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RENEWABLE ENERGY RESEARCH AND DEVELOPMENT ACTIVITIES IN SAUDI ARABIA

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RENEWABLE ENERGY RESEARCH AND DEVELOPMENT ACTIVITIES IN SAUDI ARABIA

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Abstract

Even though the Kingdom of Saudi Arabia is a leading oil producer, it is keenly interested in taking an active part in developing new technologies based on renewable energy, which can hopefully be considered as alternatives to depleted sources of energy, such as hydrocarbon resources. Also it is a wise view that such exhaustible resources ought to be more wisely used in developing other products more beneficial and useful to mankind. Furthermore, renewable energy sources, solar and wind have been proven as reliable sources of energy especially in remote area where conventional energy sources are expensive. Hence, Saudi Arabia has engaged in several international joint research projects with developed countries. The experiences gained during these international joint programs assist in establishing a series of independent solar energy projects. Research, development and demonstration activities in the Kingdom have confirmed that solar energy has a multitude of practical uses. These include lighting, cooling, cooking, water heating, crop/fruit drying, water desalination, operating irrigation pumps, operating meteorological stations, and providing road and tunnel lighting, traffic lights, road instruction signals etc. Furthermore, the applied research projects verified the technical and economical feasibility of using renewable energy in power production and water desalination for remote areas where electrical power grid is not available and expensive to extend. Furthermore, Long-term research currently underway in Saudi Arabia could prove of the greatest benefit not only to the Kingdom but also to its neighbors, and to the whole world.

INTRODUCTION

Most of the world's energy consumption is greatly dependent on fossil fuel as its source. However, it is exhaustible and is now used very rapidly due to the continuous rise of the world's population and development. Thus, this valuable resource need to be conserved and its alternatives need to be considered. Even though Saudi Arabia is a leading oil producer, it is keenly interested in taking an active part in developing new technologies based on renewable energy, which can hopefully be considered as alternatives to depleted sources of energy, such as hydrocarbon resources (Al-Athel, 1997). Also it is the Kingdom's view that such exhaustible resources ought to be more wisely used in developing other products more beneficial and useful to mankind (Al-Athel 1997). Furthermore, renewable energy sources, solar and wind have been proven as reliable sources of energy especially in remote area where conventional energy sources are expensive.

The Kingdom of Saudi Arabia extends from Azimuth 50 to Azimuth 35 and from latitude 17 in the south to latitude 32 in the north. The average annual solar radiation falling on the Arabian Peninsula is about 2400 kWh/m^2. Table 1 shows the daily total global solar radiation kWh/m^2 and percent possible daylight hours recorded at selected station of solar radiation network (Al-Abbadi et al., 2000). These tables emphasizes the fact that solar insolation is available in all the areas of Saudi Arabia at high intensity all year round.

In respect to wind energy potential a study on the northern, eastern (costal) and central regions resources showed that the annual extractable energy density, at height of 40 m, are found to be 890, 599 and 488 kWh/m^2 respectively (Al-Abbadi et al., 1997). Therefore, recognizing these major natural resources, it is believed that such valuable renewable sources of energy should be fully exploited for the benefit of the country.

Table 1 Daily total global solar radiation kWh/m^2 and percent possible daylight hours recorded at selected station of solar radiation network for the period 1996-July 2000 (Al-Abbadi et al., 2000).

Station	Monthly Mean Daily Total Kilowatt-Hours/m^2				Percent of Possible Daylight Data Hours			
	JAN	APR	JUN	OCT	JAN	APR	JUN	OCT
Abha	4.906	7.049	6.778	6.215	99	100	93	99
Al Ahsa	3.998	6.699	7.941	5.591	95	100	99	78
Jeddah	4.343	6.881	7.336	5.576	74	96	95	97
AlJouf	3.481	7.025	8.331	5.215	100	100	100	100
Solar Village	4.093	6.631	8.006	5.660	100	100	100	100
Wadi Al-Dawasser	4.569	7.167	7.660	6.083	100	97	100	98

From the first photovoltaic beacon established by the French at the small airport of Madinah Munnawara in the early 1960's (Sakr, 1987), applications of solar energy in Saudi Arabia are growing. Research activities commenced with small scale university projects in 1969 and the systematized major R&D work for the resources assessment of renewable energy and development of applied research project in solar energy technologies was started by the King Abdulaziz City for Science and Technology (KACST) in 1977 (Al-Athel, 1997). Since then KACST has entered into several cooperation agreements with developed countries concerned with such technologies as a means of transferring renewable energy technology to the Kingdom and utilizing it in promoting development.

INTERNATIONAL JOINT RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMMES

Two major joint-international cooperation programs were introduced where cost is equally shared between Saudi Arabia and a developed country, such as United States and the Federal Republic of Germany. These joint programs have been focused on projects that have been of mutual interest to both countries. These programs resulted in the development of large demonstration plants, such as electricity generation, desalination, agriculture and cooling applications and solar hydrogen production and utilization (Huraib, 1995)

Joint program with USA:

Two Saudi Arabia-USA joint programs were established. The first program was the SOLERAS program (SOLar Energy Research - American / Saudi) that addressed solar energy technological and economical related issues. SOLERAS began in 1977 and concluded in 1987. The second program started in 1989 with the united state Department of Energy (DOE) and addresses the other renewable energy technologies beside solar energy research and development.

SOLERAS:

In the SOLERAS program, each country contributed US$50 million to the budget. The program was focused on the following fields of solar energy utilization: rural / agricultural applications, urban applications, industrial applications and resource development activities. A brief discussion of the experience gained and technical contribution of the projects conducted within the program will follow.

Rural / Agricultural Applications:

The major goal was to examine the feasibility of using solar technologies in remote areas. These included the Saudi Solar Village Project and the Solar Controlled Environment Agricultural Project.

Solar Village Project:

The Project site is located about 50 km northwest of Riyadh. Its objective is to use photovoltaic solar energy to provide power to remote villages not connected to the national electric power grid. The entire project site occupies an area of about 67,180 m^2 and comprises 160 concentrator photovoltaic arrays with a total peak output of 350 kW DC, an 1100 kWh lead-acid battery storage facility, a 300 kVA inverter, and a solar powered weather-data monitoring station. During the first period of its operation, the station supplied 1 to 1500 kWh of electric energy per day to three remote villages (Huraib, 1995). The system is capable of completely automatic operation and is designed for both stand-alone and co-generation modes of operation and has been operational since 1981.

The experience acquired through this project has been very significant in advancing the technology and the development of national manpower in related fields.

Solar Controlled Environment Agricultural Project:

The objective of this project is to integrate controlled agriculture with solar energy to demonstrate the commercial feasibility of such facilities in climate zones similar to those of Saudi Arabia and the Southwest of USA. To benefit researchers and other academics, SOLERAS has produced a set of nine volumes outlining the designs of the solar-assisted greenhouses in the full detail necessary for designers. A summary report has also been produced to give a brief outline of the respective design as a quick reference (Khoshaim et. al., 1983).

Urban Applications:

The objective of the Urban Applications was to improve the quality of life at hot, arid environment by investigating the use of solar energy in the active cooling of buildings. Such objective was pursued by funding university research and field test projects with a total cost of 15.5 million US dollars (Al-Athel, 1993).

Universities R&D Solar Cooling Projects:

These projects were curried out at four of the Saudi universities aiming to assist and enhance their research capabilities in solar energy technology. The universities solar cooling research laboratories were equipped with the necessary apparatus and instrumentation. At King Faisal University the objective was to evaluate the performance of solar passive concepts and materials used in building design and construction under the hot Saudi environment.

The objective at King Saud University Laboratory was to conduct research on active solar cooling. Two lithium bromide water absorption chillers powered by evacuated tube solar collectors and a thermoelectric cooling system powered by flat plate photovoltaic array were tested.

The projects at King Fahad University for Petroleum and Minerals and the King Abdulaziz University aimed to study the performance of a Rankine cycle air-conditioners powered by evacuated tube and parabolic trough collectors.

Solar Active Cooling Systems:

The objective of the engineering field test is to stimulate the development of advanced active solar-cooling systems for typical conditions of hot-arid and hot-humid environments and explored the feasibility of using solar energy for cooling of building envelopes. Four active solar cooling commercial projects were tested in USA (Al-Athel, 1993).

Carrier Corporation built two systems, with cooling capacity of 53 kW and 35 kW. A third system was built by the United Technology Research Center, with a cooling capacity of 63 kW, and a fourth system was built by Honeywell Technology Center, with a cooling capacity of 49 kW. All systems are energized by solar energy. The experience gained from the operation and maintenance of the systems resulted in the ability of the manufacturers to deal with many solar air conditioning issues. These issues include the mismatch of collector's output with absorption refrigeration requirements, breakage of evacuated-tubes solar collector, and deterioration of the solar collector reflective surface film. These tests contributed to the commercialization of solar cooling on a competitive basis with conventional systems (Huraib, 1995).

Industrial Applications:

The goal of these applications was to use solar technologies in industrial applications that require thermal or electric energy. The solar-powered seawater desalination plant was the major demonstration project developed. The solar desalination Pilot Plant was completed in December 1984. It uses an indirect contact heat transfer freeze process to produce 200 cubic meter of potable water per day. Solar energy is collected by a distributed array of dual-axis tracking, point focus concentrators. The annual average solar energy collected per day is 2200 kWh. The operation, maintenance, and performance results enabled solar collector component manufacturers to use the project as a test bed for new concepts, investigated solutions to mirror edge protection against environment, improved tracking mechanism design and developed a third generation solar collector. The operation of the pilot plant contributed also in learning more about the freeze desalination processes and the development of a new commercial equipment (Huraib, 1995). However, the plant was closed down for economical reasons (Huraib, 1995).

Resource Development Activities:

The resource development activities include the collection and analysis of solar resource data, granting universities multi-year funding to conduct basic solar energy research, organizing and sponsoring several major international technical solar workshops and annual short courses in solar-related fields, and disseminating the technical knowledge acquired during the program. The total expenditure in this area was US $5.1 million (Al-Athel, 1993) Under this scheme six international solar workshops were held in Saudi Arabia and USA. A list of titles and venues of those workshops is provided in Table 2.

As part of the collection and analysis of solar resource data, SANCST (the Saudi Arabian National Center for Science and Technology), a former name of KACST, produced the first "Saudi Arabian Solar Radiation Atlas". This document is based on the data obtained from the archives of the Ministry of Agriculture and Water for the period from 1971 to 1980, covering 17 stations which measured the duration of sunshine and 41 stations which measured global solar radiation, throughout the Kingdom (Saudi Solar Atlas, 1983).

RENEWABLE ENERGY RESEARCH AND DEVELOPMENT PROJECT:

The second program of collaboration between the DOE and KACST, is currently addressing the research, development and demonstration in other technologies of renewable energy, namely, wind, geothermal, bio-mass, etc., in addition to solar energy. The activities included in this program are: Solar Energy for Remote Applications (Annex I), Assessment of Solar Radiation Resources in

Saudi Arabia (Annex II), and Assessment of Geothermal Resources in Saudi Arabia (Annex III). The activities of Annex III did not start yet.

Table 2 International workshops held under the SOLERAS program.

S. No.	Title	Location	Year
1	Solar Cooling Technology	King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia.	1980
2	Solar Desalination	Denver, Colorado, USA	1981
3	Solar Storage	King Abdulaziz University, Jeddah, Saudi Arabia	1982
4	Solar Thermal Collectors	Lake wood, Colorado, USA	1983
5	Solar Buildings	King Saud University, Riyadh, Saudi Arabia	1984
6	Solar Energy Applications in Remote Areas	New Mexico Solar Energy Institute, New Mexico State University, USA	1985

Solar Energy for Remote Applications (Annex I):

In remote areas, water is very important for the life of the community, for watering stock and for irrigation. In Saudi Arabia, the major source of water is underground, and supplies are drawn to the surface using diesel engines. These engines need a continuous fuel supply for regular operations. Fuel supply to remote areas can be very costly. Solar energy can, therefore, be a competitive alternative source for water pumping and desalination.

The first PV powered brackish water pumping and desalination plant was installed in 1994 at Sadus village, 70 km north of Riyadh, in collaboration with the National Renewable Energy Laboratory (NREL), USA. The plant has two separate PV fields. One (980 W_p) is to energize a submersible pump for pumping water from a well, at a depth of 50 meters from ground level, and the other (10.08 kW_p) is to provide power to a reverse osmosis unit (R.O.U) and to other accessories and equipment. The R.O.U. produces 600 liters/hour of potable water, from feed water with total dissolved solids of 7000-1000 ppm. The potable water is stored in a tank, which is used by the inhabitants of the Village (Al-Awaji, 1995). The preliminary investigation has shown an excellent overall performance of PV plant for water pumping and desalination, however, the potable water recovery rate is only about 30%. The ROU was recently upgraded to achieve a recovery rate of 60% with the same energy input. Meanwhile, the plant performance after this upgrade is under verification. Simultaneously, a separate study was performed to incorporate a solar thermal desalination system (probably a pilot plant of solar stills) with the existing PV powered R.O.U in order to use the high rejection rate of brine for water distillation to further increase the recovery rate.

Assessment of Solar Radiation Resources in Saudi Arabia(Annex/II)

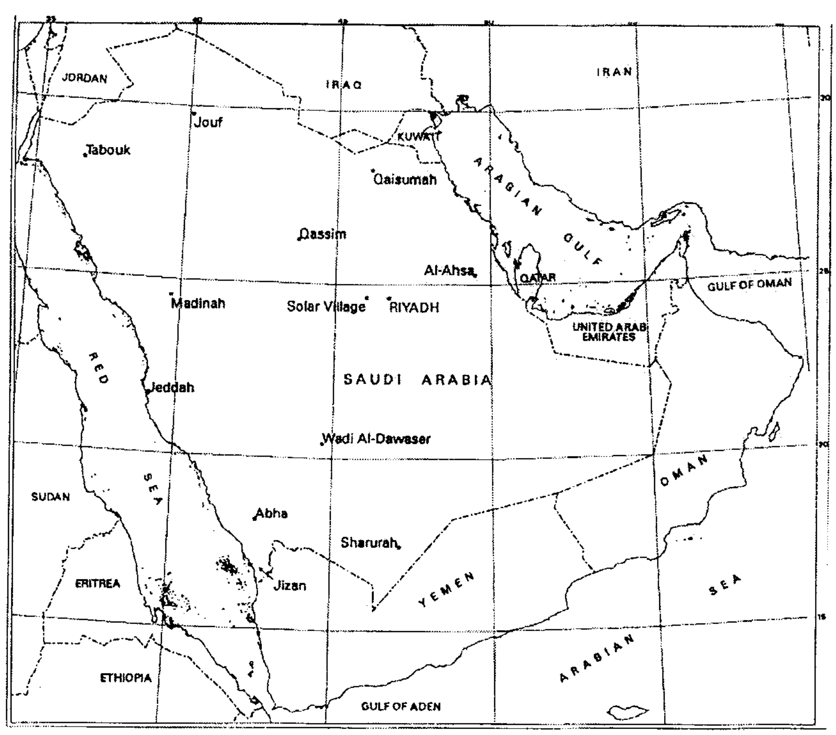
Reliable quantitative data on the daily and annual distribution pattern of solar energy at given locations are essential not only for assessing the economic feasibility of solar energy, but also for the thermal design and environmental control of buildings and greenhouses.

From 1993 to the present (2000), the energy research institute at KACST and the National Renewable Energy Laboratory's (NREL) of DOE conducted a joint solar radiation resource assessment project to upgrade the solar resource assessment capability of the Saudi Arabia. The project is operated under the Joint Saudi Arabia United States Project on Renewable Energy Research.

The goals of the project were to improve the monitoring of solar radiation resources for alternative energy within Saudi Arabia. In addition to exchange technical expertise in the principles of solar radiation measurements, instrumentation, network operations, data quality assessment and management, solar radiation modeling, and to generate a solar radiation atlas for the Kingdom. The Project has resulted in deployment and operation of a high-quality 12-station network for monitoring solar total horizontal, direct beam, and diffuse radiation in the Kingdom, and a new edition of a solar radiation atlas for the Kingdom.

The 12 network sites are Solar Village (Riyadh), Gassim, Al-Ahsa, Al-Jouf, Tabuk, Madinah, Jeddah, Qaisumah, Wadi Al Dawasir, Sharurah, Abha and Gizan. Figure 1, shows the geographical distribution of the network station around Saudi Arabia.

Figure 1. Map of solar radiation network stations in Saudi Arabia



All the network stations are connected to a central unit for data collection and the entire instrument are calibrated routinely in order to provide reliable and accurate data. Furthermore, KACST participated in the World Meteorological Organization (WMO) 1995 International Pyreheliometric Comparison (IPC) in order to obtain traceability of their radiometer calibrations to the WMO World Radiometric Reference.

Furthermore, the project is working on establishing a national solar radiation database for Saudi Arabia. NREL has applied techniques for estimating the total column water vapor and aerosol optical depth from the measured meteorological and radiometric data to support the data base project.

Joint program with Germany

The program was devoted to addressing several solar energy related issues through a joint R&D program enveloping several agencies from Saudi Arabia and the Federal Republic of Germany. The program activities started in 1982 with the Solar Electric Stirling Engine Concentrator (Solar Thermal Dish Project), and it was then expanded to include sizable projects dedicated to the advancement of solar hydrogen technologies [1].

The Solar Thermal Dish Project:

This project was a joint program between KACST and the former Federal Ministry of Research and Technology, Bonn, BMFT (Germany). The project aimed to develop, construct and test the performance of, a first generation of solar thermal dishes, consisting of two dishes designed to produce 50 kW of electrical power each.

The Solar dish is 17m diameter large-scale membrane solar concentrator. It uses a large hollow reflector that tracks the sun. Each unit is coupled with Stirling engine to convert the solar thermal energy collected into mechanical energy to drive 50-60 kW_p electrical AC generator. The operation mode of the dishes involves a grid-connected mode, with the electric utility grid, to evaluate co-generation mode, and a stand-alone mode to demonstrate the system's capability of providing electric power for remote sites. The Solar Thermal Dish Project, which has succeeded in generating 50 kW of electricity from a single concentrator dish is still considered the largest dish of its type in the world. The project's budget was approximately 8 million Deutsche marks (Al-Athel, 1997).

Solar hydrogen (HYSOLAR):

In 1986 the Federal Republic of Germany and the Kingdom of Saudi Arabia signed an agreement on cooperation in research, development and demonstration of solar hydrogen production and its utilization, HYSOLAR (HYdrogen from SOLAR energy). Several research organizations and universities from both countries joined HYSOLAR. In Saudi Arabia, the organization includes KACST, King Saud University (KSU) in Riyadh, King Abdul Aziz University (KAAU) in Jeddah and King Fahd University of Petroleum and Minerals (KFUPM) in Dhahran. In Germany, the following organizations were involved: the German Aerospace Research Establishment (DLR) in Stuttgart and Cologne, the University of Stuttgart (USTGT) and the Center for Solar and Hydrogen Research (ZSW) in Stuttgart [Aba Oud, 1998].

The HYSOLAR program included testing three photovoltaic-electrolytic hydrogen producing facilities. A 2kW-laboratory scale facility at KAAU, Jeddah, 10kW-testing facility at DLR, Stuttgart and 350kW-pilot plant at KACST, Riyadh. HYSOLAR activities included also R&D activities for hydrogen utilization in fuel cells, combustion engines and catalytic burners. In addition, fundamental investigations in photoelectrochemistry, electrochemical catalysis and instationary combustion, system studies for central and de-central applications and R&D work on concentrating photovoltaic systems have been carried out. Table 3 summarizes the HYSOLAR activities and organizations involved. A brief discussion of the accomplishments of some of the main HYSOLAR activities follows:

350 kW Solar Hydrogen Demonstration Pilot Plan:

The solar hydrogen pilot plant is situated at Solar Village, Riyadh, and is considered as the world's largest solar powered hydrogen generation plant. The electrolyses system of the plant is connected to the 350 kW Solar Village photovoltaic system that generates DC electricity used by the advanced alkaline water electrolysers to produce 463 cubic meters of hydrogen at normal pressure per day. The new features of the electrolyser allowed it to operate under variable solar conditions with an intermittent mode of operation that was not been investigated before. Results of the plant operation showed some improvements are required such as PV-field and electrolyzer hardware improvement, improvement of the AC power supply for the rectifier, and installation of a new pressurized air system and adaptation of specific measurement techniques (Huraib et al., 1996).

Table 3. HYSOLAR Program activities and organizations involved (Aba Oud, 1998).

HYSOLAR tasks	Institutions
Hydrogen production	
350 kW demonstration plant, Riyadh	KACST, DLR
10kW research and test facility, Stuttgart	DLR
2 kW test facility, Jeddah	KAAU, KACST
Hydrogen utilization	
Catalytic combustion	USTGT, KACST
Hydrogen engines	KACST, USTGT
Fuel cell technology	DLR, KACST, KFUPM
Fundamental research	
Photoelectrochemistry	USTGT, KSU
Electrochemical energy conversion	KSU, KAAU
Instationary combustion	USTGT
System studies	
Hydrogen energy systems	DLR
Photovoltaic	
Concentrating photovoltaic	ZSW systems

Hydrogen Utilization Laboratory:

The development of hydrogen utilization for domestic, agriculture and industrial applications, e.g. cooking, cooling, lighting and electrical energy generation was one of HYSOLAR program aims. As part of this task, a successful experiment was conducted in making modifications to an internal combustion engine so that it could use hydrogen as a fuel instead of petrol. Beside that R&D activities on phosphoric acid fuel cell (PAFC) were initiated at the Energy Research Institute, KACST, in 1991 under the framework of the HYSOLAR Program. Within the task of hydrogen utilization, the PAFC R&D work progressed successfully with "in-house" know-how for the development of half cells, mono cells, 100 W, 250 W and 1 kW stacks (Aba Oud, 1998).

The HYSOLAR program activities were concluded by the end of 1996 with many great success and extensive contributions to the solar R&D community in general and solar hydrogen in particular. Competent research teams have developed valuable technical and experimental equipment as well as demonstration plants, which have been built. HYSOLAR has stimulated numerous other activities on the national and international scale. The team members of the respective projects have reported on their R&D work and their results were published in more than 150 publications and an extended final report on HYSOLAR was (Steeb and Aba Oud, 1996). A total of 15 contributions were accepted for presentation at the 11th World Hydrogen Energy Conference 1996 in Stuttgart (Aba Oud, 1998).

KACST INDEPENDENT ACTIVITIES:

Wind Energy Resource Assessment:

In 1995 the energy research at KACST has pursued to assess the wind energy potential of the country. The project also aiming to update the wind energy atlas funded by KACST and generated by a research team from KACST and King Fahd University of Petroleum and Minerals (KFUPM) (Al-Ansari, et al., 1986). This atlas was based on data measured at airport sites and at height 8-10 m above ground. Hence, the atlas lacks the accuracy for assessing wind potential for energy utilization and the effect of height on wind speed. These shortcomings made it necessary to update the atlas and to initiate the wind resource assessment project. For the past period of the assessment project seven sites were surveyed. A wind station is generally comprised of a tower, sensors and a data acquisition system. The tower is a steel tube having a length of 40 m. Wind speed sensors are installed at heights 40, 30 and 20 m. Each height has two sensors. In case one sensor fails, the other still operates, thus, ensuring continuos data collection. Wind direction sensors are also installed at two heights, 30 and 40 m. Two sensors are installed for the reason stated above. Other meteorological sensors to measure global insolation, ambient temperature, relative humidity and barometric pressure are also configured to the wind station (Al-Abbadi, 1997).

Photovoltaic (PV) Applied Research Projects:

The energy research institute at KACST has conducted several independent PV applied researchs aimed to study the technical and economical feasibility for application in remote areas where conventional energy sources are expensive to use. Such applications include highway lighting and warning applications, cooling and refrigeration and powering agriculture green house. Some of these applications will be briefly discussed. Table 4 summarizes PV systems installed and sponsored by KACST for research and development purposes.

Table 4. List of PV systems in Saudi Arabia installed and sponsored by KACST

Projects	*Capacity* kW$_p$	*Location*	*Construction & Operation*	*Application*
1. PV Power System	350	Solar Village	1981-1987	DC/AC Electricity for Remote Areas
2. Solar Hydrogen Production Plant[1] (HYSOLAR program)	280	Solar Village	1987-1993	Demonstration Plant for Solar Hydrogen Production on Larger Scale PV System
3. 2 kW Solar Hydrogen	1.08	KAU, Jeddah	1986-1991	Testing of Different Electrode Materials for Small Scale Solar Hydrogen Plant
4. 3 kW$_p$ Test System	2.8	Solar Village	1987-1990	Demonstration of Climatic Effects
6. Water Desalination using Photovoltaics	11.06	Sadous (65 km north of Riyadh)	1994-1996	600 liters/h PV/Reverse Osmosis Interface
7. Grid-connected System Evaluation	6	Solar Village	1996-1998	Reducing Electrical Peak Load on Power Lines
8. PV-powered Green House[2]	14.7	Muzahemiah Testing Farm	1999-	Evaluation of PV-powred agriculture green hous

[1] same PV system in # 1 was used for powering the solar hydrogen plant

[2] in cooperation with the "Japan greening project".

Solar powered highway devices project

Modem highway safety standards require the deployment of lighting and warning devices that improve the motorist's ability to avoid potential road hazards. Remoteness of some highways made it impractical and costly to connect them with the national electric power grid. Based on a request from the Saudi Arabian Ministry of Transportation, KACST conducted several experiments to determine the economic feasibility of using solar energy in highway illumination. KACST utilized photovoltaic systems to power highway devices in various remote locations within Saudi Arabia. Table 5 summarized these experiments (Al-Athel, 1997). These projects generate approximately 1500 kWh of solar electric energy per day with a calculated cost of about US$0.1/ kWh (Huraib, 1995). These projects allowed Saudi Arabia the unique opportunity of demonstrating that modern highway safety standards can be achieved in remote regions where no grid power exists.

Table 5. PV powered highway devices (Al-Athel, 1997)

Project Titles	PV Array Size (w_p)	Battery Size (Ahr @120 hr rate)	Location
Over height Vehicle Direction and Diversion	1,560	1,954	Mujahidin-Jouranah Interchange
Traffic Counter	160	108	Jeddah-Makkah Expressway
Illuminated Steep Grade Warning Sign	520	300	Uraija-Muzamizah Expressway
Sign Lighting at two interchanges	26,255	32,736	Dammam-Abu Hadriah Expressway
Lighted Warning Signs at Pedestrian Crossing	130	200	Sabt Tanumah
Illuminated 240 meter long tunnel	48,720	6,000	Shaar Descent
Illuminated 546 meter long tunnel	57,600	4,916	Shaar Descent

Weather Effects Evaluation:

A 3 kW PV power system has been established at Solar Village in order to evaluate the resulting effects of changing direction, rotation, dust and temperature on photovoltaic measurements as well as to test the efficiency and output of the PV system. The performance evaluation of various photovoltaic flat-plate and concentrator module technologies is conducted as a continuous activity.

Thermal Applied Research Projects:

Development of Solar Water Heating Systems

Recently, it has been observed that electricity consumption has drastically increased in Saudi Arabia, which creates a mismatching situation in demand and supply. One way to reduce electricity consumption in water heating sectors is to introduce solar water heating systems (SWHS) for different hot water applications (domestic and industrial use, etc.). An experimental study on manufacturing low cost SWHS, from locally available materials, is under way at the Energy Research Institute. Later, know-how about these experimentally and seasonally tested SWHS will be handed over to the interested industries for mass production and commercialization. Under this scheme, a constant technical backup to the local manufacturer will be provided to continuously upgrade and improve SWHS. It is reported, that a thermosyphon domestic SWHS based on locally fabricated, 3.6 m^2 solar collectors will provide sufficient hot water for a family of five people in Saudi Arabia and it would cost SR 4,500 (One Saudi Riyal (SR) = 0.27 U.S.$). This shows that the final cost of locally fabricated and environmentally tested SWHS will be about 60% cheaper than the imported SWHS (Al-Athel, 1997). Obviously, this cost of SWHS will be drastically reduced during mass production of the SWHS.

Solar dryers

Drying immature dates is a problem for many countries where the relative humidity is high during the drying season. Drying dates using solar energy is important in reducing the maturation time as well as minimizing the loss of dates. The Energy Research Institute in cooperation with the Ministry of Agriculture and Water has conducted studies to develop the most efficient system for drying dates using solar energy. In this connection, a number of solar dryers have been designed, installed and experimentally tested at Al-Hassa and Qatif agricultural experimental sites. Such designs included several forced convection tunnel-shaped dryers. For further reduction of drying cost a simple plastic basket-shaped design, installed directly on date bunches while on tree, utilizing natural convection has been tested. Utilizing agricultural green house as a low cost option, available in most of the farms and not utilized during drying period also have been evaluated for date drying.

CONCLUDING REMARKS

Research, development and demonstration activities in the Kingdom have confirmed that solar energy has a multitude of practical uses. These include lighting, cooling, cooking, water heating, crop/fruit drying, water desalination, operating irrigation pumps, operating meteorological stations, and providing road and tunnel lighting, traffic lights, road instruction signals etc. Furthermore, the applied research projects verified the technical and economical feasibility of using renewable energy in power production and water desalination for remote areas where electrical power grid is not available and expensive to extend.

Through joint international programs KACST has achieved major success in the advancement of solar energy technology and transfer besides learning several administrative and management type of lessons from operating these programs. Nevertheless, the experiences gained during the international joint program assist in establishing a series of independent solar energy projects at ERI, KACST. Long-term research currently underway in Saudi Arabia could prove of the greatest benefit not only to the Kingdom but also to its neighbors, and to the whole world.

The Solar Village project features a wide range of equipment for tapping, solar energy: photovoltaic panels, flat-plate collectors, solar thermal dishes, etc. On-site laboratories and computer systems collect and analyze data for further solar energy research and application. This facility contributed greatly in the advancement and development of skilled national manpower in renewable energy resource assessment and applied research development, operation and maintenance.

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