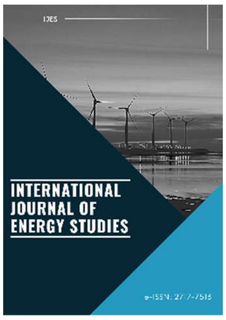
INTERNATIONAL JOURNAL OF ENERGY STUDIES

e-ISSN: 2717-7513 (ONLINE); homepage: https://dergipark.org.tr/en/pub/ijes



Research Article

Int J Energy Studies 2023; 8(3): 557-579

DOI: 10.58559/ijes.1317267

Received : 20 June 2023
Revised : 12 July 2023
Accepted : 14 July 2023

Investigation of electricity distribution, shortages in the Gaza strip, and the role of renewable energy technologies for addressing the electricity crisis

Sameh M. S. Younis[a*], Güven Tunç[b]

[a]*Department of Energy Systems Engineering, Faculty of Technology, Gazi University, Ankara, Türkiye, ORCID: 0009-0009-9263-6295*

[b]*Department of Energy Systems Engineering, Faculty of Technology, Gazi University, Ankara, Türkiye, ORCID: 0000-0001-7038-8168*

*(*Corresponding Author:samehyounis@hotmail.com)*

Highlights

- Addressing the Electricity Crisis: Study Reveals Solar Energy as Viable Solution for Gaza Strip.
- Negative Impact on Health and Economy: Electricity Shortages in Gaza Strip Highlighted.
- Renewable Energy Revolution: Solar Power Identified as Best Intervention for Gaza's Electricity Crisis.
- Sustainable Energy for Palestine: Research Advocates Investment in Solar Power for Gaza Strip.

You can cite this article as: Younis SMS, Tunç G. Investigation of electricity distribution, shortages in the Gaza strip, and the role of renewable energy technologies for addressing the electricity crisis. Int J Energy Studies 2023; 8(3): 557-579.

ABSTRACT

This study examines the electricity crisis in the Gaza Strip and its impact on public well-being. Adopting a sequential exploratory mixed-methods approach, data were collected from 350 households and key institutions. The research assesses the current state of renewable power technologies applicable to the region and develops a performance matrix to identify the most suitable technology for providing clean and affordable electricity. The findings highlight solar energy as the most viable solution for addressing the electricity shortage in the Gaza Strip. Moreover, the study underscores the adverse effects of electricity shortages on vital services, including health, water, and sanitation, as well as the fragile economy. The research recommends strategic investments in solar energy as a reliable and cost-effective solution, readily accessible to meet the energy needs of the Gaza Strip and Palestine at large. This study provides a valuable resource for national and international NGOs, offering insights into the strengths, weaknesses, opportunities, and threats within the Gaza Strip's electricity sector.

Keywords: Gaza Strip, Renewable power technologies, Energy access, Energy poverty, Electrical crisis

1. INTRODUCTION

Electricity is a vital resource that powers essential services such as healthcare, transportation, and communication, making it indispensable in modern societies. However, in the Gaza Strip (GS), the supply and distribution of electricity have been a constant challenge, with frequent power cuts and shortages. These outages have adverse effects on the region's economic, social, and health sectors, ultimately hindering its overall development. Furthermore, Palestine faces a unique situation in the Middle East due to several factors such as an unstable political climate, financial crisis, high population density, and lack of natural resources. The Palestinian Central Bureau of Statistics (PCBS) reported that as of the end of 2022, there were approximately 14.3 million Palestinians worldwide, with 5.35 million residing in the State of Palestine. Palestine has one of the highest population density in the world, where the population density in GS is 5740 people / km^2 [1].

The physical disconnection between GS and West Bank, including East Jerusalem, presents both technical and political challenges for energy transportation, storage, and importation [2]. Israel's control over energy imports to Palestine, predominantly through Israeli companies, hinders open trade in electricity and petroleum products and restricts development initiatives [3]. Abu Hamed et al. have emphasized the high cost of energy in Palestine compared to neighboring regions [2]. Additionally, the absence of a clear national energy policy, fragmented institutional framework, and incomplete framework in Palestine pose further obstacles. Political instability, economic conditions, and limited indigenous resources have increased energy demand, while concerns over political risks have deterred significant investments in energy and industrial sectors [2]. In the long run, renewable energy holds significant potential for fostering sustainable energy development in Palestine [4].

Palestine has significant solar, wind, and biomass energy potential, with abundant sunshine hours exceeding 3000 annually [5]. In Gaza Strip, average solar resource ranges from 5.4-6 $kWh/m^2/day$ [6]. Solar photovoltaic and thermal systems utilize global solar radiation, while solar concentrating systems harness beam solar radiation [7]. Compared to Ankara, Turkey (4.36 $kWh/m^2/day$), and Madrid, Spain (4.88 $kWh/m^2/day$), Palestine exhibits exceptional solar energy potential [8, 9].

The Gaza Strip has experienced rapid population growth, resulting in a significant increase in energy demand that is primarily met through imports. Therefore, finding alternative, clean energy sources is critical for the region's future. However, several challenges impede power generation in GS, including political instability, economic crisis, infrastructure deficits, and insufficient implementation of strategies to manage supply and demand. In addition, the region faces significant economic challenges in importing electricity and fuel. For almost 15 years, GS has suffered from an energy crisis, with severe electricity shortages for the past decade. These energy shortages have severely impacted essential services such as health, water and sanitation services, and undermined the fragile economy, particularly the industrial and agricultural sectors. The continuous conflict with Israel, including four wars on Gaza in 2008, 2012, 2014, and 2021, exacerbates the electricity crisis and causes high levels of stress that adversely affect people's physical, mental health, and well-being.

Gaza Strip requires around 550 MW of electricity with an increase in demand during peak winter and summer months, reaching up to 622 MW. Nonetheless, the primary electricity sources in GS, namely the Gaza Power Plant, Egyptian Power Lines, and Israeli Electricity Lines, can only provide 50% of the required electricity [10]. With the limited supply, residents initially resorted to using candles and small generators which led to unfortunate incidents of human and material losses from fires caused by candles or generator explosions [11]. Today, the majority of residents use other sources like street generators, batteries, and PV cells, however, these sources are limited and lack flexibility [11]. Hence, it is crucial for the government to shift towards sustainable energy sources for a better environment, economy, and well-being of the people.

There are existing reviews in the specialized literature that discuss the energy situation in the Gaza Strip and Palestine. Since January 2010, the United Nations document emphasizes the severe deterioration of electricity supply in Gaza Strip. Insufficient funds for purchasing industrial fuel to operate the Gaza Power Plant have led to daily electricity cuts of 8-12 hours, exacerbating living conditions and disrupting various essential services including healthcare, hospitals, clinics, education, and water and sanitation [12].

In 1995, Abualkhair [13] highlighted the energy crisis in Palestine, revealing that 65 localities lacked access to the public electricity network. The author highlights the West Bank region's estimated annual electricity consumption of 890 GWh, averaging 496 kWh/capita. In contrast, the Gaza Strip exhibits the modest consumption rate in the region, with 47.91 GW h per year. Five years later, Abu Hamed et al. [2] reached similar conclusions for the year 2009. Despite an increase in electricity consumption to 1606 GWh and 3808 GWh in Gaza Strip and West Bank respectively, the rates remained the lowest in the region. Additionally, the costs were significantly higher compared to other areas, placing a greater burden on household expenditure [2].

A comprehensive comparison by Nassara and Alsadi [14] examined the solar energy potential in Gaza Strip, favoring PV solar cell plants and the parabolic trough system for the energy market. The study found that the PV system, due to its flexibility and ease of installation on rooftops, was preferred over the parabolic trough system. Building a 555 MW PV system at a cost of approximately $800 million would result in electricity prices ranging from $0.07 to $0.11 per kilowatt-hour, significantly lower than the current price of $0.29 to $0.46 per kilowatt-hour [15]. Certain studies in the literature [14, 16-26] suggest that renewable energy offers a potential solution to decrease dependence on external energy sources in GS.

The principal aim of this research endeavor is to offer a comprehensive understanding of the current energy landscape within the Gaza Strip, focusing particularly on the critical concern of electricity shortages and their adverse repercussions across multiple domains of human existence. Moreover, this study endeavors to investigate the various alternative strategies employed by individuals in their pursuit of workable solutions. To achieve this, a straightforward questionnaire comprising 350 households was administered to elucidate the alternative measures adopted by individuals to mitigate the challenges posed by electricity shortages. Additionally, an in-depth examination will be undertaken to assess the viability of renewable energy sources as a potential panacea to this complex predicament.

2. MATERIALS AND METHODS

2.1. The Impact of Electricity Shortage

Electricity plays a vital role in improving health and achieving the Sustainable Development Goal 7 (SDG7), which emphasizes the importance of establishing an environment that combines health with essential infrastructure, including electricity [27]. Unfortunately, the ongoing electricity crisis in Gaza Strip means that its two million inhabitants have limited access to power supply, with only a few hours of electricity available each day.

This electricity shortage crisis has had a significant impact on the health situation in Gaza. Prolonged power cuts have led to the suspension of dialysis units, the postponement of surgeries, and negative effects on operating rooms and intensive care units due to the suspension of central air conditioning systems [11]. Furthermore, the use of traditional lighting methods such as candles and firewood during power cuts has led to suffocation and even death of many individuals [28].

Electricity shortage also affects the sewage systems in Gaza, with over 70% of households supplied with water through municipal water networks for only a few hours every few days due to insufficient power supply. This means people have to rely on private water sources with low health standards and uncensored. In addition, the wastewater treatment plants have had to shorten their treatment cycles, leading to an increase in pollution levels in the wastewater, which is discharged into the sea, thereby polluting the seawater, fish, and beaches. There is also a constant risk of sewage overflow in the streets [11].

2.2. Power Outages and Health in Gaza: Exploring the Impact

The electricity crisis in Gaza has resulted in a constant state of emergency and is having a profound impact on the health of the population. In the first four months of 2010 alone, 27 people lost their lives and 37 were injured due to incidents related to the use of generators. These incidents included generator explosions, fires, and carbon monoxide poisoning. Tragically, three of the fatalities were children who died from carbon monoxide poisoning, and another three children were killed in a fire while attempting to refuel a generator [12].

2.3. Impact of Electricity Cuts and Shortage on Health Sector

The health sector in Gaza Strip has been severely affected by the ongoing electricity crisis. Critical surgeries and emergency services have been canceled, leading to a decline in the overall health situation. Sanitation and sterilization of equipment have been cut back, and patients are being discharged early from hospitals due to frequent, intermittent power outages. Essential medical equipment such as neonatal incubators, imaging machines, ventilators, and dialysis machines are breaking down due to the lack of a constant power supply. This has forced hospitals and clinics to rely on backup generators, which are not designed to work for prolonged periods and are often damaged as a result. Moreover, replacement parts for these generators are usually unavailable.

In order to minimize risks to patients, hospitals have faced the necessity of postponing certain elective surgeries due to the unreliable nature of generators. Additionally, they employ Uninterruptible Power Supply (UPS) devices to mitigate the potential harm caused by power outages and fluctuations to delicate medical equipment. However, the efficacy of UPS usage has been hindered by limitations imposed by Israeli authorities on the import of required batteries. Power cuts also have adverse effects on clinic refrigeration, posing a threat to vaccine quality.

The United Nations (UN) coordinates the delivery of fuel to run backup generators to ensure the operation of life-saving equipment and water and sanitation services. However, the situation remains challenging as the use of backup generators is not a sustainable solution to the electricity crisis [12, 29].

2.3.1. Water and sanitation

The smooth functioning of Gaza's sewage treatment plant necessitates uninterrupted power supply for a two-week treatment cycle. Interruptions in electricity significantly disrupt sewage treatment, resulting in the discharge of partially treated and untreated sewage into the environment. Insufficient wastewater treatment capacity forces Gaza's water authorities to release 60-80 million liters of raw and partially treated sewage daily into the Mediterranean Sea to prevent sewage flooding in residential areas. Moreover, electricity is crucial for water pumping purposes, both for domestic use and irrigation. However, due to the intermittent operation of pumps, the water supply for domestic use remains inadequate, raising concerns regarding hygiene and health. Synchronized electricity supply is necessary to ensure water wells can pump water to households, but currently, most households receive water for only 5-7 hours per day [12].

2.3.2. Electricity impact on psychosocial & mental health status

In GS more than 148,000 women [1] are exposed to gender-based violence (GBV). Protracted humanitarian crisis in Palestine in general and specifically on GS has been worsening all forms of GBV which include sexual violence, domestic violence and child marriage. Many studies showed that there's a negative impact on women's condition due to the increased crisis of electricity and fuel because it is disrupting their daily life especially household tasks where they are exposed to tension, depression and violence [11].

Electricity cuts are worsening the symptoms of mental health patients and delaying their recovery. E.g., it's so difficult for patients suffering from post-traumatic stress disorder -PTSD- and depression to sleep in a complete dark because it can cause a state of severe anxiety.

Another example is patients suffering from obsessive compulsive disorder (OCD), they wash their hands excessively and this access to water can be valid to them by electricity, and the cut off in it will cause extreme relapse to them [30].

2.4. Grid Sources for Power Generation in Gs

The electricity demand in GS is about 550 MW, which increases up to 622 MW during peak summer and winter months [10]. The three primary sources of power generation in GS are Gaza Power Plant (GPP), Israeli electricity lines, and Egyptian power lines. GPP has a maximum capacity of 140 MW when all four turbines are operational. However, in summer, only three turbines are used, generating around 62 MW [15]. The plant runs on liquid fuel (diesel), and each turbine consumes between 135,000 to 150,000 liters of diesel per day, with an annual cost of $211,306,350/year when it operates at 110 MW. The second source of electricity, Israeli electricity lines, provides 120 MW to the Palestinian Electricity Authority at an estimated cost of $132,887,051/year. The third source, Egyptian power lines, has a capacity of 23 MW but is currently out of service due to constant malfunctions and requires maintenance [16].

3. RESULTS AND DISCUSSIONS

Online survey was conducted using google forms. The survey had covered 350 households all over GS. The results of the survey are listed in Table 1. More than one third of Gazan population received less than 12 hours electricity power from all electricity sources. The majority of population received additional source of electricity power beside the grid sources. 30.3% of the people can afford to pay for the other sources, 59% of them are paying through borrowing, and 26.3% of the people are not capable to pay.

Table 1. Statistics of using electricity sources other than grid sources (according to the questionnaire).

Variable	Category / Frequency	Surveyed people	
		Number	%
Number of hours received per day from all electricity sources (Grid sources, SG, PV solar, Batteries)	24	112	32
	12-20	105	30
	6-12	91	26
	< 6	42	12
Alternative sources of electricity supply used	Street Generators	203	58.1
	Batteries	123	35.2
	PV Cells	14	4
	No other sources (Grid only)	10	2.7
Financial capability to afford the cost of other sources	Capable	106	30.3
	Capable through borrowing	152	43.4
	Not Capable	92	26.3

3.1. Alternative Solutions to Overcome The Electricity Shortage

The total available electricity in GS from the three main grid sources is 283 MW. So, the percentage of electricity deficiency is about 50%. Residents tended to find alternative solutions to overcome shortage in electricity. The most striking of these solutions are the PV cells, batteries, and street generators.

3.1.1. Street Generators (SG)

In order to cope with the electricity crisis in GS, residents turned to commercial generators known as Street Generators (SG) for a solution. Since 2009, SGs have become a popular investment for residents who need electricity in their homes, shops, and institutions. As of September 26, 2020, there were approximately 420 commercial generators operating in GS, which sold electricity to over 50,000 subscribers. Together, these generators produce around 40 MW of electricity. On average, a 200 KW electric generator consumes around 45 liters of diesel per hour, which costs $1.4 per liter. If generators work for eight hours per day, they consume about $504. To run all generators for eight continuous hours per day, they consume around $100,800/day. The price of electricity from SGs is sold to consumers for $0.86 - $1.18 per kWh, which is six to eight times higher than the normal price per kWh from the Gaza Electricity Distribution Company. The number of SG beneficiaries is estimated to be around

300,000, or 15% of the population of GS. However, SGs pose many health and environmental risks due to the fumes, gases, and noise they emit, and the smoke they produce contains several toxic components that affect human health, such as sulfur oxide, toxic nitrogen oxides, and carbon monoxide [28].

The researcher gathered electricity data for each individual year from 2017 to 2020, sourcing it from UNITED NATIONS Office for the Coordination of Humanitarian Affairs (OCHA) [31]. Subsequently, these collected data points were amalgamated and visually presented in Figures 1 and 2.

According to data presented in Figure 1, the average number of hours of electricity delivery per citizen per month in the Gaza Strip has experienced a significant decrease from May 2017 to October 2018. This decline can be attributed to three main factors: instability in the Egyptian power lines in 2017 and their complete disruption from March 2018 onwards, frequent breakdowns in the Israeli power lines, and fuel shortages at the Gaza power plant. However, starting from November 2018, there has been an increase in electricity hours due to the stabilization of Israeli power lines and regular fuel supplies to the power plant. In 2020, there has been an improvement in electricity hours compared to previous years, which can be attributed to the availability of additional fuel for the Gaza Power Plant.

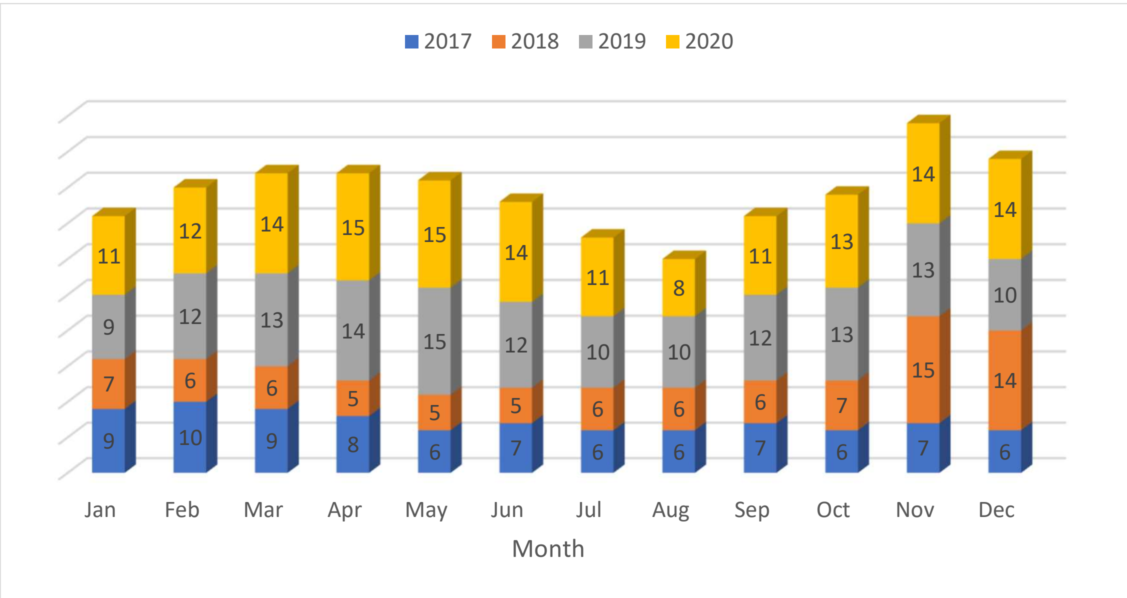


Figure 1. Availability of electricity per month (average hours per day) [31].

In Figure 2, a comparison is made between the amount of electricity shortage and the amount of electricity available from the three main sources in Gaza Strip, with the average values taken for each season between 2017 and 2020. On average, there is a shortage of 294 MW of electricity during this period. The largest shortage occurred in spring 2018 when the entry of fuel to the Gaza power plant was prohibited due to political reasons, causing the plant to completely stop in May 2018. Conversely, the smallest gap occurred in spring 2020, even though the available power was not at its highest level. This is because the loads in the summer and winter seasons are higher than those in the spring and autumn seasons.

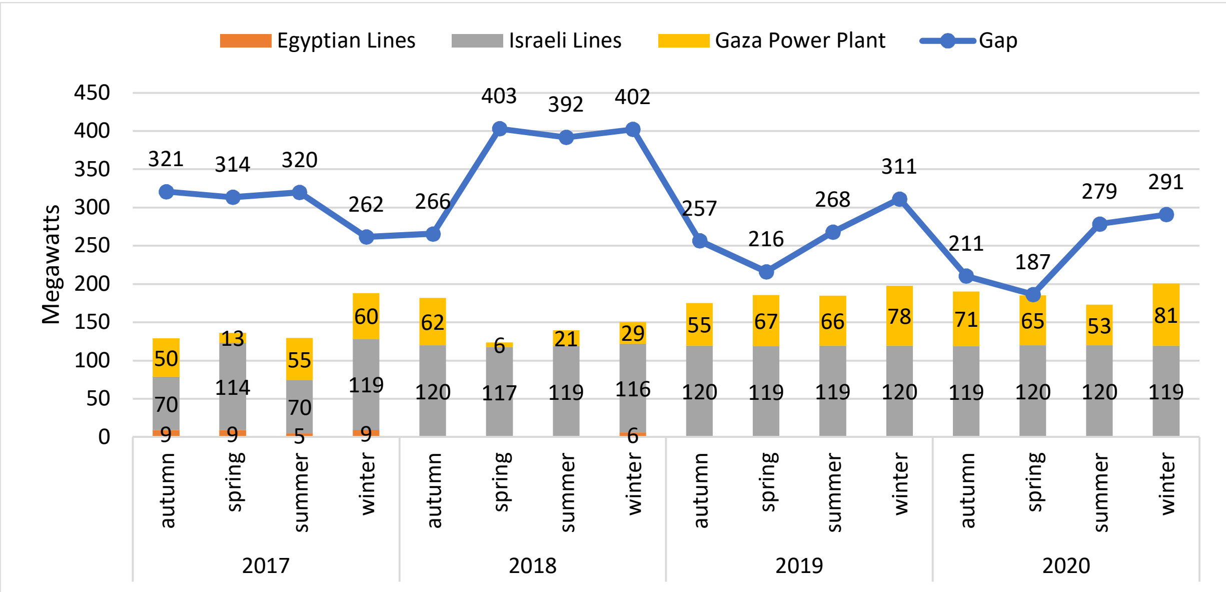


Figure 2. Electricity gap in Gaza Strip for 2017-2020 [31].

3.2. Potential Renewable Power Technologies in Gs

The burning of fossil fuels leads to environmental pollution and Climate Change, which is caused by the emission of greenhouse gases such as CO2. This emission not only threatens the ecological balance of the environment but also depletes the world's reserves of fossil fuels. To address this, renewable and sustainable sources of energy such as solar radiation, wind, biomass, gravity, tides, and geothermal energy are being developed and exploited to preserve resources for future generations. Remarkable advancements have been achieved in enhancing the efficiency and output of renewable energy, alongside notable reductions in operational and maintenance costs. Furthermore, renewable energy is clean, endless, widely available, and does not contribute to environmental pollution.

3.2.1. Wind energy

According to historical data from the European Commission Website [32], Figure 3 illustrates the average wind speed at 10 meters above sea level in GS over five consecutive years from 2012 to 2016. The data shows that the average wind speed in GS is approximately 2.9 m/s throughout the year and remains relatively constant. This consistency is due to the location of GS, which is a narrow strip next to the sea that is exposed to stable wind patterns year-round [33].

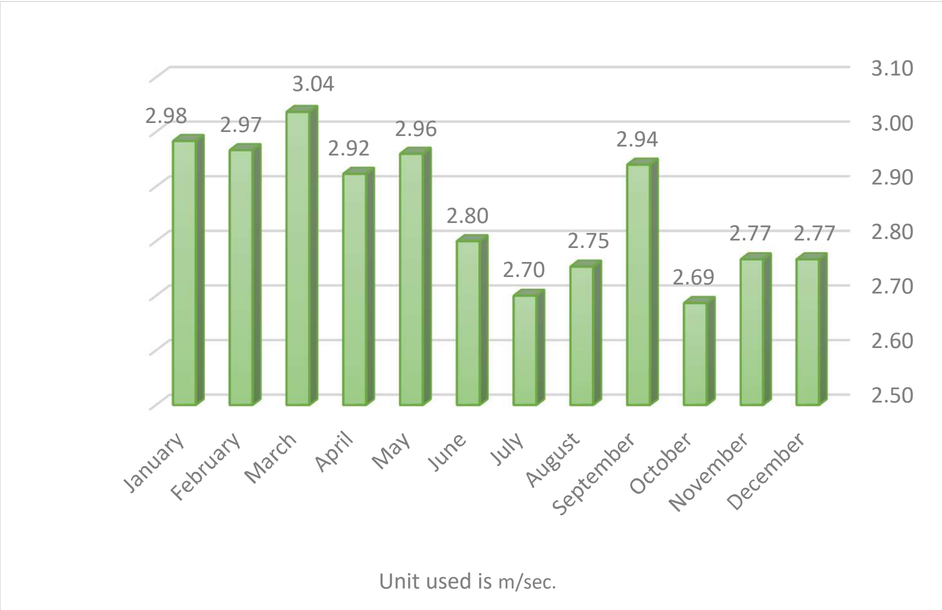


Figure 3. Average wind speed in GS [32].

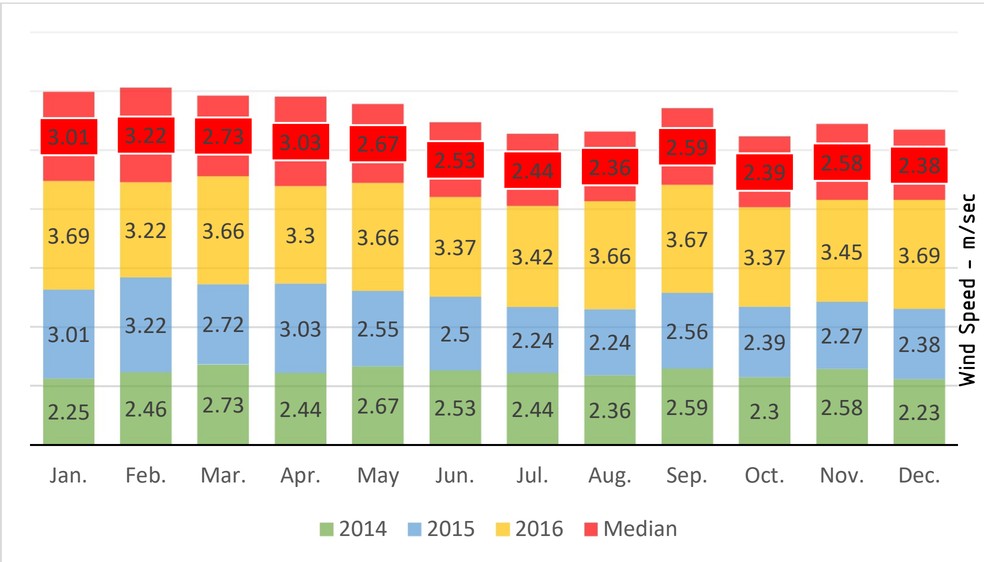


Figure 4. Monthly average wind speed over 2014,2015, and 2016 in GS [32].

The graph below Figure 5 is called a wind rose diagram. A wind rose is a graphical tool utilized by meteorologists to provide a concise overview of wind speed and direction distribution at a specific location. This graph shows the wind rose diagram for GS. It highlights the wind speeds and directions in Gaza. It is clear that the vast majority of wind directions are in between the west and the south-west. Thus, the south-west direction is approximately the main direction should the wind turbine is a horizontal axis type.

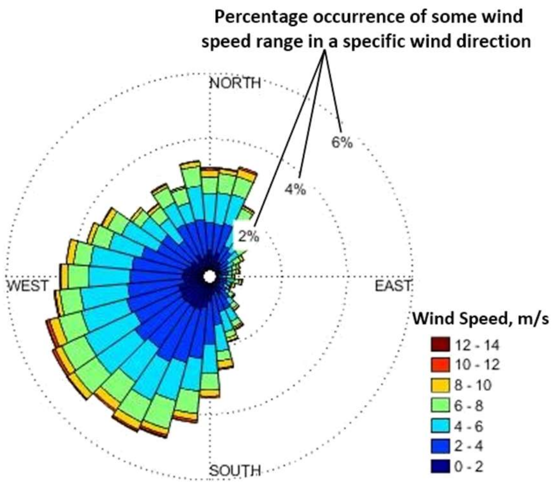


Figure 5. Wind Rose Diagram for GS [34].

3.2.1.1. Wind speed statistical distribution

We used Weibull distribution to analyze the time series data which based on the European Commission Website [32]. The software program used to analyze the data was MATLAB.

Figure 6 presents the mean wind speed at different elevations for the Weibull-distributed time series data between 2012 and 2016. Figure 7 describes the histogram of the average wind speed data over the period 2012-2016 at the elevation of 10 meters.

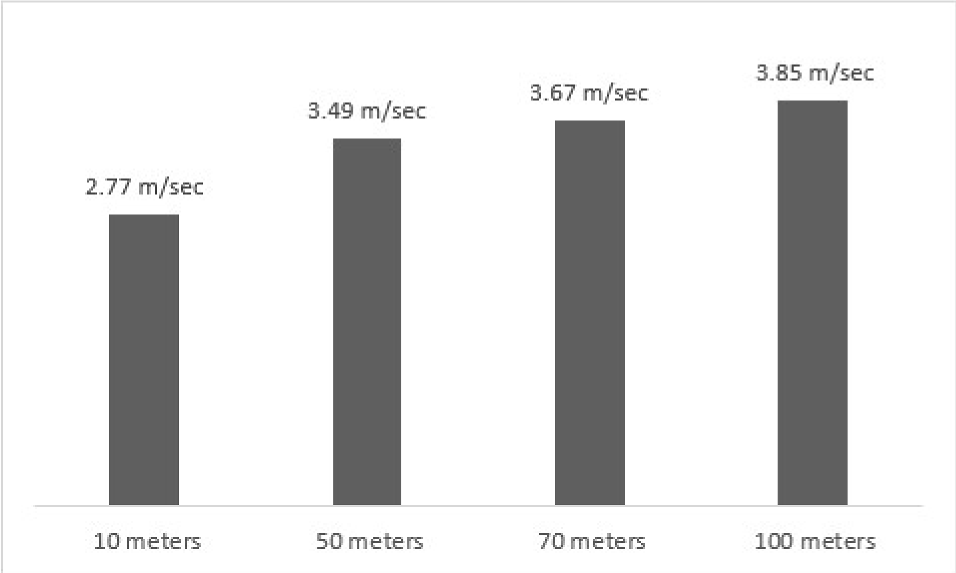


Figure 6. Weibull-distributed Mean Wind Speed at different Elevations in GS.

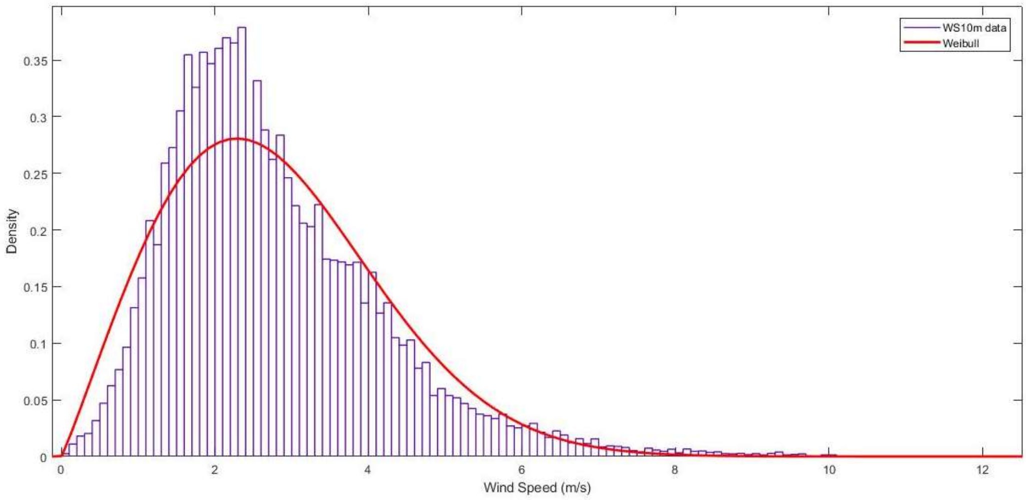


Figure 7. Fitted Weibull distribution for the average wind speed over the period 2012-2016 at 10 m elevation [34].

3.2.1.2. Characteristic curve of wind turbines

A wind turbine generates electricity based on a power curve that represents the relationship between wind speed and the amount of electrical power produced. However, there are limitations to this process. For instance, when wind speeds are below the cut-in speed of the turbine, the blades cannot rotate and no electricity is generated. Moreover, the energy output is directly proportional to the surface of the blades and cubically dependent on wind speed, meaning even a slight change in wind speed has a significant effect on energy output. Typically, the cut-in speed is between 2.7 and 4 m/s. Unfortunately, wind speeds in GS range from 2.77

m/s at 10 m elevation to 3.85 m/s at 100 m elevation, making it infeasible to install wind turbines for electricity generation in GS [35].

To safeguard the integrity of the turbine power train, each wind turbine is equipped with a wind speed limit, known as the rated output speed. This ensures a consistent energy output, referred to as the rated output power. When wind speeds exceed a predetermined threshold beyond this limit, a secondary threshold is triggered, causing the turbine to halt operation to prevent any potential damage. [35].

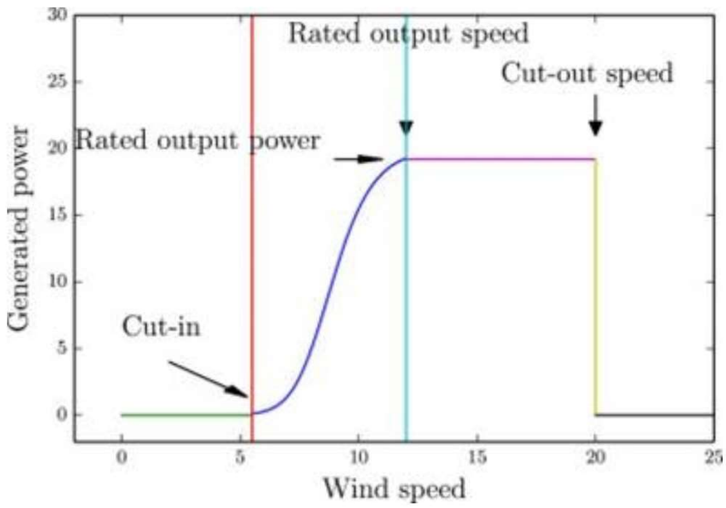


Figure 8. Characteristic curve of wind turbines [35].

3.3. Wave Energy

Extracting energy from sea waves has great potential for renewable energy. This method offers several advantages over other forms of energy generation such as solar or wind energy. Wave energy has a higher energy density compared to these other sources, meaning that more energy can be extracted per unit area [36]. Wave power devices can also generate power up to 90% of the time, which is significantly higher than wind turbines and solar panels [37].

Despite these advantages, there are some challenges facing the use of wave energy. One major challenge is converting slow, random, and high-force oscillatory motion into useful motion. The power levels of waves vary depending on their height and period, which can also make it difficult to position devices optimally. Additionally, harsh weather conditions can make it difficult for wave energy devices to withstand the force of the waves [37].

In the port of Gaza, there is a research wave power station with an output power of almost 10KW [38]. See Figure 9 for photos from the site.

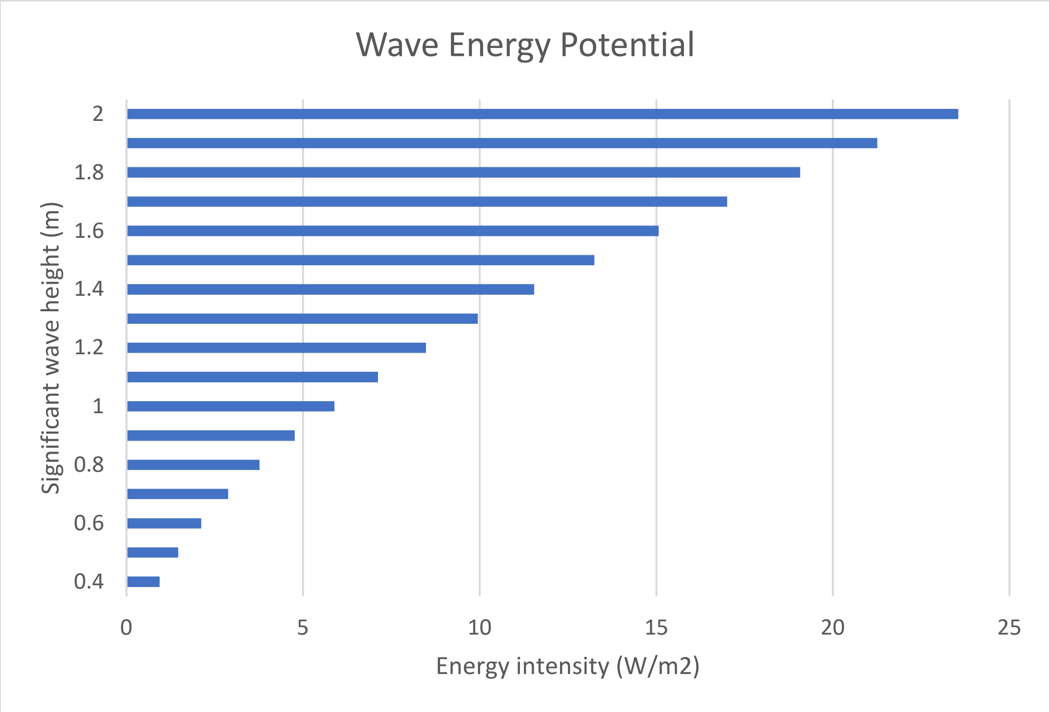


Figure 9. Energy intensity per wave hight.

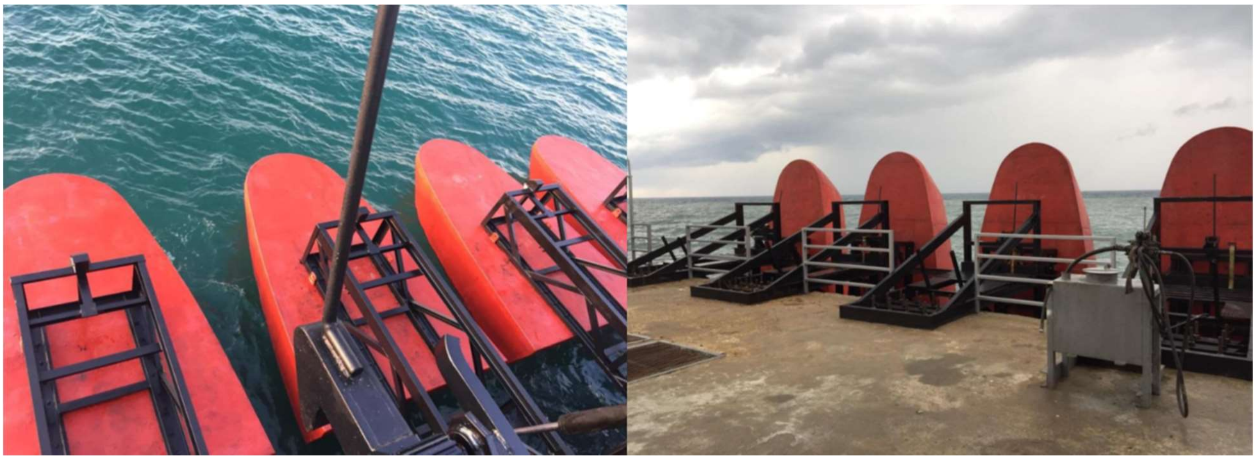


Figure 10. Wave to Energy station in operation (left) and in emergency mode (right) [38].

3.4. Solid Waste to Energy

In GS, the average solid waste production is approximately 0.9 kg/day/capita, which results in an estimated 1800 tons/day of waste. The majority of municipal waste is composed of organic matter (50%), plastic (17%), and paper/cardboard (11%). One approach to extracting value from solid waste is through incineration, which can generate electricity. On average, 500 to 600 kWh of electricity per ton of waste incinerated can be produced. Therefore, incinerating the 1,800 tons of waste produced daily in GS could generate approximately 900 MWh of electrical energy. This implies that a power plant with a rated power of approximately 100 MW could be established based solely on incinerating solid waste in GS [39].

3.5. Solar Energy

Research indicates that Palestine possesses significant solar energy potential, attributed to its high annual average of solar radiation reaching approximately 5.4 kW h/m2/day on a horizontal surface, accompanied by approximately 3000 sunshine hours annually. Furthermore, the solar radiation on a horizontal surface demonstrates variation, ranging from 2.63 kWh/m^2/day in December to 8.4 kWh/m^2/day in June.

Figure 11 reports the data of the monthly average solar radiation in GS. The data in Figure 11 are based on the European Commission Website. We can see a clear trend in both months, June and July with an average radiation of around 320 kWh/m^2 per month.

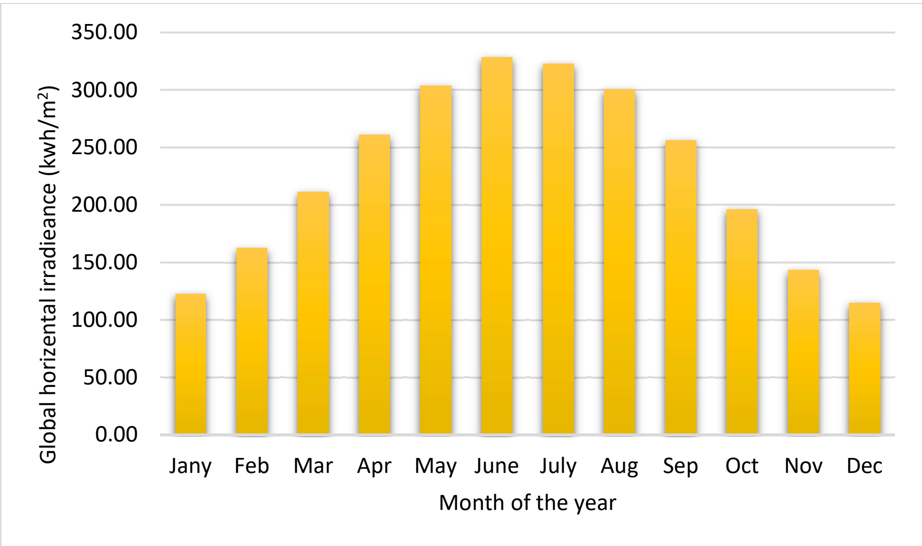


Figure 11. Montly average solar radiation in GS [32].

The high solar radiation in Palestine, presents a great opportunity for utilizing solar energy for various applications such as water heating, water pumping, crop drying, water desalination, and electrification of remote areas.

The calculation for estimating the electricity output of a photovoltaic (PV) system worldwide can be expressed by the formula:

$$E = A \times r \times H \times PR \quad (1)$$

Here, E represents the energy generated in kilowatt-hours (kWh), A denotes the total area of the solar panels in square meters (m2), r represents the efficiency of the system in percentage, H represents the annual average solar radiation on tilted panels (excluding shadings), and PR represents the performance ratio, typically ranging from 0.5 to 0.9 with a default value of 0.75[40].

The performance ratio (PR) value, an important metric in assessing the efficiency of photovoltaic systems, depends on various factors such as the site conditions, technology employed, and system sizing. Detailed analysis reveals specific losses that contribute to the PR value. These losses include inverter losses (4% to 10%), temperature losses (5% to 20%), DC cables losses (1% to 3%), AC cables losses (1% to 3%), losses at weak radiation (3% to 7%), and losses due to dust and snow (2%) [Reference]. Understanding these factors and their associated losses is crucial for optimizing the performance of photovoltaic systems and achieving maximum energy output.

Based on calculations and the average annual radiation of approximately 2723 kWh/m^2 in Gaza, it is determined that a photovoltaic (PV) power plant with an efficiency of 15% and an area of 5 km^2, representing 1.37% of the total area of Gaza Strip (365 km^2), can generate 1531 MWh of electricity using equation number 1.

4. CONCLUSIONS

Based on the reviewed information, the Gaza Strip faces a significant and pressing issue of power outages, necessitating the identification of appropriate solutions. This study's findings agree with those of Abualkhair, indicating that electricity consumption in the Gaza Strip is the lowest in the region, accompanied by higher costs compared to other areas.

The research conducted on the energy crisis in the region yields the following conclusions:

1. The Gaza Strip is suffering from a significant shortage of energy, particularly electrical energy, which negatively impacts the mental and physical health of the residents, as well as all aspects of their daily lives.

2. Current solutions to the energy crisis are individual, with little consideration for their negative effects. Candles, for example, have resulted in numerous fires, while standalone generators are costly.
3. There are several challenges to the adoption of renewable energy in the Gaza Strip, including weak government support, low community awareness, insufficient funding, technological limitations, and low investment in the renewable energy sector.
4. The production of renewable energy in the Gaza Strip is hindered by the scarcity of space, given the high population density. Optimal use of solar energy, which is abundant in the region, and a greater focus on wave energy production are necessary to overcome this challenge.
5. The energy crisis in the Gaza Strip is multifaceted, with factors such as the blockade imposed by the occupying power, transportation challenges, distribution issues, and limited resources all contributing to the problem.

Findings from the questionnaire revealed the following key observations:

1. The availability of uninterrupted electricity supply for 24 hours was limited to a mere 32% of the population in the Gaza Strip, despite utilizing all accessible energy sources. A notable portion of the population received electricity for 12-20 hours (30%), 6-12 hours (26%), while a concerning 12% endured less than 6 hours of electricity per day.
2. Among the surveyed population, the majority sought alternative means to mitigate the electricity deficit. The utilization of street generators emerged as the most prevalent solution, with 58.1% of respondents resorting to this method. Battery usage accounted for 35.2% of the population, while a mere 4% relied on solar cells. Regrettably, 2.7% of the population lacked access to any alternative solutions.
3. Financial implications played a significant role in the adoption of alternative measures. Approximately 30.3% of the population demonstrated the capacity to bear the financial burden and additional costs associated with implementing alternative energy sources. Conversely, 43.4% perceived the financial burden as substantial, while 26.3% were unable to afford the expenses incurred by the available alternatives.

With regard to the use of renewable energy to solve the electricity crisis, it was found that wind energy is not feasible in the Gaza Strip, wave energy needs challenges and capabilities that outweigh the current ones in the Strip, and the use of solid waste to energy needs a high cost, so the researcher believes that using solar energy is the best choice to solve the problem of power outages in GS. And this result corresponds with the research conducted by Nassara and Alsadi, who presented a comprehensive model proposing solar energy as a viable solution to address the electricity issue. Therefore, the utilization of solar energy emerges as the optimal solution, as supported by collective evidence.

To mitigate environmental pollution, the Gaza Strip should seriously consider transitioning to clean energy sources. A long-term strategy, along with a supportive legislative and legal framework, should be developed to facilitate the adoption of renewable energy. Additionally, maximizing the utilization of solar energy is a feasible solution to address the local energy needs of the region.

NOMENCLATURE

AC	Alternating Current
DC	Direct Current
GBV	Gender-Based Violence
GPP	Gaza Power Plant
GS	Gaza Strip
JSC	Joint Service Council
kWh	Kilo Watt Hour
MWh	Mega Watt Hour
OCD	Obsessive Compulsive Disorder
OCHA	Office for the Coordination of Humanitarian Affairs
PTSD	Post-Traumatic Stress Disorder
PV	Photovoltaics
RPM	Revolution Per Minute
SDG	Sustainable Development Goals
SG	Standalone Generator
UN	United Nations
UNRWA	United Nations Relief and Works Agency for Palestine Refugees in the Near East
UPS	Uninterruptible Power Supply
WHO	World Health Organization

ACKNOWLEDGMENT

We would like to express our sincere gratitude to: The staff of the power plant in the Gaza Strip (Engineer Muhammad Al-Shanti) and Palestinian Central Bureau of Statistics (PCBS) for providing data used in this research. Their expertise, assistance, and support have been instrumental in the successful completion of this study. We would also like to thank the participants who generously gave their time and effort to participate in this study.

DECLARATION OF ETHICAL STANDARDS

The authors of the paper submitted declare that nothing which is necessary for achieving the paper requires ethical committee and/or legal-special permissions.

CONTRIBUTION OF THE AUTHORS

Sameh M. S. Younis: Brought the Idea, conducted the literature review and wrote the manuscript.

Güven Tunç: Found the research gap, Re-examined the spelling and grammar of the article.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

REFERENCES

[1] "The Palestinian Central Bureau of Statistics reviews the conditions of the population in Palestine on the occasion of World Population Day, 11/07/2022. Under the slogan "A World of 8 Billion People: Towards an Adaptive Future, Seizing Opportunities and Ensuring Rights and Choices for All, The Palestinian Central Bureau of Statistics (PCBS), 2022.

[2] Hamed TA, Flamm H, Azraq M J. Renewable energy in the Palestinian Territories: Opportunities and challenges. Renewable and Sustainable Energy Reviews 2012; 16 (1):1082-1088.

[3] Yaseen B. Renewable energy applications in Palestine. 2nd International Conference for the Palestinian Environment, Palestine, 2009.

[4] Sandano R. A techno-economical appraisal of a PV domestic plant on a Irish dwelling. 2016.

[5] Bernal-Agustín JL, Dufo-López.R, Rivas-Ascaso DM. Design of isolated hybrid systems minimizing costs and pollutant emissions. Renewable Energy 2006; 31(14): 2227-2244.

[6] Ismail MS, Moghavvemi M, Mahlia TMI. Analysis and evaluation of various aspects of solar radiation in the Palestinian territories. Energy Conversion and Management 2013; 73: 57-68.

[7] Mekhilef S, Saidur R, Kamalisarvestani M. Effect of dust, humidity and air velocity on efficiency of photovoltaic cells. Renewable and Sustainable Energy Reviews 2012; 16(5): 2920-2925.

[8] Çağlar A, Yamalı C, Baker DK, Kaftanoğlu B. Measurement of solar radiation in Ankara, Turkey. Journal of Thermal Science and Technology 2013; 33(2): 135-142.

[9] Avila JMS, Martín JR, Alonso CJ, Escuin SCC, Cadalso JM, Bartolomé L. Atlas de Radiación Solar en España utilizando datos del SAF de Clima de EUMETSAT. 2012.

[10] G.E.D.C.LTD. Gaza Electricity Distribution Company report. 2019.

[11] T.U.N.O.f.t.C.o.H.A. (OCHA). The Humanitarian Impact of Gaza's Electricity and Fuel Crisis. 2015, Available: https://www.ochaopt.org/content/humanitarian-impact-gaza-s-electricity-and-fuel-crisis-july-2015.

[12] U.N.O.f.t.C.o.H.A. (OCHA). Gaza's Electrıcıty Crısıs: The Impact Of Electricity Cuts On The Humanitarian Situation," 2010.

[13] Abualkhair A. Electricity sector in the Palestinian territories: Which priorities for development and peace?. Energy Policy 2007; 35(4): 2209-2230.

[14] Nassar Y, Alsadi S. Assessment of solar energy potential in Gaza Strip-Palestine. Sustainable Energy Technologies and Assessments 2019; 31: 318-328.

[15] Shanti M. "Information about Gaza power plant," S. Younis, Ed., ed, 2022.

[16] Nassar Y, Alsadi S. Economical and environmental feasibility of the renewable energy as a sustainable solution for the electricity crisis in the Gaza Strip. International Journal of Engineering Research and Development 2016.

[17] Ouda M. Prospects of Renewable Energy in Gaza Strip. Energy Research Development Center in Islamic University of Gaza 2003.

[18] Hamdan L, Zarei M, Chianelli R, Gardner E. Sustainable water and energy in Gaza Strip. Renewable Energy 2008; 33(6): 1137-1146.

[19] Mogheir Y, Tayef M, Gabayen S, Foul A. Concentrating Solar Power Using Parabolic Trough, (Pilot Project in Islamic University of Gaza). Energy Procedia 2013; 42: 754-760.

[20] Elnaggar M, El-Khozondar H, Bashir M, Salah W. Enhancing solar water heater system for utmost useful energy gain and reduction in greenhouse gas emissions in Gaza. International Journal of Environmental Science and Technology 2022; 1-16.

[21] Hussein M, Albarqouni S. Developing empirical models for estimating global solar radiation in Gaza Strip, Palestine. The Islamic University Journal (Series of Natural Studies and Engineering) 2010.

[22] Asfour O. Integration of a stand-alone photovoltaic solar system into Gaza Strip residential buildings. World Congress on Sustainable Technologies 2012; 71-74.

[23] El-Khozenadar H, Khatib T, Attaee B, El-Khozondar R. Assessment of solar e-cookers social acceptance in Gaza Strip. Nature Scientific Reports 2022; 12(1): 17226.

[24] Elnaggar M, Edwan E, Alnahhal M, Farag S, Samih S, Chaouki J. Investigation of energy harvesting using solar water heating and photovoltaic systems for Gaza and Montreal QC climates. Palestinian International Conference on Electrical and Computer Engineering (PICECE), Gaza City, Palestine, 2019.

[25] Abu-Dabbousa T, Al-Reqeb I, Al-Mutayeb Y, Alattar J, Zainuri M. Performance Comparison of Different Manufacturers Solar PV Modules Used in Gaza Strip. International Conference on Electric Power Engineering–Palestine (ICEPE-P), Gaza City, Palestine, 2021.

[26] Abu-Zarifa A. System Design of Photovoltaic-Solar Home Lighting for Household in Gaza Strip. International Conference on Geological and Environmental Sciences, Singapore, 2014.

[27] Chen Y, Chindarkar N, Xiao Y. Effect of reliable electricity on health facilities, health information, and child and maternal health services utilization: evidence from rural Gujarat, India. Journal of Health, Population and Nutrition 2019; 38: 1-16.

[28] A.-M.C.f.H. Rights, "Possible solutions between commercial generators and smart counters," 2018, Available: http://mezan.org/post/27064.

[29] U.N.O.f.t.C.o.H.A. (OCHA), "'Immediate risk' of mass hospital closures and infrastructure collapse for 2 million in Gaza," 2018.

[30] W. H. O. Report, 2017.

[31] U. N. O. f. t. C. o. H. A. (OCHA), "Electricity in the Gaza Strip," 2017-2020.

[32] E.C. Website. Available: https://commission.europa.eu/index_en

[33] Abu-Zarifa A. Design of a stand-alone power wind turbine optimized for low wind speed in Gaza. International Journal of Energy Engineering 2014; 4(5): 89-93.

[34] Elnaggar M, Edwan E, Ritter M. Wind energy potential of Gaza using small wind turbines: A feasibility study. Energies 2017; 10(8): 1229.

[35] Manwell JF, McGowan JG, Rogers A L. Wind energy explained: theory, design and application. John Wiley & Sons, UK, 2010.

[36] Clément A. et al. Wave energy in Europe: current status and perspectives. Renewable and Sustainable Energy Reviews 2002; 6(5): 405-431.

[37] Drew B, Plummer AR, Sahinkaya MN. A review of wave energy converter technology. Sage Publications Sage UK: London, England, 2009.

[38] Alrayyes T. Wave to energy station. Aknan-Tech for Integrated Technical Solutions. 2019.

[39] Thöni V, Matar SK. SOLID WASTE MANAGEMENT IN THE OCCUPIED PALESTINIAN TERRITORY West Bank including East Jerusalem & Gaza Strip. CESVI 2019.

[40] Messenger RA, Ventre J. Photovoltaic Systems Engineering. Taylor & Francis Group, 2010.