

IEA/SolarPACES

Task I: Electric Power Systems

Task Meeting Summary:

Sydney, Australia

15 March 2000

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November 19, 2001

IEA/SolarPACES Task I Participants:

Since the last task meeting summaries published in December 1999, we held an IEA/SolarPACES Task I: Electric Power Systems task meeting in Sydney, Australia on 15 March 2000. Please find enclosed my summary of this meeting. The table below provides a snapshot of Task I at this time, including activities currently underway and defined in our recent Program of Work (November 1999), with minor modifications based on discussions at the meeting in Sydney.

Task I: Electric Power Systems (C. E. Tyner, Operating Agent)

Sector 1. Central Generation Systems (Manuel Romero, Sector Leader)

- Direct Solar Steam (DISS)
- THESEUS Project
- EuroTrough
- Solar Two Final Evaluation
- 10-MW Solar Thermal Power Plant for Southern Spain (PS10)
- Solar Gas Turbine with Tower Reflector
- Hybrid Power Plant Assessment/TIPP

Sector 2. Distributed Generation Systems (Wolfgang Meike, Sector Leader)

- SAIC USJV Project
- Dish Engine Critical Components Projects
- Remote Dish System Development
- EuroDish
- Reliability Database

Sector 3. START Missions (Greg Kolb, Sector Leader)

- START Missions
- Egypt/WB Support (NREA Parabolic Trough Collector Testing)
- Brazil/GEF Support

Sector 4. Market Barriers and Opportunities (Tom Williams, Sector Leader)

- Developing Projects – India, Egypt, Morocco, Mexico, South Africa
- Identification and Evaluation of Market Barriers
- Database of Project and Market Opportunities
- Technology Roadmapping
- STEPS - Expert System for Solar Thermal Power Stations
- SYNTHESIS - Private Support of Solar Thermal Power Projects
- SolWin/RENIP Plan
- Life Cycle Assessment (LCA) of STE Power Stations

Thanks for your active participation in Task I activities and for helping expand our areas of cooperation.

Sincerely,

Craig E. Tyner
Operating Agent, Task I

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Sydney, Australia

15 March 2000

(in conjunction with Task II and III meetings and the 10th SolarPACES Symposium)

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IEA/SolarPACES Task I Distribution

IEA/SolarPACES Task I Meeting: Concentrating Solar Power Systems

15 March 2000
Sydney Australia

Meeting Summary

The Task I meeting, attended by 31 participants, covered key activities throughout the Task. Sector 1 development activities included DISS, the Israeli Beam-Down, and TIPP (Thermal Integration with Power Plants), while project activities included PS10, Solar Tres, THESEUS, and Australian Big Dish and CLFR projects. Sector 2 activities included EuroDish, SAIC/STM 25-kW dish/Stirling, SES/Boeing 25-kW dish/Stirling, the U. S. 10-kW remote power system, and a reliability tracking database. START (Sector 3) discussions covered on-going START activities (including conference participation). Sector 4 discussion highlighted South Africa and Mexico opportunities, technology roadmapping, and a project development database.

Task I Meeting

Craig Tyner opened the meeting as Task I Operating Agent. He asked for input on moving project-related opportunities from Sectors 1 and 2 to Sector 4. There were a lot of options suggested; pending final discussions with the Sector leaders, we will probably move all project opportunities to Sector 4, except those with a technology reasonably defined. Thus, for example, PS10, Solar Tres, and THESEUS would not move, but all the GEF activities would. Tyner also discussed the web-based POW database and how it might be simplified. Grasse indicated it was up to us. Tyner will also work on a web-based input form for next year's annual report input.

Manuel Romero led Sector 1 discussions.

Eduardo Zarza discussed issues with the DISS project, including the difficulties of measuring pipe wall temperature distributions. They have had to modify the thermocouples in the pipe wall (inside the glass envelope), to solder them in place. This requires drilling to release the vacuum, cutting a hole in the glass to provide access, induction soldering, repairing the selective coating (with a Solgel process), and sealing the glass pipe (including reestablishing the vacuum). They use a high-voltage probe to find pin-hole leaks to repair. Finally, they put 50mbar of krypton into the system. After repairs, measured delta T's are closely in agreement with expectations. These gradients are now within material stress tolerances. Since horizontal operation seems feasible based on testing to date, they may not need to repeat the testing with tilted collectors. The system has been operated in once-through mode for three clear days, with success.

Michael Geyer discussed the THESEUS status. Greek law allows renewables (up to 30% of grid) to be put on the grid for 90% of the retail tariff (about 8c/kWh, considerably less than the avoided costs of 18-20c/kWh because of subsidy). Crete has received applications for 100MW (mostly wind), in excess of the 30%. Decisions on selection were delegated to the regional government on Crete. For a variety of reasons, all previous permits were voided, with reapplication required in a more open process. The new process is underway, with no dates defined. In 2001, the power grid will be deregulated, so things may change again. Permitting and detailed design will continue (up to \$1M only) using EU funds over the

next 18 months or so.

Within the EU, an effort was made to coordinate all the renewable premiums, in particular, so that individual countries could not limit payments to energy produced within their country, but had to include imported renewables also. A new draft is being prepared to find a compromise to take forward.

Stephen Kaneff discussed the new Big Dish activity, based on the Power Dish Mark 3 (430m²). He showed costs of \$300k Aus for production on 2 units, dropping to \$80k Aus for a production run of 2000 (includes cost of receiver and steam piping to ground). The Mark 3 collector aperture is now 430m² (with possibilities up to 2500m² in the future). He projects transport losses of no more than 4% (heat and piping cost losses) for a well designed system. Options exist for injection of steam into a variety of points in a power plant, with direct injection of superheated steam into the turbine as the preferred approach. Levelized costs range from 20¢ down to about 5¢/kWh, depending on resource, dish cost, etc. Dish layout has been well defined to limit piping and losses. Solar-only costs are projected to be 6-9¢/kWh (depending on resource) for a 200 dish system. He also described co-generation options utilizing lower-temperature energy for desalination. This would make the power competitive with the grid, and cut water costs in half (relative to other options) in good circumstances. At \$240k/dish (appropriate for the 18 dish showcase), power costs would be about 10¢/kWh at 2600kWh/m²/year. Transfield is the manufacturer. The White Cliffs site has had 2% of installed cost as O&M per year. An overview of the results is available, and Kaneff will send it to Greg Kolb. They have automated washing systems, and costs are included in the O&M costs.

David Mills discussed the CLFR activity. They also assume 2% of installed cost/year as O&M. Manual mirror cleaning is projected to be cheaper than automated cleaning systems. Market niches include coal saver (hot water or steam at 280C; steam at 365C) with many world-wide sites of 10-100MW (500-1000MW potential in Australia), with low cost and high emissions offset. Land requirements may be an issue, even with the compact technology. Solar/biomass may also be an option, and is a good match (turbine can be used by solar when biomass is not available) in areas with both resources (very limited, however). Future options include a combined cycle evaporator input; coordination with TIPP might be useful. Mining and other RAPS (remote area power supplies) are >700MW (typical sizes of 10-50MW) in Australia, but costs must be <10¢/kWh (US), although subsidy is available in Australia (but generally for Australian technology) for the next 5 years.

Wolfgang Meike provided some additional project information. CLFR will be at Stanwell Power Station near Rockhampton, adding 3 to 4.2 MW (electric equivalent) to the plant. Contract negotiation is underway, with steam system design progressing. Construction is expected to begin in the first half of this year, installing 3% first for testing. The Big Dish system is proposed at Mica Creek Power Station at Mt. Isa with CS Energy. It will be 18 dishes, 430m² each, providing 2MW at 485C, 6.2MPa (into 33MW power plant). Construction could start later this year, although negotiations are still underway, and the project is not certain.

Manuel Romero added to his conference presentation on PS10. They have \$5M from the EU, expecting final approval any time, with project kickoff to follow (end of March). Heliostat testing is already underway. Manuel does not expect final resolution of premium issue in 2000. However, he expects at least 11Pts/kWh (7.2¢/kWh) plus subsidies up to 70% (in IDAE promotion plan); \$200M in subsidies are available, as are about \$28M tax deductions. High premiums (15-19¢/kWh) are much less likely, although there could be a reduced premium for later plants. They are also investigating the opportunities for a biomass hybrid of a PS10-like plant. It would use a gasifier, with solar providing drying prior to gasification. Solar share would be 22-32%, depending on biomass capacity factor. Economic analysis is still very preliminary, but so far it looks good. This option could be used if solar-only turns out not to be feasible.

Craig Tyner summarized the status of Solar Tres, a 10MW molten salt power tower with a 2.6 solar

multiple and 16 hours of storage. It would operate up to 24 hours/day. Ghersa, Bechtel, and Boeing are actively pursuing the project. Solar input would be 97MWt, with a solar multiple of 2.6. 16 hours of storage would be used, providing a capacity factor of over 50%. 24-h/day power production would be possible in the summer.

Michael Epstein updated the status of Israeli activities. On the beamdown project, component development was done under the MAGNET-STEPP program, with funding from the Ministry of Trade and Industry. System integration was supported by USISTC-STEPP. Boeing has responsibility for system integration and control, the industrial tower design, and an improved (small) heliostat (3 prototypes operating). Ormat has system integration and power block responsibility (280kWe using a helicopter turbine), along with high temperature ducting. Rotem is responsible for secondary concentrators and the high temperature receiver. The main secondary is 5m high, 2-m inlet and 46cm outlet. The receiver is fabricated, and delivery was expected last week. The tower reflector is complete, and aligned. It is 73m² (860 replaceable facets), with a washing/maintenance device; it is passively cooled. Flux measurement (at CPC) has been completed and looks very close to calculated. Installation should be complete by June, with 8 months of testing by April, 2001 (overall delayed close to a year since the original plans). The next phase is to find a demo opportunity (10MW).

Michael Geyer discussed the TIPP (Thermal Integration in Power Plants) activity, involving DLR, CIEMAT, Sun•Lab and industry (Fichtner, Bechtel, Pilkington and others). Cycle analyses and heat balances have been completed. Various cycle configurations (with various solar fractions) at standardized sizes have been developed, and the next meeting of the team will be at Energex in July. The final report should be available by the end of the year.

Michael also summarized the status of GEF activities in Egypt, India, and Morocco. The Egypt project had a high-level workshop in Cairo in January, attended by 102 participants (Bechtel/Boeing, Abengoa, IST, Fichtner, Pilkington, Solel, etc.). They expect to have a plant operating by 2003 (140MW with 33 MW solar (2400 kWh/m²/year)). This plant is part of official planning with all official high-level approvals. The plan includes two additional 300 MW plants, with a total of 4GW desired by 2020. Meeting minutes include Michael's report on the meeting. Total cost was estimated to be \$144M, including \$70M for solar (partly covered by \$49M grant from the GEF). Solar share is estimated to be 10%. Peak bottom firing will be allowed. Alliances are being formed. Request for pre-qualification (including investors with equity readiness) was released 10 days ago and is due back April 17. There will be no technology specification, but mature technology is required. SolarPACES was acknowledged for its support. Updates will be available at the September ExCo. Fekry stated that Zannoun wants a SolarPACES review of the final Lahmeyer report. I asked him to send a formal request for this support. Greg Kolb and Michael Geyer agreed to participate.

In India, pre-qualification responses for the consulting were due in mid-February (now delayed to mid-March), and results will be out in a few weeks. GEF has delegated management to KfW (not the bank). KfW has allocated \$250M in soft loans, along with the \$49M GEF grant. Money goes to the State of Rajasthan Department of Energy, to be implemented by the Rajasthan State Power Corporation (RSPCL), with power sales to the electricity authority. The supplier will need to provide 5yrs O&M. An additional consulting contract for RFP/RFQ and implementation will follow. Final tender document is expected by 10/15; responses due in December. An award is expected in early 2001, with operation in 2003.

In Morocco, consultant submittals were due in early February. It is a 150MW IPP project, with costs of \$114M, with \$44M GEF grant. A consultant will be selected by summer.

Wolfgang Meike led Sector 2 discussions.

Peter Heller reviewed highlights of his conference presentation on the EuroDish project. The system cost goal is \$5000/kW. Automated and remote control is operational. Receiver tubes are brazed, not

welded, and the cavity is water-cooled. Drives use AC servo-motors. Next steps include additional development on cavity, beam control system and drives, and engine controls. 2 new units will be installed in April, and testing will go on for 8 months. Eventual applications will include remote dishes and Hyphire (hybrid heat-pipe receiver) and biodish (with ceramic receiver) systems.

Craig Tyner presented SAIC, SES, and remote dish systems. Many characteristics of the remote dish are similar to the EuroDish. SAIC has 3 25-kW systems operating at utility sites in Phoenix, Arizona. All are hybridized, one with natural gas, one with hydrogen, and one with landfill gas. SES/Boeing has 2 systems operating and providing power to the grid at the Boeing test site in Huntington Beach, California. Availability has been 95%. The 10-kW remote dish is operating in an unattended mode at Sandia's NSTTF.

Tyner also summarized information received from Carlos Ramos in Mexico regarding their desire to gain experience with dish systems. While they have funding for development and operations, they are looking for ways to fund purchase of a 5-10-kW dish system for grid and off-grid applications. There were no suggestions on how SolarPACES could provide support, other than technical support to their efforts to get GEF or other grant funding. No SolarPACES members have adequate budget to provide direct support.

Tom Williams described the reliability database, which provides a mechanism for tracking O&M issues during development. He offered participation to other SolarPACES members in using the system once it is fully operational.

Greg Kolb led START (Sector 3) discussions.

Previous START missions have been to Egypt, Jordan, Brazil, and Mexico. Activities include an ISES rural electrification conference in South Africa (to be covered by Louis Van Heerden); work with Brazil to get them back on board; the Energex 2000 conference in Las Vegas in July (with several sessions and a workshop); and a CIEMAT/DLR activity with Argentina to investigate interest. He then presented the type of information conveyed by a START mission. Babcock-Borzig has taken over Steinmuller, and is potentially a supplier of volumetric air towers. There were a number of suggestions for improvements, and Greg asked for input to a further revision.

Michael Epstein described a proposed Chemistry START Mission to Japan that could take place (with ExCo approval) after correspondence between the ExCo and Japan clarifies their interest. Aldo will contact Greg to decide how to move forward. An official request from Japan would be required.

Tom Williams led Sector 4 discussions.

Louis Van Heerden summarized the South African situation (see conference notes). They are looking at site characterization (TMY data, etc) and technology screening. Smallest size being considered is 50MW, although they are also considering distributed generation.

Greg Kolb summarized the Mexico GEF ISCCS situation. He described the project history. The feasibility objective was to assess the economic viability and technical feasibility of an ISCCS plant at the Cerro Prieto, Baja Norte site owned by CFE. A competitive procurement could be issued in 2000-2001, with a plant on line by 2004. Unlike Richard Spencer who has stated they will not specify technology for Egypt or Morocco, Ernie Terrado of the World Bank has emphasized that troughs are the only suitably proven technology for Mexico. Solar output would be 40MW peak. Energy projections seem to be very aggressive. Net plant efficiency increases from 53.9 to 62.7% (peak). No duct burning was considered, although an evening peak might encourage it. About 10% of the solar performance goes to offset small inefficiencies in the non-optimized combined cycle system. The site is in an active seismic area, which could force the project to a new site. Additional updates to the report are underway; ultimately the decision to proceed will be made by the Bank and CFE.

Tom Williams gave an update on Technology Roadmapping of troughs and dishes. The first trough roadmap was completed in 1999. A dish roadmap was partially completed, but still under development, with the most recent meeting in February. Output of the dish roadmap included consensus around some key issues: reliability growth endorsed; converters must be commercial for some other markets, and should be broadened to CPV; broader size range should be considered for remote applications (smaller than 10 kW); grid connected market will need subsidies; and distributed market business planning is difficult. A draft will be available in April. A follow-up activity for troughs will be held in June in conjunction with the ASME meeting. Finally, the DOE/EPRI technology characterizations will be updated based on roadmapping results. Peter Heller and Wolfgang Meike agreed to help review the updated dish roadmap.

Tom Williams then described the web-based project development database. The on-line system would be easy to maintain and contain key information on all activities. Tom made assignments for the projects. Robert Pitz-Paal suggested that we include information about funding agencies, grant opportunities, etc. Tom will take an action item to formulate a database for these types of issues, including tracking for grants, etc.; also looking for opportunities, START missions, etc. Zarza suggested we need very high-level information for dissemination in places like Spain (i.e., perhaps other START mission opportunities).

Tyner closed the meeting with a few business items. It was generally agreed that in future meetings, we will start with Sector 4 activities.

Next Meetings:

The next meeting will be held jointly with Task III (on one day) in Egypt on September 23, with a follow-up public panel discussion in Cairo on September 25. The following meeting will be held in Cologne (in conjunction with a 1-day solar symposium honoring Manfred Becker) about June 21, 2001.

Task I Meeting Action Items (all designated 0003-#):

1. Tom Williams will complete the project development database, including information on funding agencies, grant opportunities, etc.
2. Project contacts will provide initial information into the project database once it is complete.
3. Tyner will prepare a web-based system for annual report input.

Appendix A: Meeting Agenda

IEA/SolarPACES Task I: Electric Power Systems Task Meeting

Sydney, Australia
Wednesday, March 15, 2000



Agenda

(Updated After Meeting)

09:00 **Introduction and Opening Remarks (Craig Tyner, Operating Agent)**

- Task I Issues/Updates
Move commercial opportunities to Sector 4?
- 1999 POW Summary and Web-Based Version

09:15 **SECTOR 1: Central Generation Systems (Manuel Romero)**

- DISS operational issues Zarza
- THESEUS Geyer
- Big Dish Project Status Kaneff
- CLFR Project Status Mills
- Australian Project Status Summary Meike
- PS 10 Romero
- Solar Tres / Solar Two Tyner
- Tower Reflector Epstein
- EuroTrough Project Lüpfer
- Hybrid Plant Assessments / TIPP Geyer

10:45 **BREAK**

11:15 **SECTOR 2: Distributed Generation Systems (Wolfgang Meike)**

- Distal II / EuroDish Heller
- 10-kW Remote Power System Tyner for Diver
- U. S. USJVP (SAIC) and DECC (Boeing) Tyner for Mehos and Mancini
- Mexico Parabolic Dish Development Tyner for Ramos
- Reliability Database Williams for Mehos

12:45 **LUNCH**

14:00 **SECTOR 3: START Missions (Greg Kolb)**

- START Activities Kolb
- START "Message" Update Kolb
- START Mission options All

15:00 **BREAK**

15:30 **SECTOR 4: Market Barriers/Opportunities (Tom Williams)**

- Egypt, India, Morocco, EU, Spain, Germany Status Geyer, others
- South Africa Status Van Heerden
- Mexico ISCCS Project Status Kolb
- Technology Roadmapping Williams
- Project Opportunity Database Williams

17:00 **Additional Business, Action Items (Tyner)**

17:30 **ADJOURN**

Additional Meetings: Monday, Mar 13, Task II and Tuesday, Mar 14, Task III

Appendix B: Meeting Participants

Appendix C: Presentation Summaries