Solar Power for Households in Iraq

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Doi: 10.23918/eajse.v6i2p31

Abstract: This paper assesses the feasibility of implementing solar power as a source of energy to generate electricity for households in Iraq. Detailed review of the baseline energy production, consumption, and requirements of households in Iraq was completed as a part of this research. It is concluded that there is currently insufficient electricity production in Iraq to satisfy the daily electricity requirements of the average household. This research demonstrates that it is possible to use solar photovoltaic cells to generate sufficient electricity to meet the energy requirements for the average household. Detailed analysis was also carried out to determine the various factors that need to be considered during the implementation of solar PV cells in the average Iraqi house to maximise per unit electricity output of each installation. Feasibility assessment of the climate in Iraq indicates that the weather conditions are suitable for successful application of solar power given the high levels of solar radiation across all the regions. However, it is also been identified that there are several factors that have the potential to reduce the efficiency of solar PV cells, including but not limited to pollution levels in urban areas and the dusty nature environment, particularly in the southern regions. Overall, the application of solar cells in households (rooftop) can be successful and is a potential source of clean electricity that can replace widespread use of diesel cogeneration in Iraq.

Keywords: Solar Power, Solar Photovoltaic Cells (PV Cells), Energy Use in Iraq

1. Introduction

Countries in the Middle East have yet not adopted government subsidies to power production and distribution within the solar energy because of the cheap and plentiful supply of oil resources. Due to the low-cost nature of fossil fuels, currently governments do not have the incentive to adopt alternative forms of renewable energy such as solar power. Based on the current situation in Iraq, it can be inferred that tangible actions to ensure sustainability in environment is not considered as a high priority when it comes to government policies. The countries, peoples and government do not appreciate the importance of transitioning to renewable energy to address the challenges of climate change. Efforts to implement and develop renewable technologies within the region has been mostly on the individual initiatives and non-governmental establishments.

The challenge faced in Iraq is that despite abundance of oil and gas resources, there are widespread energy shortages across the entire country. This has been primarily due to corruption and lengthy wars (which commenced since 1980s) which eventually lead to disruption and full-scale destruction of the infrastructure.

Received: October 8, 2020
Accepted: November 22, 2020
Barzanchi, A. A., Kareem, S.A., & Bayaty, N. M. (2020). Solar Power for Households in Iraq. *Eurasian Journal of Science & Engineering*, 6(2), 31-38.

In Iraq, the most promising source of renewable resource is solar energy. If the country was to adopt this form of energy, it would reduce CO2 emissions in line with many other developed countries in the world. Solar energy is becoming increasingly important because of the climatic change in the form of global warming. This report also provides analysis of the feasibility assessment of adopting solar energy in Iraq to manage the electricity generation shortages that are currently prevalent across most regions in the country. This includes an assessment of the extent of the electricity shortages in the country in the past and today, and in turn proposes possible solutions to address these shortages using solar power.

2. Literature Review

The electricity problem in Iraq has been widely documented and discussed in literature given that is a common and well-known public issue that is experienced by Iraqi households. There have been several studies which have proposed the use of renewable energy as a potential source for electricity, not only to address the electricity shortage issue, but also reduce the carbon footprint of Iraq (Kazem et al. 2012).

Solar energy and the associated technologies can be utilised in many ways to generate clean energy in Iraq. Kazem et al. (2012) identifies solar water heating as the simplest application of solar technology which comprises of a system of solar collectors and storage tanks. They concluded that these systems are viable and applicable in Iraq, particularly when coupled with latent heat absorbing materials (e.g. PCM) to provide extended thermal storage times. Adoption of these technologies has been limited due to lack of awareness.

Another practical technology is the use of solar air heating which is also widely published in literature. This form of technology utilises solar air collectors, normally unglazed, to capture energy from the sun and insulation using an absorbing medium (Patel et al., 2017). This type of technology increases ambient air temperatures by a factor of 2 and can be also be used for cooling purposes to save energy. Similar application is a thermal wall (also known as Trombe wall) which also uses solar air collectors to heat ambient conditions, particularly in winter (Abaas & Chaichan, 2009). Screening assessment of Trombe walls shows that such technology is highly applicable for use in Iraqi houses given the suitability of environmental conditions and potential for low cost of implementation of the technology through locally sourced material such as adobe, stone, concrete and bricks.

On an industrial/commercial level, several larger scale technologies exist that have the potential for implementation in Iraq (Abaas & Chaichan, 2011). Concentrated Power Stations (CPS) use a series of mirrors and lenses to concentrate large area of sunlight into a small area which is connected to an electrical power generator. Other large scale, solar ponds have been considered in Iraq by several authors such as (Shah et al., 2017). These technologies operate by using a pool of very saline water that prevent convection and thus support accumulation of thermal heat in lower areas. Despite ideal temperature conditions in Iraq for this technology, Shah et al. (2017) documented that the dusty environment is detrimental to the efficiency of such systems and therefore limits the applications. Similarly with solar chimneys which regularate temperature in buildings, however suffer from issues with dust accumulation (Chaichan, 2011).

The key factor influencing the widespread adoption of solar energy for electricity is the availability suitable grid systems and the lack of smart grids (Al-Douri & Abed, 2016). The concept is premised

on the ability consumers being able to provide electricity back in the grid and to have an integrated network that incentivises adoption of renewables such as solar.

1. Energy production, consumption, and requirements by households

Electricity production and consumption in Iraq is presented in Figure 1 below. This shows that despite the high amount of electricity being produced and imported each year, only a fraction of the total supply ends up being consumed by households (residential use). The poor infrastructure in Iraq has resulted in a significant transmission loss due to the current inefficient power grid system.

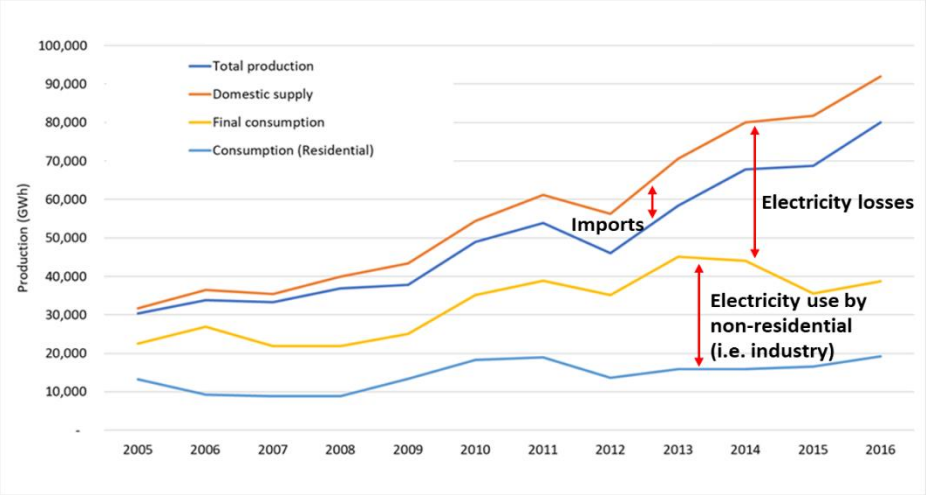

Figure 1: Electricity production, supply and consumption in Iraq from 2005-2016 (IEA 2018)

The breakdown of electricity consumption in Iraq is shown in Figure 2. This shows that approximately 50% of the energy consumption is used for residential purposes with the remaining being used for public services and industry. This means that if a possible solution to the electricity shortage (e.g. solar PV cells) addresses the requirements of households, then most of the requirements of the country will be satisfied as well. Reports show that households in Iraq receive a daily average of less than ten hours of electricity from the national grid (Ministry of Electricity, 2012).

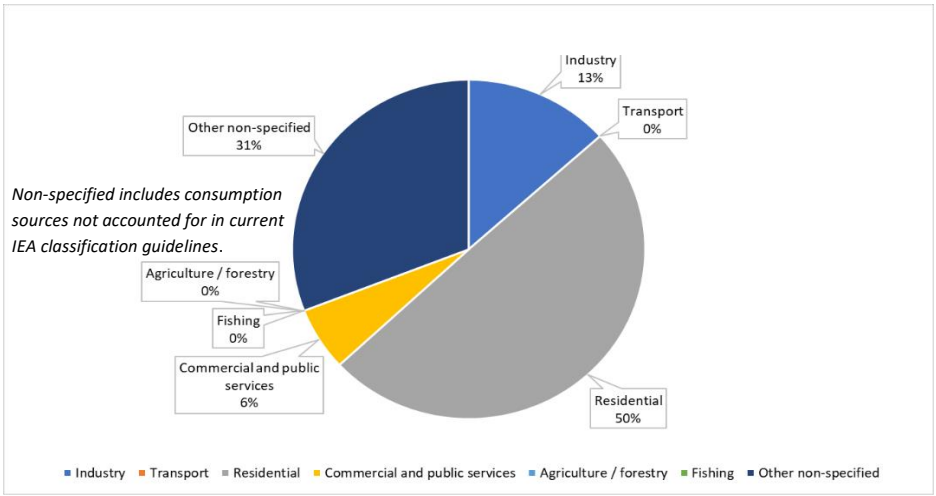

Figure 2: Electricity consumption breakdown in Iraq for 2016 (IEA 2018)

A significant portion of the electricity is generated from non-renewable resources such as oil and gas. Figure 3 shows that renewable sources only contribute a small portion to the overall production, of which almost all of it using hydro power. Currently, solar power is not used in Iraq as an electricity source mainly due to the oil and gas being a lower cost alternative and lack of government focus to reduce carbon emissions. Several attempts have been made to trial use of solar electricity for street lighting, but this has not made a material impact on the overall adoption solar of PV cells (Perlin, 2010).

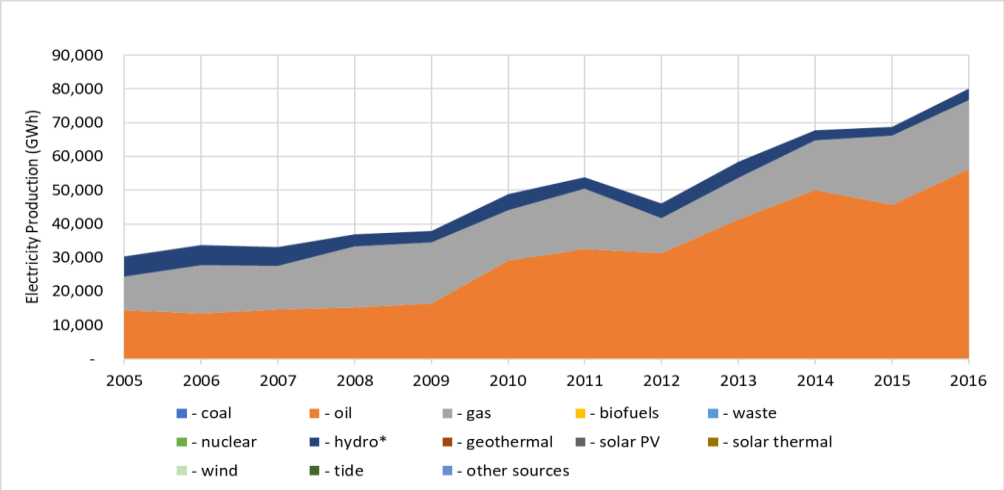

Figure 3: Sources of electricity production in Iraq from 2005 to 2016 (IEA 2018)

To determine whether solar PV cells could be a solution to the current electricity shortage, an assessment of the total electricity requirements was made for the average household. The approximate power consumption for typical appliances and systems used in houses was determined (Energuide, 2018) and the total electricity requirement was calculated in Table 1. The requirement for the average household in Iraq was calculated to be 5150 kWh per year.

Table 1: Annual electricity consumption per year for typical households (Energuide, 2018)

Type of Appliance	Capacity	Length of use	Consumption per year
Combination Fridge-Freezer A+	150 W	365 days – continuously	201 kWh
Dishwasher	1200 W	48 weeks – 5 days per week	288 kWh
Microwave oven	1000 W	48 weeks – 1.5 hours per week	90 kWh
LCD TV	250 W	335 days - 4 hours per day	241 kWh
Washing Machine, A+++	2500 W	48 weeks - 4 times per week (0.9 kWh/cycle)	173 kWh
Evaporative air cooler	250 W	2 units - 8 months for 24 hours a day	2880 kWh
Boiler	3000 W	365 days - 1 hours per day	1095 kWh
Lighting	500 W	365 days – 6 hours per day	182 kWh
Total			5,150 kWh

Figure 4 below shows that the 5150-kWh electricity requirement per year far exceeds the current consumption levels for the average household. This data clearly demonstrates that there is gap between energy requirements of households and current electricity supply available. However, based on calculations of solar energy output on a typical house in Iraq has the potential to completely offset the electricity shortage, as demonstrated in Figure 4.

The calculation was made based on the following assumptions:

- Average house in Iraq being a one to two story brick building.
- Covers area of 100-200 m^2 with a flat rooftop. Easily accessible with stairs making installation in households relatively simple.
- Even the lowest efficiency solar cells (15% efficiency) can provide up to 15 kW per day. This can provide more than 5475 kWh per year which provides 3000 kWh more electricity than what is required by the average household.
- Solar panels will only cover approximately 20 m^2 of a typical rooftop. Assuming an average light radiation of 0.1 kW/m^2, even a lower efficiency panel will generate the required electricity for an average household.

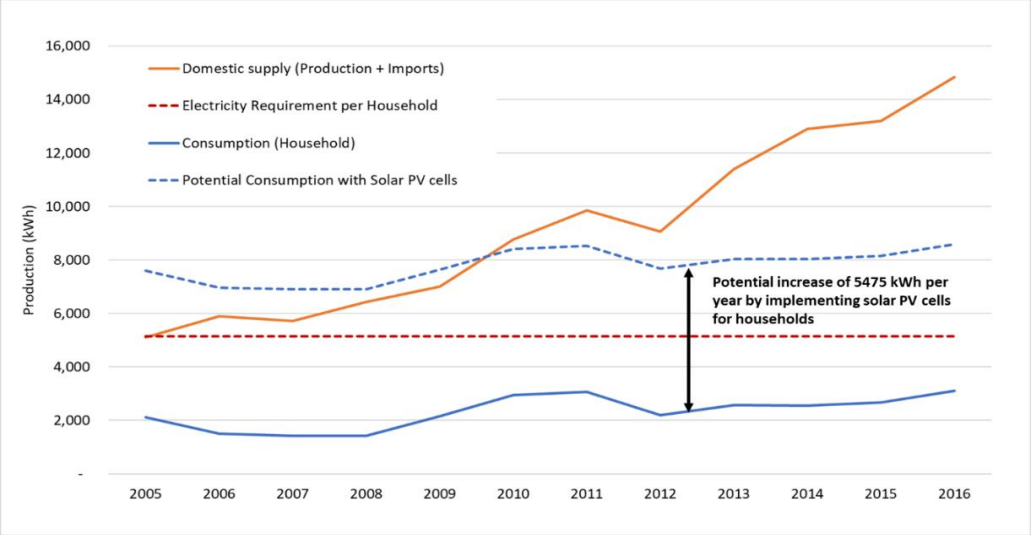

Figure 4: Potential benefits of solar PV cells to meet household electricity requirements

(Energuide, 2018)

2. Feasibility of Using Solar Cells in Iraq for Electricity

Based on solar radiation data, it is evident that Iraq receives a substantial quantity of solar radiation with an average of (6.5-7) kilowatt-hours per square meter. This is because the climate is continental, and the country is located near the solar belt. The periods of sun brightness range from 2800 to 3300 hours per year which makes it suitable for the successful implementation of technologies which utilise solar energy (Chaichan et al., 2015).

Table 2: Solar radiation levels for regions in Iraq (Hussain & Mahdi, 2018)

No.	Location	Latitude (N)	Longitude (E)	The annual solar radiation Mj /m2/year
1	Al-Basrah	30°31’	47°50’	6835.46
2	Al-Nasiriya	31°01’	46°15’	7263.97
3	Al-Samaua	31°16’	45°15’	7123.67
4	Ali ash Sharqi	32°07’	46°44’	7021.23
5	Ad Diwaniya	31°57’	45°00’	7021.23
6	Al-Najaf	31°57’	44°15’	7135.20
7	Al-Hai	32°08’	46°05’	7030.82
8	Kerballa	32°34’	44°03’	7185.74
9	Ar Rutba	33°02’	40°15’	7114.44
10	Baghdad	33°18’	44°30’	6997.46
11	Haditha	34°08’	41°13’	6662.75
12	Khanaqin	34°21’	45°25’	6556.30
13	Kirkuk	35°28’	44°21’	6660.17
14	As Sulaymaniyah	35°32’	45°29’	6727.42
15	Al-Mosul	36°19’	43°05’	6318.83
16	Zakho	37°08’	42°50’	6835.46
17	Tuz Khurmato	34°56’	44°38’	6640.00
18	Tikrit	34°35’	43°37’	6530.00

The solar radiation trend for Iraq shown in Figure 5 below shows an increasing level of solar radiation from North to South. However, it is important to note that the potential for successful implementation of solar cells is high across the entire country, including the Northern most regions. (Hussain & Mahdi, 2018)

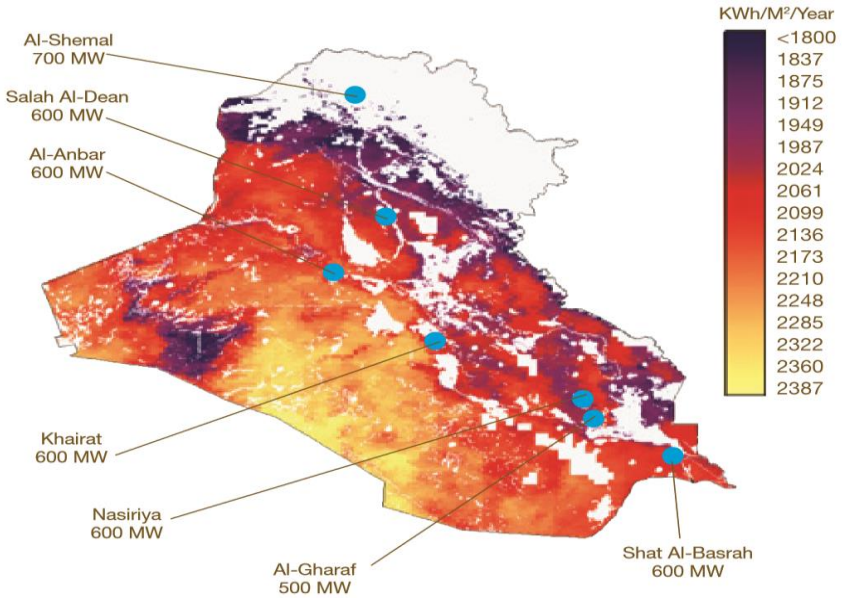

Figure 5: Solar radiation trend across Iraq (The German Aerospace Center (DLR), Iraq Ministry of Electricity)

The efficiency of the solar cell is influenced by many weather factors such as:

- High temperature can reduce the efficiency of a solar cell because it impacts the PV voltage.
- High relative humidity tends to decrease the intensity of solar radiation and hence reduce efficiency.
- Dusty or high pollution environment will reduce the efficiency of solar cells as it also reduces the solar radiation. Studies have shown that it can reduce by as much as 5% (Chaichan et al., 2015).
- Wind can also have a positive impact on solar cell efficiency because high wind flow can provide a cooling effect and thus increasing the productivity of the PV cells.
- Daily conditions such as cloud cover, smog and rain could reduce production of electricity by as much as 20% from the solar cell (compared to a clear day).
- Shading (i.e. time of day) can impact electricity production. As a rule of thumb, solar cells need to be in the direct contact with the sun to generate electricity.
- Angle and orientation of the solar cells need be optimised to ensure that it gets the most sunlight each day.

3. Conclusion

An assessment of the feasibility of using solar power as a source of energy to generate electricity for households in Iraq has been completed. This was done by first looking at the baseline energy production, consumption and requirements of households which show that currently there is not enough electricity production in Iraq to meet the daily electricity requirements of average households. The assessment carried out in this report demonstrates that it is possible to use solar photovoltaic cells (PV cells) to close the gap between and meet all the requirements for the average household.

Detailed analysis was also carried out to determine how solar PV cells can be used in the average house to maximise the amount of electricity that can be generated. The assessment showed that even the lowest efficiency solar cells (15% efficiency) can provide more than 5475 kWh per year to households which provide 3000 kWh more electricity than what is required by the average household. In addition to this, the climate in Iraq makes it a suitable site for solar power given the high levels of solar radiation across all the regions. However, there are several factors identified that reduce the efficiency of solar PV cells, including pollution levels in urban areas and the dusty environment. Despite these impacts, it is concluded that the application of solar cells in households (rooftop) can be successful and is a potential source of clean electricity that can replace widespread use of diesel generators in Iraq.

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