EXECUTIVE SUMMARY AND CONCLUSIONS

This study was carried out by LIFE Ltd on behalf of the European Photovoltaic Industry Association (EPIA) and represents only one part of three, the other two being carried out by the companies IT POWER Ltd and TEAM Ltd.

EPIA was awarded a contract by the European Communities Directorate General for Energy - DG XVII - within the ALTENER Programme to assess current status of Photovoltaic (PV) Industry and to find the right policies and strategies to boost the European PV Industry and the photovoltaic market to the year 2010.

In this study the present status of photovoltaic technologies has been analyzed. In particular a deep analysis of the crystalline silicon production process together with a detailed sensitivity analysis have been carried out by means of a specially developed computer code.

The study was carried out with the data available between June and September 1994.

It is obvious that the general methodology introduced has a general validity and the interested reader can use it for several scopes using the updated values of the various parameters involved in the methodology itself.

Furthermore a strategy for the development of the photovoltaic technology has been formulated and one possible technological evaluation to the year 2010 is described to reach a kWh cost < 0.20 ECU (actualized at 1994 money value).

An analysis of the Balance of System (B.O.S.) cost was also undertaken together with a comparison between the PV-kWh cost and the Fossil Fuel-kWh cost.

The analysis of the present status of photovoltaic technologies leads to the following final considerations.

x-Si based PV modules

The crystalline silicon technologies, mono and poly, are at present best suited to the production of PV modules which can be used for large scale power plants for electricity generation.

The present production cost of these modules is about 3.3 ECU/Wp for integrated production plants from wafer to module with production volumes of about 2 - 3 MWp/year/shift.

Actions aimed firstly at improving increases in the overall process yield, which is currently rather low, and afterwards to improve conversion efficiencies will be able to reduce the present costs to about 1.8 ECU/Wp.

This result is therefore obtained through the optimization of the processes and of the existing plants without introducing new design devices which could certainly produce better efficiencies (up to 18%) but which at the same time need new investments in the production lines with equal or higher results in terms of cost/Wp.

An increase of the plant production volumes has a limited effect on the production costs which are above all affected by the material costs which account for 50% of the module cost.

Therefore any volume increases should be justified by a real market demand increase rather than by hopes for reductions in costs.

In our opinion, in order to take best advantage of cost reductions arising from economies of scale, the optimum plant would have a production of 10 MWp/year/shift.

Alternative technologies

To further decrease module costs below 1.8 ECU/Wp it is necessary to develop technologies different from the traditional x-Si.

Five possible alternatives have been examined each one being in a different technological development stage and there are not, at present, any particular reasons to prefer one to the others; nevertheless it can be noted that at least two of them (Si-Ribbon and α-Si:H), after years of intense activity, are now suffering a "slump", as studies and research investments have moved in favour of thin film polycrystalline x-Si, CIS and CdTe.

But in any case these technologies are not yet considered as qualified "products" in terms of life-time and industrial certainty and therefore the economic evaluations do not depend on ascertained experimental results but on extrapolations from laboratory plants which only assume the pilot line characteristics in a few cases.

This means that in this field it is necessary to carry out considerable investments in Research and Development to overcome the threshold of 1.8 ECU/Wp and consequently to allow PV diffusion into the energy market.

B.O.S. problem

The present B.O.S. cost of large grid connected plants is about 2800 ECU/kWp, representing about 46% of the present plant cost.

The analysis carried out on the data gathered from recent European plants foresees a decrease of B.O.S. cost down to about 2250 ECU/kWp.

This situation is very negative because it makes the efforts carried out at technological level to decrease the module Wp costs almost useless.

To avoid this it is necessary that a module cost decrease corresponds to an equivalent B.O.S. cost decrease, so that the plant cost would be made of two approximately equal components.

The most positive indications come from the recent results obtained in USA by the KERMAN Photovoltaic Power Plant which take the B.O.S. cost just to 40% of the overall plant cost (tracking system excluded). This means a B.O.S. cost of about 1 ECU/Wp.
As far as the B.O.S. part related to the area is concerned, an even more positive answer could come from the PV use in pre-existing structures or which have to be built for other purposes: roofs, terraces, platform shelters, buildings façades.

In such instances the costs related to the ground preparation and to the majority of the support structures are avoided because they are attributed to the buildings.

Finally, this analysis has as a main result the fact that the present module and B.O.S. technologies are able to reach the objective of the ALTENER Programme which foresees 500 MWp installed in Europe in 2005, a module cost of about 1.8 ECU/Wp, a B.O.S. cost of 1 ECU/Wp for a kWh cost equal to 0.18 ECU/kWh (1994 money value).

It is necessary to observe that the foreseen Research and Development actions which would allow the above objectives to be reached, are not by themselves sufficient to ensure that for the indicated dates the modules production lines and the systems for energy management and control will be able to achieve the performances and the economic results aimed for.

In fact, to turn the research results into products, investments to improve the production lines and a reasonable time to start the new production process are needed.

These results would not be sufficient, however, to achieve the objective suggested at the Madrid Conference "An Action Plan for Renewable Energy Sources in Europe" of 16 TWh/year of PV electric energy in Europe by 2010.

To reach this objective, in our opinion it is necessary to produce electricity at a cost not higher than 0.12 ECU/kWh (1994 money value), to which corresponds a module cost not higher than 0.8 ECU/Wp, a B.O.S. cost of 1 ECU/Wp, a module efficiency of at least 120 Watt/m^2, a plant life-time of at least 25 years and a transfer coefficient from the module to the electric grid of at least $K_T = 0.85$.

The present technology is not able to ensure these performances but the new alternative technologies are very promising and they could meet the requested objectives as long as considerable investments are rapidly carried out.

These investments are needed to transfer the research results already achieved firstly into pilot lines and afterwards into production lines.

At the same time it is necessary to sustain the market with demonstration plants of suitable dimensions to monitor results step by step. The projected ALTENER target of 500 MWp to be installed in Europe by 2010 could be viewed in this context and suitable case studies should be undertaken.

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