

# Achievements and barriers of renewable energy in Palestine: Highlighting Oslo Agreement as a barrier for exploiting RE resources

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## ABSTRACT

Oslo agreement was signed in 1993 between the Palestinians and the Israelis as a gesture of hope for the autonomy of the Palestinians on their lands. Palestinians lands was divided into three administrative regions: Areas A, B, and C. These divisions were signed as a temporary transitional period of 5 years, during which the transfer of control over areas C and B to the Palestinian National Authority, was not implemented until the time of writing this research. This work aims to shed light on the impact of the geopolitical division on the possibility of exploiting renewable energy resources on C areas, and the role of that in achieving the Palestinian vision of reducing total dependency on the Israeli side as a net importer of Energy. To conclude, 96% of the total potential of solar energy is in West Bank, while Gaza has only 163 MW. Area C obsesses over 62% of solar energy potential, while about 75% of the potential in area (A + B) is upon the roof tops. It is expected, 98% of the total renewable energy potential is solar energy potential. Only 0.12% of the total A and B lands are suitable for producing solar electricity.

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## 1. Introduction

The sharp changes in the prices of solar PV technologies as well as wind energy have led to widespread outreach and strong growth in relying on RE for power generation. In 2018, the total investment in developing countries (excluding India and China) reached 47.5 billion, nearly 22% from the previous year, while MENA countries is a promising market because of the steady increase in energy demand. In addition to the availability of solar energy in particular in these countries, the amount of investments in 2018 was 16.1 billion dollars, an increase of 61% compared to 2017, \$ 10.1 billion is for solar projects, with wind energy investment five times as much, compared to the previous year [1,2].

Palestine is one of the MENA countries which has taken concrete steps to revive investment in RE, as a clean and independent source of electricity production, to achieve its energy security, it has a

wealth of solar energy, around 3000 sunny hours all year round and a high average solar radiation on horizontal surface 5.4 kW h/m<sup>2</sup>/day [3,4]. While it ranked first in the lowest rate of consumption of electrical energy per capita (0.79 MW h/inhabitant) and primary energy intensity (a measure of the total amount of energy required to generate a unit of (GDP). During the past decade, Palestine ranked third among the MENA countries in terms of population growth rate of 2.9%. Palestine is a country under Israeli occupation, is prevented from exploiting its natural resources. Unstable political conditions and the lack of all traditional energy sources in Palestine led to its dependence on neighboring countries at 100% to obtain fuel, moreover, its 90% dependence on importing electrical energy from neighboring countries [3].

This research aims to provide an overview of the obstacles to investment in RE in the Palestinian territories, and to shed more light on the impact of the Oslo agreement (OA) and the

*Abbreviations:* RE, Renewable Energy; MENA, Middle East and North Africa region; GDP, Gross domestic product; PCBS, Palestinian Central Bureau of Statistics; PENRA, Palestinian Energy and Natural Resources Authority; IRENA, International Renewable Energy Agency; WB, WB; Oslo Agreement, OA; PNA, Palestinian National Authority; PCBS, Palestinian Central Bureau of Statistics; RCREEE, Regional Center for Renewable Energy and Energy Efficiency; IEC, Israeli Electric Corporation; GPP, Gaza power plant; PPA, power-purchase agreement; DISCOS, Distribution Companies; PERC, Palestinian Electricity Regulatory Council; PEC, Palestinian Energy Research Center; PETL, Palestinian Electricity Transmission Company Ltd; SWH, Solar Water Heaters; PSI, Palestinian Solar Initiative; FIT, Feed in Tariff; NIS, New Israeli Shackle; VRE, Variable renewable energy; OCHA, Occupational Safety and Health Administration; GPP, Gaza power plant; GHI, Global Horizontal Irradiation.

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administrative division of the Palestinian territories into A, B, C regions on investment in RE projects.

This research paper will ensure that the following questions will be answered: To what extent has the Palestinian Energy Authority achieved its vision of involving RE as a source of electric energy in Palestine? What are the most important obstacles to achieve the 2020 vision? What is the extent of the impact OA and the division of the Palestinian territories on investments in RE? To answer these questions, Palestinian Central Bureau of Statistics (PCBS) were used, Palestinian Energy and Natural Resources Authority (PENRA) statistics, International Renewable Energy Agency (IRENA) statistics were used, to assess the current status of RE in Palestine and compare them with the target that was supposed to be reached in 2020, then evaluate the difficulties and failures that prevented reaching this goal.

In the second section of this paper, we will highlight the impact of the territorial division created by Oslo Agreement on the possibility of using RE sources to achieve energy security sought by the Palestinian National Authority. This section will be addressed through several sub-sections, the first of which is: refuting the need of the Palestinian Authority for more lands. Secondly: making approximate calculations of the potentials of RE sources on lands classified as C. Finally, discussing the possibility of benefiting and planning in those lands.

### 1.1. Geographical and energetic characteristics of Palestine

(Historical Palestine) as presented in Fig. 13 is estimated about 27,000 km<sup>2</sup>, which is part of the (Fertile Crescent). Palestine today, is consisted of two completely separate geographical blocks, the WB (5661 km<sup>2</sup>) (and the besieged Gaza Strip (362 km<sup>2</sup>), The Jordan River borders the WB to the east, while it is surrounded by Israel in other directions. It is divided into 11 governorates: Hebron, Bethlehem, Jerusalem (East Jerusalem), Jericho, Ramallah and Al-Bireh, Salfit, Qalqiliya, Nablus, Tulkarm, Tubas and Jenin. While the Gaza Strip is located on the edge of the Sinai desert, far east of the Mediterranean, is divided into five main governorates: Rafah in the far south, Khan Yunis, Deir al Balah, Gaza and North Gaza [5].

Palestinians are not allowed to utilize or travel between WB and Gaza; only Israeli trucks and vehicles can move between the outskirts of the two zones. Then again, WB lands were separated into three classes, as per understandings between Palestinian National Authority (PNA) and Israel. Israel didn't satisfy the commitments of this division, and the resulting loss of normal assets, as shown exhibit later in this article.

According to Palestinian Central Bureau of Statistics (PCBS), during the past two decades, the population has grown dramatically from 2.7 million to 4.8 million in the period 1997–2016, while the population in 2019 was 5.039 million.

RCREEE indicates a rapid population growth rate of 2.9%, with lowest GDP and highest economic growth rate, this in turn increases the demand for energy [6,7].

WB and Gaza Strip suffer from a very poor energy security, with expensive and limited sources of electric power. About 35% of Palestinians have experienced interruption of electricity supplies [8].

The electrical current available in the Gaza Strip meets half of the demand, while in the peak period in summer and winter the electric current is available from 3 to 4 h during the day, and despite the WB enjoying a permanent current during the day, it has started to suffer in recent years, due to the increased demand on the energy which is associated with increased population.

Palestine relied on the Israeli Electric Corporation (IEC) company to buy 90% of the electricity needs in 2015, Fig. 1. Whereas, the Palestinian demand for electric energy grew at a rate of 7.2% during

the years between 2001 and 2013, and faster than the Israeli demand for electric energy [9].

By 2030, the Palestinian needs will be represented 11% of the total Israeli demand, with a growth rate of 3.5%, and this necessarily means an increase in the level of dependence on the Israeli side in filling our growing needs for electrical energy [10].

As for WB, it depends on by 99% to meet its increasing need for electric energy, the rest is to be imported from Jordan. While Gaza relies on 64% on the Israeli side, Gaza power plant (GPP) provides about half of its capacity, the rest is imported from Egypt.

GPP relies on diesel for power generation, the plant was opened in 2004 with a total capacity of 130 MW by PPA (power-purchase agreement), and because of high cost of fuel, it is being run in half of the capacity, while the Israeli armed aggression negatively affected the storage capacity of the fuel.

### 1.2. Energy sector institutions in Palestine

In 1995, the municipalities that supplied electricity were restructured into six main bodies, known as distribution companies (DISCOS), Fig. 2, Table 1, they buy electricity from IEC at a high price and have to sell it at a higher price to the Palestinians, these companies suffer from several problems, and the most important one is the poor financial levy. In 2015, 36% of the total electrical energy purchased from Israel was not collected, even when it is collected by the municipalities, and because of the municipalities suffering from the financial deficit, a portion of the collected money is deducted before delivery to distribution companies. This deteriorating financial structure leads to the accumulation of debts owed to IEC, which is reflected in the quality of electrical supplies to Palestinian citizens. DISCOS are restricted; Israel prevents Palestinians from building their own transmission systems and to develop connection points to pump electrical energy. All of what we mentioned reveals the need to think of renewables solutions to get out of this situation [12].

PENRA is the governmental body that was established by presidential decree, with many responsibilities, such as policy-making and laws regulating the energy sector, including generation, transmission and distribution. Palestinian Electricity Regulatory Council (PERC) is another regulatory institution, was established in 2009 under Law No. 13, aims to monitor and evaluate the energy sector, in addition to monitoring tariff work and issuing licenses related to energy generation and distribution. While Palestinian Energy Research Center (PEC), is a national center that works on research related to enabling RE, rationalizing energy consumption and its final use [13].

Palestinian Electricity Transmission Company Ltd (PETL), is a link between the IEC and the Palestinian DISCOS as transmission system operator, and it does not have a transformation infrastructure, it is supposed to manage the energy flow from Israel to four high-voltage stations throughout WB. Fig. 3 Shows the organizational structure and institutional frameworks of the Palestinian energy sector, as they play a key role in the efficiency of including RE as an independent source of electricity in Palestine.

Nowadays, Palestinian territories are facing more difficult challenges related to energy and infrastructure, these challenges are linked to time steadily due to the incremental population, economic advancement and growing urbanization [14]. The following table shows selected indicators of the energy sector in Palestine between 2014 and 2018, Table 2. As shown, Energy dependency has increased, with an increase in population, and decreasing in the share of RE.

Overall, Palestinian energy sector faces many technical challenges, as it does not have physical means to transfer energy, and a lot of legal and legislative challenges, to maintain the balance of

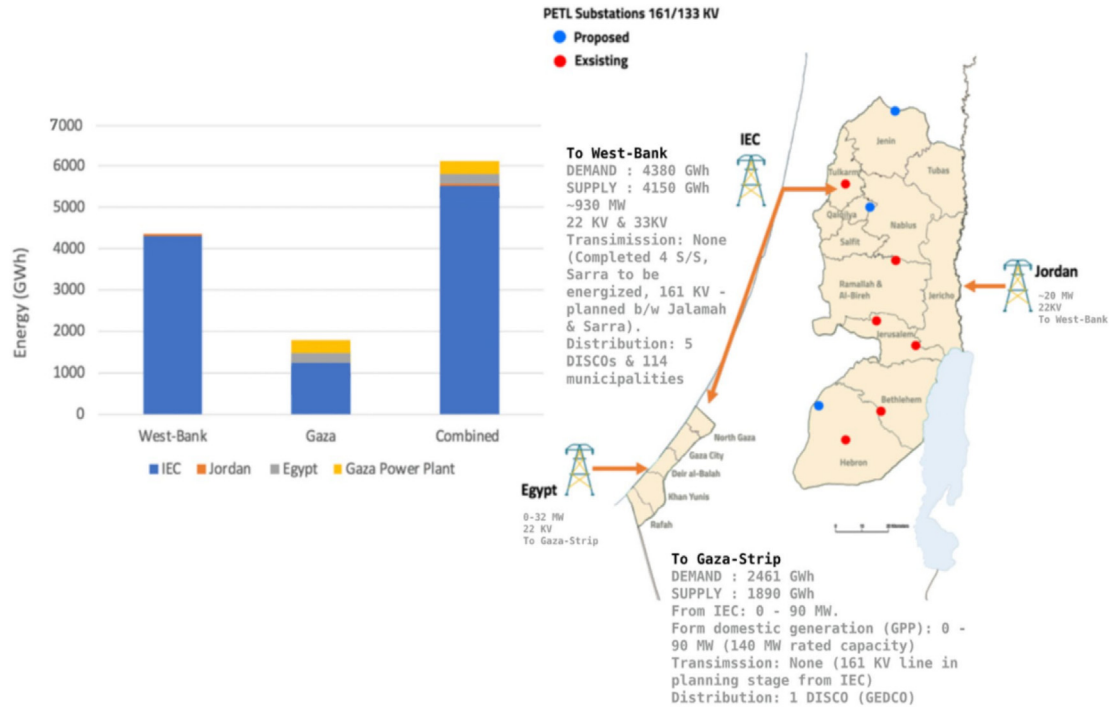


Fig. 1. The four sources of electricity in Palestinian territories [11].

energy supplies and encourage investment in RE [16]. All the Governmental bodies assume a critical job in adjusting power division arranging practices to make strong, long haul vitality systems [17].

1.3. Renewable energy in Palestine: potential, investments, and prospects

The dependence of PNA on Israel as the main source of electrical energy, made PENRA issue a vision that relied on basic pillars: Increase self-reliance of generation, and dependence on local resources by increasing the share of RE sources in the production of electric energy, optimizing energy use and enhancing its efficiency [13].

In Palestinian Territories, RE is the only independent source, although there are many options for energy supplies, but in the end, it needs the operating fuel that we import from a single source, Israel [3].

Earlier, estimates of RE potential in Palestine indicated that solar energy is able to cover 13% of electricity demand, wind energy capacity able to cover 6.6% of electricity needs, while biogas can cover 20% of the needs of the rural people [18].

Basil and Yassin [19], considered Palestine as a moderate country with wind speeds, Wind energy can be used in limited cases, while this energy cannot be utilized in Gaza in any way [20].

Palestine is an agrarian nation; it has separate semblance of engender products that canbe used as power ascent [21]. Additionally, squander and the natural bit of metropolitan waste can be utilized conceivable to deliver biofuel from them with unimportant extra land necessities or effects on nourishment and fiber crop creation. While burning olive cake can create 1.3% of all power utilization in Palestine [22].

Biomass power produced by consuming wood and rural waste is confined to cooking and warming purposes in provincial zones and comprised 9% of the all-out expended vitality in Palestine [23].

Al-Jaber [24] showed that, the proportional vitality of the biogas holds 127 GW h, dependent on the specialized data given. Another RE source is Geothermal energy, Palestine is alluring for geothermal vitality use, Gaza strip and north of Palestine are High potential areas [25].

The potential of solar energy in Palestine is high and promising,

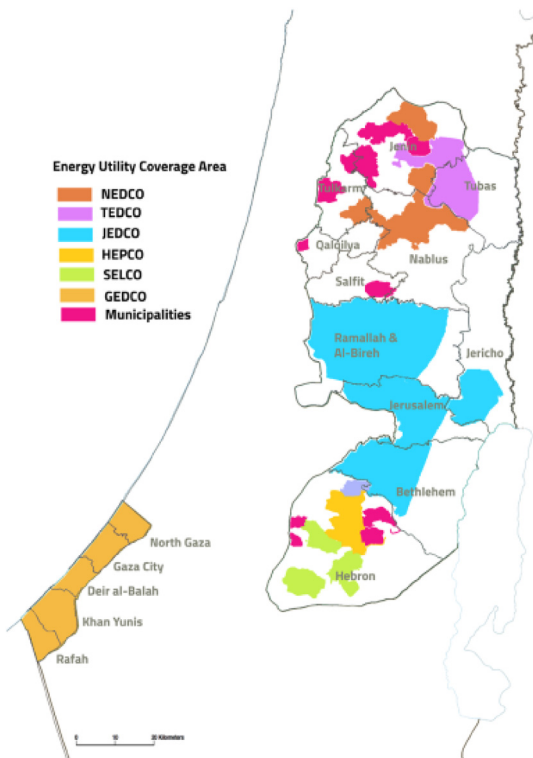
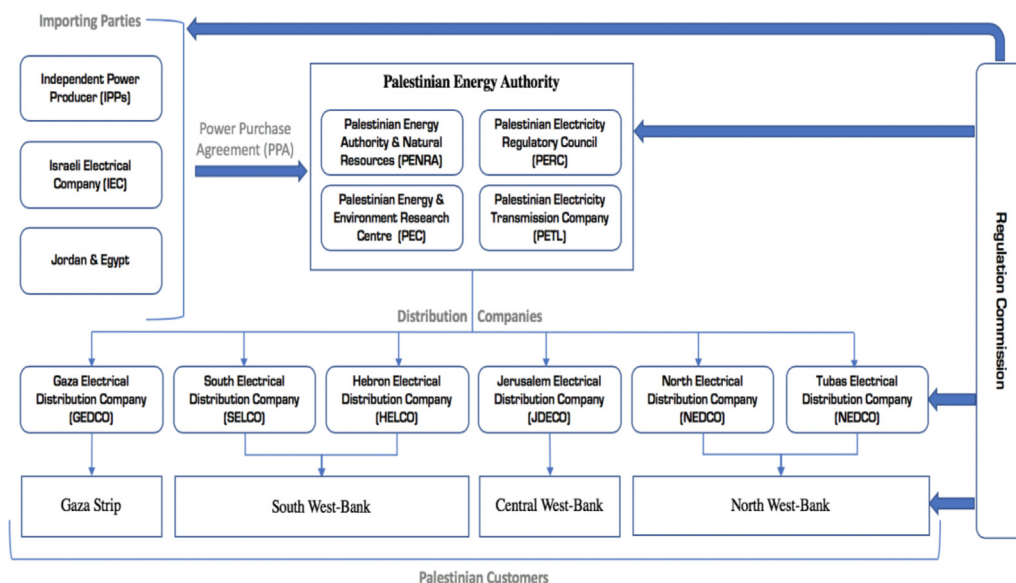


Fig. 2. Districts of influence of distribution companies [13].

**Table 1**  
Distribution companies.

#	Abbreviation	Name	Location
1	NEDCO	Northern Electricity Distribution Company	Northern West Bank
2	JDECO	Jerusalem District Electric Company	Ramallah and around area
3	HEPCO	Hebron Electric Power Company	Hebron municipality
4	SELCO	Southern Electric Company	Southern municipalities Yatta, AlThaherya
5	GEDCO	Gaza Electricity Distribution Company	Gaza
6	TDECO	Tubas District Electricity Company	Tubas city and region



**Fig. 3.** The institutional structure of the Palestinian energy sector [13].

**Table 2**  
Selected indicators of the Palestinian energy sector 2014–2018 [15].

Indicator	Year				
	2014	2015	2016	2017	2018
Renewable energy share in the total final energy consumption (%)	13.8	13.8	13.6	10.3	10.7
Energy Dependency Rate (%)	80.3	84.8	84.7	87.3	86.9
The Energy Consumption of the Transport Sector to the total energy Consumption (%)	48.7	43.6	45.6	46.6	45.4
The Energy Consumption of the Household Sector to the total energy Consumption (%)	38.4	41.4	39.7	38.4	38.0
The Energy Consumption of the Service Sector to the total energy Consumption (%)	7.6	8.5	8.8	8.8	9.8
The Energy Consumption of the Industry Sector to the total energy Consumption (%)	4.2	5.2	4.8	5.4	6.1
Energy Intensity (MJ/USD)	3.8	3.9	4.0	3.8	3.6
Annual Electricity Consumption Per Capita (KWh/Capita)	1048.0	1151.4	1141.9	1138.3	1148.7

with 3000 solar hours per year, and average solar radiation on a horizontal surface 5.4 kW h/m<sup>2</sup>/day. 56% of Palestinian family units have Solar Water Heaters (SWH) framework on their rooftops. Palestine is the MENA nation with the most elevated utilization of SWH [4]. The Palestinian National Energy Plan (2011–2013) [26] presents that notwithstanding wood, coal, and peat, RE is utilized for warming water in private structures, the abuse of RE sources involves around 18% of the all-out vitality utilization in Palestine, this way, the yearly development of sunlight-based force use is nearly 1%. Notwithstanding, this Plan features that the utilization of sun-oriented vitality is low in contrast with the accessible limits of the all-out vitality utilization, just 8% of sun powered force is utilized. It ought to be noticed that this rate has declined over the previous years. Moreover, it has not stayed up with the general development and extension of different parts, nor has it fulfilled the vitality need.

During the previous ten years, the energy division in Palestine has faced a key change from a minor shipper of biofuels to depending on dispersal reliance on capricious energy sources notwithstanding improving framework. Three headings were embraced to accomplish the energy security system: improving petroleum derivative foundation, receiving a sustainable power source as an elective vitality source, and vitality proficiency measures [13].

In light of the above mentioned, there were numerous activities and arranging devices that were advanced by PENRA and legislative and non-administrative offices [27].

PENRA propelled PSI (Palestinian Solar Initiative) activity, which was affirmed by the Council of Ministers in 2012 Under Law No. 16/127/13/C.D/S.F [28], the activity intends to introduce 5 MW on the tops of 1000 homes, 5 kW for each home, until the end of 2015. The innovative was designed to encourage the acceptance of solar

energy as a good source of electricity, by adopting Feed-in-Tariff (FIT) and Net-Metering regulations. Through FIT, whole profitability of the sunlight-based cells is siphoned to the fundamental framework, while the client takes the electrical energy from the system. The value contrast of purchasing and selling is the thing that urges the client to introduce PV systems. PSI started with a tariff of 1.03 NIS/kWh for the first 100 homes. Unfortunately, this tariff continued to go down, which formed a barrier to install more PV systems. For Net-Metering, if there is a surplus of energy generated from the PV system that is pumped to the main grid, and vice versa, the surplus grid is sold at a price difference from the purchase that may reach 75% of the original tariff, to encourage investors in these systems [29]. The previous law gave the PERC the authority to determine the purchase price of electricity from photovoltaic systems according to capacity, operating year and type of source, and the validity of the promotional tariffs was specified for a period of twenty years from the date of the promulgation of the law.

By 2012, the general strategy for RE in Palestine was adopted to increase its contribution to total energy by 25% by 2020.

In the same year, another resolution was issued [30], regarding the control of funds that the private sector may invest in RE sources, and that they are not private funds to the Palestinian people, but rather private funds.

As for Law Decision [31], it included defining the powers of all parties related to RE in Palestine, and adopted three main mechanisms to encourage investment in RE.

1. PSI, which is for the domestic sector that has a capacity of 5 kW and less and subjected to a distinct tariff.
2. Net metering systems for projects with a power of more than (5 kW) in all sectors, on

It should not exceed a specified percentage determined by the RE strategy.

3. Bidding or solicitation of offers on competitive bases in accordance with the laws in force related to the establishment Power plants.

All systems, devices, spare parts and equipment of RE sources and energy rationalization are exempted and its production inputs from customs duties.

The government has the right to allocate government land or own private land for the purpose of establishing RE plants and to produce electricity in accordance with the provisions of the laws in force. The Council of Ministers decided to approve all instructions regulating the construction of generation stations that rely on RE sources by adopting of law No. (11/79/17/C. D/R.H) for the year 2015 [31], Where its specified mechanisms to encourage investment in RE projects of capacity more than 1000 kW, through Competitive offers and Direct offers. As for grant projects and international aid, PENRA will prepare all relevant documents and agreements to issue the license from the Council of Ministers.

In 2017, PENRA instructed to cover the self-need of subscribers and sell surplus thereof with a system of incentives contract, for the purposes of encouraging investment in RE [32]. The instructions include incentives for power plants, net measurement projects, and incentives for financing entities.

By 2018, power plants had exempted from income tax for the first seven years from the date of operation. While loans granted by financing institutions and banks to power generation projects from clean sources are treated as loans granted to small and medium-sized enterprises, in parallel with the provisions of the income tax law [33].

Fig. 4 Summarizes the laws enacted by PNA to stimulate investment in RE in Palestine, and the actual installed capacity of RE sources.

Generally, previous legislations are based on achieving the National Vision for Renewable Energy to gradually obtain 240 GW h (at least) from RE sources, Equivalent to 20% of the electricity produced domestically by the year 2020 [26], which unfortunately did not reach this goal for reasons we will be mention later. As we previously reviewed, in the context of PENRA pursuit of energy security through taking several paths, one of which is energy efficiency, and Reliance on RE sources should be accompanied by energy efficiency improvement, especially in the residential sector that consumes 62% of final energy in Palestine, PENRA had drawn up a national plan for energy efficiency and rationalization of energy, NEEAP (National Energy Efficiency Action plan), which aims to achieve the strategic national vision of the Palestinian energy sector, by improving savings in electrical energy at least 5% of the total demand for electricity by 2020. Parallel to the above, another path was taken to achieve the desired energy security, by developing natural gas fields as an energy source and its compatibility with RE sources. In such a country under occupation, the easiest way is to use solar energy [7].

Between 2012 and 2020, PENRA had taken many measures, legislation and created governmental and non-governmental bodies to achieve its vision, Which included two main scenarios: the first relies mainly on solar energy technology, while the second relies more on the development of wind energy to collect 138 MW representing 5% of the total energy consumption in Palestine. Table 3. Illustrates the PENRAs vision and its scenarios (MW units) [3].

Unfortunately, this vision was not achieved, or even approaching 130 MW, and the implementation showed that the reality was different than expected, according to IRENA statics 2019 [34], the total installed capacity at the end of 2018 was 36 MW, while the total production was 46 GW h. In 2017 the capacity installed was 35 MW, and the total production was 43Gwh [17].

The following Table 4. Summarizes the current situation of RE sharing in energy sector in Palestine.

The reality here differs from predictions, since we are interested in long-term planning, we must learn from our experiences and mistakes. In the next section, we will conduct a comprehensive review of the challenges and obstacles that prevented us from achieving the 2020 vision.

#### 1.4. Challenges and obstacles that prevented PENRA from achieving the 2020 vision

Despite the awareness of the government and the Palestinian authorities of the importance of RE and taking serious steps in this direction, there are difficulties and external - internal problems that prevented reaching the desired goal, Fig. 5.

RE projects need a high level of technology, financing, and serviceable infrastructure related to implementation, maintenance, energy storage, transmission, and distribution. The projects also require some kind of political, social, technical and financial support. In addition to obtaining building permits and the acquisition of land for this type of project. In the occupied Palestinian territories, the challenges of RE projects are related to: the complex political situation and the resulting territorial division, military incursions, settlement expansion, and the increased risk of investment. In addition to the poor structural and credit structure of PNA, particularly, DISCOs and PTEL. Other obstacles are: the infrastructure problems that are exacerbated by the increase in population growth, distribution losses (technical and non-technical) and the legislation and laws regulating RE sector in Palestine.

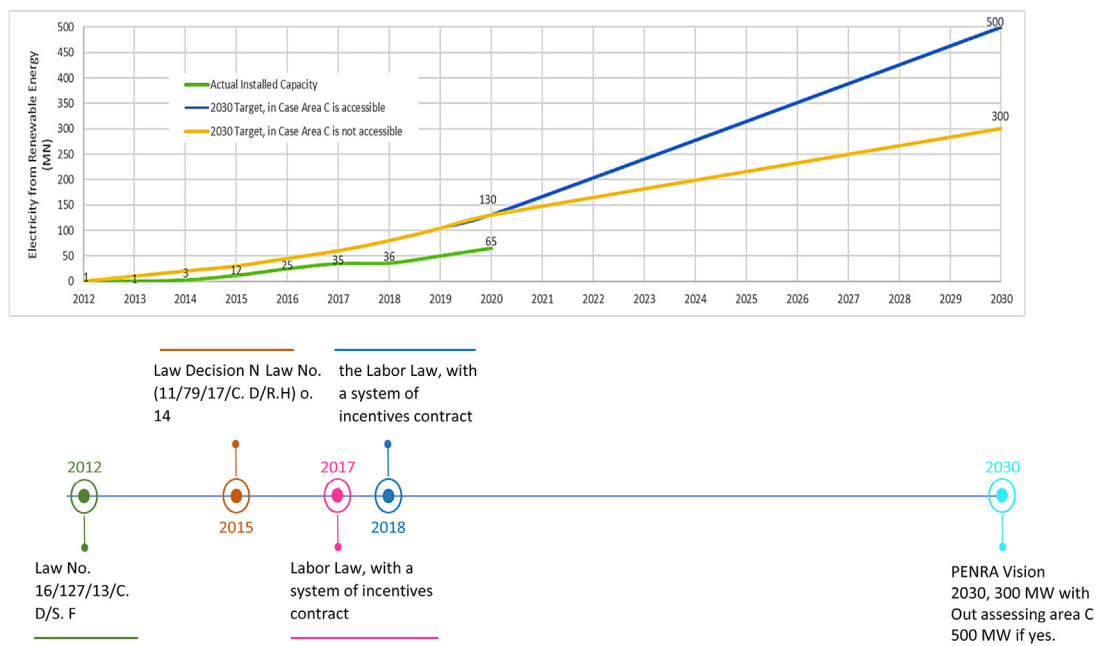


Fig. 4. Laws enacted by PNA to stimulate investment in renewable energy in Palestine, and the actual installed capacity of RE sources, from 130 MW targeted to 2020, only 40 MW have already been achieved.

Table 3  
PENRA vision 2020.

RE Technology	2020 Target (MW)
Rooftop Solar	25
Utility-scale PV and CSP	40
Wind	44
Biogas (animal and landfill)	21
Total	130

The high potential of solar energy in Palestine is not the only factor to advance the RE sector as an electricity source [18], We note that between the years 2017–2019, we are no longer able to continue the escalation of investment in photovoltaic energy, compared with what happened in the period 2012–2016, this means that we faced many barriers, including restricting the development of energy sector infrastructure to enable distribution companies to empty energy with minimal losses, which could be technical and non-technical, Up to 25%, which is considered a very high level [12,14,35].

Generally, the role of the private sector in investment must be significant and effective [36]. Although the private sector shows a lot of interest in investing in RE projects, and projects have already been created and licenses issued, however, energy can only be sold to a single buyer by law, which is PTEL for projects that have a capacity of more than 1 MW, but the financial credit of PTEL is not

trustworthy, which raises the risk of not paying their financial payments. Ultimately, the financial credits of PTEL depend on the financial credits of distribution companies (DISCOs), so the serious financial structural improvements made by PTEL cannot be taken in consideration unless they are linked to improving the financial performance of DISCOs, and also linked to improving the financial position of municipal council funds, so that they do not have to transfer part of the electric energy revenue to cover their financial deficit [10].

The risks and the resulting uncertainties are one of the most important obstacles in investment in RE projects, since the risks relate to many years of the Israeli military occupation of the Palestinian territories and the lack of Palestinian sovereignty over its lands. These risks are multiplied in the Gaza Strip, due to the economic blockade, the Israeli military attacks, the destruction of infrastructure, as well as internal political conflicts [35]. One of those shows that the implementation of small projects (rooftop projects) at family or local community level is the safest path to investment, so that it can be considered independent and does not require relations related to politics, location or borders, and the success of these projects may constitute an encouraging nucleus for utility scale projects. Even solar projects on rooftops have become less attractive to local households investment due to reduced sales tariffs for distribution companies. In 2012, PSI was launched, with the goal of obtaining 5 MW by the end of 2015, according to this initiative, the family buys the solar system under a green loan, and

Table 4  
Current situation of RE sharing in energy sector in Palestine.

Current	Expected	Notes on expected amounts
<b>RE share</b> –21.6% of installed capacity; –12.1% of generation; 1.3% of electricity consumption	130 MW of installed capacity by 2020 (10% of generation); 300–500 MW (25% of generation) by 2030	Renewable Energy strategy 2012. Currently only 40 MW installed.
<b>VRE</b>	65 MW solar, 44 MW wind by 2020; 400 MW solar, 50 MW wind by 2030	65 MW solar target on track, wind power development is not.

VRE (Variable renewable energy).

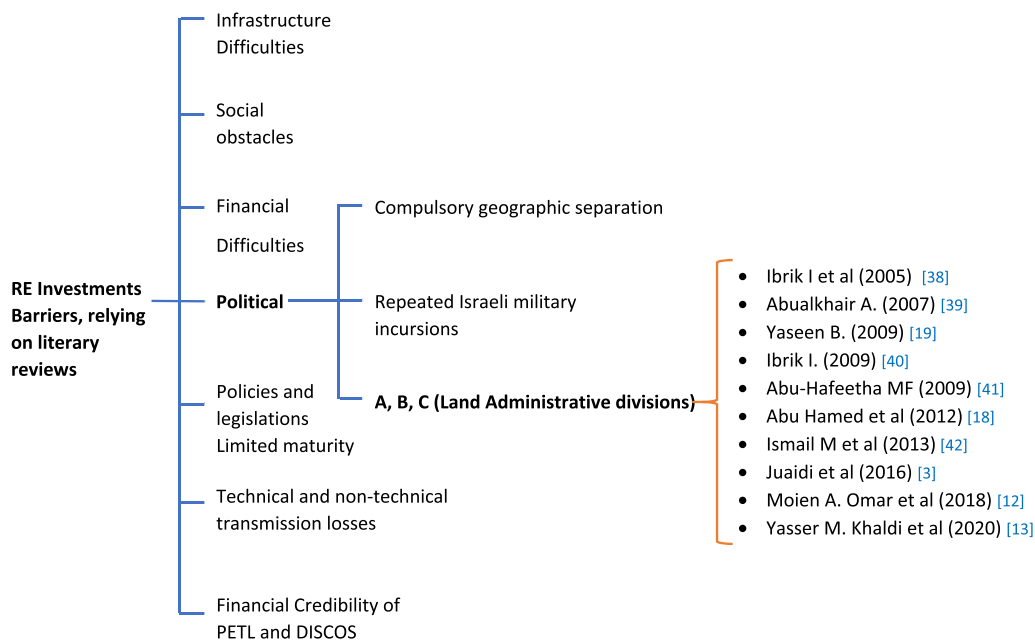


Fig. 5. Challenges facing the exploitation of RE sources in Palestine, relying on literary reviews.

it sells electric energy produced to the distribution companies with a tariff set by PERC, this tariff was attractive at the beginning of the initiative, but it is no longer because of its reduction over time. There are also obstacles related to societal awareness of the importance of RE, in addition to the need for technical training, and the weakness of laws and legislation related to RE in Palestine. However, we can consider these obstacles to be overcome and addressed [27,37].

Collectively, Palestinian researchers Fig. 5., non-Palestinian international organizations, and institutions of the international community, all agree that the political situation in Palestine and the split of lands is one of the biggest obstacles to Investing in RE projects.

- Ibrik I et al. (2005) [38].
- Abualkhair A. (2007) [39].
- Yaseen B. (2009) [19].
- Ibrik I. (2009) [40].
- Abu-Hafeetha MF (2009) [41].
- Abu Hamed et al. (2012) [18].
- Ismail M et al. (2013) [42].
- Juaidi et al. (2016) [3].
- Moien A. Omar et al. (2018) [12].
- Yasser M. Khaldi et al. (2020) [13].

But it deserves to mention that, previous literary reviews mentioned briefly and transiently the effect of dividing lands of the WB on the possibility of exploiting the potentials of RE sources and achieving energy security.

Policy casts its shadow and weight on all aspects of Palestinian life. The Israeli occupation of the Palestinian land increases the risks of long-term investments, preventive savings behaviors and stimulates the hoarding of funds instead of their investment, as Israeli military operations in the WB and Gaza have destroyed both working and fixed capital, and destroyed Infrastructure and productive base. The geographic isolation between the WB, Gaza, and East Jerusalem also increased the complexities of the Palestinian investment and economic situation, in addition to the Israel's

control of the crossings, borders and trade [43].

The administrative situation of the Palestinian territories imposed by OA in 1995, in which the lands in the WB and Gaza were parted into three executive divisions, namely A, B and C. The presence of more than 60% of the WB lands under Israeli security control means (area C) necessarily obstructing all development and investment initiatives and developing the infrastructure, and making the opportunity to establish a RE (utility scale) project on those lands equal zero. In the next section of this paper, we will highlight the concept of these divisions and their impact on investment in RE projects (utility scale projects) [3].

## 2. The impact of Oslo agreement on the exploitation of RE sources in Palestine

### 2.1. Introduction

During the past 100 years, different kinds of governments have occurred on Palestine, each of which had its geopolitical control and land accession [44]. From the Ottoman Empire (1850–1917) to the British Mandate (1917–1948), through the Jordanian guardianship (1948–1967), until the Israeli occupation and the establishment of a national homeland for the Jews, until the coming of the PNA [44,45]. In 1948, Israel occupied 78% of historic Palestine, while this occupation was completed throughout the Palestinian territory) WB and Gaza) in 1967 [44,46].

When Israel occupied the rest of Palestinian lands in 1967, it maintained or rated the Ottoman Empire's classification of Mawat and Miri lands, canceling the registration of Palestinian property rights to their lands, in preparation for confiscating it [44,47].

PNA was established in 1994, and the Palestinian Ministry of Local Government emerged from it [44,48]. On September 28, 1995 the second Oslo/Oslo II (agreement was signed between PNA and Israel as an occupying power, WB areas (excluding East Jerusalem) were divided into three administrative regions: A, B, and C [49]. Mostly, this division was done on the basis of population density, not geography [50]. Fig. 14.

This division was signed as a temporary transitional period of 5

years, during which the transfer of control over areas C and B to PNA, was not implemented until the time of writing this research.

Area A, is under the Palestinian administrative, civil, and security control, including the major Palestinian cities (Hebron, Bethlehem, Jericho, Ramallah and Al-Bireh, Salfit, Qalqiliya, Nablus, Tulkarm, Tubas and Jenin). While Area B, mostly forms the Palestinian villages located on the outskirts of A, it is under Palestinian administrative control, while security control remains in the hands of Israel as an occupying power. Area C aggregate about 62% of all WB lands, which is precious in natural resources and the most fertile with the biggest reserves of people less lands, including Jordan Valley [49]. 150,000 Palestinians live in these lands, while the number of settlers reaches 350,000, living in 200 settlements [46]. Areas A and B are separated islands as shown in Fig. 6. Palestinians do not have the right to establish infrastructures or roads between these islands to achieve geographical contact [51]. 96% of the total Palestinian population live on lands A and B, which constitute 38% of area of WB, while 4% of the population lives on the land of C, which constitutes 62% of total area of WB.

All Israeli settlements (except East Jerusalem settlements) already exist on lands classified as C, as seen in Fig. 8, with the continuity of expansion nine times more than the actual building, while number of settlers tripled in the period between 1994 and 2012 to become twice the number of Palestinians in the region, this is a geographical and demographic occupation of the lands Palestinian [45]. According to OCHA [52], in 1972 the number of settlers in the lands classified as C was 1200 settlers, while in 1993 they numbered 110,000 and the numbers continued to grow until they reached 350,000.

The Palestinian population have the lowest necessities of life and social development, while the settlers enjoy all forms of infrastructure, social and economic development, the presence of these colonists on the lands of C, suffocates the Palestinians who are on the lands of B and constitutes a burden and restrictions on the residents of areas A that prevents development and executes the opportunity to establish Independent country [50].

Overall, observers believe that Israel will eventually annex C lands with the granting of Israeli citizenship to the Palestinians who live in these areas. In 2012, the Levi committee appointed by the government recommended that half of the WB should be annexed

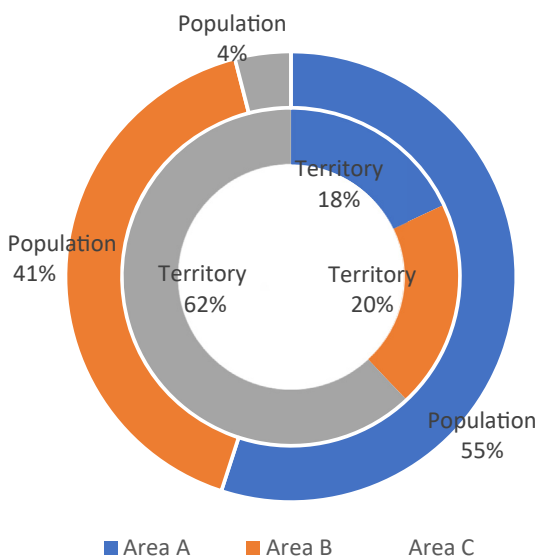


Fig. 6. Distribution of the percentage of the Palestinian population and areas on lands A, B and C.

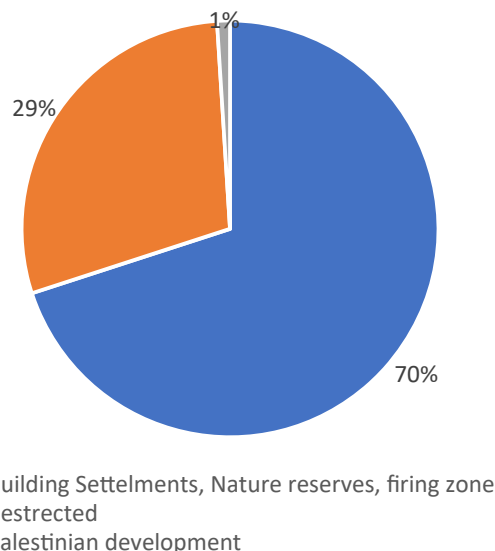


Fig. 7. The C lands are divided according to the ratio of area used for different purposes.

to Israel, and this committee did not consider the existence of illegal settlements in accordance with the law Israeli [50].

On the other hand, the World Bank considered that lands classified as C constitute the future of the Palestinian economy and sustainable development as components of the future state [51,55,56]. Since the arrival of PNA until 2012, the Palestinian economy has experienced significant growth due to international aid flows, but this growth has not been sustained after 2012 because of the reduction in the international aid budget. The World Bank has indicated in many reports the importance of using classified lands to raise GDP, these reports reflected of the economic potential of classified lands C, as rich in natural resources, and the potential for direct and indirect benefits. The direct benefits relate to the Dead Sea minerals, agriculture, construction, telecommunications, stone quarry, mining and tourism which can add 2.2 billion US dollars annually, as added value. While improving the infrastructure can be classified under the indirect benefits [55]. The World Bank estimates also indicated that if the Israeli restrictions which are imposed on Area C are removed, additional cumulative

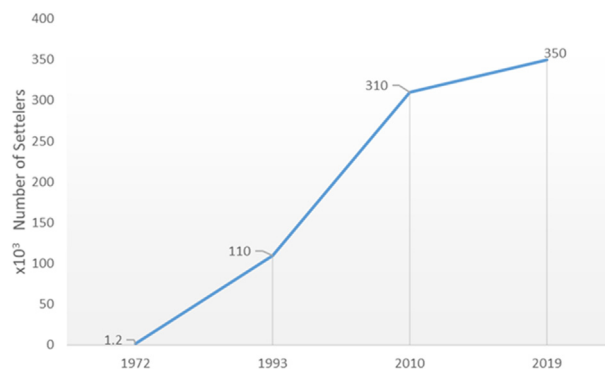


Fig. 8. Srael considers (C areas) as an extension of the alleged state of Israel, pursues a policy of constriction the lives of Palestinian citizens and pushing them to emigrate towards A areas [52,53]. Every year, 500–600 Palestinian establishments on C lands are demolished. The Palestinians are not allowed to build or plan in Area C, as they are entirely under Israeli control. About two thirds of the land area is devoted to build settlements, nature reserves, and military zones, while less than 1% of the total area is devoted to Palestinian development as presented in Fig. 7

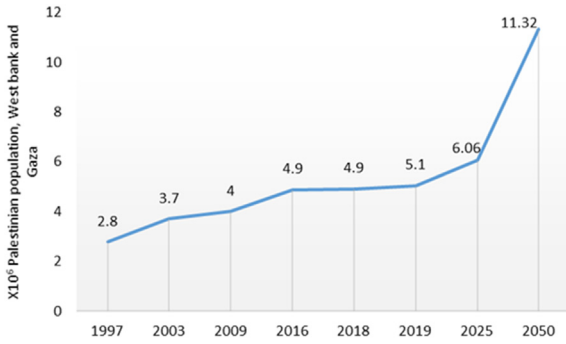


Fig. 9. Palestinian Population (1997–2050 as expected).

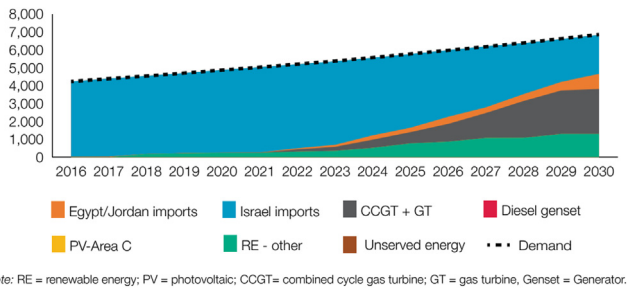


Fig. 10. PENRA Vision 2030, WB power supply (GWh) [13].

economic growth of 33% will be achieved in 2025 [36].

In the next section, we will discuss the possibility of RE sources in classified lands C and the possibility of planning for the establishment of huge land projects (utility scales).

## 2.2. Renewable energy sources in classified lands C

### 2.2.1. Why we need (area C lands)?

In a PCBS report, the report indicated the lack of open (non-agricultural) lands due to increased population growth and Israeli control over lands C [57,58].

Over years, the need for lands increases, when the OA was signed in the mid-nineties, the Palestinian population reached 2.783084 million, this number almost doubled in 2019 into 5.039 million, and this number is expected to double again by 2050 to 11.320 million as shown in Fig. 9. As a result of that Land reserves devoted almost exclusively to non-agricultural purposes are running out. This land shortage makes it very difficult to establish huge projects in RE [50].

If we take the selected indicators of land use, we found the huge loss in the area of cultivated land in the WB between 2000 and 2011, from 1515 km<sup>2</sup> cultivated to 930 km<sup>2</sup>, respectively, this decline is due to the increase in the population and the need for lands for urban expansion in areas (A + B) [59].

The total area of the WB is 6220 km<sup>2</sup>, while the areas under the control of the PNA constitute 40% of the total area (2488 km<sup>2</sup>), and the rest is the area that classified lands C with an estimated area of 3732 Km<sup>2</sup>

According to the Palestinian Ministry of Local Government, the area of agricultural and urban lands constitutes about 1861.6 km<sup>2</sup>, while the built-up lands are 459.2 km<sup>2</sup>, knowing that this area increases with population growth. This means that the open lands available in classified areas A and B for building RE projects are few and eroding over time [60].

According to PEC and PETL Only 0.12% of the total A and B lands are suitable for producing solar electricity [35], we are talking about utility scale solar power generation CSP and PV, this means just 3 km<sup>2</sup> is available. One of them claims [35], that Jordan Valley is one of the most important and best places to establish solar energy projects as seen in Fig. 15, as the largest reserve of unoccupied, easy nature lands and receives solar radiation 5.4–6.0 kW h/m<sup>2</sup> per day/year, In addition to the importance of its agricultural lands, fertile soil and warm climate, which makes it a treasure for agriculture and the development of energy and infrastructure. Unfortunately, 78.3% of the lands of Tubas and the northern Jordan Valley are classified within the lands of C, while about 88.3% of the lands of Jericho and the Jordan Valley are classified within the lands of C [60], and this means that they are out of the Palestinians authority.

At the time of writing this research, Israeli Prime Minister Benjamin Netanyahu issued a plan to annex the Jordan Valley to his country. This plan comes within the (Deal of the Century), or the US peace plan.

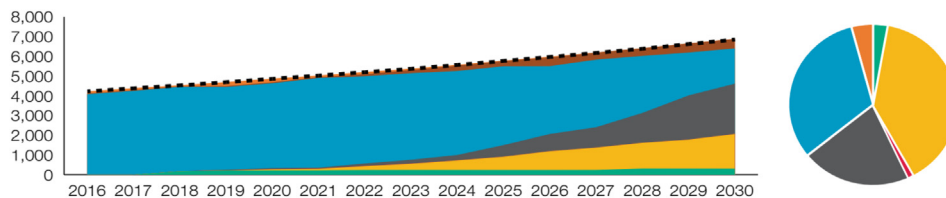


Fig. 11. PENRA Vision 2030, WB power supply (GWh), Maximum Independence Scenario [13].

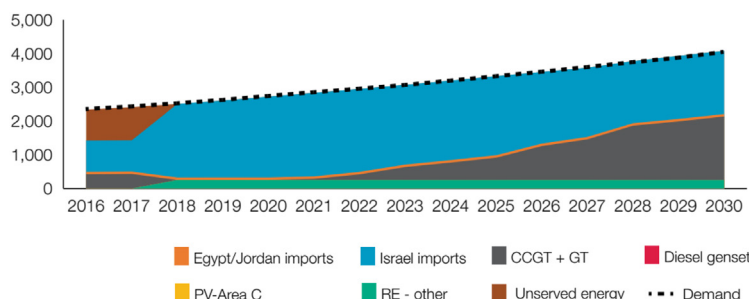


Fig. 12. PENRA Vision 2030, Gaza power supply (GWh) [13].



Fig. 13. Current Palestine's regions [5].



Fig. 14. OA land classifications [54].

Fig. 15 indicated that, the best area in the WB with highest solar energy potential south of Hebron, which is the regions C. On the other hand, for 100kw wind turbine, the potential of wind production is low. Hilly East Hebron in West Bank is the best Palestinian region with wind potential, Fig. 16. If we want to construct wind farms, it is not possible to establish these farms in populated areas such as areas A due to safety considerations and the need for

open spaces. This means that Gaza is not fortunate in this direction for two reasons, which are lack of spaces and high population density, moreover, to the low wind speeds.

In WB as shown in Fig. 17, areas with high potential for direction and orientation cannot be exploited due to their proximity to the border with Israel, the latter being forbidden for security reasons. In addition, areas that have the potentials of wind energy, are

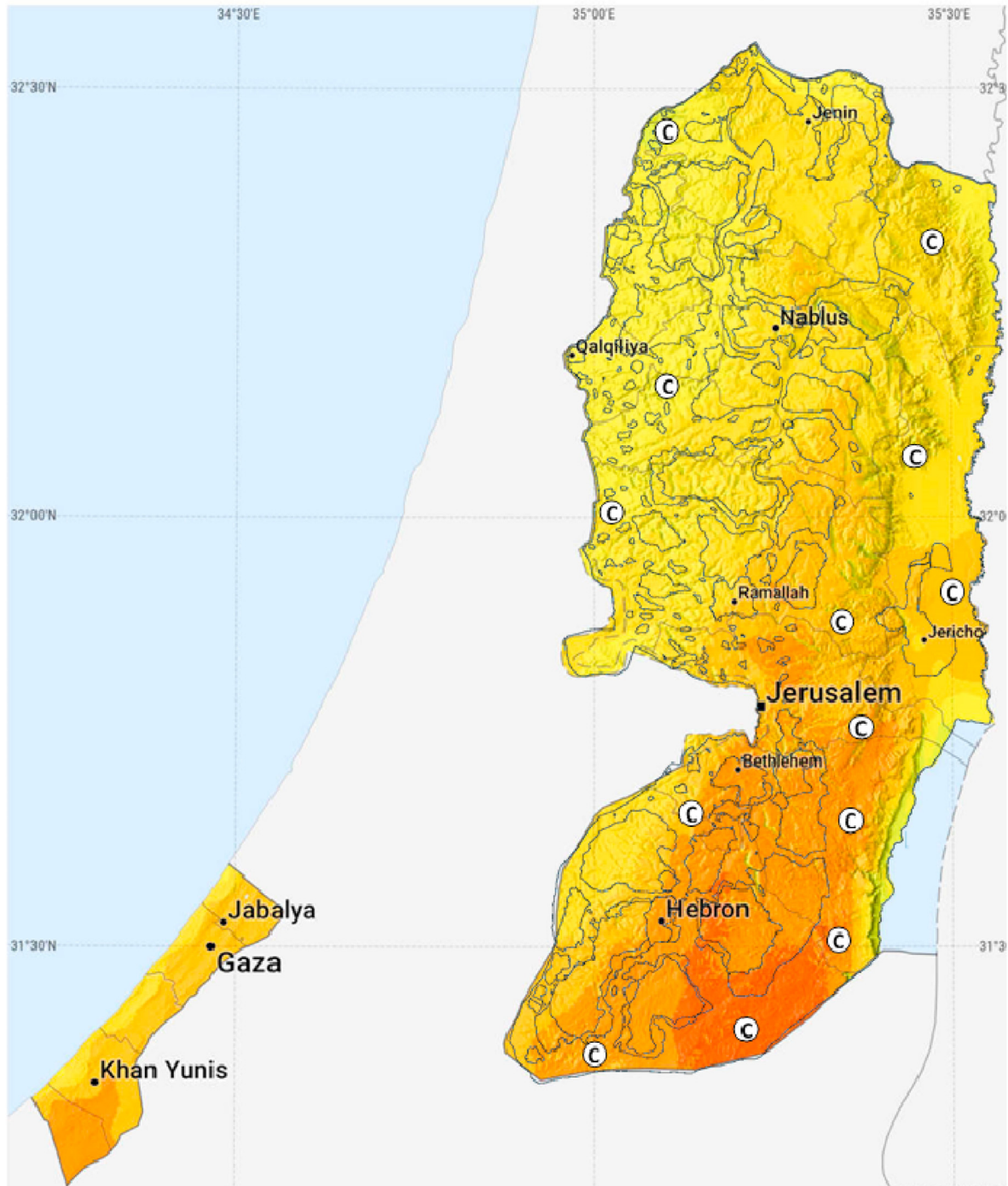


Fig. 15. Global Horizontal Irradiation (GHI) of West Bank and Gaza [61], Zoning map (A, B, C) is projected, depending on Geomolg (Geospatial Information System in Palestine (, Ministry of Local Government [62].

mountainous areas located within the mountain range of Palestine and have a difficult geographical nature, noting the geographical interruption between these areas because of the territorial division (A, B, C) [5,63].

Biogas landfills, its nature is different from wind farms or PV, CSP utility scale projects, because it is difficult to be expanded along the lands, the larger biogas might trick for landfills can be built-up on place. Power from biogas engender is dispatch able that wind product is perpetual, and a speculator can syn when to propagate

dominion. This expel the indigence for firming up arrangements through accompaniment generation. Biogas generation will depress over repetition, but can be thought relatively invariable until 2030. Although biogas is a prime supply straddle, it is definite in gradation and cannot be scaled up.

It deserves to be mentioned, that the Palestinians see (C lands) as a base for developing an electricity transmission infrastructure. Israel supplies us with electricity through 270 low voltage connection points, which increases the technical loss.

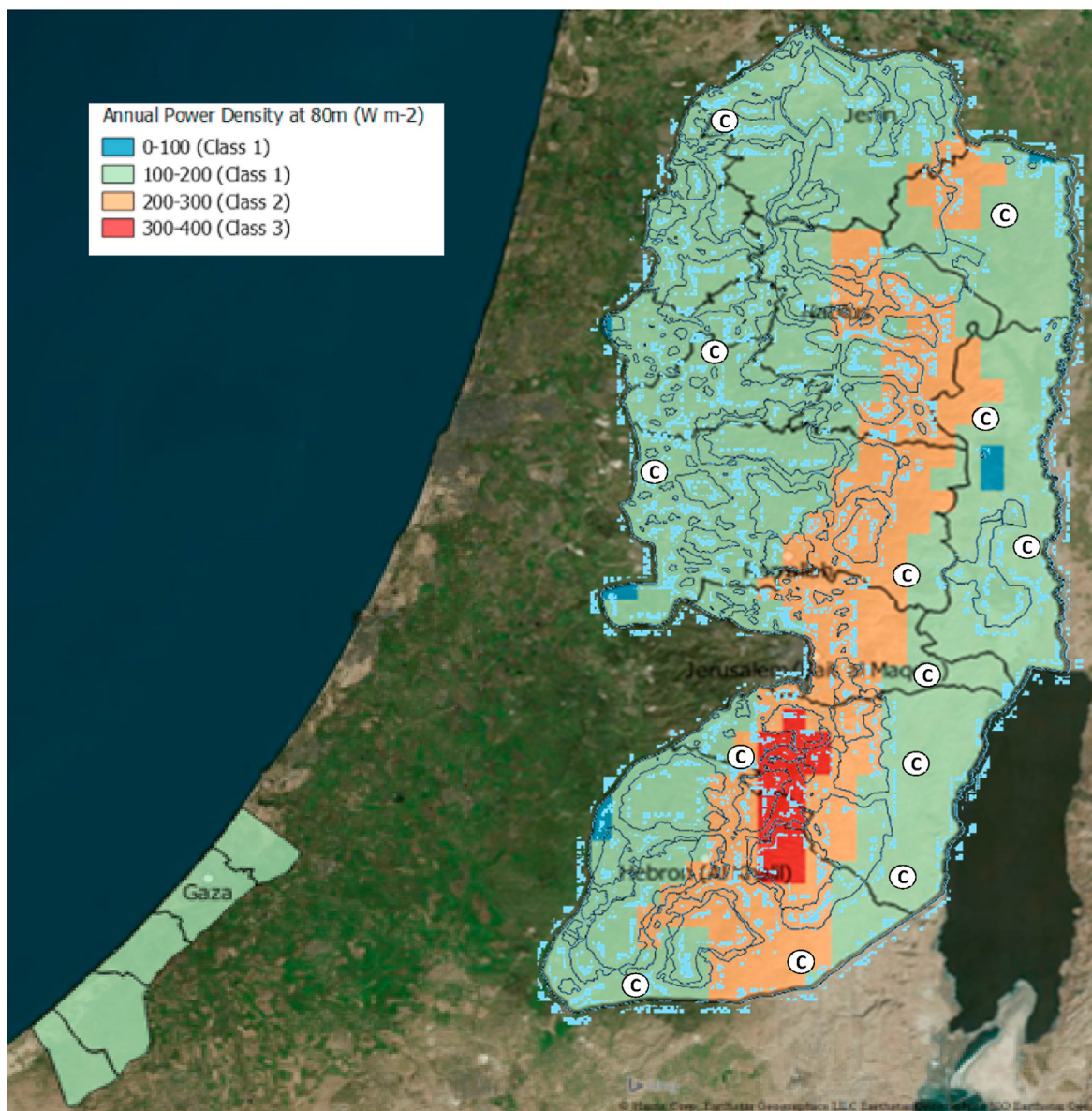


Fig. 16. 80 m wind annual power density (WB and Gaza) [20], Zoning map (A,B,C) is Projected depending on Geomolg (Geospatial Information System in Palestine) Ministry of Local Government [62].

2.2.2. RE potential in area C

RE sources are the only independent sources, especially solar energy, they are the only sources that cannot be relied on any part.

PENRA's vision 2030, seems to be attractive, it depends on reducing relying on the Israeli side, in addition to developing power generation from gas-dependent stations, and increasing imports from countries other than Israel, along with 500 MW of solar energy as presented in Fig. 10. For WB this scenario ensures a fair balance between the production of solar energy and the gas power generation with what is imported from Israeli side, while ensuring a precaution of imports to fill a sudden shortage in supplies, while the contribution of RE is 19% as domestic generation and 30% if we can access area C, PENRA called this option as (maximum independence scenario) as seen in Fig. 11.

For Gaza strip this vision is different (Fig. 12), especially for domestic renewable generation due to Confined spaces, and high population density, which makes rooftops solar energy generation the only option in terms of RE share. the solar potential in Gaza is

limited to roof top spaces so it can't make more than 6% of energy demand.

In order to approximate the possibility of RE in lands C, some assumptions must be made. According to NERL (National Renewable Energy Laboratory) [64,65], the following spaces Table 5. are required for solar, wind generation (m<sup>2</sup>/KWp).

According to PEC and PETL only 0.12% of the total A and B lands are suitable for producing solar electricity [35], we are talking about utility scale solar power generation CSP and PV, this means just 3 km<sup>2</sup> is available, while if we use 3% of area C, we will get over 3000 MW as presented in Table 6.

While the next estimations are for the solar collector that we can harvest from rooftop systems, the data of (number of rooftops) and their areas as seen in Table 7, are according to PCBS and PEC. The only chance for Gaza Strip is the rooftop instillation, which can provide 163 MW.

Table 8 presents the estimations of the potential of RE in Palestine are based on several assumptions. These estimates are

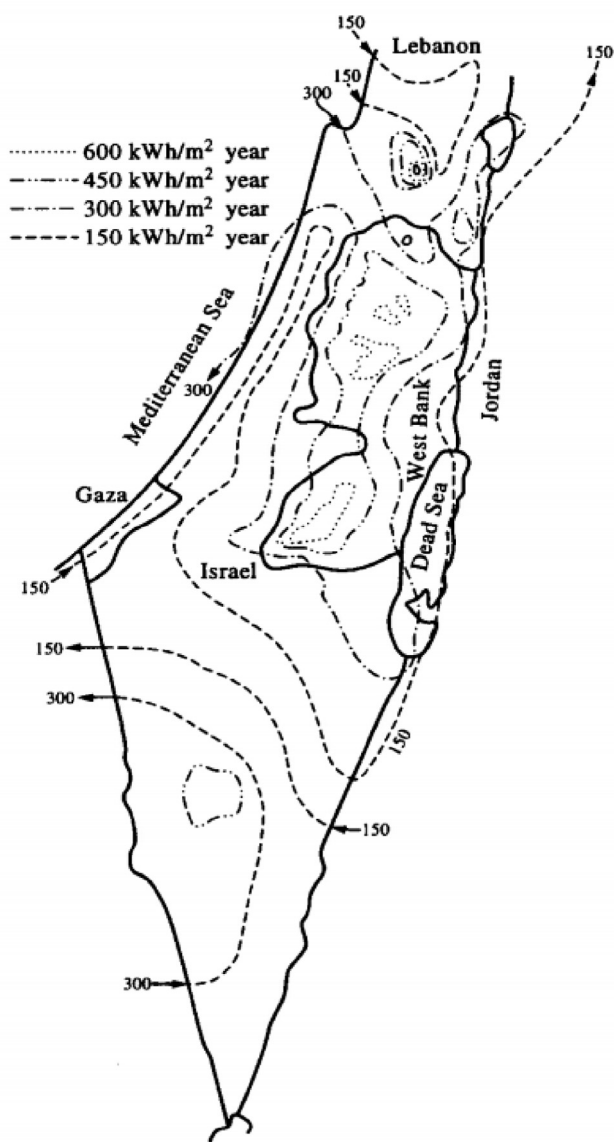


Fig. 17. Contours of wind energy potentials [63].

**Table 5**  
Required spaces for solar, wind generation, (m<sup>2</sup>/KWp).

Rooftop solar	8–12
Utility-scale PV	24–32
CSP	31–40
Wind	210–330

**Table 6**  
Approximated Potential capacity (MW), for A, B, C areas.

	Total surface		Available according to PETL		Potential capacity (MW Peak)
	(Km <sup>2</sup> )	(%)	(%)	(Km <sup>2</sup> )	
<b>Areas A and B</b>	2488	40%	0.12%	3	103
<b>Area C</b>	3732	60%	2.64%	98.5	3374
<b>Total</b>	6220	100%	2.76%	101.5	3476

Depending on the above approximations, areas (A + B) can provide only 103 MW as utility scale solar, while Area C could provide 3476 MW, if 3% is used.

important, and many facts can be drawn from.

- a: Available area as a percentage of land (A + B) and C respectively: 0.012%, 2.64% and 25 m<sup>2</sup>/KWp.
- b: due to PCBs and PEC assumptions and data (9 m<sup>2</sup>/KWp).
- c: All areas that apply the following conditions: higher than 1000 m above sea level, and wind speed between 4 and 8 m/s, with specific area, 330–210 m<sup>2</sup>/KWp.
- d: Jenine landfill, Hebron landfill, Ramallah landfill. 800 tons of waste will give 41,800 m<sup>3</sup> of biogas per day = 251 MWh/day, 750 MW h/day from 172 digesters.

To conclude, 96% of the total potential of solar energy is in WB, while Gaza has only 163 MW, this makes sense. Area C Obsess over 63% of solar energy potential, while about 75% of the potential in area (A + B) is upon the roof tops. As expected, 98% of the total RE potential is solar energy potential.

**2.2.3. The possibility of planning, utilizing, and establishment of utility scale RE project**

In 2008, the World Bank presented a report, describing the status of obtaining licenses from Israeli authorities for residential or economic construction as a mysterious, costly, and almost impossible process [66]. Less than 1% of the total area (C) is devoted to Palestinian development, while the rest of the land is not allowed for the Palestinians to use it according to the severe restrictions on the Israeli side, as 68% of the C lands are designated for building settlements, while 30% are reserved as military zone areas and natural reserves. Preventing the Palestinians from obtaining building permits frustrated them, and made them build their homes without a permission. Therefore, in the period between 2000 and 2012, 2829 demolitions were carried out by the occupying authorities [67,68]. In 2011, the PNA presented a deliberate plan to organize 32 Palestinian population groups on the lands of C, and since then until the time of writing this paper, no Palestinian organizational plan has been approved by the Israeli Civil Administration (ICA). What is going on lands C are colonial plans (while the Palestinians try to reverse them without success [44]. A lot of studies have been done about the possibility of planning in the lands of C, but the result is the same (the area is under occupation) and all Palestinian attempts to plan in these lands have been aborted under one pretext which is (it contradicts any plans with the British mandate plans for the region [44,46,69]).

All these Israeli intransigence's come in the context of the recognition by international law that the WB is occupied land and the settlements on its territory are illegal bodies.

Civil administration data showed that, between 2000 and 2016, the Palestinians submitted 5475 applications for licenses, only 226 applications were approved [45]. There is a perception among the political leadership in Israel that areas C were found, above all, to serve the needs of the Israelis, a region viewed with the view of ambition to annex them to Israel. Therefore, Israel is deepening its

**Table 7**  
Estimations of rooftops solar potential in Palestine.

West Bank						
	No. Of Rooftops for PV	Area per Rooftop (m <sup>2</sup> )	Rooftops available	Well Oriented	Available Surface (m <sup>2</sup> )	Potential Capacity (MW)
Residential	326,867	150	30%	30%	4,412,709	490
Public	123	200	40%	100%	9811	1
Schools	1349	160	50%	100%	107,925	12
Commercial	3066	300	30%	100%	275,944	31
Gaza						
	No. Of Rooftops for PV	Area per Rooftop (m <sup>2</sup> )	Rooftops available	Well Oriented	Available Surface (m <sup>2</sup> )	Potential Capacity (MW)
Residential	90,472	150	30%	30%	1,221,373	136
Public	77	200	40%	100%	6189	1
Schools	851	160	50%	100%	68,075	8
Commercial	1934	300	30%	100%	174,056	19
Total West Bank and Gaza						697

**Table 8**  
Estimations of total potential of RE sources in Palestine.

Potential available renewable energy capacity (MW)				
Utility-scale PV or CSP				
	Areas A and B		Area C	Total
West Bank	103		3374	3477
Gaza	0			0
Rooftop solar				
	Residential	Public	Commercial	Total
West Bank	490	13	31	534
Gaza	136	8	19	163
Wind and biomass				
	Wind areas A, B, C	Biomass (animals)	Biomass (landfill)	Total
West Bank	45	7	18	70
Gaza	0	2	0	2
Total				
West Bank				4081
Gaza				165
West Bank and Gaza				4246

control and exploiting the resources of the region to create a prosperous reality for the Jews while ensuring a non-existent Palestinian presence, and to impose the fait accompli in the future [50,70]. The political divisions of Palestine between Gaza and WB made them, over the years, an unreliable space for planning or investment [71].

Therefore, we can consider that planning in Palestine is a special type, and thus spatial planning becomes the basic for development projects in view of the existing political situation, so the potential effects of these projects must be examined on the geopolitical aspect and vice versa [6]. PNA and international partners working in the field of development in Palestine think that Class C lands are the basis for the success of the two-state solution, and to ensure the sustainability of the Palestinian economy.

530 MW is the technical capability on rooftops for solar energy systems, while 100 M is the potential in case of utility scale in areas A,B, this potential is multiplied by a factor of 30 in C- lands. On the other hand, the possibility of utilizing C lands is questionable due to the difficulty in reaching a peace settlement with the Israeli side [10]. In addition to the challenges associated with establishing a backbone to transfer electricity, which requires using these lands, this is another major challenge.

To understand the possibility of using classified C lands, we interviewed the head of the RE Division of PENRA:

” At the present time we are not able to exploit the potentials of C lands, it is almost impossible to obtain a license to establish RE projects over these lands, and more than that without extending the cables of transformation over the lands named C, even if the project is based on lands A, B” (interview [72]).

To confirm the fact that solar energy is not established or used on C lands, Depending on the data provided by PENRA of RE utility scale projects (existing and for which a license was issued), and dropped them on the map as shown in Fig. 18, so that it becomes clear to us that all projects are on A, B lands [62].

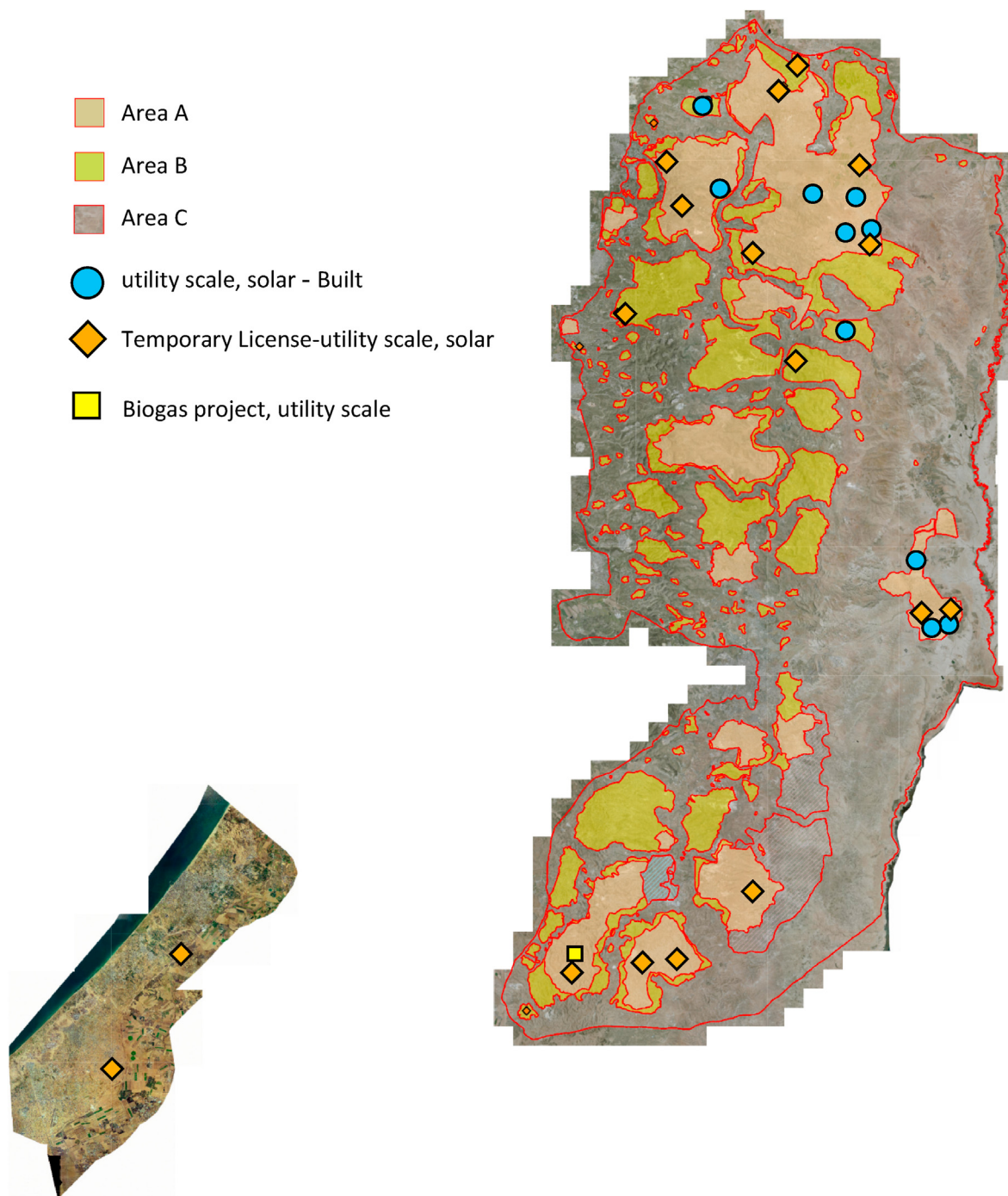
In the context of PENRA endeavor to exploit the C lands, we should not forget the possibility and importance of the roofs of buildings, as it came to be able to meet the vision of PENRA 2030, it is safer in the event of armed conflicts and is not linked to geopolitical circumstances as it is cheaper.

Finally: It is important to start serious talks with the Israeli side regarding the Palestinians’ right to these lands, with the need to submit plans to generate energy in order to elicit solutions to problems relating to the stability of the network, for the benefit of both parties.

### 3. Conclusion and policy implications

This paper reveals that, despite the urgent need for RE sources as an independent source of energy and its availability in Palestine, there are many obstacles and difficulties that prevent its dependence on a level that meets the view of PENRA. These difficulties are summarized in several aspects:

Infrastructure difficulties, social obstacles, financial ones, policies and legislations limited maturity, technical and non-technical transmission losses, financial credibility of PETL and DISCOs and political obstacles. The political situation in Palestine is known for all, Policy casts its shadow and weight on all aspects of Palestinian life.



**Fig. 18.** Renewable energy utility scale projects (existing and for which a license was issued), in West Bank and Gaza strip. Based on PENERAs Data [73]. Zoning map (A, B, C) is projected, depending on Geomolg (Geospatial Information System in Palestine (, Ministry of Local Government [62].

As part of political factors, this investigation has shed light on administrative situation of the Palestinian territories imposed by the Oslo Agreement in 1993, in which the lands in the WB and Gaza were parted into three executive divisions, namely A, B and C.

The presence of 60% of the WB lands and more, under Israeli security control means (area C) necessarily obstructing all development and investment initiatives and developing the infrastructure, and making the opportunity to establish a RE (utility scale) project on those lands equal zero.

Finally, 96% of the total potential of solar energy is available in

WB, while Gaza has only 163 MW, this makes sense. Area C obsess over 63% of solar energy potential, while about 75% of the potential which is area (A + B) is upon the rooftops. As expected, 98% of the total RE potential is solar energy potential. Only 0.12% of the total A and B lands are suitable for producing solar electricity, we are talking about utility scale solar power generation CSP and PV, this means just 3 km<sup>2</sup> is available, while if we use 3% of area C, we will get over 3000 MW. Despite these enormous potentials on lands classified as C, until now the possibility of planning on these lands is almost non-existent, due to the total control from the Israeli side

of these lands, and considering them as an extension of the State of Israel.

### CRediT authorship contribution statement

**Nour Abboushi:** Formal analysis, Writing – original draft, Writing – review & editing. **Husain Alsamamra:** Conceptualization, Writing – review & editing.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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