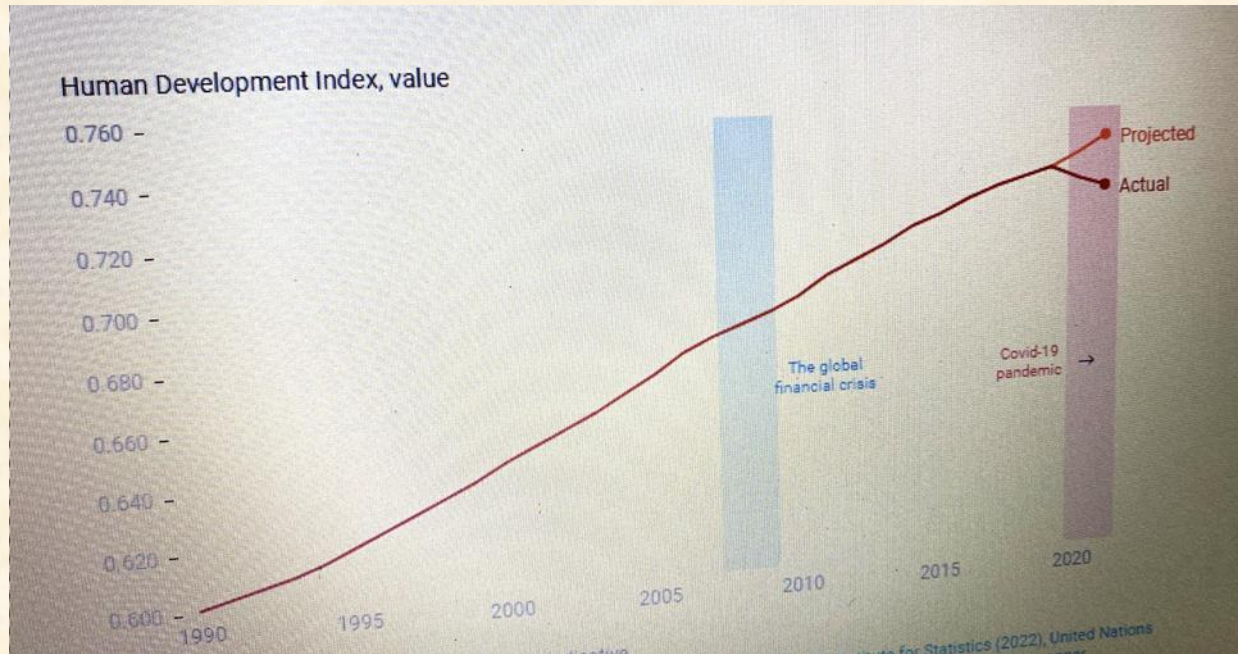
- 110 MW Heliostat power in Chile

# ENERGY CONSUMPTION AND QUALITY OF LIFE

- The United Nations defines a parameter called the Human Development Index (HDI) to provide a quantitative measure of the quality of life. This index includes three categories, namely,
  - Life expectancy
  - education
  - Gross domestic product (GDP)
- The value of HDI is  $0 < \text{HDI} < 1$

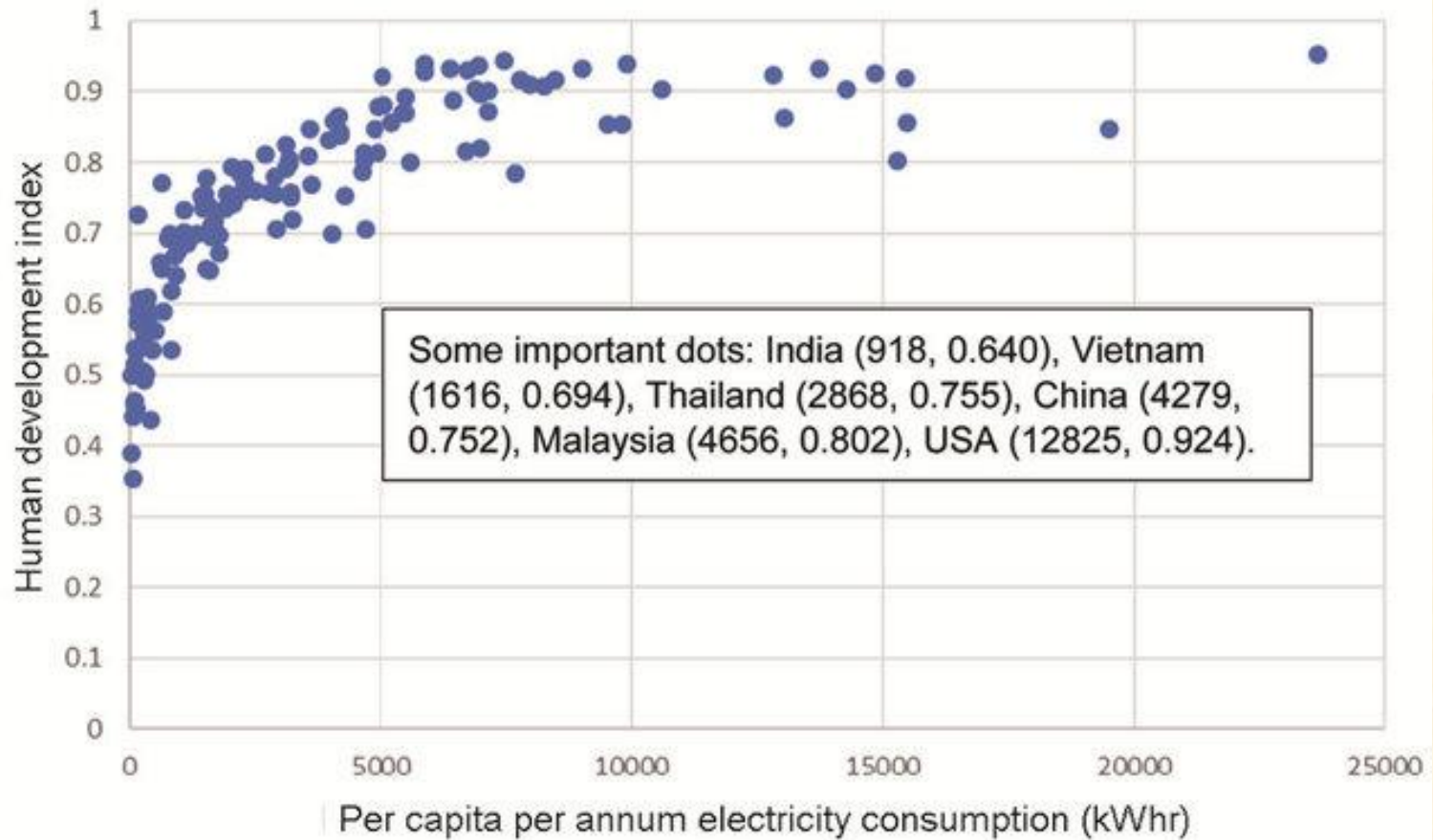


# World average HDI



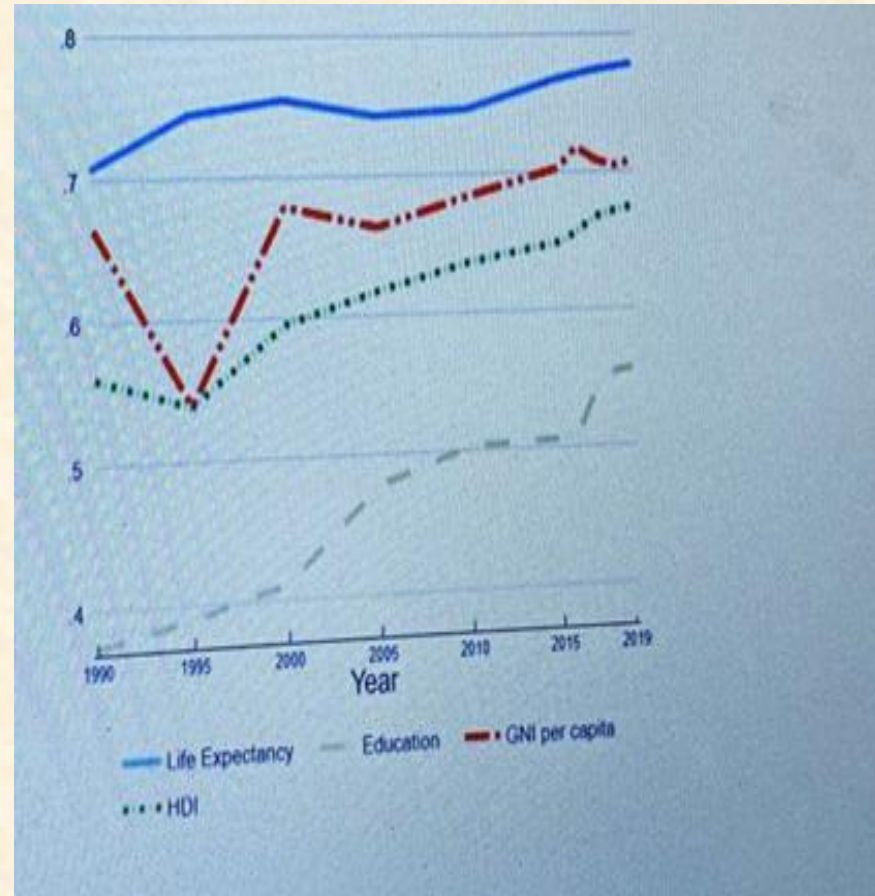
Al-Mustaqbal University College  
22 Oct. 2022

# Variation of HDI with electrical consumption



# HDI in IRAQ

- Iraq's HDI value for **2019** is **0.674**— which puts the country in the medium human development category— positioning it at 123 out of 189 countries and territories. Between 1990 and 2019, Iraq's HDI value increased from 0.560 to 0.674, an increase of 20.4 percent.



**Table A: Iraq's HDI trends based on consistent time series data and new goalposts**

	Life expectancy at birth	Expected years of schooling	Mean years of schooling	GNI per capita (2017 PPP\$)	HDI value
1990	66.0	9.6	3.2	8,168	0.560
1995	68.4	9.1	4.2	3,541	0.539
2000	69.1	8.7	5.0	8,980	0.595
2005	68.3	10.2	5.8	8,050	0.617
2010	68.6	10.4	6.4	9,275	0.636
2015	69.9	10.1	6.8	10,485	0.649
2016	70.1	10.1	6.9	11,589	0.656
2017	70.3	11.0	7.0	10,891	0.667
2018	70.5	11.1	7.3	10,581	0.671
2019	70.6	11.3	7.3	10,801	0.674

### 10 highest HDIs

Rank	Country	HDI
		2021 data (2021-2022 report) rankings
<b>Very high human development</b>		
1	 United Arab Emirates	0.911
2	 Bahrain	0.875
2	 Saudi Arabia	0.875
4	 Qatar	0.855
5	 Kuwait	0.831
6	 Oman	0.816
<b>High human development</b>		
7	 Algeria	0.745
8	 Egypt	0.731
8	 Tunisia	0.731
10	 Jordan	0.720

### 10 lowest HDIs

Rank	Country	HDI
		2021 data (2021-2022 report) rankings
<b>Low human development</b>		
1	 Yemen	0.455
2	 Sudan	0.508
3	 Djibouti	0.509
<b>Medium human development</b>		
4	 Mauritania	0.556
5	 Comoros	0.558
6	 Syria	0.577
7	 Morocco	0.683
8	 Iraq	0.686
<b>High human development</b>		
9	 Lebanon	0.706
10	 Palestine	0.715

# Electrical energy consumption per capita in IRAQ

- Electricity consumption per capita in **IRAQ** was **1110 kWh** in 2020. It remains much lower than in neighboring countries (1 760 kWh per capita in **Jordan** in 2019 and 3045 kWh in **Turkey** in 2020).
- In USA                      12825 kWh
- In China                    4279 kWh
- In Kuwait                15,213 kWh
- In Saudi Arabia    9401 kWh

# ELECTRICAL POWER PRODUCTION IN IRAQ

- Power production in Iraq and some other countries.

Country	Population (M)	Electrical Power Production kWh
Canada	<b>38,654,738</b>	$649.6 \times 10^9$
UK	<b>67,508,936</b>	$310 \times 10^9$
Germany	<b>84,377,788</b>	$490.6 \times 10^9$
Spain	47.35	$258.5 \times 10^9$
Italy	60.32	$275.3 \times 10^9$
Saudi Arabia	36	$697.9 \times 10^9$
EAU	<b>9,441,129</b>	<b><math>121.8 \times 10^9</math></b>
Kuwait	<b>4,410,975</b>	<b><math>65.9 \times 10^9</math></b>
IRAQ	<b>44,496,122</b>	$19.3 \times 10^9$

# POWER PLANTS IN IRAQ

- There are three types of power plants in Iraq.
- 1-Thermal Power Plants (9)

Name	Location	Capacity (MW)	Notes
thermal Nassiriyah power plant	Nassiriyah	840	
Al-Mussaib	Babil	1,280	[1]
Doura	Baghdad	640	[2]
Bayji	Saladin	1,320	[3]
South Baghdad	Baghdad	355	[4]
Al-Shemal	Mosul	2,100	[5]
Al-Hartha	Basra Governorate	400	
An Nassiriyah	Dhiqar	840	
Besmaya	Baghdad		

- Total production =7775 MW



- 2-Gas power Plants (25) total production 14107 MW

Name	Location	Capacity (MW)	Type	Notes
Mulla Abdulla (New)	<u>Kirkuk Governorate</u>	222	Open-cycle	
Khor Al Zubayr	<u>Basra Governorate</u>	252	Open-cycle	[6]
Al-Mansurya	<u>Diyala Governorate</u>	728	Open-cycle	[7]
Al-Anbar	<u>Al-Anbar Governorate</u>	1,642.6	Combined-cycle	[8]
Shatt Al-Basra	<u>Basra Governorate</u>	1,250	Open-cycle	[9]
Erbil	<u>Erbil Governorate</u>	1,500	Combined-cycle	[10]
South Baghdad 1	<u>Baghdad Governorate</u>	246	Open-cycle	
South Baghdad 2	<u>Baghdad Governorate</u>	400	Open-cycle	
Daura 1	<u>Baghdad Governorate</u>	146	Open-cycle	
Daura 2	<u>Baghdad Governorate</u>	750	Open-cycle	[11]
Al-Rasheed 1	<u>Baghdad Governorate</u>	94	Open-cycle	
Taji 1	<u>Baghdad Governorate</u>	156	Open-cycle	
Taji 2	<u>Baghdad Governorate</u>	160	Open-cycle	
Sadr	<u>Baghdad Governorate</u>	160	Open-cycle	
Al-Quds 1	<u>Baghdad Governorate</u>	450	Open-cycle	
Al-Quds 2	<u>Baghdad Governorate</u>	450	Open-cycle	
Al-Quds 3	<u>Baghdad Governorate</u>	500	Open-cycle	[12]
Al-Najybia	<u>Basra Governorate</u>	500	Open-cycle	
Sulaymaniyah	<u>Sulaymaniyah Governorate</u>	1,500	Combined-cycle	[13]
Dohuk	<u>Dohuk Governorate</u>	500	Open-cycle	[14]
Rumaila	<u>Basra Governorate</u>	1,460	Open-cycle	[15]
Taza	<u>Kirkuk Governorate</u>	292	Open-cycle	[16]
Hilla	<u>Babil Governorate</u>	250	Open-cycle	
Karbala	<u>Karbala Governorate</u>	250	Open-cycle	
Al-Najaf	<u>Najaf Governorate</u>	250	Open-cycle	

Yusufiyah Location: Salahuddin 8 X 210 MW construction halted? -|||| Nassiriyah GAS power  
nassiriyah 500 MW open cycle

# 3-Hydropower (8)

Renewable [\[ edit \]](#)

Hydroelectric [\[ edit \]](#)

Name	Location	Capacity (MW)	Type	Notes
Adhaim Dam	Saladin Governorate	27	Conventional	
Darbandikhan Dam	Sulaymaniyah Governorate	249	Conventional	<sup>[17]</sup>
Dukan Dam	Sulaymaniyah Governorate	400	Conventional	<sup>[18]</sup>
Haditha Dam	Al Anbar Governorate	660	Conventional	<sup>[19]</sup>
Hemrin Dam	Diyala Governorate	50	Conventional	Operational
Samarra Barrage	Salah ad Din Governorate	84	Conventional	Operational
Mosul Dam	Nineveh Governorate	1,052	Conventional	<sup>[20]</sup>
Mosul Dam Regulator	Nineveh Governorate	62	Run-of-the-river	

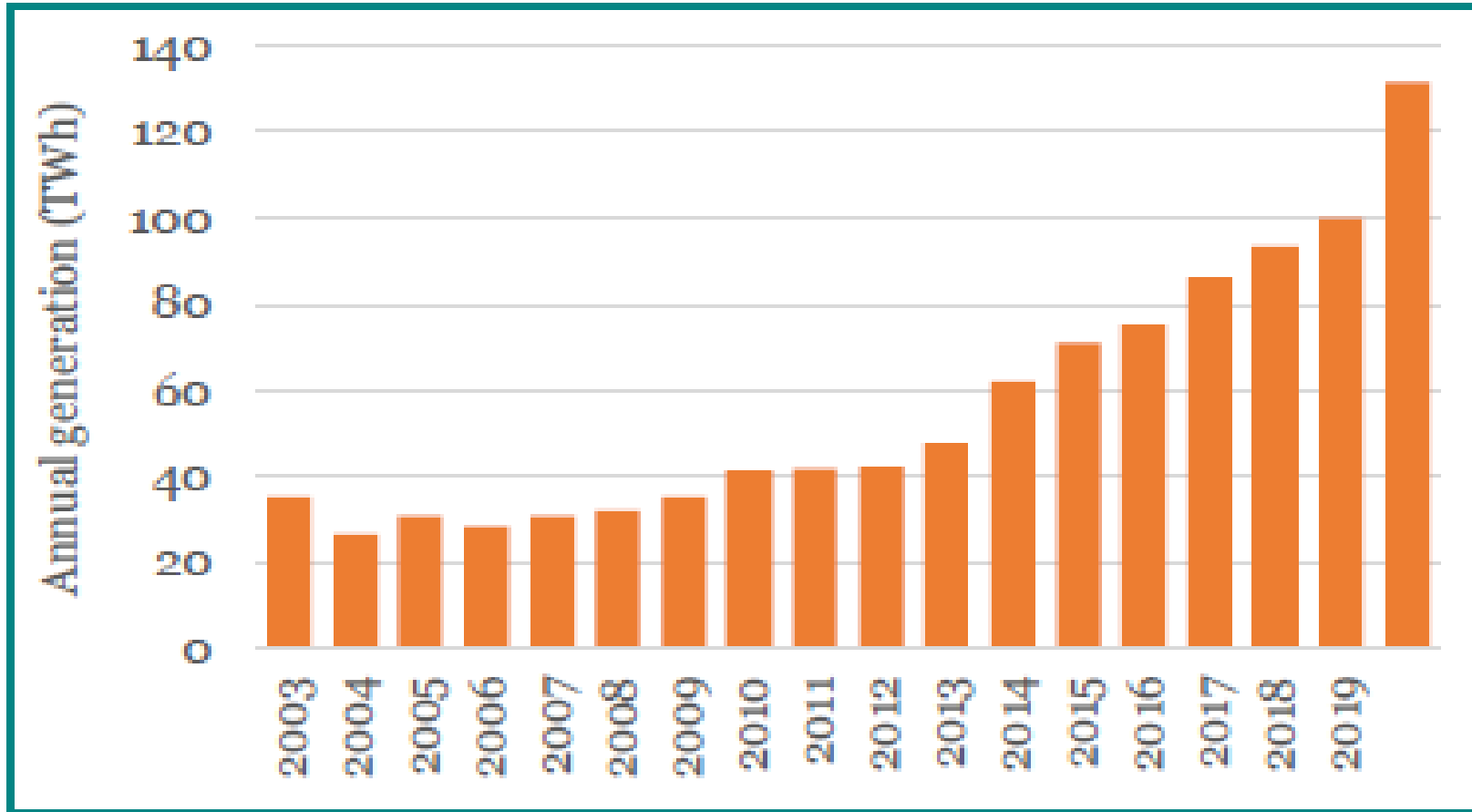
- Total production=2584 MW

- The information in the above tables is summarized below,

Station type	Number	Total capacity (MW)
Thermal	7	7777
Gas turbine	25	14107
Hydropower	8	2584

- These information shows that the number of gas turbine power stations is three folds of the thermal power station but produce only twice the power of the thermal. Some of these gas turbine stations are compound stations.
- This is incorrect policy since the thermal sations are more economical.

# Histogram of Electrical Power Production in Iraq



# Electrical Power Consumption in IRAQ and Some Other Countries

Country	Power Consumption per Capita per Year kWh/year
Canada	$16.8 \times 10^3$
Saudi Arabia	$18.88 \times 10^3$
Kuwait	$14.97 \times 10^3$
Iraq	$0.434 \times 10^3$

- According to this table the required power generation per year in Iraq should be
- $666.165 \times 10^9$  kWh/year = 75900 MW

# IMPACT OF USING FOSSIL FUEL ON ENVIRONMENT

- The use of fossil fuel to run electrical power stations (thermal and gas) has a great impact on local environment. The burning of his fuel produces huge quantities of green house gases (GHG).
- For example if we consider a gas turbine unit that generates 100 MW electricity with a conversion efficiency of 30% the amount of carbon dioxide emitted to the environment equals about  $25 \text{ kg/s} = 90000 \text{ kg/h} = 90 \text{ ton/h}$
- Therefore for a capacity of generation equals 25000 MW (average production of Iraq).
- Mass of carbon dioxide=22500 ton/h

- According to the above results it is recommended to switch from fossil fuel energy to solar energy which environmental friendly. However the cost per unit electrical power produced from solar energy is still high compared with that produced using fossil fuel.
- For solar energy 1kW costs \$2921.
- For thermal energy 1 kW costs \$850
- Also the land area required is different.
- For solar PV system each MW requires about  $0.125 \text{ km}^2$ .
- Therefore the area required for 100 MW power station is  $12.5 \text{ km}^2$ .
- For gas power station the area requirement is about
- $0.00139 \frac{\text{km}^2}{\text{MW}}$ .
- For a power station of 100 MW the land requirement equals
- $0.139 \text{ km}^2$ .

# Conclusions

- 1-The electrical power generated in Iraq now only covers 30% of total requirements.
- 2-The most important renewable energy resources in Iraq are: solar energy, Bio-mass and municipal waste.
- 2-Solar energy is the most abundant in Iraq and can be used easily to replace partially the fossil fuel used to produce electrical power.
- 3-There is a good potential of using municipal waste to produce electrical power.
- 4-The cost to produce electrical power from solar energy is more than that of using fossil fuel now.
- 5-The Iraqi Government should encourage people to use P-V panels to produce electricity.
- 6-Government investment should be directed towards constructing thermal power plant not gas turbine plants.



THANK YOU FOR LISTENING

