THE APPLICATION OF PARABOLIC TROUGH TECHNOLOGY UNDER JORDANIAN CLIMATE

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ABSTRACT

- Parabolic trough solar thermal power plants are a proven technology in the utility scale since mid of the eighties. Between 1984 and 1991 nine power plants with an overall capacity of 354 MW have been installed in the Mojave Desert in California. Since these power plants can be equipped with a thermal storage or a fossil back-up they offer a fully dispatchable electricity generation capacity. This technology will be a very interesting near term option for countries with high solar irradiation levels and small resources of fossil fuels like Jordan.
- This paper discusses the numerical simulation of parabolic trough solar thermal power plants under Jordanian climate for Ma'an site. An analysis of the daily power output, direct normal irradiation and the efficiency for the Ma'an site has been carried out. The results show that Ma'an site is preferable.

Jordan Solar potential and land resources are optimal for the implementation of solar thermal power technologies due to:

- Jordan is poor in terms of natural resources, including energy, compared with neighbouring Arab countries.
- Also Jordan is totally dependent on imported oil to meet its energy demand
- Most regions in Jordan offer direct normal insolation above 2000 kWh/m2yr
- The best sites, in the southern part of the country, exceed 2300kWh/m2yr

The research work aims to:

- Utilise the application of solar electricity generating systems for power production in Jordan by using parabolic trough collectors technology for the benefit of supplying electricity to the remote areas in Jordan.
- To design and simulate the parabolic trough collector loops and its power block for electricity production under Jordanian climate.

- To make initial assessment of financial and economical aspects of the SEGS.
- To identify the best suitable site for erecting the SEGS plant in Jordan.

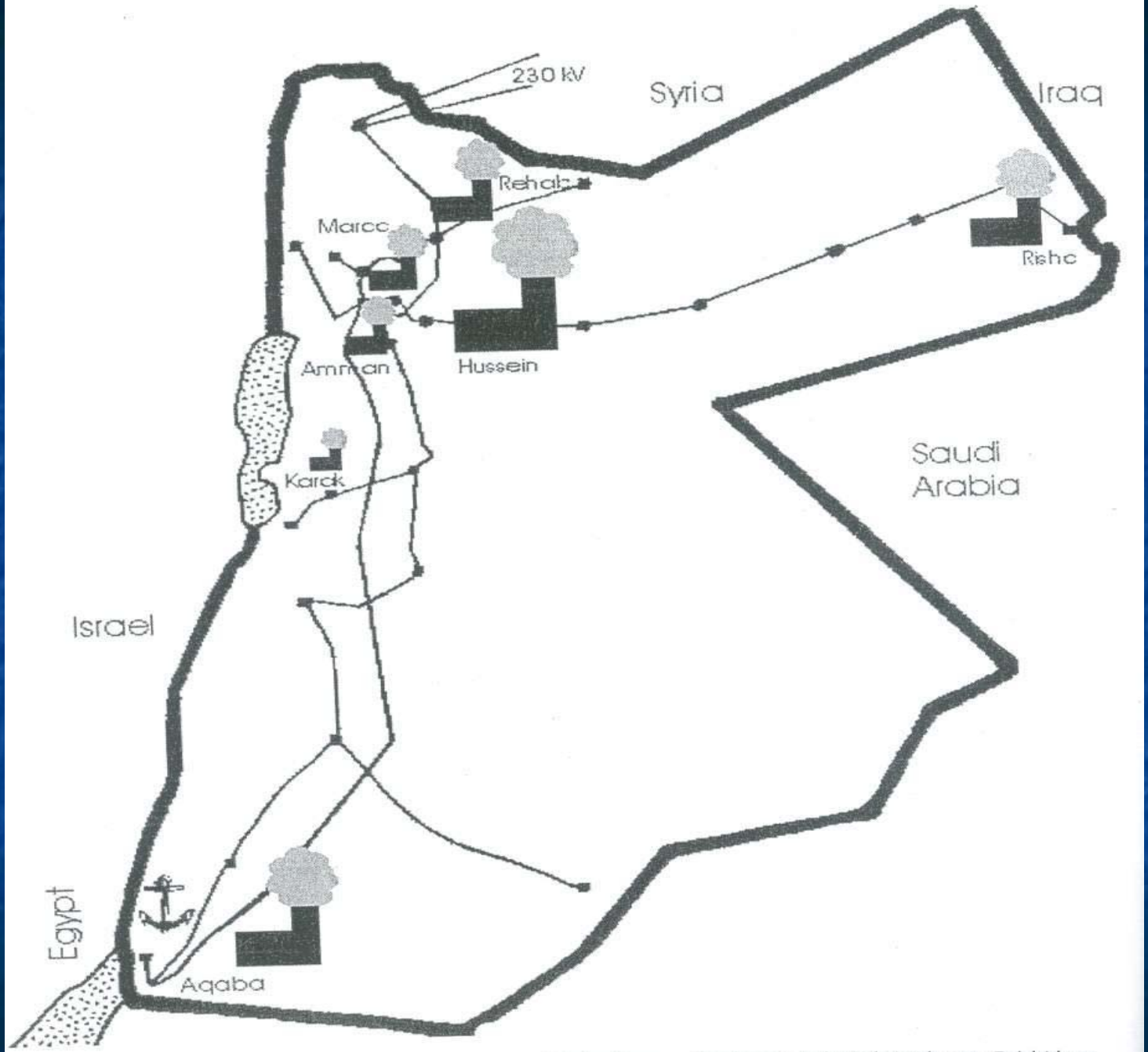
SITE SELECTION

- Desirable physical characteristics of a favourable SEGS site include high direct radiation, flat topography, suitable water supply and access to electric transmission facilities and availability of auxiliary fuel supplies. Additionally, socio-political issues such as existing land use and cost, potential environmental and cultural impacts, and local public acceptance can strongly influence the feasibility of a SEGS project. Hence, the evaluation of site criteria is an important yet sensitive in the assessment of SEGS potential in Jordan.
- In designing and operating any SEGS it is necessary to have reliable Meteorological or satellite data.

In the present study two solar radiation sites where chosen as following:

- The southern region (latitude 30.12' N, and longitude 35.43' E) represented by Ma'an area. In this region, the yearly sum direct normal irradiation is 2360 kWh/m2. The land cost in this region is 80% lower than that in Amman.
- The northern region (i.e. Irbid) has been excluded in the present study; due to the availability of sufficient power supplies to this region from the wind turbine fields (Al-Ibrahimia and Hofa) and the gas turbine plant at REHAB.

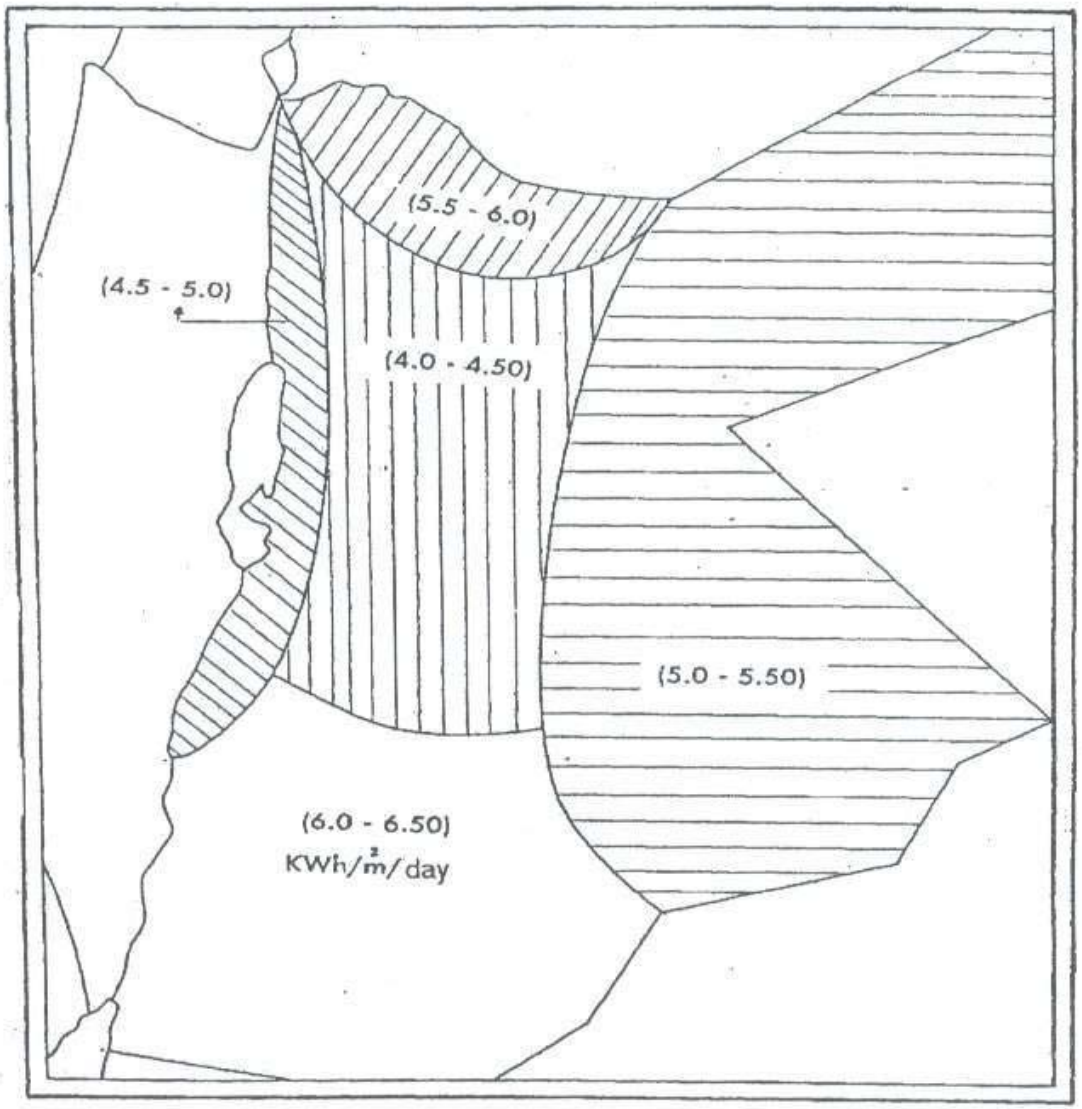

Syria
Iraq
Umm Qais
Pella
Jerash
Bethany
Amman
Mount Nebo
Dead Sea
Madaba
Mukawir
Israel/Palestine
Jordan
Petra
Wadi Rum
Saudi Arabia
Aquaba
Egypt
Gulf of Aqaba [Red Sea]



Major Power Stations and High-Voltage Grid Lines

In the designing and selection of solar power systems the following data is considered:

- *Detailed solar data for the specific site;*
- *The consumer demand profile at the same site;*
- *The performance characteristics of the solar collectors;*
- *The characteristics of the steam turbines.*



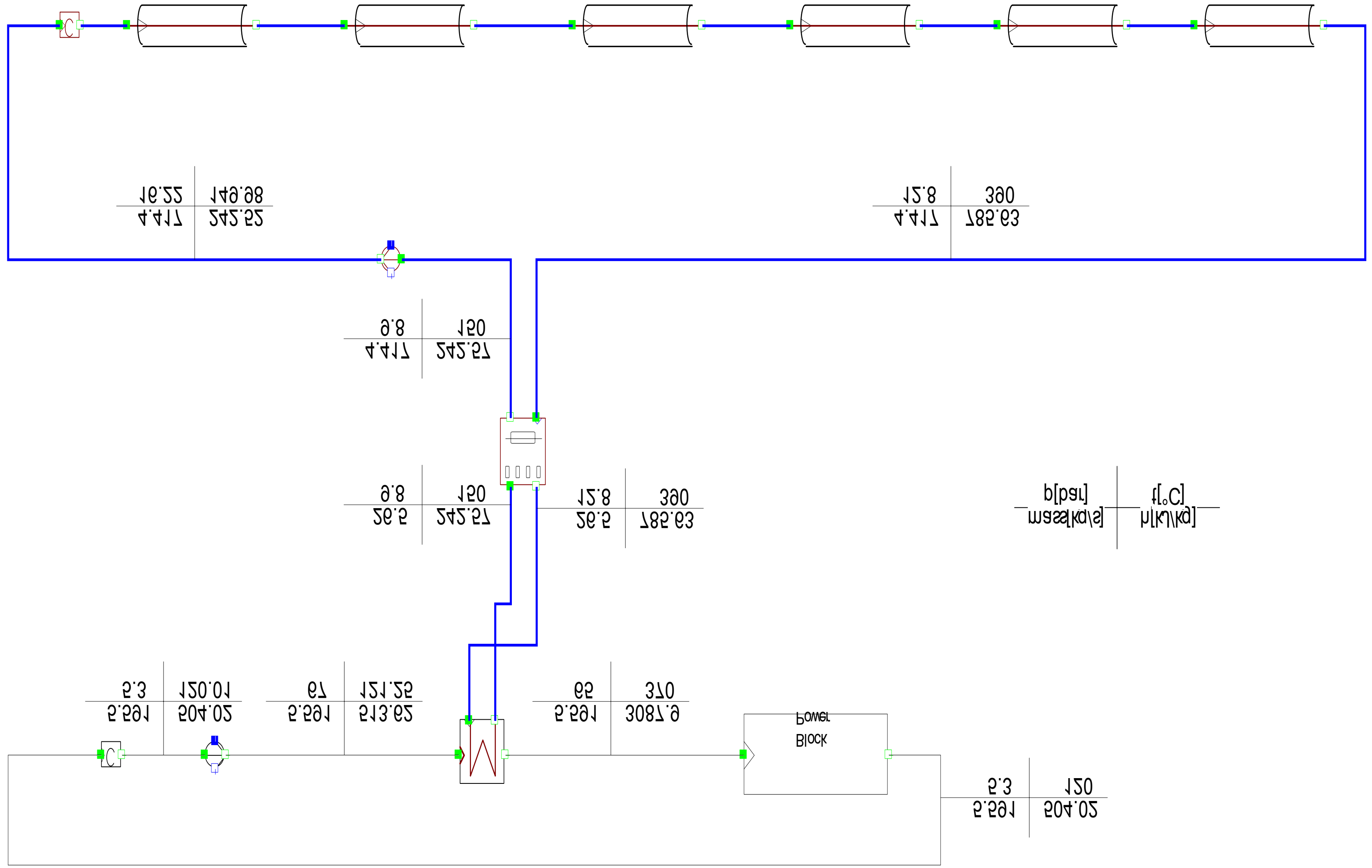
Classification of Solar Radiation in Jordan by the Ministry of Energy and Mineral Resources

Factors should be taken into account for the calculation of the power cost, such as:

- Land availability
- Accessibility
- Existing high voltage lines
- Power plant equipment cost
- Maintenance and operation

DESIGN CRITERIA:

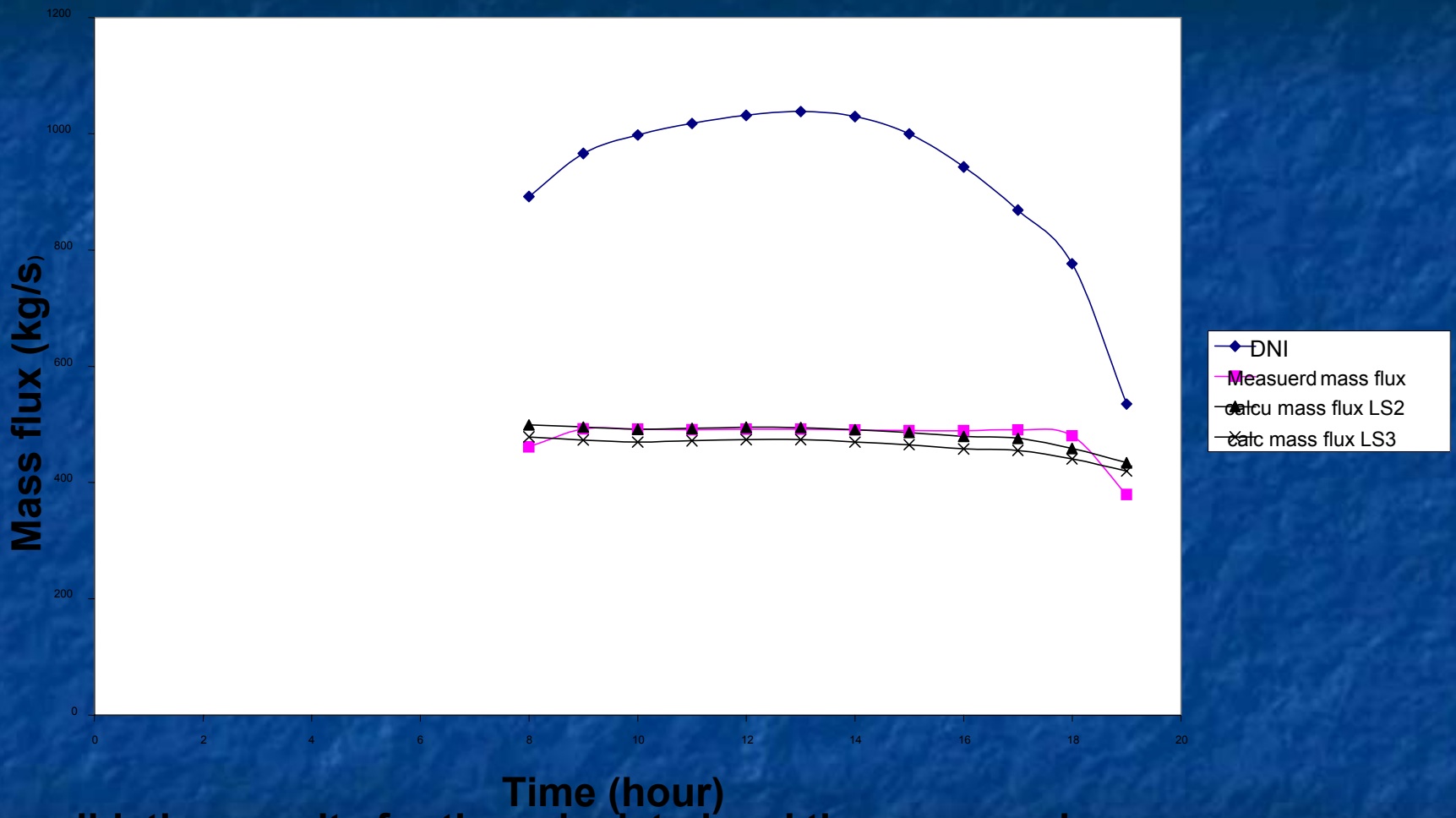
- In the present research study we have designed and tested a plant that consists of parallel rows of parabolic trough collectors with each row having six collectors in series.
- The solar field consists of an array of 9 parallel rows of LS-3 (LUZ System 3) collectors.
- The preliminary design where carried out using the LS-2 collector type to be validated with the SEGS VI plant of LUZ International to check the performance of the collectors system, then modified later using LS-3 type, which proved to be more efficient than LS-2.
- It has been decided to design a power plant having an output of 5MW which can be extended to 30 MW.
- The steam turbine of the model KKK was chosen in the present study for the designed electricity production of 5MW.



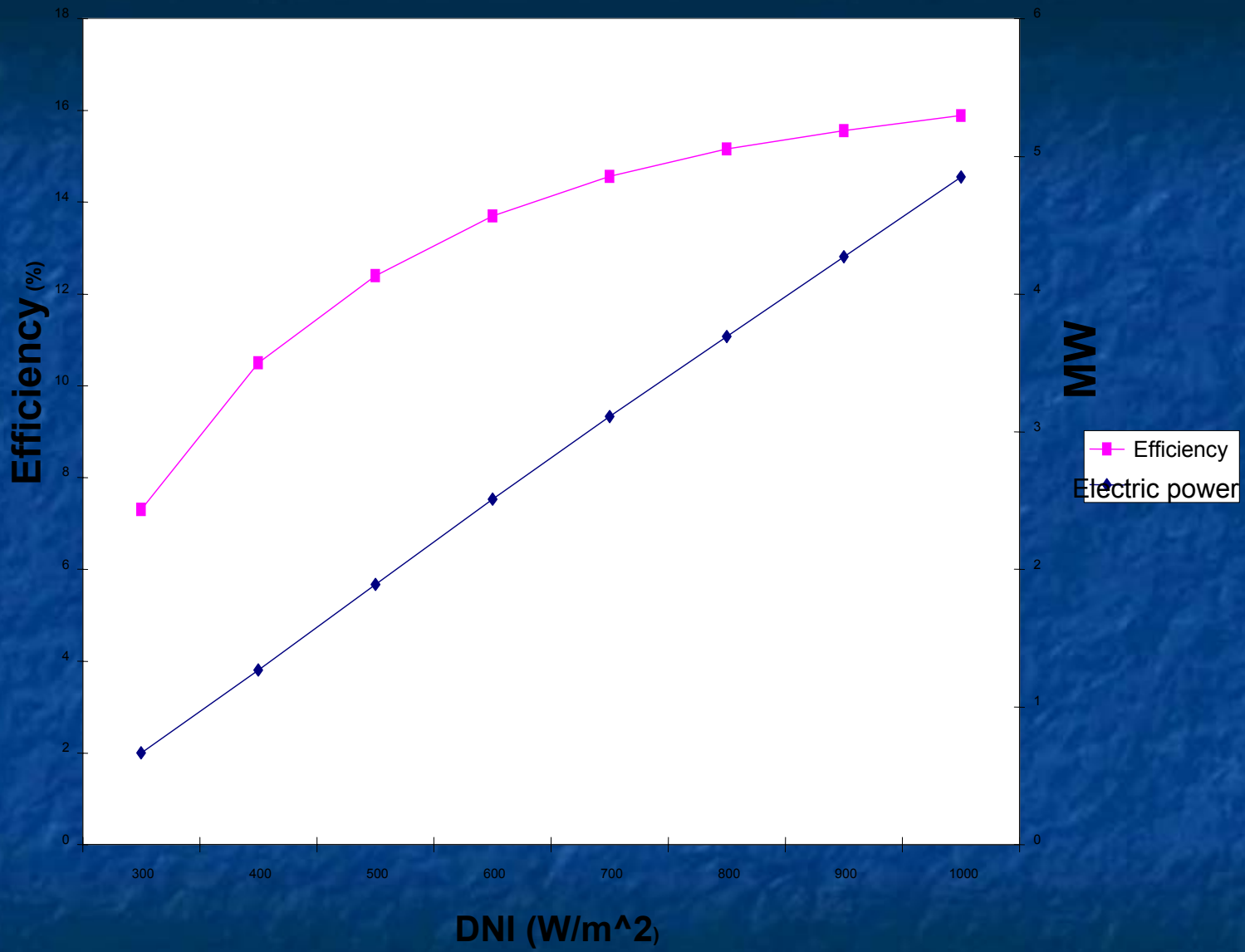
Power Block
p[bar] t[°C] mass[kg/s] h[kJ/kg]

Table 1: Specifications of parabolic trough solar collector assemblies

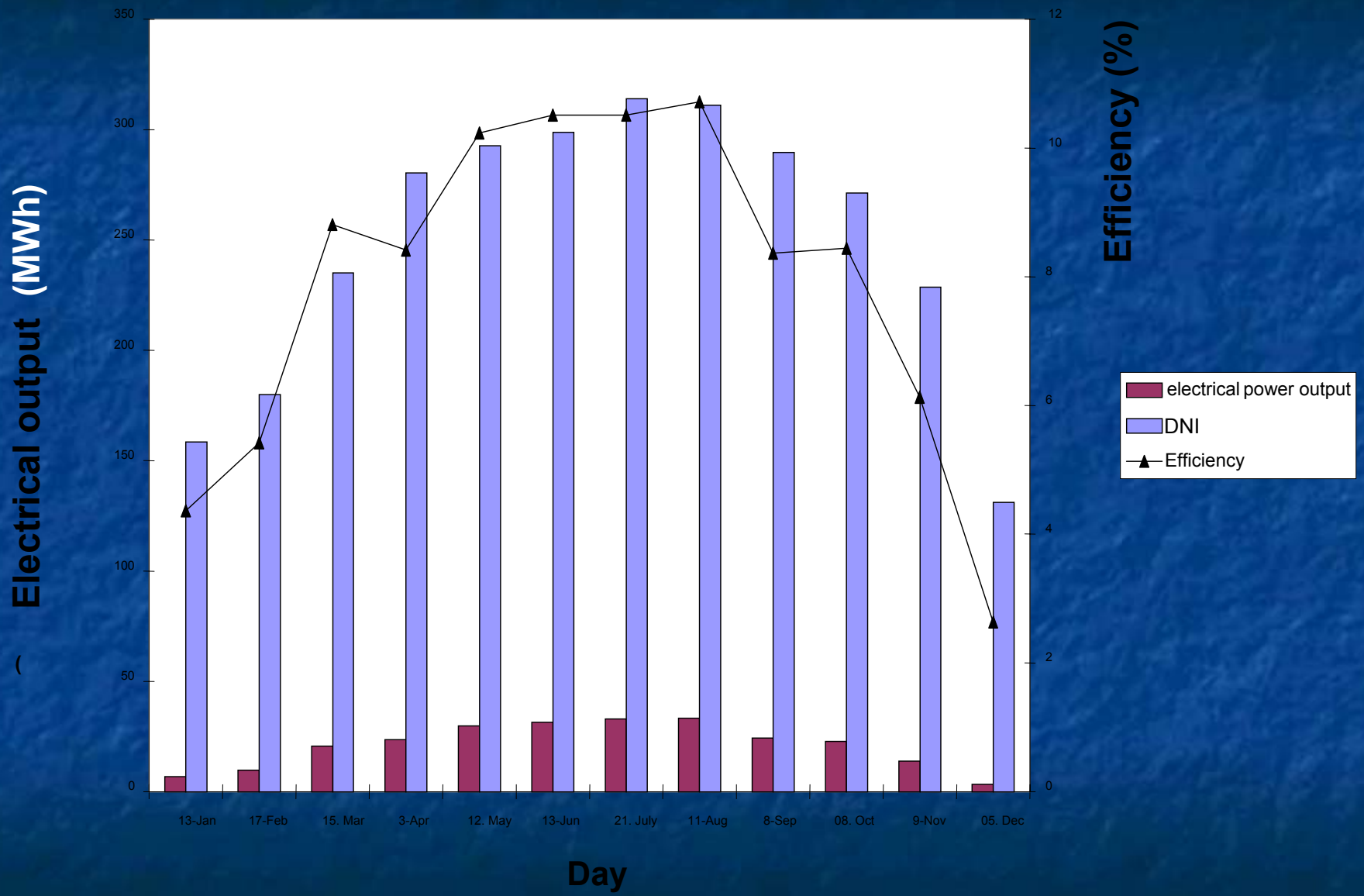
Collector type	LS-2	LS-3
Aperture diameter (m)	5	5.76
Length (m)	47.1	98
Optical Efficiency	73 %	76.5 %
No. of collectors	16	6



The validation results for the calculated and the measured mass flux for SEGS VI plant.



The power output and mean efficiency for Maan city on 22-6 at different normal direct irradiation.



The daily output power, direct normal irradiation and the efficiency for Maan site

Conclusions

- Solar Electricity Generating Systems are needed to meet the growing electricity demand and to be prepared to replace the fossil resources to reduce global emissions.
- The simulation of the designed plant has been finalised and proved to be good. The goal of this present study is to encourage Jordan to deploy the solar thermal electricity systems and to back up the previous studies done by START mission.
- The present study identified that Ma'an site is recommended.

Findings from the recent study have shown that solar thermal electricity generation is possible at 0.124 Euro/kWh (0.10JD/kWh), while the electricity cost from conventional power plants is 0.04JD/kWh. The result of the present system analysis shows that the cost of electricity from the parabolic troughs system can be competitive. Also the production costs can be decreased with increased size as the case of LUZ at California.

Thank you

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