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Joint ICTP-IAEA Workshop on Vulnerability of Energy Systems to Climate Change and Extreme Events

19 - 23 April 2010

Technical and economical assessment of the utilization of photovoltaic systems in residential buildings: the case of Jordan

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Jordan

Joint ICTP/IAEA Workshop on Vulnerability of Energy Systems to Climate Changes and Extreme Events, ICTP, Trieste, Italy, 19 - 23 April 2010

Red Sea-Dead Sea Conduit

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Amman - Jordan

Introduction

- Jordan is an arid to semi-arid country with land area of 90,000 km^2 located to the east of the Jordan River.

- Jordan is known to be one of the most water scarce countries in the world. The average total quantity of rainfall is approximately 7200 MCM/year.

- Approximately 85% of the rainfall evaporates back to the atmosphere, the rest flows in rivers and wadis as flood flows and recharges groundwater.

- The adoption of non-conventional sources (e.g. desalination) for water supply reinforcement is inevitable in the near future for Jordan's sustainable development.

- Desalination of seawater from the Red Sea might be economically feasible by efficient use of non-conventional energy resources in Jordan such as Hydropower and solar technologies.

- The Red Sea-Dead Sea canal will feed water to Dead Sea in addition to produce power and desalinated water to the region covered by the Red Sea-Dead Sea area.

Current Water Situation in Jordan

- Jordan is considered to be one of the 4 poorest countries worldwide in water resources.
- The available renewable water resources are dropping drastically to an annual per capita share of 140 m^3 in recent years, compared to 3600 m^3/capita in 1946.
- Predictions are that by 2025 water supplied will exceed available renewable resources by 33%

Fig(1): Zarqa's River in Jordan

Fig(2): Jordan's once fertile land has painfully turned into hostile terrain

- Typical water related problems in Jordan include:

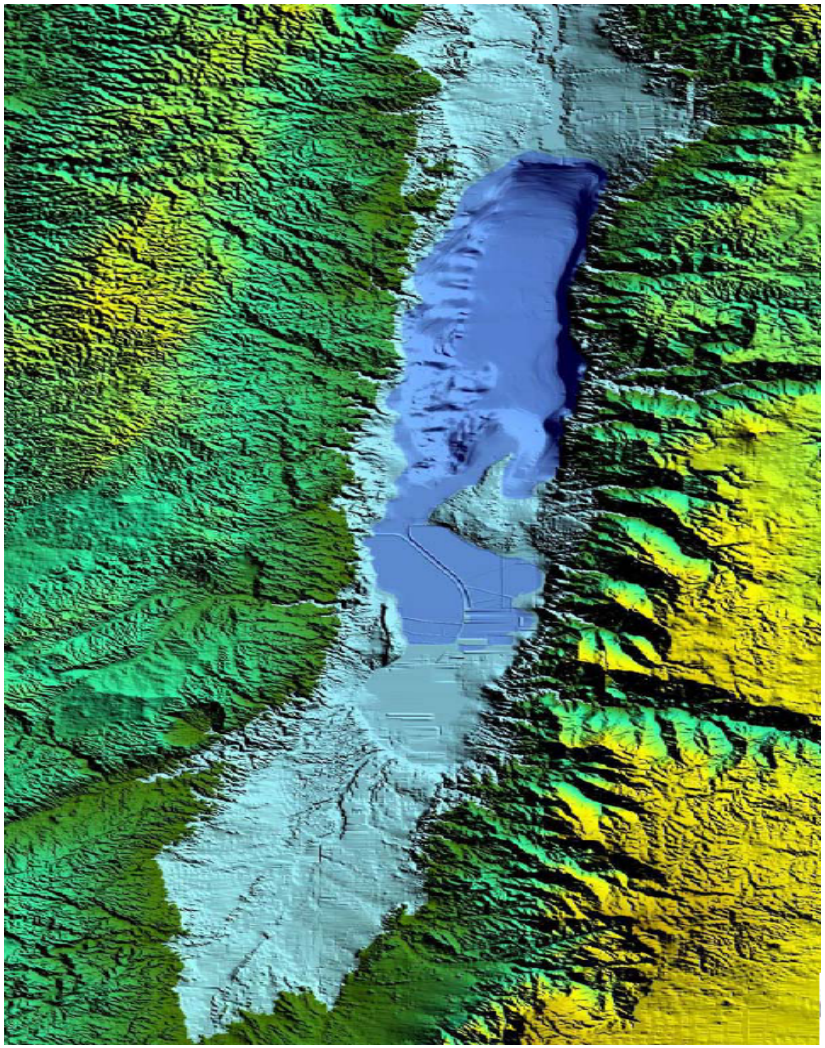
1. The inefficient management of national water resources;
2. Subsidized water to end users;
3. Poor aquifer and surface water quality;
4. Inefficient irrigation networks, illegal water use;
5. Inefficient use of irrigation water.

- Jordan has adopted a National Water Strategy that stresses on the need to tap the full potential of surface and ground water to a feasible extent.

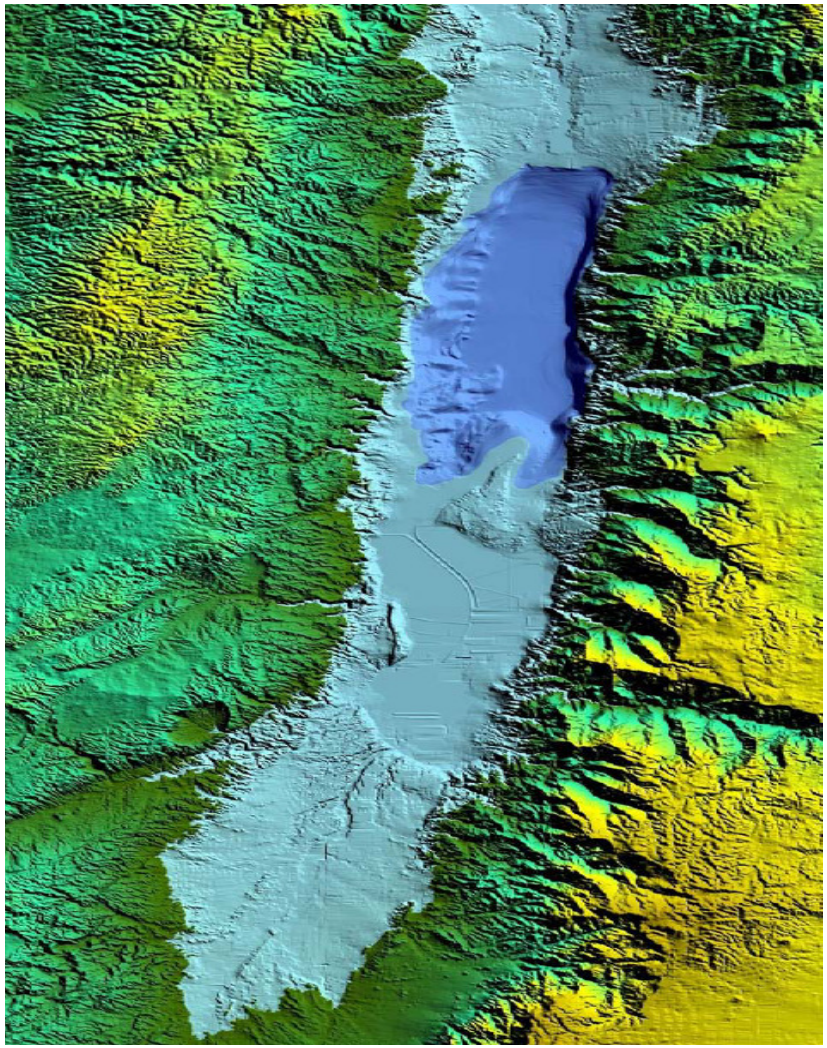
Dead Sea Problem

- The Dead Sea constitutes the lowest point on earth.
- The level of the Dead Sea has declined from -395 m below sea level to -420 m in the last 50 years causing damages to the entire eco-system of the Dead Sea basin
- Current rate of decline is about 1m/year
- Inflow of water has decreased from 1,300 MCM/year in the 1930's to approximately 300 MCM/year in 2000.

a



b



- Fig.(7): Reduction in the Dead Sea surface area: (a)-329m (b) -410 m

c

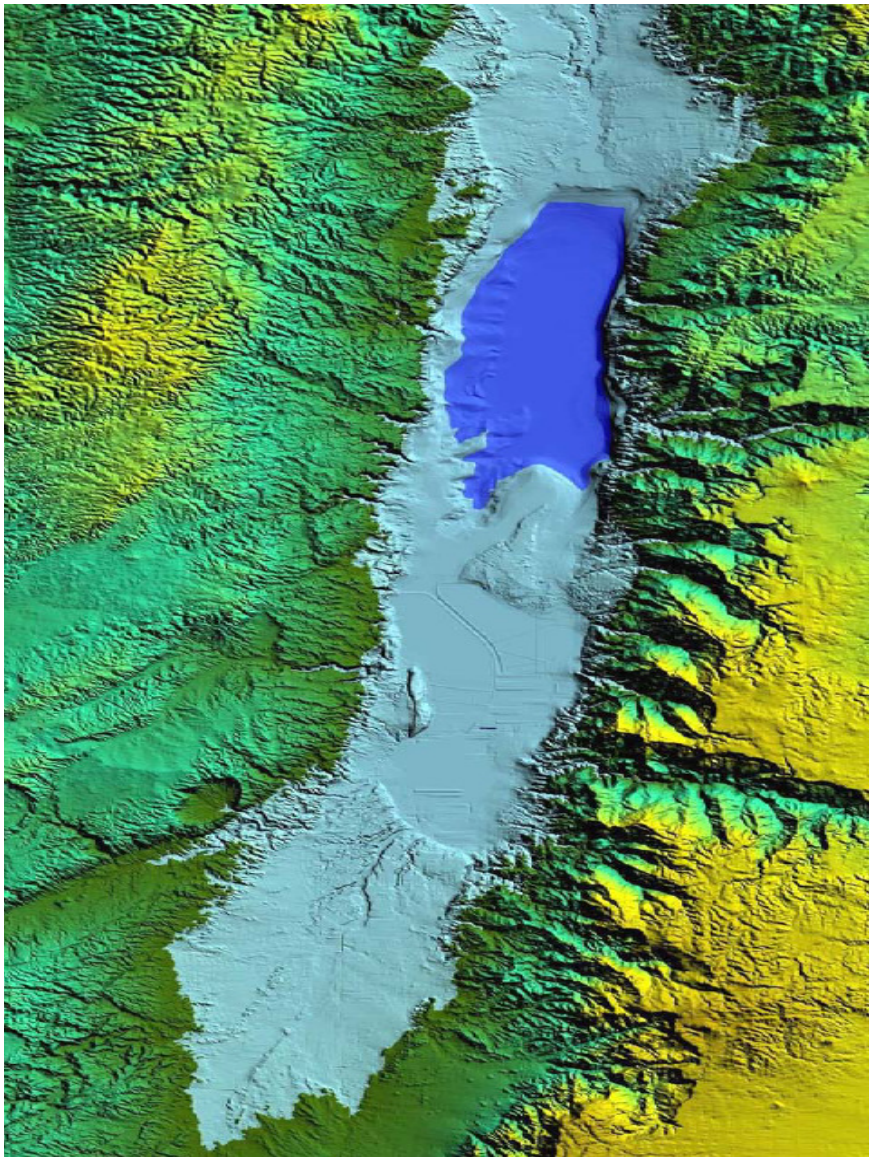


Fig.(7): Reduction in the Dead Sea surface area: (c): -550m

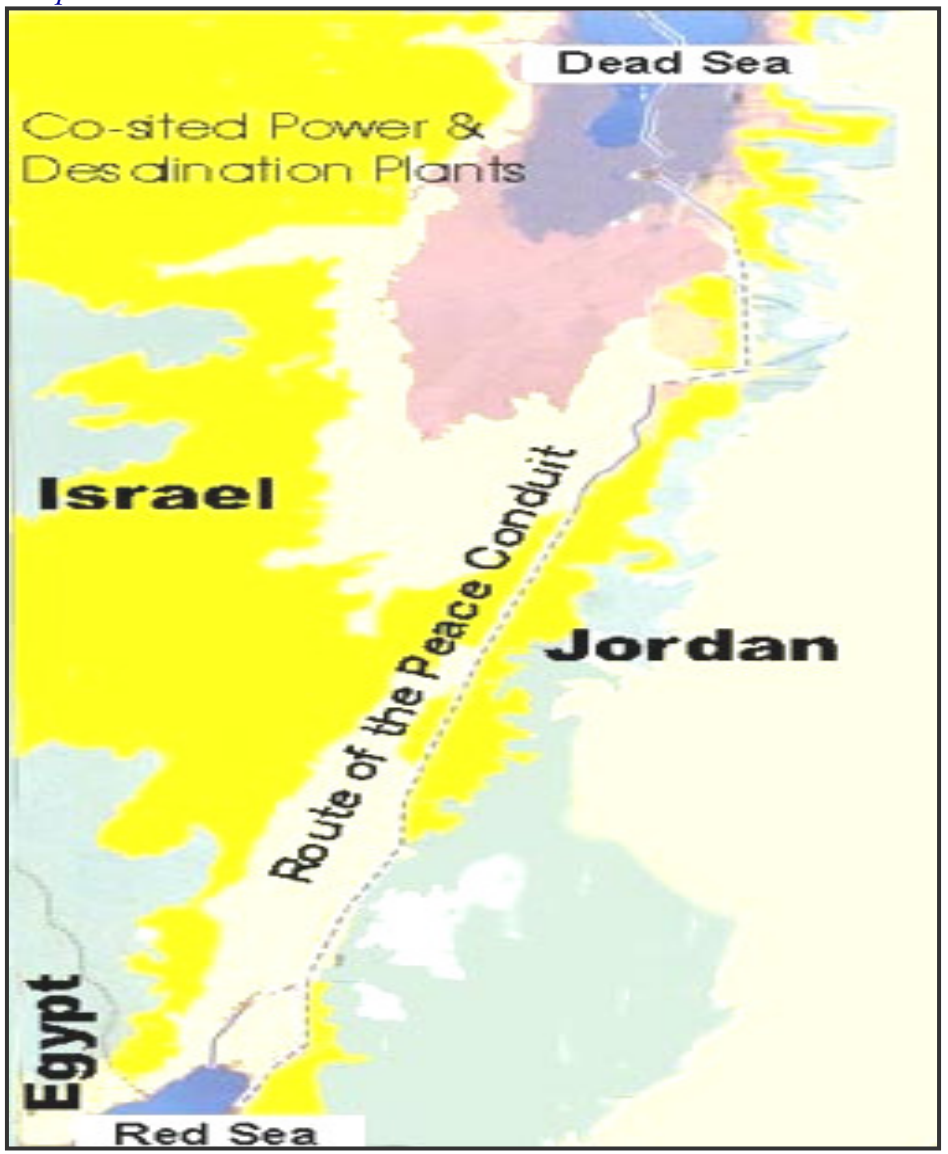
A grave environmental damage has ensued to the land and ground water resources surrounding the Dead Sea.

Fig(9): (a) exposure of large mudflats (b) shrinkage of the lake

- Fig(9): (c): Development of sinkholes

Alternative

- The Dead Sea is drying up, with severe negative consequences on the ecosystem, industry and wildlife in the area.
- There have been several proposals for a canal to transport Red Sea water to the Dead Sea (Peace Conduit).



Fig(10): Red Sea-Dead Sea Conduit

The Red Sea-Dead Sea Conduit alternative Harza Study

- The idea of connecting the Dead Sea to the Mediterranean goes back to the 19th century, when engineers suggested the possibility of using the natural elevation difference between the two seas to produce hydroelectric energy.

- After one century an industrial engineering group from Chicago (Harza) introduced this canal and made an estimation to the whole project.

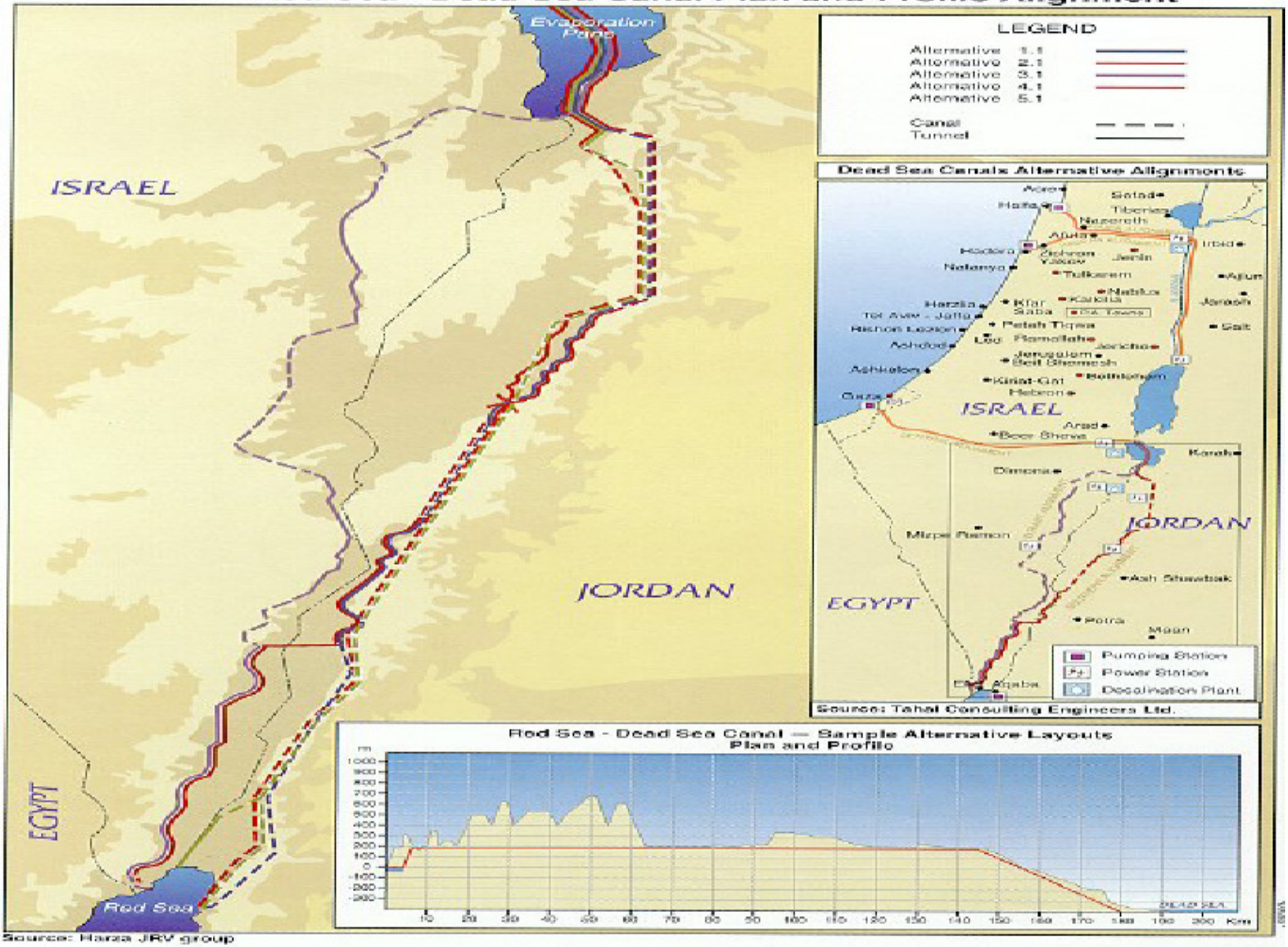
Impacts of Conduit Project

1. Preservation of the historical and environmental values of the region.
2. Introducing a solution to regional water problems, economics such as tourism and industry.
3. It will exploit a unique renewable energy source (400 m drop to generate hydro-power energy).
4. Energy will create new source of fresh water

Paths for The Canal

- First. path passes throw the Jordanian land from Aqaba the Dead sea
- The other one form Eylat to the dead sea
- The third from Mediterranean sea to the dead sea, where the water desalination depends on the reveres osmosis

JRV - Red Sea - Dead Sea Canal Plan and Profile Alignment



Source: Harza JRV group

Harza Study Principles

- The Harza plan is based on two principles:

1. The location of the Dead Sea which is 400 m below the level of the Red Seas.
2. the canal project would take advantage of the natural drop to restore the lake to its normal level.

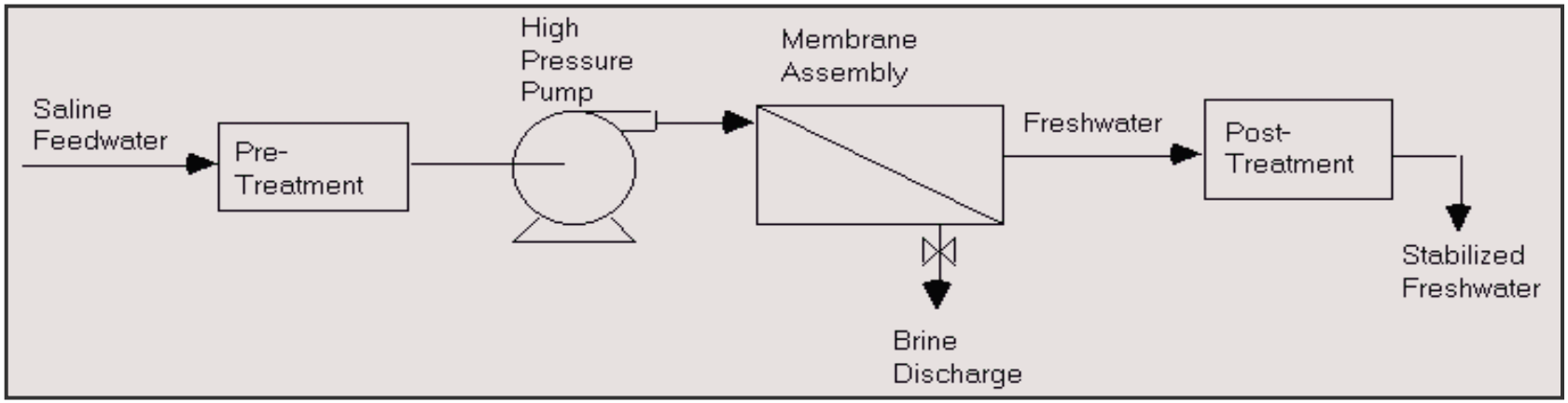
- The harza design consists of power generation and water pumping stations on the path that passes throw the Jordanian land from Aqaba to the Dead Sea, where the water desalination depends on the reveres osmosis.

Main Ideas of the Study:

1. Up to 1900 MCM/ year sea water will be pumped from Red Sea via pipelines.
2. Length of Conduit: 180km.
3. Desalination of 800 to 850 MCM/year fresh water with 20 to 300 mg/l TDS.
4. 45% of the sea water will be recovered as fresh water
5. Generate hydroelectric power.

Desalination Process

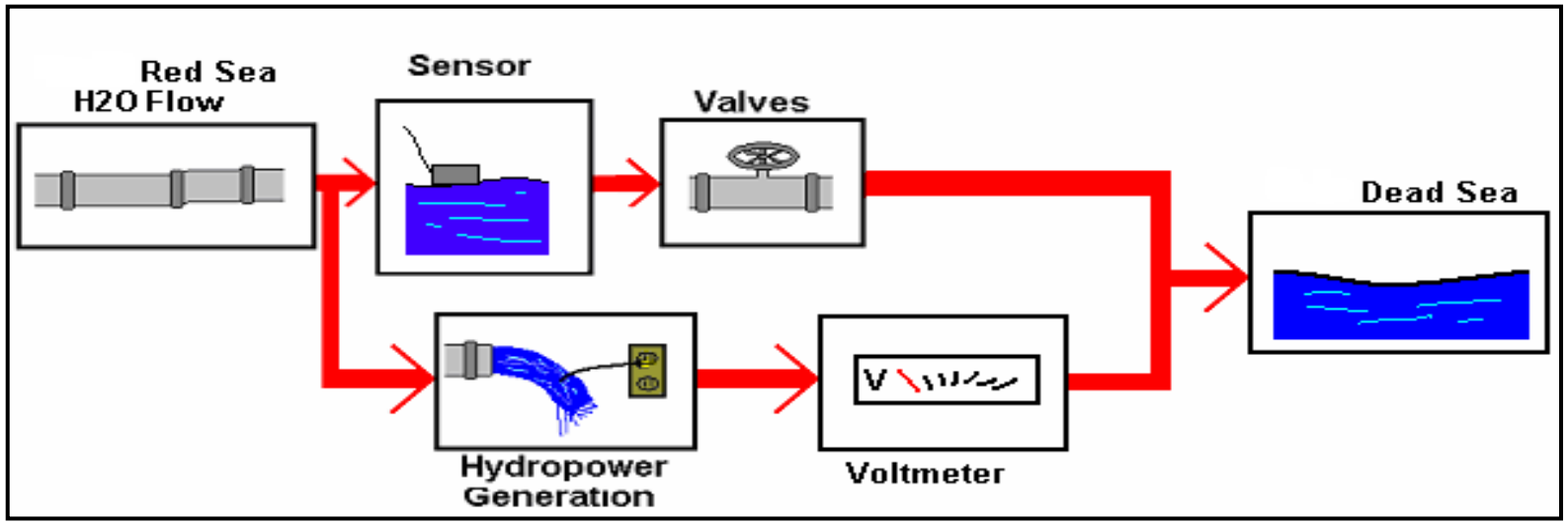
- Desalination is a separation process used to reduce the dissolved salt content of saline water to a usable level.
- There are two types of membrane process used for desalination: reverse osmosis (RO) and electrodialysis (ED).



Fig(12): Desalination Process

Hydropower Generation

- The basic principle of hydropower is that if water can be piped from a certain level to a lower level, then the resulting water pressure can be used to do work on mechanical component which can be used to derive electrical generators



Fig(14): Hydropower Generation Process

Evaluation of the canal project from different aspects

- The RSDSC is the most expensive alternative between the three paths. the construction cost around 5x10^9 US$ and annual operational cost around 5x1^6 US $
- The economic benefit to tourism from both sides would amount to $320 million.
- The value of income from energy production for the first 18 years would be $80 million

Evaluation of the canal project from different aspects

- The dilution of the Dead Sea water mass with sea water may cause losses for Arab Potash Company.
- The saltwater may leak to the groundwater contamination

- The save of the external sources of energy in these projects is around 22% only taking into account the pumping of the desalinated water to Amman and Jerusalem

Conclusions

- The Dead Sea is a severely disturbed ecosystem, greatly damaged by anthropogenic intervention in its water balance.
- During the 20th century, the Dead Sea level dropped by more than 25 meters, and presently it is at about 416 meters below mean sea level.
- This negative water balance is mainly due to the diversion of water from the catchment area of the lake by neighboring countries.
- The concept of the Inter-Seas Project is based on the exploitation of some 400 metre difference in height between sea-level and the Dead Sea for the desalination of the water and the production of hydroelectric power.

Conclusions

- The country's annual water demand currently exceeds 1 billion m^3 and is projected to rise to over 1.3 billion m^3 by 2005.
- Water desalination by using solar energy is very attractive and the produced water can be used for agriculture purposes by planting the area along the conduit route.

Utilization of Renewable Energy in Jordan

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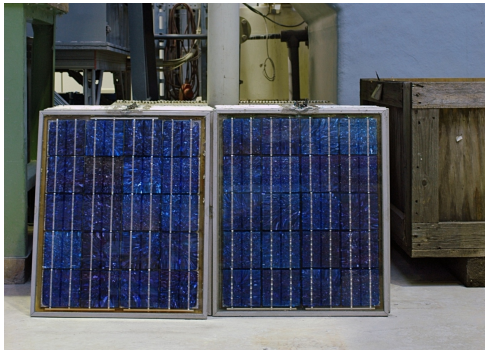


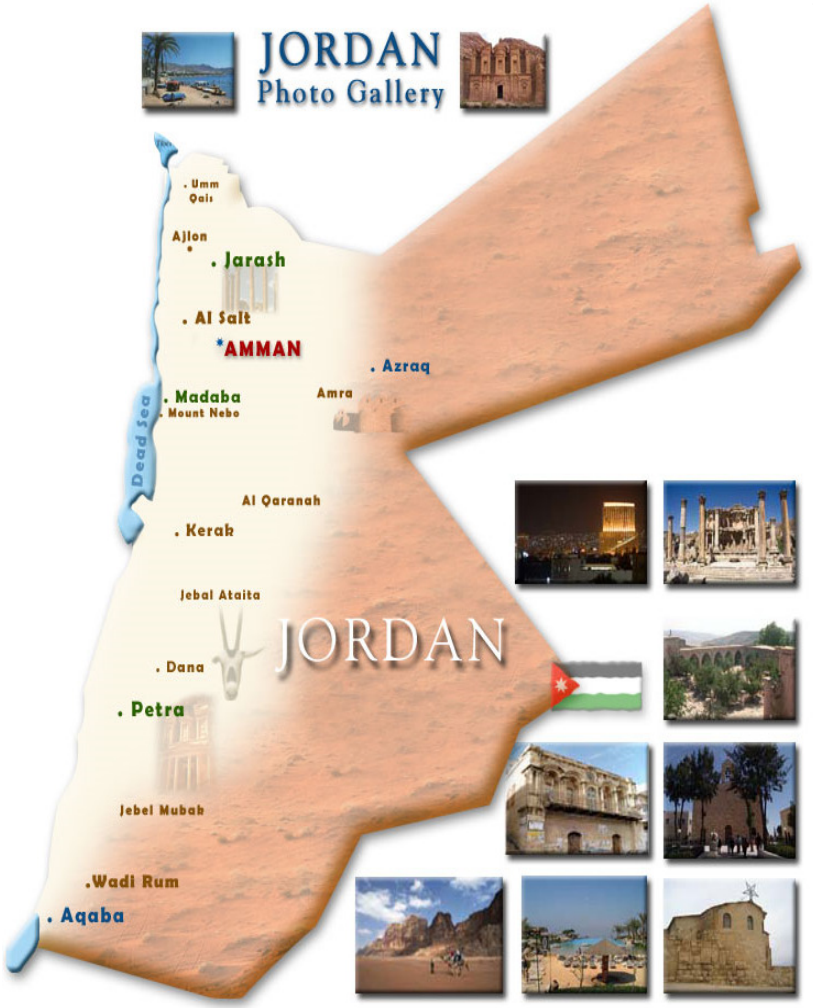
- About Jordan
- University of Jordan + Renewable Energy Center
- Energy policy in Jordan
- The energy situation in Jordan
- Solar intensity in Jordan
- Real applications of renewable energy resources in Jordan
- Jordan renewable energy future planes and sustainability
- Renewable Energy in SMC
- Examples of PV applications
- What is required?
- Conclusions

Contents of presentation

- **Location:** Middle East, northwest of Saudi Arabia.
- **Geographic coordinates:** 31 N, 36 E
- **Area:** total: 89.213 km^2
  land: 88.884 km^2
  water: 329 km^2
- **Land boundaries:** total: 1,635 km
- **Coastline:**26 km
- **Climate:** mostly arid desert; rainy season in west (Nov. to April)

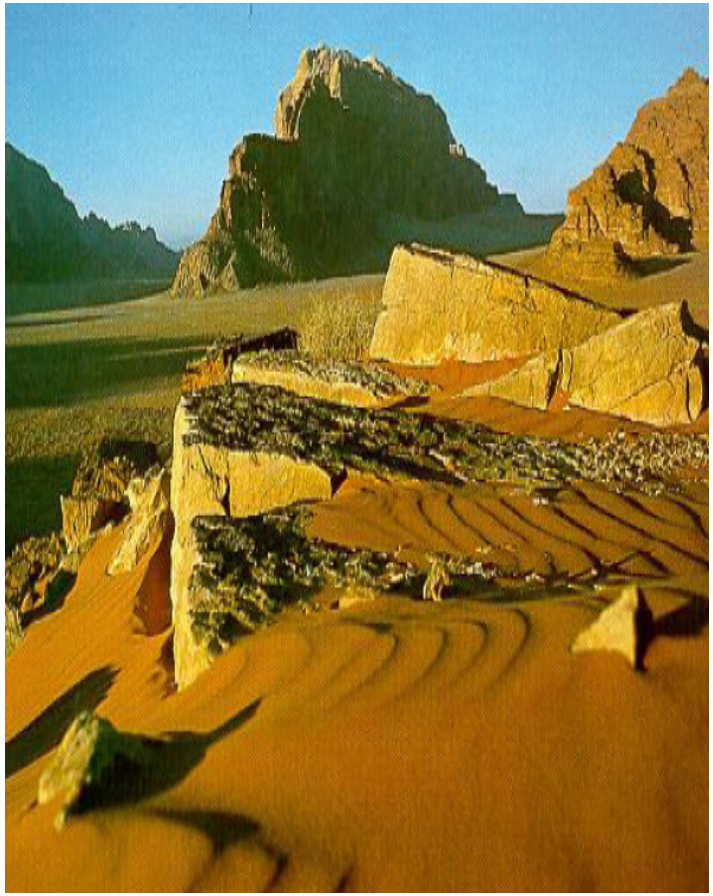
About Jordan (1)

Total Population:
5.852 million
Total area:
89,342 sq.km
GDP:
14,190 million JD
(19,985 million US$)
GDP per Capita:
2,425 JD(3,415 US$)
Electricity Consumption:
2,403 KWH/Capita
Population Under Supply:
99.9%



About Jordan (2)

- **Terrain:** mostly desert plateau in east, highland area in west; Great Rift Valley separates East and West Banks of the Jordan River



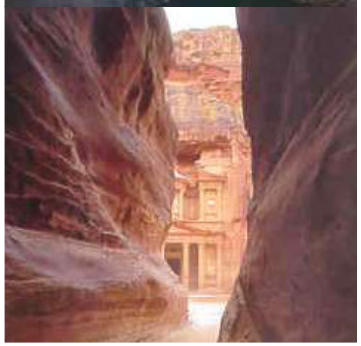
- **Elevation extremes:**

lowest point: Dead Sea -408 m

highest point: Jabal Ram 1,734 m

- **Land use:** arable land: 3.32% , permanent crops: 1.18%, other: 95.5%

About Jordan (3)



Country:

The Hashemite Kingdom of Jordan, known as Jordan. A country located in the heart of the Middle East;

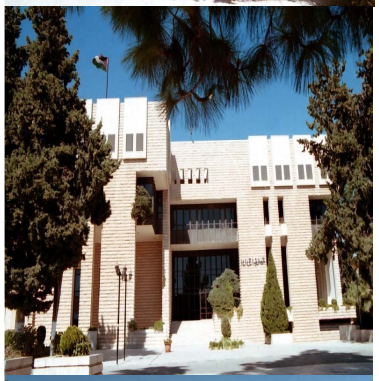
A population of over 5 million.

City:

Amman, the capital of Jordan, a city of about 2 million people. Like Rome, originally established on 7 hills.

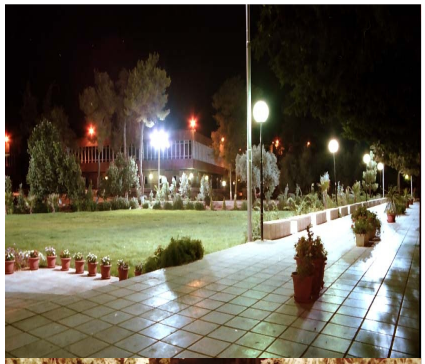
Nearby attractions:

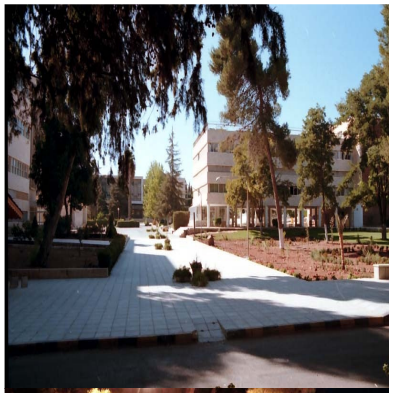
- Intact Roman Theatre in Amman, from UJ 15 minutes by car.
- The Dead Sea, River Jordan and the Baptism Site, 40 minutes;
- Petra, 3 hours;
- Jerusalem, 1 hour, and Damascus, 3 hours.



University of Jordan
One-Campus University

- UJ prides itself on the beauty of its one-campus university.
- The landscape (area of 120 Ha (1,200 dunums)) is composed of flat ground and mild slopes covered with evergreen pines, elms and olive trees.
- Special climate, breezy and cool for most summer days and rainy in the winter time with many spectacular sunny days. In some winters, snow falls.
- Springtime is breathtaking when wild flowers of all kinds of exotic colors and almond, plum, and apricot trees blossom.
- Four distinct seasons: Spring, Summer, Autumn, and Winter.






Brief History

- Established in 1962, UJ is the leading and the oldest institution of higher education in Jordan. It is often referred to as the “mother” university.
- UJ has 18 academic faculties, two deanships, 11 centers, and many other facilities.
- The number of faculty members stands at about 1200 at present.
- It has a student population, at both the graduate and undergraduate levels, of about 38,000. Graduate students: 4,000; undergraduate students: 34,000. The overall ratio of female to male students is nearly 60 to 40.
- UJ began with the year system. In 1972-73 it switched to the credit-hour system. It was the first in the Arab-World to do so.
- UJ is a “public” university: it is semi-independent, neither totally state-run or supported, nor privately endowed or invested.




Faculties

At the undergraduate level, students have the choice to select from among 63 different programs.

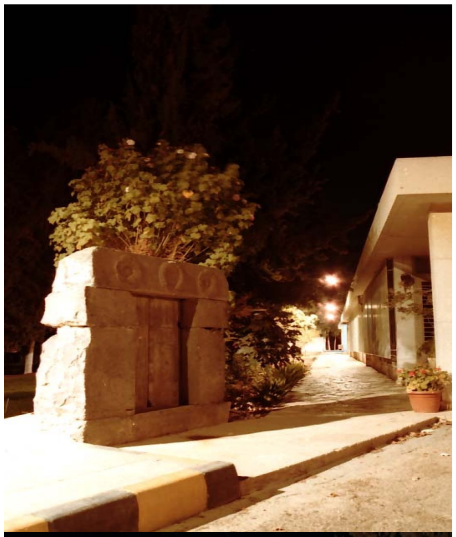
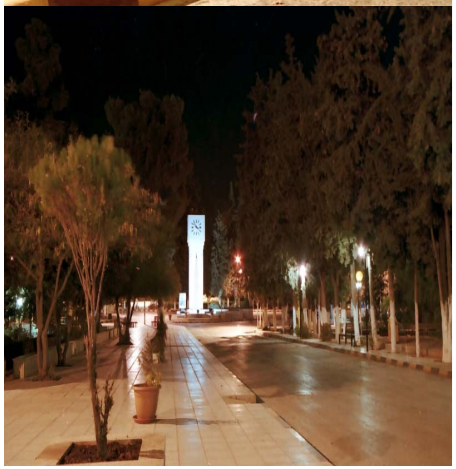
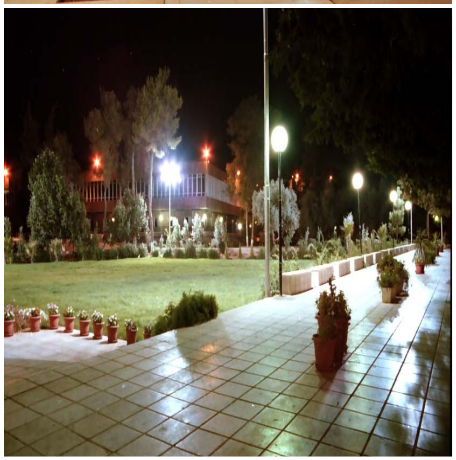
- **Engineering and Technology: 1975**



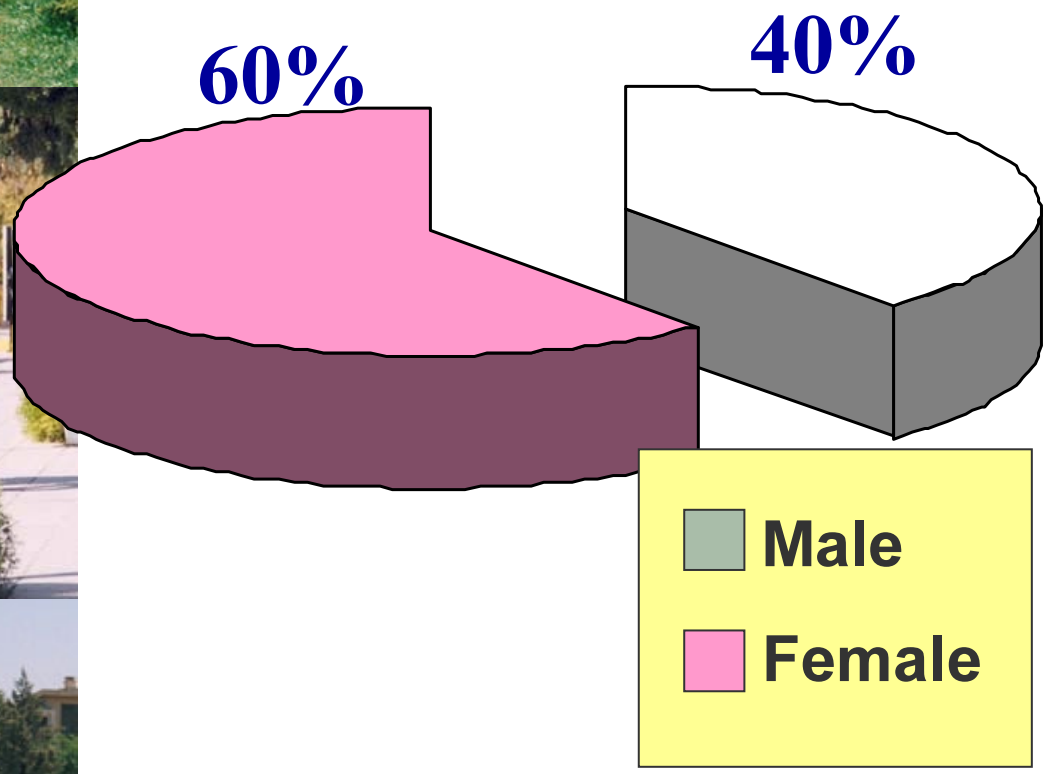




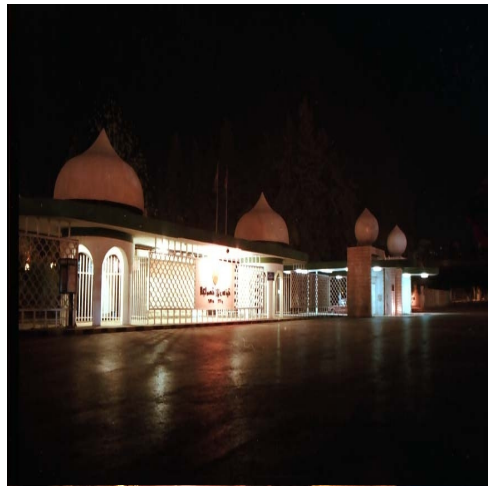


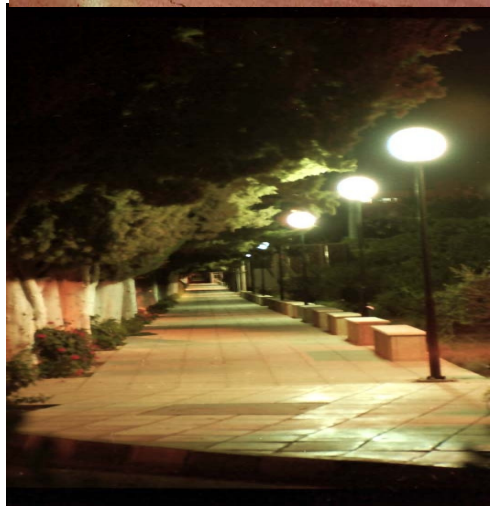




Overall Gender Distribution of Students at UJ



more than 77 countries represented on campus, and over 12% are international students.





Renewable Energy Center:

Renewable Energy Center; 2006

Mission :

- **The amounts of available conventional energy resources are decreasing with time:**

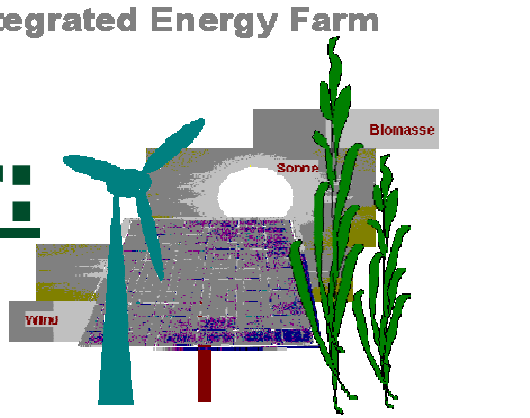
- **Development of renewable energy technology is thus needed to fulfill the energy demand in the future.**

- **The environmental degradation associated with the production and consumption of fossil energy today threatens human health and the quality of life, while affecting ecological balance and biodiversity.**

- **The desert area of the Middle East region with its abundance of solar radiation could transmit the power generated to countries substituting the use of fossil fuels for higher economic benefits and to contribute massively to the protection of the global environment.**

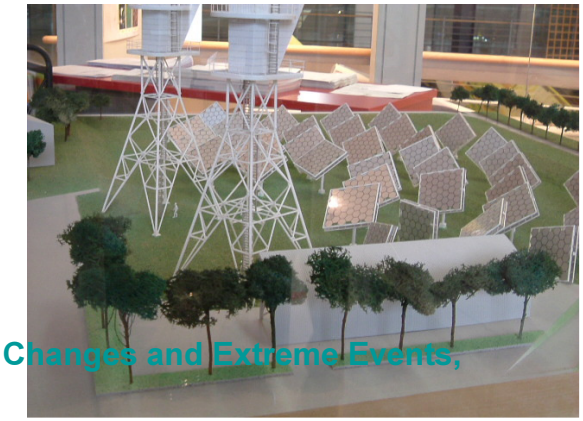
Renewable Energy Center:

Vision



- To use and promote green power, clean durable, sustainable, no noise, no pollution and free energy from the wind and sun.

- We feel strongly about the threats of carbon dioxide and work hard to improve the environment and decrease the use of fossil fuel which will be debated in the coming future.



Recent Related Experience:

Eco Street

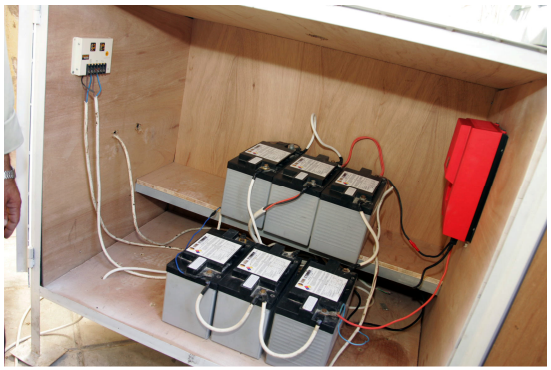
Solar Car

Eco House

Solar Cooker

Recent Related Experience:

Solar Cafeteria



- The utilization of solar energy sources is very attractive because they are nondepletable sources of energy and they are relatively pollution free.
- Jordan is an energy-importing country, about 96 % of its needs being supplied from abroad as crude oil and refined products.
- Annual growth rate of primary energy in Jordan is 2.4 % and for electricity is 7.7%.
- The share of solar energy in the total energy mix in Jordan is estimated to be around 1.2% during the year 2009.
- It is therefore unlikely that any future energy scenario for Jordan will not include a significant proportion of its energy coming from Renewable Energy. In order to reduce dependence on the imported oil, Jordan has pursued programs for promoting solar energy

Conventional energy not reaching poor.

Current Situation

- 1/3 of the world's people depend on bio-mass to meet their household energy needs
- Over 2.4 Billion people, rely on wood, charcoal or dung for cooking.
- 1.6 million people (mostly women and kids) are killed by smoke from indoor cooking fires
- 1/4 of world's people have no access to electricity
- No. of people without electricity was increased till 1985 and decreased after 1985.
- 1.6 billion of people without electricity.
- 1.3 billion of world's people will have no electricity in 2030

Facts (1)

Solar electrification bring life to rural

Solar PV

- Solar PV is a solution to household electrification without grid extension
- ½ million PV solar home systems for the electrification in rural areas of developing countries have been installed in 2003.
- Solar electrification bring life to rural and improve it
- PV modules used for Solar home system in 2002 is 20 MW
- Solar PV modules production in 2002 is 500 MW
- Solar PV electrification has had great impacts on improving the economic and social lives of most beneficiaries.

Energy and Electricity Sector in Jordan

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ICTP, Trieste, Italy, 19 - 23 April 2010

Electricity Sector in Jordan

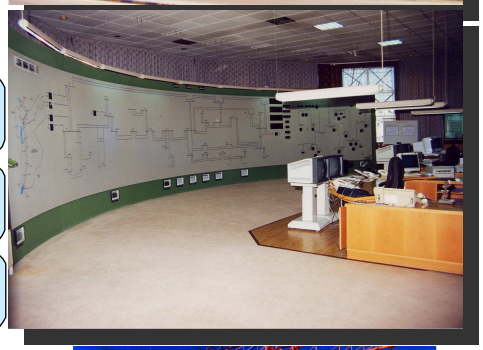
Policy Maker → Ministry of Energy & Mineral Resources

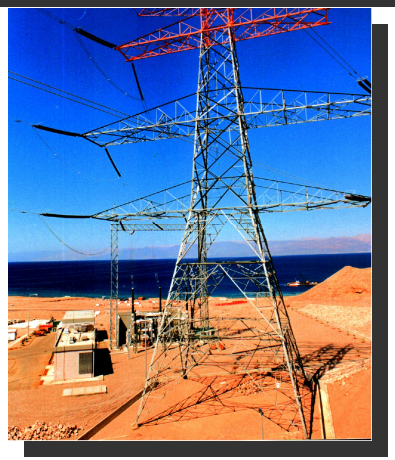
Observer & Regulator → Electricity Regulatory Commission

Generation & Power Producers
- CEGCO
- SEPGCO
- AES JORDAN PSC

Transmission
- Interconnection
- NEPCO

Distribution
- JEPCO
- IDECO
- EDCO

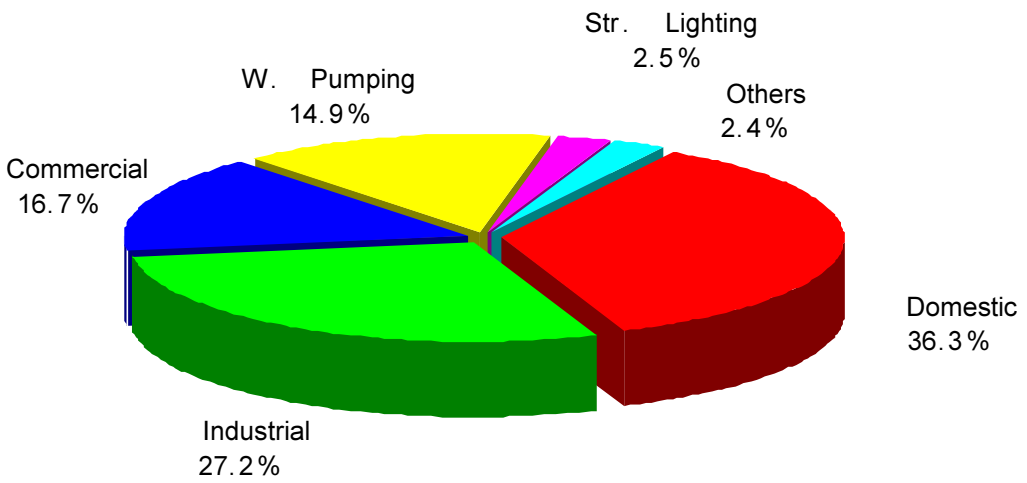




Jordanian Power System (2008)

Peak Load: **2260 MW**
Generated Energy: **13838 GWh**
Generation Installed Capacity: **2670 MW**
Consumed Energy: **11509 GWh**

Electricity Consumption

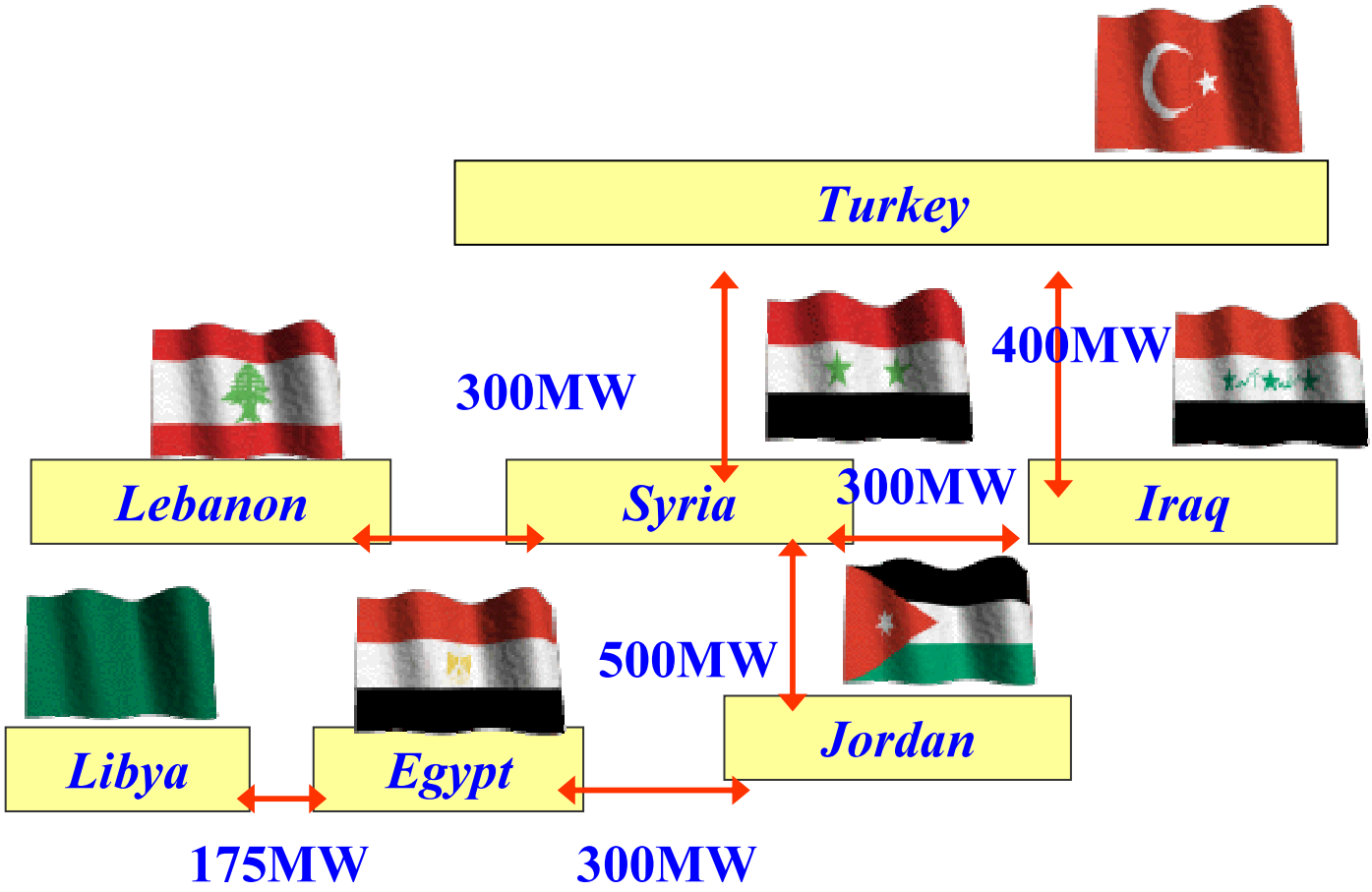


Electricity Demand Forecast

YEAR	MW	%	GWH	%	KWh/capita
2009	2437	-	15090	-	2516
2010	2601	6.7%	16116	6.8%	2621
2011	2773	6.6%	17180	6.6%	2726
2012	2977	7.4%	18399	7.1%	2909
2015	3590	6.4%	22184	6.4%	3816
2020	4773	5.9%	29883	6.1%	4376

We need about 300 MW each year till year 2020

Interconnection Projects



Jordan Nuclear Strategy

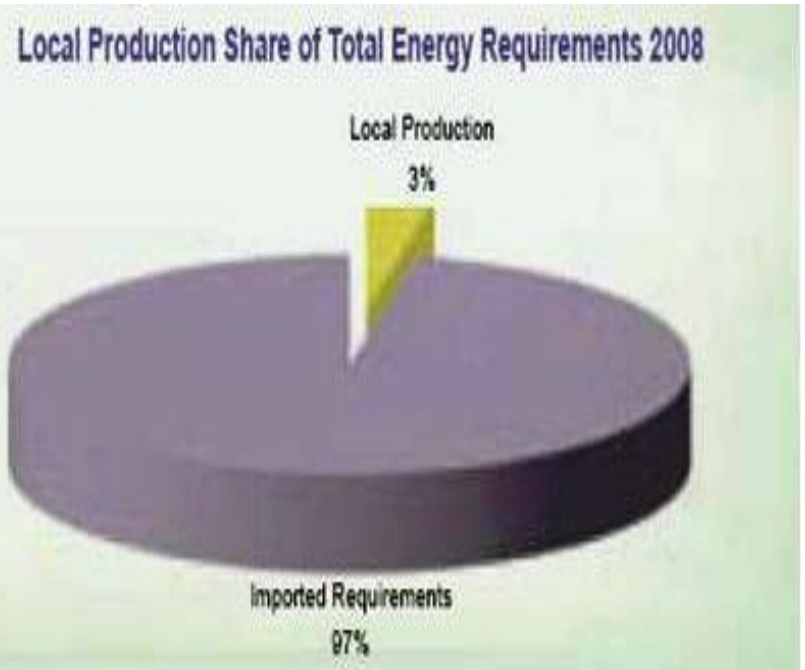
- The Jordanian Atomic Energy Commission started during the year 2008 to take the necessary procedures to construct the first nuclear power station of a generation capacity (700-1000) of MW through signing several cooperative nuclear agreements with many experienced countries for implementing the adopted nuclear plant during the period (2018-2020).

Oil Shale

- Oil shale in Jordan is available in great quantities in the southern part of the Kingdom. These quantities are estimated at about (40) billion tons, or the equivalent of (28) billion barrels of oil. The cost of extracting the oil barrel from oil shale is considered feasible economically, in the light of the increasing rise of oil prices, witnessed in the world oil markets.
- MEMR signed three memorandums of understanding with specialized companies to utilize the oil shale in Al-Lajoun area. These companies were given a respecting period to offer the technology they have, the production mechanism they use and the results of the research they do, after which they go into partnership agreements with the government.
- MEMR & NEPCO signed a memorandums of understanding with Estonia to built an Oil Shale Power Plant (OSPP) using direct burning technology with a proposed capacity between 600MW and 900MW,& the OSPP is expected to be in operation by the year 2014-2015.

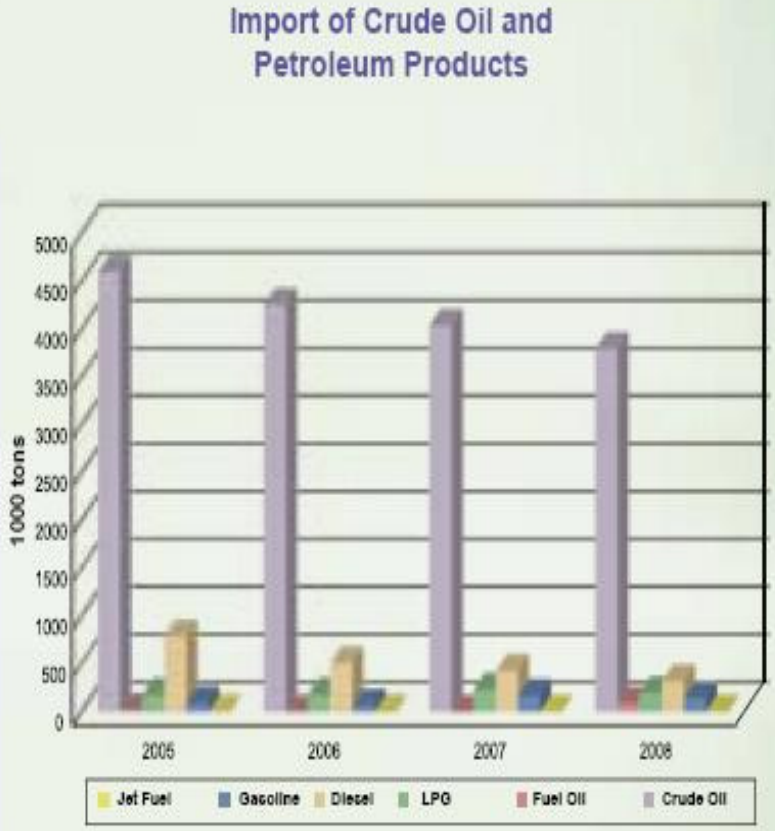
Local Production of Oil & Natural Gas

	2005	2006	2007	2008
Crude Oil (000 Tons)	1.1	1.2	1.2	1.1
N.Gas (Billion CF)	8.5	8.9	7.7	7.2
Total (000 Toe)	**180**	**187**	**166**	**154**



Import of Crude Oil and Petroleum Products (000 Tons)

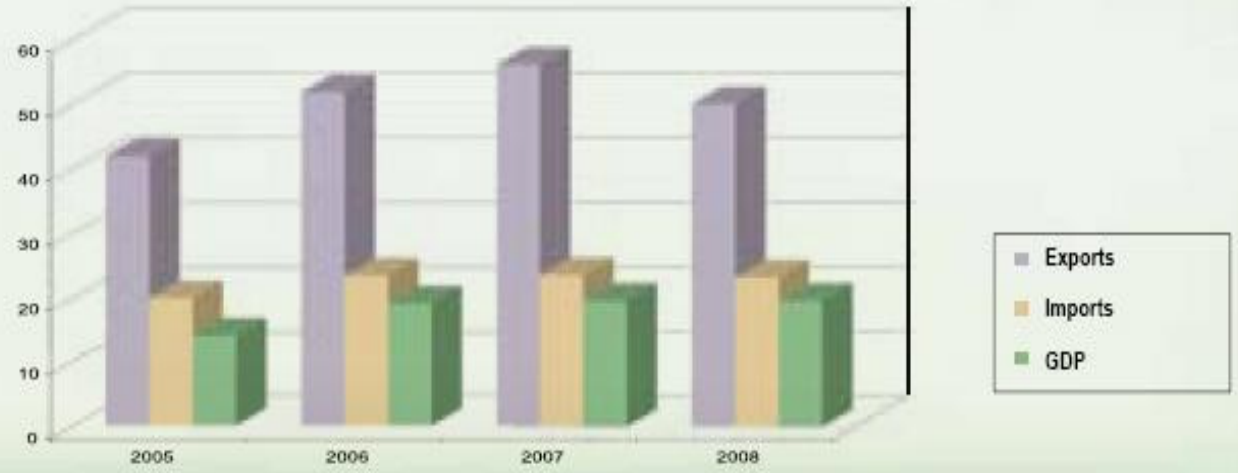
	2005	2006	2007	2008
Crude Oil	4602	4258	4040	3795
Fuel Oil	19	–	–	91
LPG	178	182	233	196
Diesel	785	509	429	320
Gasoline	93	65	166	141
Jet Fuel	1	1	1	1
Total	**5678**	**5015**	**4869**	**4544**



Cost of Consumed Energy

Year	Cost of Consumed Energy (Million JD)	Cost of Consumed Energy Related to		
		Exports%	Imports%	GDP%
2005	1776	58.2	23.9	19.7
2006	1913	51.8	23.4	19.1
2007	2280	56.1	23.5	19.5
2008	2763	50.0	23.1	19.5

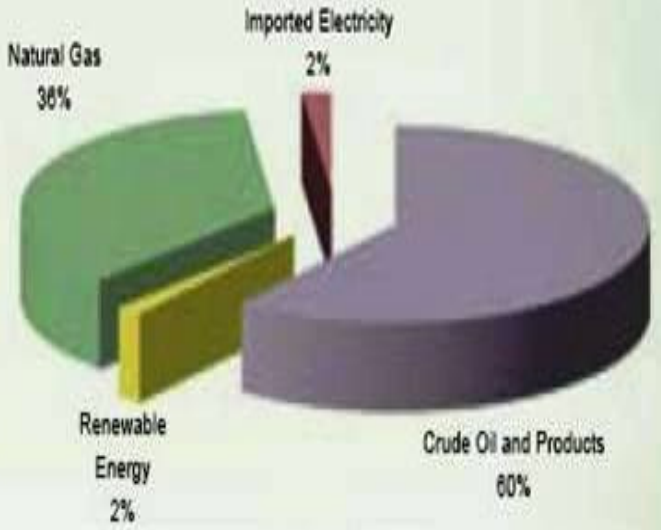
Cost of Consumed Energy as a Percentage of Exports, Imports and GDP (%)



Primary Energy Consumption

	2005	2006	2007	2008
Crude Oil and Products (000 Toe)	5325	4953	4906	4426
Renewable Energy (000 Toe)	83	110	118	128
Natural Gas (Billion CF)	56.4	76	92	104
Imported Electricity (000 Toe)	238	124	53	137
Total (000 Toe)	**7028**	**7187**	**7438**	**7335**

Primary Energy Consumption 2008



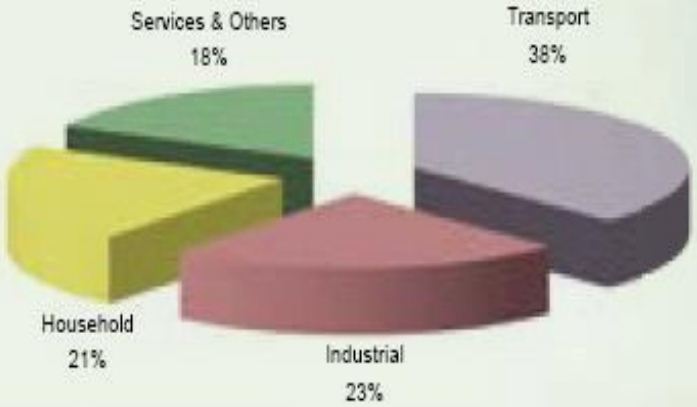
Final Energy Consumption

	2005	2006	2007	2008
Transport	1779	1822	1912	1767
Industrial	1159	1182	1192	1095
Household	1060	1064	1070	1010
Services & Others	804	821	853	835
Total (000 Toe)	**4802**	**4889**	**5027**	**4707**

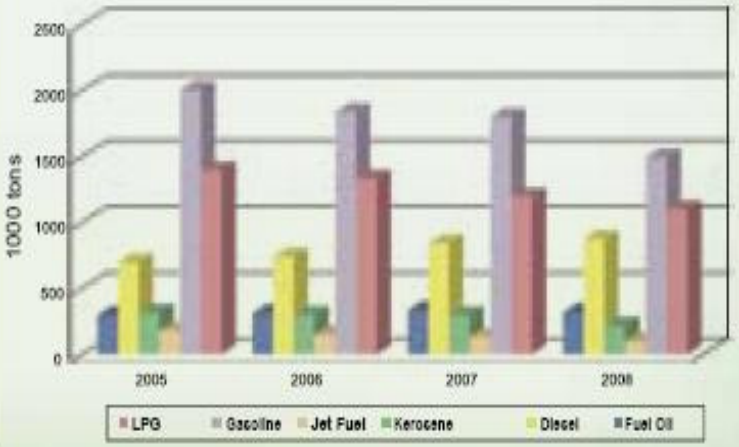
Petroleum Products Consumption (1000 Tons)

	2005	2006	2007	2008
LPG	299	313	335	319
Gasoline	697	741	840	873
Jet Fuel	314	300	297	216
Kerosene	181	150	131	100
Diesel	2005	1837	1794	1493
Fuel Oil	1395	1333	1193	1100

Final Energy Consumption by Sector 2008

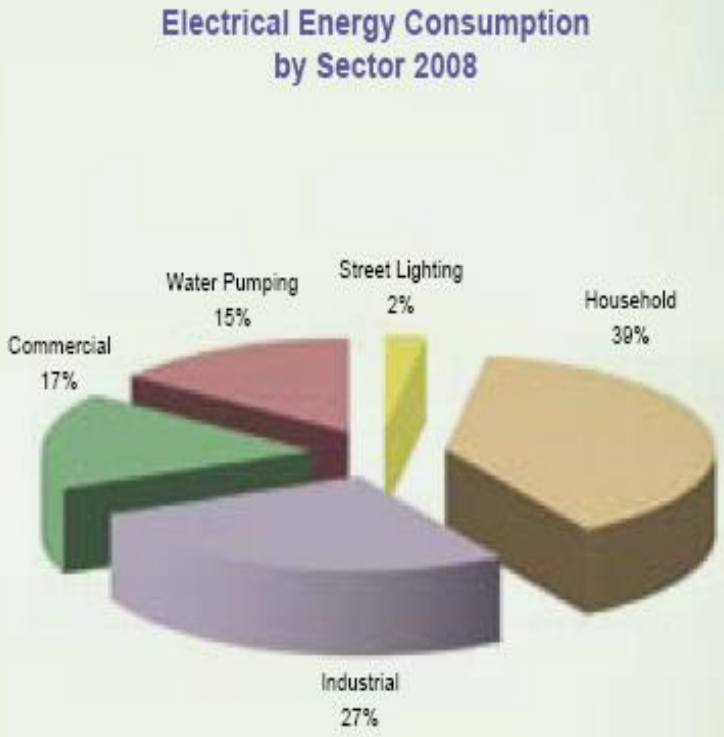


Petroleum Products Consumption



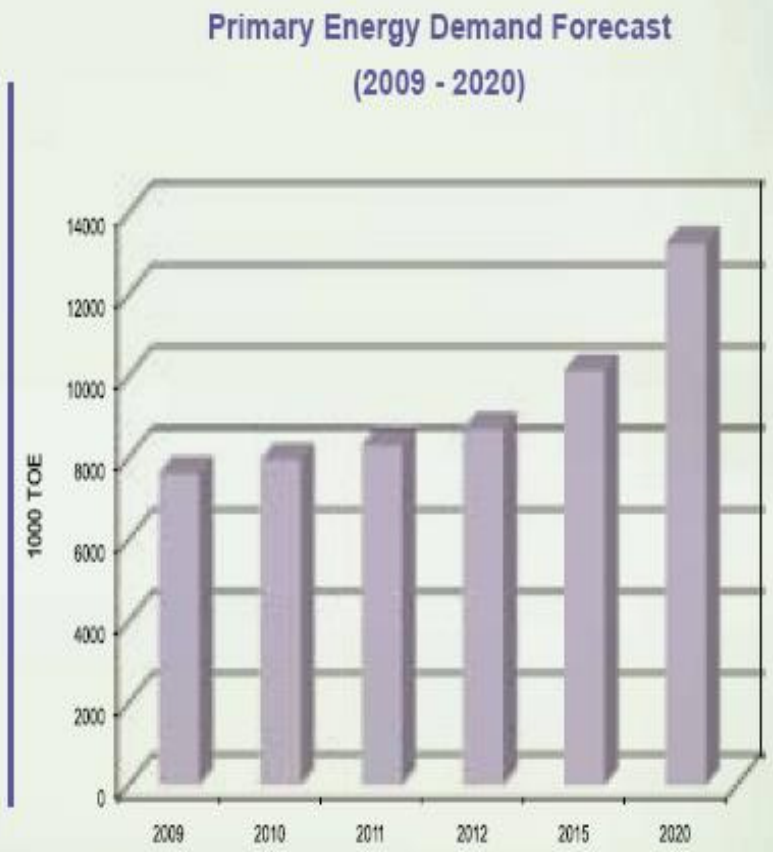
Electricity Consumption (GWh)

	2005	2006	2007	2008
Household	2989	3434	4017	4459
Industrial	2659	2758	2918	3128
Commercial	1317	1516	1757	1925
Water Pumping	1298	1396	1592	1713
Street Lighting	248	261	269	284
Others	201	228	–	–
Total	**8712**	**9593**	**10553**	**11509**



Energy and Electricity Demand Forecast in Jordan

Year	Primary Energy		Max. Demand		Electrical Energy	
	1000 toe	Growth (%)	MW	Growth (%)	GWh	Growth (%)
2009	7629	4.0	2437	7.8	15090	4.9
2010	7957	4.3	2601	6.7	16116	6.8
2011	8315	4.5	2773	6.6	17180	6.6
2012	8714	4.8	2977	7.4	18399	7.1
2015	10145	5.2	3590	6.6	22184	6.6
2020	13259	5.5	4773	5.9	29883	6.1



- Considerable efforts have been made and great progress has been achieved in the application of solar, wind, biogas and hydro energy utilization.

- Solar pond: evaporation of 90 million m^3 per year of the Dead Sea Water for Potash production.
- Solar water heaters: more than 200 000 unit saving $ 10 million of imported oil per year.
- PV: more than 150 kW capacity.
- Mechanical wind pumps: Yearly pumping water 40,000 m^3.
- Electric wind pumps: Yearly pumping water 40 000 m^3 .
- Bio gas plants: 1 MW capacity.
- Hydro power: 10 MW.
- Wind power: 0,5 MW.
- Geothermal: Small projects (drying, fish farming, medical treatement…)

Renewable energy technologies considered in the MED-CSP study in addition to concentrating solar thermal power plants

Real applications of renewable energy in Jordan

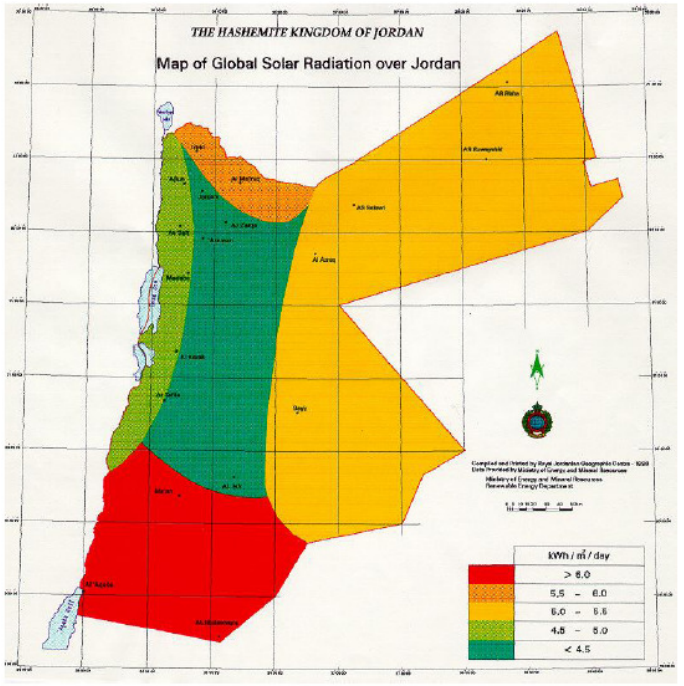
a) Solar Energy

- Jordan is blessed with an abundance of solar energy.
- The annual daily average solar irradiance is 5-7 kW/m^2 .
- The utilization of solar energy for domestic hot water began in Jordan after the oil crisis in 1973.
- Solar water heater becomes popular as more than 25% of total houses in Jordan are now supplied with solar heater.
- The number of houses utilizing solar water heaters in Jordan by the end of 1992 was estimated to be 158,669.
- Energy required for space heating and hot water purpose is estimated to be 12% of the total energy consumed in Jordan.

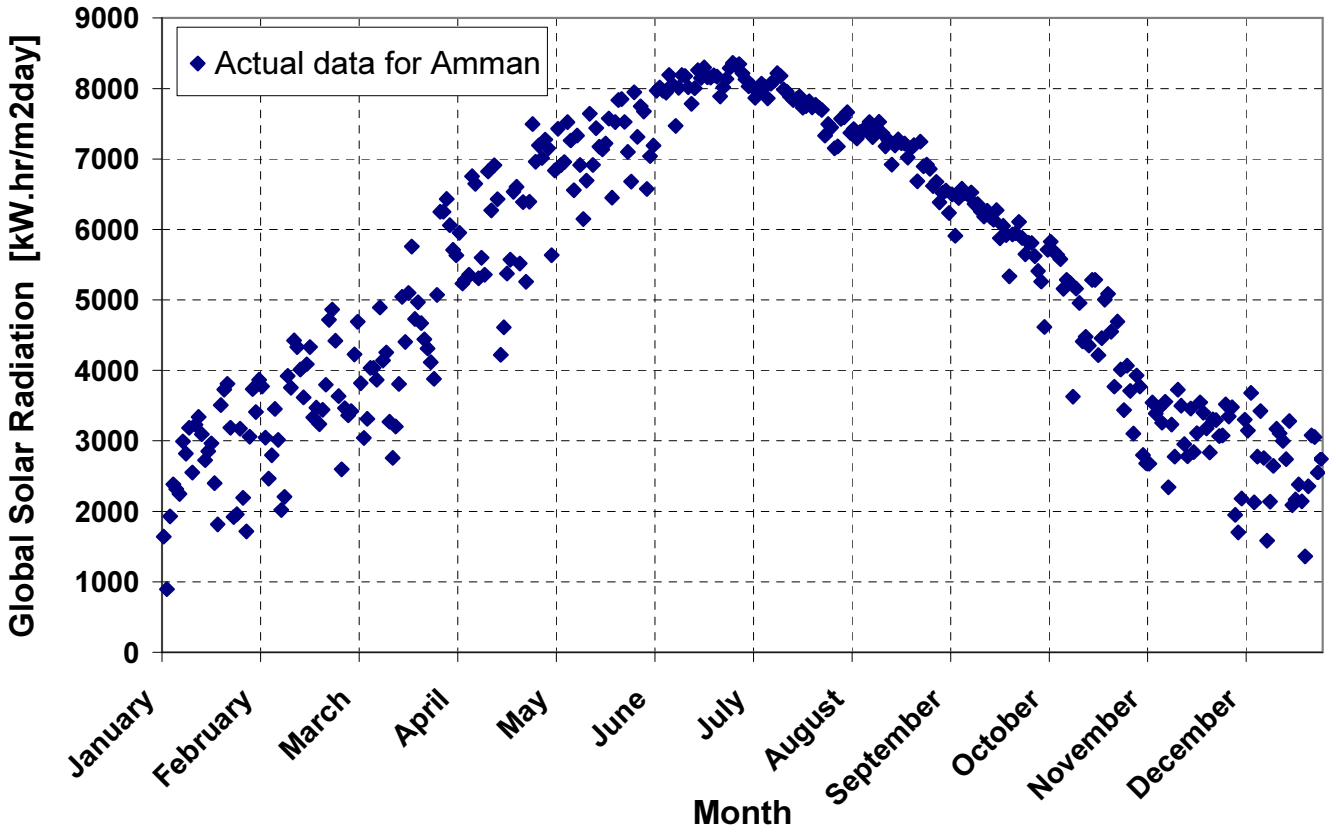
Solar Collectors indoor-outdoor testing facility

- Jordan has an average insulation intensity on a horizontal surface ranges between 5-7 kWh/m^2, which is one of the heighest in the world.
- This corresponds to a total annual of 1600-2300 kWh/m^2.
- The average sunshine duration is more than 300 day/year.
- According to the solar atlas in Jordan, the country is divided into five areas
- The annual average daily global irradiance:

1. Southern region: 6-7 kWh/m^2.
2. Eastern region: 5.5-6 kWh/m^2.
3. Middle region: 5.5 kWh/m^2.
4. Norten region: 5.5 kWh/m^2..
5. Western region: 4.5 kWh/m^2.

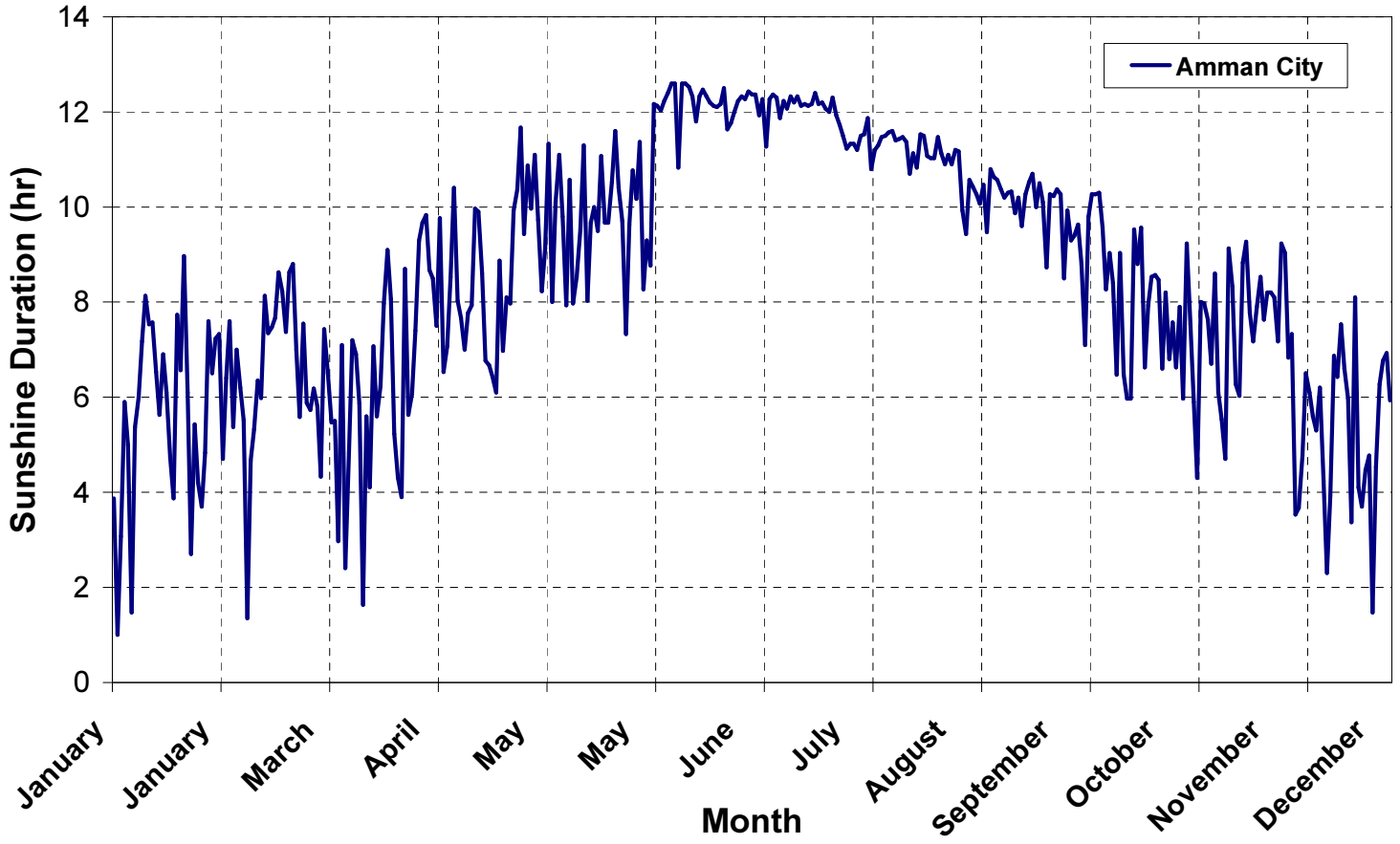


Solar Intensity in Jordan



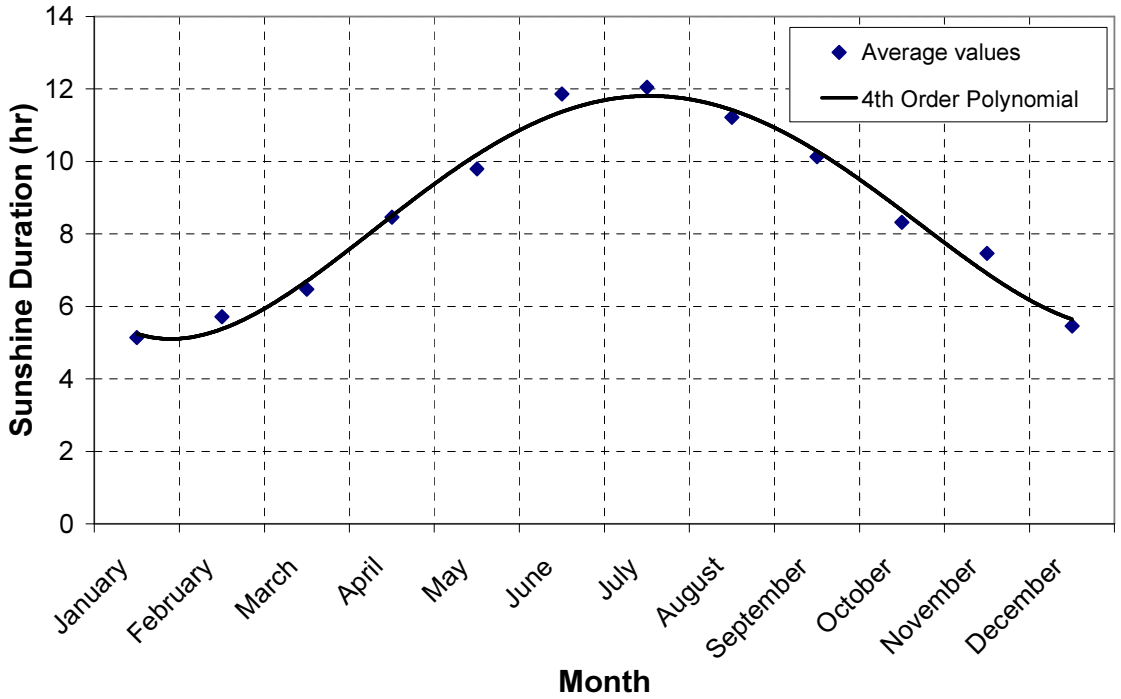
Global daily solar radiation data in Amman, Jordan by days

daily solar radiation data in Amman, Jordan by days



Sunshine duration data in Amman, Jordan by days

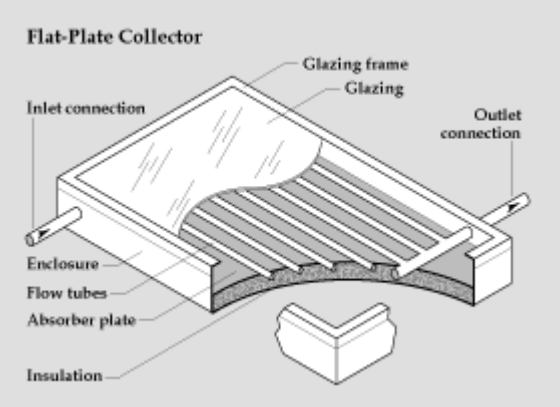
❑ The maximum value of sunshine duration in Amman occurs in June and July (mean value is **11.86 hr** for June and **12.05 hr** for July) and the least in December (mean value **5.14 hr**).



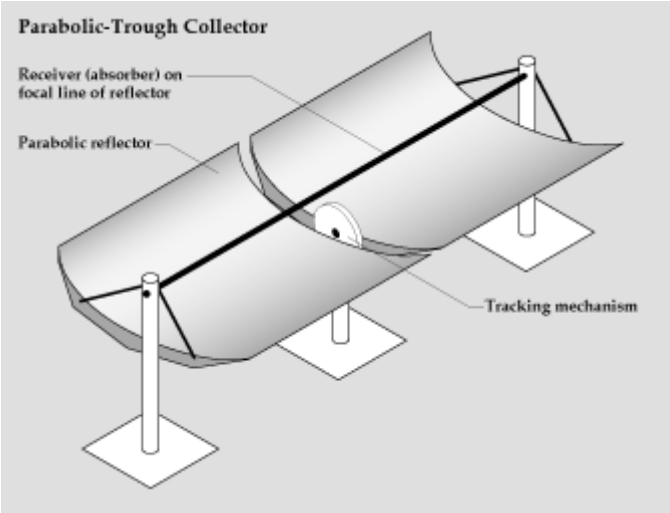
The mean value of the monthly sunshine duration in Amman, Jordan.

Sunshine Duration, Jordan

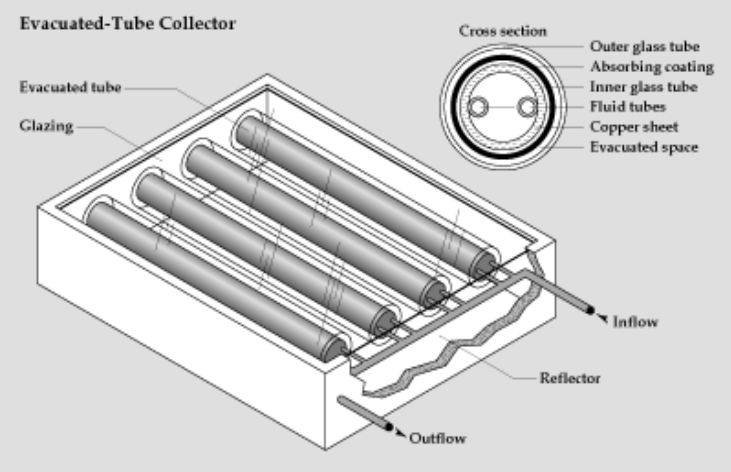
Solar energy systems will soon become economically viable if research and development efforts concentrate on cost reduction of these systems, i.e., development of cheaper materials, simpler and more efficient systems.



Flat-plate collectors



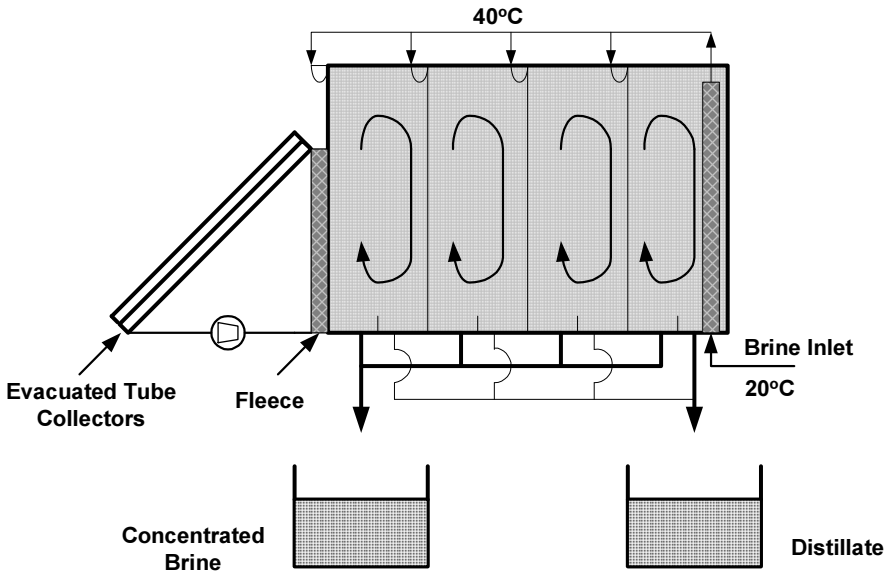
Concentrating collectors

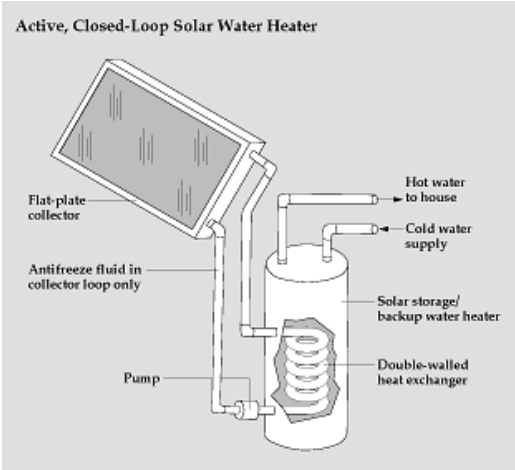


Evacuated-tube collectors 77°C to 177°C

Solar Collectors (1)

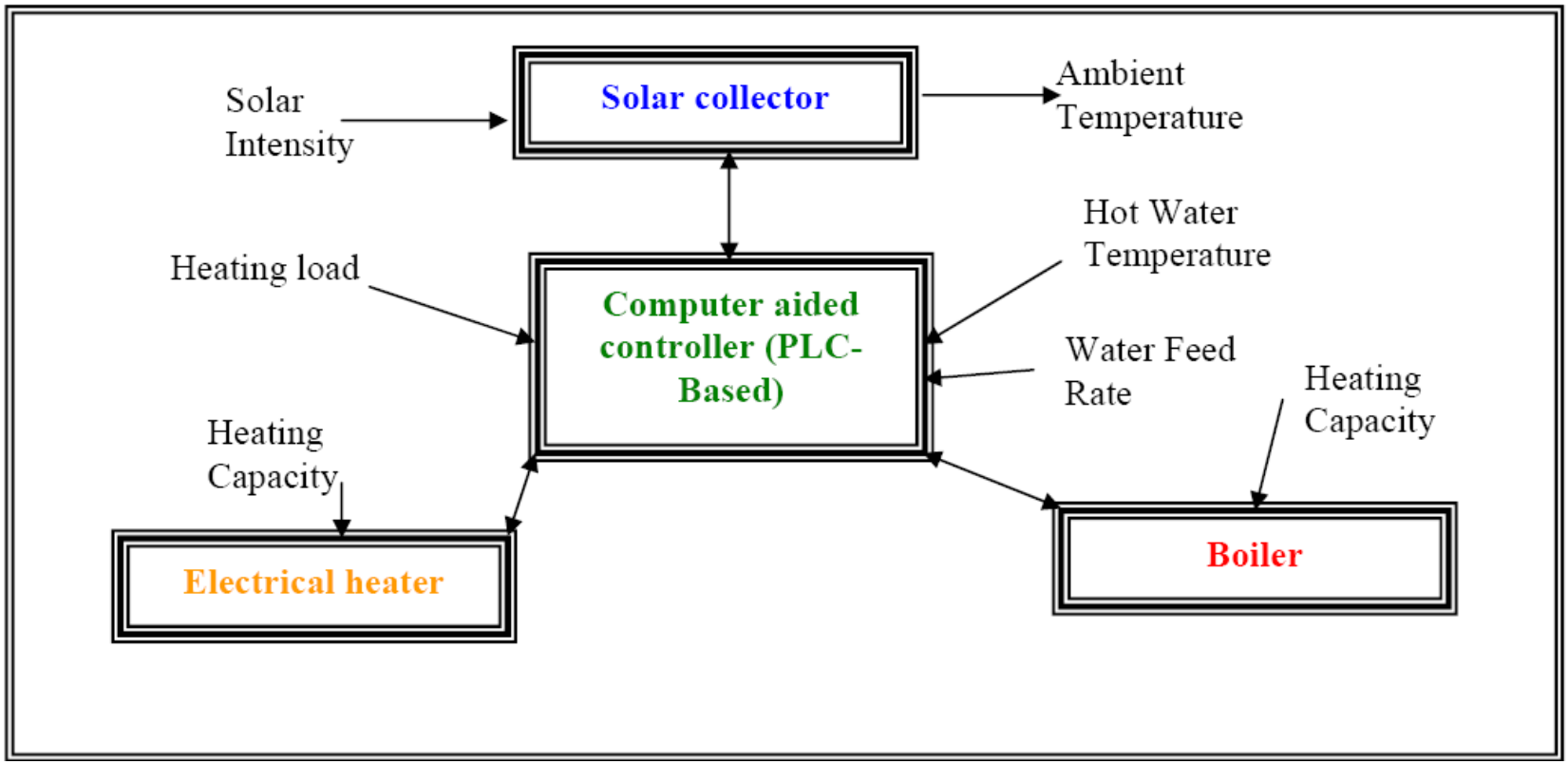
The distillate output from a 4-effect distillation unit is 8.7 kg/m^{2}h with an energy input of 2.0 kW/m^2, for an active cross section of 1m^2



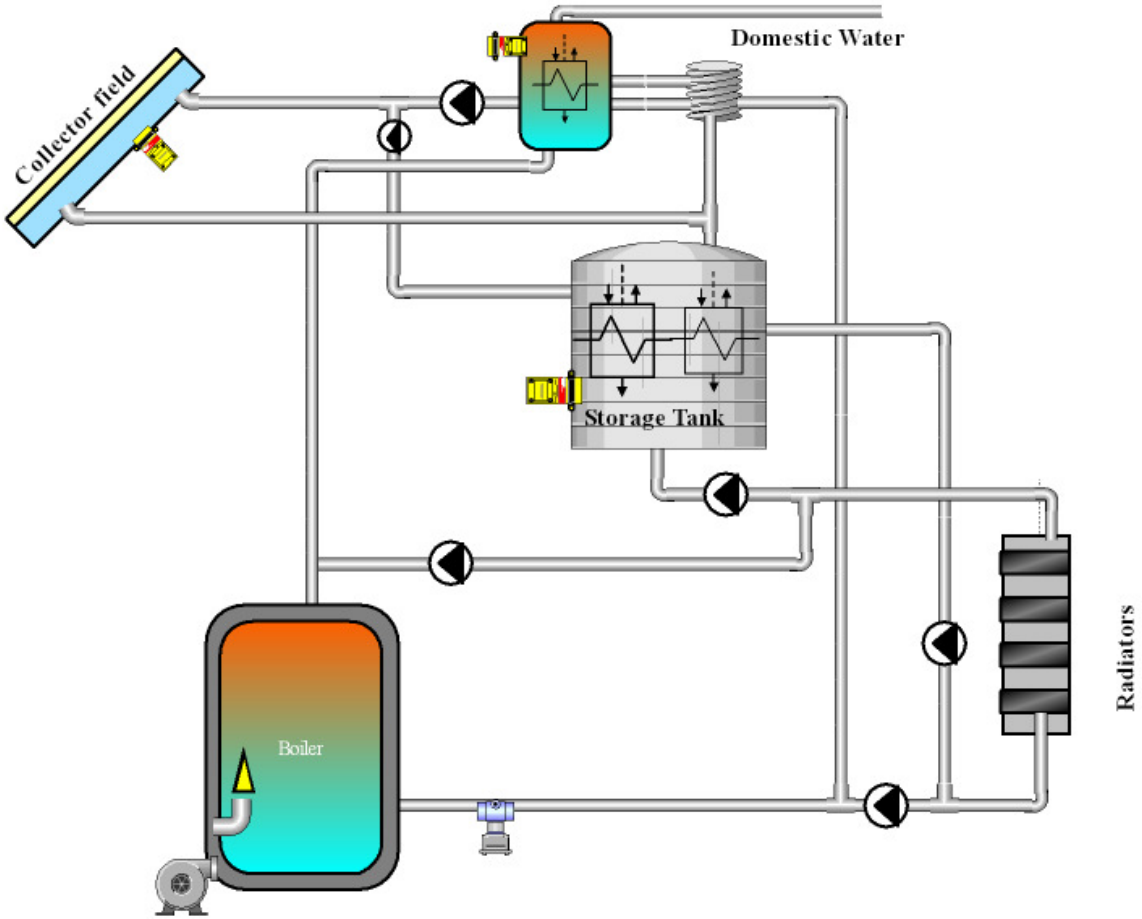


Active, indirect system.

Integrated solar system providing domestic hot water and supplementary space heat



The initial features and characteristics of the boiler-solar-electrical integration system

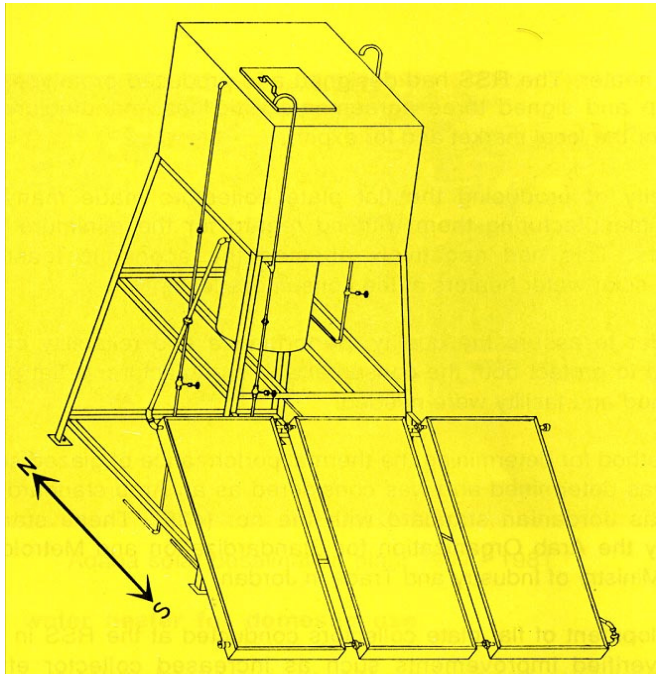


A schematic diagram of the integrated solar energy saving system with boiler, electrical heater, solar collector and storage tanks

Integrated Solar Energy (1)

Solar water heater for domestic use in Jordan

A typical solar water heater in Jordan is the thermosyphon type consisting of 3 collectors with an area of approximately 4 m^2, storage tank, cold water supply tank, stand and the required piping.

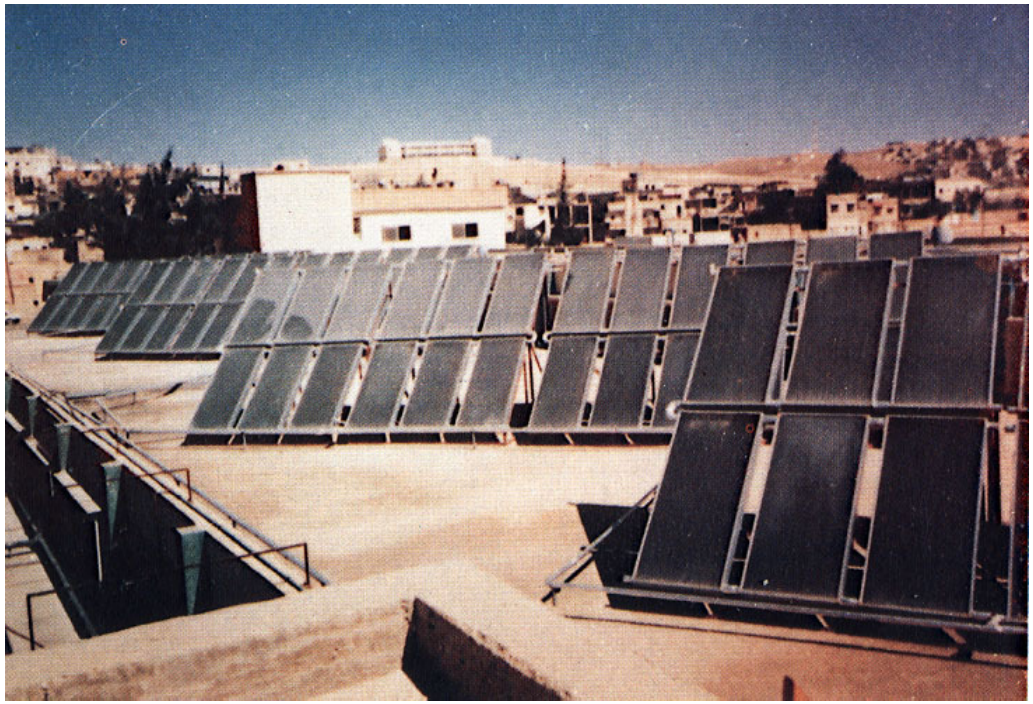


Examples of solar water heater for domestic use in Jordan

Examples of Solar Water Heater in Jordan (1)

Jordan dairy factory solar water heating system in Russeifa

The total collecting area installed was 128 m^2 (96 flat plate collectors, 1.3 m^2 each) with storage tank of 5 m^3 capacity in order to keep water at acceptable temperature.



Jordan dairy factory solar water heating system in Russeifa

Examples of Solar Water Heater in Jordan (2)

Coral Beach Hotel solar water heating system in Aqaba

The total collecting area installed was 180 m^2 (90 flat plate collector, 2 m^2 each), with a hot water storage tank of 12 m^3 and the necessary piping and control devices.

Coral Beach Hotel solar water heating system in Aqaba

Examples of Solar Water Heater in Jordan (3)

Solar desalination using solar heat pipe principle

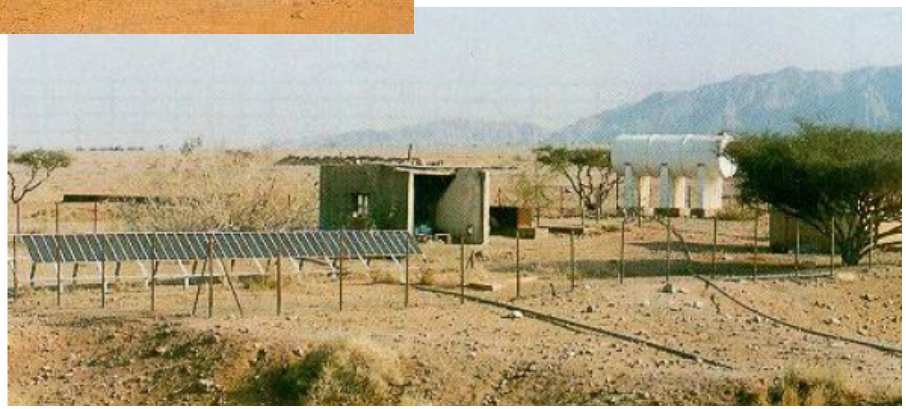
- The plant consisted of **15** modules having a gross area of **375 m^2** with an effective solar collecting surface of **300 m^2**.
- The modules were arranged in 5 rows/column matrix pointing to the south in the Aqaba city (latitude 29° 30') with an inclination angle of **15°** so as to maximize the solar collection during the summer months.

Solar desalination using solar heat pipe principle

Photovoltaic Applications

- **Photovoltaic:** Photovoltaic generators are known for their
- low maintenance requirements.
- high reliability in stand-alone applications;

  therefore, these systems are suited to supply the basic energy needs in remote areas,
- Some examples of PV applications are the following:
- Emergency telephones.
- Rail Radio communication systems.
- Relay stations for radio telephone communication
- Non-directional radio beacon systems.
- Provision of minimum basic energy needs in (electric lighting, educational TV, and small refrigerators for the reservation of medicines and vaccines) for schools, mosques and clinics in remote areas.
- Water pumping in remote areas.



PVP system, Jordan

- **Location:** 150 km east of Amman.
- **Installed at:** January 1987.
- **Capacity:** 110 m^3 of water per day.
- **System description:** Two PV-Systems,
  - Sub system 1 which is a PV-generator with 1,76 kW peak power. a 1,4 kW Dc/AC inverter and a 1,1 kW submersible pump.
  - Sub system 2 is a PV-generator with total peak power of 1,656 kW, a 1,4 kW Dc/AC inverter and a 1,1 kW submersible pump, and two water storage tanks each 55 m^3.

Al-Hazeem PVP system

- **Location:** 50 km north of Aqaba.
- **Installed at:** April 1986.
- **Capacity:** 40 m^3 of water per day.
- **System description:** PV-generator type SM 55 manufactured by Siemens/Germany with 2,225 kW peak power. a 1,4 kW Dc/AC inverter and a 1,1 kW submersible pump. and water storage tank of 55 m^3.

Rahmeh PVP system

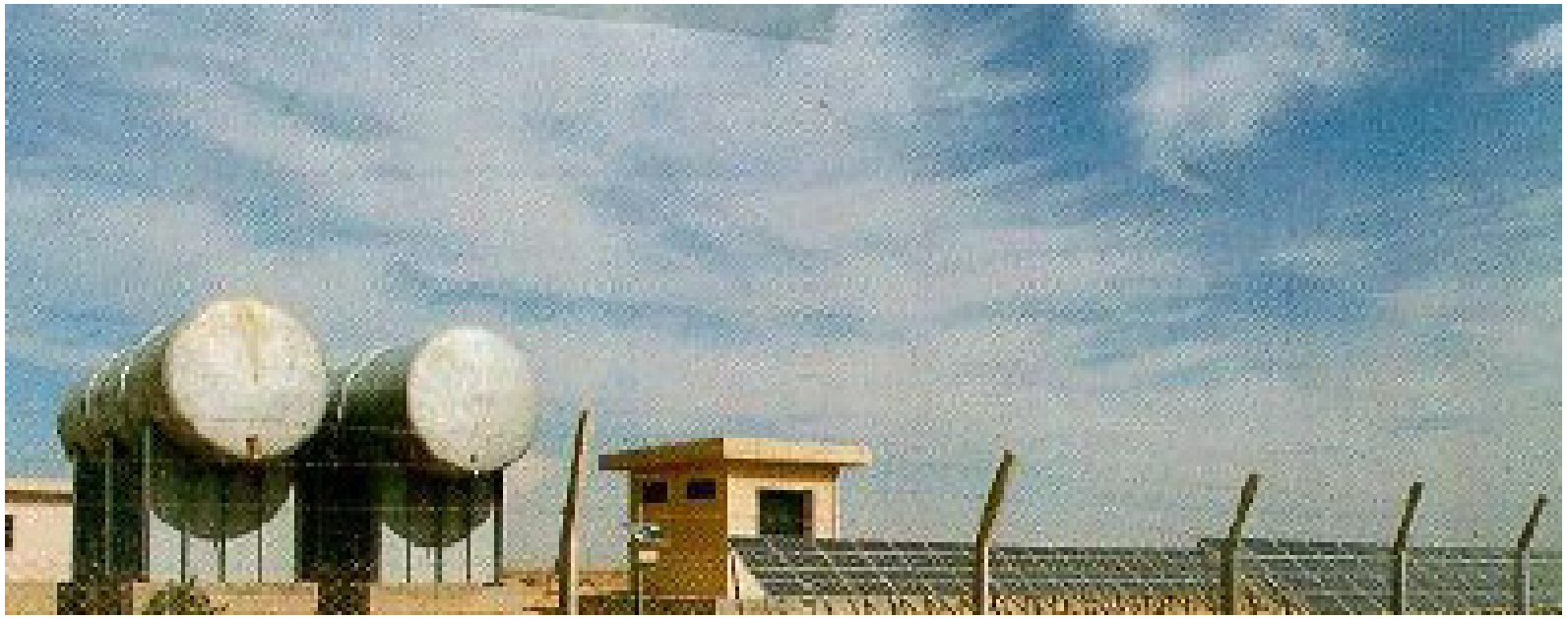
- **Location:** 105 km east of Amman.
- **Installed at:** second half of 1992.
- **Capacity:** 100 m^3 of water per day.
- **System description:** PV-System of an array of 90 monocrystalline moduels type SM 50 manufactured by Seimens solar/Germany 4,5 and 3,5 kW peak power. a 3,5 kW Dc/AC inverter and a 2,2 kW submersible pump. and water storage tank of 55 m^3.

Wadi El-Ritem PV Pumping System

- **Location:** 105 km north of Aqaba, in Wadi Araba.
- **Installed at:** first half of 1992. Financed by the federal repuplic of Germany.
- **Capacity:** 54 m^3/day
- **System description:** PV-System of 4,5 kW total peak power. a 3,5 kW Dc/AC inverter and a 2,2 kW pump. and water storage tank of 54 m^3.

Umruk 2 photovoltaic pumping system

- **Location:** 160 km south of Amman.
- **Installed at:** June 1992.
- **Capacity:** 45 m^3/day of water.
- **System** description: PV-generator of 6,3 kW. a 3,5 kVA Dc/AC inverter and a two 2,2 kW submerciple pump. And 2 water storage tank of 55 m^3.



Sharq El Hasa PVP-System

- **Location:** 130 km east of Amman.
- **Installed at:** August 1989.
- **Capacity:** 40 m^3/day of water.
- **System description:** PV-generator of 2,15 kW. a 3 kVA Dc/AC inverter and a 2,2 kW pump. And water storage tank of 110 m^3.

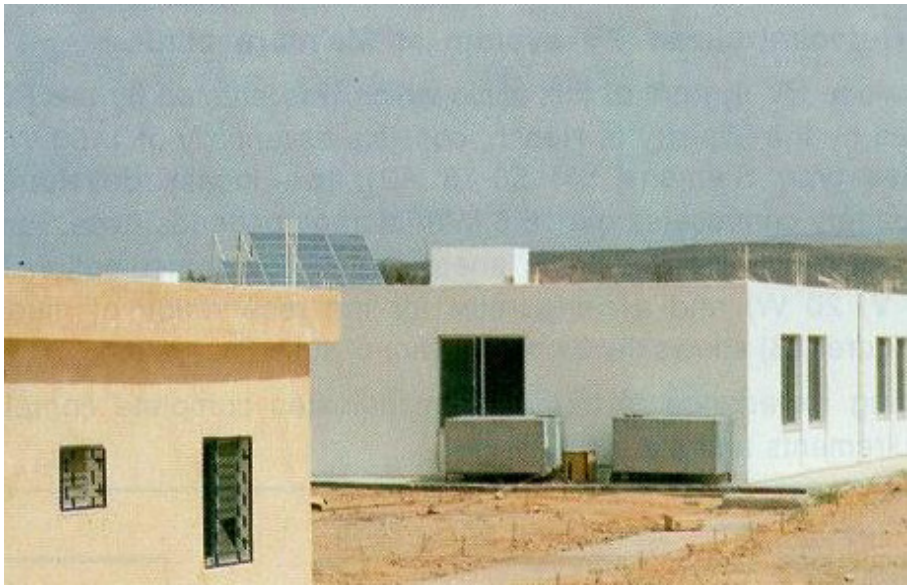
Shomari PVP-System

- **Location:** 70 km east of Amman.
- **Installed at:** December 1991.
- **Capacity:** 70 m^3/day of water.
- **System description:** Two PV-Systems:

- Sub system 1 which is a PV-generator with 3,6 kW peak power, a 2,2 kW Dc/AC inverter and a 2,2 kW centrifugal pump.
- Sub system 2 is a PV-generator with total peak power of 1,8 kW, a 2,2 kW Dc/AC inverter & a 1,5 kW screw pump, and two water storage tanks each 55 m^3.

Wadi albuttom PVP-System

- **Location:** southern part of Jordan.
- **Installed at:** 1986.
- **Capacity:** 1,344 kW peak.
- **System description:** adjustable mounted 1,344 kWp PV modules array (35 AEG PQ 10/401 PV modules connected in parralel), a 21,6 kWh storage lead acid batteries and a locally manufactured charge/discharge controller).



Gregra Photovoltaic PV system

- **Location:** Beer Mathkour.
- **Installed at:** 1987.
- **System description:** 538 Wp PV arrray, 600 W charge regulator, 7.2 kW charge batteries.

Beer mathkour clinic PV system

b) Wind Energy:

- The wind atlas of Jordan indicates that large areas have an average annual wind speeds in excess of 6-6.5 m/s; some more limited areas have an average wind speed above 7 m/s.
- Two major wind farm pilot plants have been commisioned in Jordan with a rated power of 320 kW and 1,125 kW respectively. There are many other wind energy water pumping stations especially in remote areas.
- After the new electricity law was enacted in 1999, it is now expected that new wind farms will be installed. A 100 MW wind farm has been studied and identified as suitable for implemintaion at Wadi-Araba. Local industries have the potential of manufacturing considerable percentage of wind farm components.

- **Example:** Al-Ibrahemiya Wind Farm:

- The first grid connected wind energy demonstration plant was installed in Jordan in April 1988 at the site of Al-Ibrahemiya
- The station consists of 4 Danish wind turbines each rated 80 kW and has a rotor diameter of 24 m.

c) Biomass:

- A techno-economic feasibility study for 1 MW size electric power generation from municipal solid waste has been carried out in cooperation with UNDP.
- Direct combustion biomass provides some energy for cooking and heating in some rural areas. It has been estimated that the animal and solid wastes in Jordan represents an energy potential of about 100 thousand tons of oil equivalent annually.

d) Hydro Power:

- Hydro power sources are very limited in Jordan. Currently, the only hydroelectric station that generates elecrticity is King Talal Dam with a power generation of about 25 GWh per year.

The King Talal Hydro Power Station

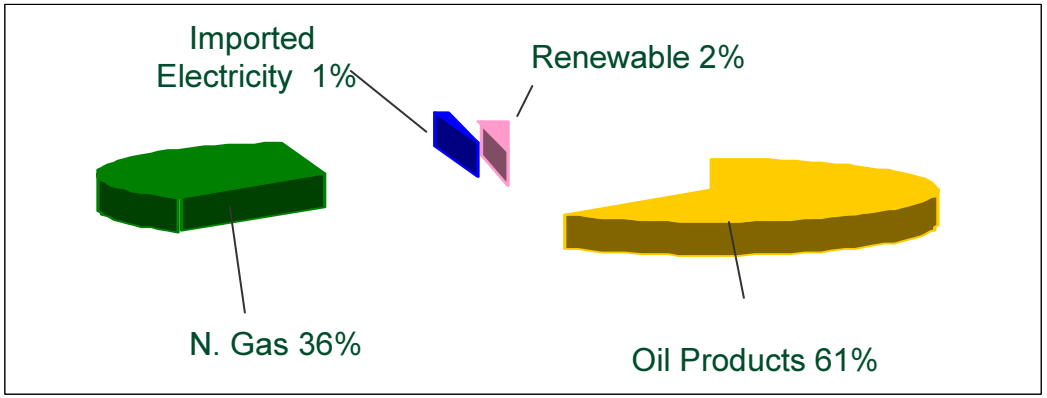
- Government should and must design incentive packages to promote private sector investments in renewable energy and other off-grid generation.
- Allow duty free importation of renewable energy hardware to promote widespread usage
- Provide tax incentives to producers of renewable energy and related accessories to promote their widespread use;
- Encourage financial institutions to provide credit facilities for renewable energy investments, especially for low-income segments of the population
- Promote research and development on wider and appropriate use of renewables as supply options

What is required?

Renewable Energy Strategy

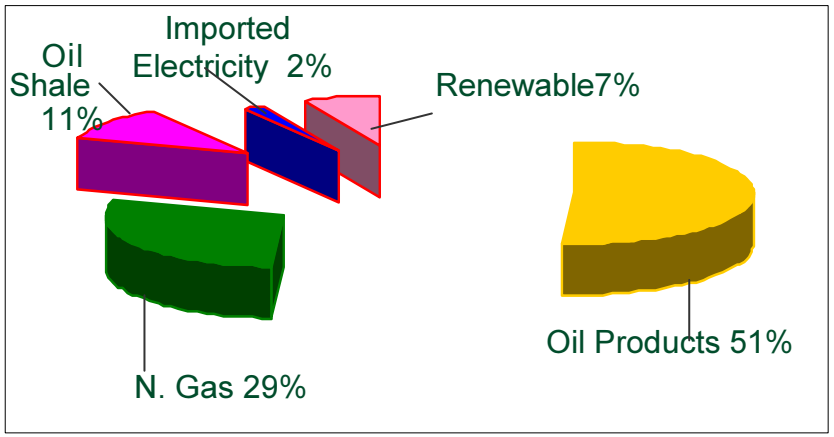
The Energy Mix in Jordan (2008 – 2020)

2008



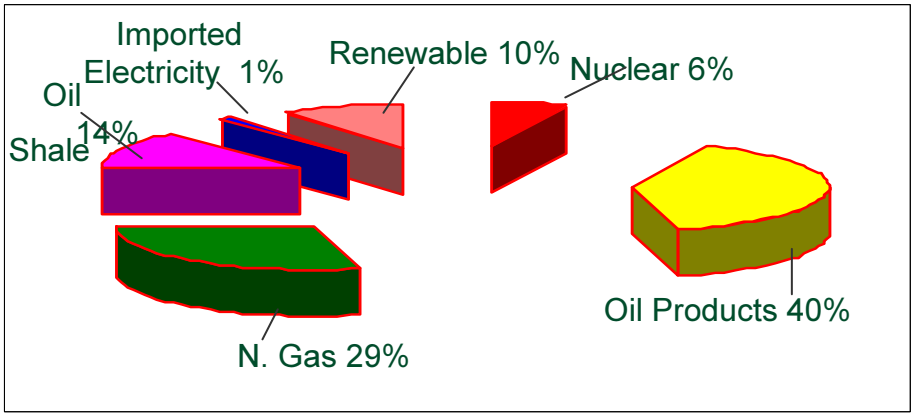
Domestic Resources 4%, Imported 96%

2015



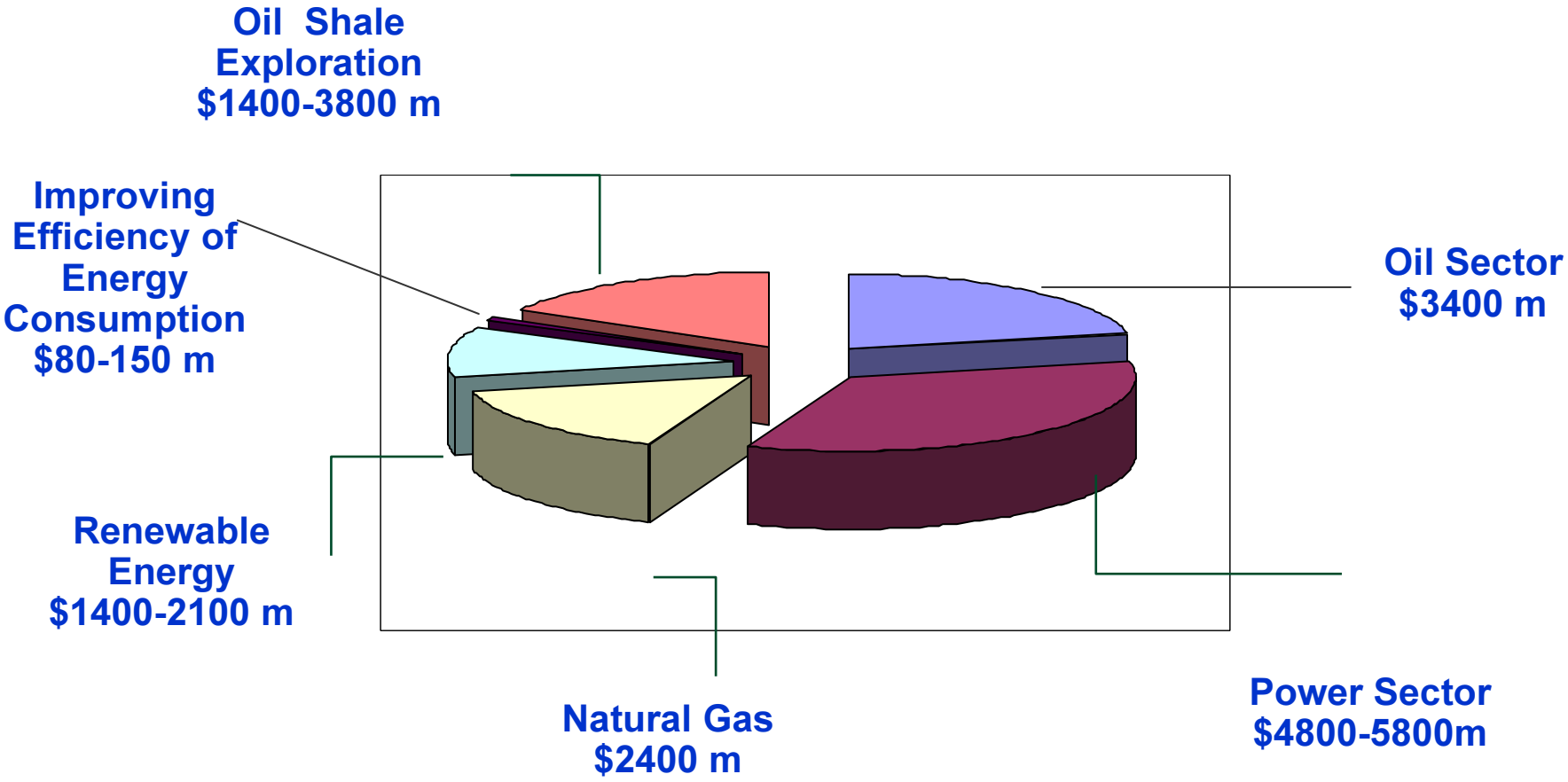
Domestic Resources 25%, Imported 75%

2020



Domestic Resources 39%, Imported 61%

According to the Master Plan the required investment in the energy sector is around $14-18 billion over the period (2008-2020)



Renewable energy

Jordan is Promoting Renewable Energy to share 7% in the primary energy mix in 2015 , and 10% in 2020 :

600 - 1000 MW Wind Energy

300 - 600 MW Solar Energy

Wind Power

Jordan has an ambitious program in wind energy development, where 600 MW of wind turbines to be installed by the year 2015, to be doubled by 2020 on BOO basis.

- **First wind project : Al Kamshah (north of Jordan) 40 MW wind project is in final stage of negotiation with the preferred bidder (Greek company) and planned to be in operation during the year 2010.**

- **Second wind project: Al Fujeij, Shoubak (South of Jordan) 90 MW is already tendered for prequalification in April 2009 and planned to be in operation in 2011.**

- **Third wind project will come as wind park pooling project in southern part of Jordan with a capacity of (300-400) MW to be launched in one international bidding process at the end of 2009.**

Solar Power

- 30 % of households to be equipped with Solar water heating by the year 2020.
- Planned Installed capacity: concentrating solar power, PV and hybrid plants with capacity of 300 to 600 MW by 2020.

- Jordan imports 96% of its energy needs costing more than 20% of the country's GDP.
- The energy demand in Jordan has doubled during the last 20 years and the annual growth rate of primary energy is 2.4% and for electricity is 7.7%.
- Such a rapid increasing demand is due to the high growth rate of population & the expansion of economical activities in various fields.
- Government of Jordan developed a comprehensive energy strategy through the Royal Advisory Committee on the Energy Sector in 2007.
- According to the new strategy, the total anticipated investment in the energy sector is expected to reach **$15 billion** by 2020.
- The current energy mix shows that only **4%** is supplied from local sources and the strategy envisages the local content to increase to **39%** by 2020 out of which **10%** should come from renewable energy.

Energy situation in Jordan

- A new Energy Law including renewable energy has been drafted and submitted to parliament for ratification and endorsement. It was issued last month.
- The new law offers fiscal incentives and encourages independent power producing projects to generate electricity on BOT basis
- Wind park projects to generate a minimum of 600 MW of electricity and Solar farms to generate a minimum of 600 MW by 2020.

The strategy estimated the volume of required investment in million dollars, at the 2007 rates in energy sector for the period (2008-2020) in accordance with the different programs and projects for the sector between (13268-17335) million US$ i.e. 1.2 billion US$ annually distributed as follows:

National energy strategy in Jordan

- Jordan has an average insulation intensity on a horizontal surface ranges between 5-7 kWh/m^2, which is one of the heighest in the world.
- This corresponds to a total annual of 1600-2300 kWh/m^2.
- The average sunshine duration is more than 300 day/year.
- According to the solar atlas in Jordan, the country is divided into five areas
- The annual average daily global irradiance:

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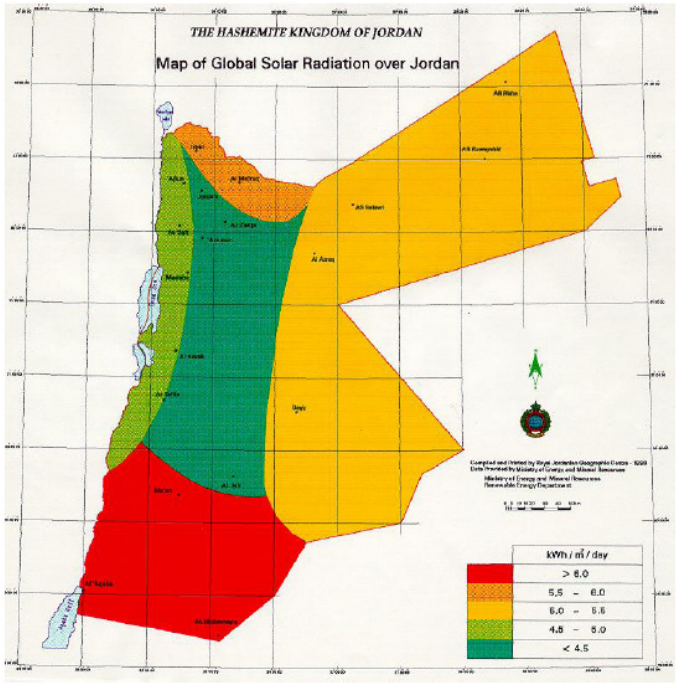
2. Eastern region: 5.5-6 kWh/m^2.
3. Middle region: 5.5 kWh/m^2.
4. Norten region: 5.5 kWh/m^2..
5. Western region: 4.5 kWh/m^2.



Solar Intensity in Jordan

Renewable Energy in Southern Mediterranean Countries

Joint ICTP/IAEA Workshop on Vulnerability of Energy Systems to Climate Changes and Extreme Events,
ICTP, Trieste, Italy, 19 - 23 April 2010

- The Southern Mediterranean Countries (SMC) are: (Algeria, Egypt, Jordan, Lebanon, Morocco, Palestinian Territories, Syria, Tunisia)
- The Mediterranean region has large potential for the use of renewable energies, particularly solar energy, due to its high level of solar radiation.
- Only a small variety of solar thermal technologies, mainly solar water heaters, is used in the region.
- The Southern Mediterranean region have weak ability to attract foreign direct investments (FDI).
- The region's share of the world's FDI is no more than 1.5% as compared, to 47.3% share of Europe in 2005.

Southern Mediterranean Countries

- The population growth in the region is going hand in hand with urbanization, which is causing increased energy demand and environmental pressures.
- For example, Cairo is growing on average by 1000 inhabitants each day. Density in the heart of Algiers has reached 200,000 inhabitants per km^2
- The Mediterranean climate has more than **2,300** hours of sunshine per year (900 hours in Germany)
- The solar energy irradiated on the ground equals **1–2** barrels of fuel oil per square meter per year

- The SMC still have substantially lower per capita energy consumption and related carbon emissions than the world's averages.
- This is because most of those countries are relatively non-industrialized, have low levels of ownerships of automobile and home appliance, and consume some proportions of “non-commercial” energy (e.g. biomass) especially in rural areas.
- For example, Morocco, Lebanon, Jordan and Palestine are importing more than 95 % of their energy needs.
- Oil and gas represent more than 90 % of the Total Primary Energy Supply (TPES), see Figure.

- The annual daily average solar irradiance is 4.9-5.9 kWh/m^2.
- Several pilot applications especially for water pumping, telecommunications and lighting for remote sites have been successfully introduced.
- The largest PV program exists in **Morocco**, where 160,000 solar home systems in about 8 % of rural households were installed with a total capacity of 16 MW.
- Photovoltaic pumping applications are relatively developed in **Tunisia** with a total existing capacity of 255 MWp.
- Solar thermal technology in the form of water heaters is achieving different degrees of market penetration in all the Southern Mediterranean Countries.

Share of solar energy in the total energy supply

- The Mediterranean Countries have a great potential for renewable energy, including solar and wind, as well as hydro and geothermal in specific cases, which are still unexploited.

- Share of renewable energy in the primary energy supply of the Southern Mediterranean Countries has been relatively low and varies from a minimum of 0.6 % in Tunisia to a maximum of 19 % in Palestine.

Share of renewable energy

Share of renewable resources in the TPES (2005)

Country	Total primary energy demand (mtoe)	Share of Renewable resources (%)	Share of solar energy (%)	Share of renewable in electricity generation (%)
Morocco	12.30	21.9	0.13	10
Algeria	36.00	2.0	1.0	1.0
Tunisia	7.33	0.6	0.0	missing
Egypt*	51.42	4.4	0.0	14.1
Palestine	1.20	19.0	8.5	0.0
Jordan	7.03	1.2	0.95	0.0
Lebanon	5.30	2.8	1.7	11.0
Syria	20.25	6.5	0.0	9.9

*for the year 2003/04

Share of renewable energy

Country	Capacity (MW)	IPP projects	Start-up
Algeria	360	project for a power plant with desalination is to be built at Arzew	2005
		New natural gas combined cycle IPP projects in Tipaza, Oran, Annaba and Jijel.	
Egypt	685	Sidi Kerir power plant	2002.
	683	Port Said power plant	2002
	683	Suez power plant	2003
Tunisia	470	Rades Combined Cycle plant by CP	2002
		Barca BOO project	2006
Morocco	1340	Jorf Lasfar coal fired power plant	2001
	50	wind farm in Tetouan	2000
	385	Tahadart Natural Gas Combined Cycle plant	2004

Renewable energy projects in SMC

Country	National Targets			
Algeria	5% of power generation by 2010			
Egypt	20% RES share of primary energy supply until 2020			
Jordan	10% RES share of primary energy supply until 2020			
Syria	4% RES share of primary energy supply until 2020			
Morocco	National Strategic Plan for Renewable Energy (2001): 12% RES share in national energy balance until 2010 New RE and EE legislation under discussion (2007): 20% RES share in electricity production and 10% of the national energy balance until 2012			
Tunisia		2010	2020	2030
	Primary energy consumption(ktep)	11000	16600	24700
	Renewable energy consumption (ktep)	300	950	1600
	Renewable energy share in primary consumption (%)	2.7	5.6	6.4
	Renewable energy share in electricity production (%)	5.8	11.7	12.2

National Renewable Energy Targets

- Jordan imports 96% of its energy needs costing more than 20% of the country's GDP.
- The government of Jordan developed a comprehensive energy strategy through the Royal Advisory Committee on the Energy Sector in December 2007.
- According to the new strategy, the total anticipated investment in the energy sector is expected to reach **$15 billion** by 2020.
- The current energy mix shows that only **4%** is supplied from local sources and the strategy envisages the local content to increase to **39%** by 2020 out of which **10%** should come from renewable energy.

Energy situation in Jordan

- A new Energy Law including renewable energy has been drafted and submitted to parliament for ratification and endorsement.
- The new law offers fiscal incentives and encourages independent power producing projects to generate electricity on BOT basis
- Wind park projects to generate a minimum of 600 MW of electricity and Solar farms to generate a minimum of 600 MW by 2020.

The strategy estimated the volume of required investment in million dollars, at the 2007 rates in energy sector for the period (2008-2020) in accordance with the different programs and projects for the sector between (13268-17335) million US$ i.e. 1.2 billion US$ annually distributed as follows:

National energy strategy in Jordan

- Issuing the draft law of renewable energy and establishing energy efficiency fund (financing the fund).	20
- Al-Kamshah proposed wind power project with a capacity about (30-40) MW on BOO system.	50-60
- Al-Fujaj proposed wind project (the grant provided by GEF) with a capacity of about (60-70) MW on BOO system.	90
- Al-Hareer proposed wind project with a capacity of (30-40) MW (in stages).	150-300
- Wadi Arabah proposed wind project with a capacity of about (30-50) MW.	45-75
- Utilization of Solar Energy for electrical power generation with a capacity of (300-600) MW	530-830
- Municipal waste exploitation project for electrical power generation project with a capacity of about (20-30) MW	30-40
- Utilization of agricultural products project to produce biogas fuel (Ethanol).	50-100
- Projects of building units for electrical power generation using wind energy with a capacity of 300 MW during the period (2015-2020).	450-600

Planned RE projects in Jordan

The Need to the Renewable Energy in the World

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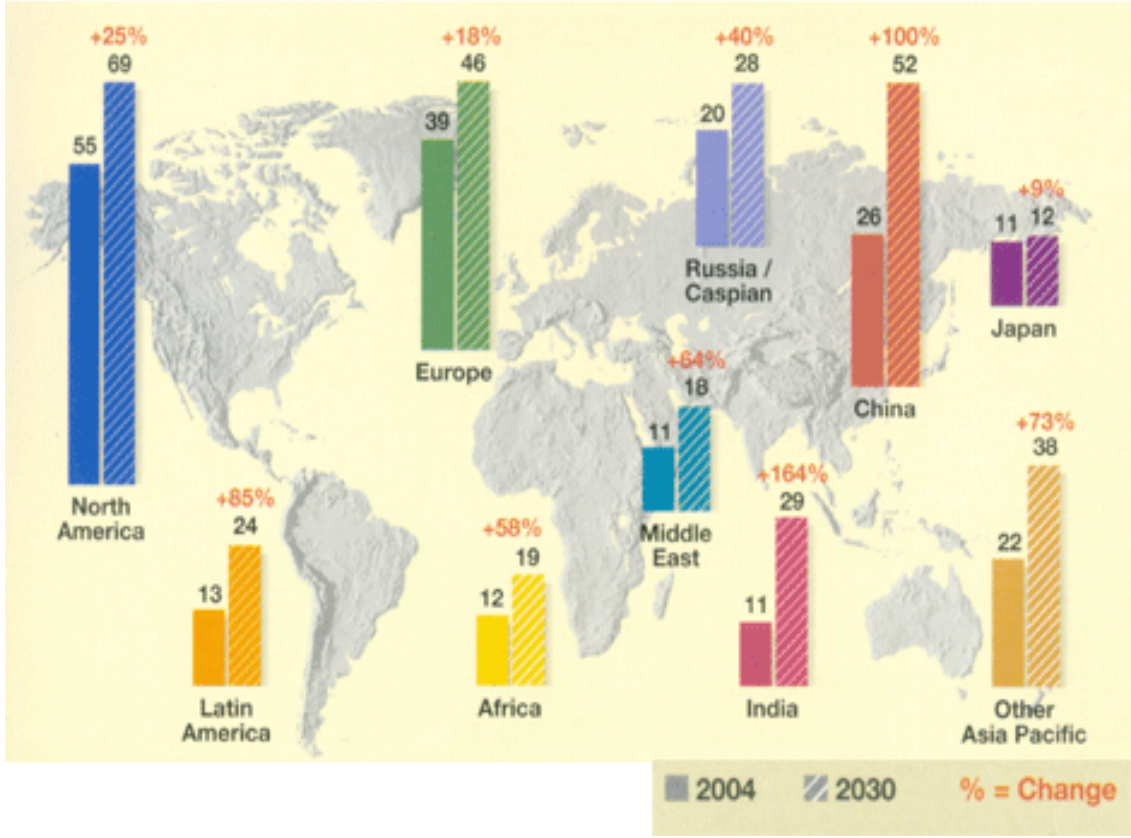
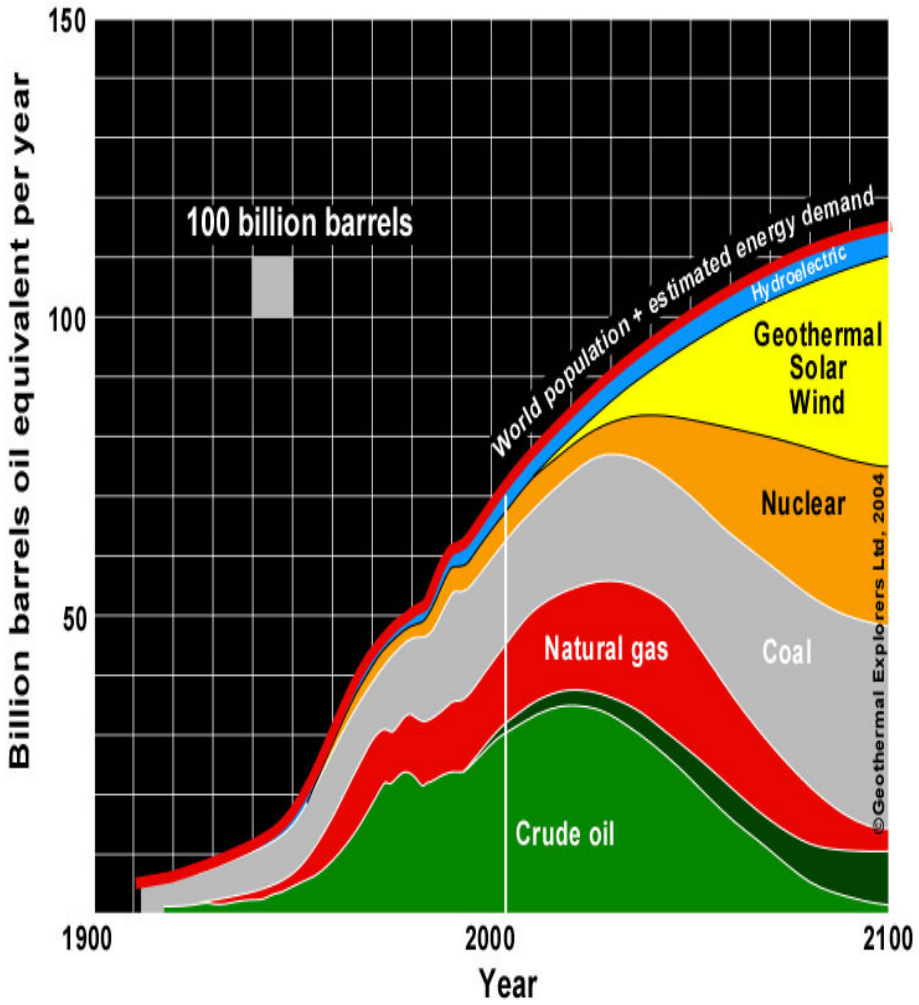
EU political and legislative level:

- Achieving the target of **12%** of overall energy consumption being produced from renewable energy in EU15 in 2010;
- In order to promote progress, since 2000 the EU has, in a legislative framework, set two indicative targets for renewable energy:
  - To increase the share of electricity generated by renewable energy to 22% in 2010 for EU15 (compared with 14% in 2000)
  - To increase the share of bio fuels in diesel and petrol used for transport to 5.75% in 2010 (compared with 0.6% in 2002).

GROWING WORLD ENERGY DEMAND
(millions of barrels per day)

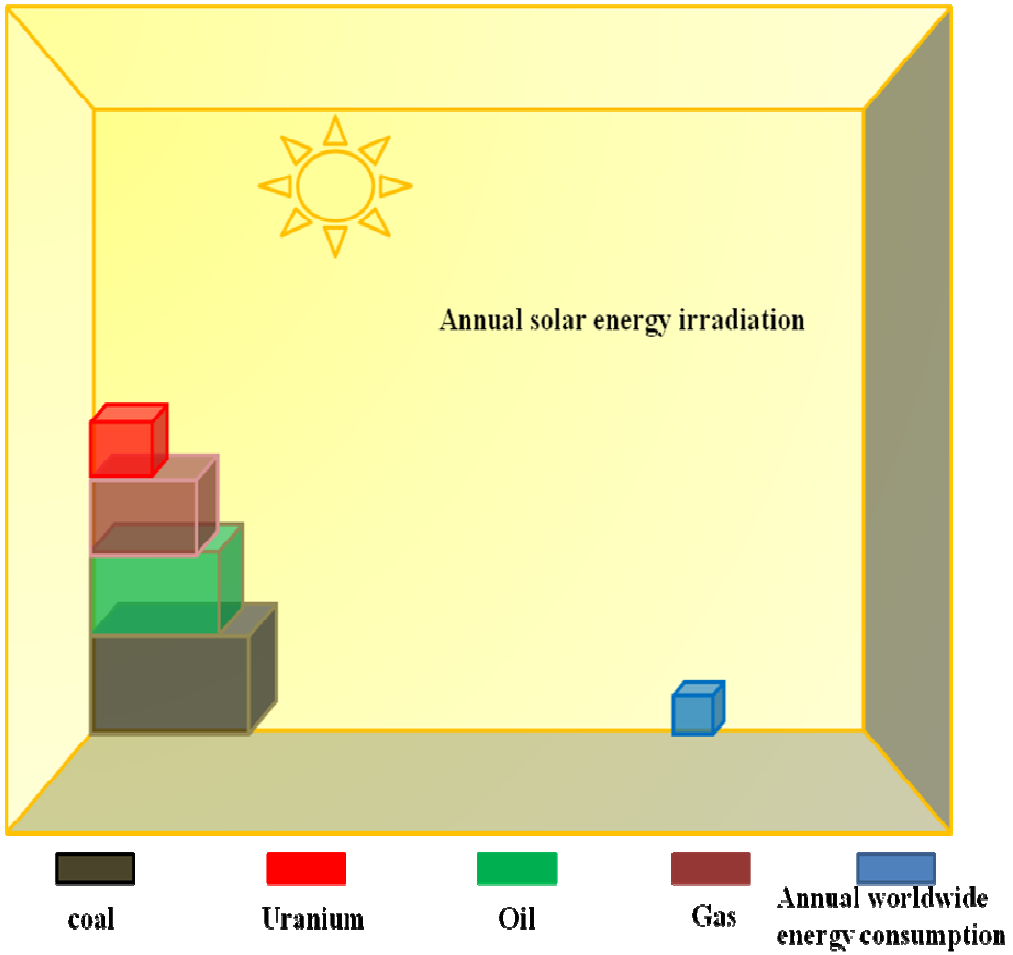


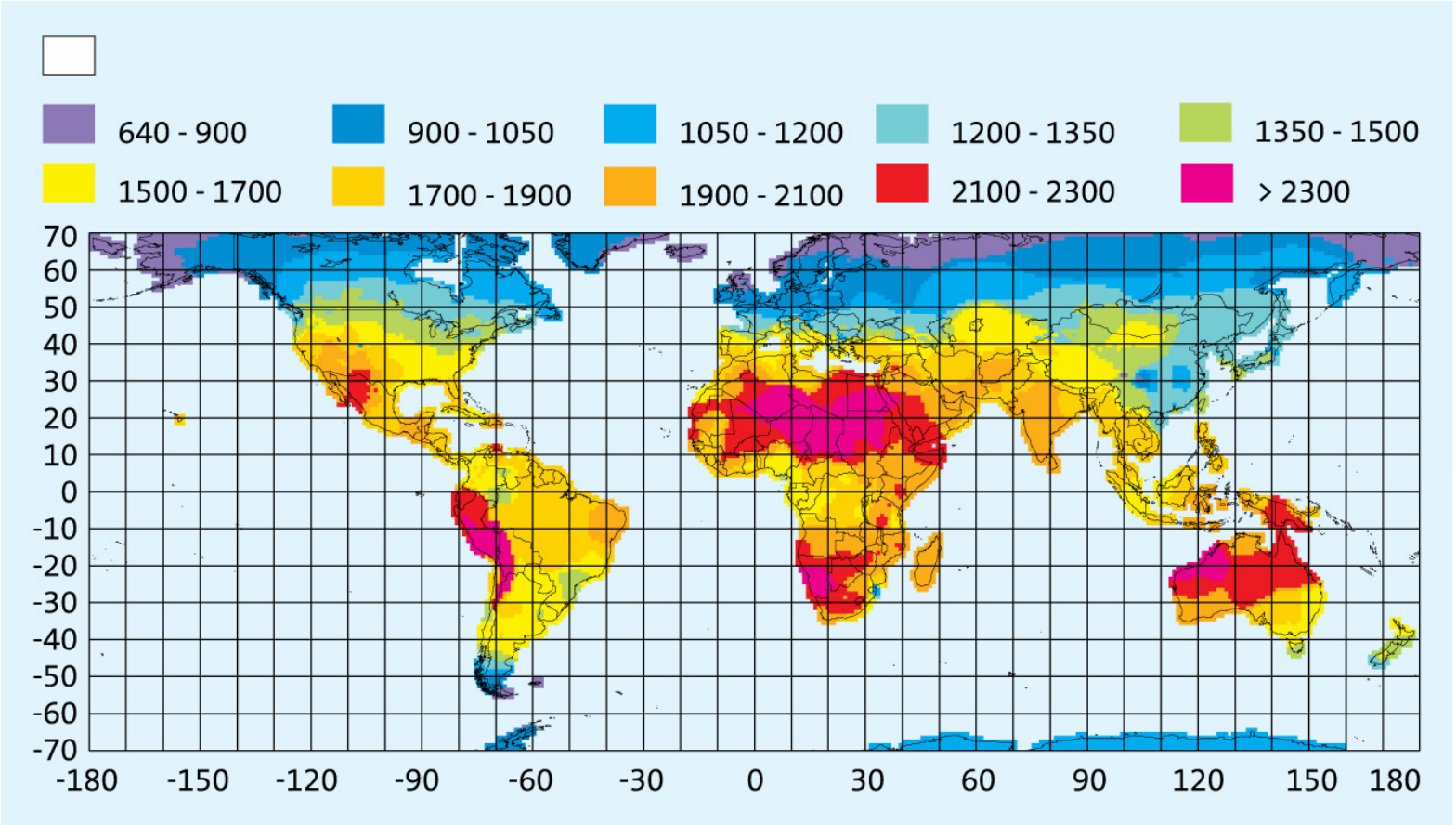
Energy demand in the world



Energy demand in the world

Energy content of annual solar radiation reaching the Earth's surface in comparison to worldwide energy consumption and fossil and nuclear energy resources, BMWi



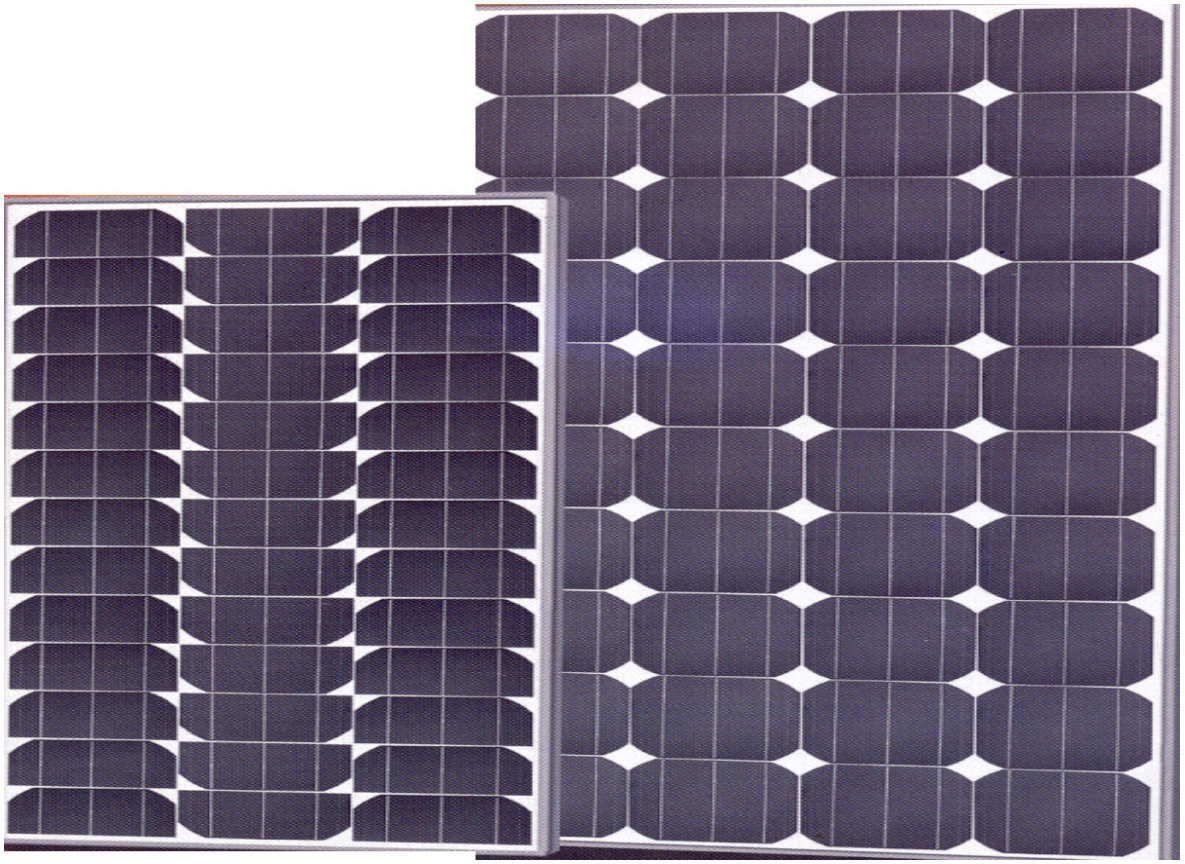


Worldwide distribution of annual solar irradiance

- Government should and must design incentive packages to promote private sector investments in renewable energy and other off-grid generation.
- Allow duty free importation of renewable energy hardware to promote widespread usage
- Provide tax incentives to producers of renewable energy and related accessories to promote their widespread use;
- Encourage financial institutions to provide credit facilities for renewable energy investments, especially for low-income segments of the population
- Promote research and development on wider and appropriate use of renewables as supply options

What is required?

Photovoltaic



- Solar energy put to full use would help to give the world energy independence, minimizing dangerous pollution levels and our dependence on fossil fuels.
- Some people feel solar will be practical when all the oil runs out. This is not true!.
- Solar is cost effective right now, especially when you consider the cost to our health from air pollution, solar is just as competitive as any other energy source.
- Solar is certainly economical. Solar offers long-term savings - buildings have a higher resale value with solar, as conventional fuels become scarcer and more expensive. Solar save money and conserves energy.

Conclusions (1)

- It is clear that renewable energy technologies have great potential for contributing to a sustainable energy mix in the region. However, more action is needed and should include:

1) Integrating renewable energy policies into national energy policies with defined and targeted contributions.
2) Strengthening relevant national institutions.
3) Encouraging renewable energy technology transfer and supporting local industries seeking to develop or use renewable energy technologies.
4) Enhancing resource assessment activities for wind and biomass.
5) Intensifying capacity building and public awareness programs.
6) Initiating new financial mechanisms for supporting renewable energy adopting, particularly in rural areas.

Conclusions (2)

- To encourage the wider adoption and use of renewable energy technologies and thereby enhance their role in the country's energy supply matrix,

- "Government should and must design incentive packages to promote private sector investments in renewable energy and other off-grid generation."

- "Government must also provide requisite support for research and development in emerging technologies like cogeneration and wind energy generation…"

Conclusions (3)