Renewable Energy Applications in Palestine

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I. Introduction

The Palestinian territories are facing critical situation concerning the achievement of sustainable development. Several problems have contributed to the continuous deterioration of the political, economic, social and environmental conditions and hindered development initiatives. The lack of a Palestinian infrastructure for close to four decades has impeded any realistic progress on the energy front. Scarcity of conventional energy resources and the limited renewable resources has created unrealistic price control, energy shortage and future energy crisis. The national and comprehensive energy policy is still not clear due to the continuous Israeli occupation, weak and fragmented institutional framework and the incomplete framework of the Palestinian State. Renewable energy market is strongly affected by the political stability in the region, economic situation of the people, rising demand on energy and availability of the indigenous resources. The environment of political risk and uncertainty has inhibited investors from making large scale energy or industrial investments. In spite of all these challenges, Palestine has gone forward to utilize its natural resources for rehabilitation and construction.

II. Energy Situation

A. Primary Energy Resources

Due to the absence of fossil fuel resources, Palestine has to import all its needs (100%) of petroleum products from Israeli market and about 92% of electrical energy from the Israeli Electric Corporation, a total energy bill of more than 385 M€ per year.

Indigenous energy resources are quite limited to solar energy for photovoltaic and thermal applications (mainly for water heating), and biomass (wood and agricultural waste) for cooking and heating in rural areas. Potential of wind energy is relatively small but not yet utilized in Palestine. Biogas also not yet utilized whereas its production is estimated at 33 million cubic meters, equivalent to 10 M€. Recent exploration of natural gas in Gaza gives hopes and new opportunities for gas industry in Palestine. The initial investment to develop this industry is evaluated to 310 M€ which necessitates marketing of 1.5 billion m3. The local demand is estimated to 1.1 billion m3 per year. Oil shale is available in substantial quantities (1200 MT), but a project in this area tends to be much more costly than other renewable energy sources and not politically feasible, at least at the moment [1].

B. Energy Supply

The Total Primary Energy Supply (TPES) for the year 2007 accounted 1402 ktoe. The indigenous production (renewable) contributed 19% of TPES, while the remains were imports from Israel. Energy supply and share of fuels in TPES are illustrated in Fig. 1[2, 5].

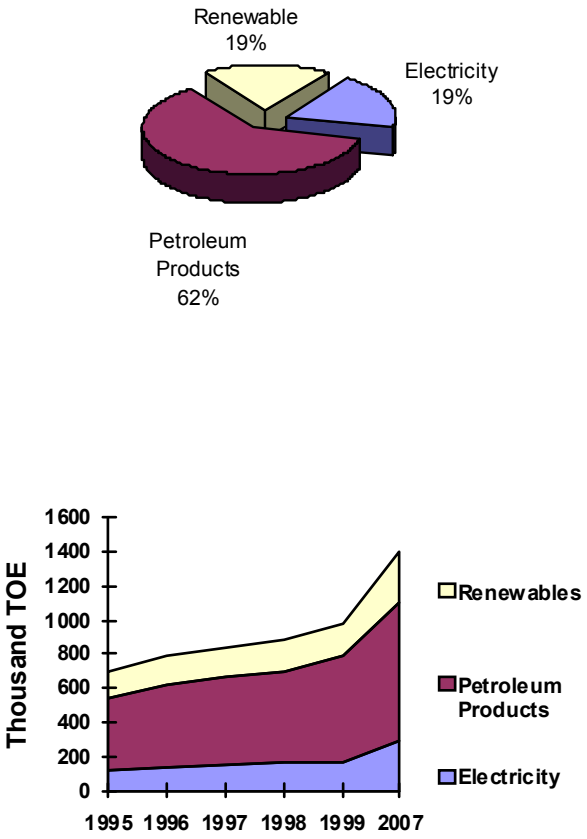

Figure.1: Total primary energy supply by fuel and sector, 2007

C. Energy Demand

The total final energy consumption (TFEC) by fuel type and sector for the year 2004 is presented in Fig. 2.

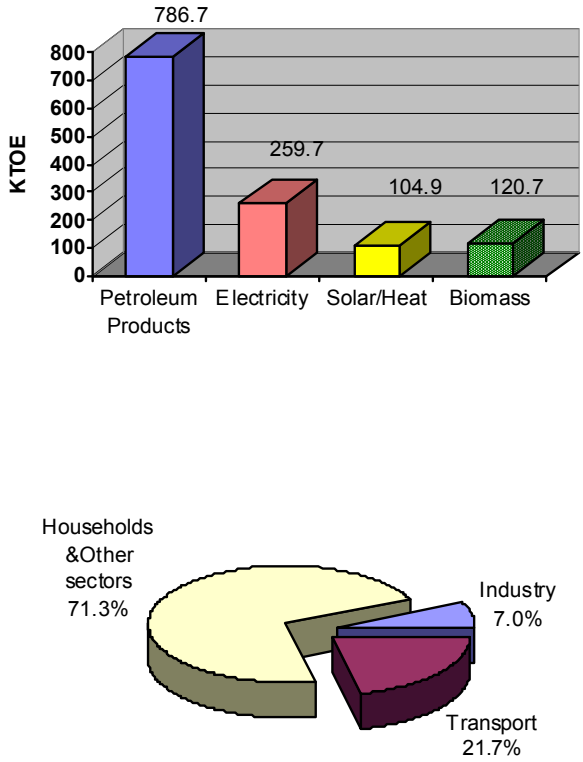

Fig. 2: Total final energy consumption by fuel and sector,2007

It is worth to mention that residential sector contributes to larger part of increase in the total final energy consumption due to the large expanding of the housing sector.

Also the electricity consumption by sector was as follows:

- ❖ Residential 61%
- ❖ Commercial 22%
- ❖ Industrial 9%
- ❖ Others (water pumping, street lighting,….) 8%

D. Energy Prices

The cost and consumer prices of electricity in Palestine are the most expensive if compared to other countries in the region since almost all energy consumed is imported and it is heavily taxed. It reaches the average of 0.13 €/kWh. The average price paid to Israeli Electric Company is 0.07 €/kWh including V.A.T.

The kWh rate is used in pricing consumed electricity, thus the prices of KWh units is flat (not progressive) to all consumed units, thus the price of kWh is usually called here the Flat Rate, meaning applicable to all consumed units.

The kWh rate is defined as follow:

kWh price = Purchase price + Oper.& Mainten. Cost + Profit Margin

The tariff system is still not unified in Palestine. Each electric utility has its own tariff system. In all facilities, electrical meters are used to monitor the consumed quantity and fixed monthly fees are added to each invoice to cover the depreciations and development of electrical services and facilities.

The prices of energy products are somehow dependable on Israeli pricing; some extra values are usually added to compensate the big losses of energy and shortages in revenues and for development projects such as rural electrification projects. No subsidizing policy is pursued in Palestine, thus customers are always eligible for changes of prices according to world market and directly affected by Israeli tariffs.
Table 1 below shows the average prices of different types of energy in Palestine, and table 2 shows the average tariffs according to the type of consumers and regions.
The average annual income per capita in Palestine is 1030 €, whereas the electricity bill composed about 10% of the family income.

Table 1: Consumer Energy Prices in Palestine (2008)

Price of Electricity	0.09 – 0.13 €/kWh
Price of Gasoline	0.92 €/liter
Price of Diesel	0.72 €/liter
Price of Liquid Fuel	0.3 €/Kg
Price of Kerosene	0.72 €/liter
Price of firewood	95 €/ton

Table 2: The average tariffs according to the type of consumers and regions

Distribution Utility	Household Price €/kWh	Commercial Price €/kWh	Industrial Price €/kWh
Municipality of Nablus	0.1244	0.1304	0.1098
Municipality of Jenin	0.1128	0.1097	0.1097
Municipality of Qalqilya	0.0810	0.0808	0.0790
Municipality of Hebron	0.0972	0.0972	0.0868
South Electrical Comp.	0.1008	0.0878	0.0800
Jerusalem District EC	0.0920	0.1062	0.0950
Gaza Electrical Comp.	0.0755	0.0762	0.0760

Energy prices are projected to increase by more than 3% per year [3].

E. Prospects of Renewable Energy Usage in Palestine

The utilization of renewable energies is one of the strongest alternatives in Palestine due to absence of fossil fuel resources and several years of occupation. Palestine has to import all its needs of petroleum products and about 92% of electrical energy from Israeli market, a yearly energy bill of more than 500 MUS$. In spite of the small area (6000 km2) and limited number of inhabitants, a large portion of the country (about 60%) is considered as rural areas where more than 100 communities live in bad socio- economic conditions and still suffer from ignorance and restrictions from development plans that fit their needs and specific conditions.

Out of 3.9 million inhabitant total population (year 2007), about 18,500 inhabitants (0.5% of population) have no electricity at all scattered in more than 65 communities and concentrated in the south of West Bank. About 4.5% of population (165,000 inh) have partial electricity services through decentralized diesel generators. Their communities concentrated in the North of W.B.

Indigenous energy resources are quite limited to solar energy for photovoltaic and thermal applications (mainly for water heating). Utilization of solar energy for water desalination is still the subject of research and investigation in Palestine. Biomass (wood and agricultural waste) is traditionally utilized for cooking and heating in rural areas. Utilization of geothermal technology could be feasible in Palestine as a source of energy for heating and cooling. Utilization of wind energy could be feasible in some locations for either grid-off electricity production or water pumping. Potential of wind energy seems to be limited in the mountains (elevation of about 1000 m) where the speed surpasses 5 m/s and the potential about 600 kwh/m². Biogas production is still under investigation and few demonstration projects are existing in Palestine. Biogas potential is over than 33 million m^3, equivalent to 10 M€.

F. Renewable Energy applications in Palestine

1. Photovoltaic electricity (PV).

Photovoltaic electrification in isolated rural villages and communities in Palestine is considered feasible and effective compared with other alternatives like electrical grid and diesel generators.

The PV electrification could be using the decentralized stand alone and centralized systems depending to the nature of the load and the distribution of houses.
Photovoltaic electrification is limitedly used in different rural areas in Palestine mainly for schools, clinics, Bedouins communities, agricultural and animal farms, and private homes. The total installed capacity is about to 50kWp.

The policy of PV electrification focuses on settling the communities threatened from land confiscation and people eviction due to occupation practices especially after construction of the separation wall. It is urgently needed to enhance the living conditions of these communities by offering more and better quality services and implementing sustainable development plans. The policy contributes to development of renewable energy resources and reliance reduction on imported fuels, and eventually leads to environment protection and sustainable development in the region.

The most recently PV electrification project was implemented by the energy research center at An Najah National University. It's about electrifying a Palestinian village Atouf by PV centralized power system. The village includes 25 houses, school, and clinic with power capacity about 24 kWp. The project is considered a successful renewable energy application in Palestine. The project was financed by EU. Another Project for street lighting and electrification of public sites at Jib Aldeeb community is going to be implemented by Arij[1] institution. This project is financed by UNDP/PAPP, GEF and SGP[2].

2. Solar water heating

Solar water heaters (SWH) are extensively used in the residential sector in Palestine (more

[1] Palestinian research and development institution, www.arij.org

than 70% of households use solar family systems), whereas, it is limited in the service (hospitals, hotels, universities) and industry sectors. About 50% of hospitals and hotels depend on electricity and petroleum products for water heating, and those equipped with SWH can only cover 40% and 25% of their demand from hot water by solar in hospitals and hotels, respectively. The existing installed capacity (up to year 2007, PCBS) in all sectors is totaled 1,500,000 m2 (the highest in the region, of which 7100 m2 in the service sector. This can produce 940 GWh per year and saves 85 M€ yearly to the national economy. The corresponding avoided emissions of CO2 are evaluated at 650,000 tons per year or avoided damage 2.3 M€. The market of SWH (13 M€) can be doubled if proper policy with efficient financial scheme is adapted for promotion and encouragement the use of solar collective systems, beside improvement and control of the quality. A further potential for SWH is foreseen in the service sector through extending the existing installations to cover more demand (about 60%), and also through new installations in the unequipped centers. This is estimated at about 8500 m2, 9800 m2, and 1000 m2 of solar panels in hospitals, hotels and universities, respectively.

The most commonly used system is the thermosyphonic open circuit type in which the heated water is used directly by the consumer. The system consists of 2 or 3 flat plate collectors, each measures 1.7 m2, a rating of 2750 kcal/ day (iron collector) as a yearly average output, oriented to the south, tilted 42°. For climate conditions, three collectors are generally used in hilly areas, while two collectors are utilized in the Jordan Valley, Jenin, Tulkarm and Gaza Strip, table 3 illustrates the technical specifications of the Thermosyphonic system [4].

Table 3: Specifications for Flat Plate collector and Hot water Storage Tank used in Thermosyphonic system

Collectors	
Number of collectors	2 or 3 collectors per system
Box	0.5 mm galvanized steel 190*190*10 cm
Absorber plate	0.5 mm black steel
Risers	0.5” O.D steel pipes, 7,9 or 13 risers
Headers	1.0” O.D steel pipes
Insulation	3 cm polyurethane or rock wool
Cover	0.4 mm ordinary glass ,2 pieces on each collector
Hot Water Storage Tank	
Size	150 – 200 liters
Shell	4 – 5 mm steel
Insulation	6 cm polyurethane or rock wool
Outside Cylinder	0.4 mm galvanized steel
Electric Heater	2.5 kW (optional)
Pressure	12 bar

The vacuum tube collectors are recently invaded the local market; it considered a new technology and very few systems are installed so far where no technical specifications are available regarding this technology as it is fully imported from China right now.

Use of collective systems is very limited and has to be introduced in an efficient way. The solar heating is competitive with other means of heating (unit price is about 400 €). In

addition, the system pay-back period is less than 2 years, when compared to that of electric systems. Industry of solar water heaters in Palestine is a small and simple industry and needs to be developed and structured.

1. Solar desalination and cooling

Use of solar energy for water desalination is still the subject of research and investigation in Palestine. Due to water shortage, high salinity especially in Gaza Strip and eventually high cost of drinking water, solar desalination seems feasible for obtaining fresh water. Regarding solar cooling, neither studies carried out nor installations are available in Palestine. In the meanwhile, a high potential of solar cooling/ air conditioning is foreseen for food industry and service sectors. Studies and researches are important for assessment of potential and determination of applicable systems.

2. Solar drying

Solar drying is a commonly used technique in Palestine for preserving fruits, vegetables and even yogurt. The actual application is very limited, being financed and owned by charities and voluntary institutions. Greenhouses agriculture is a well established practice in Palestine, used for planting many vegetables and flowers. It has many advantages over the traditional planting. Saving of lost irrigation water and enhanced productivity increase confidence in the feasibility of such systems.

3. Wind Energy

Wind power provides sustainable and clean energy (a green energy source). Generating electricity from the wind does not require an input fuel; and hence removes the risk of electricity interruptions due to political interference or unaffordable fuel price rises. Further, there are no environmental costs, such as carbon emissions, in the generation process. Wind power has the added advantage that it is widely proven worldwide. In many countries, wind power has become a major part of plans for sustainable development. According to the Global Wind Energy Council, the wind industry has been expanding at an annual growth rate of 28% over the past ten years. Based on available data and topographical features of Palestine, potential of wind energy seems to be limited to the mountains (elevation of about 1000 m); regions of Nablus, Ramallah and Hebron where the speed surpass 5 m/s and the potential about 600 kwh/m2.Initial studies shows that the wind regime is suitable for operating a wind turbine for wind power generation in city of Hebron in West Bank. Al-Ahli Hospital is located in the south-western part of Hebron at ~1000m above sea level on a site of 27500 m2. The average wind speed at 10 m could be as high as 6.2m/s in this region according to detailed data supplied by the Weather Authority.

The proposed and the required wind turbine(s) to be installed at Al –Ahli Hospital (has been approved and in the installation process) is expected to be around ~700KW total power production capacity, the following is the general outline of the tentative specifications for the required wind turbine [6].

- Annual Wind Average 7-10 m/s
- Max Cut-in Wind Speed 3 - 4 m/s
- Cut-out Wind Speed for excessive wind ≈25 m/s
- Hub Height 45 m- 55 m
- Nominal Power 750 kW
- Operating Atmospheric Temperature From -10º to 40ºC

- Lower Tower Diameter 2-5 m
- Upper Tower Diameter 1.5-2 m

Wind atlas is in the developing process for Palestinian Territories. Further researches and more field measurements for wind are required. Utilization of wind could be feasible in some locations for cut-off electricity production and water pumping.

4. Bio energy

Biogas production is still under investigation and few demonstration projects are existing in Palestine. The Biogas potential in Palestine is over than 33 million m3

Biomass (wood and agricultural waste) is traditionally used for cooking and heating in rural areas. Being Palestine one of the many olive oil producing countries in the region, the interest now is directed to utilize the olive mill solid waste (OMSW) to be used as clean source of energy. The olive harvest season is all year round and so the OMSW as a raw material is also constantly available. The annual average amount of OMSW is around 76,000 tons.

The municipal solid waste in Palestine could be used as a source of energy, a new developing proposal projects were released by PEC to generate electricity from burning the wastes (WTE). The proposal project is for constructing an 18 MW waste to energy (WTE) power plant in order to get rid of municipal solid waste (MSW) of the northern provinces of the west bank; this is done by a controlled combustion of the wastes which is exploited generate electricity. Thus, converting MSW to a valuable material rather than being an environmental and economical burden [7].

5. Geothermal Energy

The utilization of geothermal technology as a source of energy for heating and cooling has been started in Palestine during the MED-ENEC project in one of the ITEHAD subdivision villas in Ramallah city and through establishing the first company in the region utilize the geothermal energy in residential and commercial sectors called MENA Geothermal.

MENA Geothermal has installed a 25 KW heating and cooling system in the Etihad residential subdivision in the city of Ramallah (Fig. 3), a project that was cosponsored by Union Construction and Investment Corp (UCI) , the European Union's MED-ENEC Project , and the Palestinian Energy Authority. This system is designed to achieve a minimum COP (coefficient of performance) of 4.5 year round compared to a conventional system that experiences a COP of roughly 2.3. That is, for every unit of electricity the geothermal system uses, it provides 4.5 units of energy, giving a geothermal system a worst case efficiency rating of 450%.

System Features

- Villa Area: 306 m2
- Vertical Closed Loop
- Total number of heat pumps: 2

With the soaring global energy prices, Palestinians are paying $0.18 per kWh of electricity and $1.9/L of diesel fuel. This geothermal system reduced the annual heating and cooling costs from $3,000 per year, to merely $850 per year; that’s over 70% savings! The simple payback period for this geothermal residential system is 5.4 years [8].

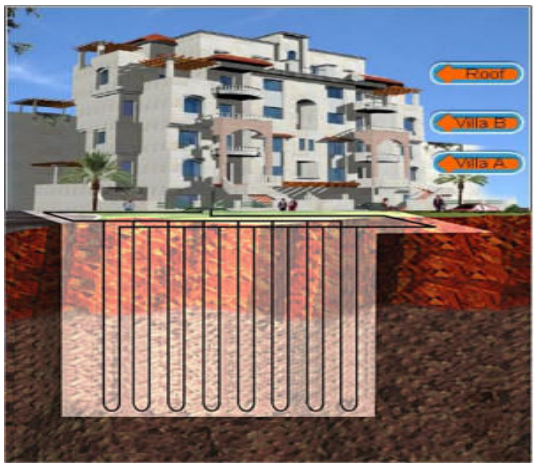

Fig.3: Geothermal system of the villa in Etihad subdivision

In the commercial sector, the geothermal technology was implemented in the UCI Headquarters Building in Ramallah, Palestine (Fig.4) which considered the largest geothermal heating and cooling project in the Middle East and North Africa. This green building utilizes a vertical closed loop installed 150 meters deep. Two commercial heat pumps distribute hot and chilled water to a fan coil distribution system. No energy goes wasted in this system: heat extracted from this building in cooling is rejected to the earth and the building's hot water, increasing the geothermal system efficiency. In addition, a heat recovery fan coil is installed in the vent extract to gain energy from the conditioned ventilation system.

System Features

- 260 kW Cooling Load
- 230 kW Heating Load
- Vertical Closed Loop at 150 m deep
- 2 Geothermal Reversible Chillers
- Fan Coil Distribution
- Expected Savings: $30,000 per year


Fig.4: UCI headquarter building in Ramallah

To reach the maximum benefit of this technology and make it more feasible, buildings should be efficiently improved in terms of energy efficiency such as improving the building insulation thereby reducing the total heating and cooling energy requirement and the total required geothermal ground loop.

The concept of this technology is utilizing the heat from the ground to be used as heating or cooling source. The most appropriate method in Palestine is to use the closed loop by digging holes in the ground vertically, as the land is limited in Palestine for horizontal.

G. Barriers for development of RES in Palestine

1. Policy

A clear comprehensive and general energy policy at a national level is still absent; neither for development of renewable resources nor for energy efficiency. This is due to the continuous Israeli occupation, weak and fragmented institutional framework and the incomplete framework of the Palestinian State. It is envisaged that all energy institutions be gathered in a representative council of energy and the national energy plan and strategy be developed to include policy on financial aspects and resources, policy on identifying priorities and national projects, policy with regard to scientific collaboration between energy institutions/ researches and the local industries. The major policy barriers are:

- Absence of governmental initiatives and concern for development of renewable resources.
- Absence of regulations & provisions to control the quality in the market.
- Absence of qualified testing labs & bodies.
- Israeli occupation & obstacles on import/ export trade movements.
- Heavily tax system and high cost of clean/ efficient technologies.
- Lack of incentives & proper financing schemes.
- High political risk in implementing solid RE projects. This leads to abandonment of the local/ international investments and the external financial aids to participate in the development process.

2. Technical

- The technological capability in both human and institutional terms is relatively weak.
- Lack of professional technical handbook for sizing, design, installations of RE technologies.
- Lack of professional training on new applications & designs.
- Lack of regulations & provisions to implement standards or control quality
- Lack of professional labs, testing & certification facilities
- Lack of pilot projects and expertise especially for new applications of different types of RE.
- Furthermore, trade and industry of RE technologies in Palestine is strongly affected by the Israeli market due to the occupation and Israeli monopolizing practices on the trade movements across the borders and obstacles on import/ export of material and products.

3. Market

Due to the relatively high comparative cost of RE, there are a range of financial barriers, from high front-end cost to lack of adequate financial institutions, for the effective development and dissemination of renewable energy systems. The income in remote areas where RE can enhance the living conditions of people is very low compared to the cost of the systems. Also, low income leads to little or no personal savings to assist in alleviating the problem. Unfortunately, the mainstream financial institutions which can be recourse are not generally supportive of RE projects.

Also, high interest rates are a serious obstacle because they restrict the use of credit facilities, especially when expected gains cannot be easily visualized. Another feature is the high transaction costs, or cost of doing business generally, and the cost of learning about an option to ensure proper selection and installation. These costs are always uncertain and are not properly analyzed, so that the actual cost may be higher than the calculated cost and in some cases may offset the expected gains of the measure.

More specific the main barriers are illustrated as:

- Absence of independent local distributors and importers.
- Disability to export the products due to absence of export's regulations, restrictions and obstacles imposed by Israelis.
- Absence of private sector involvement and governmental initiatives for development RE market.
- Inefficient industrial processing and inadequate quantity of production to cover the market demand.
- High initial investment.
- Lack of awareness programmes at both end users and suppliers for the RE and efficient technologies.
- Small scale of national projects due to the nature of small country. Unfortunately, this is usually out of concern of the regional supporting programs.

4. *Social*
    - Lack of awareness in the selectivity of proper energy system
    - Lack of awareness in the benefits of energy conservation and clean technology.
    - Low income of the family to cover the investment cost of the efficient energy system, especially for the new and efficient technologies [7].

H. General policy recommendations

- Development of proper financing schemes with involvement of government, private sector (investors, local banks), and international financial institutions proper to local needs and facilities.
- Creation of a national fund with participation of the government, private sector and external financial aid for supporting development actions of RE and EE.
- Development of governmental policies, regulations, provisions and incentives to encourage use and investment in RE technologies. The incentives to local industry could be duty license reduction & VAT exemption for raw material/ equipment, and to the end users building tax/ license reduction.
- Imposition of standards, regulations and certifications for improvement the level of market quality.
- Establishment of national testing facilities/ research centers and labs.
- Experience exchange, know-how transfer and upgrading of technical skills especially for the new applications.
- Mobilization installation of large scale systems in the residential, commercial, industrial and service sectors (such as health, education, tourism and sport) by the government initiatives of legislative measures.
- Give attention to small scale projects which when accumulated can produce a value.

- Development of bilateral cooperation agreements for development of collaboration projects in the region.
- Dissemination of awareness to both demand side and supply side for the new applications and efficient technologies that would help in penetration of the RE technologies in the local market.

I. Palestinian National Plan for increasing the RE share

1. *Plan's Rationale*

The five-years plan for developing renewable energy and increasing energy efficiency comes in harmony with the policy of the Palestinian Energy Authority (PEA) that aims at developing the energy sector, finding more sources of renewable energy, and increasing energy efficiency in order to realize the mission and aims of the Palestinian Energy and Environment Research Center (PEC) as it has become a part of the Energy Authority group under direct supervision of its chairman.

It has become necessary to make the best efforts to develop renewable energy and raise energy efficiency within a well-studied national plan with clear objectives, elements, and activities. Decision and policy makers should take decisive measures to support development and energy programs especially after the huge increase of oil prices. In addition, sources of traditional energy are becoming scarcer and scarcer since all oil products and about 92 % of electric power are imported from Israel.

The exploitation of renewable energy sources especially solar energy is too low relative to available potential sources. Usage of solar energy does not exceed 8.5 % of the total amount of energy consumption TFC. It should be noted that this rate has been decreasing gradually in recent years and does not keep up with the general average of increase in sectors and demand of energy.

In addition, energy efficient usage is low. It should be noted that a lot of appliances available in the market have low efficiency in energy consumption, leading to unjustified consumption. This is a result of not giving importance to renewable energy sources and including their programs in development policies and priorities.

2. *Plan Objectives*

The two main objectives are:

- To raise the rate of renewable energy contribution in the Palestinian energy balance to reach 20% of the final total consumption of energy, and this through increasing solar energy exploration by 8.5% in the buildings, industrial, electricity production sectors, and also by utilizing solid wastes to generate electricity. This increment is expected to be about 240 GWh/yr from solar energy and solid wastes that is equivalent 19 MUSD annually.
- To improve energy usage especially in the industrial and buildings sectors and to reduce their needs of imported energy by a minimum rate of 1.6 %, i.e. to save 62.84 GWh/yr that equals 5.712 million dollars annually.

3. *Plan Elements*

- The plan of PEC during the coming five years is based on the following key elements:
- Development and adaptation of a clear policy for renewable energy and energy efficiency and approving measures and regulations in this respect.
- Enhancement use and manufacturing of renewable energy by encouraging investment especially in solar thermal energy, photo-electric energy, biomass and agricultural wastes, wind energy, geothermal thermal energy, and residential solid wastes.
- Development and implementation of national programs that aim at reducing energy consumption in housing, commercial, industrial, and transport sectors especially in the fields of lighting, water heating, steam production, refrigeration, space heating and freight.
- Upgrading of the local market for clean and efficient technology through evaluation of the technology available in the local market (whether imported or locally-produced) and identification of standards and key factors for improving the level of quality.
- Awareness dissemination, know-how transfer and upgrading of technical capacities for the new and efficient technologies that contributes to sustainable development and enhancement of the national economy.
- Provision of suitable scientific and technological research & testing facilities that support researches and encourage investment in clean and efficient technologies. As a first stage, laboratories of solar heaters, and household electric appliances.
- Contribution to the regional efforts and global initiatives (CDM, GEF, etc) of the climate change that aim at sustainable and clean development through introducing Palestine to international energy programs and projects that serve the Palestinian energy sector [9].

J. Master program in Clean Energy at Palestinian University

A joint international master of engineering program was established at Al –Najah National University in 2005 in "Clean Energy and Conservation Strategy". The main partners of this program are:

- Al –Najah National University –Palestine
- Royal Institute of Technology-KTH, Sweden
- Berlin Technical University, Germany

The objective of this program is to establish an educational centre at the Energy Research Centre of An-Najah National University aiming at providing quality education on the Master's Level in the fields of energy efficiency and clean energy. Also the centre should be able to provide training for the graduates, specialists and professionals currently working in energy related sectors.

The program provides basic and advanced education in fields of Energy Efficiency and Clean Energy in both Economically and Environmentally Sustainable way.

The program is carried out within the Tempus Joint European Project in a close co-operation with the leading technical university Kungliga Tekniska Hogskolan(KTH) –Sweden, and Berlin Technical University –Germany.

The program consists of Core and Elective courses in two major fields:
Clean Energy and Energy Efficiency & conservation [10].

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