Climate change mitigation and potential role of the Renewable Energy in Jordan

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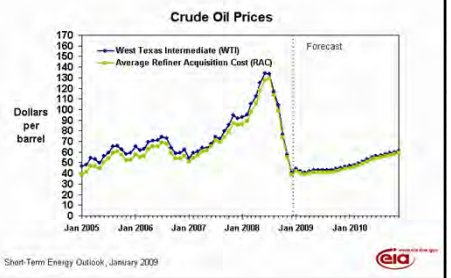
Abstract

- The World is facing an increased demand of energy in all its different forms.
- Energy is considered as an economical and strategic problem for countries, especially those which import oil, like Jordan.



Abstract

- The oil-importing developing countries in particular suffered from the sudden and dramatic rise and fluctuation in their energy bills.
- Traditional energy resources (fuel) are limited in Jordan.
- Therefore we are looking for other energy resources (renewable energies).

Abstract

- Jordan gave a great deal of consideration to the environmental-friendly technologies, and specifically to the utilization of renewable energies, especially solar energy and wind energy.
- Rural and remote areas in Jordan represent more than 80% of the total area of Jordan.

Abstract

- These areas lack from basic electrical and water networks.
- The yearly average of solar irradiance is 5.4 kWh/m^2.d.
- That makes Jordan a very attractive environment for solar applications.
- Besides, there are many promising wind potential areas in Jordan.

Abstract

- In Jordan there are an intensive efforts through our institution NERC and other bodies to contribute capacity building in the field of Photovoltaic systems and other alternative energies systems design and installation, to be aware of the new techniques in order to have the future installations in Jordan more efficient and reliable, contributing to achieve increased solar fraction of the total energy mixture in Jordan, and consequently, climate change mitigation.

Objective

- The aim of this presentation is to show the efforts done by Jordan government in the field of renewable energies utilization contributing in climate change mitigation through research institutions in Jordan since 70s, and to give a brief about the utilized renewable energy technologies and installations in Jordan.

Intended measures to achieve targets - Government

Short Term

- Issuing and activating the "Renewable Energy Law" by Ministry of Energy and Mineral Resources.
- Legislation should be included within the "Renewable Energy Law" to regulate the relationships between investors of renewable energies and National Electric Company for the purpose of connecting to the electrical grid.

Intended measures to achieve targets - Government

- Long Term
- Updating the atlas of solar radiation for the country.
- Issuing wind atlas to show the promising wind sites for wind farms installations.
- Issuing legislations to activate the principle of "Clean Development Mechanism", CDM. Take necessary actions to utilize this principle in funding renewable energy projects.

PV Installations (2006) and Projection till (2020) - Government

2006

- Capacity, 0.5 MW
- Produced Energy, 1 GW.hr
- Produced Energy 78 (TOE)
- Saving in Primary Energy 226 (TOE)

PV Installations (2006) and Projection till (2020)- Government

2020

- Capacity, 10 MW
- Produced Energy, 18 Gw.hr
- Produced Energy, 314 (TOE)
- Savings in the primary Energy 905 (TOE)

Wind Installations (2008) and Projection till (2020) - Government

- 30 – 40 MW wind farm in Al –Kamsheh to the north of Jordan is now to be erected, in addition to two already existed farms in the north with total capacity of about 2 MW.
- The government target is to have 300 MW installed in 2015 and 600 MW installed in 2020, and the promising sites were chosen to install these capacities.

Intended measures to achieve targets - Government

- Facilitate the establishment of Silicone, PV and hydrogen factory, and construction of PV erected factory with a capacity of 1000 kW. The idea behind this project is to supply the energy demand for the factory and sell the excess of electricity to national network. A MoU was signed by the Ministry of Energy and Mineral resources in Jordan (MEMR) with the German firm "City Solar" for this purpose.

Intended measures to achieve targets - Government

- To exempt pv systems and components from governmental sales tax and customs.
- Accreditation of PV systems lab. At NERC (National Energy Research Center) by Jordan Institution for Standards and Metrology for the purpose of PV testing and systems imported from outside Jordan.

Clear days and sunshine hours average numbers (NERC Measurements)..

Month	Average No. of clear days	Average No. of hours of sunshine
January	20	232
February	22	260
March	24	296
April	25	275
May	25	348
Jun	30	405

Clear days and sunshine hours average numbers - Study

Month	Average No. of clear days	Average No. of hours of sunshine
July	31	380
August	31	390
September	29	334
October	25	280
November	26	264
December	22	233

National Energy Research Center (NERC) www.nerc.gov.jo

The National Energy Research Center (NERC) has been established in Jordan for the purposes of research, development and training in the fields of new and renewable energy and raising the efficiency of using energy in the different sectors of the economy.

Center's Divisions

Photovoltaic division.

Wind energy division.

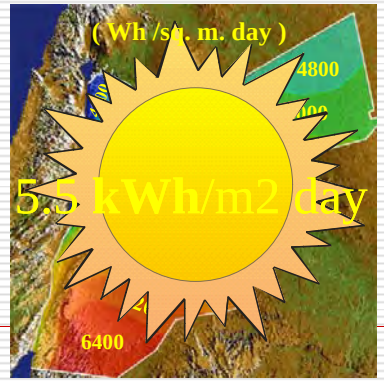
Rational use of energy & solar thermal division.

Oil shale and bioenergy division.

Photovoltaic division

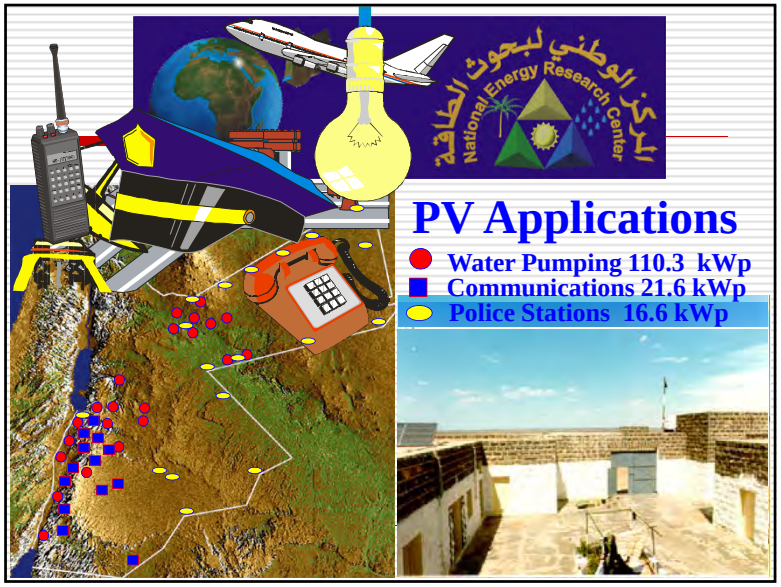
The Photovoltaic division in NERC aims at national capacity building in the field of photovoltaic and its applications through research & development, PV systems installations, training and consultations in cooperation with international, regional and local sides.

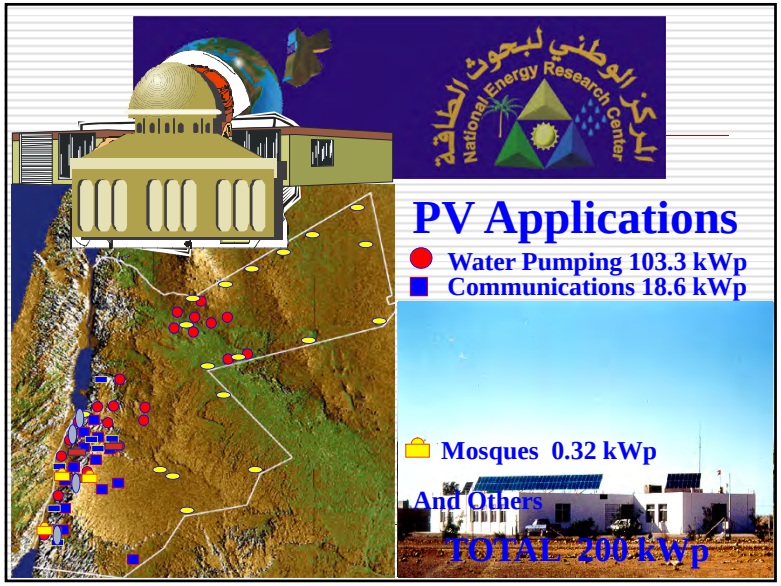
Annual Mean of Average Daily Total Horizontal Solar Radiation



Photovoltaic division

- The main task of PV division in NERC is utilizing the solar energy and converting it into electricity for different applications in remote areas (rural electrification, water pumping, and water desalination), besides, preparing solar atlas for Jordan.





PV Installations in Jordan

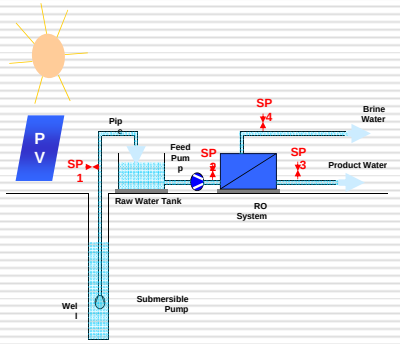
- TOTAL Installations by NERC of about 200 kWp
- And by all institutions and companies in Jordan the total is about 500Wp

Recent Installations/Mulgan

- PV array: consists of-10 years old- 40 modules, type (BP275) each rated at 75 Wp, (3000 Wp total).
- The PV generator is divided into two- 20 modules- sub arrays, each sub array is divided into 5 parallel strings with 4 serious modules in each string.

Brackish water reverse osmosis desalination facility – Aqaba City

- A well with 100 m depth was drilled by the Water Authority of Jordan (WAJ) in the chosen site to extract brackish water over the life of the project.

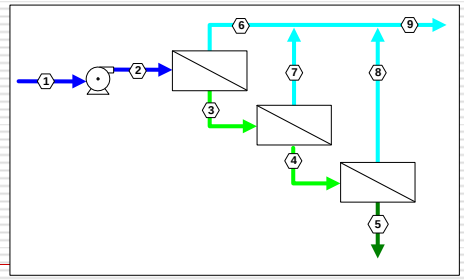


Brackish water reverse osmosis desalination facility – Aqaba City

- In addition to the installed solar power supply system (16.8 kWp) of the RO facility, a utility grid connection was obtained to be used to operate the RO facility up to 24 hours per day to produce 70 m3 of potable water.

Brackish water reverse osmosis desalination facility – Aqaba City

- Flow rate: 15 GPM (3.4 m3/h) of fresh water at a recovery ratio of 60 %



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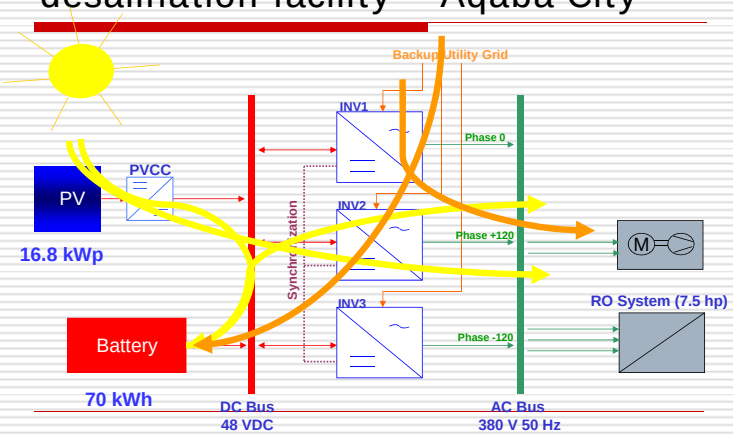

Brackish water reverse osmosis desalination facility – Aqaba City

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Brackish water reverse osmosis desalination facility – Aqaba City

Research projects..

- "Integrated Water & Power Points in Jordan (IWPP)" supported by the Higher Council for Science & Technology. (Amman-Jordan). Upgrading the equipment and data acquisition system of the PV systems Laboratory (2005-present).

Research projects..

- National solar radiation measurements project supported by the Ministry of Planning & International Cooperation-Jordan (2005- present).

Research projects..

- Design, offering, ordering, installation, and commissioning of a hybrid (Photovoltaic, diesel) generator to supply a telecommunication station with electric power.

Research projects..

- Maintenance and troubleshooting of a hybrid (Photovoltaic, Grid) powered brackish water pumping and desalination station, using reverse osmosis technology
- Installation and observation of several solar irradiance measuring stations, for the purpose of preparing a detailed solar atlas for Jordan through (IWPP) Project mentioned above.

Research projects..

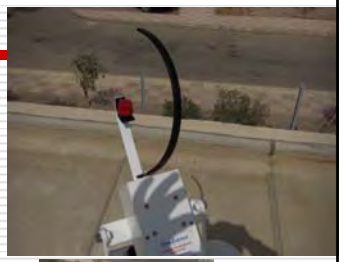
- Design and manufacturing a solar powered (Photovoltaic) agricultural multipurpose tractor.
- Maintenance and troubleshooting of 22 solar powered (Photovoltaic) water pumping stations in different sites in Jordan.

Research projects..

- "Optimal Engineering Design for Dependable Water and Power Generation in Remote Areas Using Renewable Energies and Intelligent Automation“ (OPEN-GAIN) / The main objective of this project is to develop a new model-based optimal system design approach to economically improve the overall performance, dependability, reliability and availability of co-generating water-electricity plants powered by renewable energy for remote arid areas using high level of automation to meet specific cost requirements.

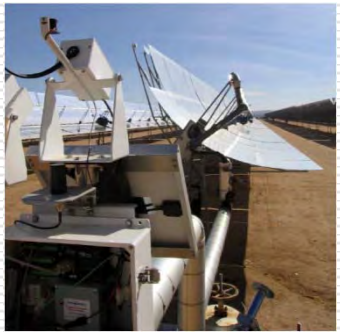
Research projects.

- "Concentrated Solar Power & Desalination“
- The main objective of this project is to obtain cost-effective and durable technical solutions for the use of solar energy in large scale solar desalination applications using real solar irradiance data,



Research projects..

as important step towards the construction of a pilot solar desalination plant.



Research projects..

- PV powered Reverse Osmosis (PVRO)-Systems will be compared with Non-Concentrating Solar Collector driven Thermal Desalination (NCTD)-Systems as well as with Concentrating Solar Power (CSP) driven RO/TD Systems (CSPD).

Wind Energy Division

The Wind Energy division in NERC aims at national capacity building in the field of wind energy and its applications through research & development, wind generators installations,

Wind Energy Division

training and consultations in cooperation with international, regional and local sides, besides, preparing data base for wind promising sites in Jordan and preparing wind atlas.

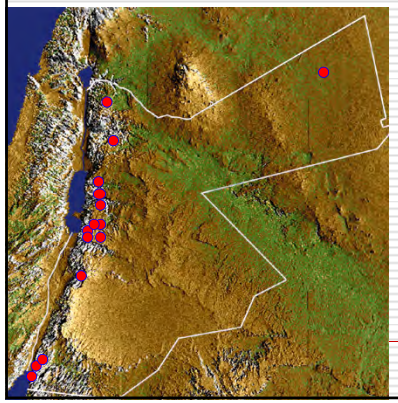
Wind Energy..

- Preparation of wind data base: Due to the lack of reliable wind data in Jordan, NERC is conducting wind measuring campaign in the promising sites in Jordan as a first stage based on the availability of wind measuring systems at different height (10,30, 40) meter above ground level.

Wind Energy..

- Twelve systems are installed at the following sites north and south of Jordan which are shown on the Map

Wind Measuring Systems

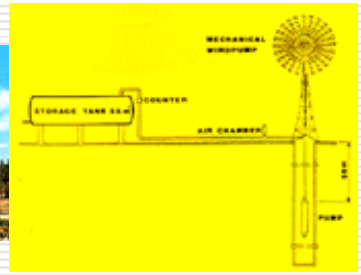


Hofa **Kamsha**
Fakoe **Zabda**
Tafila **Fujaij1**
Fujaij2 **Fujaij3**
Fujaij4 **Fujaij5**
Al Rajif **Aqaba1**
Aqaba 2 **Aqaba 3**
Al Reesheh

Water pumping/Wind Pumping Systems

- Mechanical wind pumping system was developed locally and was internationally tested and certified by Germanischer Lloyd (GL). It is transferred to Jordan industry for manufacturing and distributing in Jordan and neighboring countries.

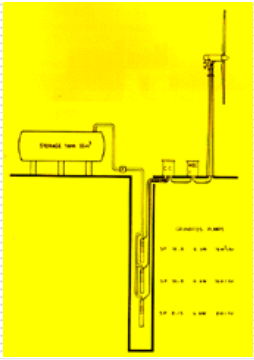
Mechanical Wind Pumping System



Mechanical Wind Pumping System

- Type : Locally made
- Rotor diameter : 7.5 m
- Tower height : 12 m
- Pump type : piston pump (Single acting)

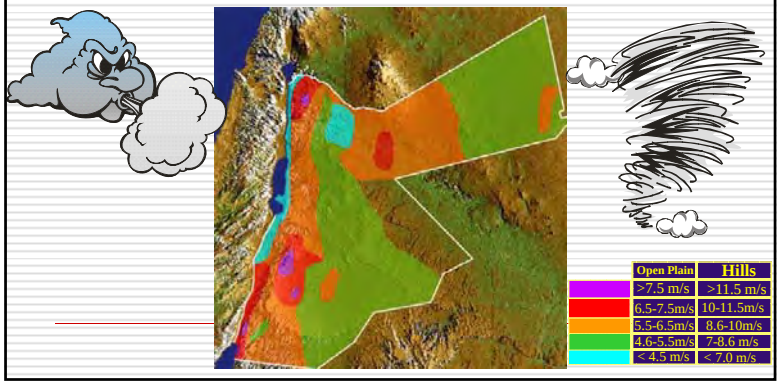
Electrical wind pumping systems



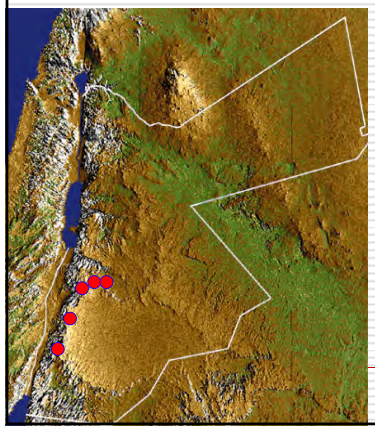
Electrical wind pumping systems

- Type : Aeroman
- Electrical generator : 17 kVA
- Rotor diameter : 12.5 m
- Tower height : 15 m
- Pumps type : electrical, submersible

Wind Resources at 50 meters above ground level



Wind Pumping Stations



Jurf El-Daraweesh
Twana
Elaka
Hamad 2
Althaghra

MWPS at Jurf

Static Water level : 50 m

Consumers : inhabitants & Cattles

Rotor Diameter : 7.5 m

Tower Height : 12 m

Pump Type : Piston Pump

Electrical WPS at Jurf

Static Water level : 50 m

Consumers : inhabitants & Cattles

Rotor Diameter : 12.5 m

Elec. Generator : 17 KVA

Tower Height : 15 m

Pump Type : 3 electrical submersible pumps

MWPS at Twaneh

Static Water level : 20 m

Consumers : inhabitants & Cattles

Rotor Diameter : 7.2 m

Tower Height : 9 m

Pump Type : Piston Pump

MWPS at Elaka

Static Water level : 1.9 m

Consumers : Animals in the region

Rotor Diameter : 4 m

Tower Height : 9 m

Pump Type : Piston Pump

MWPS at Hamad 2

Static Water level : 12 m

Consumers : inhabitants & Cattles

Rotor Diameter : 6 m

Tower Height : 9 m

Pump Type : Piston Pump

MWPS at Thaghra

Static Water level : 7 m

Consumers : inhabitants & Cattles

Rotor Diameter : 6 m

Tower Height : 9 m

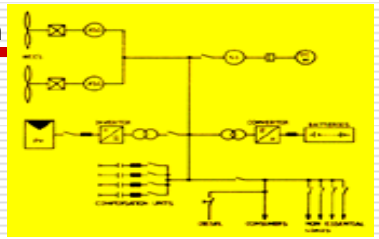
Pump Type : Piston Pump

Electrification of Jurf

Hybrid Power Supply system

Installed in 1987

The village was connected to National electric Grid in 1996



Consists of:

- Two 20 KW WECs type AEROMAN
- 10.176 KWp PV generator
- 330 KWh storage battery block

Oil Shale and Bio- Energy in Jordan

- **1. Oil shale**

Oil shale is the most abundant fossil energy resource discovered in Jordan. The proven reserves are about 50 billion tons capable of yielding some 50 billion barrel of crude oil. Several oil shale studies have been conducted for either direct burning through circulating fluidized bed boilers to generate electricity or through pyrolysis retorting methods to extract liquid petroleum. Retorting tests have shown the oil yield is 10% and the gas yield is 5% by weight. Moreover, studies have indicated that oil shale commercialization would be feasible once oil prices rise to more than $35/bbl.

Oil Shale and Bio- Energy Activities

- **Services**
- Conduct R&D in the technologies of combustion and retorting to develop different oil products.
- Manage and operate demonstration projects, laboratories and research units through cooperation with concerned institutions.
- Provide technical consultation and information for the growing oil shale industry.
- Setting national master plan for oil shale development and best utilization methods in cooperation with local and international institutions.

Oil Shale

- **Research**
  - Conduct a study of organic solvent extraction of oil from rock composites using soxhlet extractors.
    - Conduct a study of oil shale ash utilization in the construction materials.
    - Study the process of oil shale firing using CFB.
    - Conducting several retorting tests on a lab scale unit.

Oil Shale

- **Projects**
- Design and construct a small fluidized bed burner rated 10 kg per hour to burn oil shale.
- A three-year cooperative research and development agreement with The Higher Council for Science & Technology (HCST) has been signed to implement oil shale research extraction and conversion (retorting) program.

Oil Shale

- **Success Story**
- Shale oil is being extracted for the first time in a lab scale retorting apparatus.
- The successful firing of oil shale in a self sustainable manner using CFB.

Oil Shale and Bio- Energy Division

- **2. Bio- Energy**
- **Services**
- Adopting appropriate technology of bio-energy like biogas, biomass, and biofuels to widen its utilization for energy and environmental benefits and increase their contribution in the total energy mix.
- A capacity building and raising awareness by training and information dissemination.
- Design and installing small biogas units with a capacity of 1 kW and fed by animal organic waste for the purpose of generating electricity and/or farms heating, and improving environmental and hygienic conditions.

Bio- Energy

- **Research**
- Conduct studies of the costs of the energy unit generated from biogas. As a case study, biogas plant in Rusaifa, had been studied and concluded that there was a potential of 30 MW electrical generation. The proposed technology was economical and requires digging holes inside the body of the landfill and sucking the biogas and burns it in internal combustion engine. The electricity cost of this method was estimated by 20 fills per kWh.
- Conducting studies about bio-diesel production from energy crops.
- Studies to design small biogas units of 1 kW capacity for animal farms.
- Studies to convert biomass like olive cake and organic waste into energy.

Bio- Energy

- **Projects**
- The biogas project in Rusaifa is the first of its kind in the Middle East region with a capacity of 1 MW and expanded up to 3.5 MW in the year 2006**.**
- A capacity building and training program has been implemented with the following activities:
- Information Dissemination and Awareness in cooperation with Jordan Environment Society (JES).
- Solid Waste Recycling in cooperation with Jordan Environment Society (JES).
- Implementing a Training program for the country in which 243 engineers, technicians and environmentalists were trained.
- Curriculum modification and lab up-grading by JUST.
- Biogas and solid waste management master plan.

Bio- Energy

- **Success Story**
- The Biogas plant at Russaifa has proved success as an environmentally sound and efficient technology that utilizes municipal solid waste for the production of electricity and bio-fertilizer. The plant was operated in the year 2000 to produce 7 million kW.h yearly. Based on the success of this project, the capacity was extended to 3.5 MW and funded by Greater Amman Municipality.

The Rational Use of Energy and Solar Thermal Division

- **1. The Rational Use of Energy**
- The Rational Use of Energy Division in National Energy Research Center has been established since the beginning of 1990s for the purpose of research, development, training and raising the efficiency of using energy in the different economic sectors.

The Rational Use of Energy

- The division was staffed with a team of qualified engineers who were trained by international experts and equipped with all needed instruments to carry out all measurements needed for the energy auditing

The Rational Use of Energy

- **Services**
- Conducting free preliminary energy studies at factories, hospitals and hotels to specify the energy saving potential in the facility.

The Rational Use of Energy

- Perform detailed energy audits which include collecting energy, water and production data from the establishment and conducting detailed measurements for the energy consuming equipment. At the end of the study, a detailed report which includes analysis of the current energy situation in the establishment and the needed actions to be taken to improve the energy use efficiency in the form of specific "energy projects" which if implemented will yield the calculated savings.

The Rational Use of Energy/Services

- Implementation of energy projects and assists in obtaining providing financing if needed in cooperation with a consortium of seven local companies in addition to a local bank led by NERC.

The Rational Use of Energy

- Projects
- The division had and is currently implementing many international applied research projects

The Rational Use of Energy

- Success Story
- "Fixing Compressed Air Leaks Saves the Operation of a 110 kW Compressor".
- This study was carried out in one of the apparel factories in Jordan in January 2006. The plant comprises 4 air compressors. All 4 compressors are screw type. The maximum working pressure was 7.5 bar.

The Rational Use of Energy

- Compressed air is used extensively in the plant especially in washing area, packaging area and sand blasting area. It was noticed that there are many compressed air leaks in the plant. A No-Load leakage test was conducted in the plant on one of the Fridays, where the production in the plant was completely stopped. The test was conducted for each area separately.

The Rational Use of Energy

- The test showed that the leakage in the washing area is 6.615 m3/min, while the leakage in the packaging area is 12.285 m3/min, which means that the total amount of leaking air is 18.9 m3/min. This amount is equal to the Free Air Delivery (FAD) of one of the large compressors in the plant, which is of 110 kW capacity.

The Rational Use of Energy

- This compressor operates only to make up the leaking air. So if 90% of the leaking points were fixed, the annual saving resulting from this measure is 37 800 JD.

The Rational Use of Energy

- The process of fixing the leaks has started in the plant. The priorities of the leaks to be fixed were determined, and a complete ongoing program for leaks fixing was established.

The Rational Use of Energy and Solar Thermal Division

- Solar Thermal
- NERC conducts research & development and demonstration projects providing technical consultations in the field of solar energy, it also aims at developing the appropriate equipment and systems for application in Jordan and know-how transfer of solar energy applications.
- NERC's main field of expertise in the field of solar thermal energy extends to:
- Solar desalination.
- Solar water heating systems for domestic, commercial and industrial applications.
- Solar water system for heating of swimming pools.
- Solar space heating and cooling.

Solar Water Heater Story in Jordan

1970 RSS designed and produced pilot systems.

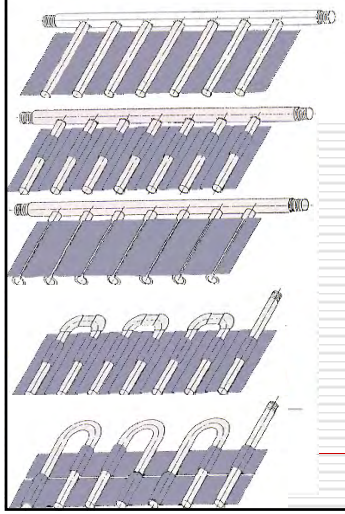
1973 Two local workshops produce 50 units a year

1986 12% of all dwellings in Jordan use solar water heaters.

1992 more than 20% of all houses in Jordan use solar water heaters (about 158,700 units)

2000 25 workshop and factories producing 10,000 units annually (40,000 m2 of solar collectors) for local market and export to neighboring countries.

Development of Flat Plate Collectors



Different models were designed, constructed and Tested to increase the efficiency by improving the contact between the risers and absorber plate and to increase lifetime by eliminating unnecessary welding.

Development of Flat Plate Collectors

Testing of flat plate Collectors was essential for the Development and useful for the Industry. As a result, a simple and effective methodology for the development of flat plate collectors is developed.

Solar Water Heater Impacts

Employment:

250 employees in workshops and factories producing solar water heater = 0.3 % of the total work force in the industrial sector in Jordan.

Thank You