RENEWABLE ENERGY BUSINESS OPPORTUNITIES IN IRAQ Reflection Study Final Version 2022

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Part 1: Introduction and background

The ever-increasing demand for electrical energy causes a higher demand for fossil fuels namely, oil and gas. Based on International Energy Association (IEA), the electricity demand rose by 5% in 2021, and half of this increase is met by fossil fuels, which puts more risk on more carbon dioxide emissions to reach record levels in 2022 (Associaition 2021). In Iraq, the infrastructure and services have been deteriorating over the last 60 years, which is due to many military coups and many government changes. In 1990, the first Gulf war broke out, in this war the US coalition targeted the power plants that caused over 95% destruction at all stations. From 1990 to 2003, the sanctions against Iraq were a near-total financial and trade embargo imposed by the United Nations Security Council, which causes even more destruction for the energy sector. In addition, based on (World Population Review n.d.) Iraq is currently growing at a rate of 2.32% per year, which expects to reach 80m by 2050. Nevertheless, successive governments have consistently failed to find solutions to this problem.

Based on the latest published report by the Ministry of Electricity and Renewable Energy in 2018, the energy demand is increased from 10827 to 13002 MW, and the majority of the produced energy comes from fossil fuel-based sources by 70% and with only 2% from hydroelectricity plants. Therefore, this puts more pressure on the environment, where Iraq accounted for 8% of world methane emissions (Nation 2020), and 0.5 % for world carbon dioxide emissions (Roser 2020).

This leads to frustrating outcomes, and based on (USAID 2017) the projected change in climate in Iraq will include:

- Mean annual temperature is increased by 2°C by 2050.
- Fewer frost days and more frequent heatwaves.
- Mean average rainfall is decreased by 9% by 2050.
- Decrease in runoff of 22 % (countrywide average).

Therefore, it is essential to adopt renewable energy sources as an alternative source of energy on different levels, namely households, rural areas, urban areas and large-scale levels for hundreds megawatts.

Research objectives

The main objectives of this project are;

- To determine the different types of renewable energy sources in Iraq, and to identify the feasibility of each one.
- To examine the approaches to integrate these sources into consumer usage.
- To investigate the challenges that this sector is facing, and what are the possible opportunities and recommendations to facilitate the utilisation of renewable energy sources.

Research methodology

In this research, the data are collected based on the quantitative and qualitative manner. In order to study different types of renewable energy in the country, a literature review study has been conducted. By this study, the feasibility of the different sources of energy is revealed. Therefore, the most feasible sources are selected for further analysis.

After selecting the most suitable sources of energy, another method is the qualitative approach is used. By this method, other information from different people is collected and considered. The collected qualitative data is used to understand the concerns, experiences of the people about renewable energy, and what are the challenges that users counter when they utilized renewable energy sources, and what are the possible solutions.

This method is based on interviewing different actors. The actors are governmental figures, researchers, Iraq Response Innovation Lab (IRIL) partners, private sectors and consumers.

Various issues have been raised during the interviews, such as the challenges that renewable energy facing in the private sector, governmental policies, supply chain, the impression of people about utilising renewable energy sources and technical difficulties.

Another qualitative approach that is used is conducting a focused group discussion, where the issue the renewable energy and the community renewable energy are discussed.

In the focussed group discussion, a group of five people of different ages (25-50) have participated. The following questions and issues are discussed:

- How much do the participants know about renewable energy?
- How many types of renewable energy do the participants aware of in particular in Iraq?
- Have the participants ever tried to or thought of using one form of renewable energy source?

- If the answer is Yes to the previous question, what is your experience and what is the best way to improve it.
- If the answer is No, what are the reasons for not using renewable energy?

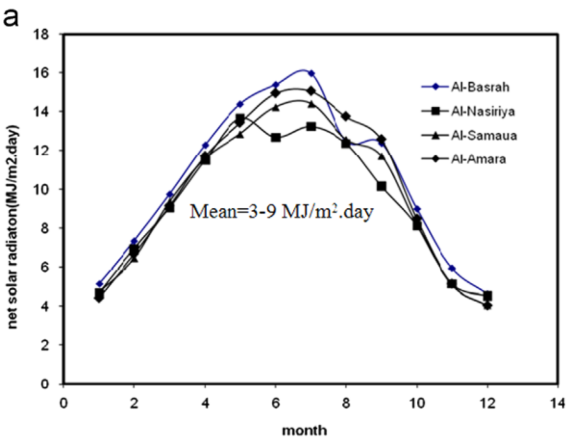
In addition, in this discussion, the issue of the community renewable energy and other countries' experiences have been introduced as an alternative solution in the country. The participant's opinions and the possible approaches to implement these in the country have been discussed. The outcomes of the quantitative approach are introduced in part 2, while the outcomes of the qualitative approach are introduced in part 3 and part 5.

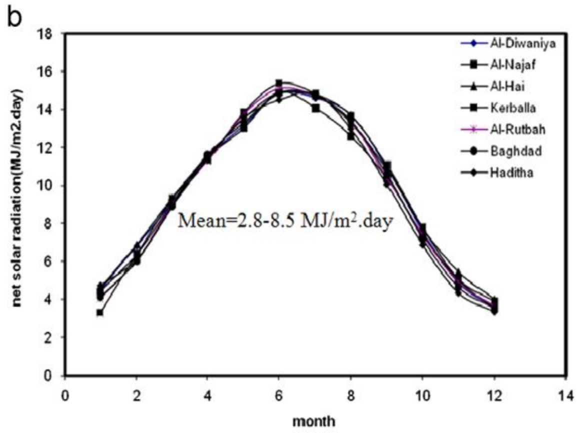
Part 2: types of the renewable energy sources in Iraq

In Iraq, there are several types of renewable energy sources, namely solar systems, wind turbines and anaerobic digestion systems (Electricity-Iraq 2021). In order to study the feasibility of each type of source, a review of the previous studies is conducted.

Solar Energy

Solar radiation is considered the most obvious renewable energy source available in Iraq, therefore utilising this source may contribute extensively in the solution of the power deficiency. The solar energy that reaches the earth is about 233 petawatts and only 24 terawatts of average power consumed by mankind every year (Hernandez 2014). The global mean of solar radiation is 170 W/m^2. While Iraq has the highest solar radiation power density of 270-290 W/m^2, achieving a peak power density of 2310 kWh/m^2/year (Al-Kayiem 2019), which is considered the highest among the others in the region (for instance, United Arab Emirates receives 2120 kWh/m^2/year (Bachellerie 2016)). This is encouraging data to give Iraq a hand to remain an energy supplier in the future. Solar radiation is investigated across the country considering the sunshine duration, humidity and maximum and minimum temperature. Abdul-Wahid and Hassan (Abdul-Wahid SN 2010) have conducted a study for solar radiation for different sites, in the south including Al-Basrah, Al-Nasrya, Al-Samawa and Al-Amara, in the middle consists of Baghdad, Haditha, Al-Rutba, Kerbala, Al-Hai, Al-Najaf and Al-Diwaniya and the north includes Kirkuk, Khanaqin, Sulaymania, Mosul and Zakho. The result of this study is shown in Figure 1.





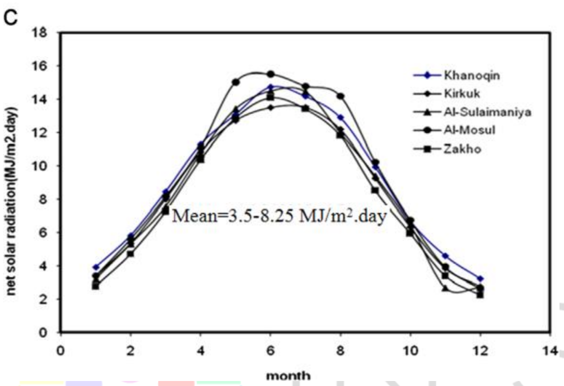


Figure 1: The solar radiation (Abdul-Wahid SN 2010)
(a) South of Iraq
(b) Middle of Iraq
(c) North of Iraq

It is clear from the results that the net of solar radiation in the south and middle of the country is higher than in the north (Abed 2014).

The net solar radiation was calculated based on the following parameters: sunshine duration, cloud cover, relative humidity and the maximum and minimum temperature (Abed 2014).

The result of these calculations is presented in Table 1.

Table 1: Meteorological Office (Iraq). The measurement for the period 1961-1992 for all stations (Al-Dulaimy 2012).

No.	Location	Latitudes (N)	Elevation (m)	The annual solar radiation MJ/m^2 per year
1	Al-Basrah	$30^o\ 31'$	2.4	6835.46
2	Al-Nasiriya	$31^o\ 01'$	3	7263.97
3	Al-Samaua	$30^o\ 16'$	6	7123.67
4	Al-Amara	$31^o\ 50'$	7.5	7021.23
5	Al-Diwanyia	$31^o\ 57'$	20.4	7021.23
6	Al-Najaf	$31^o\ 57'$	50	7135.2
7	Al-Hai	$32^o\ 08'$	14.9	7030.82
8	Kerballa	$32^o\ 34'$	29.0	7185.74

9	Al-Rutbah	$33^o\ 02'$	615.5	7114.44
10	Baghdad	$33^o\ 18'$	34.1	6997.46
11	Haditha	$34^o\ 08'$	108	6662.75
12	Khanoqin	$34^o\ 21'$	202.2	6556.3
13	Kirkuk	$35^o\ 28'$	330.8	6660.17
14	Al-sulaimaniya	$35^o\ 32'$	853.0	6727.42
15	Al-Mosul	$36^o\ 19'$	222.9	6318.83
16	Zakho	$37^o\ 08'$	442	6835.46

For a long period of time (1961-1992), the results in table 1 show that the annual average calculates for solar radiation is generally higher in the south and middle of the country than the north sites. In addition, the work published in (Abed 2014) shows that the calculations and measurements considering the north, middle and the south of Iraq have an average of 10 to 16 MJ/m^2/day for 5 months in the north, and of the middle and the south have 6 months. The results also show that the western desert of Al-Anbar has 8 months of sunshine duration, which makes it a promising place to drive all photovoltaic (PV) and solar concentrated power.

Figure 2 demonstrates the estimated PV power generation potential, which represents the average daily/yearly totals of electricity production (21ht). From this map, it is clear that the potential of high electric production from the PV system locates in the western of the country. The map is based on the average of data that is collected for a period of 20 years (1999-2018).

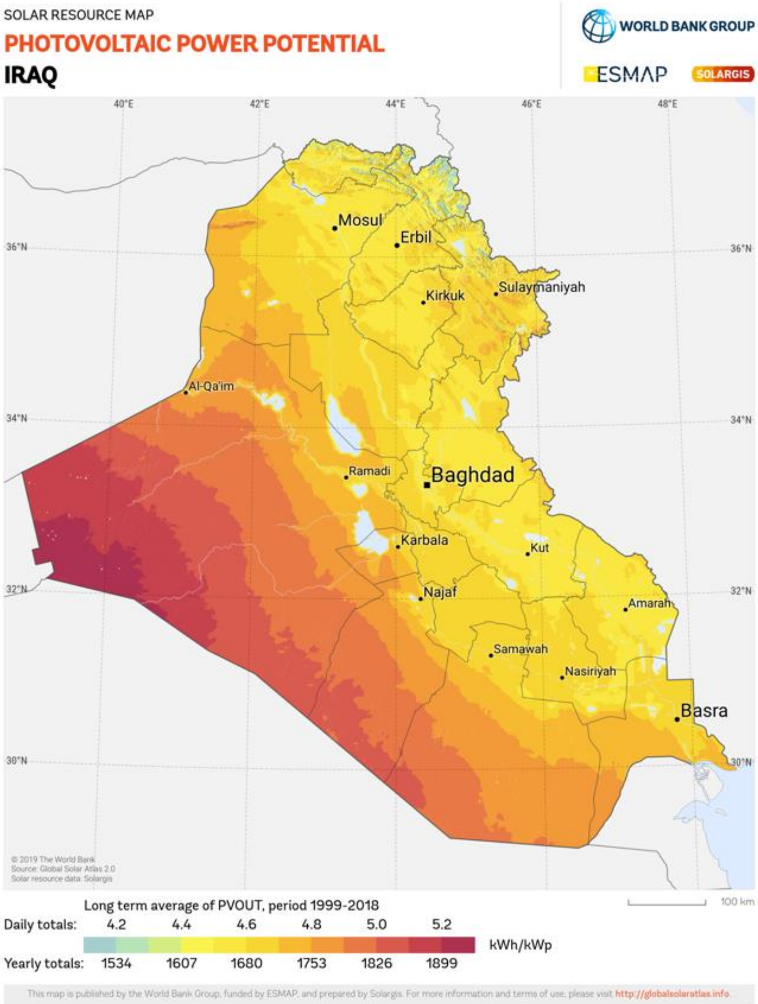


Figure 2: PV system Power Potential in Iraq

Wind Energy

Several studies have been conducted to investigate this sector in Iraq, where the data is collected from twenty-three stations across the country (Kazem 2012). The daily model of the wind speed has a maximum value varied between 5 to 10 m/s in the middle of the day and the early morning hours. The profile of the wind speed in Iraq can be divided into three territories (Kazem 2012). The first one represents 48% of the country and has wind speed between 2-3 m/s. The second territory represents 35% of Iraq and the wind speed varies between 3.1-4.9 m/s. The third territory represents 8% of Iraq and the wind speed is approximately 5m/s (Al-Kayiem 2019). In general, the average wind speed in summer is higher than in the winter. The aforementioned data is based on data measurement between 1978 to 2008 (Al-Jibouri 2014). Table 2 presents the annual mean wind speed for some areas in Iraq. Figure 3 represents the mean wind speed profile at the hight of 50m for the data collected over a period of 2008-2017.

Table 2: Annual mean wind surface speed (m/s) for some areas in Iraq, averaged over the years 1978–2008. *(Al-Kayiem 2019)*

Annual average wind speed	**Mosul**	**Haditha**	**Rutba**	**Baghdad**	**Nekhaib**	**Umarra**	**Basra**	**Nasiriya**
at 10 m height	1.3	3.4	3.7	3.1	3.8	4.0	3.8	4.4
at 50 m height	1.6	4.4	4.5	3.7	4.6	4.8	4.6	5.3

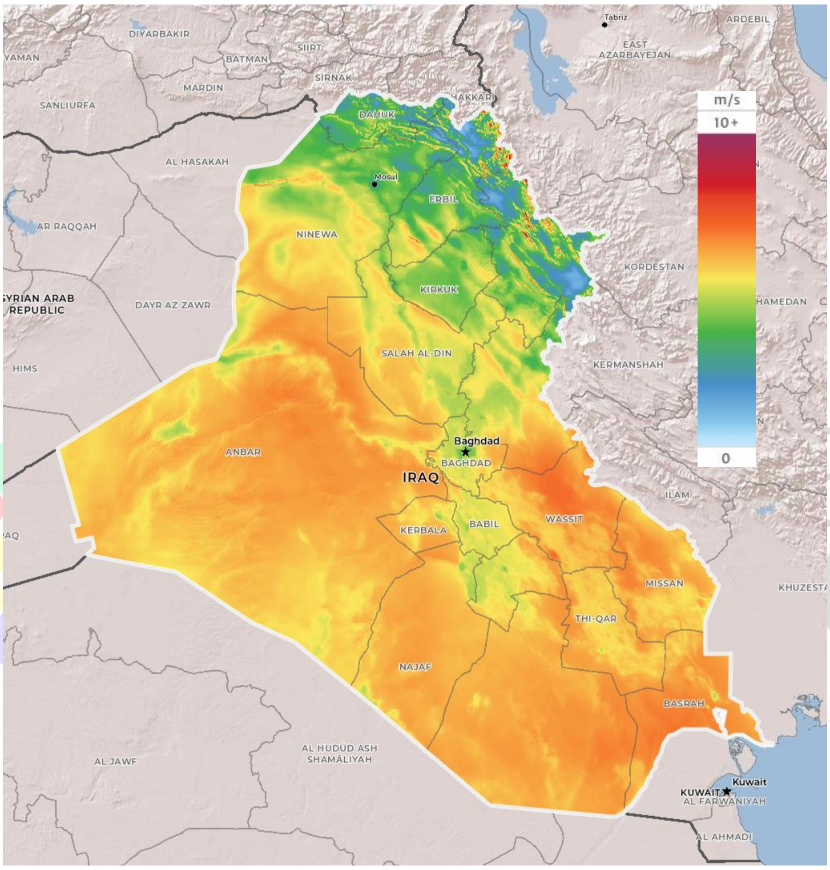


Figure 3: Mean wind speed at 50 m (Global Wind Atlas n.d.)

The wind speed has a significant impact on the output power of the wind turbine, and this can be characterised by so-called ‘wind turbine power curve’. The power curve for different manufacturers are shown in Figure 4.

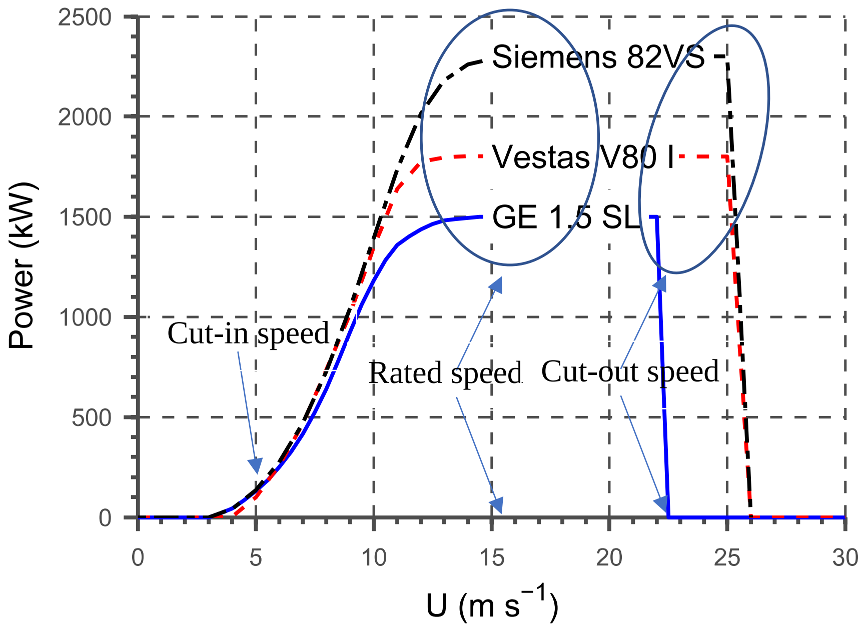


Figure 4: Power curve of Wind turbine (Lydia 2014)

In Figure 4, three parameters that can define the operation of the wind turbine, namely, cut-in speed which is the minimum speed the turbine starts to deliver a useful power. Rated speed is the wind speed at which the turbine deliver the rated power, which is the maximum output power of the electrical generator. The maximum wind speed where the wind turbine can generate power is define by cut-out speed (Lydia 2014).

Based on the power curve that is presented in Figure 4, it can be concluded that the wind power is not efficient source of power in Iraq, as the highest wind speed in different places in Iraq hardly reaches 5 m/s. Therefore, in this project, wind power is excluded from the research.

Biogas energy

One of the main sources for the biogas is the livestock manure and Iraq is very rich in livestock. Table 3 presents the number of livestock for different places in Iraq and for different animals (Planning n.d.).

Table 3: Number of animals by governorates survey central statistics organization

Provinces	Buffaloes	%	Goat	%	Cattle	%	Sheep	%
Nineveh	6616	5.6	79133	10.7	43615	3.5	1193769	19.9
Kirkuk	1326	1.1	54141	7.4	72062	5.8	553433	9.2
Diyala	5935	5.0	130347	17.7	113328	9.2	538073	9.0
Anbar	329	0.3	51816	7.0	86362	7.0	767906	12.8
Baghdad	34346	29.2	22634	3.1	135725	11.0	101662	1.7
Babylon	5034	4.3	37619	5.1	142421	11.6	223452	3.7
Karbala	4556	3.9	5183	0.7	22784	1.8	41378	0.7
Wasit	7097	6.0	122982	16.7	147656	12.0	550449	9.2
Salahuddin	1653	1.4	61750	8.4	101613	8.2	639628	10.6
Najaf	10403	8.8	5385	0.7	38609	3.1	85358	1.4
Qadidiyah	6573	5.6	62312	8.5	89970	7.3	277808	4.6
Muthana	1967	1.7	28539	3.9	24908	2.0	253277	4.2
Dhi Qar	6534	5.5	49867	6.8	96740	7.9	362561	6.0
Maysan	11061	9.4	18301	2.5	86799	7.0	368454	6.1
Basrah	14348	12.2	6289	0.9	29555	2.4	51931	0.9
Total	117778	100	736298	100	1232147	100	6009139	100.00

The manure of animals is collected in what is so-called a digester, where the mixture of gases is produced (more details about the system is presented in part 4) and one of the elements of this mixture is methanol which is used as a source of energy for heating or electric generation. However, this sector is unfortunately neglected by the government. This is due to the abundance of oil and natural gas, which causes the abandonment of this source of energy (Kazem 2012). However, several Iraqi researchers conducted studies to investigate biomass as an alternative source of energy. The effect of using bio-ethanol and methanol in compression- and spark-ignition engines are considered in studies. The results of these studies show the usefulness of adding ethanol and methanol to conventional Iraqi diesel and gasoline. Using bioethanol or methanol helps to reduce the high sulfur contents of Iraqi diesel, and improve the octane number of gasoline (Saleh 2010) (Chaichan 2010).

Part 3: Community Renewable energy

What is community renewable energy?

It is the community that has the main role in initiating, developing, operating and benefiting from renewable energy development. It comes in different shapes and sizes, growing from the needs and the available sources of the community. It can be varied in terms of technology, sizes, structure, governance and funding options (Jarra Hicks 2014). Figure 5 depicts the main idea of community renewable energy,

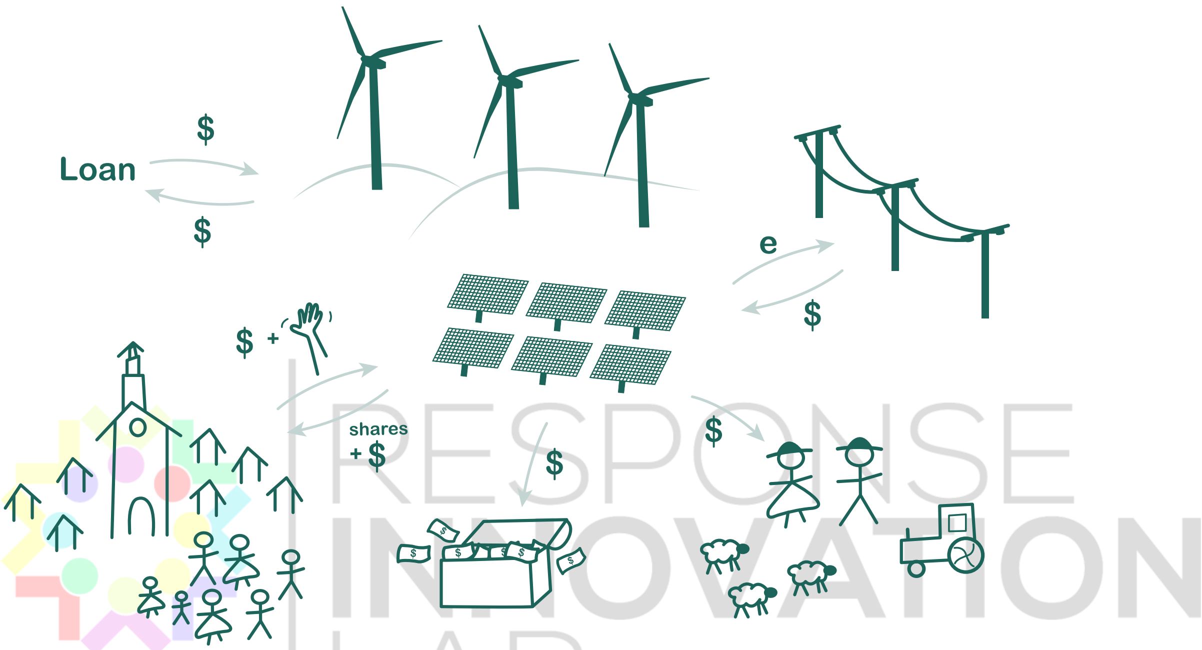


Figure 5: Community Project Energy (Jarra Hicks 2014)

Motivations of community renewable energy

The main motivations of the community renewable energy are (Jarra Hicks 2014):

- Local energy security

  In some communities, the concern about the supply of energy forces people to consider taking a lead in the production of the energy (this could be the main motivation in Iraq communities, as the government and private sector continuously failed to solve this problem).

- To boost their regional economy

  This is another motivation, communities are willing to get economic benefit from this industry.

- Reducing carbon emission:

  People take action to reduce their carbon emission footprint and the issue of climate change.

In general, the community-owned renewable energy can be characterised by the contribution to:

Decarbonising, **D**ecentralising, **D**emocratising and **D**emonstrating (The four D’s of CORE).

Generally, the benefit of the community renewable energy can be divided into five broad areas; political, economic, environmental, social and technological, which can be demonstrated by Figure 6

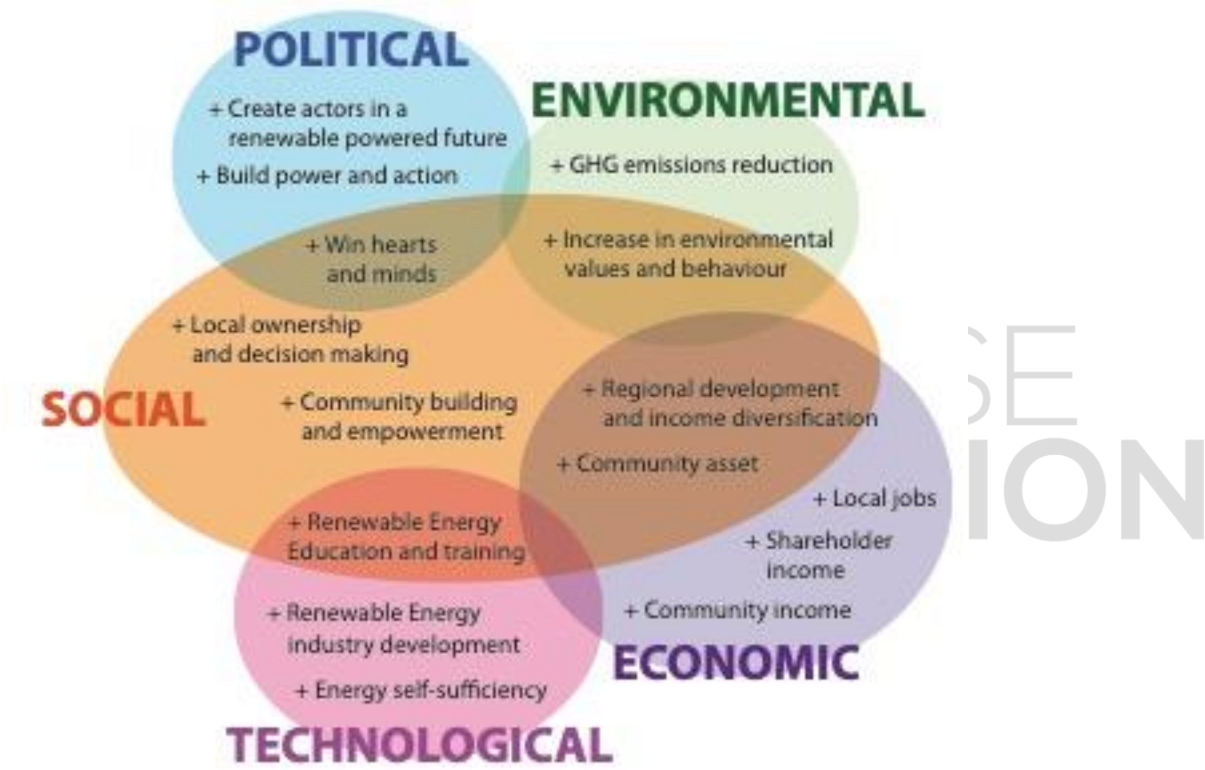


Figure 6: Motivation and benefit of the community renewable energy. (Jarra Hicks 2014)

Challenges

The main challenges of developing the community renewable energy are (Ison 2012):

- Financing the development phase of (social feasibility, technical feasibility, planning approval) of community renewable energy projects
- Getting a fair price for the electricity produced.
- The feasibility and cost of grid connection.
- Reducing the financial administration costs to a point that ensures the business case practicable.

Examples

There are several examples of the successful implementation of community renewable energy;

UK Community Renewable Energy

In the UK, the community energy sector has increased three times from 2005 to 2011 (Jelte Harnmeijer September 2013).

Figure 7 shows the renewable energy community by technology and country,

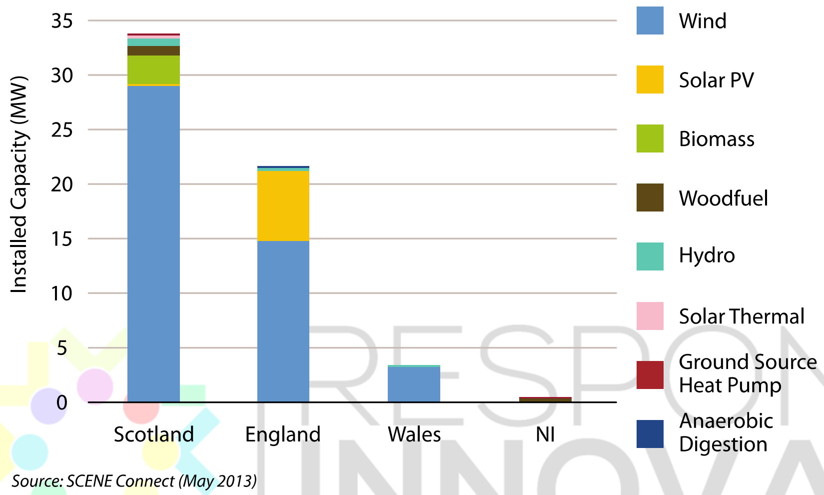


Figure 7: UK community Renewable Capacity by country and Technology (Jelte Harnmeijer September 2013)

It is clear from Figure 7 that Scotland has the highest energy production based on the community renewable energy, in which wind energy has the highest share. For the solar system, England has larger production than other countries.

Investment and ownership

In the UK, the diversity of arrangements has been grown through which the communities can participate in renewable energy, which can be divided into;

- Community-led ownership: The implementation and financing of the project are led by the community.
- Joint ownership: The implementation of the project is accomplished by an energy developer and the community-benefit organisation, which can be represented by a charity, purchases stakes in the project.

- Public/community-led ownership: A public body and the community are involved in the project. The public body is involved in the implementation and financing, and the community has full or part ownership of the project.

Figure 8 shows the diversity of the implementation of the community renewable energy in the UK (Jelte Harnmeijer September 2013),

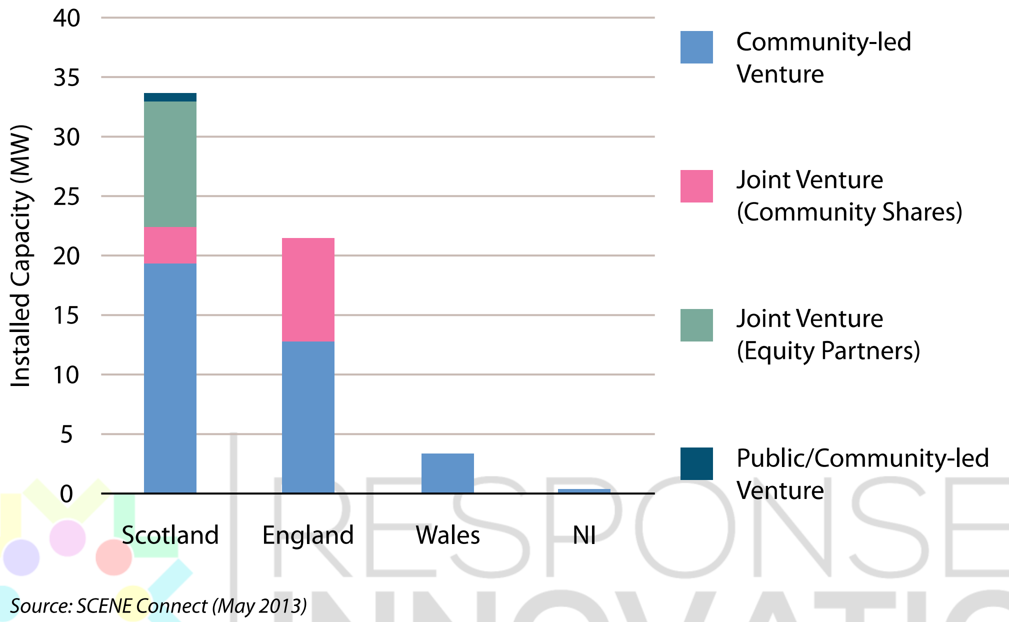


Figure 8:Ownership type of the UK community renewable energy (Jelte Harnmeijer September 2013)

Community renewable energy in New South Wales (Solar system) (Fitzpatrick 2013)

This project is located in New South Wales (NSW) in Australia. The investment works based on a trust-based investor model, which plans to link local investors with high quality solar projects.

The first project is a 15kW system at the Royal Hotel in Boggabri, NSW. In this project, 60 250W Trina solar panels and a 15kW SMA inverter are used and was completed on June 10 2013. It had just under 10 investors, an agreed investor term of 7 years, and a planned total term yield of 171 per cent.

In this business model, the modules are owned by investors and they sell the output of the system to a local consumer – usually the landowner. Each project has a maximum of 20 investors and a minimum investment of around $2500 or $5000, depending on the size of the project and the number of investors.

Middelgrunden Offshore Wind Farm (Initiative 2013)

In Copenhagen 1993, a group of people have decided to take the action and build the Middelgrunden wind project. However, this took seven years and a big effort before the first cooperatively owned offshore wind farm became a reality. In 2013, the 40 MW wind farm consists of twenty modern 2 MW wind turbines was developed by the Copenhagen Energy Wind and Middelgrunden Wind Turbine Cooperative supplying electricity for more than 40,000 households in Copenhagen.

The management

This project is managed by seven people. They successfully lead the project by their commitment, where the managers have different professional backgrounds and collaborating with various consultants. In the beginning, the planning and construction period was done by the working group, the management and many other people put in a lot of voluntary work to make the project happen (Initiative 2013).

The first bioenergy village in Jühnde/Germany

The first bioenergy village in Germany is Jühnde biomass plant, which is established in 2006. The goal of this project is to substitute all fossil fuels for electricity and heat production with biomass. The biogas plant is implemented for combined heat and power production, benefiting from liquid manure and whole plant silage of different crops. During the winter, the high heat demand is covered by an additional wood chip peak boiler. The heat is distributed via a district heating grid providing 145 houses and the electricity is completely fed into the grid (Initiative 2013).

Two local cooperatives operate the energy plant. Two people are required for the operation of the plants, logistics and administrative work. The biogas plant produces electricity more than the twofold demand of the village, which is approximately 5000 MWh electricity per year.

Community renewable energy in the Iraqi context

In Iraq, the lack of governmental solutions for the energy sector is one of the reasons why the community should take the initiative so that the community can lead this sector. Based on the latest report from the ministry of electricity and renewable energy, domestic usage is about 75% of the total power consumption (Electricity-Iraq 2021). Therefore the community renewable energy could be a very essential initiative, the community energy may contribute to the mitigation of the electricity crisis.

The above examples can be projected into the Iraqi case in order to initiate the community renewable energy in the Iraq community, there are several points that need to be considered (Jarra Hicks 2014),

- Initiation: At this stage, a group of visionary people should come together to set their aims and starts to develop the project. The commitment of this group is essential to sustain the business .
- Social Feasibility: This phase is very important and very challenging because at this stage a big effort is needed in order to convince people about the importance of community renewable energy. It depends on the targeted community, whether it is a rural or urban area.

  In the case of the urban area because there is a relatively larger number of households than the rural area, therefore more households can get involved in the project. In addition, based on (Morad 2018) the quantitative study in the Kurdistan region shows that the lower aged group between 18-24 years is more aware of the importance of renewable energy and climate change. Therefore, the possibility of finding individuals that can start this initiative is high.

  In the case of the rural area, the population is relatively lower, and the income is lower compared with the urban area, therefore, it is difficult to find individuals from the community to take action. Therefore, in this case, the NGO can take action as a “trigger” for this project.
- Technical Feasibility: At this stage a full technical study is undertaken to design the technical side of the project, considering whether it is a rural or urban area. In the case of rural areas, biomass energy is considered besides solar energy.
- Capital raising: There are several ways for funding the project, and this also depends on the targeted community. For the community that have more acceptance for the project, this could depend on the community share offer. For the community that have less acceptance of the idea, this could depend on grants.
- Construction and operation: At this stage, the project is developed and delivered, where the final stage includes the task of technical monitoring and maintenance and final administration.

The possible project outcomes

There are several outcomes of the community renewable energy which can be shown below:

For the rural areas, this will provide a stable source of energy in particular for those who do not have access to the national electrical power. In addition, in the case of biomass energy, this can act as a cheap source of heat energy which can be utilised to process dairy products in addition to the electrical power.

For the urban area, this will assist to provide energy security. Furthermore, a large number of PV systems require installation and maintenance. Therefore, more individuals can participate in this, which in turn, provides more jobs opportunities. In addition, this project can support regional communities and foster local economic development.

Part 4: Case studies (Technical Descriptions)

In this part, two systems are chosen, PV solar system and the Biogas system.

Section 1: PV system

In this section, three different types of the PV system implementations are considered, namely, household, governmental office and farm. The design of the PV system for all the cases are conducted by using PVsyst software, and the reports are provided in the Appendix.

The general procedure to calculate the PV system details

The is the procedure on how to determine the specification of the PV system, this procedure is for the stand-alone with batteries (off-grid) system.

Step 1: Calculate how much power is the property consuming, people in Iraq usually use the ampere rather than watt

Consumed power = ampere * voltage (usually 220V) (1)

Now, calculate the watt hour (Wh), which is the number of hours that the household depends on the solar system or private generator.

Daily watt hour= Consumed power from equation (1) * number of hours (2)

Step 2: Calculate the Watt-hour per day needed from PV modules

PV modules power= 1.3 * Daily watt hour from equation (2) (3)

The value 1.3 is the energy losses in the system

Step 3: Calculate the size of the PV modules.

In order to find the PV modules, the PV modules power from equation (3) is divided by the ratio kWh/hWp. The ratio depends on the georgical location and weather, in the case of Iraq is between 4.3 to 6.

Therefore,
the produce power by the PV system= Equation (3) / 6 (4)

Step 4: Calculate the number of the PV panels

PV panels= Equation (4)/ rated output PV (5)

Any fraction result of equation (5) approximated to the highest integer number.

Calculating the inverter size;

Step 5: The size of the inverter should be larger than the consumed power (equation (1)) by 25-30 %, this percentage is for considering the efficiency of the inverter. Also, the nominal voltage of the inverter should be the same nominal voltage of the battery.

Calculating the battery size:

Step 6: The battery capacity is determine by Amp hour(Ah)

$$\text{The Amp hour(Ah)}= \frac{The\ required\ energy\ (from\ Equation\ (3)) * Days\ of\ autonomy * 1.3}{voltage\ of\ battery} \quad (6)$$

Days of autonomy the number of days where no power produced by the PV system

Household

In the case of the household, the aim of the PV system is to replace the private generator, so that the household will rely on the PV system during the national grid power off. Below is the technical details of the project (for more details please see Appendix A.1);

Technical details

System type; stand-alone with batteries (off-grid)

The consumed power: 8 Amp * 220 = 1760 W.

The time where the household rely on the PV system is 12 hours/ day.

In the system, the seasonal tilt adjustment is considered, where during the summer, the tilt is 16^o and during the winter 50^o, this is to have more efficient operation for the PV panels.

The number of the PV modules is 10 units (2 string X 5 series).

The number of battery is 6 units.

The number of controller is 1 the technology MPPT converter.

Cost of the system

PV modules	10 X 150 $ = 1500 $
Batteries	6 X 200 $ = 1200 $
Controller	1 x 400 $ = 400 $
Support for modules	10 X 30 $ = 300 $
Cables and other materials	60 $
Labor	200 $
Total	3660 $

Iraq Response Innovation Lab

The Iraq response innovation lab is also considered as an example of the governmental office. For the governmental office the working hours is usually during the day, in this case, the need for battery backup is redundant. Below is the technical details of the project (for more details please see Appendix A.2);

Technical details

System type; stand-alone without batteries

The consumed power: 80 Amp * 220 = 17600 W.

The time where the household rely on the PV system is 10 hours/ day (8:00 am-6:00 pm).

Tilt angle is 32^{o}

The number of the PV modules is 32 units (2 string X 16 series).

The number of battery is 0 units.

The number of controller is 1 the technology MPPT converter.

Cost of the system

PV modules	32 X 150 $ = 4800 $
Batteries	0
Controller	1 x 450 $ = 450 $
Support for modules	32 X 50 $ = 1600 $
Cables and other materials	100 $
Labor	400$
Total	7350 $

Farm

In this section, a farm with 60 acres of wheat production is considered project (for more details please see Appendix A.3);

Technical details

System type; Pumping PV System

Irrigation system; Deep Well to Storage

The water consumpt[illegible]s from October to March with an average of 13 m^3/ acre for twice a week.

Tilt angle is 33^o

The number of the P[illegible]dules is 40 units (4 string X 10 series).

The number of battery is 0 units.

The number of controller is 1 the technology MPPT converter.

Cost of the system

PV modules	40 X 150 $ = 6000 $
Batteries	0
Controller	1 x 450 $ = 450 $
Support for modules	40 X 50 $ = 2000 $
Cables and other materials	200 $
Labor	500$
Total	9150 $

Section 2: Biogas system

The biogas system is another type of renewable energy, which can benefit from the process of natural interaction between microorganisms and organic wastes such as manure, sewage, agricultural by-products, and discarded food to produce a clean and burnable gas. This gas can be used in heating or electric generation (Surata 2014).

Figure 9 demonstrates the operational elements of the system,

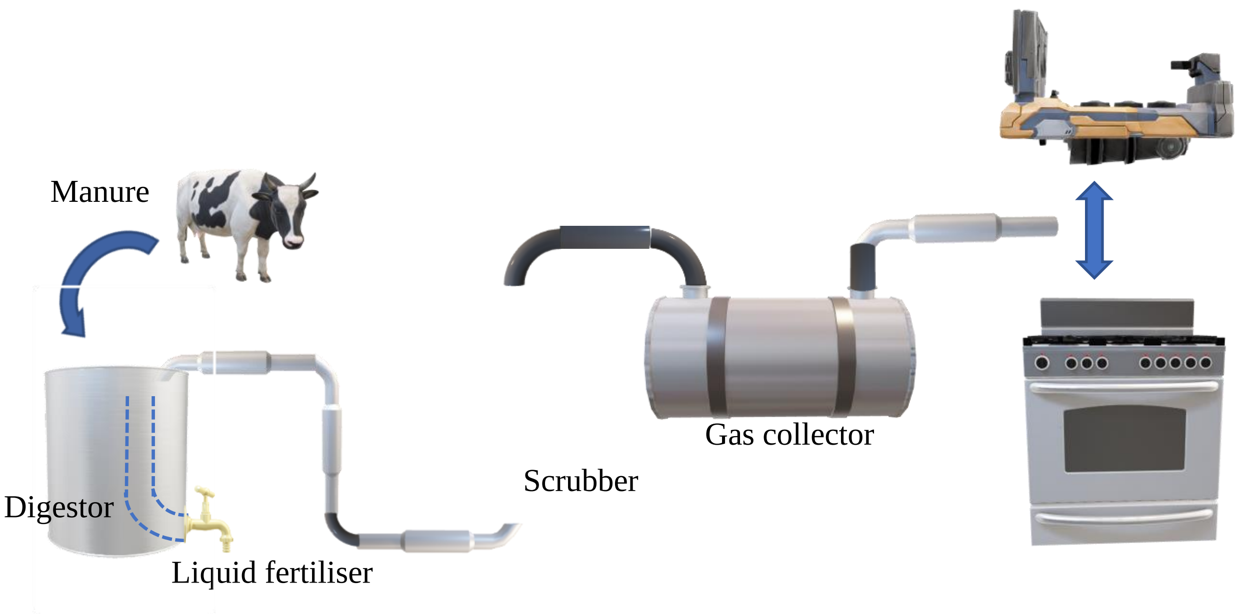


Figure 9: Biogas system

The biogas system is basically consists of;

Digestor: Which is the part where the manure is collected and the process of the anaerobic digestion occurs, where the bacteria digest the organic matter in the absence of the oxygen. The output of this process is 50-70% methane (CH_4), 20-40% carbon dioxide (CO_2) and hydrogen sulphide and nitrous oxide. The methane gas contains high energy which is used to produce heat or electricity. The output of this process is also the liquid fertiliser which is can be used for the fertilisation of the crop.

Scrubber: This is the part where the hydrogen sulphide is removed from the gas mixture. Inside the scrubber is steel wool, where the iron oxide is reacted with the hydrogen sulphide and removed.

Gas collector: The methane is collected in this part, which contains water the gas mixture bubbled inside it, this to remove carbon dioxide from the gas mixture to produce the pure methane.

The methane then is used as the gas for heating. For the case of the electricity generation, the diesel engine can be modified, where the air filter of the engine can be modified so that the methane can be injected through a valve as shown in Figure 10 and 11 (Tippayawong 2007),

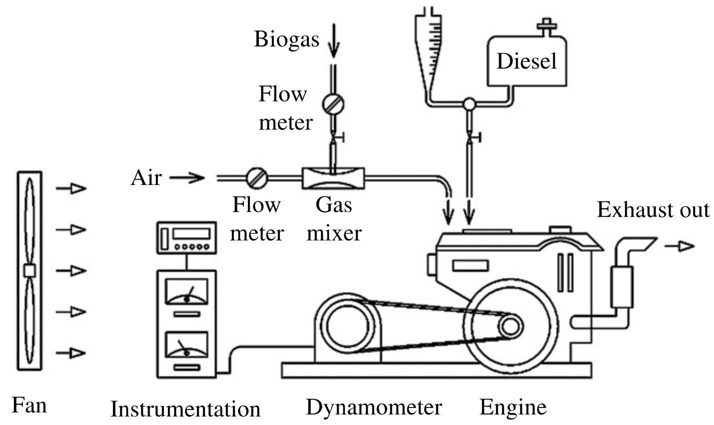


Figure 10: Modified Diesel engine (Tippayawong 2007)

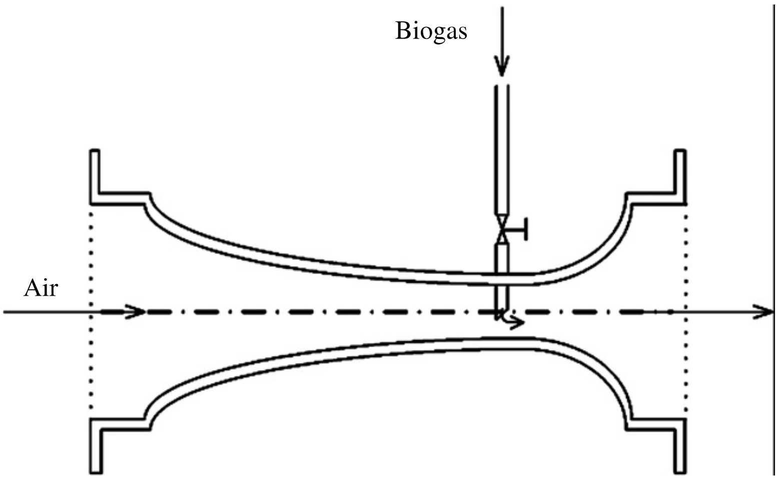


Figure 11: Biogas — inlet air mixing device. (Tippayawong 2007)

Part 5: Challenges, Opportunities and Recommendations

The sector of renewable energy in Iraq have faced enormous challenges, and many of these challenges are identified by using the qualitative approach that was explained in part 1. Many points and concerns have arisen regarding the usage and the investment in this sector, the main challenges are cited below;

Section 1: Challenges

One of the main aims of the project is to address and analyze how to facilitate the usage of renewable energy sources by the community. Therefore, the most important issue is to address the challenges that this sector is countering. Figure 12 demonstrates the main obstacles to the utilization of renewable energy.

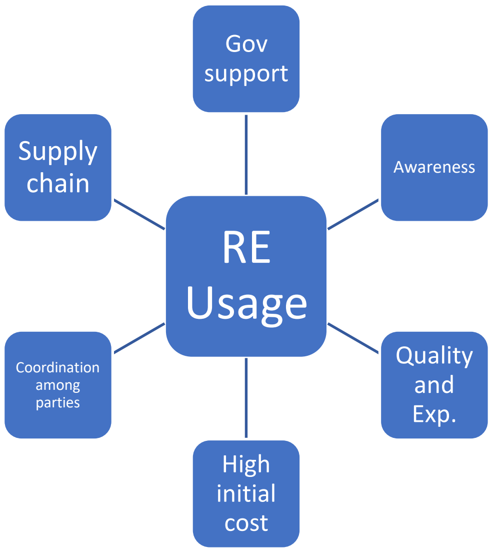


Figure 12: The main challenges of Renewable Energy utilisation.

Governmental support:

Governmental support for the implementation of renewable energy is very essential in terms of enacting legislation or policies to encourage private investment. However, the Iraqi government have not put adequate rules to encourage the implementation of renewable energy, where most of the effort has been done by the private sector.

Awareness:

People general knowledge about renewable energy is considered one of the main drives to promote the utilization of this source of energy. Based on discussions and interviews, people do not feel renewable energy is a secure source of energy that can replace the conventional one. In addition, there is negligence about the bad impact of fossil fuel on the environment.

Quality and expertise:

The quality of the products and the expertise of people who work in this field is very essential to provide a good impression about the usage of renewable energy. The quality of the products does not meet the appropriate technical standard that suits the Iraqi hot weather, which is due to a lack of good quality control by the government. In addition, the limited experience and the lack of local expertise in the Iraqi market in the field of renewable energy also has a negative impact on the reputation of the usage of renewable energy, which is due to the bad experiences of some people.

High initial cost:

The high initial cost for the installation of renewable energy is one of the main reasons why people are so reluctant for switching to renewable energy sources. Lack of funding mechanisms for the energy produced by renewable energy, unlike the energy produced by fossil fuel which received a good fund. In addition, lack of the competitors in the market causes the price to rise.

Coordination among parties:

Lack of coordination among parties is one of the reasons renewable energy do not receive much support. These parties are; manufacturers and companies, authorities, researchers and standard organisations. Each partner should have a certain role and plans and there should be a unified management system among the partners to achieve renewable energy projection. Therefore, loss of communication among them would scatter the efforts which have a bad influence on the renewable energy production.

Supply Chain:

The supply chain is a series of steps involved to get the products to the customer. Figure 13 shows the supply chain for the photovoltaic system.

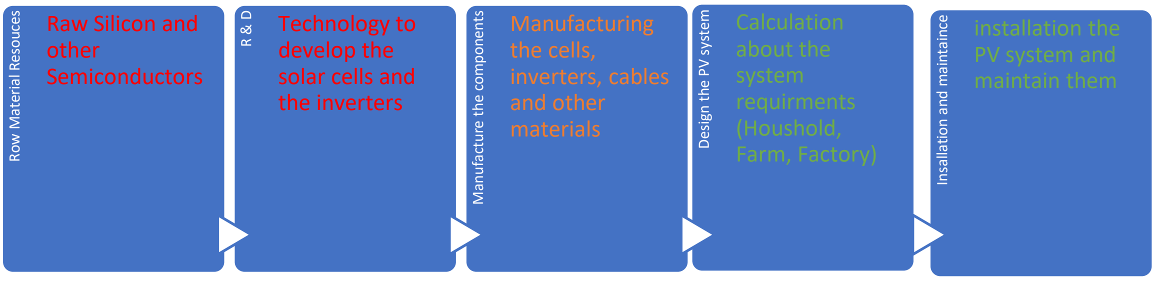


Figure 13: Supply chain for Photovoltaic System

External supply | External & possible to be internal | Internal supply

The supply chain for the photovoltaic system can be divided into three parts, the external supply, external and possible to be internal and the internal supply. Identifying the supply chain is important because this will help to find the jobs needed in the industry and what are the challenges and opportunities. For example, Iraq lacks manufacturing the components of the photovoltaic system, therefore, this could be an opportunity to establish this business in the country. In addition, for the case of the internal supply, more effort is needed in order to have quantitatively and qualitatively skilled workers in this field.

Section 2: Opportunities and Recommendations

There are several opportunities and recommendations that have been drawn from the discussion and interview which might have a good influence on the renewable energy sector in Iraq.

Recommendations and opportunities:

- Government should take the initiative and support the production of energy by renewable energy sources and there should be strategies to switch gradually to renewable energy-based electricity. In addition, the authorities should have control over the quality of the renewable energy components to ensure they meet the appropriate technical standards.

One of the possible solutions is to establish “Iraqi Association for renewable energy”. This will be responsible for:

  - Issuing certificates for workers or investors in this field.
  - Providing training courses for different levels.
  - Following up projects to ensure they meet the technical specification and the grid code.

Furthermore, Iraq lacks to incubator or research centre for renewable energy projects, therefore, an initiative to establish a “ Renewable Energy Research Centre” similar to Iraq Response Innovation Lab is essential. This centre could assist young people to develop renewable energy projects and to establish their business in the field of renewable energy.

- Raise the awareness of the importance of renewable energy among people and how this will have a good environmental impact for generations. This start from the early ages to the youth by arranging workshops/conferences.

  For example, one of the strategies is that can be followed to promote the renewable energy culture among people is that organising with the mobile phone companies to hold a competition and the withdrawn prizes are one of the renewable energy systems to be awarded as prizes to citizens after a lottery is made for the participants in this competition. The subscriber sends a sharing message to the mobile phone company, in which a certain amount is deducted from his balance, for example, one thousand dinars. If we assume that the idea of this message reached five million subscribers or more, and at least one million subscribers participated, then the total amount would be about one billion. This amount can be divided between the mobile phone company as profits for it and the other half to the organization to distribute it as prizes to the subscribers so that the organization does not pay any amount for the value of These awards. The purpose of this competition is to bring people's attention to renewable energy applications effectively and reach all societal groups.

- The Iraqi market craves local expertise for installation and maintenance. Therefore, this could create many good jobs opportunities. Training courses should be provided in various technical levels, the design level where the design is taken place using different software, and the maintenance and installation level where the on-site workers are required.

  The training course should cover the following materials;

- The basics of electricity

  In this lecture, the student will understand what is the current, voltage, power and the unit that is used to identify each component of the solar system.

- The components of the PV system
  - Solar panel: in this lecture the types of PV panels are explained and how to understand the datasheet. In addition, how to maintain and clean the panels is also provided.
  - The inverter: in this part, the types of the inverters and the datasheet are explained. In addition, explanations about the MPPT technology is provided.
  - Battery: in this part, different types of batteries that are used in solar energy are explained and what are the difference between and how to maintain them, what are the conditions that effect their operations.
  - The mounting structure: in this lesson, the design of the structure, and the types of the structure (fixed or adjustable) are explained.
- Design of the PV system
  - Energy consumption calculation: in this part the trainees will learn how to calculate the amount of the consumed and required energy.
  - Site survey: in this part, the trainees will learn what are the key information needed for the system design from the site.
  - PVsyst: the software is used to design the PV system, different configurations should be explained, namely on-grid connection , off-gird connection and pumping PV system.
- Pricing and payback period

  In this part, the trainees will learn about the pricing and the companies that supply the components of the system, and the payback period for the system

- The safety

  The students will learn about the safety measure of the system and how to avoid shock or electrocution.

Section3: Another promising projects

In addition, and based on the interviews, some projects are proposed:

Water desalination using hybrid solar energy (solar still + photovoltaic system):

With the increasing scarcity of potable water, the process of increasing the efficiency of solar water desalination systems needs to combine more than one technology to increase the amount of water suitable for human, animal and plant use. With this technology, two or more technologies can be combined with the solar still to increase the amount of desalinated water.

By using the photovoltaic system with a solar still, the efficiency of the desalination process can be increased. The photovoltaic system works as a source of energy to extract water from wells into basins which is prepared for the solar distillation process. The solar photovoltaic also is used for electric heaters (electric hydrators) that are located inside the basins to raise the temperature of the solar still, which works on the principle of global warming. The temperature of the water can also be risen by solar radiation through the transparent window, which can work besides the PV system.

The desalinated water can be mixed automatically with non- desalinated water for farms and animals. All these operations are carried out with a central electronic control unit that can control the whole process, where the amount of desalinated water depends on the size of the system being built.

The use of wind turbines with large electrical capacities to generate energy from riverbeds:

In Iraq, there are no sufficient wind rates for the use of wind energy generation systems except in specific locations of the country, and all the conditions suitable for building large turbines may not be available. Therefore, wind power generation heads can be used to generate electric power at riverbeds and on the banks of rivers, especially after dams, after which the water course is relatively fast. The fins are modified to connect the movable rotor, it is similar to what is called in Iraq (the waterwheel) in the middle of the river and the head of the wind turbine on the bank of the river.

In this way, it is possible to use these large megawatt turbines with more than one generating head and distribute them on the two banks of the river until the water velocity in the course of the river vanishes. In addition, this will save the process of building wind towers, as well as the maintenance process when it is on the ground level. Furthermore, the speed of water in the river throughout the day is approximately constant, in contrast to the speed of winds that are volatile and not available throughout the day.

Green house

The project is to build a house that meets the requirements of energy saving, such as thermal insulation and renewable energy requirements. Therefore, the house does not need the source of the national grid, where all the devices and equipment are economical in energy consumption.

In addition to a photovoltaic solar energy system, a biogas system can also be utilised, where sewage waste can be used for this purpose. The gas generated from the biogas system can be used for cooking and for generator running. Solar heaters can be used for water heating systems.

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