A Plan to replace fossil fuel with solar energy in Israel (April 2009)

Dov Raviv
MST-A Renewable Energy Company

Abstract

A price reduction to the level of $2000/kw is shown to be possible using the Concentration PV (CPV) technology. This is made possible by using the state of the art existing components such as the multijunction 37 % solar cell and other modern technologies, coupled with erection of automatic production lines requiring large investments. This decrease in cost will allow implementation of financial strategies that will allow, with a reasonable credit line level, to build the entire solar energy production facilities for whatever power required up to the level of supplying 80% of the electricity needs of Israel, over a period of 30 years. The detailed presentation of the financial strategies to allow a complete and continuous erection of the solar energy infrastructure proves unequivocally that the CPV solar technology has the potential to largely substitute the use of fossil energy within the next 30 years, wherever such substitution is feasible and practical. The implementation of such strategy is a Paradigm change in strategy from the BOTTOM-UP approach to the TOP-DOWN approach.

Introduction

The aim of MST is to reduce the price of a CPV power plant to $2,000/KWp to enable its introduction to the energy market in Israel and elsewhere as a viable power generation solution.

The lowest market price for solar plants today is $5000/KWp. This price is by no means compatible with the Israeli or world price requirements to build utility size plants.

MST has devised a way to reduce the cost of solar power plants to $2,000/KWp.

At that price the solar option is the major contender to substitute the fossil fuel plants in Israel and supply the future demand growth.

We shall show also, that the solar power is the only renewable technology that is open-ended to efficiency improvements and thus to higher productivity, lower investment cost and reduction of land requirements.

It is therefore the natural contender to be deployed in Israel and elsewhere to replace the fossil power plants.

The major roadblock to massive inroad of this technology is the level of investment required.

We shall present an affordable financial approach suitable to perform such reconfiguration of the entire Israeli electrical economy.

Cost reduction

MST has come to the conclusion that the technological configuration that bears the greatest cost reduction potential is concentrators' system by Fresnel lenses using multi-junction solar cells. The technology is mature and the efficiency increase is related solely to the cells efficiency. Thus, any increase in the efficiency of the cells is immediately applicable to the next plant to be delivered from the production line. Thus, the plant upgrade is open ended by design to such improvement.

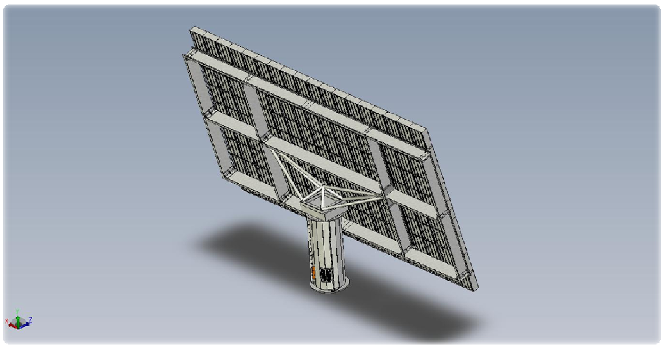


Figure 1: MST tracker configuration

The major cost reduction factor from the present sky rocketing prices is the erection of an automatic production line having a production capacity of >1000MWp per year. At this production rate, the erection price of a 1000MWp solar plant will be decreased nominally to $2,000M.

The marketing in general is a non issue, because at this price, the production line will be busy indefinitely for the Israeli market only.

A production line of 1000MW/year to be increased to 3000MW/year, an installed base of 45,000MW and a plant life of 30 years, require continuous production at full capacity. Excess production capacity will be channeled to export.

The reason that such a reduced price can be achieved, lies in the nature of the product. The Fresnel Lens light concentrator and the Multi Junction (MJ) solar cell constitute the basic power element of the plant. Thus, the plant constitutes actually of plastic, metal sheet and steel elements that lend themselves to large series low cost production.

1000MWp Plant data

Number of collectors	20,000
Collector dimensions	20mx12m
Area of collector	240 msq
Collector power	50 KWp
Plant aperture	4 kmsq
Real estate covered	10 kmsq
Energy production in Israel	2 B KWh @2394 KWh/msq/year
Energetic Concentration	500 suns
Two axis tracking mount	

Storage Plant

When the solar plants power becomes a significant portion of the entire electric grid power (more than 5%), one can't disregard its influence on the grid stability, and the energy supplied must respect standards of utility power plants. This is not possible for large solar plants because of the inherent fluctuating power delivered by the sun. Thus, a storage facility is required to accommodate for this fact.

The energy sources (solar plant, baseload and storage) must generate and supply the entire energy demand during day and night.

As the solar plant capacity is built up along the years, it will start delivering energy during the day only. After the production capacity increases beyond the day consumption, excess power is stored in the batteries and delivered during night. During the day, the storage plant is used to keep a continuous supply of energy to the grid during intermittent cloudy periods. The batteries can also be used as peak power shavers during peak loads either during day or night.

The storage process is reversible and the cycle loss (charge – discharge) is minimal (80% efficiency).

The storage plant capacity is built in parallel with the solar plant capacity. This is the place to state that ANY PV or CPV plants with an installed capacity in excess of 5-10% of the grid power needs a storage capacity identical to their capacity to protect against grid collapse in case of power loss due to clouds.

The storage batteries are developed by EnStorage in Israel and will be produced and supplied by them in cooperation with MST.

Amount of yearly collected energy

According to daily actual direct radiation data collected at Sdeh-Boker (2394 KWh/msq/year in 2002) by Prof. Faiman from the National Solar Energy Center of the Ben-Gurion University in Sdeh Boker, an entire year daily simulation of solar plant collection has been made. For a two axis tracking plant of 1000MWp, the 2002 yearly collected energy is 2.15 Billion KWh. In our energy calculations we use a conservative figure of 2.0 Billion KWh per annum.

Projected revenues in Israel

The tariff adopted for the proposed project is depicted in Figure 2.

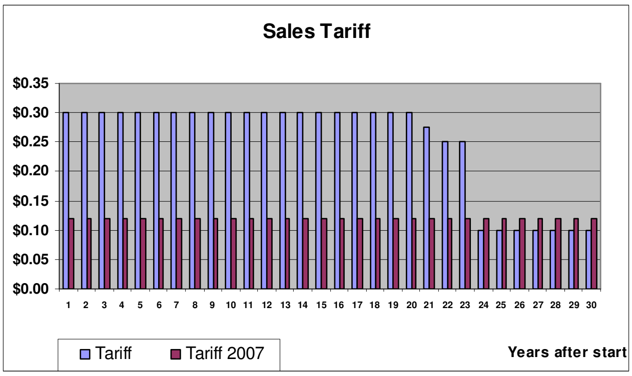


Figure 2: Tariff over a 30 years period

The feasibility of this tariff is justified by the increase in electricity cost to the consumer as shown in Figure 7 below.

The aim of the program

The grid installed capacity is 11,000MW based on fossil production of 75% coal. Israel's intention is to transform within 10 years the fossil mix and produce 60% energy by burning gas.

The annual energy production in 2007 was 50 Billion kwh. The projected increase in electrical energy demand is doubling the power and energy within 30 years (compound increase of 2.42% per annum).

Our aim is to transform the fossil energy production into solar/renewable within 30 years, that means producing yearly 100 Billion kwh.

However, due to climatic facts, we can expect transforming up to 85% only, due to sun unavailability around the year. Thus we need reaching a production capacity of 85 billion kwh. We have consulted with Shai Agassi who plans to transform the private car vehicles into electrical, about the amount of energy his project requires. He needs 6 Billion kwh yearly. This requirement is well within the uncertainty band of the projection and we did not update the requirement. This will happen along the road anyway.

In any case, the fossil installed capacity should remain in stand-by in case no solar energy is available.

The storage plants will support the fossil capacity by allowing charging during low production periods and supporting the grid in periods of peak demand. This is a side benefit of having large storage capacity.

The implementation

The scheme of achieving this goal is as follows

Build a solar plants production capacity of 1000MW per year and a storage batteries production capacity of 1000MW as well. At year 16 we add a solar plants production capacity of 2000MW per year in order to accelerate the buildup of the solar production capacity.

The planned yearly installed capacity of solar and storage is depicted in Figure 3.

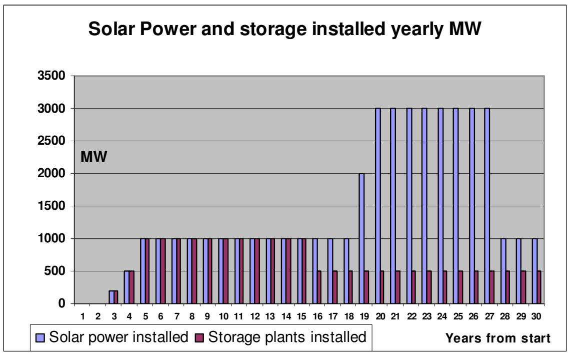


Figure 3: Yearly installed capacity

Until year 18 we install 1000MWp/year solar and than we ramp up to 3000MWp/year.

The storage starts at 1000MW/year and reduces to 500MW/year in order to comply with the power of the grid. The solar plants quantity is energy driven while the storage is grid power driven.

Figure 4 depicts the accumulated installed solar power and storage, compared with the projected grid power required.

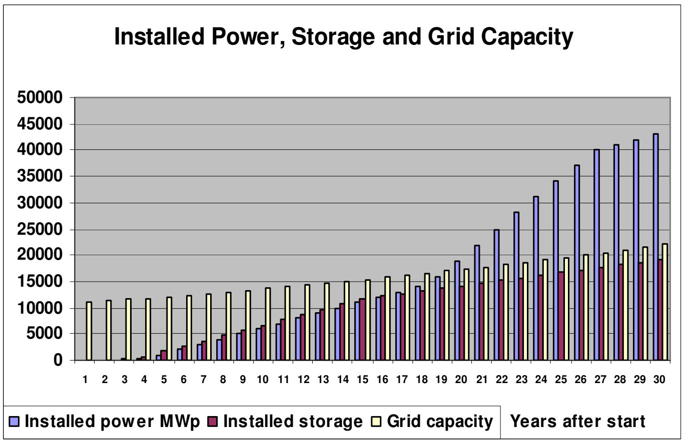


Figure 4: Accumulated capacities

One can see that the storage capacity follows closely after year 15 the grid power required.

Figure 5 depicts the required energy and the solar produced energy.

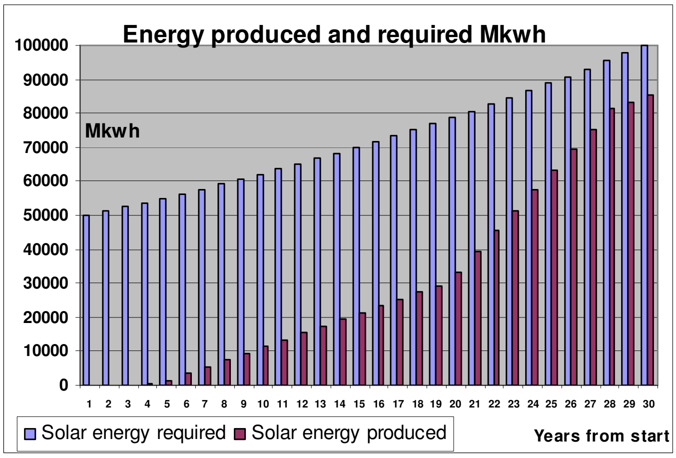


Figure 4: Solar Energy produced and required

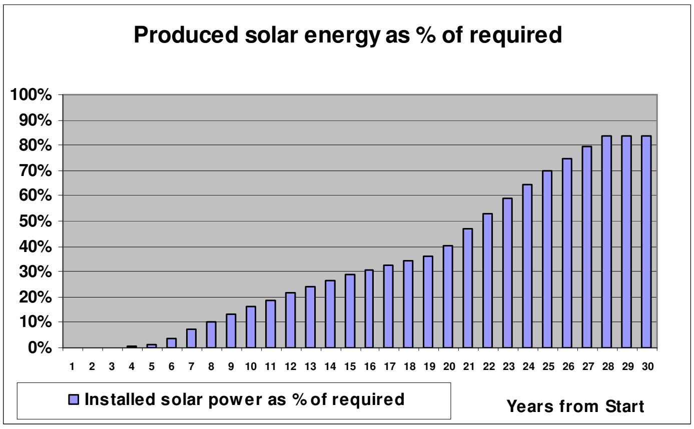


Figure 5: Solar Energy produced as % of required

Figures 4 and 5 depict the result of the installation rate defined in Figure 3. One can see that after 11 years in 2020, we supply 20% of the required energy.

After 22 years we supply 50% of the energy and after 27years we supply 80%.

Funding required

The funding required includes the investment required to build the production lines, to build and deploy the solar and storage plants, to operate and maintain those plants and the G&A., less the income from electricity sale to the grid.

Figure 6a and 6b depict the resultant cash in hand before tax. A negative figure means we have to borrow money.

Figures 6a and 6b depict the cash status during 30 years for 3 different interest rates, 0%, 3% and 6%.

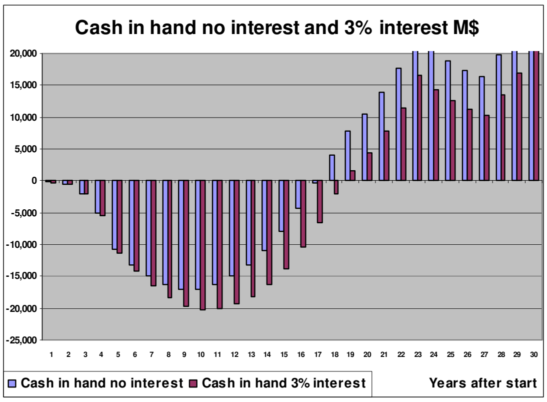


Figure 6a: Cash status before Tax, 0% and 3% interest.

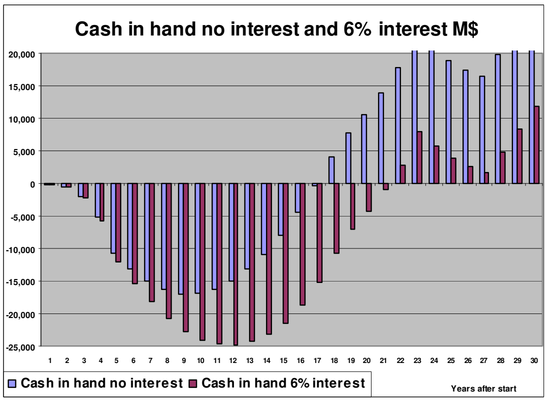


Figure 6b: Cash status before Tax, 0% and 6% interest.

The maximum exposure with no interest is at year 9 with $17.2B, and the credit line is zero at year 18.

The maximum exposure with 3% interest is at year 10 with $20.2B and the credit line is zero at year 19.

The maximum exposure with 6% interest is at year 12 with $24.9B and the credit line is zero at year 21.

The difference between 0% and 6% is $7B in exposure and 3 years in repayment.

Repercussion on IEC tariff

In order to cover the increased tariff required by the solar energy (See Figure 2), the tariff of IEC must be increased.

The calculation of the new tariff took into account the cost of the solar energy + the cost of the fossil energy produced by IEC divided by the total energy produced.

Figure 7 depicts the IEC tariff increase in US$ to achieve this.

Figure 7a depicts the IEC tariff increase in NIS to achieve this.

$0.12 and 0.48 NIS are the IEC tariffs in 2007 for private electricity consumption.

One can see that during 23 years the increase is from 0.48NIS to 0.8 NIS (66% price increase). This translates into a yearly compounded increase of 2.4% per year. Thereafter, the tariff drops below the IEC 2007 tariff continuously.

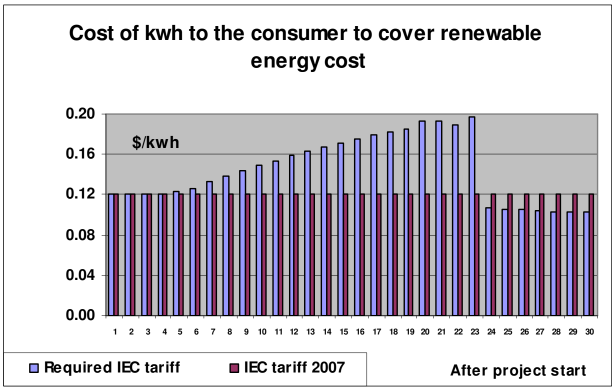


Figure 7

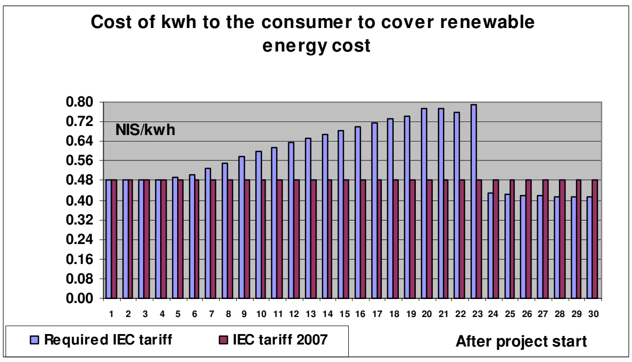
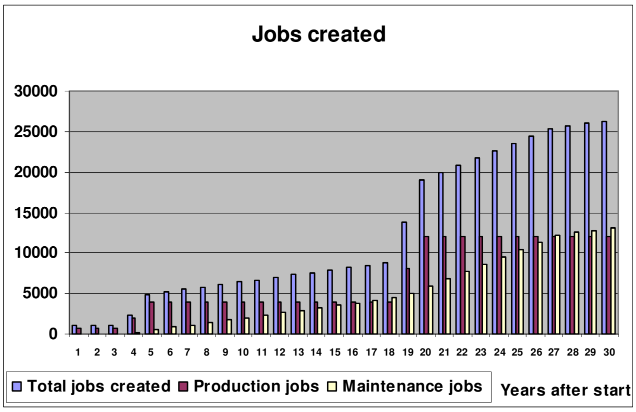


Figure 7a

This is a small price to pay to transform the fossil energy of Israel to renewable.

Job creation

Figure 8 depicts the projected number of jobs created over a period of 30 years.



After 5 years	5,000 jobs are created
After 20 years	19,000 jobs are created
After 30 years	26,000 jobs are created

Foreign currency savings

In page 82 of the 2008 Financial report of IEC, the total cost of fuel to generate 50Bkwh was 10,006 Million NIS, namely 0.2NIS pr kwh=$0.05/kwh

We can use that figure all along the 30 years period, or we can escalate it by a fixed percentage yearly.

Table 1 depicts the foreign currency saved over 30 years from producing solar energy instead of fossil.

Fuel escalation yearly	0%	1%	2%	3%	4%	5%
Saving M$ over 30 years	45,840	58,295	74,197	94,498	120,406	153,455

Table 1: Foreign currency saved as function of fuel escalation

One can see that by providing/guaranteeing a credit line of $17B to $24B depending on interest rate, Israel saves a foreign currency of $100B to $150B in addition to all benefits that this program brings.

The saving for zero escalation of fuel price will be about $46B. It is worthwhile mentioning that the Minister of Finance declared the 28-1-09 that the debt of Israel is 70% of its GDP. According to CIA Facts Book, the 2008 GDP of Israel is $188.7B. Thus the debt is $132B. The saving in import of fuel during 30 years will save Israel the entire National debt. This is a figure that our financial planners and leaders should seriously consider.

Hurdles to overcome

Land. A 1000 MWp CPV solar plant requires 10 kmsq (10,000 dunam) of land. 43,000MWp require 430 kmsq of land. This figure represents 2.1% of Israel area or 3.9% of the Negev area.

Land exists and must be provided in a timely manner to allow building this project. Regulatory bureaucratic issues must be solved in a timely manner.

Funding. Solar energy infrastructure is funding intensive. As we have shown, a credit line of about $20B is required to execute the proposed plan. The approach that such plan can be carried out by private investment is illusory. The Government has approved a plan of 250MW/year over a period of 10 years. This is 15% of the required installation rate required. Even if the plan is successful we lost 10 years and accomplished a mere 6% of the installed power required. We live on borrowed time and there is no time for financial experimentation. Energy is an essential element of our existence as a state, and its non availability is an existential threat to Israel. I dare saying that this threat is more acute than the defense, because its time constant is longer and one can not close the gap even with infinite amounts of money. The timely planning to solve the problem is a main characteristic of the problem.

Summary and conclusions

The Energy is a major issue to ensure Israel's long term existence

The world projected Energy crisis threatens Israel within a 30 years timeframe.

The sun is the only energy resource of Israel.

The CPV system developed by MST in Israel has the technical and financial attributes to solve this problem.

The Government should adopt this project as a National Infrastructure project, facilitate its funding and provide it the adequate National priorities.

The project will handsomely reward the Country and the People by providing freedom of energy supply, saving on foreign currency expense and providing tens of thousands of new jobs mainly in the Negev

This industry will develop into a major Export one.

The solution is there and The Government must only stand up to the challenge.

It is its duty to do so.