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Efficient Energy of Smart Grid Education Models for Modern Electric Power System Engineering in Iraq

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Abstract. Smart grid integrates the use of high end technologies so that the generation of energy as well as its delivery can be done with greater performance to the multiple locations and regions. As Iraq is one of the elevating countries in the energy sector and enormous projects, the need to integrate the smart grids arise. This manuscript underlines the assorted perspectives of the smart grid technologies with the integration of solar system and the implementation aspects in Iraq. With the integration of smart grid based architecture and cumulative formulation of the effectual approaches the overall energy can be optimized and higher degree of throughput can be achieved with greater values in the overall performance. In Iraq, there are many projects which are under development and many development using which the overall energy based projects are getting successful in Iraq with the overall elevated growth of the country in multiple sectors including power, security, corporate, international relations, finance and many others. In this research manuscript, the assorted factors and the projects with the multiple dimensions of energy optimization and power saving in Iraq are presented with the pragmatic results.

Keywords: Energy Projects in Iraq, Smart Grid, Smart Energy, Smart Energy in Iraq

1. Introduction

Smart Grid based power projects[1, 2] and harvesting of energy is one of the prominent domains of research in the academia as well as corporate world. Smart grid integrates the network substations with the network of transmission lines so that the dynamic generation of energy and electricity can be done with the higher degree of optimization. In smart grid, the automated control and the delivery to the channels are done with the higher degree of accuracy and minimum error rate[3-6]

The domain of electricity generation alongwith the related power elevation is one of the effectual and elevating sectors in Iraq. In year 2013, the figure associated with the capacity of electricity in Iraq as about 10,000 megawatt that intensified in the subsequent years. In addition, there are certain scenarios, where the scarcity of energy in Iraq is also seen. In year 2016, there was 4280 MW average peak electricity. In addition to these perspectives, the electricity is provided as the subsidy was also which has increased the demand of electricity a lot[7].



2. Total Consumption of Energy in Global Ranking

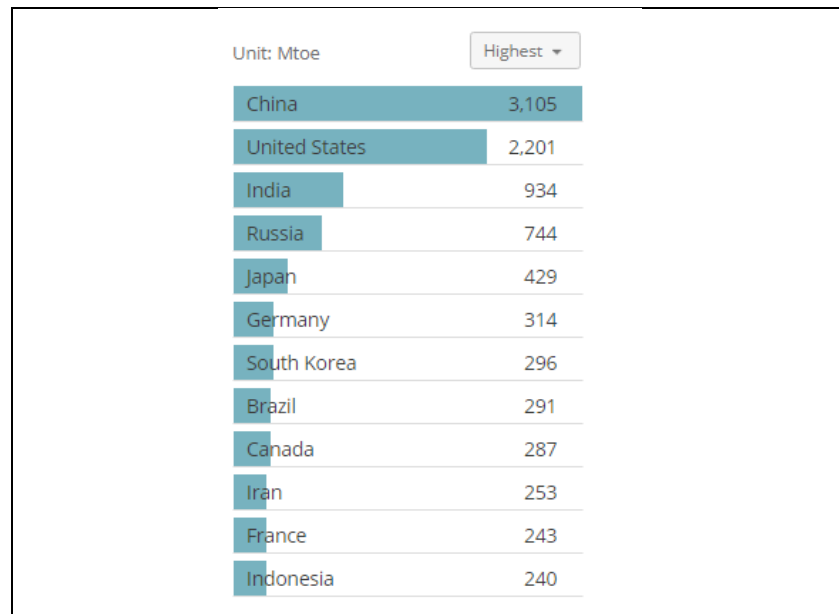


Figure 1: Worldwide Consumption of Energy (Source : YearBook of Global Energy)

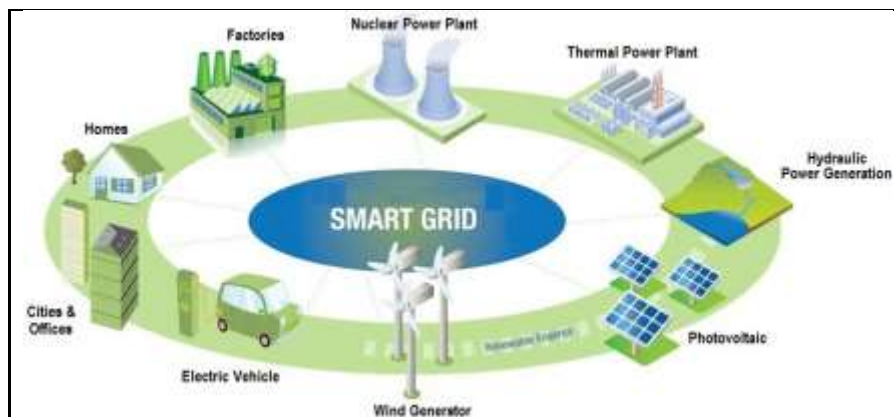


Figure 2. Smart Grid and Associated Dimensions

From the era of advent towards the evaluation of energy and electricity, these perspectives came to the existence in Iraq in year 1917 and Khan Dala building was the first where the first electric machine was integrated. Post 2003 after the war, there was huge demand and the consumption of energy and related aspects that lead to the huge projects so that the consumption can be catered effectively.

Table 1. Capacity and Demand of Energy in Iraq

Year	Installed capacity (MW)	Demand
1955	50	NP
1990	9300	NP
2003	4470	6400
2006	4280	8180
2008	6000	10000
2010	8000	14000
2016	13000	21000

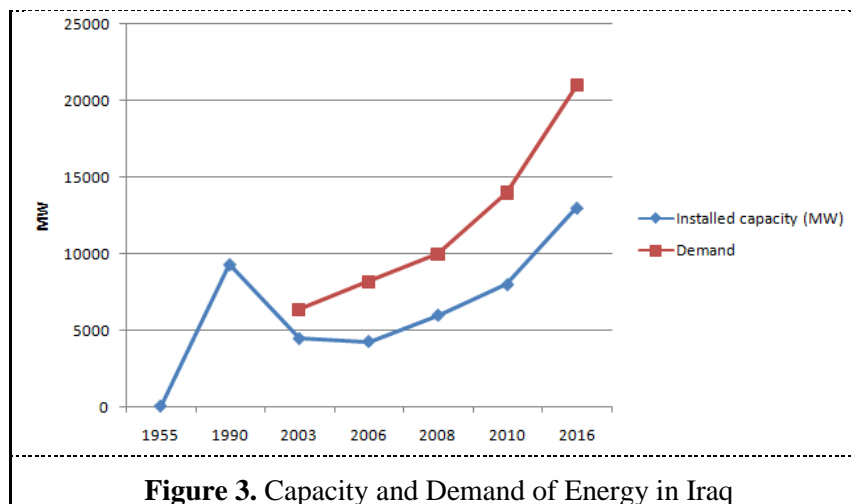


Figure 3. Capacity and Demand of Energy in Iraq

3. Problems and losses of production and distribution of energy in Iraq

- Stability Issues in the Power System
- Ineffective Power Transmission and Control
- Ineffective control on Voltage, Frequency and Losses with the theft

Table 2. Analytics on the Power System in Iraq

%	MWH	Details	No.
100	70,635,931	Total Energy	1
4.4	3,095,218	Losses in Power Plants	2
6.8	4,823,317	Losses in Distribution system	3
25	17,676,008	Losses in Distribution Grid	4
63.8	45,041,388	Distribution net Energy sold	5

The value of the Depletions or the losses is a very big number with respected to the Cumulative energy.

Cumulative Depletions in Iraqi Power System = Depletions in Power Plants + Depletions in Transmission (Line + Grid)

$TL\% = 4.4 + 6.8 + 25 = 36.2$ Function number (1)

Cumulative Energy = 100%

Cumulative Depletions = 36.2

Cumulative sold Energy = Cumulative Energy - Cumulative Depletions

$TSE = TE - TL$ Function number (2)

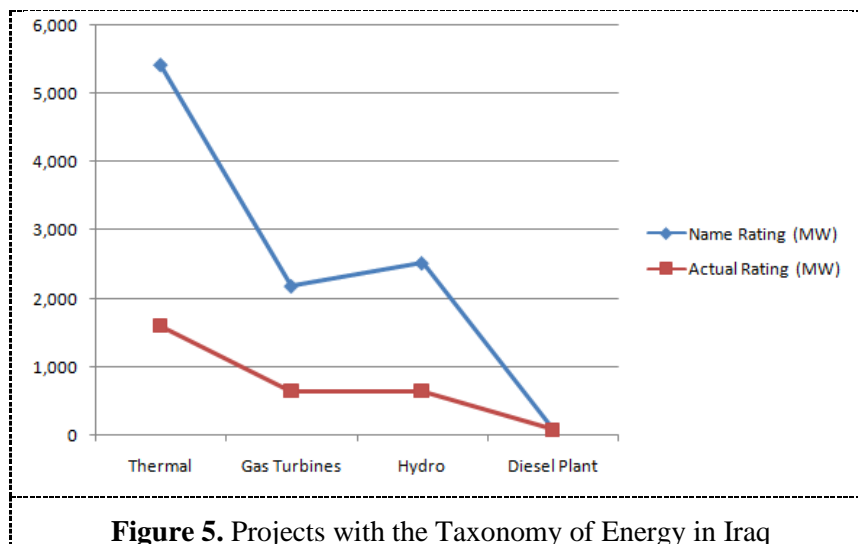
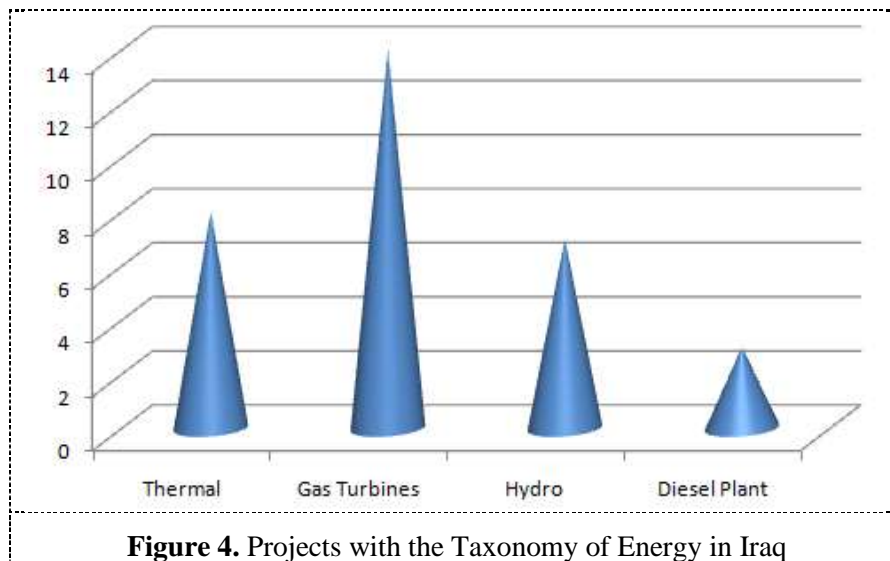
$TSE\% = 100 - 36.2 = 63.8$ it is net Energy which sold, this main problem.

The number of Depletions is so much. Then to improve power system quality and efficiency and stability. It has to search ways for improving the Depletions and increasing the stability for power system.

Table 3. Projects with the Taxonomy of Energy in Iraq

Type	Count	Name Rating (MW)	Actual Rating (MW)
Thermal Units	8	5,415	1,600
Gas Turbines Units	14	2,181	650
Hydro Units	7	2,518	650

Diesel Units	3	87	87
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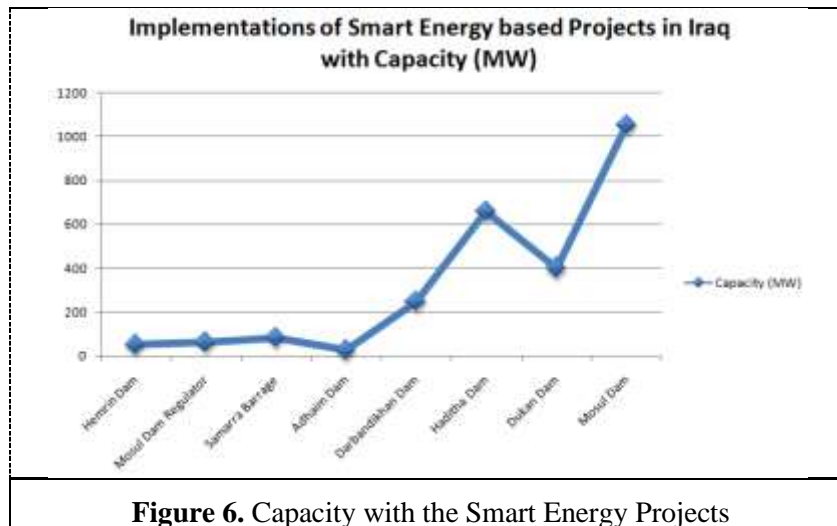


4. Smart Grid Models and Renewable Smart Energy Projects in Iraq

Following are the key projects which are under process in Iraq for the smart energy-based integration of power systems.

Table 4: Smart Energy Projects in Iraq

Name	Capacity (MW)	Location
Hemrin Dam	50	Diyala Governorate
Mosul Dam Regulator	62	Ninawa Governorate
Samarra Barrage	84	Salah ad Din Governorate
Adhaim Dam	27	Saladin Province
Darbandikhan Dam	248	Sulaymaniyah Governorate
Haditha Dam	660	Al Anbar Governorate
Dukan Dam	400	Sulaymaniyah Governorate
Mosul Dam	1052	Ninawa Governorate



Smart Grid based integration is very effective in solving the issues of electricity stability in Iraq. The approach provides the higher degree of accuracy and performance using smart grid-based technologies. Following are the perspectives in the smart grid-based integration in Iraq

- Meter Read
- Service Switch
- Distributed GEN
- Outage Events

As per the recent report and corporate updates, Siemens is expanding the service agreement to be associated with the energy sector in Iraq with the smart energy models. This is the project proposal by Siemens so that the smart energy can be integrated in Iraq and is in the implementation phases. With this approach, the government agencies will be benefitted a lot after completion of the project in different phases in Iraq.



Figure 7. Project of Siemens for Smart Energy in Iraq

5. Smart Grid Technology with Solar Photovoltaic Cell

Photo voltaic cells convert solar light photons into electricity. Photovoltaic solar cells fulfil two functions: photo-generation of charge carriers (electrons and holes) in a light-absorbing material, and separation of the charge carriers to a conductive contact that will transmit the electricity[8-10]

P-V cell material has atom which has positive charge and electron has negative charge around the nucleuse .When electron and hole pair try to recombine each other .The doping phenomenon or impurity

is added. If doping has completed there are more electron in outer cell so due to this negative charge particle of electron are free to move, the solar has both n type and p type semiconductor connected each other than electron transfer from n type to p type due to this reason voltage difference will develop at junction. When cell observed the light energy then electron will flow downward due to natural tendency and holes pair flow up ward so due to this reason electric circuit will developed.

6. Global Experiences and Success Factors of Smart Grids

- Iraq: Iraq is one of the leading countries having implementation of smart grid based projects in different locations with the assistance from multiple corporate organizations including ABB, Siemens and many others for the overall escalation of power optimization.
- Enel: The earliest scenario that is Italian based system.
- Colorado: First Smart Grid Completion in year 2008.
- Hydro One: In Canada Ontario the project was accomplished with the deployment of smart grid for more than 1 million customers
- Sydney: The smart city and smart grid based implementation for Australian Administration
- Evora: The integration of smart grid in the electricity and power based optimization for the cumulative growth.
- Massachusetts: One of the classical and effectual implementation in USA

7. Separation of chargecarrier

Two modes are available for separation of chargecarrier

- Drift
- Diffusion

In drift carrier electron are driven by electric field around the device. Generally solar cell configured large area of P-N junction which made up of steel iron material the diffusion will occurs from higher concentration to lower concentration. The recombination process occur when electron diffuse across P-N junction. The diode which is created by flow of charge that charge current is known as drift current. When the electron and holes are diffuse in the junction called depletion region, the depletion region is also called space charge region.

Mono Crystalline. These types of panel are cut from single crystal material. It looks like smooth. These are most efficient and expensive. It mounted in digit frame. In mono crystalline whole cells aligned in proper direction thus working capacity are based on sun ray. The efficiency of mono crystalline solar panel is 20 to 25%.

Polly Crystalline (Multi Crystalline). Polycrystalline has large no. of crystal material and have reflective sunshine against human body polycrystalline slightly less efficient compare to mono crystalline material. The efficiency of this type of cells are 13 to 16%

Amorphous. These types of cells are manufactured by thin film or non-crystalline materials. These are low efficient and low price in economic. It flexible in nature and the efficiency of this cells are 5 to 10%

Iraq's consumption of electricity continues to significantly exceed its generation capacity. In addition to investing in the required generation capability, it is also imperative to take advantage of the latest technology to optimise efficiency and manage demand. A Smart Grid system, integrating key applications across the entire value chain, can achieve this.

Smart Grid technology delivers proven efficiency enhancements by matching hourly demand cycles, obtained from Automated Meter Reading (AMR), with appropriate real time response across the entire electricity supply chain. Such systems have been proven to deliver long-term value to the utility, the customer, and the environment.

- Monitoring and controlling delivery of power down to the consumer in near real-time, improving efficiency and encouraging conservation
- Continuous power quality monitoring, and active management of all distribution system elements.
- Outage identification and management

- Improved planning and accommodation of infrastructure construction and maintenance schedules.
- Real time, in-field management of maintenance workers and inspectors
- Carbon emissions management
- "Customer portals" to increase customer usage awareness
- Integration of alternative energy sources and co-generation programmes
- Enhanced plant security
- Leverage of existing communications investment such as substation fibre infrastructure.

As the integrator of one of the world's largest Smart Grid projects in the MENA Region, and as a leader in technology integration in Iraq, Technology Partners is taking the lead in bringing these innovative solutions to the part of the world where they can have the greatest impact.

8. Implementation Regions with the Smart Energy based Integrations in Iraq

- Basra
- Baghdad
- Mosul

9. Main benefits of Smart Networks in Iraq and their role in the Main National Network

- Effective usage of the energy resources with the renewable implementations to avoid any attempts of losses and higher degree of accuracy with optimization
- Achievements in the energy harvesting with the sustainable resources to multiple locations in the country
- Multi-dimensional elevation in the renewable energy resources with the minimum levels of hammering in the energy resources

10. Projected Mathematical Model and the Functions

The projected work presents the mathematical model and the foundation of the equations for the optimization with the smart grid-based approach

$$\sum_{i=1}^N (Q_i(C_i) - p_i \cdot c_i)$$

The mathematical equation presents the factor Q as the Quality of Energy (QoE) as the function and Q(C) as the power depletion pattern with the pi as the price of the power associated with the appliance. The presented view of the projected smart grid-based architecture is given here with the consideration of the power grid in S substations and the modular components. With each and every key component with k as the part of S substations with the M values in the micro grid-based architecture for the smart grids.

$$(\sum_{i \in N_j} a_i)_j = \alpha_j$$

Here N refers to the cumulative values of the coalitions and the j parameters associated with the grid.

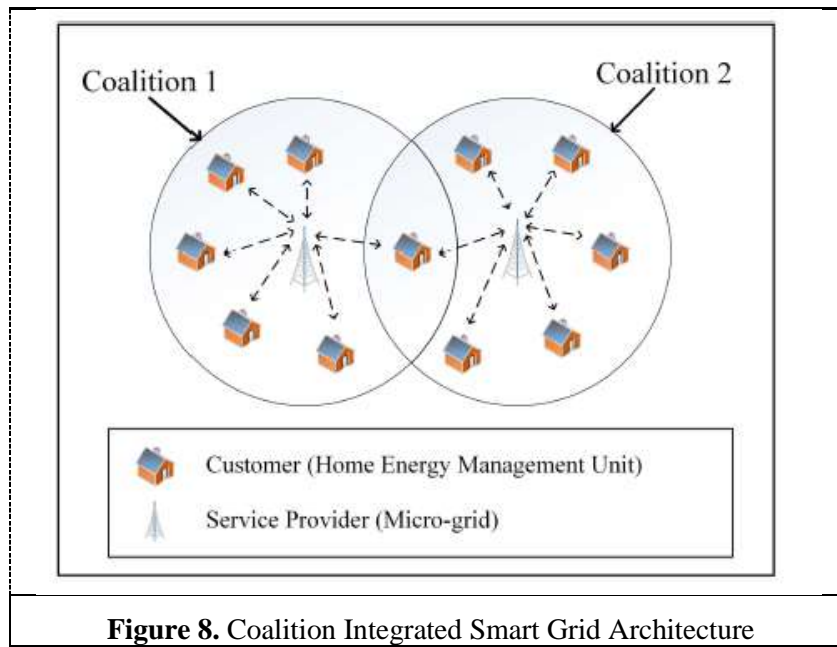


Figure 8. Coalition Integrated Smart Grid Architecture

The performance level of Smart Grid based Power Approach (SGPA) $n \in N(\cdot)$, i.e., $S_n(\cdot)$, is defined as the amount of energy consumed by the Smart Grid based Power Approach (SGPA) n , i.e., $d_n(\cdot)$, and the amount of required energy, i.e., $E_{\max} - E_{\text{res}}(\cdot)$. Mathematically,

$$S_n(\cdot) = \frac{d_n(\cdot)}{E_{\max} - E_{\text{res}}(\cdot)}, \quad \forall n \in N(\cdot)$$

where E_{\max} is the maximum battery capacity of each Smart Grid based Power Approach (SGPA) n , and $E_{\text{res}}(\cdot)$ is the amount of stored energy present in the battery of Smart Grid based Power Approach (SGPA).

Each Smart Grid based Power Approach (SGPA) $n \in N(\cdot)$ requests the energy-cloud service provider to supply $d_n(\cdot)$ amount of energy to maximize its performance factor. If Smart Grid based Power Approach (SGPA)1 and Smart Grid based Power Approach (SGPA)2 consume $d_1(\cdot)$ and $d_2(\cdot)$ amount of energy, respectively, while their energy requirements are same, the Smart Grid based Power Approach (SGPA) consumes higher amount of energy, has higher performance level. Mathematically,

$$S_1(\cdot) \geq S_2(\cdot), \quad \text{if } d_1 \geq d_2, \text{ and} \\ [E_1^{\max} - E_1^{\text{res}}(\cdot)] = [E_2^{\max} - E_2^{\text{res}}(\cdot)]$$

Therefore, the utility function of Smart Grid based Power Approach (SGPA) $n \in N(\cdot)$, i.e., $\varphi_n(\cdot)$, must satisfy the inequalities as discussed below:

The optimization module of each Smart Grid based Power Approach (SGPA) $n \in N(\cdot)$, $\varphi_n(\cdot)$, is considered to be a non-decreasing function, as each Smart Grid based Power Approach (SGPA) n tries to consume high amount of energy, $d_n(\cdot)$, to maximize its performance level, $S_n(\cdot)$. We consider that the amount of energy requested to the energy-cloud service provider changes from $d_n(\cdot)$ to $\hat{d}_n(\cdot)$. Here, $d_n(\cdot)$ and $\hat{d}_n(\cdot)$ represent the current and new amount of requested energy by Smart Grid based Power Approach (SGPA) n . Hence,

$$\frac{\delta \varphi_n(\cdot)}{\delta \hat{d}_n(\cdot)} \geq 0$$

At marginal condition, the utility function of each Smart Grid based Power Approach (SGPA), $\varphi_n(\cdot)$, is considered to be decreasing. Therefore, each Smart Grid based Power Approach (SGPA) does not increase the amount of requested energy, $\hat{d}_n(\cdot)$, on reaching the marginal condition. Mathematically,

$$\frac{\delta^2 \varphi_n(\cdot)}{\delta [d_n(\cdot)]^2} < 0$$

11. Transgression and Energy Optimization

The energy optimization can be done with the reduction in the losses with the effective treatments and analytics of transgression attempts whereby the energy transmission by the smart grids cross borders can be effectively save and optimization can be done with higher degree of accuracy with minimum losses. The transgression is one the key issues and concerns which are required to be handled by the government agencies and the monitoring modules with effective usage of energy in the panels.

12. Conclusion

The government agencies of Iraq has assented to a game plan worth over \$400 million with GE Power (NYSE: GE) to make 14 electric substations on a turnkey introduce and supply essential equipment, for instance, transformers, circuit breakers and other outside rigging to reestablish existing substations and pass on genuinely important ability to zones standing up to basic power lacks the country over. The wander addresses an imperative achievement for GE to make electric substations in Iraq, and will in like manner watch the Company reinforce the agencies to stay sponsoring through various cash related foundations, including convey credit workplaces and business banks. GE has three working environments in the country - in Baghdad, Erbil and Basra – and the association continues passing on bleeding edge development and capacity for the headway of essential essentialness, social protection and transportation structure in the country. Today, GE-created developments make to 50 percent of Iraq's ability and GE uses around 300 people in the country, more than 95 percent of whom are Iraqi nationals.

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