

# IEA/SolarPACES Task I Meeting: Solar Thermal Electric Power Systems

9-10 April 1997  
CNRS, Odeillo, France

## Meeting Summary

An IEA/SolarPACES Task I Meeting on Solar Thermal Electric Power Systems was held in conjunction with a Task III meeting and a Flux and Temperature Measurement Workshop at the CNRS Facilities in Odeillo, France on 9-10 April 1997. In addition to reviewing most of the ongoing joint activities in Sectors 1 and 2, a new Sector 4: Market Barriers and Opportunities was initiated with a brain-storming session on identifying barriers and opportunities and understanding market requirements for solar thermal; START Mission plans (part of a new Sector 3) were reviewed; and input for a Program of Work draft for 1997-2000 was collected. An updated meeting agenda, attendees list, and presentation summaries are attached.

## Detailed Meeting Minutes

To start the meeting, Craig Tyner asked all participants to verify their e-mail address and note if they have WWW access. He would like to communicate with the group electronically, via e-mail and the WWW, whenever possible. The meeting agenda is to first discuss Sector 4: Market Barriers and Opportunities, then handle miscellaneous business, discuss the program for work, and finally get status updates from Sectors 1, 2, and 3.

## Sector 4: Market Barriers and Opportunities

Tom Williams of NREL led group discussions on this new Task I topic. He divided the discussion into three areas: The approach taken was to have the group work together to generate a list of issues and potential activities that were divided into three areas: market barriers, opportunities, and market requirements. There was considerable enthusiasm in identifying issues and potential activities. Once the list was completed, a vote was taken on the importance of each (how many thought the issue rated high in importance) and then a tally was taken of those interested in working on the topic. Response was good; as asterisk is used to identify anyone who volunteered to lead an activity. Tom will summarize/refine the list and distribute it for review by anyone who volunteered to work in a specific area. The following tables summarize the discussion.

### Market Barriers

<u>Description</u>	<u>Accomplishment/Metric</u>	<u>Participants</u>	<u>Votes</u>
trends in fossil, nuclear prices	evaluation of future (yr 2000) trends	Kunberger, Meike, Hennecke,	0
increase public awareness of solar thermal	STE listed in EE policy	Heller, Hennecke, Pharabod	12
better understanding of tax issues (production and use)		Price	7
understand energy policies	involvement of policy experts	none	10

utilities prefer status quo/comfort level with established technologies		Meike	6
understand barriers to specific projects	case study on specific projects, analyze motivation	look to combine w/ other activities	7

## **Opportunities**

<b><u>Description</u></b>	<b><u>Accomplishment/Metric</u></b>	<b><u>Participants</u></b>	<b><u>Votes</u></b>
address (green) market opportunities	document environmental benefits; understand how other technologies have been successful; get STE into a utility green power market	Weinrebe, *Hennecke, Fricker	8
joint implementation (pollution credits)	dialogue w/ those working on implementing	*Geyer, Meike, Treet	5
pooling technical capabilities	international projects	none	3
roadshow for STE	number of organizations briefed on promotional missions	combine w/ awareness task	11
seek out government subsidies	# subsidized projects	none	6
additional contacts w/ world bank and others	commitments to funding	*Heller, Tyner	4
build awareness of solar summit decrees/recommendations	increase STE visibility	none	7
build awareness w/ solar enterprise zones	invited briefings; acknowledgments/ set-asides for projects	combine w/ awareness task	11
cooperate in developing financing models	specific models for other markets	*Grasse, Treet	7
sessions on commercialization w/ policy makers, etc.	1/year meeting w/ non-STE attendance	Williams, Geyer	8

## **Understanding market requirements**

<b><u>Description</u></b>	<b><u>Accomplishment/Metric</u></b>	<b><u>Participants</u></b>	<b><u>Votes</u></b>
understand motivation to approve specific projects	better understand near-term market technology	Kunberger, Meike, Hennecke,	3
identify market requirements for remote power (especially dish-Engine)	report/document W. Meike's answer (no maintenance, 24-hr power)	Meike, *Price, Stegmann, Sagie	10
understand (especially developing) country requirements	identify demand and cultural requirements, understand infrastructure	Meike, Hennecke, Kunberger	15
understand effect of deregulation on renewables		none	3
comprehensive literature review of other power technologies market research	UN, IEA are good sources	none	8
identify expanding sunbelt markets		Meike	5
identify promising sites	list of attributes of promising sites identify specific sites	Meike, Heller, *Treet, Sagie & Meinecke (list of attributes only)	10
better definition of near term technology	documentation	*Blanco, Roy	9

## Miscellaneous Business

With the reorganization of Task I to include New Sectors 3 (START Missions) and 4 (Market Barriers and Opportunities), Tyner asked for sector leader volunteers to assist with Sector 1: Central Generation (currently Michael Geyer). Wolfgang Meike volunteered with the caveat that he receive approval from Australia. (As a follow-on note, approval may take awhile, pending decisions with the Australian program on their future directions.) Tyner then reviewed and updated the list of national representatives for Task I. The national coordinators are (subject to some verification) Wes Stein (Australia); Evandro Camelo (Brazil); Anhar Hegazi (Egypt); Francois Pharabod (France); Klaus Hennecke (Germany); Michael Epstein (Israel); Oleg Popel (Russia); Manual Rodriguez (Sevillana, for Spain); Thomas Seitz (Switzerland - monitoring only); and Tyner (USA).

## Program Of Work

Next, Tyner led the group through developing the SolarPACES Program of Work for 1997-2001. He explained to participants how to fill out worksheets for each task their organization is currently doing or have planned. Although the group brainstormed the addition of a number of speculative tasks (including potential plants in Egypt, Australia, and Jordan and possible future projects based on a TSA/PHOEBUS-type demonstration plant with advanced heliostats, and DISS technology), the participants felt that because these activities were so speculative at this time that it would be better to treat the task as the definition of these projects rather than guessing the activities and schedule. A number of participants (Meinecke, Heller, Meike, Sagie, Hennecke, and Williams) were asked to complete the task worksheets during an extended 45 minute coffee break. A current (nearly final) draft of the Program of Work is attached as part of this document.

## Sector 3: START Missions

Peter Heller, DLR/PSA, reported for Michael Geyer, who was unable to attend.

START Mission to Jordan (Peter Heller, DLR): The recent Jordanian START mission was very successful. Jordan has 1.3 GW installed and predicts annual increases in demand of 80-100 MW. The grid reaches 97% of the population, and connections to Syria, Egypt and Israel are underway. After 2001, every other year 130 MW base and 30 MW peak load additions are desired. They own gas-fired power plants, but import gas from neighboring countries. They plan to build a gas pipeline to Aqaba. Baseload plants are fired with heavy fuel oil (No. 6). They had a large project planned with ENRON that has been abandoned, so they must now adjust their energy plan. The primary utility is NEPCO, a private company which generates 90% of the power. The government approved a new electricity act moving towards privatization and a market open to IPPs. Energy prices in Jordan are very low because of using subsidized fuel. There are no restrictions on emissions. Some sort of economic incentives will be necessary to make solar thermal projects happen. Three sites have been identified: Al Quawairah, Ras en Naqab, and Karanah. Al Quawairah is the preferred site. In 1990 they had 2700 kWh/m<sup>2</sup> of direct normal insolation. Based on global insolation measurements and satellite data, most regions of Jordan offer >2000 kWh/m<sup>2</sup> of DNI, but the best site in the south offers >2500 kWh/m<sup>2</sup> of DNI. Within 50 km from infrastructure (roads, grid) there is great availability of land. The START team recommended expanded collection of DNI data. There was some discussion of potential problems with sandstorms in the valley. DLR has experience with mirrors in locations with sandstorms, but doesn't feel it is a problem; the mirrors survive fine, with just the need for cleaning.

The START team recommended that the Jordanian government include explicitly an option for solar thermal in a RFP to be released later this year. They also recommended that Jordanian authorities request a GEF grant. They currently have no provisions for tax equity or pollution reduction credit in

Jordan, but the Crown Prince seems to support this idea. One risk issue for IPPs is the source and price stability of fuel supplies. NEPCO has offered to act as an O&M contractor for IPPs.

The GEF grant requires many qualifications: Jordan sign the Climate Change Convention, show that the project is part of a sustained program, submit a request from the responsible environmental bureau, and perform a pre-feasibility study that includes plant configuration, cost, performance, economics, environmental and social impacts, and regional dimensions of the project. The project should also represent the least-cost option of its type for the country. There was extensive discussion on the viewgraph bullet created by Geyer stating that a 15-30% solar fraction is required. One hypothesis was that this was somehow a recommendation from the GEF, probably based on information from us (SolarPACES). It would be a mistake to further this idea. This led to an action item to verify the GEF grant requirements and our recommendations to them.

Tyner asked the group whether the START mission to Jordan was successful. Hans Fricker said yes, it was successful, but suggested that a smaller group like in Egypt's mission was better. Grasse explained that Hegazi and Epstein were included at the request of Jordan.

Planned Brazilian Start Mission (Wilfried Grasse, ExCo Secretary): The objective is to discuss the state-of-the-art in STE for Brazil with utilities. In the past, M. Epstein of WIS had participated in plans for a combined biomass and solar thermal plant. The Mission will be headed by Greg Kolb of SunLab, and include Epstein, Geyer, Blanco, and Patricia Cordiero (SunLab). Cepel invited utilities and government and has made this an official symposium. The START team members are being treated as keynote speakers giving lectures. We will not invite SolarPACES industrial partners (such as Bechtel, Steinmueller, etc.), but will try to arrange follow-up meetings for them with the Brazilians. This is the last START mission permitted by funding this year. South Africa and Zimbabwe have expressed interest in having a START mission in the future. India has expressed some preliminary interest also. The Brazilian mission starts May 9 in Rio de Janeiro and includes both meetings and tours of possible sites.

World Bank Cooperation (Craig Tyner, SunLab): Tyner also discussed further cooperation with the World Bank, for example, including them in START missions and participating in Bank missions. Since prior MOUs the Bank had signed with others have often proven hollow, cooperation will simply be documented in a letter agreement. A draft letter has been sent to Richard Spencer, who will facilitate finalizing the agreement (hopefully soon).

## **Sector 1: Central Generation Systems**

Heller led Sector 1 discussions for Geyer.

BG Corporation Introduction (Nikki Parvin [now Nikki Ranzetta], BG (formerly British Gas)): Nikki Parvin reported that BG has requested and received approval to join SolarPACES, with their partners SolarGen and the Department of Trade and Industry. Their formal inclusion as a member of SolarPACES is pending some contractual issues. BG is the new name within the UK for British Gas. Nikki discussed why BG is interested in SolarPACES. They have worldwide gas production facilities as well as downstream responsibilities such as distribution. They have sponsored university research in gas/solar water heating, but mostly see potential for hybrid systems to expand their market. Current solar research by SolarGen includes a 35 kW prototype of a fixed bowl system in Crete. The project goal is to be operational by the end of 1997. Additionally, BG has taken note that Shell International Petroleum Co. has predicted a huge solar market in 50-60 years. (A number of BG's upper management are formerly of Shell.)

Diss Project Update (Klaus Hennecke, DLR): DISS was planned as a 6 year project to demonstrate direct steam generation in troughs at the PSA. The first 2 years ending in 1997 were funded by the EU, industry participants, and DLR and CIEMAT. Currently, they are 3 months behind schedule due to non-

technical issues with the EU. Start-up is planned for early next year. Phase I hardware for one 550-m loop of troughs (2750 m<sup>2</sup>) has been procured. The second phase consists of the addition of another loop to study parallel flow. The hardware has been ordered and will be installed next summer. The collector is a modified LS-3. The construction will be completed by Abengoa, not Solel. Solel will check the prototypes built with their drawings in Seville. With the change in Israel's status with the EU, Solel may participate as a partner in Phase 2 (according to EU regulations they were prohibited from phase 1 participation as a partner). One problem with the plant design has been obtaining re-circulating pumps with pressure capability high enough (100 bar). Another problem is trough controllers, and they are considering adapting the PSA-designed heliostat controller. They are requesting further funding from the EU, and are encouraged about their prospects.

Phase I cost is 6 million ECU, 4 million from the commission. One third of this 4 million is from partners. Ciemat/PSA and DLR contribute 1/3 of the remaining cost. One half of an LS-3 collector will be installed east-west so that it will receive full power at least once a day.

PHOEBUS Update (Peter Heller, DLR/PSA): Peter described the project and its status. The current design is limited to 30 MWe applications. It would be on a 110 m tower, and have the steam generator integrated on top of the tower. The receiver design has a peak flux capability up to 800 suns. The design uses duct burners for hybridization, and eliminates thermal storage to save money. Currently they are testing an updated 2.5 MW absorber 3m in diameter. The plan is to be operational and produce power within the next month. The REFOS receiver being developed by DLR will be tested concurrently with the volumetric Phoebus test, but on a different platform and won't interfere.

Solar Two (Craig Tyner, Sandia): Heliostat availability now exceeds 95%, an improvement over the situation when the field was first resurrected. The receiver has performed well, and is robust. A maximum of 9.9 MWe gross power has been produced, slightly less than design point due to problems with feed water heaters that will be repaired. Craig also described the problems with heat trace installation that led to the rupture of the receiver, and the design flaw in the steam generator that led to its failure. He detailed the current plant status of operating only the salt system with an air cooler while the steam generator is repaired. The plant will be fully back on-line by June, 1997.

O&M Cost Reduction w/ KJC (Craig Tyner, Sandia): In the last 5 years, \$6 million has been invested in this program that improves state-of-the-art operation and maintenance of solar plants that is applicable to all type of plants, not just trough plants. One of the recent activities is the addition of an online performance monitoring (OPM) tool. This is a computer code that lets them evaluate control scenarios changes in system performance in real time. They are also using a new mirror cleaning tool with an oscillating flow. A new cermet coating permits equal performance without an evacuated tube, or improved performance with vacuum. Overall, O&M costs are decreasing yearly while plant output is increasing.

Swiss Study Of Potential Plant (Hans Fricker, FC Consulting): Although the Swiss Meteo Study of a number of years ago had a negative outcome, it was an incentive to start the PHOEBUS study. Then, over a year ago, a Swiss program, Energy 2000, based on the public's anti-nuclear sentiment, had the goal to make 3% thermal, 1% electric of Swiss production by year 2000. They have achieved only part of this goal, and so there was renewed interest in an STE plant feasibility study. Fricker proposed a pre-study that was approved. He selected a site near a ski area and gathered meteorological data indicating 1400 kWh/m<sup>2</sup> per year (1/2 in the winter). They then placed an RFQ for a 4 MWt co-generation plant to one each central receiver, trough, and dish provider. The heat is to be used for industrial applications such as a nearby hospital. The Swiss panel selected the volumetric air tower technology with 8.5 m diameter stretched membrane heliostats based on the SBP/Steinmueller DISTAL II dishes with a 70m tower. The panel didn't like the dish proposal because it required 400 dishes. They felt that the trough proposal had lots of information on maintenance that concerned people about reliability. The oil used in

the troughs also worried people because they wanted cows to graze in the field. They want a solar plant to be very environmentally friendly. This left the tower which was also the least costly by a small margin. The electricity buyer has not yet been established, and the possibility of an IPP is being investigated.

An interesting aside Hans discussed is that a utility in Zurich sells 400 kW PV power for 10 times the going rate of 10-20 Swiss cents per kWh. The demand exceeds their supply, and they want to expand.

## **Sector 2: Distributed Generation Systems**

Tyner led the discussion for Sector Leader Tom Mancini, who did not attend the meetings.

Australian Update (Wolfgang Meike, PAWA): ANU has done a prefeasibility study for 2 systems. The first is a hybrid plant utilizing an existing 60 MWe coal fired plant, with 15 dishes (400 m<sup>2</sup>, ~1 MWe) at 480 C. They are also interested in an Allied Signal aerospace Brayton linked up with single dish for waste heat for desalination and want to develop a low volume desalination plant. Both of these studies were funded by a commercial company. Neither is proceeding at the moment. No one has come forward with funding to continue design reviews. PAWA has declined to fund the effort until the design development and review progresses.

DISTAL SBP/Steinmuller (Peter Heller, DLR): The 3 DISTAL II 8.5 m OD dishes are prepared for testing. Two Solo engines arrived last week. One engine has been installed and they will start with low pressure operation in morning and afternoon. The second engine will be installed this week. The DISTAL I dishes continue extended operation and now have accumulated 25000 hours total.

Sun•Lab Projects (Craig Tyner, Sandia): For the dish/Brayton project, DLR provided a VOBREC engine, but Cummin's exit and cost overruns at NREC have delayed the project, perhaps ultimately leading to project cancellation, although no decision has yet been made. The dish/Engine compendium update from Bill Stine is pending and may be continued next year. The Kislovodsk solar power plant project will be reported on this summer. The Stirling engine exchange is proceeding with the purchase of a Solo V-161 by Fort Huachuca. An update on the SAIC joint venture was given. The new dish/engine project RFQ was discussed.

Israel National Update (Dan Sagie, Rotem): Dan described a variety of ongoing Israeli projects, none of which has direct IEA/SolarPACES involvement. The CONSOLAR industrial consortium projects include Rotem Industries (volumetric, high temperature, high pressure receivers integrated with preheaters and secondary concentrators), Ormat Turbines (hot ducting and peripheral equipment), WIS (test facility), Silver Arrow (unmanned helicopter with dish, engine, and storage), and MLM (unmanned communication station - not solar thermal); the USISTF Program (with MDAC) including Rotem industries (volumetric receivers in combined cycle plants) and Ormat Turbines (modified gas turbine with external combustion chamber and major plant equipment); and other activities including WIS reformer/methanator testing, Ben Gurion University (Sde Boker test facility and mechanical and chemical engineering department support), and Tel Aviv University studies of two phase flow for DISS.

Life-Cycle Energy/Environment Analysis (Gerhard Weinrebe): He feels we can sell solar power at above market prices. He cited a Japanese study that found CO<sub>2</sub> emissions from a PV plant are ½ of that from a power tower. He proposed a life-cycle assessment on environmental effects of various technologies. He has already agreed to work with DLR/Stuttgart and PSI and was asking for SolarPACES cooperation. The study follows the "cradle-to-grave" energy requirements and environmental effects of technology. He presented an example study of heliostats. Tyner pointed out that Alex Jenkins of the CEC has already requested this type of information. Tyner suggested that Weinrebe contact interested people before the next Task meetings.

**Next Meeting:**

Sept 15-16, 1997; Task III & I in Albuquerque; Sept 17 tours of Solar Two, KJC or Harper Lake, etc. in Barstow.

**Task I Meeting Action Items (all designated 9704-#):**

1. Write up list and send out to group for feedback; present results next SolarPACES meeting. [Williams]
2. Verify GEF grant guidelines and our recommendations to them with Richard Spencer. [Heller]
3. Determine interest in Life Cycle Analyses before next meeting. [Weinrebe]



## Appendix A: Meeting Agenda

### IEA/SolarPACES Task I: Electric Power Systems



#### Task I Meeting

CNRS, Odeillo, France

April 9-10, 1997

#### Agenda

Wed, 13:00	<b>Sector 4: Market Barriers and Opportunities</b> Discussion of issues and potential activities associated with this new sector <ul style="list-style-type: none"><li>• Tax Issues</li><li>• Environmental Issues</li><li>• Financing</li><li>• Project Development</li><li>• Market Requirements</li></ul>	<b>Williams</b>
Thurs, 09:00	<b>Introduction and Miscellaneous Business</b> <ul style="list-style-type: none"><li>• New structure (4 Sectors) and national coordinators</li><li>• Sector leaders and assistants</li><li>• Annual Report Input and Köln Meeting Minutes</li></ul>	<b>Tyner</b>
09:10	<b>Selection of National Coordinators</b>	<b>Tyner</b>
09:30	<b>Program of Work</b> Discussion and final definition of Task I Program of Work for 1997-2000. For each activity: <ul style="list-style-type: none"><li>• Contact individual</li><li>• Objective (brief)</li><li>• Key Activities (brief paragraphs)</li><li>• Participants (including man-years and funding)</li><li>• Time Table</li><li>• Expected Results (brief paragraphs)</li><li>• Intellectual Property Restrictions</li><li>• Participants Contributions and Benefits</li></ul>	<b>Tyner</b>
13:00	<b>Lunch</b>	
14:00	<b>Status Updates</b> Sector 3: START Team Status <ul style="list-style-type: none"><li>• Jordanian Mission results</li><li>• Brazilian Mission plans</li><li>• World Bank update</li></ul> Sector 1: Central Generation <ul style="list-style-type: none"><li>• UK activities</li><li>• O&amp;M Cost Reduction</li><li>• Steam Gen Eval</li><li>• Solar Two</li><li>• Phoebus/TSA</li><li>• DISS/DSG</li><li>• Israeli/Rotem activities</li><li>• THEUSEUS</li></ul> Sector 2: Distributed Generation <ul style="list-style-type: none"><li>• Dish/Brayton</li><li>• Dish/Engine Compend.</li><li>• Australian activities</li><li>• KSPS Review</li><li>• Stirling Engine Exch</li><li>• US D/E activities</li><li>• SBP activities</li></ul>	<b>Geyer</b>  <b>Geyer et al</b>  <b>Tyner for Mancini</b>
17:00	<b>Other New Business and Action Items</b>	<b>All</b>
17:30	<b>Adjourn</b>	



## **Appendix B: Meeting Participants**

**Appendix B: Meeting Participants (con't)**

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**Appendix C: Presentation Summaries**