



**“A Task Force for the Creation of a Consortium
to Set-up a SoG-Si Production Plant”**

SAHARA

EXECUTIVE SUMMARY

Solar Grade Silicon – A Global Assessment

Author:



Contributors:



SCATEC AS

SCANDINAVIAN CENTER FOR ADVANCED TECHNOLOGY



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EXECUTIVE SUMMARY

Main objective of the Sahara project was to set up a task force to act as a leverage towards the setting up of Solar Grade Silicon (SoG-Si) production plants.

The Project was carried out within the ALTENER II Programme of the European Union (1998-2002) Contract n. 4.1030/Z/00-

The Project derived from two past studies carried out by BAYER and LIFE within EPIA under the ALTENER I Programme the first denominated “Photovoltaics in 2010” [ALTN1] in 1995-1997 and the second denominated “Present and likely future bottlenecks analysis for a sustainable photovoltaic policy” [ALTN2] in 1998-1999.

From those studies, and in particular from the second one, clearly emerged that a feedstock crisis would have happened towards 2005 unless something was done towards the production of SoG-Si; in this respect the authors were among the first to detect this problem. Infact at that time no industrial Si producers would have thought to produce Silicon for the PV Industry also in view of the very good electronic market in the same period against the crisis which hit it later.

The task force was made of the following partners with LIFE acting as the coordinator of the pull of companies involved and in this role LIFE was the main author of this final report with contributions received from its research and training Association Edenet onlus and from all partners:

- DEUTSCHE SOLAR
- ECN
- JRC ISPRA - Institute for Environment and Sustainability - Renewable Energies Unit
- SCATEC
- TRANSENERGIE

A close technical cooperation among task force partners and external relevant parties was generated also in view of the very good interpersonal relationships. This was very important to carry out a complete assessment at world-wide level of the current status of accomplished and on-going researches and industrial developments in the field of silicon production processes for solar cells applications; Authors believe that it is the most updated, clear and objective document existing in the sector. This evaluation was on one side the basis for the analysis/revision of the [ALTN2] Study which was critically reviewed and validated in its main statements and on the other side it assisted into the definition of the most suitable technologies for further industrial development.

Several Scientific and Technical Analyses, Studies, Conferences, Interviews and Private Meetings were carried out to reach objective conclusions.

The complete work is documented in this Executive Summary and four Volumes and it includes also the Proceedings of a European Workshop held at Gelsenkirchen on 7th May 2002 and which certainly represents a milestone towards a European route to SoG-Si production.

A conclusive compared analysis of the main objectives which the study SAHARA pursued and the results obtained was carried out in a synthetic way and it is enclosed hereinafter under the form of statements for a more clear reading.

A. OBJECTIVES (Sahara 'a priori' project aims)

Main fundamental objectives were :

- A.1 At technical level, to review state of the art of current industrial and R&D activities on Solar Grade Silicon production to ascertain if one or more technologies exist mature for industrial production or for pilot phase and a complete definition of the same technologies
- A.2. At economic and commercial level, to update and validate [ALTN 2] study previously carried out by BAYER and LIFE within EPIA in 1999 to ascertain if a shortage of feedstock is confirmed and therefore if the need of a SoG-Si production still remains
- A.3 In case of positive answers for points A.1 and A.2 above, to promote some kind of association actions (Joint-ventures, Consortia, Link-agreements etc.) among mainly European partners for the R&D development first, the industrial development later and the commercial phase to immediately follow for those viable SoG-Si production routes.
- A.4 At policy level, to understand what role can Public Organizations play (National Governments, European Union, etc.) and which policy could be suggested, to sustain the risk and the huge investments of the actions described in A.3 above.

B. RESULTS (Sahara 'A posteriori' projects results)

B.1 Six projects were considered for further development. These projects are:

1. The **Wacker Chemie** project with FBR development
2. The **Tokuyama** project with a new type of deposition reactor
3. The **ASiMI/REC** project with FBR development.
4. The **Degussa/SolarWorld** project with tube deposition
5. The **SOLSILC/SPURT** project with direct reduction and a melt purification cycle
6. The **ELKEM** project based on purification of metallurgical grade silicon

In particular those directly or indirectly promoted by SAHARA are:

3. The **ASiMI/REC** project, which is “ready to go” into industrial production with their relaxed Siemens process in 2003, whereas the ASiMI/REC FBR project still has to go through the pilot phase.
4. The **Degussa/SolarWorld** project, which is considered as the most ambitious project (high end technology from the world biggest producer of Chlorosilane with high end product at a price target in the range of 20 €/kg along the guidelines set forth by the “Feedstock Bottlenecks Analysis” Study), which needs a pilot phase prior to industrialisation.
5. The **SOLSILC/SPURT** project, which is already now conducted by a European consortium made of research institutions and industrial companies. This process is presently operated partly at pilot scale, partly at lab scale, and the whole process is planned for pilot phase in 2004 having as a goal a product at a price below 20 €/kg.

A “ranking” of these different technologies is not possible at the current state of development. All projects should go through the state of pilot production or industrial production; as appropriate, to allow a more detailed judgment.

Projects 3 and 4 use, indeed, a very similar technology for the production of silane, and only the foreseen deposition techniques are different. Project 5 is completely different and it is an alternative to the gas phase processes.

The SPURT consortium will deliver a different product of probably lower grade and lower price than the gas phase technologies, and they will probably address at least partly another market segment than the other producers.

- B.2 The [ALTN2] study was perfectly validated in its fundamental statements.
- B.3 Of the six projects above Sahara certainly gave its strong contribution in promoting the Degussa/SolarWorld Joint Venture, the ASiMI/REC Joint Venture and the SPURT Consortium, by means of, among others, several meetings, two European Round Tables and a European Workshop. In view of the fast moving sector, LIFE, who will continue working on this project - in particular on the setting up of an EU - warranted Rotational Fund (EU-WRF) described below - partly with its own funds and partly co-funded by the Calabria Region Government, has already scheduled a follow up workshop besides the Sahara project scope in the South of Italy later this year
- B.4 As it clearly appears from above statements in Europe four are the routes which with equal interest converge to the same objective. In particular two: Wacker Chemie and ASiMI/REC, are already at the industrial stage level with their relaxed Siemens process with Wacker Chemie already producing at 27 €/kg and ASiMI/REC to start production in 2003. Both Wacker Chemie and ASiMI/REC FBR projects still have to go through pilot phase. SPURT is scheduled for the pilot phase in 2004. Above projects pilot phases are certainly recommended together with the

Degussa/SolarWorld project ready for the pilot phase now. This last one involves an high end technology and consequently produce an high quality feedstock, possibly with an higher risk than the others but at a lower price confirming , as stated above, the [ALTN2] estimates which foresaw a price below 20 €/kg.

C. SUGGESTED POLICIES

- C.1. National Governments, Commission of the European Union etc. should finance the necessary research and piloting phase still needed for the aforesaid technologies.
- C.2 An EU-Warranted Rotational Fund could be set-up as a new tool towards So-G-Si Photovoltaics self-sustainability. The “formula” is quite similar to those already successfully implemented in several EU-Countries to incentivate electricity production from NRES and cogeneration plants. A new public/private Funding Agency should be set-up to offer “special” project financing schemes to all So-G-Si producers. The Agency will ensure, for a number of years, to the So-G-Si producers the purchase of their whole production at a pre-agreed price list, established taking into account the different product characteristics and supplying to the producers, whenever required and appropriate, some loans for the production in the form of an advance for the purchase itself. The Agency will resell the products to the market (Si-users), with a minimum gain, to regenerate the Rotational Fund and to ensure a minimum profit to the Agency itself. Only in the case of some failures in the circular scheme above (lower quality or quantity of the products with respect to the agreed standards, refuse of the product on the market, etc.) the European Union - possibly through the European Bank – will warranty the Agency repaying the possible Agency economic losses. The “formula” above should be capable to incentivate at the same time, both the So-G-Si producers, sharply reducing their own risks – by means of the warranted sale of their whole production - and to ensure to the EU Commission a strong leverage – by means of the repayment to the Agency only of the losses due to the, probably , very few not successful project financing contracts.

The Funding Agency should involve several European Banks, European Photovoltaics Associations – such as EPIA and PV-INGRID – representing in a whole the PV European Actors , JRC-Ispra Renewable Energies Unit as the advising European Commission Body neutral expert in photovoltaics and some specialised engineering and PDM (Project Development and Management) companies for Projects Evaluation, Appraisal and Control. In this last role and during Sahara, LIFE has already set-up preliminary positive contacts with several banks in Europe and above main actors delivering an “expression of interest” to the EU within the VI Framework Programme.