Dead Sea & Arava Science Center
under the auspices of Ben Gurion University of the Negev
מרכז מדע ים המלח והערבה
בחסות אוניברסיטת בן גוריון בנגב

i.GREENs
Intergrated GREEN Solutions

Building a Jordanian-Israeli virtual library for Renewable Energy

Renewable Energy in Jordan
South Jordan as a Case Study

2011

Contents

Introduction

Energy in Jordan

In Jordan, 98% of the energy needs is imported, costing 13% of the GDP in 2009, which went up to 20% because of the Egyptian Gas supply problems, the cost of the unstable gas supply is estimated to be equivalent to a 1.5 MW PV field for each day of supply cut. The energy supply is dominated by fossil fuel and is growing by 5.5% annually. The electricity generation is mainly based on fossil fuel and natural gas power plants, the total supply capacity in 2010 reached 2,600MW, Figure 1 shows the electricity consumption until 2008 which is growing by 7.4% annually.

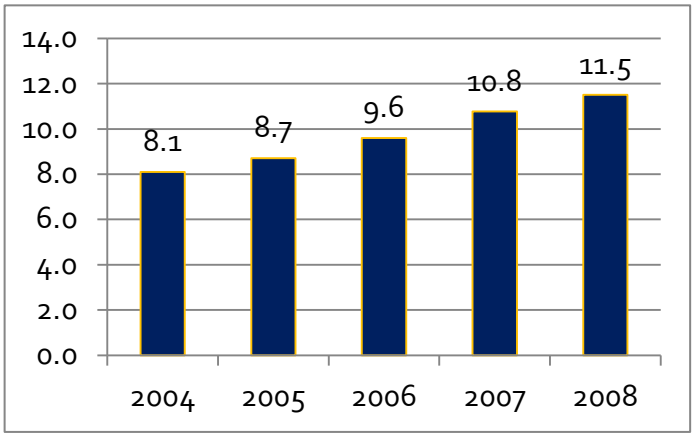


Fig. 1: Electricity consumption in Jordan (in TWh)

Jordan's Energy Mix

In 2008, and according to the National Energy Strategy published by the Ministry of Energy and Mineral Resources (MEMR), oil and natural gas contribute 97% of the total energy mix, imported electricity 1% and 2% of renewable energy, this is shown in Figure 2 for the years 1972 – 2008, the strategy states that by 2020 renewable energy should contribute 10%, oil and other fossil fuel 83%, nuclear energy 6% and imported electricity 1%. This mean 56% of the energy supply will be imported. Figure 3 shows the breakdown of the energy mix components, and gives the government plan for 2015 and 2020.

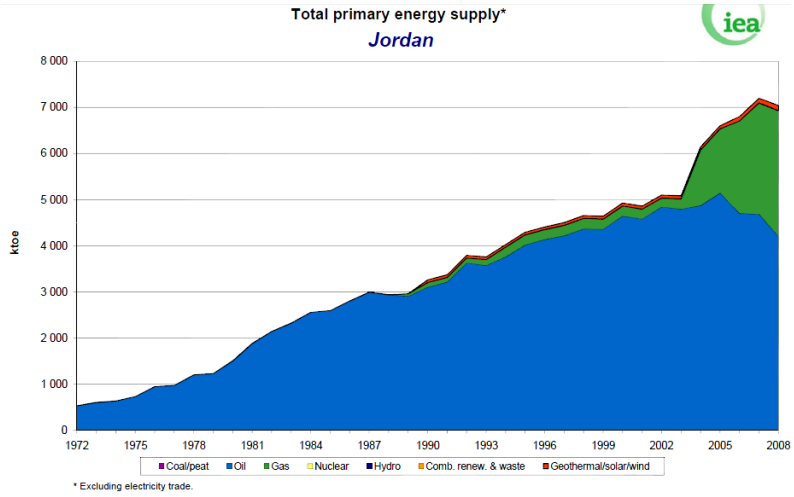


Fig 2: The Total Energy Suppy in Jordan until 2008

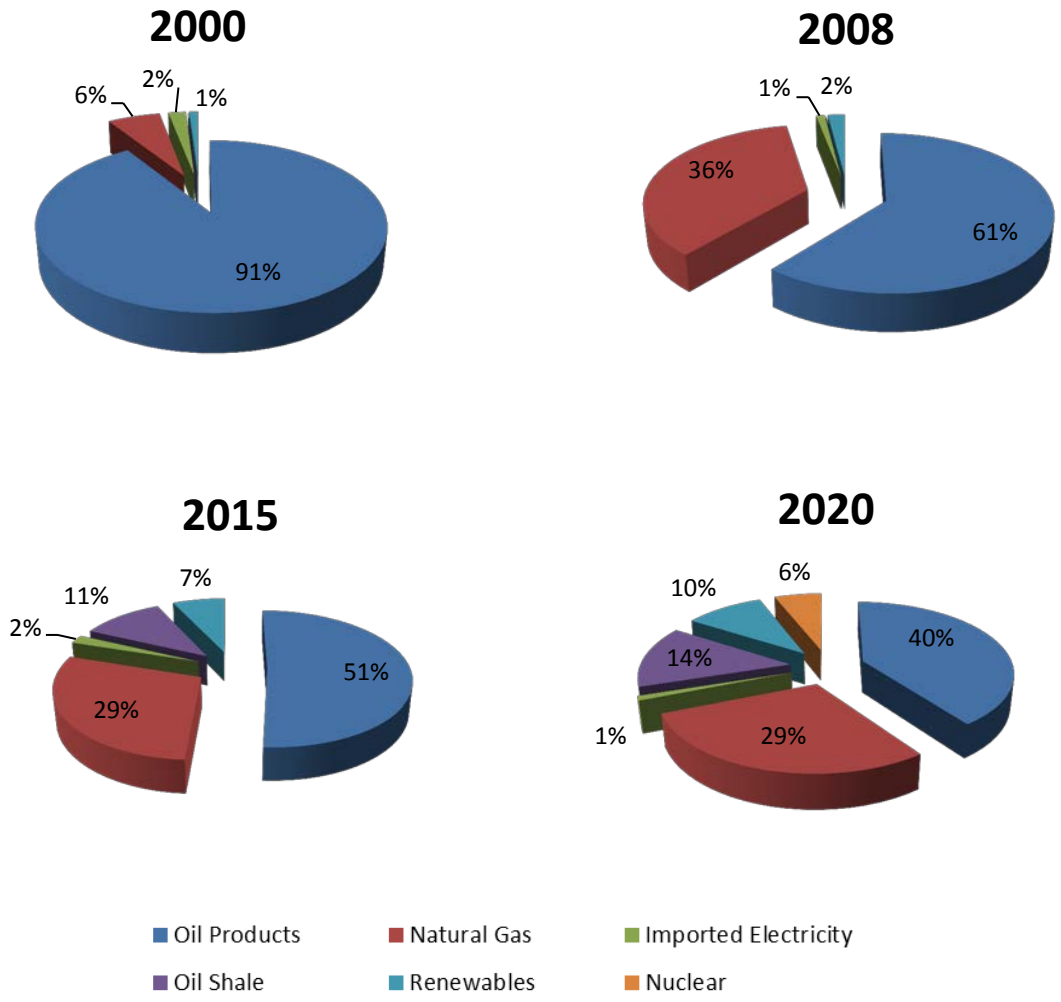


Fig 3: Energy mix breakdown for the years: 2000, 2008 and planned situations for 2015 and 2020.

Another dimension of the energy sector is the air pollution caused by it, figures show that Jordan has a relatively low CO_2 emissions out of energy production per capita, which is mainly because of the low generation capacity compared to other countries in the region. In Figure 4 we can see a declining trend of the CO_2 emissions over the period between 1995 – 2009, which is due to increasing the use of natural gas and the technology improvement in the power plants.

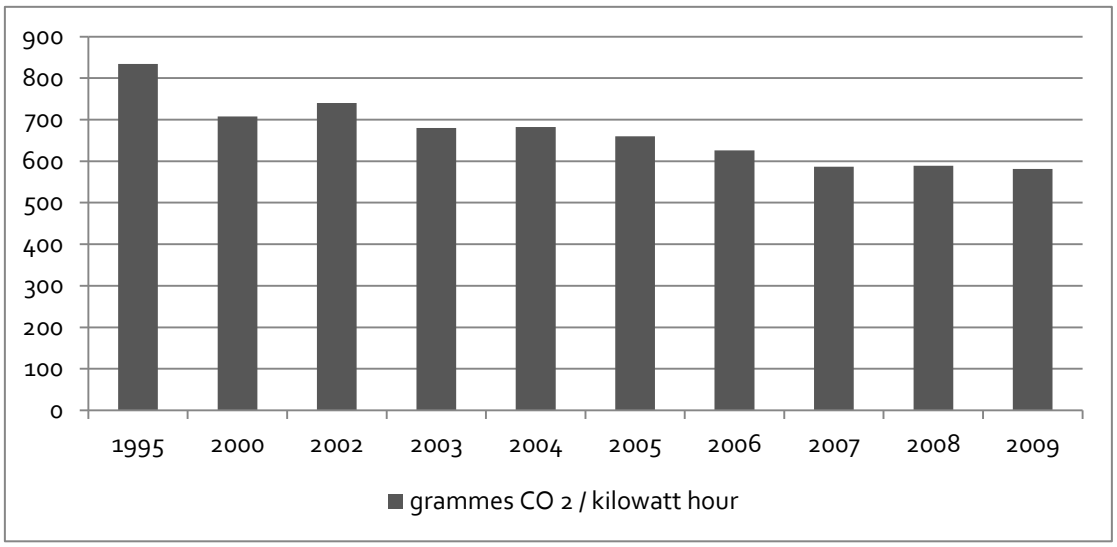


Fig 4: CO2 emissions per kWh from Electricity and Heat generation.

Renewable Energy Potential in Jordan

In the year 2009, the Jordanian government issues the Renewable Energy and Energy Efficiency law (appendix I), which states that the government of Jordan should work on:

- Exploiting Renewable Energy Sources for increasing the percentage of their contribution to the total energy mix, achieving safe supply therefrom and promoting investment thereto.
- Contributing to environmental protection and achieving sustainable development by promoting the exploitation of Renewable Energy.
- Rationalizing the exploitation of energy and improving its efficiency in various sectors.

Figure 5 shows the expected in wind and solar energy installations to meet the goals set by the national energy strategy.

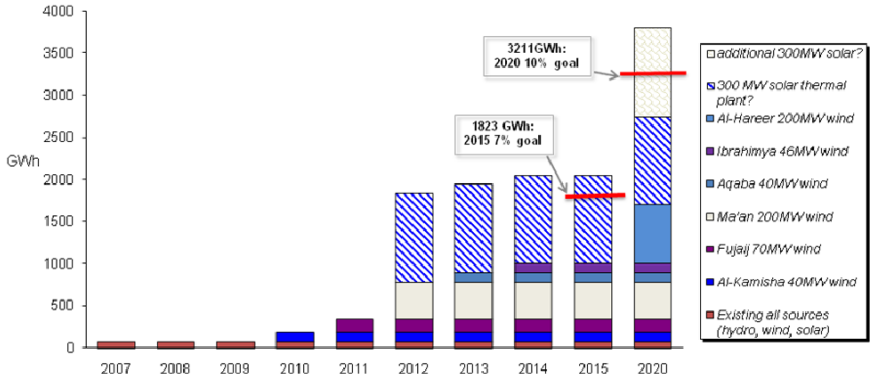


Fig 5: Projected Renewable Energy output Based on Planned Wind and Large-Scale Solar Plants

The law identifies the renewable energy resources as: Natural resources of energy including solar energy, wind energy, bio-energy, geothermal energy and hydropower.

On the other hand the total fund allocated for developing renewable energy resources in the national budget for 2012 is only 4,325,000 JDs out of 30,270,000JDs allocated for the Ministry of Energy. Most of this fund is going to wind energy projects, a small percentage (5.8%) is going to studies to update wind profile and solar radiation databases, no fund allocated for solar energy projects and municipal waste, which may be listed under different ministry budget.

Solar Energy Potential

Since the 1970s, studies have shown that the human race can receive a substantial portion of its electrical power through direct conversion of solar energy, without burning fossil fuels or creating nuclear fission reactions in the electrical generation process. The 122 petawatts of solar insolation reaching the earth's surface is plentiful compared to the 13 terawatts of the world Total Primary Energy Supply in 2005.

The south of Jordan receives a substantial amount of annual solar radiation per unit area, with an average annual total radiation exceeding 2500 kWh per year per square meter, as shown in Figure 6 and illustrated in depth in Figure 7. Different technologies can be used to convert solar energy into electrical power, and these can be categorized into two main groups: thermal technologies and photovoltaic (PV) technologies, PV technology is considered a reliable alternative to fossil fuel which can be implemented in a wide range of settings.

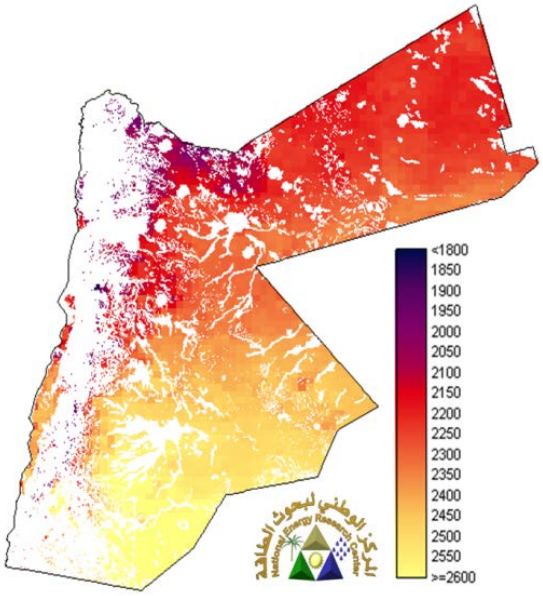


Fig 5: Solar map of Jordan (kWh/year/m^2)

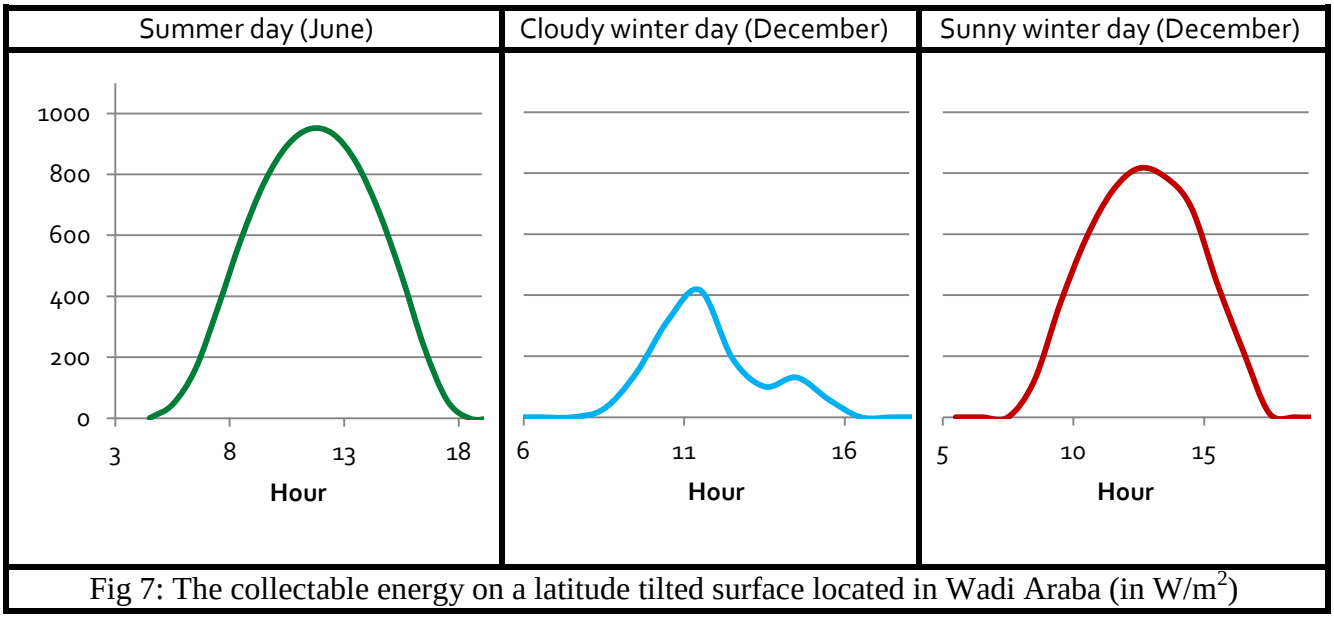


Fig 7: The collectable energy on a latitude tilted surface located in Wadi Araba (in W/m^2)

Wind Energy Potential

Wind is an important energy source, and man has long sought to harness it. It has been estimated that 1% of the daily wind energy available on earth is equivalent to the present world total energy consumption. Wind energy resources are highly dispersed and prevail mostly at sites where they are difficult to harness, such as at sea or at high altitudes.

Nevertheless, they are available at many accessible sites and are becoming increasingly competitive with conventional energy sources. As wind energy technologies continue to mature, performance is becoming more and more reliable, while at the same time costs continue to decline.

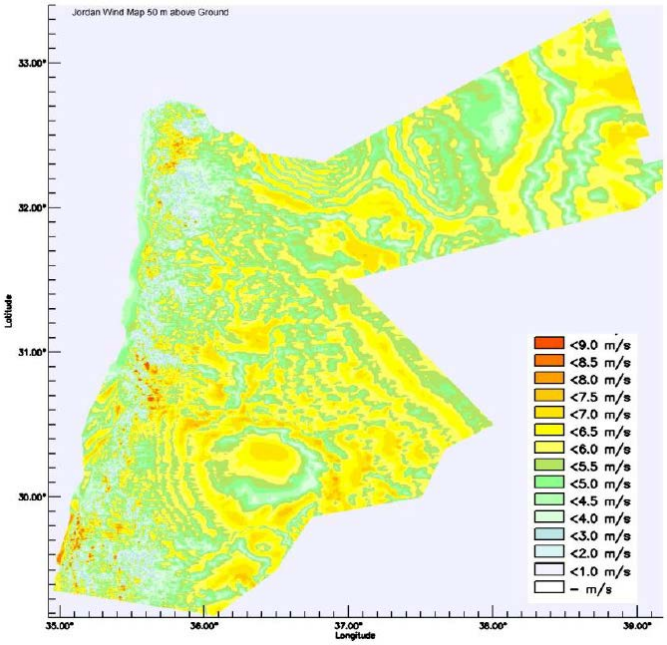


Fig 8: RSS wind speed measurement sites (shaded areas are suggested wind farm sites)

During the year 1983, the Renewable Energy Research Center of the Royal Scientific Society completed a major study assigned by Gesellschaft fuer Technishe Zusammenarbeit (GTZ) and financed by Bundes Ministerium fuer Zusammenarbeit (BMZ), in order to assess the potential of solar energy applications in Jordan. Parts of the study were inventory and processing of available wind data as a first assessment of the wind energy potential.

The study concluded that most Jordan regions, excluding the Jordan Valley, have moderate annual wind theoretical power of up to 250 W/m^2, which is suitable for water pumping and power generation at limited scales. However, there are two sites in the northern part of the country having annual wind theoretical power densities of about 275 W/m^2 and about 410 W/m^2, which are good for power production. Figure 8 shows Jordan's wind atlas built on the findings of the study mentioned above.

Biomass

Biomass power includes directly firing biomass and capturing methane from landfills, wastewater treatment plants, or agricultural methane production. Gasification of biomass is a developing technology that is currently not widely economical. Most biomass power is produced by direct fire in boilers or from agricultural or waste gas directly.

Jordan's dry climate makes substantive power from virgin biomass feedstock unlikely. Additionally, Jordan has few concentrated livestock operations that are suitable for capturing methane gas. A typical agricultural methane capture project captures the waste from a dairy cow or swine farm. According to the Jordanian Department of Statistics, Jordan

has only 30,000 to 40,000 cattle, and an unknown number of these are concentrated livestock operations with waste holding ponds that could be covered and the methane captured.

The burning of municipal and industrial waste for energy is an option, but likely a costly one. Outside of Europe, Japan, and the northeastern United States, direct waste to energy plants is limited. Generally, this is economical only when waste disposal costs are high and populations are dense. A typical municipal solid waste plant will generate a net of 500kWh per ton.

Capturing the landfill methane gas produced during the decomposition of waste in landfills is much more feasible, and there are several plants in Jordan currently.

Hydropower

Hydropower is considered one of the oldest harnessed methods of renewable energy utilization. As a renewable source of energy it was utilized to generate energy as early as the Greek era. Until recently concentration was focused on large-scale hydro, but the last three decades have witnessed a shift of interest in favor of small-scale hydropower plants, where small scale is defined as up to 10 MW.

Hydropower plants of any size can be connected to the power grid, so they all require the highest engineering standards. However, micro-hydropower plants can be simplified in order to reduce costs, especially if they are to serve isolated communities and remote villages.

Renewable Energy Situation, an Overview

Because of the country's high oil bill and the unstable gas supply, renewable energy resources are considered to have a relatively significant role. So far the amount of renewable energy resources used is very small, this makes the goal of 20% by 2020 very easy to achieve.

In the past it has primarily been projects aimed at improving the infrastructure of rural regions that have attracted the attention of foreign financiers. Until the year 2000 the UN Development Programme (UNDP) provided US$ 750,000 for a project to install wind and solar power plants for 200 remote villages in southern Jordan.

Solar Energy

As explained in our previous section, the solar energy potential in Jordan is very high, in 1983 the Royal Scientific Society established the Research Center for Renewable Energy Sources (RCRES), mainly to research and test technologies in this field.

The center, together with international funding agencies, installed several photovoltaic off-grid systems, mainly in remote communities to supply electricity for water pumping, radio and/or telephone stations and for supplying health centers, schools and a few small villages mainly in the south of Jordan. Appendix II lists the different water pumping sites, the locations of these sites are shown in Figure 9.

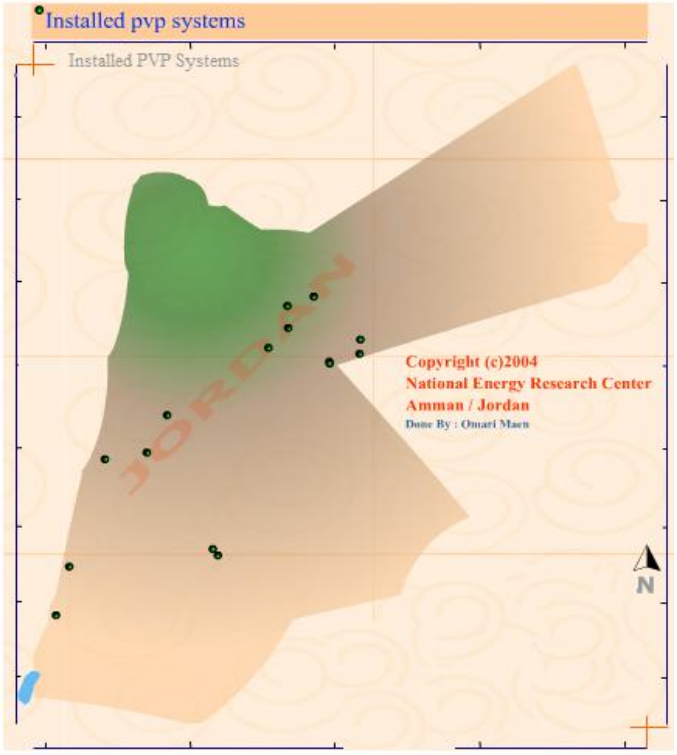


Fig 9: PV Water pumping projects in Jordan

On the other hand, Jordan is participating in the multinational SolarPACES (Solar Thermal Power and Solar Chemical Energy Systems) project run by the International Energy Agency (IEA). A preliminary study on the fundamental feasibility of a solar-thermal power station was conducted in this connection. At present, however, there are no specific prospects of such a plant being built in Jordan.

Wind Energy

The potential of wind energy is very good. Unlike solar energy, wind is location specific in Jordan, the studies show that wind energy is only feasible in certain locations in Jordan, where the wind velocities exceed 7m/s. this limitation will increase the low cost of wind energy after adding the land cost to the equation.

The potential of wind energy in Jordan has been estimated to reach a total of about 100 MW, of which 50 MW could be connected to the grid without changes of any kind. In 1988, a 320 kW pilot wind farm was commissioned at Al-Ebrahemiyh. The wind farm, owned and operated by NEPCO, consists of four 80 kW wind turbines. The annual electricity generation at the farm is about 645 Mwh.

Smaller wind demonstration projects exist in other parts of the country; they include A hybrid system that was built in 1987 and supplies electricity to a remote community near Jurf El-Darawish in the south of the country consists of two 20 kW wind turbines, a 10 kWp PV system and a diesel generator rated at 65 kW.

Biomass

Although there are few projects of using Biomass in the center and the north of the country, there are no similar projects implemented in the south of Jordan. A major project on the utilization of landfill gas for electricity generation was completed in 2000. The UNDP-assisted project, with a total expenditure of US$ 5.32 million, was implemented by the Ministry of Planning, NEPCO and the municipal authority of Greater Amman. The other project is smaller biogas plant, uses residues from olives for generating electricity

Hydropower

The hydropower resources available in Jordan are very limited, in view of the small number and yield of flowing surface water. Currently there are only two small hydroelectric plants, one with a capacity of 3 MW at the Aqaba steam power plant to make use of a downgradient in the cooling water outfall, and one with a capacity of 4 MW on the Zarqa River near Jerash in the north of the country.

Renewable Energy Research

The amount of published research in the renewable energy field in Jordan is very moderate, a smaller amount is peer reviewed, the main reason is the lack of funding which limit the access to good instruments and researchers.

The amount of research centers specialized in energy and renewable energy research is significantly higher than the amount of research published in the field, below is a list of the research centers that can be found online:

- The National Center for Research and Development (NCRD) of the Royal Scientific Society. (http://www.nerc.gov.jo/)
- The Energy Center of the Jordan University. (http://www.ju.edu.jo/centers/energycenter/home.aspx)
- Prince Faisal Center for Dead Sea, Environmental and Energy Research of Mutah University. (http://www.mutah.edu.jo/pfc_dseer/)
- The Energy Center of the Jordan University of Science and Technology. (http://www.just.edu.jo/CENTERS/ENERGYCENTER/Pages/default.aspx)

Table 1 shows the available papers published in this field, the amount of wind energy publications, compared to other renewable energy publications, reflects the share of wind energy in the national budget.

Conclusions

- Jordan's energy situation is very critical and unstable.
- These is a very high potential for solar and wind energy to help stabilizing the energy situation in Jordan.
- Further research needed to identify further options like biomass, hydropower and municipal waste.
- Detailed study should be performed in order to know the capacity and limitation of the current infrastructure and its ability to accommodate planned projects.

Paper's title	Field	Year	Type	Place of publication
Assessment of renewable energy potential, at Aqaba in Jordan	Wind Energy	2010	Peer reviewed	Renewable and Sustainable Energy Reviews
DESIGN OF STAND-ALONE BRACKISH WATER DESALINATION WIND ENERGY SYSTEM FOR JORDAN	Wind Energy	1994	Peer reviewed	Solar Energy
Report on the Analysis of Wind Conditions at the Site Aqaba, Jordan	Wind Energy	2001	Report	GTZ
EVALUATION OF FACTORS AFFECTING WIND POWER GENERATION IN JORDAN	Wind Energy	2009	Conference proceeding	The Seventh Asia-Pacific Conference on Wind Engineering
EVALUATION OF WIND ENERGY AS A POWER GENERATION SOURCE IN A SELECTED SITE IN JORDAN	Wind Energy	1988	Peer reviewed	Solar and Wind Technology
INVESTIGATION OF WIND ENERGY IN JORDAN	Wind Energy	2009	Conference proceeding	International Conference and Exhibition on Green Energy & Sustainability for Arid Regions & Mediterranean Countries
POTENTIALS OF WIND ENERGY DEVELOPMENT FOR WATER PUMPING IN JORDAN	Wind Energy	1998	Peer reviewed	Renewable Energy

Study on the Financing of Renewable Energy Investment in the Southern and Eastern Mediterranean Region	Renewable Energy	2010	Report	European Investment Bank
EDAMA Action Plan	Renewable Energy	2009	Report	USAID
Renewable energy potential assessment in Jordan	Renewable Energy	2011	Peer reviewed	Renewable and Sustainable Energy Reviews
Producing Electricity From Renewable Sources: Energy Sector Framework in 15 Countries	Renewable Energy	2002	Report	GTZ
Initial Communication Report under the UN Framework Convention on the Climate Change	Renewable Energy	1997	Report	The General Corporation for the Environment Protection, Jordan
Wind as an alternative source of energy in Jordan	Wind Energy	2001	Peer reviewed	Energy Conversion and Management
WIND SPEED AND WIND ENERGY POTENTIAL OF JORDAN	Wind Energy	1987	Peer reviewed	Solar Energy
Wind-Solar Hybrid Electrical Power Generation in Jordan	Wind Energy	2010	Peer reviewed	Jordan Journal of Mechanical and Industrial Engineering
Wind Energy in Jordan - Use and Perspectives	Wind Energy	1999	Magazine article	DEWI Magazine

Analysis of renewable energy situation in Jordan	Solar Energy	2007	Peer reviewed	Renewable and Sustainable Energy Reviews
Potential of solar energy development for water pumping in Jordan	Solar Energy	2003	Peer reviewed	Renewable Energy
Evaluation of conventional and renewable energy sources for space heating in the household sector	Solar Energy	2008	Peer reviewed	Renewable and Sustainable Energy Reviews
Study in industrial applications of solar energy and the range of its utilization in Jordan	Solar Energy	2001	Peer reviewed	Renewable Energy
Solar energy in Jordan: current state and prospects	Solar Energy	2003	Peer reviewed	Renewable and Sustainable Energy Reviews
Energy content of municipal solid waste in Jordan and its potential utilization	Solid Waste	2000	Peer reviewed	Energy Conversion and Management
The potential of hydropower generation in Jordan Micro-hydropower analysis	Hydropower	1994	Peer reviewed	Energy Policy

Table 1: Renewable Energy Publications focusing on Jordan

Appendix I

Law No. (3) Of 2010

Renewable Energy & Energy Efficiency Law

Article 1- This Law shall be called (the Renewable Energy & Energy Efficiency Law of 2010) and shall enter into force on the date of its publication in the Official Gazette.

Article 2- a- The following words and phrases wherever they appear in this Law shall have the meanings assigned to them hereunder unless the context provides otherwise:

Ministry	:	Ministry of Energy & Mineral Resources.
Minister	:	Minister of Energy & Mineral Resources.
Electricity Law	:	General electricity law in force.
Commission	:	Electricity Regulatory Commission established in accordance with the provisions of the Electricity Law.
Fund	:	Renewable Energy and Energy Efficiency Fund established in accordance with the provisions of this law.
Board	:	Board of Directors of the Fund.
Chairman	:	Chairman of the Board.
Renewable Energy	:	Energy produced from inexhaustible natural resources.
Renewable Energy Sources	:	Natural resources of energy including solar energy, wind energy, bio-energy, geothermal energy and hydropower.
Renewable Energy Systems	:	Systems and equipment based on exploiting Renewable Energy Sources for energy production.
Renewable Energy Facility	:	Facility that works on exploiting renewable energy sources and systems.
Energy Efficiency	:	Series of measures and means carried out with the aim of reducing energy consumption and improving energy efficiency in a way that does not affect the

		level of performance.
Energy Efficiency Systems	:	Systems and devices that work on rationalizing energy consumption and improving its efficiency including, among others: energy saving lamps, thermal insulation materials, thermal and electricity regulators.
Generation License	:	Permission granted by the Commission according to the provisions of the Electricity Law.
Person	:	Natural or legal person.
Licensee	:	Person licensed by the Commission to exploit Renewable Energy Sources to generate electrical power.
Distribution Code	:	Technical requirements for the connection of power production facilities to the Distribution System as well as for its operation and use prepared by the Commission to operate the Distribution System.
Bulk Supply Code	:	Code prepared by the Commission for regulating the purchase of electrical power from the Bulk Supply Licensee.
Project	:	Any project that seeks to exploit Renewable Energy Sources.
Project Agreements	:	The set of contractual documents entered with the competent bodies to exploit Renewable Energy Sources including, among others, any agreement to implement the project, Power Purchase Agreement or Land Lease Agreement.
Land Use List	:	Lands suitable for exploiting available Renewable Energy Sources.
Reference Pricelist	:	Record prepared by the Commission with the relevant bodies for specifying the mechanism of pricing the purchase of electrical power from Renewable Energy Sources.

b – For the purposes of this law, words and phrases undefined in this Law shall bear the meaning specified in the Electricity Law.

Article 3- For achieving the objectives of this Law, the Ministry shall work on the following in cooperation and coordination with the competent bodies:

a- Exploiting Renewable Energy Sources for increasing the percentage of their contribution to the total energy mix, achieving safe supply therefrom and promoting investment thereto.

b- Contributing to environmental protection and achieving sustainable development by promoting the exploitation of Renewable Energy.

c- Rationalizing the exploitation of energy and improving its efficiency in various sectors.

Article 4- a- The Ministry shall identify, in cooperation with the specialized technical bodies and centers, the geographical locations in the Kingdom of suitable nature, which demonstrate a high potential for exploiting Renewable Energy Sources, and shall establish a priority list for the development of such locations in accordance with the Ministry's energy sector master plan, and any other plans for the development of Renewable Energy Sources adopted by the Ministry.

b- The Ministry shall identify the Land Use List in accordance with the provisions of clause (a) of this Article, including areas and ownership of such lands and submit it to the Council of Ministers for approval.

c- Upon a decision from the Council of Ministers, treasury land that appears in the approved Land Use List shall be allocated for renewable energy projects while listed land owned by individuals shall be acquisitioned according to the provisions of legislations in force and in compliance with the Ministry's plan approved by the Council of Ministers.

Article 5- Notwithstanding what has been stated in the Electricity Law:

a- The Ministry may, in coordination with the Bulk Supply Licensee, issue tenders or attract proposals on competitive basis for the development of one or more sites included in the Land Use List approved in accordance with the provisions of this Law for the purposes of generating electrical power.

b- The Council of Ministers, may issue a decision states that the Bulk Supply Licensee or Retail Supply Licensee is entrusted to issue tenders or attract proposals on competitive basis for the development of one or more sites included in the Land Use List approved in accordance with the provisions of this Law for the purposes of generating electrical power and connecting to the grid,

upon recommendation of the Minister based on a report from the Commission illustrates the development of the exploitation of Renewable Energy Sources for generating electrical power exceeds the total of capacity of (500) Mega Watt of such sources,

Article 6- a- With the exception of sites that are being developed through public tenders and according to the provisions of Article (5) of this Law, any person may submit a direct proposal to the Ministry or to whom entrusted by the Council of Ministers pursuant to clause (b) of that Article in order to develop any site for the purpose of exploiting Renewable Energy Sources, regardless if this site is part of the Land Use List approved in accordance with the provisions of this Law or not.

b- The direct proposal for generating electrical power and connecting to the grid shall meet the following conditions:

1- The proposal shall contain the development plan including the preliminary design, initial financing plan, and the contribution of local inputs to the facility, supplies, construction and operation.

2- The applicant shall possess sufficient experience in the implementation or development of Renewable Energy Facilities similar to the proposal in question.

3- The proposed tariff included in the proposal for electricity to be generated and sold by the Renewable Energy Facility shall be a fixed tariff expressed as an amount per kilowatt hour, and within an acceptable range according to the Reference Pricelist.

4- Any documents or additional data necessary to fully appraise the proposal shall be submitted.

c- The Ministry or whoever is entrusted by the Council of Ministers pursuant to clause (b) of Article (5) of this Law, in cooperation with the relevant bodies, shall study such direct unsolicited proposals and notify the applicant of its decision within a period of six months from the date of submitting the proposal.

d- In the event of an initial approval on the submitted proposals, the Minister shall submit the recommendations to the Council of Ministers in order to issue the necessary decision thereon.

Article 7- a- The Ministry or whoever is entrusted by the Council of Ministers pursuant to clause (b) of Article (5) of this Law, in cooperation with the relevant bodies, shall enter into negotiations with the applicants of accepted proposals, in order to proceed to the final Project Agreements.

b- 1- After signing the Project Agreements, the Commission shall issue the Generation License in compliance with their terms.

2- The license must state terms, conditions and obligations due to the licensee, as well as the cases where the license is amended or cancelled.

Article 8- a- The electrical power generated by the Renewable Energy Facilities which are licensed in pursuance of the provisions of this Law is to be sold to the Bulk Supply Licensee or the Retail Supply Licensee in accordance with the power purchase agreements concluded in pursuance of the provisions of this Law.

b- While taking into consideration the texts of the Bulk Supply Code, the delivery rules which are stated in the Grid Code or the Distribution Code must be adhered to, as the case may be.

c- The Bulk Supply Licensee and the Retail Supply Licensee, as the case may be, shall accept the delivery and the purchase of all electrical power generated by the Renewable Energy Facility which is connected to their respective grid.

Article 9- Notwithstanding the provisions of the Grid Code or of the Distribution Code, or of any license issued under the Electricity Law:

a- The cost of interconnecting a Renewable Energy Facility to the Grid shall be at the expense of the Bulk Supply Licensee.

b- The cost of interconnecting a Renewable Energy Facility to the Distribution System of any Distribution Licensee shall be paid in accordance with instructions to be issued by the Commission.

c- The Commission may waive Renewable Energy Facilities from any provision of the Grid Code or of the Distribution Code where such waiver is necessary, in coordination with the relevant licensees.

Article 10- Any person, including small Renewable Energy Facilities and homes that have Renewable Energy Systems for the generation of electrical power, may sell the generated electrical power to the Bulk Supply Licensees and to the Retail Supply Licensees. The size and nature of such Renewable Energy Facilities and the selling price of the generated electrical power shall be specified in

accordance with instructions to be issued by the Commission. The selling price of such power should not be lower than the purchase tariff specified by the licensees.

Article 11- a- A fund to be known as (Renewable Energy and Energy Efficiency Fund) shall be established in the Kingdom with the aim of providing the funding necessary for the exploitation of Renewable Energy Sources and the rationalization of energy consumption.

b- The Fund shall have juridical personality, and it shall be financially and administratively independent. In this capacity, the Fund may perform all legal acts necessary to achieve its objectives including acquiring movable and immovable property, concluding contracts and loans, accepting aids, donations and grants, and shall have the right to litigate and delegate the Civil Attorney General or any attorney to represent the Fund in legal proceedings.

c- The Fund's headquarters shall be in the city of Amman.

Article 12- a- The Fund shall be overseen by a Board called (Board of Directors of the Fund) under the Chairmanship of the Minister and the membership of:

1- Secretary General of the Ministry, Vice-Chairman.
2- Secretary General of the Ministry of Environment.
3- Secretary General of the Ministry of Planning and International Cooperation.
4- Secretary General of the Ministry of Finance.
5- Commissioner nominated by the Chairman of the Board of Commissioners of the Commission.
6- Three representatives of the private sector with the appropriate expertise and competence appointed by the Council of Ministers upon recommendation of the Minister for a single term of four years.

b- The Board shall meet once every two months and whenever is needed upon an invitation from the Chairman or the Vice-Chairman if the former is absent. The meeting will achieve quorum if the majority of the members are present provided that the Chairman or Vice-Chairman are among them. The decisions are to be taken on the basis of vote majority.

Article 13- a- In order to achieve the objectives of the Fund, the Board shall have the following duties and powers:

1- Drawing the general policy of the Fund and presenting it to the Council of Ministers for endorsement, and laying down the necessary plans and programs for its execution.
2- Discussing and approving the annual report of the Fund's work.
3- Discussing the Fund’s draft annual budget and the year-end financial statements and forwarding them to the Council of Ministers for approval.
4- Preparing the Fund’s organizational chart and presenting it to the Council of Ministers for approval.

b- Terms and conditions related to control on the Fund's work and the principles to be followed in providing finance and expenditures therefrom shall be determined in accordance with a regulation to be issued for this purpose.

Article 14- a- The Fund shall have a Director appointed by decision from the Board upon a recommendation of the Chairman, and the services of the Director shall be terminated in the same manner thereof.

b- Duties and powers of the Director shall be determined by the Board upon a recommendation of the Chairman.

c- The Director shall represent the Fund before third parties.

Article 15- a- The financial resources of the Fund shall consist of the following:

1- The amounts allocated in the General Budget.
2- The Fund’s revenues and investment proceeds.
3- Aids, gifts, donations and grants subject to the approval of the Council of Ministers if they are from non-Jordanian sources.
4- Any other resources approved by the Council of Ministers.

b- The Fund shall enjoy all exemptions and facilities provided for Ministries and government departments.

c- The Fund’s money and rights are deemed public properties that are collected pursuant to the provisions of the State Properties Collection Law in force. To that end, the Chairman is empowered with all the powers vested in the Governor and the State Properties Collection Committee pursuant to the said Law.

d- The Audit Bureau shall audit the accounts of the Fund.

Article 16- In cases not prescribed in this Law, the provisions of the Electricity Law shall apply.

Article 17- The Council of Ministers will issue by-laws necessary for the execution of the provisions of this Law including the procedures and measures for energy conservation and energy efficiency in various sectors.

Article 18- The Prime Minister and the Ministers are charged with the enforcement of the provisions of this Law.

Appendix II [1]

Photovoltaic water pumping sites in Jordan - Some sites description

Tal Hassan

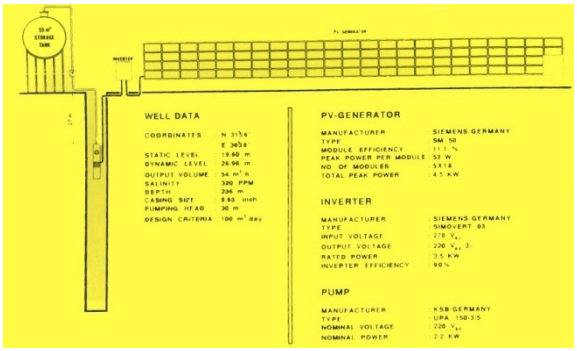
Tal Hassan Photovoltaic Water Pumping System Tal Hassan well is located in Al Zarqa governory 15 km from Al Azraq village. The photovoltaic pumping system was installed in September 1999 within the Eldorado international project. This system consists of a photovoltaic generaotr, a DC/AC inverter, a pump, and a water storage system. The photovoltaic generator consists of 108 PV modules type SM55 manufactured by Siemens Solar - Germany with a total peak power of 5.94 kW. The DC/AC inverter is a Simovert manufactured by Siemens Solar / Germany with a rated power of 7.5KVA. The pump used in this system is SP8A-37 manufactured by Grundfos/Denmark with rated motor power of 5.5 kW. The water storage system consists of two tanks with a total storage capacity of 110 m^3. This system is designed to supply the villagers, the Bedouins and their herds with about 40 m^3 /day. The project is partly supported by the German Federal Ministry for Research and Technology (BMFT) with 70 % subsidy of the system cost. Water Authority of Jordan has financed the rest 30 % in addition to drilling the wells and preparing all the necessary infrastructure. The system was installed and operated by the National Energy Research Center of Jordan (NERC).

Wadi El Ritem

Wadi El-Ritem Photovoltaic pumping system Wadi El Ritem well, 105 km east of Amman, is located to the left side of the main road between Amman and Azraq. This photovoltaic pumping system was installed and operated in the second half of 1992. It is designed to supply the Bedouins and their herds with an average daily yield of 100 m^3 of water. Wadi El Ritem system consists of an array of 90 monocrystalline PV modules type SM 50 manufactured by Siemens solar/Germany with a total peak power of 4.5 kW, a 3.5 KVA DC/AC inverter type Simovert P Solar manufactured by Siemens Solar/Germany, a 2.2 kW pump type UPA 150-3-5 manufactured by KSB/Germany and a 55 m^3 water storage tank. The project is supported by the German Federal Ministry for Research and Technology (BMFT) and the German Federal Ministry for Economic Cooperation (BMZ), and executed by the German Agency for Technical Cooperation (GTZ) in cooperation with Ministry of Water and Irrigation / Water Authority of Jordan (WAJ), and the Royal Scientific society /Renewable Energy Research Center (RERC). It is installed and operated by the Royal Scientific society /Renewable Energy Research Center (RERC) – currently named National Energy Research Center (NERC) This project has been equipped with a high tech data logger. All necessary data were collected every two seconds, averaged and saved on 10-

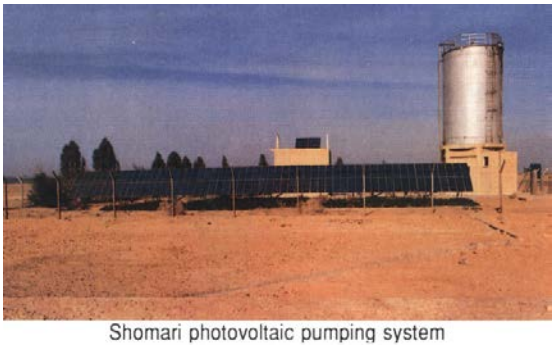
[1] *From the National Energy Research Center website:*
http://www.nerc.gov.jo/activitis/Photovoltaic/applications/Final/jordan_map2.html

minutes basis for a continuous testing period of 3 years. These data were subjected to detailed evaluation process and briefed in biannual evaluation reports submitted to GTZ and BMFT. As a result, data bank for PV water pumping systems is currently available for further applications.



Al Shomari

Shomari Photovoltaic pumping system Al Shomari well, 130 km east of Amman, is located to the right side of the main road Azraq – Umari at the distance of 14 km from Azraq town in the eastern part of the Jordanian desert. This photovoltaic pumping system was installed in August 1989. It is designed to supply the Bedouins and their herds with an average daily yield of 140 m^3 of water. Al Shomari system is divided into two identical PV sub-systems, each of which consists of an array of 56 polycrystalline PV modules type PQ 10/40/01 manufactured by AEG/Germany with a total peak power of 2.15 kW, a 3 KVA DC/AC inverter type Solarverter 3 manufactured by AEG/Germany, a 2.2 kW pump type NE62-4 manufactured by Pleuger /Germany and a 110 m^3 water storage tank (for both subsystems). Al Shomari system is a part of the joint project between Jordan – Royal Scientific Society and Egypt – the Academy of Scientific Research and Technology. This project is financially supported by the Jordanian Government. To optimize such PV water pumping systems and their components, a project between the RSS and the Higher council for Science and Technology (HCST) was carried out. This project aims at developing, manufacturing and testing a microprocessor control unit that connects, according to solar radiation intensity, one or two submersible pumps to a PV generator. Preliminary tests showed that utilization of such a unit will result in 19% increment in the daily pumped water quantity. This unit which showed a good performance during the laboratory testing, was installed in January 1994 within Al-Shomari PV pumping system to gather more data on its technical and economic feasibility, reliability, durability and lifetime. This project is installed and operated by the Royal Scientific society /Renewable Energy Research Center (RERC) – currently named National Energy Research Center (NERC).



Shomari photovoltaic pumping system

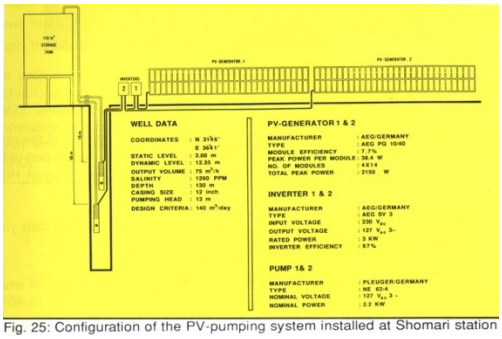


Fig. 25: Configuration of the PV-pumping system installed at Shomari station

Wadi El Buttom

Wadi El-Buttom Photovoltaic pumping system Wadi El Buttom well, 70 km east of Amman, is near the well-known tourist site of Qasr Amra in the eastern part of the Jordanian desert. This photovoltaic pumping system was installed in December 1991. It is designed to supply the Bedouins and their herds with an average daily yield of 50 m^3 of water. Wadi El Buttom system is divided into two PV sub-systems. Sub-system 1 consists of an array of 72 monocrystalline PV modules type SM 50 manufactured by Siemens/Germany with a total peak power of 3.6 kW, a 3.5 KVA DC/AC inverter type “Simovert P Solar” manufactured by Siemens/Germany, and a 2.2 kW centrifugal pump type ‘UPA 100B-4/12” manufactured by KSB/Germany. Sub-system 2 consists of an array of 36 monocrystalline PV modules type SM 50 manufactured by Siemens/ Germany with a total peak power of 1.8 kW, a 3.5 KVA, DC/AC inverter type Simovert P Solar manufactured by Siemens/Germany, a 2.2 kW screw pump type Monnppump 2 NQ14 manufactured by Netzsch/Germany and two 55 m^3 water storage tanks. The project is supported by the German Federal Ministry for Research and Technology (BMFT) and the German Federal Ministry for Economic Cooperation (BMZ), and executed by German Aerospace Research Establishment (DLR) and German Agency for Technical Cooperation (GTZ) in cooperation with Ministry of Water and Irrigation /Water Authority of Jordan (WAJ) and the Royal Scientific Society /Renewable Energy Research Center (RERC). It is installed and operated by the Royal Scientific society /Renewable Energy Research Center (RERC) – currently named National Energy Research Center (NERC) This project has been supplied with a high tech Data-logger where all necessary data were collected, saved and evaluated.

Wadi El-Buttom photovoltaic pumping station

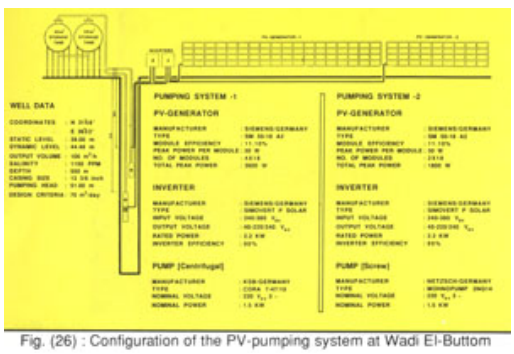


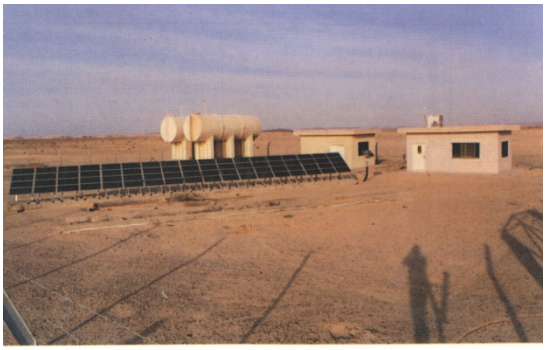
Fig. (26) : Configuration of the PV-pumping system at Wadi El-Buttom

El Hazeem

El Hazeem Photovoltaic water pumping system Al-Hazeem well, 150 km east of Amman and 50 km from Azraq Al-Janubi is located to the left-hand side (40 km) of the main road between Azraq Al-Janubi and Umari (Jordan – Saudi border). This system was installed and operated in January, 1987 to supply the Bedouins and their herds with an average daily yield of 110 m^3 of water. This system is divided into two PV-sub-systems. Sub-system 1 consists of a PV-generator manufactured by Setek/Japan with a total peak power of 1.764 kW, a 2 kVA DC/AC inverter manufactured by Grundfos/Denmark, a 1.1 kW submersible pump manufactured by Grundfos/Denmark. Sub-system 2 consists of a PV-Generator manufactured by Solarex/USA with a total peak power of 1.680 kW, a 2KVA DC/AC inverter manufactured by Grundfos /Denmark, a 1.1 kW submersible pump manufactured by Grundfos/Denmark Both systems have the same storage tanks of 100 m^3 (2*55m^3 each) . This project was supported by Ministry of Water and Irrigation/Water Authority of Jordan (WAJ), designed and executed by the Royal Scientific Society/ Renewable Energy Research Center (RERC) – currently named National Energy Research Center (NERC).

Al Hazeem Al-Dahek

Al-Hazeem Al-Dahek Photovoltaic pumping system Al Hazeem Al-Dahek well , 160 km east of Amman and 30 km from Azraq Al Janubi, is located to the left side (50 km) of main road between Azraq Al-Janubi and Umari (Jordan-Saudi border). This system was installed and operated in June 1992 to supply the Bedouins and their herds with an average daily yield of 77 m^3 of water. The system consists of a PV-generator (monocrystalline cells) manufactured by Siemens Solar/Germany with a total peak power of 3.6 kW, a 3.5 KVA DC/AC inverter type Simovert P Solar manufactured by Siemens Solar/Germany, a 2.2 kW submersible pump type UPA cora 7/12 manufactured by KSB/Germany and a two water storage tanks each 55 m^3 , This project is supported by German Federal Ministry for Research and Technology (BMFT) and the German Federal Ministry for Economic Cooperation (BMZ), and executed by German Agency for Technical Cooperation (GTZ) in cooperation with Ministry of Water and Irrigation /Water Authority of Jordan (WAJ) and the Royal Scientific Society /Renewable Energy Research Center (RERC). It is installed and operated by the Royal Scientific society /Renewable Energy Research Center (RERC) – currently named National Energy Research Center (NERC) This project has been equipped with a high tech data logger. All necessary data were collected every two seconds, averaged and saved on 10 minute basis for a continuous testing period of 3 years. These data were subjected to detailed evaluation process and briefed in biannual evaluation reports submitted to GTZ and BMFT. As a result, data bank for PV water pumping systems is currently available for further applications.



Al-Hazeem Al-Dahek PVP-station

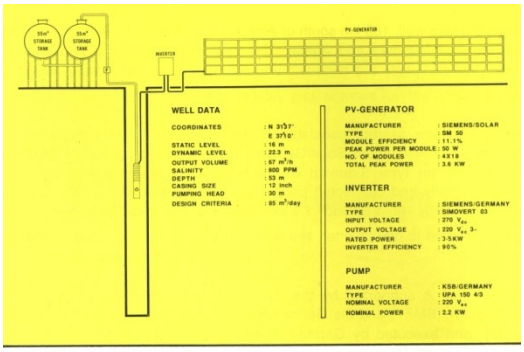
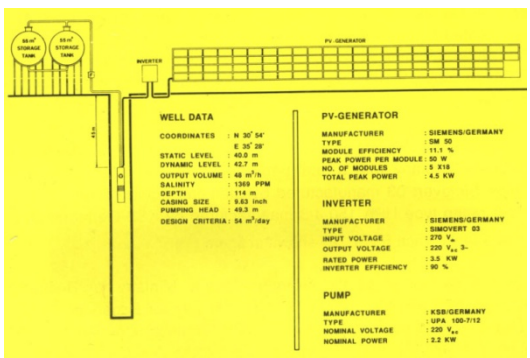


Fig. 19 : Configuration of Al-Hazeem Al-Dahek photovoltaic pumping system

Umrug 2

Umrug 2 Photovoltaic pumping system Umruk 2 well is located in Wadi Araba, about 175 km to the north of Aqaba. The photovoltaic pumping system was installed in the first half of 1992. This system consists of a photovoltaic generator, a DC/AC inverter, a pump, and water storage system. The photovoltaic generator consists of 90 PV modules type SM 50 manufactured by Siemens Solar/Germany with a total peak power of 4.5 kW. The DC/AC inverter is a Simovert P Solar, manufactured by Siemens Solar/Germany with a rated power of 3.5 KVA. The pump used in this system is UPA 100-7/12 manufactured by KSB/Germany with a rated power of 2.2 kW. The water storage system is designed to supply the villagers and their livestock with about 45 m^3/day. The project is supported by the German Federal Ministry for Research and Technology (BMFT) and the German Federal Ministry for Economic Cooperation (BMZ), and executed by German Agency for Technical Cooperation (GTZ) in cooperation with the Ministry of Water and Irrigation/Water Authority of Jordan (WAJ) and the Royal Scientific Society /Renewable Energy Research Center (RERC). It is installed and operated by the Royal Scientific society /Renewable Energy Research Center (RERC) – currently named National Energy Research Center (NERC) This project has been equipped with a high tech data logger. All necessary data were collected every two seconds, averaged and saved on 10 minute basis for a continuous testing period of 3 years. These data were subjected to detailed evaluation process and briefed in biannual evaluation reports submitted to GTZ and BMFT. As a result, data bank for PV water pumping systems is currently available for further applications.



Jafr 1

Jafr 1 Photovoltaic pumping system Jafr 1 well, 56 km east of Ma'an, is located in Jafr Village directly to the left side of the main road between Jafr and Azraq. This system was installed and operated in March 1992 to supply the Bedouins and their herds as well as the villagers and their livestock with an average daily yield of 66 m^3 of water. This system consists of a PV- generator type AEG PQ 10/40 /(later replaced by ASE50 – DGF) manufactured by TST/Germany (DASA) with a total peak power of 2.8 kW, a 3.0 KVA, DC/AC inverter type AEG SV3 manufactured by TST/Germany, a 1.5 kW submersible pump type pleuger NE 44-8 manufactured by pleuger/ Germany and two water storage tanks each 55 m^3 This project is supported by the German Federal Ministry for Research and Technology (BMFT) and the German Federal Ministry for Economic Cooperation (BMZ),and executed by German Agency for Technical Cooperation (GTZ) in cooperation with Ministry of Water and Irrigation/Water Authority of Jordan (WAJ) and the Royal Scientific Society / Renewable Energy Research Center (RERC). It is installed and operated by the Royal Scientific society /Renewable Energy Research Center (RERC) – currently named National Energy Research Center (NERC) This project has been equipped with a high tech data logger. All necessary data were collected every two seconds, averaged and saved on 10 minute basis for a continuous testing period of 3 years. These data were subjected to detailed evaluation process and briefed in biannual evaluation reports submitted to GTZ and BMFT. As a result, data bank for PV water pumping systems is currently available for further applications.

Jafr 1 PVP-station

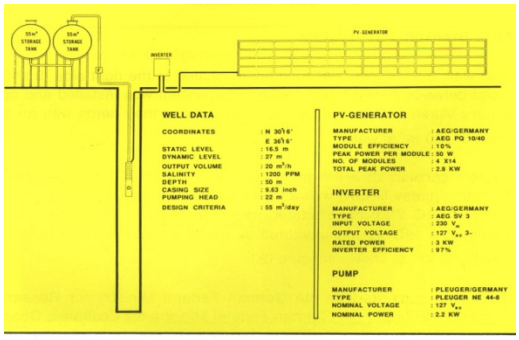


Fig. 22: Configuration of Jafr 1 photovoltaic pumping system

Jafr 7

Jafr 7 Photovoltaic pumping system Jafr 7 well, 56 km east of Ma'an, is located in Jafr village (3 km) to the right side of the main road between Ma'an and Jafr directly by Jafr village. This system was installed and operated in March 1992 to supply the Bedouins and their herds as well as the villagers and their livestock with an average daily yield of 64 m^3 of water. This system consists of a PV-generator type AEG PQ 10/40 /(later replaced by ASE50 – DGF) manufactured by TST/Germany (ASA) with a total peak power of 4.2 kW, a 3.0 KVA DC/AC inverter type AEG SV3 manufactured by TST/Germany, a 2.2 kW submersible pump type Pleuger NE 44-12 manufactured by pleuger/ Germany and two water storage tanks each 55 m^3 This project is supported by the German Federal Ministry for Research and

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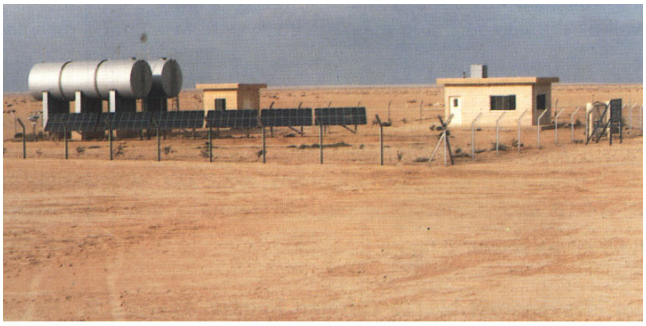

Jafr 7 PVP-station

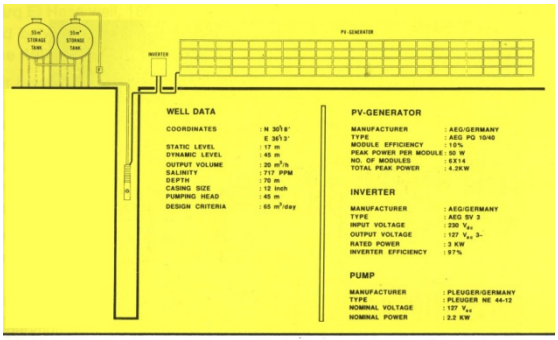

Fig.21 : Configuration of Jafr 7 photovoltaic pumping system

Rahmeh

Rahmeh Photovoltaic water pumping system Rahmeh well, 50 km north of Aqaba, is located to the right side of the main road between Aqaba and Gohr Al-Safi. This system was installed and operated in April, 1986 to supply the villagers and their livestock as well as the Bedouins and their herds with an average daily yield of 40 m^3 of water. This system consists of a PV-generator type SM 50 manufactured by Siemens/Germany with a total peak power of 2.226 kW, an 1.4 KVA DC/AC inverter manufactured by Grundfos/Denmark, an 1.1 kW submersible pump manufactured by Graundfos/Denmark and a 55 m^3 water storage tank. This project was supported by Ministry of Water and Irrigation / Water Authority of Jordan (WAJ), designed and executed by the Royal Scientific Society / Renewable Energy Research Center (RERC) – currently named National Energy Research Center (NERC).