Feasibility Study and Economic Consideration of Rooftop PV System for Replacing of Diesel Generators in Erbil City

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ABSTRACT

This study compares a diesel generator and a rooftop photovoltaic system for energy sustainability. The comparison is based on economics, maintenance costs, life cycle cost analysis, and environmental impact. The PV system is sized and enhanced using hourly solar radiation and load data per hour, considering the minimum energy production cost and environmental impact. The article generally discussed solar systems to replace private generators in Erbil city, in terms of cost, and comparisons were made between PV solar systems and other sources of electricity, especially local diesel generators. According to the research, the PV system is a more economical and ecologically responsible option for grid electricity generation. Because of their minimal emissions, solar hybrid systems are an affordable and environmentally friendly choice for producing power. The results of this study are useful for areas with equivalent climates and energy supplies. However, investors and policymakers may find the sensitivity analysis of economic factors useful in determining the viability of renewable hybrid systems. A trend towards renewable energy sources, especially photovoltaic technology, an emerging technology, has resulted from the growing demand for power and the depletion of natural resources.

KEYWORDS

Diesel Generator, Life Cycle Cost, Rooftop Photovoltaic System, Renewable Energy.

1. INTRODUCTION

Energy is essential to human progress as it influences social and economic advancement as well as quality of life. It can be conventional or non-conventional, supplying enough energy is necessary for every country to have sustained economic growth (Bakri et al., 2022).
Due to power shortages after the Second Gulf War, the Iraqi government promoted using creative local distribution networks and home diesel generators, however, precise numbers are unavailable. Some reports estimate that there are 90,000–150,000 neighborhood generators. Twenty to thirty percent of houses' electrical supply comes from medium-sized diesel generators with a capacity range from 100 to 500 kVA.

To solve power shortages, especially during the peak summer season, the Kurdistan Region Government (KRG) has encouraged private entrepreneurs and Local Provincial Councils to build medium-sized diesel generators in Erbil neighborhoods as a complement to the supplementary grid supply. These diesel generators are owned and run by independent entrepreneurs. In Erbil city center, more than 1500 neighborhood generators are supervised and operated by local power companies (LPCs) or independent entrepreneurs. Globally, renewable energy sources are becoming more popular as a viable substitute (Ustun et al., 2020, Sohani et al., 2021). Solar cells that produce power when exposed to sunlight make up solar PV panels. Using silicon solar cells in electrically linked modules is a popular way to convert solar PV radiation into power (Mohammed et al., 2013, Chiemeka and Chineke, 2009, Al-Badi et al., 2012). The Global Energy Revolution aims to efficiently integrate renewable energy sources and attain emission-free energy production sources (Abubakar et al., 2024). The effective utilization of solar energy is made possible by the extraction and conversion of solar energy into electrical power (Ismail et al., 2013). There have been significant advancements in the utilization of solar energy for a variety of purposes in recent years, and this trend is expected to continue (Sohani et al., 2021). The public and corporate sectors are becoming increasingly interested in the energy these devices can generate (Chong et al., 2011, Figueiredo and Martins, 2010). PV technology is secure, clean, and eco-friendly electricity (Bernal-Agustín et al., 2006, Ayompe et al., 2011). Because it has no moving components, this technology has a major benefit in minimal maintenance and running expenses (Lau et al., 2010).

Nowadays, diesel generators are the main self-generation technology, however, they are hazardous to the environment and human health. Solar radiation is a plentiful natural resource, solar photovoltaic (PV) systems offer a more environmentally friendly and economically feasible option for homes and businesses instead of diesel generation. (Babajide and Brito, 2021). Renewable energy sources have been developed as a solution in response to the increasing demand for energy (Ukaegbu et al., 2023). Due to transmission and distribution losses, long power expansions are inefficient and detrimental to the environment; thus, renewable energy is a financially viable solution for supplying rural settlements with the electricity they require (Ukaegbu et al., 2023, Azerefegn et al., 2020). To lessen reliance on fossil fuels, solar energy is a clean, non-polluting energy source that has site-specific viability issues in nations with solar radiation levels of 3-6 kWh/sq.m (Tomar and Tiwari, 2017).

Adoption of rooftop PV varies among nations according to several factors, including local climate, built environment, government regulations, consumer demand, industrial capabilities, product availability, and pricing structure for grid-connected PV (Tomar and Tiwari, 2017, Agarwal et al., 2023). Grid-connected Rooftop PV/Building Integrated Photovoltaic (BIPV) systems may supply power to a parallel electrical grid without storage (Salas and Olías, 2011). A connected-to-the-grid PV system's performance is affected by several elements, including the load profile, inverter efficiency, solar panel array orientation and preference, and weather (Orioli and Di Gangi, 2016). Erbil city in Iraq has a good climate and geographic location, making it a suitable site for solar power generation. Seasonal variations affect the average energy output from solar installations; in the summer, 8.61 kWh/day/kW, in autumn 5 kWh/day/kW, in winter, the average production drops to 3.02 kWh/day/kW; in spring, it rises to 6.57 kWh/day/kW, **Figure 1** shows the average solar output kW installed solar PV by season in Erbil by NASA POWER Prediction of Worldwide Energy Resources.

Figure 1. Solar average output kW installed solar PV by season in Erbil (NASA POWER Prediction of Worldwide Energy Resources).

In Erbil, Iraq, the seasonal solar PV production is determined by analyzing 8760 hourly intervals of solar and meteorological data from (NASA prediction of Worldwide Energy Resources (POWER API). The location is Latitude 36.1828^0, Longitude 44.0105^0. Moreover, **Figure 2** represents the hourly average kWh electricity per kW of solar PV installed in Erbil (Robinson, 2019-2024) .

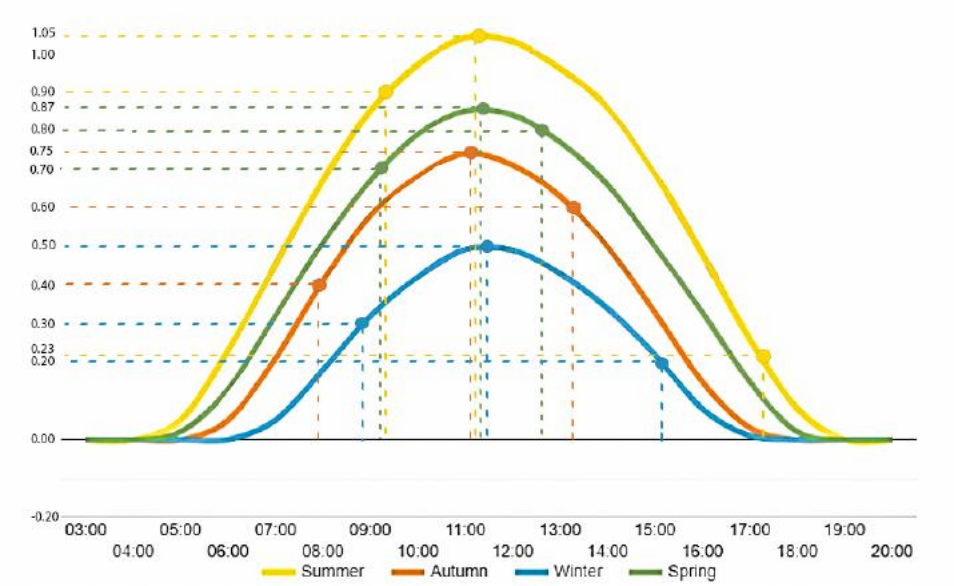


Figure 2. Hourly average kWh electricity per kW of solar PV installed in Erbil city (Robinson, 2019-2024)

For fixed-panel solar PV installations, it is recommended to keep the tilt angle at 31° South all year round for the best solar energy output in Erbil, Iraq. Adjust the angle of tilt of the solar PV panels all year long to maximize sunlight power in Erbil, Iraq. To maximize solar energy collection in the area, set the angle in the summer to 20° facing south, in autumn to 40°, in winter to 51°, and in spring to 28°. (Robinson, 2019-2024) (profilesolar.com/locations/Iraq/Erbil).

2. MAIN BODY

2.1 Photovoltaic Systems

The most efficient way to convert solar energy into electrical energy is commonly acknowledged to be PV systems. crystalline silicon is the semiconductor material of choice for the majority of significant companies for creating solar cells, combining solar photovoltaic cells, solar photovoltaic modules are reliable, durable, and low-noise energy generators that provide free fuel for the solar cells. The only resource required to run photovoltaic systems is the sun, which offers an almost infinite supply of energy, Typically converting 15% of solar energy into electrical power, a photovoltaic cell can generate 1/6 of that amount (Khayal). Solar cell manufacturing technologies are Polycrystalline, Monocrystalline, and Thin-film as shown in **Figure 3**.

Figure 3. Photovoltaic Cells: types of solar photovoltaic cells (Khayal)

There are three primary types of solar systems: standalone (off-grid), not connected to the network as seen in **Figure 4**. Besides, another system is a Photovoltaic system linked to the

public power grid (on-grid). **Figure 5** shows Network-Connected Photovoltaic Systems and the last one is hybrid systems that combine off-grid and on-grid features, allowing energy storage in batteries and connecting to the utility grid network as illustrated in **Figure 6** (Al-Wakeel, 2021).

Figure 4. Standalone (off-grid) Photovoltaic Systems (Khayal)

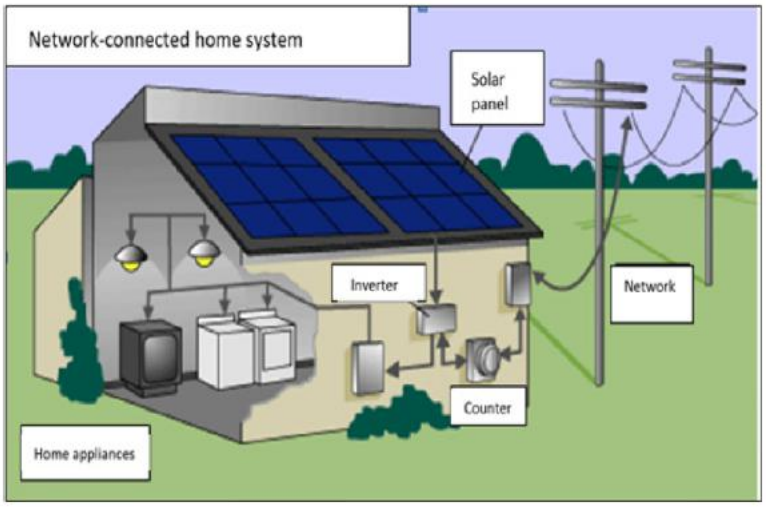


Figure 5. Network-Connected Home Photovoltaic System. (on-grid)(Khayal)

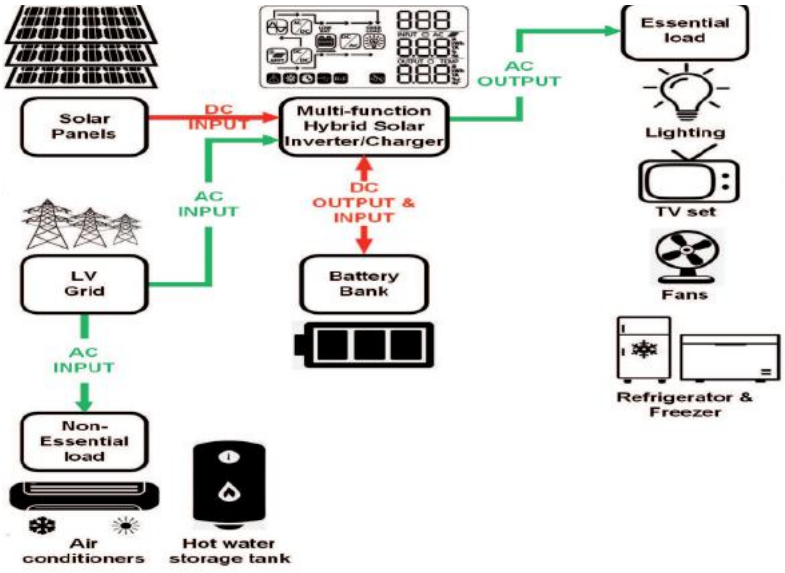


Figure 6. Hybrid solar PV system (Al-Wakeel, 2021)

2.1.1 Types of Photovoltaic Installations

(Abdulkadir and Ibrahim, 2020) examined the quantity and quality of PV installed in Kurdistan to pinpoint issues. Additionally, a home prototype was developed and possible building-applied photovoltaics (BAPV) and building-integrated photovoltaics (BIPV) were applied. The country's energy system may become more sustainable and efficient. BAPV-type installation is more common than BIPV in the Kurdistan Region, as shown in **Figure 7.**

Figure 7. (Left) BAPV system for installation, (Right) BIPV for various applications (Abdulkadir and Ibrahim, 2020)

(Abdulkadir and Ibrahim, 2020) took some samples of PV-equipped existing buildings in Erbil, Iraq, mostly houses as shown in **Figure 8**. This means that the roofs of the houses in Erbil city are suitable for installing solar systems.

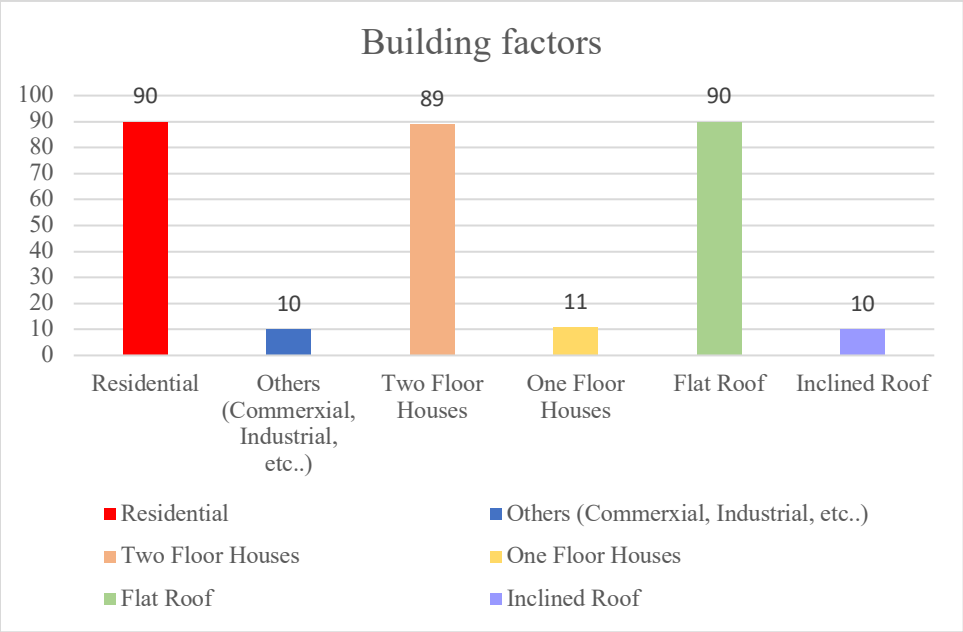


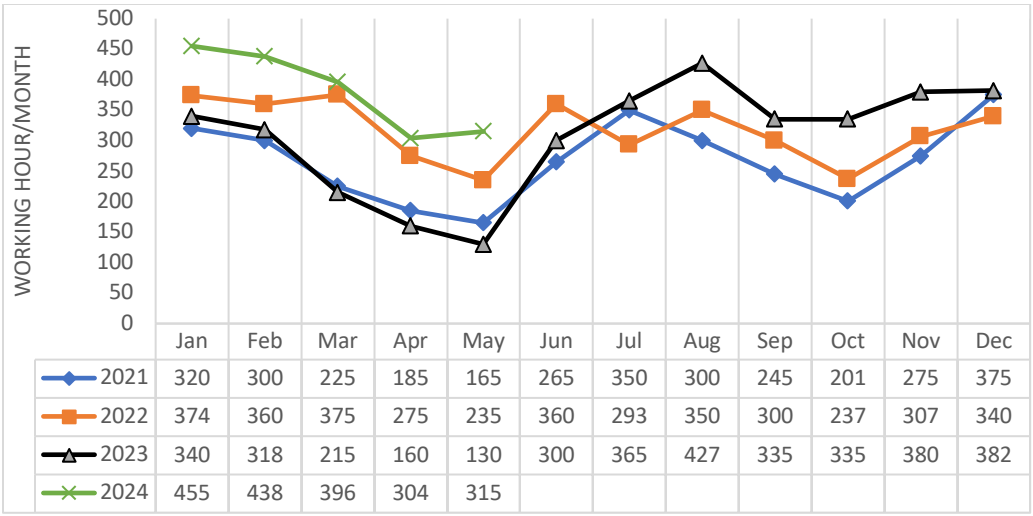
Figure 8. Types of roofs of the houses in Erbil city

Photo pictures of some neighborhoods of Erbil city that have solar systems installed on their roofs as shown in **Figure 9**.

Figure 9. Houses in Erbil city with installed PV system

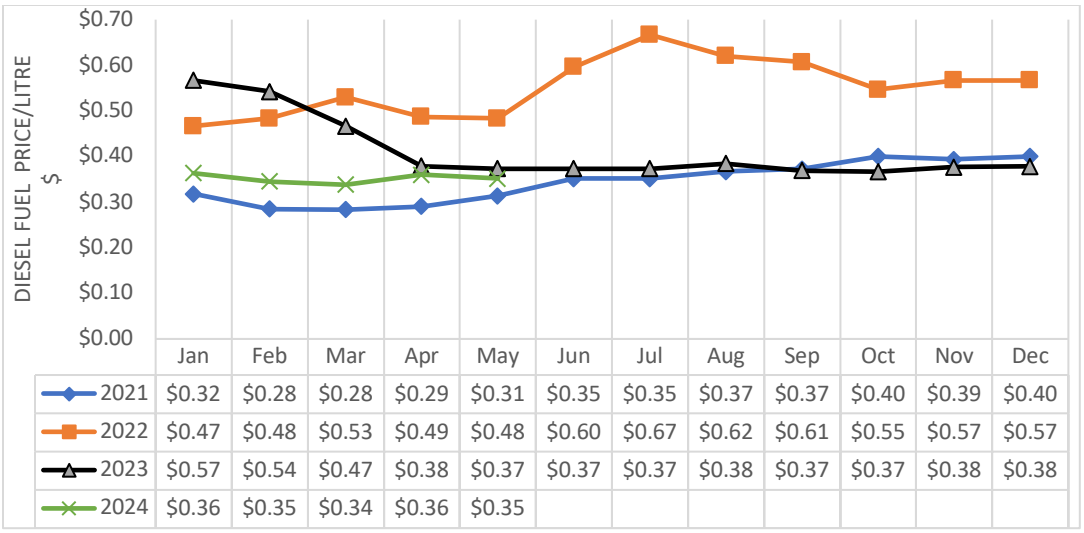
2.2 Neighborhood Diesel Generators

The supervisory and monitoring committee of private generators in Erbil province has recorded all the data and information about the diesel generators installed in the neighborhoods in the center of Erbil city and there are more than 1500 private diesel generators, registered to supply electricity to the surrounding households when the national grid is out of service. Most of their capacity varied from 75 KVA to 1325 KVA. **Figure 10** shows the number of hours of operation of generators per month for four years. According to the records of the supervisory committee of private generators, **Figure 11** shows that the price of diesel fuel per liter generators, and **Figure 12** shows that the price of kWh**,** varies from month to month, for the years 2021,2022,2023, and (till May) 2024.



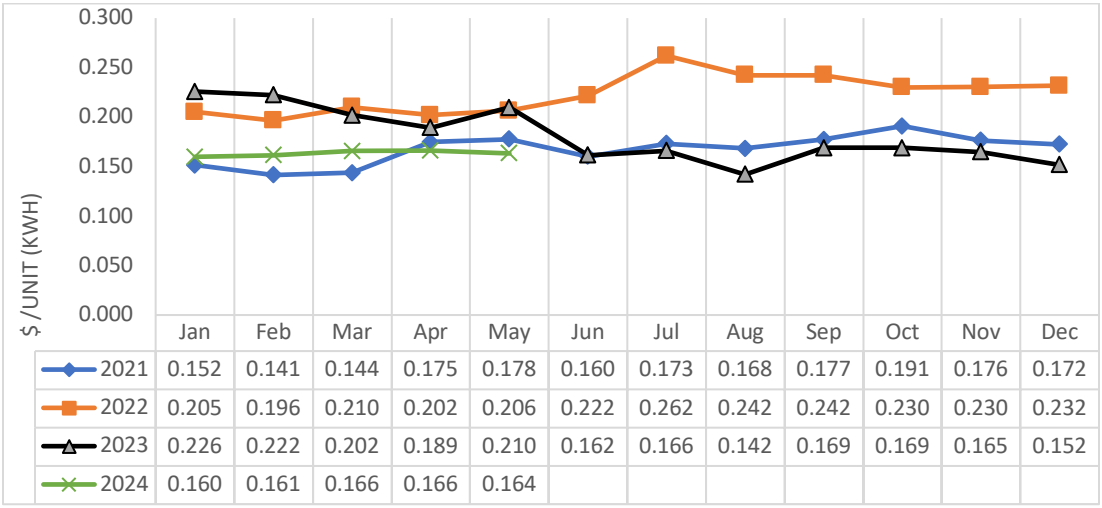
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021	320	300	225	185	165	265	350	300	245	201	275	375
2022	374	360	375	275	235	360	293	350	300	237	307	340
2023	340	318	215	160	130	300	365	427	335	335	380	382
2024	455	438	396	304	315							

Figure 10: The number of hours of operation of generators per month for four years (Supervisory Committee of private generators in Erbil province)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021	$0.32	$0.28	$0.28	$0.29	$0.31	$0.35	$0.35	$0.37	$0.37	$0.40	$0.39	$0.40
2022	$0.47	$0.48	$0.53	$0.49	$0.48	$0.60	$0.67	$0.62	$0.61	$0.55	$0.57	$0.57
2023	$0.57	$0.54	$0.47	$0.38	$0.37	$0.37	$0.37	$0.38	$0.37	$0.37	$0.38	$0.38
2024	$0.36	$0.35	$0.34	$0.36	$0.35							

Figure 11. Gas prices by month for every four years (Supervisory Committee of private generators in Erbil province)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021	0.152	0.141	0.144	0.175	0.178	0.160	0.173	0.168	0.177	0.191	0.176	0.172
2022	0.205	0.196	0.210	0.202	0.206	0.222	0.262	0.242	0.242	0.230	0.230	0.232
2023	0.226	0.222	0.202	0.189	0.210	0.162	0.166	0.142	0.169	0.169	0.165	0.152
2024	0.160	0.161	0.166	0.166	0.164							

Figure 12. The price of kWh in dollars every four years (Supervisory Committee of private generators in Erbil province)

In addition, **Figure 13** shows that the neighborhood generators have an irregular appearance and a lot of cables and wires, and they spread black smoke.

Figure 13. Neighborhood diesel generator on a mid-road pavement and redundant utility support insulators in the Kuran neighborhood of Erbil City.

2.3 Comparing Photovoltaic Energy Sources and Diesel Generators Economically

Researchers, who looked at the KRG's position as a source of national electrical power, found that electricity demand which is mostly supplied by fossil fuel products is always rising. This research aims to lower daily load demand and add produced electricity to the grid by presenting a cost and environmental analysis of a 10-kW grid-connected solar system for a government building. It is determined that the city receives enough solar radiation all year round to support the building of a photovoltaic system. Photovoltaic geographical information system (PVGIS) software was used to calculate the location's solar potential energy. August has the best potential for energy production (1,660 kWh), while winter has the lowest potential for production. Though it is expensive, the suggested grid-connected photovoltaic system may pay for itself in 19 years and doesn't need any other resources when it is installed. While PV modules run off of no extra resources, fossil fuel-powered generators have resource costs as seen in **Table 1** (Ali et al., 2020).

Table 1. Resource costs for fossil fuel generators (Ali et al., 2020)

Resources	Resource required to generate 1 kWh	Resource fost for generating 1 kWh	Total cost of generating 16,184 kWh/year
Gasoline	0.2732 L	$0.136	$2210.95
Natural Gas	0.2838 m^3	$0.7095	$11,482.54

The proposed PV system after calculating the cost with an annual average energy production of 16,184 kWh, can generate an annual income of around $242.76, with a 19-year repayment period

for the initial cost of $0.015, based on the region's charging rate. A 10-kW grid-connected photovoltaic system has an average lifespan of 25 years, with a net profit of about $1,456.56.

(García et al., 2019) searched for the installation and running costs for several choices over the 30-year project life are shown in **Figure 14**. Compared to the analysis, solar PV had the lowest life cycle cost of € 26,444, even though it had the highest installation cost. When irrigation systems were linked to the grid for energy, their life cycle cost (LCC) was € 41,593. However, because diesel generators have significant operating costs, their LCC was € 70,748. If state law permitted farmers to sell excess energy, they may benefit. Over 30 years, grid power accounted for 64% of the diesel generator's LCC, while the solar PV plant accounted for 37%.

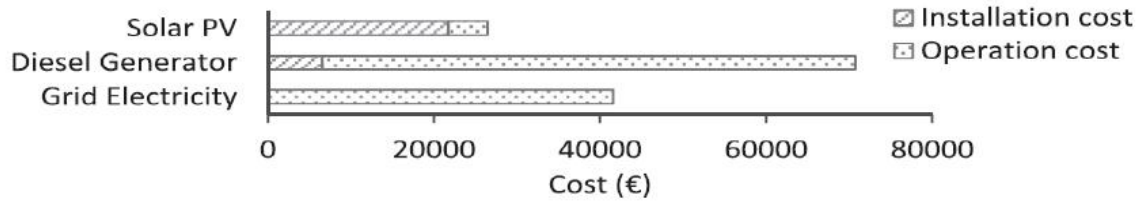


Figure 14: Installation and operation costs (in Euros) for the different options for a 30-year lifespan (García et al., 2019)

(Hussain et al., 2021) investigated the techno-economic evolution of two energy systems (conventional and renewable) that are connected to a grid. About the photovoltaic/grid and diesel/grid energy system scenarios (A and B) shown in **Figure 15**, the economic optimization aim is provided, taking into account component costs and economic assumptions derived from the Iraqi market and laws. **Table 2** shows a comparison between two different scenarios, the diesel generator runs alongside the solar system all day, producing 2346 kWh per year while using nearly 1826 letters of diesel fuel annually. According to the analysis, a diesel generator can produce 2346 kWh, but a solar system can produce about 7895 kWh. For scenario A, this means a net present cost of $1079 and an energy cost of $0.035/kWh, and for scenario B, it is $12287 and $0.598/kWh. Given that solar energy also makes an important contribution to grid energy support, the analysis concludes that solar energy is a more economical option than diesel generators.

Table 2. Shows a comparison between two different scenarios (Hussain et al., 2021)

Scenarios	Energy Produce	Net present cost	Energy cost
Scenario A	7895 kWh	$1079	$0.035/kWh
Scenario B	2346 kWh	$12287	$0.598/kWh

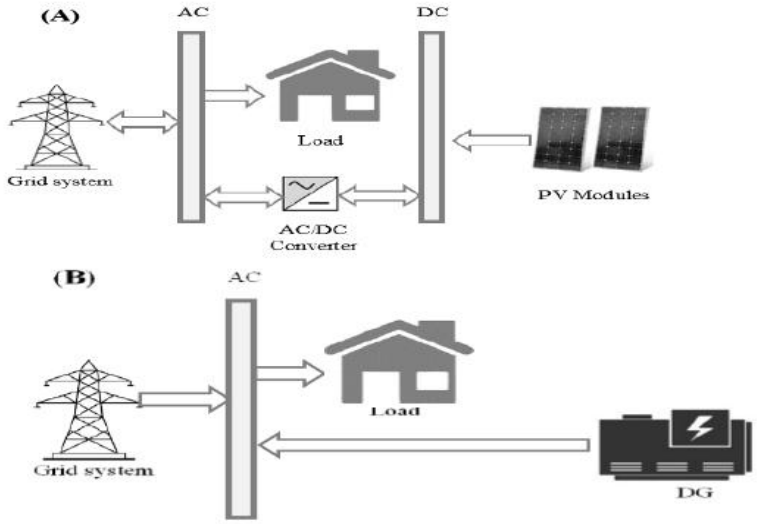


Figure 15. Investigated system scenarios (A) PV/grid and (B) DG/grid (Liu et al., 2021)

An economic study of the suggested diesel solar PV battery system with and without a grid is shown in **Table 3**, and it shows that the system performs better when the grid is built in (Okedu et al., 2015).

Table 3. Economic Analysis of Diesel, Solar without and with Grid System (Okedu et al., 2015)

Scenarios	NPC ($)	LCOE ($/kWh)	Operating Cost ($/yr)	Excess Electricity (kW)	Renewable Fraction
Without Grid Modeled	79.144	0.064	5.534	18.2	0.95
With Grid Modeled	38.215	0.0017	2.684	0.8	0.63

(Jalil and Mohammed, 2022) investigate the competition between renewable and conventional energy, as well as its economic growth, demand for solar energy, and annual cost decrease with an emphasis on important projects in the Middle East and the American oil fields, results as shown

in **Table 4.** The running costs of solar energy are 81% cheaper than those of government power, 75% cheaper than those of diesel generators, and 51% cheaper than those of investment stations that use beneficiary fuel. When the solar system runs throughout the day and is not dependent on batteries which are the primary source of these expenses, its capital and operating costs can be lowered by less than half.

Table 4. Comparison of operational cost between different sources of electric power(Jalil and Mohammed, 2022).

Power source	**Operating cost** ($/kWh)
National Processing	0.1
Gas generators (fuel only except oils, generator extinction, maintenance work)	0.076
Gas generators (fuel, oils, generator extinction, maintenance work)	0.17
Solar System(ON GRID)	0.0057
Solar System(ON-OFFGRID)	0.0183
Investment plants (government fuel processing)	0.038
Investment plants (fuel processing from the investor)	0.1

(Al-Wakeel, 2021) showed that the present levelized cost of electricity (LCOE) from several energy sources, including solar panels, neighborhood diesel generators, open-cycle gas turbines (OCGT), and combined cycle gas turbines (CCGT). **Table 5** indicates that rooftop photovoltaic systems offer a cost-effective replacement for neighboring diesel generators.

Table 5. Comparison between fossil fuel-based power generation technologies and LCOE of solar PV (Al-Wakeel, 2021).

Power generation technology		**LCOE (US$/kWh)**	**References**
OCGT		0.04-0.06	(Alva et al., 2019) (Istepanian, 2020)
CCGT		0.07-0.11	
Neighborhood diesel		0.64-1.30	
Solar PV	Utility-scale	0.018-0.085	(Alva et al., 2019) (Istepanian, 2020) International Renewable Energy Agency (IRENA), "Renewable Power
	Commercial Rooftop	0.062-0.064	International Renewable Energy Agency (IRENA)
	Residential Rooftop	0.063-0.265	

2.4 Comparison by environmental impact

Particulate matter consists of a blend of liquid droplets, soot, and ash. The quantity of particulate matter released per unit of fuel used by a generator is known as the particulate matter emission factor, and it is influenced by the generator's output, fuel type, and operating technique. This substance is known to produce air pollution and respiratory problems. Reducing pollution emissions and providing electricity to isolated rural regions are two benefits of integrating green energy into the diesel system. It would be financially feasible to incorporate renewable resources like wind and photovoltaics, which would lessen greenhouse gas emissions-related global warming. This renewable hybrid design is a good substitute (Thirunavukkarasu and Sawle, 2021).

For emission analysis, because grid-connected solar PV systems provide a significant amount of electricity and lower fuel combustion and greenhouse gas emissions into the atmosphere than grid-only or diesel generator systems, they are considered more ecologically friendly (Shamim et al., 2022).

The emissions of three alternative system configurations for Younus Khan Scholars' Garden are displayed in **Table 6**. It demonstrates how adding renewable energy sources to the grid lowers annual greenhouse gas emissions, making the suggested grid-tied solar photovoltaic system more ecologically friendly and cleaner (Thirunavukkarasu and Sawle, 2021).

Table 6. Emissions of different models (Thirunavukkarasu and Sawle, 2021).

Components	Amount (kg/yr.) (Grid-only system)	Amount (kg/yr.) (Grid-tied system)	Amount (kg/yr.) (Diesel generator system)
CO_2	1,038,060	864,857	1,797,196
CO	0	0	11,329
Hydrocarbons	0	0	494
Particulate matter	0	0	68.7
SO_2	4,500	3,750	4,401
NO_X	2,201	1,834	10,642

On an annual basis, the planned grid-tied solar PV system reduces greenhouse gas emissions by 953 tons of CO2, 4.13 tons of SO2, and 2 tons of NO2. Based on the data, almost every area in Bangladesh may benefit from grid-tied solar photovoltaic systems because of the country's abundant solar radiation. According to the study, the suggested approach may lessen the strain on

the grid and increase the production of renewable energy, which would reduce the consumption of fossil fuels and enhance energy security. Because of their improved dependability and service quality, grid-connected solar PV systems which come with a high installation cost are very lucrative and ecologically benign, contributing significantly to Bangladesh's electrification as well as that of the rest of the globe (Thirunavukkarasu and Sawle, 2021).

Figure 16 shows that a 64-kW plant generates 86% of the CO2 that the existing system produces, but a 46 kW RPS system produces 26 871 kg, 61% less than the system. The CO2 emissions of a 91-kW solar PV system can be reduced by approximately 100 percent. Because the 238-kW system sells more electricity to the grid than it purchases, it has a lower carbon footprint than the current system, making rooftop solar PV more environmentally friendly.

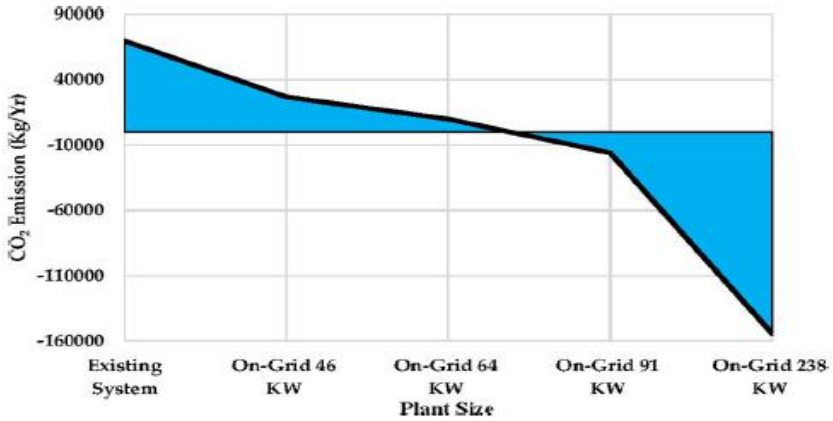


Figure 16. Co2 emissions from various sizes and the existing system (Podder et al., 2021)

According to the study by (Ijeoma et al., 2024)in Nigeria's commercial sector, the solar PV, battery, and generator combination is stable and may maintain its economic viability with up to a 60% difference in diesel prices, with an ideal transition occurring after a 70% increase.

The report highlighted the need for adopting sustainable practices and technology in all companies across the country emphasizing the potential for reduced energy costs and environmental benefits. Integrating a hybrid energy system may have a beneficial impact on the environment and result in significant long-term cost savings (Ijeoma et al., 2024).

A detailed review of the environmental pollutant emissions from the ideal Baseline (BL) system is given in **Table 7**, with particular attention to the direct emissions brought on by the usage of a diesel generator.

Table 7. Emissions from baseline system (Ijeoma et al., 2024)

Pollutant	Value	Units
Carbon Dioxide (CO_2)	10,935	Kg/year
Carbon Monoxide (CO)	68.9	Kg/year
Unburned Hydrocarbon (UHCs)	3.01	Kg/year
Particulate Matter (PM)	0.418	Kg/year
Sulfur Dioxide (SO_2)	26.8	Kg/year
Nitrogen Oxides (NO_2)	64.8	Kg/year

Khan et al., (2014) assessed the cost of changing from fossil fuel power to solar energy, looked at the electricity consumption and CO2 reductions at Sulaymaniyah International Airport in Kurdistan, Iraq, and provided theoretical projections for potential CO2 emission reductions.

The airport is considering installing a solar power facility that, with predicted setup costs, could supply 7.3% of its electrical demands. Coal and gas are the main sources of CO2 emissions; hence it is important to utilize them as little as possible to generate electricity. The appealing and practical alternative of PV is further investigated in this study. The cost analysis of a plant in the region has been conducted previously (Khan et al., 2014).

The demand and expenses for electricity consumption at international airports are shown in **Figure 17**. With its steady cost reduction and rising efficiency, solar photovoltaic technology has a lot of promise to become a viable and appealing replacement for fossil fuels in the environment. By using photovoltaic cells to convert traditional fossil fuel energy to solar energy, the airport could be able to lower its CO2 emissions. The carbon footprint of one kilowatt-hour of electricity produced by various methods is not exact, but using various life-cycle analyses, an average value can be obtained in **Table 8**. An estimate of the reduction in emissions is possible since the average CO2 emissions from solar PV and coal are 0.105 kg CO2/KWh and 0.909 kg CO2/kWh, respectively.

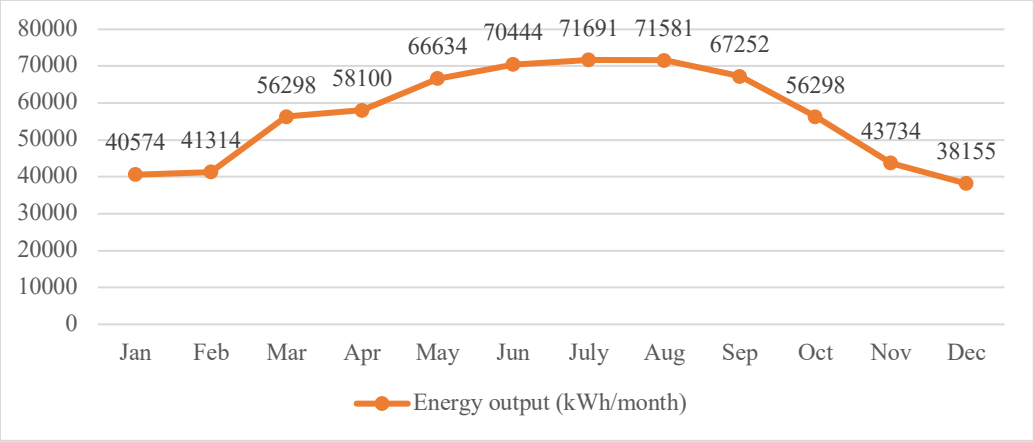


Figure 17. Monthly energy consumption and its costs for Sulaymanyah International Airport (Khan et al., 2014)

Table 8. CO2 released for one kilowatt-hour is produced by some power generation methods grams of CO2/kWh (Khan et al., 2014)

Source	Coal	Natural Gas	Oil and Diesel	Solar/ PV
ADEME Carbone Inventory, low	800	430	-	60
ADEME Carbone Inventory, high	1000	-	-	150
PLC, Inc	889	517	894	-
Oak Ridge National Labs	948	449	748	-
Average	909	465	821	105

Energy Production	Carbone Dioxide Emissions (kg CO2)
Fossil Fuel	682075*0.909=620006.18 kg
Solar Photovoltaic	682075*0.105=71617.88 kg
Total Reduction in CO2 emissions	548388.3kg

3. DISCUSSION AND COMPARISON

The study's findings are shown in tabular form. Overall about studies, according to the figures, charts, and tables solar photovoltaic systems are more environmentally friendly and emit comparatively less damaging pollutants into the atmosphere than diesel generators. The graphs and tables indicate that the diesel generator's large carbon output seriously harms the environment. In addition to causing serious health hazards, pollution weakens the ozone layer. It has been determined that solar photovoltaic (PV) systems do not harm the environment.

Installing a solar power system is generally more expensive economically than purchasing a diesel generator set of the same kVA capacity. According to the part of charts, there are no maintenance costs for the PV system or the diesel generator set during the first month. The number of diesel generator sets and PV systems steadily increased from the second to the next months. While the diesel generator sets experienced a significant increase, the PV system continued to develop at the same rate.

The PV system is initially more expensive to start than a diesel generator set, and the diesel generator needs more maintenance when it is in use. According to the environmental impact, PV rooftop solar panels offer a sustainable and eco-friendly alternative for backup power systems. Solar system reduces the carbon footprint as they generate clean energy without emitting greenhouse gases. When compared to generators that run on fossil fuels, solar panels have a far smaller environmental effect and last 20 to 25 years.

According to research, diesel generators have a negative impact, although they are a conventional backup power source, diesel generators have drawbacks in terms of emissions and environmental effects. The environment and public health are negatively impacted by diesel generator emissions, which include carbon dioxide, nitrogen oxide, and particulate matter.

4. CONCLUSIONS

This article generally discussed the comparison in terms of cost and environmental impact between the local diesel generators and solar energy systems, the research conducted in this field showed that electricity from solar rooftop PV systems is a well-described alternative to diesel generators in every way for Erbil city and some other places as a support of it. Because there are more than 1500 generators in Erbil city center, due to the lack of mains electricity, these generators work for an average of 10 hours a day, which is a lot of time on the health of citizens over the long term, the cost of electricity generation and minimal maintenance from PV panels becomes significantly lower due to the absence of fuel costs and government incentives in many regions. Diesel generators, while cheaper to install initially, incur continuous costs for diesel fuel, which can be subject to market fluctuations and increase the total cost of ownership over time. Additionally, PV systems can benefit from net metering, which allows excess energy to be

sold back to the grid, further enhancing their economic attractiveness. According to regional research, diesel generators require regular maintenance, including oil changes, moving parts, filter replacements, and engine servicing. The operational cost of diesel generators is also higher due to the ongoing need for fuel and the potential for frequent repairs associated with wear and tear, also Diesel generators emit significant amounts of CO2, NO2, SO2, and particulate matter. From an environmental perspective, PV systems generate electricity without emitting greenhouse gases or other pollutants, contributing to a reduction in carbon footprint.

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