Abu Tor Economic Research Collaborative

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Gaza Electricity Reform & Restoration

Fast Track Approach to Economic Revival

Authors:

Karim Nashashibi

Yitzhak Gal

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Executive Summary: suggested reforms in the electricity sector

- A program of institutional reform for the electricity sector in Gaza and a selected set of measures aimed at sustaining the current increase in electricity output from 25 MW in October 2018 to 70-80 MW thanks to the Qatari financing facility, beyond its expiration in April 2019. The humanitarian and economic benefits of the increase in electricity availability have been dramatic and should be sustained. Additional projects in solar energy would raise electricity output from 190-200 MW in December 2018, to 290 MW within one year.
- The corner-stone of the proposed reform is restructuring the Electricity Distribution Company (GEDCO), while ensuring steady supply of fuel for the Gaza Power Plant (GPP). A first step in this reform is launching a financial audit of GEDCO, as proposed by the EU to the PA Minister of Finance and Planning in June 2017. The Minister has now approved the audit and the Palestinian Energy Authority (PENRA) has unveiled a two year plan for structural reforms of the electricity sector in Gaza. PENRA would play a leading role in this reform and work closely with GEDCO and local Gaza authorities.
- Transforming GEDCO from a state run institution into a commercially viable and sustainable company will require, changing the Board and management, raising electricity bill collections, reducing illegal connections, issuing transparent financial accounts, establishing a revenue protection program and installing pre-paid and smart meters. Rebuilding GPP fuel storage tanks, rehabilitation and maintenance of transmission lines and sub stations would also be required.
- A relaxation of the Israeli siege on Gaza, and an improvement in economic conditions would be essential in phasing in GEDCO's reforms successfully.

- In support of this reform a financing mechanism (Trust Fund) spearheaded by donors would be established for the purchase of diesel fuel to ensure a consistent and reliable source of fuel supply for two years, until GEDCO reforms are fully phased in, bill collection is raised and electricity delivery services are upgraded to regional standards.
- Donors would provide the Trust Fund with a grant of $ 120 million for the first year and $ 80 million for the second year, when a higher rate of bill collection occurs. It would be a revolving fund to which all electricity bill collections would accrue. As GEDCO financial situation improves, it will be able to pay for the 120 MW supplied by IEC, thereby reducing "net lending" and reducing PA budget deficit.
- The Trust Fund would also finance GEDCO's structural deficit resulting from diesel fuel costs per kw/h more than double the electricity tariff, until much cheaper natural gas is piped to the Gaza Power Plant (GPP) by 2021.
- Past ad-hoc financing by donors of fuel purchases for the GPP provided a welcome and immediate relief to the population with higher electricity availability, but were not leveraged with a reform program to bring about a lasting transformative change and financial sustainability to the electricity sector.
- Financing committed by Qatar to provide diesel fuel for the GPP for six months (till April 2019) opens a window of opportunity to mobilize Trust Fund financing and phase in the GEDCO reforms. This would ensure that the supply of diesel fuel and the current level of electricity delivery is not interrupted and becomes consistent and predictable over the next two years. Both financing facilities would bridge the time period until natural gas reaches the GPP.
- To diversify Gaza's energy sources and reduce its dependence on Israeli electricity imports, a new strategy of exploiting solar energy in Gaza is proposed, at competitive prices, combining utility scale PV plants, small and medium special purpose solar systems, and roof top and on land micro systems for hospitals and schools.

Foreword and Acknowledgements

The dire economic and humanitarian environment in Gaza motivated us to address a critical input for daily life in Gaza, health and education facilities, water and sanitation facilities as well as all aspects of economic and business activities: availability of electrical power. While several worthy energy projects have been approved, Gazans cannot wait for several years until they are launched and completed. Support from Konrad Adenauer Stiftung enabled us to focus on what can be done in Gaza, within one-two years, to raise electricity availability from 4-5 hours per day October 2018 to 15-20 hours per day for the next two years. Through a combination of providing fuel to the Gaza power plant, supported by a reform of the Electricity Distribution Company and a financing mechanism considered by the donor community, and the addition of a few strategically located solar power stations, we believe that this objective is doable.

Our two principal collaborators at KAS, Marc Frings and Johannes Lutz have spared no effort in promoting a creative research environment, with free-flowing ideas and mobilizing several experts in the field as well as major stakeholders in the donor community. Their brain-storming meeting in their Ramallah office was particularly successful.

Our partner in Gaza, Omar Shaaban, founder of Palthink, has been very responsive in answering our multiple questions and in getting feedback from Gaza policy makers. Dr. Mohammad Mustapha, CEO of the Palestinian Investment Fund read through the draft and provided valuable insights. Azem Bishara, CEO of Massader, who has pioneered the construction of three solar stations in the West Bank, provided insights about developing solar energy in Gaza. Meetings with Zafer Melhem, PENRA's CEO, were very productive, and we were inspired by his five-year plan for the development of the Electricity Sector in Gaza. We had good discussions with COGAT staff as well.

Discussions with several members of the donor community in Ramallah and Jerusalem have been particularly fruitful: UNSCO and the World Bank have been at the forefront of Gaza electricity reform: in particular, Jonathan Lincoln and Jamie Mcgoldrick from UNSCO, Bjorn Phillip and Monali Ranade from the World Bank have been leading this effort. They have been supported by the Chair of the ENERGY Working Group, Hilde Haralstad, Norway's Representative, and her colleagues in the group. Alessandra Viezzer from the European Union zeroed in on the main obstacle in moving forward GEDCO reform, namely the need for a

financial audit of GEDCO, which now has been approved. Jonas Blume head of KFW provided us with valuable comments and ideas on how to move forward. As always, John Clarke, head of the Quartet Office shared with us his political and operational insights, which remain valid until this day. His colleague, Henrik Moberg, shared with us his vast knowledge on natural gas and electricity in Gaza. Gas4Gaza could hardly move forward without him.

Staff at KAS office in Ramallah has been very helpful, particularly Bishara Sahhar, (Administration and Finance Manager), Hana Hijazeen and Majd Assali who has excelled in her graphic presentations.

Abu Tor Economic Research Collaborative Ltd. is a Jerusalem-based think tank that brings together Palestinian, Israeli, and international economists in an effort to respond to current challenges with practical solutions. The Collaborative focuses on the Palestinian political economy, its relations with Israel, and its economic links to other countries in the region. Sound economic analysis aimed at improving living conditions in the Palestinian territories and enhancing Palestinian capabilities and empowerment, paves the way for advocating policy changes among various stakeholders and moving toward resolution of troublesome issues.

Konrad-Adenauer-Stiftung e.V. (KAS) is a German political foundation, associated with the Christian Democratic Union (CDU) of Germany. The foundation is represented through over 90 country and regional offices worldwide. In the Palestinian Territories, the Konrad-Adenauer-Stiftung supports since 1996 local and regional initiatives that are directed towards the two-state solution. The country office is currently working in the fields of policy analysis, the rule of law, energy security, strategic thinking, civil engagement, and dialogue programs. For more information about our work in the Palestinian Territories and to download any of our publication please visit: https://www.kas.de/web/palaestinensische-gebiete/home/en

Table of Contents

EXECUTIVE SUMMARY: SUGGESTED REFORMS IN THE ELECTRICITY SECTOR 2

FOREWORD AND ACKNOWLEDGEMENTS 4

TABLE OF CONTENTS 6

ABBREVIATIONS 7

INTRODUCTION 8

1. THE POLITICAL AND ECONOMIC CONTEXT 10

2. THE ELECTRICITY CRISIS: INFRASTRUCTURE AND INSTITUTIONAL BREAKDOWN 15

3. PLANNED PROJECTS AND IMPEDIMENTS 21

4. IMMEDIATE MEASURES NEEDED TO ALLEVIATE THE ELECTRICITY CRISIS 27

5. EXPLOITING SOLAR ENERGY IN GAZA 33

ANNEX A: DETAILED FAST-TRACK SOLAR ENERGY PROGRAM 38

Abbreviations

COGAT	Coordinator of Government Activities in the Territories Unit (Israeli entity)
GDP	Gross Domestic Product
GEDCO	Gaza Electricity Distribution Company
GPP	Gaza Power Plant
GWh	Gigawatt Hour
IEC	Israeli Electric Corporation
IPP	Independent Power Producer
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt Hour
MW	Megawatt
MWh	Megawatt hour
NIS	New Israeli Shekel (Israeli currency unit)
PCBS	Palestinian Central Bureau of Statistics
PEC	Palestinian Energy and Environmental Research Center
PENRA	Palestinian Energy and Natural Resources Authority
PPA	Power Purchase Agreement
PV	Photovoltaic
DFG	De Facto Government
PIF	Palestine Investment Fund
PA	Palestinian Authority
DISCOs	Electricity Distribution Companies
RE	Renewable Energy

Introduction

During the last decade, Gaza's infrastructure has been in steady deterioration to the extent that the UN declared in 2012 that Gaza would be "unlivable" for its 2 million people by 2020. The blockade imposed on Gaza in 2006 is entering its 12th year. Israel, Egypt as well as the Gulf States, have become increasingly aware that the situation in Gaza is unsustainable; with the looming humanitarian crisis causing political instability in Gaza, the West Bank and neighboring countries. After eleven years of separation, the process of governance reunification in Gaza has been periodically stalling, but prospects for reconciliation between the Hamas administration-- De Facto Government (DFG) in Gaza and the Palestinian Authority (PA) in the West Bank, have introduced a new political dynamic, with Egypt playing a central role. Concerted efforts by neighboring countries and the donor community are now needed to bring about a sustainable agreement between the two governments, reduce on going tensions, and stabilize the region.

There is now a strong geopolitical sentiment that the economic and humanitarian crises in Gaza need to be addressed in an effective and sustainable manner[1]. Recent deterioration in the political environment, and the renewed eruption of violent clashes, make that need even more urgent. Dealing with the ongoing electricity crisis is the first step towards economic revival. Hospitals, schools, water desalination, sewage treatment facilities and agriculture are at the receiving end of the electricity crisis, with the poorest segments of the population enduring most of the distress, as electrical generators and clean water are beyond their means. Due to a deterioration of the economic situation, UNRWA has not only experienced a sharp increase in demand for its services from its 1.3 million registered refugees and its 267 schools, but it has also incurred drastic financial cuts by the United States from $ 130 million in 2017 to $ 67 million in 2018.

This project can revitalize the economy of Gaza, through fast-track rehabilitation and development of its electricity infrastructure. It can also be implemented within the current governance framework, where DFG and PA officials cooperate at the ground level, without having to wait for a full reconciliation between the two sides. Bringing back electricity

[1] World Bank, *Economic Monitoring Report to the Ad Hoc Liaison Committee* (September 27, 2018), p. 21.

performance from 4-5 hours per day to 10-15 hours per day, may be only one dimension of a comprehensive plan to re-develop the Gaza economy, but it is an essential starting point which would have major humanitarian impact and ramifications on all other sectors, particularly on clean water delivery and sanitation treatment, but also on health and education. Manufacturing, agriculture, exports and transportation would all be revived towards outperforming their 2005 levels. It will also substantially reduce Gaza's dependence on Israel for its energy development providing greater flexibility in implementation.

Developing Gaza's off-shore gas reserves, building a seaport and airport, and laying a 161 kv electricity line from Israel are all essential and cost effective projects but would take several years to be fully implemented. This study proposes a strategy based on practical solutions to raise the electricity output from existing facilities within one year, and to develop new sources of solar energy.

The dimensions of the electricity crisis are addressed, particularly the breakdown of the electricity infrastructure and the institutional underpinnings of the electricity sector, such as the failure of providing a consistent supply of fuel for the Gaza power plant (Gaza Electricity Generating Company, GPP), as well as issues surrounding electricity bill collection, accountability and revenue sharing among various stakeholders.

The study then concludes with an action plan of short term measures to be implemented within a year, supported by a set of institutional reforms which would aim at ensuring a steady supply of fuel to the GPP for two years and a comprehensive reform of the electricity sector in Gaza, while developing Gas for Gaza infrastructure to supply the GPP.

The structure of the study is as follows:

1. The political and economic context and political feasibility
2. Dimensions of the current crisis: infrastructure and institutional breakdown
3. Survey and analysis of existing strategies and projects for the rehabilitation and development of the electricity infrastructure of Gaza; timeline and possible impediments.

4. A plan for raising GPP electricity generation from 25 MW (October 2018 within the Electricity Distribution Company (GEDCO) current financial limitations)—to 80- 90 MW under a reform program and a Trust Fund Financing Mechanism.
5. A plan for exploiting the solar energy potential in Gaza in light of the dramatic improvements in solar energy technology and decline in costs. This new strategy would complement the gas track, albeit with a shorter timeline and fewer impediments

1. The political and economic context

Gaza's political context is dominated by three factors and their dynamics: Israel's Gaza blockade since 2006; Egypt's control of the Rafah border crossing and discussions with Palestinian factions; and the DFG and PA governance in Gaza. There were several political watersheds which contributed to the deterioration of economic and humanitarian conditions in Gaza: The unilateral withdrawal of Israeli settlements from Gaza in 2005 without any coordination with the PA on governance and security; Hamas' victory in the 2006 elections and the abduction of an Israeli soldier (Gilad Shalit); and the takeover of the Gaza Strip by Hamas in June 2007; and Israel's four assaults on Gaza in 2006, 2009, 2011, and 2014. They all caused extensive damage to the infrastructure, particularly to the GPP storage tanks which were bombed in 2006 and 2014. The destruction of housing and infrastructure during the 2014 war caused the largest damage estimated at $ 3.5 billion, with only $ 1.8 billion in reconstruction implemented by mid 2018 (54%)[2]

a) Israel's restrictions and economic blockade

Gaza's major resource is its human capital of 1.9 million people squeezed in an area of 360 square kilometers[3]. The population is well educated, , with 48% of the population younger

[2] World Bank, *Reconstructing Gaza - Donor Pledges* (March 13, 2018).
[3] Palestinian Central Bureau of Statistics (PCBS), press release on the situation of the Palestinian population on the occasion of World Population Day (July 11 2018), p. 1.

than 18, and resourceful as reflected by a fast growth in exports during 1995-2005 and the development of advanced agriculture[4]. Far more than the West Bank, Gaza is totally dependent on trade and movement of people for its economic growth. Gaza's economy is also highly complementary to that of the West Bank, but after twelve years of separation and siege, its economic integration with the West Bank has been sharply scaled back.

Israeli policies since 2001 have been reflected in widespread restrictions on Gaza's economic activities, movements of people and access to markets. These restrictions were exacerbated with a debilitating blockade beginning in 2006. Both imports and exports have been severely restricted. Real imports per capita have declined by half, from $ 800 million in 2000 to 420 million in 2016. Real exports per capita also declined from about $100 in 2000 to $ 56 million in 2016[5]. Imports of capital equipment declined sharply under the Israeli siege with the introduction of the "Dual Use"[6]; as of May 2018, there were 67 items on the Dual Use list, including wood, lacquer, machinery, spare parts, fertilizers, cranes, and construction steel bars[7]. This has undermined any attempt at developing Gaza's infrastructure and deprived exports from key inputs, such as plywood which is used for furniture exports.

Gaza's exports to its largest markets, Israel and the West Bank were prohibited since 2007 but access to these markets has been liberalized since 2015. Nevertheless, exports in 2017 to Israel, the West Bank and abroad were only one fifth of their level in 2005[8]. In September of 2000, 26,000 workers were commuting daily to Israel, but by January 2001, with the onset of the second intifada, this movement of workers was stopped, depriving Gaza of a major source of income. Restrictions on movement of people, in and out of Gaza, were intensified after the 2006 election which brough Hamas to power and the 2007 Hamas take over of the Strip. Gaza was likened to "an open air prison" where most students could not pursue their education in the West Bank or abroad, workers and management could not be trained abroad or receive training in Gaza from foreign experts.While businessmen and traders would receive permits

[4] Eight Gaza farms were certified by the EU in 2005 under stringent rules of operation, to export produce and flowers to European Union countries. Only two farms were certified in the West Bank.
[5] real exports declined from 10.5% of GDP in 2000 to 4.5% of GDP in 2017.
[6] Imports which could be used for both civilian and military purposes.
[7] Karim Nashashibi, "Gaza: From Humanitarian Crisis and Economic Decline to Economic Development", in Arie Arnon and Saeb Bamya, The Aix Group , *Improving the Gaza Economy and Utilizing the Economic Potential of the Jordan Valley,* (January 2017) pp. 49,51-52.
[8] Truckloads of exports from Gaza declined from a monthly average of 15,255 in 2000, to 9,319 in 2005 and 212 in 2017. For a detailed analysis of these restrictions and their impact on economic activity see Karim Nashashibi, ibid, pp. 31 – 37.

to travel to Israel, in 2017 they were sharply reduced from 12,150 (monthly average) in 2016 to 5,963 in 2017, a 51% drop.

Real GDP per capita declined steadily in 2017 from $ 451 in Q1 to $ 415 in Q1, 2018[9]. This has been compounded by a decline in external assistance by some countries (e.g. US) and by international organizations (UNRWA). The outlook for 2018 is for a further yearly decline in economic activity, as indicated by a large decline in real GDP during the first two quarters of 2018 (-4%).

The implosion of the Gaza economy, coupled with dire humanitarian consequences—rise in unemployment to 54% and in poverty to 53% have triggered a major shift in the Israeli approach to Gaza: since October 2017, a segment of the Israeli political and official establishment realized the necessity of improving daily living conditions for the Gaza population to defuse another conflagration similar to the 2014 war. Mordechai, Milstein and Amitay called for a Marshall Plan for Gaza, led by the international community[10]. They focused on the new generation of Gaza's population and highlighted their level of unemployment and despair which would destabilize the security situation if not addressed by a major lifting of Israeli restrictions and resumption of normal economic activity.

This marked a fundamental shift in COGAT's approach to project approval in Gaza including their advocacy for a new transportation infrastructure to Gaza, establishing an industrial Zone at Eretz and allowing daily movement of Gaza workers to Israel. It also reflected their approval of the Jenin power station, which has already been commissioned and which will be using Israeli natural gas as feedstock. More recently, a major sea water desalination plant in Gaza, was also approved by COGAT. This critical mass of development projects, all approved or launched within the last year, indicate a major shift in Israel's approach to Gaza's and West Bank development and provides a platform for further development projects outlined in this study, particularly in solar energy. However, this new developmental vision for Gaza contrasted sharply with the daily Israeli restrictions on movement of trade and people which has impoverished the Strip; particularly with respect to movement of people and fishing limits which were periodically reduced to 3 miles and raised to 9 miles instead of 20 miles allowed

[9] PCBS, *Quarterly National Accounts*, at constant prices.
[10] Yoav (Poli) Mordechai, Michael Milsteina and Yotam Amitay, *The Next Gaza: The Gaza Strip between a Dead End and a Glimmer of Hope*, Institute for National Security Studies (October 2017), p. 17.

under Oslo. Unless this contradiction is resolved, the Gaza economy and social fabric, with rates of unemployment of 54% and poverty of 53%, are certain to collapse.

b) Border crossing with Egypt and Gaza governance

The imposition of a blockade on most imports in 2007 by Israel, prompted a tunnel trade with Egypt which reached a peak in 2013 under President Morsi. It also became a major source of tax income for Hamas. With the closure of the tunnel trade under President Sissi, in the fall of 2013, Gaza's trade became once again entirely dependent on Israeli policies. The Rafah border crossing with Egypt which was open to people and provided a critical outlet for students, family reunions and business travel, has been mostly closed, except for humanitarian cases, adding a second blockade to the dire economic and humanitarian situation in Gaza. Egypt supplied Gaza with some electricity, averaging 7 MW per month in 2017, well below the potential of about 24 MW, due to flare ups of clashes in Sinai and technical breakdowns. Maintenance of the line between El Arish and Gaza became quite difficult and since April 2018, electricity supply from Egypt to Gaza has been mostly shut down.

Nevertheless, Egypt's political role has been critical in trying to bridge the gap between Hamas and the PA on Gaza governance. The Cairo Agreement of October 12, 2017 established a framework for a joint governance of the Strip. It has been only partially implemented: Hamas transferred its border crossing authority to the PA, thereby foregoing any tax income it collected earlier on some categories of imports from Israel. PA administration has also shared in the administration of some ministries and agencies—the Gaza Electricity Distribution Company (GEDCO) and the Palestinian Water Authority, a critical step in bringing about management reforms and project implementation. In January 2018, the PA has also reinstated electricity supply from IEC to its previous 120 MW level[11] and has continued to pay for it. GEDCO shifted its fuel purchases to Egypt which is cheaper (NIS 2.5 per liter instead of NIS 3 from Israel (net of taxes) but did not have the resources to support a 70 MW electricity generation by the GPP on a consistent basis, falling back on the operation of only one turbine

[11] The PA had imposed sanctions on Gaza in June 2017 for failing to move forward on the reconciliation, including asking IEC to reduce electricity exports to Gaza from 120 MW to 70 MW.

producing 25 MW. By October 2018, Gaza was only getting 120 MW from Israel, paid for by the PA and 25 MW from the GPP paid for by GEDCO, about 5-6 hours of electricity per day.

Financing from Qatar ($ 60 million) in October 2018 to provide sufficient diesel fuel for the GPP to operate three turbines, has raised electricity output to 70-80 MW a level expected to be maintained for the next six months (till April 2019)[12]. This raised electricity availability to 12-15 hours per day has improved humanitarian conditions substantially, reducing spending on fuel for generators and raising household spending as well as delivery of water and sanitation services[13]. As a result, all facets of daily life and economic activity have improved[14]. This major uplifting in Gaza's living conditions opens a window of opportunity to phase in the GEDCO reforms outlined below and kick in Trust Fund financing to ensure that there is no interruption in the supply of diesel fuel and that it becomes consistent and predictable over the next two years.

Overall, the process of reconciliation sponsored by Egypt has stalled, with several outstanding issues left unresolved: payment of salaries by the PA to 23,000 Hamas civil servants and 3,000 security personnel[15]; establishing a joint police force of 4,000; restoring full PA personel salaries which were reduced to 50% in 2017, reinstating the PA secular judiciary system and returning PA land and property confiscated by Hamas. Most of these issues could be solved by mobilizing resources from donors to consolidate the two administrations, with early retirement for some of the redundant personel and one off payments for others[16]. Pending such an agreement, the two administrations continue to work together in education, health and other government agencies particularly in Electricity and Water. GEDCO, whose Board has a strong Hamas representation, has been working closely with PENRA in Ramallah. Similarly Gaza's water authorities (CMWU) have been working closely with Ramallah's Water Authority. The launching of a major desalination plant in southern Gaza (55 MCM) by the head of the Palestinian Water Authority, CMWU and the EU , which spearheaded the financing (Euros 456

[12] This achievement has been the result of efforts by the UN Special Coordinator Nicholay Mladenov and his staff at UNSCO.
[13] OCHA, *Monthly Humanitarian Bulletin* (December 14, 2018), p.3.
[14] Qatar also financed $ 90 million in wage arrears, $ 30 million of which had been disbursed by mid January 2019, raising purchasing power and economic activity.
[15] Hired by the Hamas dominated Palestinian government before June 2007.
[16] Arie Arnon and Saeb Bamya editors Aix Group ,*Improving the Gaza Economy and Utilizing the Economic Potential of the Jordan Valley,* (January 2017) Pp. 39-43.

million) could not have been done without the active participation of the DFG. Pragmatism and the need to deliver essential services have prevailed over party differences and ideology.

2. The electricity crisis: infrastructure and institutional breakdown

The causes of the electricity crisis can be summarized in three interrelated factors: failure to expand sources of energy; failure to maintain and upgrade the electricity grid; and failure in governance in Gaza by both the PA and the DFG.

a) Failure in expanding sources of energy

Since 1948 there has been very little capital investment in Gaza's infrastructure[17]. Neither Egypt which, administerd Gaza betwee 1948 and 1967, nor Israel which occupied it since 1967 invested any significant amount in Gaza's electricity. If anything, Israel's investment in Gaza infrastructure has been negative considering the bombing of the Gaza electricity power plant in both 2006 and 2014 and the destruction of the Gaza airport in 2002. Until 2004, most of the electricity consumed in Gaza was imported from Israel . The Israeli electrical grid provided 120 MW to Gaza through 10 medium voltage stations of 12kv. This, coupled with the original electricity network fed from the Egyptian grid, established a balance between supply and demand. However, little attention was given to the growth of demand for electricity in Gaza, now estimated at 450 MW, as a result of high population growth and expansion of housing. Substancial growth of income between 1967 and 2005 also contributed to the surge in demand[18].

A major opportunity for expanding supply arose in 1999 when British Petroleum discovered a 1.2 trillion cubic feet offshore gas field, 20 miles from the Gaza coast, labeled Gaza Marine[19]. Development of the Gaza Marine field would have required Israeli cooperation, which,

[17] Sara Roy, The Gaza Strip: The Political Economy of De-development (3rd ed., 2016).

[18] Three factors contributed to the rise in incomes after 1967: a) Allowing Gaza workers to work in Israel, albeit with declining numbers. b) establishing trade relations with Israel and the West Bank. c) a surge of investments following the Oslo agreements in 1993 and in anticipation of a Final Status agreement by 2000.

[19] British Petroleum was acquired by British Gas, and subsequently by Shell Oil which recently divested its share of the license (55 %) to the Palestinian Investment Fund. See PIF Press Release - *New Arrangements for Gaza Marine Development License* (April 2018), http://www.pif.ps/en/article/166/Press-Release---New-Arrangements-for-Gaza-Marine-Development-License

following the second Intifada 2001-04, was problematic. Also, because the West Bank and Gaza market is too small to justify investment in the field development, It would have required an additional credit worthy off-taker, in a difficult geo-political environment where major gas fields were also discovered off shore from Israel. While the second Intifada, which erupted in 2001, chilled PA-Israel relations, by 2004 and 2005 a major effort by the PA and the donor community to develop Gaza Marine could have been launched. It would have covered the energy needs of Gaza and the West Bank for 25 years and contributed substantial exports to Jordan. Instead, the issue was neglected and is only being revived in 2018[20].

While this opportunity could not be exploited at the time, it motivated the Palestinian private sector (CCC) to build a power plant in Gaza (GPP) in partnership with the PIF[21]. With a 140 MW capacity it was designed to use diesel fuel as a temporary feedstock, to be eventually replaced by natural gas. As an Independent Power Producer (IPP), it started operating in 2004 under a twenty year power purchase agreement (PPA) with a substantial "take or pay" capacity charge[22]. In parallel to the construction of the GPP, the Gaza electricity grid should have been upgraded by the PA energy authority (PENRA), with high voltage substations and transmission lines. This was not done, partly due to the PA's relative neglect of Gaza's development, and partly due to Israeli restrictions on imports of equipment (cranes, electrical parts, transmission lines) and restrictions on travel of engineers, technicians and workers for training. As a result, the electricity grid deteriorated, preventing the GPP to operate beyond its 70 MW output. By 2006, electricity distributed in Gaza reached about 210 MW (120 MW from IEC, 70 MW from GPP and 20 MW from Egypt's Canal Company) somewhat short of demand but without causing a crisis.

However, between 2006 and 2018, electricity supply remained stagnant at that level, while population increased by 40% and demand rose to 450-500 MW. This marked the beginning of the electricity crisis with rising suppressed demand, estimated at 250 MW. This imbalance between supply and demand resulted in rationing electricity supply to 4-5 hours per day by rotating supply to various neighborhoods. This had negative repercussions on all sectors of

[20] The PIF is soliciting bids from international oil drilling companies to acquire drilling and gas development rights.

[21] Gaza Electricity Company owned by CCC (67%) and PIF (33%).

[22] Averaging $ 2.5 million per month regardless of the electricity output and recently (2016) reduced to $ 2.1 million.

the economy: water supply and sanitation, health and education, irrigation in agriculture and manufacturing

The cost of electricity by using diesel fuel imported from Israel to the GPP (NIS 1.05 per kw/h, including capacity charge but net of taxes) is almost three times higher than the cost of buying electricity from Israel (NIS 0.37 per kw/h) or the cost of using natural gas at the GPP (estimated at NIS 0. 30 per kw/h). Converting the GPP to use of natural gas imports from Israel back in 2005 and importing an additional 100 MW of electricity from Israel more efficiently through a 161 kv line would have been the logical and most cost effective way of expanding sources of energy for Gaza. These projects have now been revived and approved by COGAT, (see below section 3).

Solar energy, the only independent sourse of energy which does not rely on imports from Israel, has been also neglected, even though Gaza ranks among the world's best locations for solar systems[23]. Rooftop solar panels, widely used in Israel, could have been used in Gaza to generate 40 MW of electricity[24]. GEDCO rolled out rooftop solar programs, aiming at installing 200 systems but wasn't able to implement more than 10%. Moreover, imports of solar panels and batteries into Gaza were restricted by Israel beginning in 2007, but liberalized beginning in 2016.

Over the last decade Gaza benefited from three medium voltage lines from El Arish power plant in Egypt at an average price of NIS 0.27 per kw/h, entirely paid by the Arab League . However this supply has been unreliable, partly because of violent episodes in Sinai, and partly due to deterioration and lack of maintenance of the grid. Although electricity imports from Egypt would periodically reach 24 MW, (April 2018), monthly average imports from Egypt in 2017 were 7 MW , due to breakdowns and interruptions. Despite proposals by the Islamic Development Bank to finance 22 kv feeders from Egypt to Gaza, which would have increased the import capacity to 60 MW, the project was put on hold[25], due to security considerations. Since April 2018, no electricity has been imported from Egypt. Nevertheless, Egypt is expected

[23] 3000 sunshine hours per year and Global Horizontal Irradiance (GHI) over 2,000 kw/h per squared meter. See *World Bank, Securing Energy for Development in the West Bank and Gaza* (June 2017), p. 68.
[24]PENRA identified a solar energy capacity in Gaza of 163 MW, mostly through rooftop panels. See *World Bank, Securing Energy for Development in the West Bank and Gaza* (June 2017), p.70.

[25] *World Bank, Securing Energy for Development in the West Bank and Gaza* (June 2017), p. 64.

to have a surplus of electricity by 2021, and with the right focus, it could readily export to Gaza 600 MW[26].

b) Failure to maintain and upgrade the Gaza electricity grid

In 1995-97, during the beginning of PA rule in Gaza there was a rehabilitation program for the transmission network, spearheaded by the Energy Authority mostly to improve the distribution of electricity through low and medium voltage lines and to improve distribution efficiency.

As mentioned in section 2a, GPP, with four turbines, was designed to produce 140 MW. However, even when fuel was available, it was never able to produce more than 90 MW (fleetingly in May 2006), and its typical output was about 60-70 MW. The main reason for this shortfall was that the surrounding electricity grid could not absorb higher outputs. Depreciated and inefficient feeders, lack of maintenance of transmission lines, coupled with inadequate load breakers resulted in frequent interruptions and poor voltage regulation. Even before the Israeli import restrictions, a decade of PA governance in Gaza did not produce sufficient maintenance or upgrading of the transmission lines, substations and feeders to support the GPP in reaching full capacity output. In particular, upgrading output to 90 MW would have required building a sub-station in southern Gaza and reconstructing the storage tanks destroyed in the 2014 Israeli bombing.

c) Failure in governance: institutional breakdown

The institutional foundations of electricity generation in Gaza is the Palestine Electricity Company (PEC) which owns the GPP, and GEDCO which imports and distributes electricity in Gaza. PEC has a twenty year contract (2004-24) with the PA with the sole focus of generating electricity by the GPP when diesel fuel is available[27]. GPP receives fuel bought from Israeli suppliers by Petroleum Authority in Ramallah, and generates electricity, which is then distributed by GEDCO. Its main source of revenue is the monthly capacity charge (take or pay)

[26] The 2014 Cairo Agreement promised to expand Egyptian electricity supply to 600 MW.
[27] 67% of PEC is owned by the CCC and the PIF, while 33% is owned by the public, with shares of the company traded on the Palestinian Stock Exchange. Its market capitalization is about $80 million.

of $ 2.5 million per month[28], which it receives from GEDCO or the PA regardless of the electricity generation level. With little risk attached to its operations, PEC has been able to distribute 10% dividends every year.

GEDCO, on the other hand, is a major player in Gaza, managing electricity supply, distribution, bill collection and maintenance of the electrical transmission grid. It is entirely owned by the PA and is considered as the Gaza arm of the Palestinian Energy Authority (PENRA). It has 10 board members, five representing PENRA and other PA agencies and five made up of municipalities representatives. It is chaired by a PENRA's deputy minister who is also GEDCO's CEO. Since 2007 municipal representative were mostly appointed by Hamas which tipped the governance balance towards meeting municipal needs rather than covering expenses and maximizing profits. Bill collection rates have declined from 80% in 2005 to about 50% in 2008-17, and 32% in 2018. This deterioration in electricity bill collection was partly due to the Israeli siege and the sharp decline in households income. Also, when electricity availability declines to 4 hours per day, custmers become reluctant to pay their bills. Diversion of revenue to municipalities and other parties, and inability to prioritize purchases of fuel for the GPP has resulted in a deterioration of GEDCO's financial status (see below).

GEDCO was responsible for providing fuel for the GPP while the PA Petroleum Authority was responsible for fuel payments. In 2004 and 2005 the PA was paying for the fuel needed for producing 70 MW. In 2006 the PA requested that the European Union take over payments for fuel as part of its budgetary support to the PA. This mechanism worked smoothly until 2009, when the PA, under financial stress, requested that the EU allocate the funds used to buy fuel for the GPP, to PA budget support. In return, the PA committed to pay for the GPP fuel (about NIS 50 million monthly). This was a fateful decision which, over time, reduced the GPP electricity generation. Between 2011 and 2015, average electricity generation was reduced to 45 MW and by 2018 to 25 MW due to the inability to pay for fuel costs, either by the PA or by GEDCO[29].

Since GEDCO was not paying for the 120 MW imported by Israel, the PA felt that it should at least pay for the fuel for the GPP. GEDCO was able to pay for fuel periodically through the PA

[28] Reduced in 2016 to $ 2.1 million.

[29] The PA contribution to purchase fuel for the GPP declined from NIS 50 million per month in November 2009, to NIS 30 million per month in 2010, and eventually, shifting the responsibility to GEDCO in 2015.

Petroleum Authority (about NIS 22-25 million per month) to purchase diesel fuel from Israeli suppliers during 2015-17. At the same time it resisted payments for the excise tax incorporated in the fuel price and amounting, with the VAT, to 106% of the base price. In response, the PA Council of Ministers would periodically exempt these purchases by 60-70% of the tax but the DFG objected to any tax payment.

Occasionally, GEDCO would buy diesel fuel from Egypt, which costs half the Israeli price, (NIS 2.9 from Egypt vs NIS 6.0 from Israel), and in times of financial crises, it would also receive one off grants from Kuwait, Turkey and Qatar to purchase fuel, most recently the $ 60 million grant from Qatar in October 2018 mentioned above. However, this financial assistance from donors was not leveraged with the Gaza authorities to undertake a structural reform of GEDCO's operations towards sustainability of fuel purchases and financial viability. Consequently it only financed temporary bursts of electricity consumption without transformative structural change.

Underlying its financial difficulties in buying fuel, GEDCO has a severe structural deficit, where the cost of the fuel per kw/h of NIS 1.05 is substantially higher than electricity tariffs (NIS 0.5 per kw/h) and the IEC import price for electricity of NIS 0.365. The gap between the cost of providing electricity to Gaza consumers and the low electricity tariff and collection rates has been estimated at 4-5 percent of Gaza GDP for 2013[30]. The higher GPP electricity output, the higher the deficit.

With high technical losses in the distribution network (30%), including illegal diversions of electricity, and low bill collection rates, due to many exemptions and payment arrears, including from refugee camps and public buildings, it is not surprising that GEDCO could not mobilize more than NIS 24 million per month to buy fuel (out of NIS 50 million needed per month to operate at 70 MW).

To make up for the dire electricity shortages, a booming generator industry emerged. It is reported that 47% of businesses in Gaza and 30% of households own generators. Generator operators would collude with local authorities and GEDCO to provide four hours of additional electricicity to blocs of households against payments of NIS 4 per kwh. While electricity produced by generators cost about NIS 2.77 per kw/h, substantially more than electricity from

[30] *World Bank, Securing Energy for Development in the West Bank and Gaza* (June 2017).

Israel or from the GPP, there is an additional cost of pollution--both from diesel fumes and noise. In addition, shortages of electricity resulted in a burst of illegal connections, lowering the payment ratios[31].

While GPP electricity generation has been volatile, imports of electricity from Israel have been both consistent and reliable, providing 120 MW on a sustained basis[32]. It should be emphasized that the main reason for the consistent delivery of electricity from the IEC was the payment guarantee provided to the IEC through the collection of PA tax revenue by the Israeli Treasury from the tax clearance system.

In summary, since the EU stopped financing the purchase of fuel from the GPP in 2009, the fuel supply system broke down forcing the GPP to operate erratically with fuel supplies often running out and the electricity generation coming to a halt. Low electricity bill collections, coupled with revenue and fuel diversions to municipalities and other parties, starkly illustrated lack of GEDCO's control over revenues as well as lack of transparency and accountability. Fundamentally, GEDCO was in need of acomprehensive structural reform to operate on a commercial basis and build up a positive performance and credit record, eventually becoming a bankable offtaker of electricity and gas.

3. Planned projects and impediments

The Palestinian energy authority, PENRA, developed an elaborate five year plan (2018-2023)[33] to repair and upgrade the electricity infrastructure in Gaza. The main elements of this plan were approved by COGAT and benefited from strong support from the donor community.

a) Gas for Gaza (G4G)

Considering that Gaza Marine may take several years to be developped, the PA opted for a transitional solution: Bridge Gas from Israel until Gaza Marine is developped. Israel had a

[31] Since electrical power is delivered to neighboring blocs on alternating schedule, customers hook up illegally to neighboring networks to get electricity when their own network is under blackout.
[32]With the exception of a June-December 2017 when imports from Israel were reduced to 70 MW at the request of the PA to pressure the DFG.
[33] PENRA, Gaza Power Sector (2018-2023). See Office of the Quartet, Report to the Ad Hoc Liaison Committee March 2018, pp. 6-8, http://www.quartetoffice.org/files/OQ_AHLC_March_2018%20Report.pdf

surplus of natural gas readily available for both Gaza and the West Bank without development costs. While Bridge Gas would increase its dependence on Israel, so would other development projects in Palestine, including the Jenin and Hebron power stations which will rely on Israeli gas and gas transportation infrastructure. Economic development and trade would inevitably result in closer economic linkages, and greater cooperation with Israel.

G4G is the most advanced energy project for Gaza and the most realistic, considering that the project would be very profitable, with modest investment ($80 million) and positive feedback on financing from the EIB and EBRD. A Task Force founded in 2015 and chaired by the Office of the Quartet (OQ) including PENRA, COGAT and the Netherlands, focused on piping natural gas from the Israeli gas pipeline transportation network to the GPP. The trajectory of about 40 km pipeline to the Gaza border has been approved and the project cost is estimated at $ 64 million. The pipeline from the Gaza border to the GPP will only be 3.9 km, has been mapped and is ready to to be submitted for construction bids. It may cost about $ 10 million. Simultaneously, and in keeping with the original design, the GPP would be converted to the use of natural gas (instead of diesel fuel) costing about $ 8 million. Since the cost of natural gas is one third of the equivalent diesel fuel, It would recoup its investment within a year by saving over $ 80 million in fuel costs[34]. In a normal economy and without conflict, this project would have been implemented a decade ago when the Tamar gas field came on stream.

Implementation steps:

- PENRA obtains financing for the project mostly from donors and partly from Palestinian banks. It makes a deposit with the Israeli contractor in charge of building the pipeline in Israel.
- PENRA drafts a contract with a Gaza contractor in charge of building the Gaza segment of the pipeline.
- PENRA and CCC agree on a contract to convert the four turbines of the GPP to the use of natural gas. The CCC lease on the GPP expires in 2024. Discussions will be needed to discuss GPP's future and its relationship with CCC.

[34] At a 90 MW output level, fuel costs may be $ 130 million (without taxes) over a year whereas, natural gas would only cost about $ 45 million.

- PENRA, or a new special purpose public entity negotiates with Noble/Delek a gas purchase agreement.

Timeline for project implementation:

- If the project were to be launched towards the end of 2019, it would take 2.5 years, till 2022 to complete. So far, G4G is on schedule.

Impediments to project implementation:

- Payment for gas: A Gas Purchase Agreement will require identifying the buyer— the PA Petroleum Authority-- or a new special purpose public entity linked to the PA. It would also require some payment guarantees which could be initially provided by a combination of donors. The PA, facing a $ 600 million unfinanced budget deficit in 2018, and $ 1 billion deficit in 2019 will not allow its tax receipts to be mortgaged by gas providers, as it has done for Gaza's electricity purchases from IEC. The Jenin power plant and other energy projects in the West Bank would also require guarantees. Some national (eg OPIC) or regional (EIB) financial institutions may provide guarantees.
- Gaza governance: A power purchase agreement, be it for gas or electricity, would require the purchaser of the energy—say a special purpose public entity or the Petroleum Authority-- to ensure that GEDCO is able to perform on a commercial basis with full transparency and accountability. Reforming GEDCO and raising its performance level to regional standards could only be done with active involvement of PENRA in association with local authorities. It is clear that payment modalities (PPA), relations with donors and with Israeli institutions will require a full engagement by PA institutions in Ramallah for these projects to move forward and for the necessary financing to materialize. A broad agreement between the PA and DFG on restructuring the electricity sector would be necessary for this process to succeed even if full fledged reconciliation does not take place.

b) 161 kv line from IEC

IEC could readily supply Gaza with an additional 100 MW. A 161 kv line to provide this energy has been approved by COGAT within the framework of the 2016 Electricity Agreement and awaits a decision by PENRA/PA to move ahead with a PPA. Estimated costs for providing this connection from the Israeli grid to Gaza, building 22kv feeders and upgrading the transmission and distribution lines range around $ 200 million.

Upgrading of the electricity distribution network will be necessary for this project to move ahead and will also serve to evacuate higher capacity utilization by the GPP to 90 MW and eventually to 270 MW with the addition of a new "one block 153 MW capacity" to the existing four turbines at the GPP plant.

Implementation steps:

- Provide a deposit to the contractors on the Israeli side to start construction of the infrastructure necessary to support the 161 kv line.
- Initiate construction for upgrading Gaza's transmission and distribution lines
- Negotiate a long term Power Purchase Agreement (PPA) with IEC.
- Assuming that a PA affiliated special purpose public entity would be the electricity buyer, establish financial guarantees and collateral to secure the PPA.

Timeline for project implementation:

- This project would take 2.5 to 3 years, till 2021-22.

Impediments to project implementation:

- As in the case of G4G, the two major impediments are payments guarantees for the supplier of electricity (IEC) and having a governance structure with a credit worthy buyer and a bill collection mechanism in Gaza to justify the $ 200 million investment. It should be emphasized that negotiating a PPA and providing guarantees may be difficult and time consuming. The PA sovereign risk is high and the cumulation of 3-4 purchase agreements under the same debtor (PA) will make agreements even harder to reah. The West Bank electricity PPA, has been under negotiations with IEC and Israeli authorities for over two years, without a conclusion as of mid-January 2019.

c) Upgrading the Egyptian power supply

Egypt has been supplying Gaza with electricity through three transmission lines from the El Arish power generation hub and the Egyptian Canal Company. While the capacity of the lines is 28 MW, it has hardly produced more than 25 MW and has been plagued by frequent interruptions, voltage drops and technical breakdowns. The monthly average import from Egypt in 2017 was 7 MW. This electricity transmission from Egypt to Gaza has been interrupted since April 2018.

PENRA's view is to repair and upgrade the transmission lines to 50 MW with 66kv connections. This increase in output could be easily accommodated by Egypt. External financing of about $ 50 million would also be available from donors to implement this project, which is expected to take two years for completion.

Impediments to project implementation:

- The two obstacles to implementation are political and security related. There has to be a PENRA leadership for this project and sustainable governance in GEDCO and Gaza, acceptable to the Egyptian authorities, supported by an agreement between the PA and Hamas. In addition security needs to be established on the El Arish/Gaza corridor to bring the electricity lines to their potential output and to upgrade them to 64kv connections.

d) Solar energy

Under PENRA's five year vision for the power sector in Gaza, solar energy potential played a secondary role. The 1st phase of the strategy consisted of installing rooftop solar panels in schools and public buildings, generating 8 MW. A second stage expansion of solar energy to 30 MW would involve building a solar field on PENRA's 200 dunum land in Southern Gaza which would add 22 MW.

None of this has been implemented in a systematic approach and solar energy remains limited to private sector intiatives mostly consisting of rooftop solar panels on its buildings.

e) Energy saving measures

Considering that technical losses amount to at least 20% of the electricity distributed[35], upgrading and repair of low voltage and medium voltage networks, may add another 20 MW of electricity to overall supply. It may be cheaper and easier to raise electricity supply by efficiency measures, --good maintenance-- than by launching new projects to generate more electricity. For instance if all lights in public biuldings were to be switched to LED technology, a 20 % saving in the demand for electricity by these entities could be achieved[36]. PENRA's vision included potential efficiency savings estimated at 6 % per year, but this efficiency program is yet to be implemented.

f) In summary, PENRA's short term vision (within one year) would:

- Raise electricity generation from the GPP from 25 MW (October 2018) to the usual 70 MW with two turbines and moving to 90 MW with a third turbine, continuing to operate with diesel fuel, but with a reconstruction of storage tanks to insure uninterrupted supply of fuel.
- Upgrading the Egyptian supply from 7 MW average output in 2017 to its current potential capacity of 25 MW. Adding another 25 MW through a second transmission line would require major infrastructure work, which could not be executed in the short term.
- 8 MW in rooftop solar energy.

This scenario has two problems: i) unless GEDCO and its governance are restructured and there is a reliable financing mechanism to ensure a predictable and sustainable supply of fuel, increasing output to 70 MW, let alone 90 MW is not realistic. ii) Expecting Egypt to start delivering 24 MW on a consistent basis, let alone doubling the output to 50 MW is also unrealistic under existing political conditions. It may require a comprehensive reconciliation agreement between Hamas and the PA under Egyptian sponsorship to establish firm grounds for this electricity export. Moreover, it would require a maintenance and repair plan for the electricity lines on the El Arish/Gaza corridor with all the necessary security. At this point none of these two conditions are in the process of being met.

[35] Actual losses are about 30 % but at least one third of these are diversions of current from transmission lines to private households or entities.
[36] US Department of Energy, Solid State Lighting (June 2016), p.28.

4. Immediate measures needed to alleviate the electricity crisis

The projects submitted by PENRA and the Quartet office have focused on "bricks and mortar" approach to construct pipelines, transmission lines, substations and other heavy electrical installations. They are all cost effective and worthy projects that should be implemented but may take two to four years to be completed.

More fundamentally, these projects need institutional building blocks to make them work: a functional and performance driven electricity distribution company, an effective electricity bill collection mechanism, and an enforcement system to protect revenue and prevent illegal connections. It would also require a maintenance plan for transmission lines, substations and converters, financial transparency and accountability to instill confidence among donors and banks and develop credit worthy institutions which can back up Power Purchase Agreements for electricity, fuel and natural gas imports.. Without a well performing institutional framework payment issues will arise, fuel supply will be interrupted, cost recovery will lag, and we would slide back into a dysfunctional status quo.

This is our starting point: how to develop an institutional base which can attract financing and support a doubling of electricity output from 145 MW to about 290 MW within one year.

a) GEDCO reform

GEDCO is the key electricity institution in Gaza. In October 2018, it imported 120 MW from IEC, paid by the PA, and obtained 25 MW from GPP (one fourth of its potential) by buying diesel fuel from Egypt from its bill collection revenue.

As mentioned in section 2, even though GEDCO is listed as a "Private Limited Company", it is owned by the PA with strong municipal councils representation and has been operating as a state owned electricity distribution company. Its Board is dominated by local municipalities whose members are mostly affiliated with Hamas and whose political objectives may supersede financial ones. In 2005 it had about 500 employees but by 2018 employment has exceeded 1000, even though electricity output has been stagnant over the last 13 years.

Of the electricity distributed (145 MW) in Gaza by GEDCO, it is reported that 30% of it is lost partly due to technical problems and partly diverted through illegal connections. Of the 70% which do reach consumers, most public buildings, hospitals, mosques, refugee camps have not been paying their bills. What is needed is a financial audit, with a full statement of payment exemptions, payment arrears, debts, and payment enforcement through electricity cut offs and court proceedings.

Gaza had developed a culture of paying their bills although, over the last few years, this culture has regressed. Under the Israeli Civil Administration since 1967 bill payment became prevalent to virtually all electricity consumers and an enforcement mechanism was put in place. When economic activity was normal, as in 2005, bill collection was around 80%.. Since then, with the Israeli blockade and falling income, this institutional base has deteriorated and bill collection has declined to 32%. There are many reasons for this: i) when electricity availability declines to 4-6 hours a day, customers become resentful and stop paying their bills; ii) when neighbors hook up illegaly to electricity lines, it gives the customer incentives to do the same and not to pay his bills; iii) when a refugee camp is known to be informally exempted from payment, workshops move into it and operate without payment. This has happened in the West Bank.

A comprehensive restructuring of GEDCO would need to be fully supported by PENRA, management and staff, as well as personel involved in grid maintenance and enforcement of bill payments. Such a widespread reform would only be acceptable if clear and predictable objectives are stated in terms of fuel purchases, electricity output and other performance criteria.

As mentioned earlier, PENRA and GEDCO have been working closely with the DFG and we expect that this cooperation would be enhanced throughout the reform. GEDCO has been included in the PENRA revenue protection program implemented in the West Bank by electricity distribution companies (DISCOs) but it has not been implemented in Gaza. From the DFG perspective, it would welcome a reform process which would lead to a predictable and sustainable supply of fuel for the GPP, and a much higher electricity output for which they would take credit. It should be emphasized that bill collection, enforcement mechanisms, elimination of illegal connections, can only be fully executed if there is public support by the civil society, the DFG and Hamas.

The main elements of GEDCO governance reform are:

- Conduct a financial audit of GEDCO by an international accounting firm. This is a first and essential step in the reform. In June 2017, the EU was seeking approval from the PA Minister of Finance and Planning to undertake an audit of GEDCO, which it would finance. The Minister has now approved the audit and the World Bank and EU are working together to determine the scope and implementation of the audit.
- GEDCO's Board should be restructured. Businessmen and members of professional organizations should be appointed, with a clear mission of providing reliable electricity services and achieving financial sustainability. Board members should be selected on merit grounds and pursue the company's goal of financial viability and sustainability. Hamas affiliated presence in the Board can be reduced to 3-4 seats, representing municipalities but it needs to be fully engaged in the reform. By contrast to the current situation, there should be a separation between the Chair of the Board and the GEDCO CEO.
- Management should also be restructured to focus on raising electricity output, reducing "technical losses", raising the collection rate, and executing a comprehensive maintenance plan. GEDCO's bill collections should be "ring fenced" against any diversions and used for fuel purchases and network maintenance. Personel policy should be clearly adressed with a review of all positions in the company.
- In addition to a detailed annual report, it should issue financial accounts, with a clear accounting of all diesel fuel shipped to the GPP and charges associated with fuel purchases. These reports should be certified by an international accounting firm.

b) Restoring Gaza Power Plant operations to potential capacity

In the short run, there are no alternatives to the GPP to raise electricity availability from 25 MW to 290 MW[37], a consistent supply of diesel fuel for two years would be needed to bridge the time period until natural gas is pumped to the GPP. This would require a financing mechanism for the purchase of diesel fuel to ensure a consistent and reliable source of fuel

[37] Excluding the temporary electricity boost provided by the Qatari fuel purchase of $ 10 million per month, allowing the second and third turbine to operate and boosting electricity output to 70-80 MW

supply, until GEDCO reforms are fully phased in, bill collection is raised and electricity delivery services are upgraded to regional standards. Such a mechanism was established successfully with the EU during 2005-09, but without any reform conditionality. Soon after, when the PA took over the payment mechanism, payment consistency broke down, payments for fuel declined, and eventually stopped altogether.

What we propose in this study, is to call upon donors to support this reform agenda by establishing a Trust Fund to finance diesel fuel purchases for the GPP for up to two years, through a grant of about $ 120 million (net of taxes) for the first year and $ 80 million for the second year, when electricity bill collections are expected to rise.

This financing mechanism would dovetail with the expiration of the Qatari fuel facility in April 2019. It would ensure a consistent and sustainable fuel supply to the GPP until natural gas comes on board in mid 2021. This six-month period must be used for arranging and kick-starting the proposed GEDCO reform and the related trust-fund mechanism.

The Trust Fund would be a revolving fund where all bill collection proceeds would be remitted. It would be chaired by a representative of an international or regional institution, who would also chair an oversight committee to monitor the implementation of the reform program which would improve GEDCO's performance to regional standards[38]. It would be financed by donors until improved performance covers all of its costs, including payment of the 120 MW imported from IEC which would substantially reduce PA "net lending"[39]. A GEDCO reform agenda will accompany this Fund to ensure full transparency and accountability of financial transactions, and delivery of its objectives with respect to electricity output, bill collection, revenue protection and a rigorous grid maintenance program.

During the second year, higher collection rates and transmission efficiency would reduce external financing to $ 80 million and possibly lower, depending on progress in bill collection rates. It should be emphasized that with higher supply of electricity, bill collection will increase more than proportionatly as consumers regain confidence in electricity delivery. A major

[38] Over the past two years Kuwait, Qatar, and Turkey financed the purchase of fuel for the GPP on an ad hoc basis, but because this financing was not conditional on reforms which would lead GEDCO to financial sustainability, the financing of fuel consumption did not have a transformative impact.

[39] Monthly Israel deductions from PA tax revenues to pay for electricity and water exported to Gaza by IEC and Mekorot.

improvement in GEDCO's performance would strengthen Palestinian institutions in obtaining Power Purchase Agreements with Israeli suppliers, be it for gas or electricity through the 161 kv line. It would position GEDCO to become a bankable off taker when the GPP is converted to the use of natural gas. Such upgrading in Gaza's governance would require PA administration involvement, mostly through PENRA, to work with local authorities and carry out the various steps of electricity reform.

The major financial reform provisions are:

- The PA exempts the fuel imported from Israel from the excise tax"BLO" and VAT. This has been achieved with the Qatari fuel which is being imported by a UN agency benefiting from tax exemptions.
- Raising the bill collection rate from 32% to 60% over a two year period[40] by establishing a strict revenue protection program[41] which focuses on the largest sources of revenue and introduces safeguards against any revenue diversion. Installing pre-paid and smart meters (40,000 units over two years), in line with PENRA's five year plan.
- Raising the electricity current tariff of 50 agoras-- which has not been changed in 11 years—to 55 agoras, as in the West Bank, as a first step. While the PENRA vision of an equilibrium short term tariff is NIS 1.20 per kw/h[42], getting there can only be gradual.
- The poorest households would be exempted from paying the first 160 kw/h per month of their consumption[43]. These households would be identified through existing household surveys and income tests. This subsidy would be paid to GEDCO by the PA and entered in the PA budget as social expenditure.
- Enforcing electricity bill payments to all public schools, mosques, government buildings and refugee camps. A clear statement of who is paying and who is not should be published and a campaign needs to be launched to pressure the non-payers to pay their bills.

[40] in 2005 GEDCO collection rate was 80%.
[41] Such a program has been implemented in the West Bank with World Bank technical assistance.
[42] PENRA vision: Gaza Power Sector (2018-2023) Development Plan January 2018. See *World Bank, Securing Energy for Development in the West Bank and Gaza* (June 2017), p. 19.
[43] The Income test managed by UN agencies is critical to avoid having this subsidy benefitting all consumers. Average consumption in the West Bank and Gaza is 200-300 kw/h per month , World Bank, Securing Energy, p. 39.

- Launch a public campaign to reduce the 30 % electricity losses due to technical malfunction and illegal electricity connections. Since the Qatari oil in Gaza is being perceived as “free”, a campaign needs to be launched when new donor financing occurs that the “free electricity” period has ended and everyone will now have to pay.
- Concurrently with the supply of diesel fuel to GPP under this mechanism, GEDCO will revert all electricity bill collections to the Trust Fund, after deducting monthly management costs (about NIS 4 million and capacity charges paid to PEC (NIS 6 million). Any excess in bill collection revenue over and above the financing of the structural deficit should be transferred to the PA in partial payment for the 120 MW supplied by IEC.

A major relaxation of the Israeli siege and a revival of economic activity would be greatly facilitate achieving these objectives, particularly compliance with electricity bill payments. Not all of these measures need to be taken at the same time. It should be emphasized that as electricity supply increases and reduces the need for generators, and as economic conditions improve, consumers will become more willing to pay their bills. This process will enable phasing in the more difficult measures.

GEDCO’s structural deficit stemming from the difference between the cost of fuel and electricity tariff per kw/h will be covered by the Trust Fund. It may amount to NIS 50 million at the 70 MW generation level and NIS 62 million at the 90 MW level. The higher the output, the larger the losses. However, with the expansion of electricity from solar energy , these losses will decline as a share of the new product mix. Also, the humanitarian and economic need for electricity in Gaza is so vital that the gains in economic activity, tax revenue, and humanitarian relief will far outweigh the financial losses of GEDCO.

To summarize, GEDCO will incur two sources of losses: a) the difference per kw/h between the cost of its GPP electricity generation and the tariff charged to consumers per kw/h and b) the subsidy provided to poor households for the cost of the first 160 KW/h consumed. Some financial reconciliation between GEDCO, the PA and the Trust Fund will have to be attained to finance these losses.

c) Additional measures to support the ramping up of electricity output

- Rebuild the fuel storage tanks of the Gaza Power Plant (GPP) destroyed during the 2014 war. This fuel reserve of 28 days will enable the third and possibly the fourth turbine to operate on a consistent basis and raise generating capacity from 70 MW to 90-110 MW. Ttransmission lines and feeders would need to be upgraded to evacuate the additional energy. Rebuilding the tanks will take 3 months and cost about $ 2.5 million.
- Undertake an immediate rehabilitation and maintenance program for transmission lines, sub-stations, and low and medium voltage networks. Install 150 automated load breakers, as in PENRA's plan. This will increase network efficiency, reduce outages and bring down the high technical losses to standard levels.

5. Exploiting solar energy in Gaza

Though solar energy has been considered as part of PENRA's vision for the power sector in Gaza, and several small-scale projects are in process, solar energy plays a secondary role in present plans for the electricity sector in Gaza.

The study proposes a new strategy of exploiting the solar energy potential in Gaza as a major part of the proposed fast track program for the electricity sector . This will diversify Gaza's energy sources, reduce its reliance on Israel and provide competitively priced electricity (about 100 MW) as is being done in Jenin, Tubas and Jericho and as was done on a larger scale in Jordan. This new strategy would complement the natural gas track, albeit with a shorter timeline.

a) New-generation solar PV solutions

New-generation solar-energy solutions are based on: (a) advanced Solar PV panels that produce double the electrical power per m^2 of panel-area than just a few years ago; and (b) new, advanced, cost-effective electricity storage technologies that stores electricity produced by the solar panels in day-time for use at night-time.

The much higher production capacity per m^2 of the new PV panels is translated into reduced land area that is required for solar power plants. These advanced panels require only about 10,000 m^2 per MW (= 10 dunoms, or 1 Hectare, compared to about 20 dunoms a few years ago).

These new-generation solar-energy systems can supply electricity at competitive costs. The proposed technologies enable diversified, scalable solutions that can be installed relatively fast (up to 12 months).

b) Smart storage solutions for continuous supply of electricity

In certain cases, these solutions are designed as hybrid systems that combine also facilities that produce electricity at nights, from gas/diesel backup generators, in addition to storage batteries.

Such systems are monitored by a smart control module that is continuously and automatically optimizing energy generation. Namely direct use of solar energy from the panels in high-radiation day-time; automatic switch to discharging power from the storage batteries in low-radiation and night times, and activation of backup gas/diesel generators when needed. That way, these smart systems can supply electricity 24/7 at competitive cost of around $0.10-$0.12 for small/medium size systems, and below $0.10 for utility-scale systems – as detailed below.

Such solutions are already applied, with great success, in Jordan and other countries facing similar challenges – either as grid-connected installations, or stand-alone solar power stations.[44]

c) Technical notes on sun radiation, storage and optimization of energy production

Even in high-radiation area, such as Gaza, there are only 6-8 hours of high sun radiation per day. These hours need to be used for generating energy both for direct use and for charging the storage batteries (for supplying electricity in low-radiation and night-time).

[44] See for example http://www.solarpower.co.il/; https://www.lti-reenergy.com/renewable-energies/photovoltaic/local-turnkey-solutions; http://www.bren-energy.com/technology/; http://vipenergyltd.com/; http://www.eliopig.it/en/products/biogas-plants

Given that, in conjunction with other technical aspects, systems designed for 24/7 supply of electricity usually requires solar panels that produce during the high-radiation hours up to 2 additional MWs per hour (MWh) of electricity for storage, per each MWh produced for direct use. Hence, a system designed for 24/7 supply of 10MW per hour, for example, may require solar panels with production capacity of 30MW (30 MWp capacity).

Considering lower electricity demand at night-time, there are ways to reduce required electricity production for storage. That can be achieved through smart use of backup gas/diesel backup generators at night-time; or in cases where the solar PV system is connected to the electricity grid.

d) Experience in other parts of the Middle East

The strategy proposed for Gaza is based, , on the experience gained in Jordan and the UAE. The renewable energy program in Jordan started with a first round of projects based on highly attractive feed-in tariff. Then they moved to new rounds of "competitive-price-based" projects where bidding companies compete on the lowest price that the Jordanian electricity company will pay for electricity supplied from the solar power plant (under long term PPA). As a result, Jordan is moving ahead with an impressive set of projects that supply the Jordanian electricity company with electricity at most competitive prices - around $6 cent/kwh since 2016; which is roughly half the cost of electricity production by the "old" conventional power plants.[45]

The Jordanian strategy is to develop medium-size PV units (mostly 40 – 60 MW units), which are built in several "solar power production centers" (in Maan, Mafraq and a few other locations). These new centers are planned to develop gradually into 200 – 500 MW "solar power production centers", each.

e) Highlights of the proposed solar energy plan for Gaza

[45] The BOO (20 years) PPA contract for the Mafraq PV IPP 60 MW Project (due for operation 2018) set a tariff of 6.13 USD cents/kWh. The PPA contract for the 61 MW Risha PV IPP project (due for operation by the end of 2018) set a tariff of 5.92 USD cents/kWh (sources: MENASOL Renewable Energy in MENA Project Map Infographic 2016, http://www.iecoafrica.com/files/uploads/files/Renewable%20Energy%20in%20MENA%20Project%20Map%20Infographic%20.pdf ; and MENASOL MENA Solar Market Outlook for 2017, https://www.apricum-group.com/wp-content/uploads/2016/12/MENA-Solar-Outlook-2017.pdf).

The solar energy plan that this study proposes for Gaza includes the following elements:

Three utility-scale PV plants in locations where vacant land tracts are available:[46]

- A larger solar PV plant facility with production capacity of 75 MW (75 MWp) on 750 dunoms, in a large tract of land on the south, west of Rafah.
- A smaller solar plant with production capacity of 30 MW (30 MWp) on 300 dunoms, in a relatively vacant strip of land near the northern border of Gaza, west of the Salah A-Deen Road.
- Another 22MWp solar plant of 200 dunoms owned by PENRA near Rafah.

These plants can be installed and operated by experienced solar companies within 12 months from financial closure.

The location, technical and financial aspects of these projects are detailed in Annex A. To the extent that some of these units may be close to Gaza's border with Israel, they would need detailed coordination with Israeli security authorities. They would also need to be coordinated with the upgrading of the relevant electricity distribution lines to evacuate the additional energy.

A set of small-medium special-purpose solar systems (up to 10 MWp each):

These solar systems will be installed beside key electricity-consuming sites in Gaza, and provide diversified fast-track reliable solutions for desalination plants, wastewater treatment plants, etc.

Several such projects are already in the pipe-line in Gaza, including special purpose PV plants for the existing Sheikh Ajleen WWTP in Gaza and the new Gaza Buriej Central WWTP (financed by Germany's KfW). We propose an extended network of such small-medium special-purpose solar systems, which will cover most of the key electricity-consuming sites in Gaza.

The proposed short-term plan is to choose three such key sites, where the need for reliable 24/7 supply of electricity is most urgent:

[46] see Map 1 in Annex A

- Solar PV plant for the NGEST project (The Emergency Sewage Treatment Project on the site of Northern Gaza WWTP in Beit Lahia), including its planned expansion.
- Expanded solar PV plant for the UNICEF Southern Gaza Desalination Plant in Khan Younis, including its planned expansion.
- Solar PV plant for the Khan Younis WWTP (in construction, estimated completion early 2020).

These facilities can be installed and operated by experienced solar energy companies, in about 12 months from agreement and financial closure. The technical and financial aspects of these projects are detailed in Annex A.

Roof-top and on-land (where feasible) micro solar systems (3kW to 250kW):

- A set of critical hospital/health-care sites (can be installed in a few months).
- A selected set of projects to power drinking water purification and agricultural uses (pumping, water treatment at farm level, etc.) and other local uses (can be installed in a few months).
- Comprehensive roof-top solar PV programs - for public buildings (schools, municipalities, etc.) and for residential buildings.
- Initial steps have alrady started in Gaza in that direction. One example is a tender for 5 micro systems (around 25 KWp each) under a KfW funded school construction programme. However, the scope of these steps is too small in comparison to the potential and needs. The programs proposed in this study aim at large-scale explotation of this potential (as detailed in Annex A).

Summary Table: Proposed Fast Track Solar Energy Solutions[47]

[47] Notes: (a) the projects are based on proposals submitted to the authors by experienced solar energy companies; or similar projects in Jordan, the UAE and Israel; (b) the technical and political feasibility of these projects has been discussed and checked with relevant Palestinian, Israeli and donor parties.

Category/plant	Total generation capacity (MWp)	Expected supply during day-time (MW per hour)	Total land area (dunoms)	Notes
Utility-scale plants				
Rafah-West Solar Plant	75	25-35	750	Incl. storage, 16 hour supply
Rafah – PENRA compound	22	22	200	No storage, day-time supply only
Northern solar plant	30	30	300	No storage, day-time supply only
Small-medium-scale special purpose plants				
NGEST project solar plant	10	3-5	100	Incl. storage, 24/7 supply
UNICEF Desalination (Khan Younis) solar plant	10	3-5	100	Incl. storage, 24/7 supply
Khan Younis WWTP solar plant	10	3-5	100	Incl. storage, 24/7 supply
Micro roof-top & on-land solar installations				
Critical healthcare facilities in 8 hospitals, total	3	1	Mainly roof-top	Incl. storage, 24/7 supply
Drinking water purification & agricultural uses – selected sites, total	1	0.3-0.5	10	Incl. storage, 24/7 supply
Schools and other public buildings – target for first year, total	4	4	roof-top	No storage, day-time supply only
Residential houses	10	10	roof-top	No storage, day-time supply only
Grand total in 12 months	**175**	**101-117**	**1,560**	

Annex A: Detailed Fast-Track Solar Energy Program

1. Utility-scale PV plants

We propose three utility-scale PV plants in locations where vacant land tracts are available.

a) The "Rafah-West" utility-scale 75 MWp solar PV plant

The first 75 MWp utility-scale solar PV plant is proposed to be installed on 750 donums west of Rafah, where vacant land is available.

Location and required land area:

It is proposed to designate an area of 750 dunoms for the first 75 MWp facility on part of a vacant land strip, about 1 km wide and 8 km long west of Rafah, near Gaza's eastern border with Israel, north-east of the Kerem Shalom Crossing (Area A1 on Map 1). This location was suggested for a large-scale PV solar field in the Portland Trust's "Global Palestine, Connected Gaza" detailed spatial analysis.[48] We propose following that suggestion.

Operation considerations and the design of the first 75 MW facility:

Given the acute shortage of electricity and the specially weak situation of the electricity transmission network (high-voltage grid) in the Rafah area, the proposed 75 MW facility will be designed as per the following main guidelines:

- Being able to supply electricity to the local Rafah-area grid; no dependence on the Gaza Strip main high-tension grid.
- Steady and reliable supply of 25-35 MW for 16 hours per day (hour/d), from 7am to 11pm.

Gaza is rich with the Sun's energy, enjoying 3,000 sunshine hours per year and 2,000 kwh per m^2.[49] Nevertheless, given radiation patterns (as shown in Charts 5.1 and 5.2 below), steady 16 hour/d supply of 25-35 MW electricity to the local grid of the Rafah area requires:

Design that includes considerable storage capacity, which would enable steady supply of 25-35 MW during day-time hours of weaker or no radiation and in evening hours (25 MW in the winter and 35 MW in the summer.

[48] A Palestinian private Sector Initiative in Cooperation with The Portland Trust, "Global Palestine – Connected Gaza: A Spatial Vision for the Gaza Governorates", April 2016, pp. 132-133

[49] World Bank, "Economic Monitoring Report to the Ad Hoc Liaison Committee", September 2018, p. 68.

Extra production capacity, for charging the storage batteries during strong-radiation hours with enough electricity for the low radiation / no radiation hours (see Charts 5.1 and 5.2).

According to preliminary calculations, steady supply of 25 MW during winter day-and-evening-time (16 hours/d) requires production capacity of 75 MW. Approximately two thirds of the produced electricity during sunny winter days and hours of strong radiation will be stored in advanced, high-capacity batteries for use in clouded/rainy days and hours of weaker or no radiation.

In summer days this production capacity will enable supply of up to 35 MW during day-and-evening-time (16 hours/d).

Chart 1: Indicative Electricity Generation for Supply and Storage, and Discharge from Storage Batteries – A Typical Winter Day (A 75 MWp plant; MW per hour)

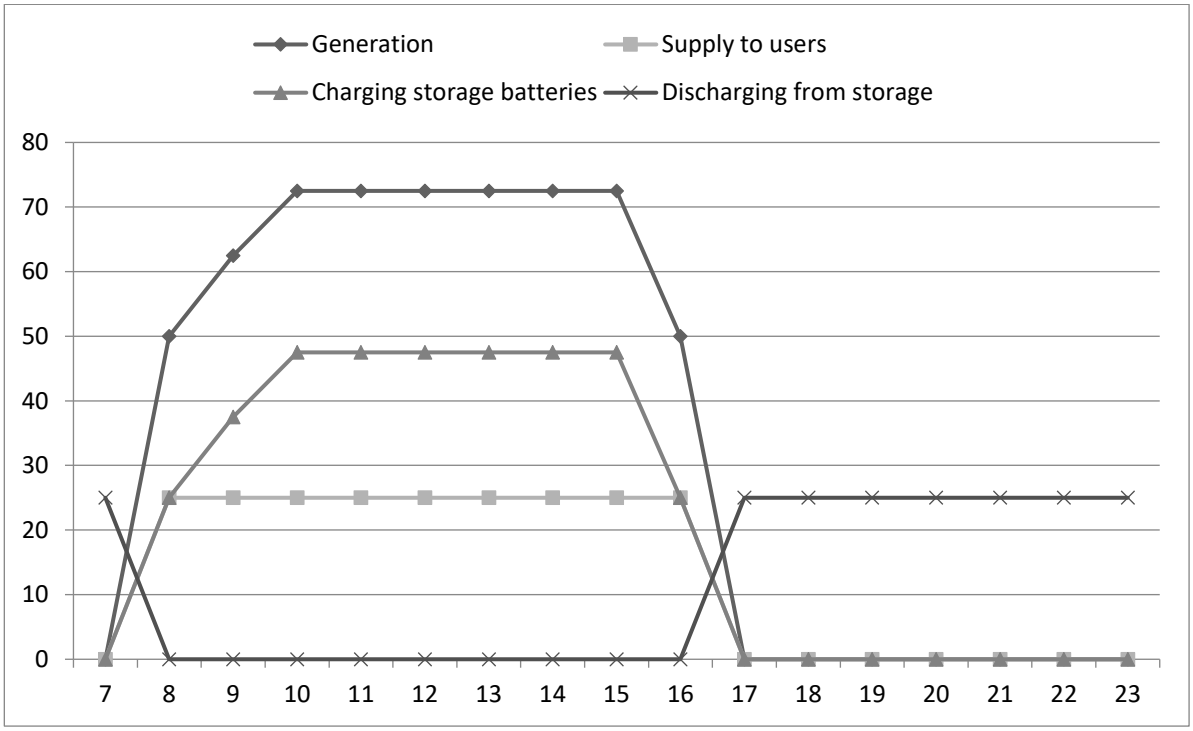
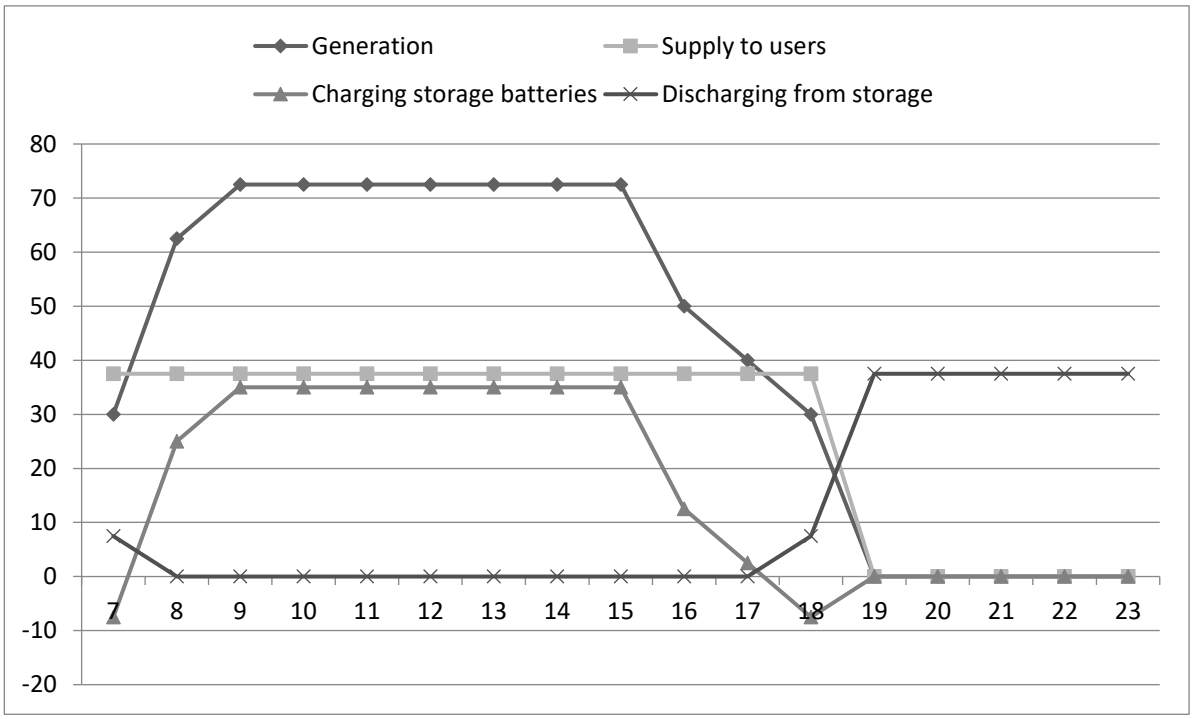


Chart 2: Indicative Electricity Generation for Supply and Storage, and Discharge from Storage Batteries – A Typical Summer Day (A 75 MWp plant; MW per hour)



Source: computed from Solar Company proposal

Financing and risk-mitigation considerations:

The basic element of "standard" BOT/BOO (Build. Own, Operate) arrangements for financing solar-energy projects is usually a long-term Power Purchasing Agreement (PPA) between the electricity producing company (the "Solar Company") and the public-sector entity that purchase the electricity and distribute it to the customers. This public entity needs to be financially capable to take upon itself (independently or with governmental backing) the commitment of purchasing electricity at the agreed-upon volumes and rate, for the long period of the PPA (typically 25 years).

Based on the PPA, the Solar Company closes the financing package of the project (typically, 30% equity and 70% loans from banks and other sources).

Several solar companies have expressed interest in such projects in Gaza under BOT or BOO financial arrangements. However, considering the special security, political, business and financial conditions in Gaza, certain financing and risk-mitigation measures are required:

- GEDCO, as the public-sector entity that distributes electricity in Gaza, must be reformed as per the lines proposed in this study above, in order to qualify (financially and administratively) as a party to the PPA.
- Nevertheless, GEDCO will be needing donor support for the first two years, until it shows sufficiently good results in its collection rates and other performance criteria, as specified above.
- In order to provide GEDCO with the required financial backing, a special financial backing and support mechanism will be set up by the donor community, as detailed below. That mechanism will provide initial and bridging financing, as well as guarantees to the Solar Company and its bankers; against strict commitments of the Special Purpose Entity to meet agreed-upon high bill-collection targets, and administrative arrangements that will ensure that.
- As indicated below, the cost structure of the project enables full return of investments and financing for all parties: the Solar Company and its bankers (including their required profit and interest margins), as well as the donors' initial and bridging financing.

Cost of electricity and the proposed financial model:

As costs of solar cells are on a fast declining trajectory,[50] electricity supply rates of PPAs across the Middle East region are on a similarly fast declining trajectory as well.

Based on preliminary proposals of Israeli and international solar companies for utility-size projects for Gaza, the rate requested for supply of electricity (including costs of storage, etc.)[51] is up to 0.09$ per KWh.[52]

Using $0.13 per KWh as a benchmark leaves a margin of $0.04 per KWh to serve the required "risk premium" of the mitigation mechanism proposed above, as well as relatively fast return of donors' support to the proposed revolving fund.

Capital investment in utility-size PV solar projects is also on a declining trajectory. In the preliminary proposals for a 150 MWp plant mentioned above, overall investment in the PV panels and all related infrastructure and EPC costs are estimated to range between $0.8 million-$0.9 million per MW of production capacity. Namely, around $65 million for the proposed 75 MW facility. The storage batteries and related elements (steam turbine) add some $25-$30 million to the required capital investment.

Donor participation of around 50% in soft loans to the project, in addition to the other risk-mitigating measures detailed above, are expected to reduce risks to a level that would enable the Solar Company to invest its own equity (30%) and raise the remaining 20% form private-sector sources/investors under commercial terms.

b. The Northern Gaza 30 MWp utility-scale plant

[50] Average global Capital Cost (CAPEX) per MW of production capacity in utility-size PV solar plants declined 60% from 2010 to 2016 (World Bank, "Securing Energy for Development in West Bank and Gaza" (June 2017) , p. 69. Solar cell module prices continued to fall in 2017, with average global prices down an estimated 6% for the year, to $0.39 million per MW (Renewable Energy Policy network for the 21st Century, "Renewables 2018: Global Status Report" (2018), p. 96). Falling CAPEX has been reflected in the rate charged per KWh of electricity supplied by utility-size solar PV facilities. The US average rate of installed utility-scale solar PV fell in 2017 below $0.06 per KWh; while new 2017 projects resulted in bids at new record lows. In some markets, bidding for projects to begin operations from 2019, were as low as below $ 0.03 per KWh (Renewables 2018 report, ibid).

[51] In addition to the direct cost of storage batteries, these additional costs include steam turbine and other costs related to the reduced efficiency of electricity generation from stored solar energy through the steam turbine (40% turbine efficiency).

[52] Electricity supply rates under recent PPAs between the Jordanian Electricity Distribution Company (JEDCO) and Solar Companies, for even smaller utility-size facilities, are around $0.06, not including storage and related costs (World Bank, Securing Energy (June 2017), p. 68). See also reference to specific projects in the introduction to this chapter above).

The Northern Gaza Solar PV utility-scale plant is proposed to be built on a designated area of 300 dunoms within the relatively vacant area on the northern-western corner of the Gaza Strip – between the "No-Go" border area (300 meter strip just south of the border line) on the north, the Salah Ad-Deen road on the east and the built area of Beit Lahia on the south (Area A2 in Map 1).

The total size of this area (Area A3 on Map 1) is roughly 10,000 donums, of which the proposed solar plant needs 500 dunoms. A preferable plot seems to be immediately west / north-west of the Beit Lahia Waste Water Plant; but the required 300 dunoms can be installed on other plots within this area.

Given the better upkeep of the electricity transmission network (high-voltage grid) in the northern part of the Gaza Strip, the proposed 30 MW first facility will be designed as a grid connected facility, with no storage and related elements.

That will make it less expensive than the first facility proposed for the Rafah-West plant - $36 million according to the $1.2 million per MWp benchmark used by PENRA for budgeting such projects.

The financing and risk-mitigation considerations detailed for the Rafah-West plant apply in this case as well; and similar solutions and financial model are proposed:

The following changes should, however, be taken into consideration:

- The rate requested for supply of electricity by the Solar Company which will be chosen for this project (under BOT/BOO agreement) will be considerably less than the $0.09 rate per KWh of the Rafah-West plant (net of Gaza special political and financing risk costs).
- Using the same $0.13 benchmark would leave a margin of probably around $0.05-$0,06 per KWh to serve the required risk premium of the proposed risk-mitigating mechanism, as well as relatively fast return of donors' support to the proposed revolving fund.

In this case too, donor participation of around 50% in soft loans to the project ($18 million), in addition to the other measures detailed above, are expected to reduce risks to a level that would enable the Solar Company to invest its own equity (30%) and raise the remaining 20% form private-sector sources/investors under commercial terms.

c. A third 22 MWp utility-scale plant in the PENRA compound in Rafah:

This plant is proposed to be designed and financed similarly to the Northern Gaza plant.

Map 1: Indicative Location Map of Proposed Utility-Scale Solar Plants



2. Small and medium special-purpose solar systems

We propose small and medium special-purpose solar systems (1 MWp to 10 MWp each) for key water and other facilities. These solar systems are proposed to be installed beside key electricity-consuming sites in Gaza, as special-purpose plants that provide diversified fast-track reliable solutions for desalination plants, wastewater treatment plants, industrial zones, etc.

Palestinian authorities have marked several such sites, where medium/small solar systems are called for; including about 25 high-priority water and wastewater treatment facilities. Part of these projects have also been included in the list of projects supported by COGAT.[53]

The short-term plan proposed by this study is to choose three key sites, where reliable supply of electricity solutions is needed most urgently.

These solar systems can be installed and operated by experienced solar energy companies, in about 12 months from agreement and financial closure. Where needed, these facilities can be designed as hybrid systems, enabling use of diesel fueled generators as a backup, with sophisticated control and optimization mechanism.

The study proposes attending to the following three critical water desalination and wastewater treatment sites:

- Solar PV plant for the NGEST in Beit Lahia, including its planned expansion (doubling its capacity to 68,000 cubic meters of waste water treatment).[54]
- Expanded solar PV plant for the UNICEF Southern Gaza Desalination Plant in Khan Younis, including its planned expansion from 6,000 cubic meters per day (cum/d) to 12,000 cum/d.
- Solar PV plant for the Khan Yunis WWTP (in construction, estimated completion early 2020).[55]

Each of these sites requires steady supply of significant volume of electricity. It is proposed to design for each of these three sites 10MWp solar plants, which would enable steady 24/7

[53] COGAT, "Ad Hoc Liaison Committee Gaza Projects" (September 2018), p. 4
[54] COGAT, ibid; World Bank, http://documents.worldbank.org/curated/en/757561530291927286/pdf/Disclosable-Version-of-the-ISR-Northern-Gaza-Emergency-Sewage-Treatment-NGEST-Project-P074595-Sequence-No-30.pdf
[55] UNDP, http://www.ps.undp.org/content/papp/en/home/operations/projects/environment_and_energy/KYWWTP.html

supply of around 3 MW of electricity[56] (production to storage batteries in high-radiation hours; discharge form batteries in low/no radiation hours, use of diesel generators as backup; and smart control module for optimal use of all these sources).

100 dunoms of land will be needed beside each of these sites for the 10MWp plants. Being smaller plants, the required investment per MWp (and for the storage batteries and related equipment) is expected to be higher than for the utility-scale plants mentioned above. However, preliminary proposals submitted to us, indicate that overall investment in the PV panels and all related infrastructure and EPC costs will not exceed the $1.2 million per MWp benchmark. Namely, up to $12 million per each 10 MWp plant. The storage batteries and related elements (steam turbines/back-up generators) may add up to 50% to the required capital investment.

The rate requested for supply of electricity on BOT/BOO basis, by Solar Companies, will be somewhat higher than in the case of the utility-scale plants – $0.10-$0.11 per KWh (24/7 supply, including storage and backup generators). Still, the $0.13 benchmark rate would leave a sufficient margin to serve the required risk premium, though the return of donors' soft loans would be considerably slower.

Other financing aspects, however, may compensate for that:

- Since these water desalination and wastewater treatment projects are already financed by donor grants, those donors may agree to extend some grants to the solar plants that power these facilities as well.
- If, for example, such a solar plant receives grants that cover 25% of investment, that may reduce the requested rate by around $0.02 per KWh. Namely, reducing requested rate per KWh to a rate similar to that of the utility-scale plants (for 24/7 supply, including storage and backup costs).

3. Micro roof-top and on-land solar systems (3kW to 250kW)

[56] As some of that capacity may be needed only after the expansion of these facilities, the solar/hybrid plants can be built in two phases.

a) Critical healthcare facilities and other vital public-service facilities; water purification for drinking and agricultural uses

Micro solar systems are proposed to be installed on the roofs or beside several categories of sites that need reliable electricity supply solutions, though their consumption is relatively small: healthcare facilities and other vital public-service facilities; water purification for drinking; and agricultural uses (pumping, water treatment at farm level, etc.).

The short-term plan proposed for this category of electricity consumers is as follows:

- Installation of solar micro-systems in critical healthcare facilities in 8 hospitals, marked by Palestinian authorities and COGAT as high-priority.[57]
- A set of micro-systems that will power local brackish water purification facilities for drinking, solar pumping systems and water reclamation for irrigation.[58]

Suppliers specializing in this category of solar PV systems can supply "ready for installation" units almost immediately; and these systems can be shipped, installed and operated in a few months.

Where needed, these systems too can be designed as hybrid systems, enabling use of diesel fueled generators as a backup, with sophisticated control and optimization mechanism.

A first round of "pilot installations" can be done in 3- 6 months. Then, a second round of more comprehensive program can be launched, covering all sites that need this kind of solution.

These facilities can be designed for day-time operation (without storage), or for 24/7 operation, according to the specific need of the site.

Being diversified and modular, these systems can be designed as sets of stand-alone micro-systems for various departments of a hospital, for wells used for pumping of water for drinking or agriculture (solar pumping and solar water treatment), etc.

Considering the low capital investment of each micro-system (overall cost of $15,000-$20,000 for a 10-15 KW unit), the first round of installations suggested above could be financed by donors (outright purchase).

[57] COGAT, "Ad Hoc Liaison Committee Gaza Projects" (September 2018), p. 6

[58] See COGAT, ibid, P. 10 – suggesting a target of reclaiming 40,000 cubic meters of brackish/polluted water per day for irrigation of 10,000 dunoms of agricultural land.

b) Rooftop solar PV panels on public, commercial and residential buildings

Though the electricity-generation potential of roof-top solar PV panels in Gaza is smaller than in the West Bank, it is still significant, estimated at a total of about 160 MW. Most of it on residential buildings.[59]

That potential was already identified as an important "electricity safety net" for critical public services as well as households; and much cheaper alternative to expensive diesel generators. As of April 2017, UN agencies (OCHA and UNRWA) were supplying emergency fuel support to 186 such critical health, water and sanitation facilities;[60] while significant share of businesses and households have either installed diesel generator or are purchasing electricity form operators of such generators.

Roof-top solutions are much more expensive to install than the alternatives described above. Average investment per KWp of roof-top fsystems was estimated at $2,500-$3,000 in 2016[61], more than double the benchmark investment in on-land larger units ($1,200 per KWp).

Nonetheless, in cases where there is no available land area for on-land micro units, the roof-top solution is by far superior to presently used diesel generators. In these cases, this study proposes solar solutions similar to the micro systems described above, but with roof-top solar panels instead of on-land panels.

According to the World Bank calculations, the total annual fuel bill of vital health, water and sanitation facilities in Gaza is $10 million a year; which have been provided as emergency contributions by various donors. Half of that goes to health facilities (circa $5 million).[62]

That magnitude of emergency fuel bill ($5 million per year) is large enough to equip all critical health facilities with roof-top (or on-land) solar systems in one year (a total of 1 MW for 8 hospitals, as marked by Palestinian authorities and COGAT).[63]

Hence, the following program for health and public schools, water and sanitation facilities is suggested:

[59] World Bank, Securing Energy (June 2017), p. 70.
[60] World Bank, ibid, p. 72.
[61] World Bank, ibid, pp. 69, 108
[62] Ibid, p. 72.
[63] COGAT, ibid, P. 6.

- Establishment of $20 million fund, which will finance a program of roof-top solar (or on-land micro systems where land is available) for health facilities, and a selection of most vital water and sanitation facilities.
- Contract Solar Companies for the execution of these projects, under PPAs, and financing and risk-mitigation terms, as suggested above for the on-land small/medium systems.
- Under these contracts, the contracted Solar Companies can complete the said comprehensive program in 12-18 months.

In parallel, another fund can be established for installation of roof-top solar PV systems on residential houses, using aggressively subsidized program of grants long-term soft loans and tax rebates on imports of solar panels.

- That program can be executed through local installers, who will also be responsible for re-payment of the soft loans (with back-to-back arrangements with homeowners, directly or through banks).
- From the perspective of the homeowners, the program will provide "electricity safety net" while significantly saving on their payments to operators of diesel generators from whom they purchase electricity at present.