פרופ' אהרן רואי, אי.פי.די.סי.
"עלות קווט"ש סולרי בתחנות סולריות תרמיות"
פורום אנרגיה, מכון נאמן, הטכניון, חיפה

The Cost of a Solar kWh Electricity from Solar Thermal Power-Plants and the Fossil Fuel-backing Issue.

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1. The purpose of installing solar power plants in Israel.

Various actions are taken all over the world for reducing the consumption of fossil fuels, with the aim of controlling the global warming problem. Israel is among the committed countries. **Clean energy** is a growing asset in the world economy. Solar power plants in Israel will help decelerate the expanding fossil fuel imports, reduce air pollution and mitigate the global greenhouse effect. Production of clean energy sources will grow a local source of energy, create jobs and boost the economy.

Affiliate to creating renewable energy, fossil fueled systems with increased efficiencies are developed in order to decrease the use of fuels. Noteworthy are the **combined cycle** power plants with the high net conversion of **55-57%** in practice**.** They will cut down a definite amount of pollution for each kWh of plant output. The quantity of **fossil fuel which is avoided** is **equivalent** to a **clean energy** quantity**. Both** renewable energy and efficient fossil-fired systems help **replace or decrease** the use of fossil fuel**. Clean energy** in its various modifications is greatly supported in many countries.

2. The Cost of Solar kWh Electricity Today

For comparison, following are some representative installed costs (and net efficiencies) of several types of fossil fuel-fired power plants in use: **Combined Cycle** (55-57%), $1000/kW**; Steam** Boiler (38-45%), $1500-1800/kW; **Gas-Turbine** (33-37%), $500/kW.

Solar-Only Power-Plants (solar troughs)

The Investment Part:

The solar field:	$4000/kW (installed)
The Power block:	$1000/kW (installed)
Total solar power-plant investment:	$5000/kW (installed)

Based on an annual solar insolation of 2300 kWh/sq.m. (d.n.) in the Negev and 1700 kWh/yr of solar electricity dispatch per kW (installed), and interest rate of 5%/yr thru 30 years (CRF of 0.06505),

The Capital Cost per kWh electricity output will be:
(0.06505/yr)X($5000/kW) / (1700kWh/kW/yr) =
($325.25/1700)/kWh = $0.191 = 19 cents/kWh.

The 0&M Part
The operation and maintenance is estimated at 5 cents/kWh.

Total Electricity Cost: **24 cents/kWh**.

Comments:

a. For **1% interest** (CRF of 0.044): Capital Cost will be 12 cents, and total Cost, **17 cents/kWh**.

b. Very low interest-rates have been announced by governments and national banks in order to induce creating of jobs, combat unemployment, and enhance growth of the economy..

c. Clean energy is much valued and is greatly supported.

d. The real costs of electricity in Israel seem to be represented by about 15 cents/kWh.

3. Fossil fuel-assisted solar power plants (hybrids).

Several solar thermal power technologies are available to-day. With hybrid modifications amounts of fossil fuel are used in order to increase plant capacity. However, this raises a question, as the power block of the solar

thermal power plant operates at efficiencies below 40%, whereas advanced fossil fuelled power plants show higher efficiencies. This means a waste of some fuel as compared to the use of fuel in efficient fossil power plants. This effect is amplified at some parts of solar hybrid plants system where the fuel is used at quite a low efficiency.

Also, how to define the fraction or the part of the solar clean energy in the hybrid plant electricity output?

Following is a straightforward scheme which specifies an explicit **quantification** of the **clean energy** contribution of the hybrid fossil-solar thermal power-plant; hence a clear route for effecting **incentives directly to the clean energy quantity.** This will encourage power producer to decrease fossil fuel use. Thus:

The clean electrical energy output of the power plant is defined by **the total electricity output (in kWhe)** of the plant, **minus the fuel electricity-equivalent (kWhe) of the amount of fuel used in the plant. The resultant electrical clean energy should deserve substantial incentives.** The "**feed in" price (solar energy revenue) will be paid for this clean energy quantity (according to a Solar Energy Rate).**

The fuel electricity-equivalent is defined as the electricity amount (kWh) that could be produced in a practical high-efficiency fossil fired power plant (it could be a combined cycle of 55% efficiency, i.e., the standard plant) from that amount of fuel which is used in the hybrid plant. The exact standard depends on decision at a national level.

The amount of fossil-related plant output is obtained by difference (total plant output minus the clean energy output). Its selling **price will be the usual national grid Ta-oz rate.**

As for the production-cost of the clean energy output of the power plant (in $), it will be the total production cost of the total output ($) of the plant, minus the cost of the said fuel electricity-equivalent as practically produced at the standard plant) (or perhaps, the fuel national grid cost-rate, at present; to be decided at a national level).

These definitions and specifications for solar may be compatible with those for **other** renewable **energy hybrids** (PV, wind, biomass) and thus form a **common basis** for **comparison.**

Needless of mention is the responsibility to operate and keep a full record of all fuel supplies into the power plant, to enable fair accounting

4. Backing – גיבוי

In Israel there are 20 to 40 fossil-fuel power generation-units and they all take part in providing the full national power load, hour by hour, day and night, 365 days a year. Each unit is backed by **all others**. Units get in and out of the gang, following the load and set priorities. Several of the units are small, even of below 20% capacity factor. Supply of electricity at solar hours is of utmost merit as these are peak hours. Any solar power at any time is most welcome.

For a stand-alone power-unit and no grid around, the addition of a gas-turbine unit seems most beneficial. It is a low-cost solution, fast to install, quick starting (20 minutes) and does not require cooling water; also thrifty on land requirements. This solution is of advantage from several practical respects.