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

16 September 1997
Sandia National Laboratories, Albuquerque, New Mexico, USA

Meeting Summary

An IEA/SolarPACES Task I Meeting on Solar Thermal Electric Power Systems was held in Albuquerque, New Mexico, USA, on September 16, 1997. The meeting was held in conjunction with a Task III meeting and tours of the Kramer Junction SEGS Plants and Solar Two near Barstow, California. An updated meeting agenda, attendees list, and presentation summaries are attached. A report from Greg Kolb on the IEA meeting on global climate change, held in Paris on September 15-16, is also attached, as is the requested Task I review of Brazil's GEF Proposal completed after the meeting.

Detailed Meeting Minutes

To start the meeting, Craig Tyner asked for an update of the attendance list. He reviewed the national coordinator list and added Nikki Ranzetta as the UK representative. Others include Wes Stein (Australia); Evandro Camelo (Brazil); undefined (Egypt); Francois Pharabod (France); Klaus Hennecke (Germany); Michael Epstein (Israel); undefined (Mexico); Oleg Popel (Russia); Manuel Rodriguez (Spain); Thomas Seitz (Switzerland); Craig Tyner (USA); and Nikki Ranzetta (UK). He then discussed the 1997-2000 Program of Work. Tasks were classified as one of four categories: information sharing, task sharing by member counties (newly added), task sharing through Task I, and cost sharing.

Sector 1: Central Generation Systems (Wolfgang Meike, Sector Leader)

Note that by mutual agreement, Wolfgang Meike, PAWA, Australia, agreed to succeed Michael Geyer, DLR/PSA as Sector Leader, Sector 1, allowing Michael more time to focus on Sector 3.

Gilbert Cohen - KJC Operations and Maintenance Study. Gilbert discussed the Kramer Junction Company (KJC) Operations and Maintenance (O&M) cost-shared program with Sandia. It is a $7M program over 5 years with the goal of reducing the O&M costs by 30% in actual expenditures or by increasing output of the plants. He focused on 4 topics: mirror reflectivity maintenance, the development of alternate mirror panels, the development of alternate heat collection elements, and the development of a performance model.

KJC developed a mirror-washing rig using high-pressure (200 bar) water that achieves cleanliness near the level of scrubbing. Overall, the site is maintained at an annual average reflectivity of greater than 92%. Gilbert explained the testing of ECP 305+ and thin glass mirror panels as an alternative to the standard thick glass that is subject to breakage by high winds. KJC has also been developing with Solel an improved Cermet selective surface coating for HCE's. It has emissivity of less than 0.08 at 350°C and absorptivity greater than 96.1 (3-4% better than old coating). In addition, the new coating is stable in air at high temperature, a real advantage for replacement applications.

Gilbert discussed KJC's recent record breaking performances also described in the Pilkington press release. The original power rating of the KJC SEGS plants is 30 MWe, but they are capable of safely producing almost 40 MWe. Annual net solar-electric efficiency of 13.5% was achieved for SEGS VI.

Based upon their projections, the O&M cost reduction program will save KJC $50 million over the next 20 years in reducing O&M expenditures to $139 million.

Peter Heller - TSA Status. Peter described the goals of the TSA project: to test and evaluate 2nd generation absorbers, evaluate the automatic aiming-point strategy, and attach TSA to the electrical grid. The TSA has been operated since 1993 to demonstrate the Phoebus technology including the receiver, storage, and steam generation and is now grid-connected. In 1996, 26 new wire-mesh absorber elements designed to reduce construction costs were installed and tested. Tests at the nominal operating temperature of 700°C and lifetime tests were performed and will be followed by evaluation and estimation of the lifetime. The discovery of colored rings caused by oxidation indicates some improvements in the wire mesh winding procedure are still possible. The auto aiming strategy has worked well and limited the temperature difference across the surface of the TSA receiver to 50°C.

Michael Geyer – DISS. Two test loops with 8 collectors and adjustable tilt are being erected at the PSA. The test loop will be installed next to the CESA-1 tower with N-S orientation. The selective surface coating of the DISS system limits the outlet temperature to 420°C, but the system should be able to achieve 450°C in theory. Additionally, the first LS-3 test loop in Europe has been installed at the PSA. The LS-3 loop is 50m long and uses Dow Syltherm oil to increase the temperature difference along the length.

Michael Geyer – THESEUS. THESEUS, like Colon Solar, resulted from the 1996 call for projects from the EC THERMIE program. Partners include Greek utility PreussenElektra, Pilksolar, Fichtner, the PSA, and others. The objective is to build a 50 MWe SEGS plant on the Greek island of Crete. Crete has one of the highest insolations in the Mediterranean and no pipeline to the main land. A grid already exists and there is significant demand for new power, although the citizens oppose new fossil plants. The load has a dual peak, one near noon and one in the evening. The base load is provided by steam turbines, with diesel engines and gas turbines provide peaking power for 25 cents/kWh. The solar plant can be operated for 13.8 cents/kWh. However, there have been a number of non-technical problems complicating the project. The local gas turbine lobby therefore opposes the solar plant because they fear the price competition. Also, the site selection was politically sensitive and a local official had secret plans to build a 100 MWe fossil plant. To add to the confusion, Enron and Greenpeace together have pledged to build a 50 MWe PV plant at 9c/kWh, not knowing that this would endanger the SEGS project. A wind project also feels threatened by the solar.

Manuel Blanco - Colon Solar. Colon Solar is a re-powering project that integrates a central receiver with the existing Cristobal Colon 66 MWe oil-coal-gas power plant in Huelva, Spain. Utilities have led the project and include: Sevillana de Electricidad, Endesa, and Electricidade de Portugal. Industry Partners include: ABB, Abengoa, Babcock Wilcox Espanola, and PROET. CIEMAT, DLR, and AICIA are the research partners. Since this is a commercial project, low risk technology is planned. The solar system will produce only saturated steam and have a small solar fraction. Sometimes the plant will operate as a combined cycle, other times only as a Brayton cycle. Additionally, the plant is configured such that the utility needs the solar contribution for the plant to be competitive and so will be unlikely to shut it down in the future. The performance figures are:

- Gross efficiency (LHV) with sun: 58.7% (70% capacity factor), 49.8% (100% capacity factor)
- w/o sun: 51.6% (70%), 44.8% (100%)
- original plant efficiency: 37.7%

The system's 489 Heliostats will be 70 m^2, providing a total of 21.5 MWt input. The cost of the project will be 41.7 M ECU, with the solar plant costing 15.7 M ECU, and the conventional plant costing 22.0 M ECU. Phase I to develop the basic and detailed engineering of the plant and perform a feasibility study costs 3.22 MECU (40 % THERMIE funded). The partners have already signed an agreement to operate

the plant in the future. Phase II to build the plant and demonstrate its feasibility at full scale will cost 38.5 M ECU. The project will seek 5 M ECU of the total project cost from the EC in addition to favorable financing. The power produced will cost 3 Pts/kWh, and the estimated cost of the solar power is 18 Pts/kWh.

U. Fisher - Weizmann Cassegrian System Status. Weizmann expects to complete the tower reflector in Feb, 1998 and test the 500-kWt receiver in December, 1998. The receiver is expected to be tested with a gas turbine in fall, 1999.

Robert Litwin - Solar Two Project and Receiver Design. Bob discussed Solar Two with an emphasis on the receiver. Solar Two is intended to improve the accuracy of commercial molten-salt plant predictions, reduce the risks of scale-up, and disseminate the knowledge gained. The working fluid is a sodium-potassium nitrate mixture with freezing point of 221°C. The salt-in-tube receiver consists of 768 tubes in 24 panels and has a serpentine flow path that produces outlet temperatures of 565°C. The salt enters the north side of the receiver, then switches sides (East to West, West to East) midway on its path to the south side of the receiver. The receiver is rated for 42.2 MWt, has a design flow of 102 kg/s (224 lb/s), and an absorptivity of 0.96. The thinner-wall tubes permit the Solar Two receiver to have only 50% the surface area of the Solar One receiver. The plant will undergo a 100 hr acceptance test soon, whereas the receiver has almost completed its acceptance testing. An efficiency of 88% and an outlet temperature of 565°C (1050 F) have been measured. Normal operation has been demonstrated including fill, drain, transition to serpentine flow, operation in cloud transients, etc. In addition, irregular operation such as panel thawing, tube replacement, part-field availability, and operation in high winds has been demonstrated. Decoupled operation of the solar system and electric power generation has also been achieved. Last week the plant produced 9.6 MWe, and has produced 9.9 MWe in the past. The receiver has excellent thermal/hydraulic performance and the control system has performed well also. Boeing has improved the pressurized inlet tank level sensors and made changes to the valves used with the salt. A receiver panel made with an advanced material will be installed at Solar Two and a small prototype advanced design made with the same material will be tested at Sandia next year.

Sector 2: Distributed Generation Systems (Tom Mancini, Sector Leader)

David Menicucci - SOLO V161 at Fort Huachuca. The Fort Huachuca project was originally funded by the US Department of Defense and consisted of a Cummins Power Generation 7.5 kWe system including their dish, a Clever Fellows Stirling engine and a Thermacore sodium heat pipe receiver. When CPG folded, there was still interest at Fort Huachuca to continue with the project, so an agreement was made to retrofit the system with a 10 kWe SOLO V161. The system will be operated for two months with direct illumination, two months with a Thermacore heat pipe receiver, and then for at least 2 years of routine operation after that. The Fort Huachuca operator was trained in Germany at SOLO so that he may perform engine maintenance. The small Cummins dish has circular, stretched membrane facets and has experienced some durability problems, including damage caused by hail. All 12 facets spare facets have been used, so backup options are being explored. The directly illuminated engine package is being installed now, and testing is planned to begin October 1, 1997. One difference from the German system is that closed loop dish tracking will be used.

Wes Stein - Tennant Creek Project. Currently, they are investigating Fresnel lens systems with evacuated tube collectors for low temperature steam production. They are also looking at air conditioning systems. The ANU Big Dish's first market is steam production, but emerging opportunities for the Big Dish are Brayton, desalination, and thermo-chemical systems. A Big Dish will also be installed in Israel. The Big Dish mirror panels are made of expanded foam and common roofing materials. The dish weighs 10.5 tons, whereas the receiver's mass is 500 kg. Wes predicted that many Combined Cycle plants would be installed in Australia in the future. He also proposed using the Big

Dish in a hybrid CC plant by oversizing the steam turbine and providing a supplemental boiler for times that solar is unavailable.

Tom Mancini - Kislovodsk Solar Power Plant Feasibility Study. The Kislovodsk Solar Power Plant Feasibility Study (KPPFS) was reviewed by SolarPACES. The proposed project consists of a 1.5 MWe Power Plant, 500-kWe dual-dish/Stirling, and 1 MWe trough PV. The review team found the feasibility study offered good, first-order systems design, cost analysis, and cash flow analysis. The review team offered three recommendations: 1) down select the three technologies to one or develop each in series rather than parallel to reduce technical risk; 2) The system components should be tested thoroughly before the systems are deployed; and 3) More industry and less government participation should be sought, and more focus put on expanding industry capabilities to provide export potential.

Scott Rawlinson - Solarization of the NREC Brayton. The NREC Brayton will be solarized with the DLR VOBREC4 receiver, providing a backup PCU for Allied Signal and additional options for the dish/Engine program. The NREC engine uses commercial turbocharger parts, has an 825°C typical turbine inlet temp and a 3:1 pressure ratio. The VOBREC receiver has a Silicon Carbide absorber, a quartz window, is about 90% efficient, and is designed for 100 kWt throughput. The package will be tested first at NREC, then will be tested on Sandia's Test Bed Concentrator (TBC) in February 1998.

Kelly Beninga – SAIC Dish/Stirling USJVP. The USJVP is a joint, three-phase project between SAIC/STM and the USDOE. The 90-m2 dish has 16 stretched membrane facets and radial trusses. The PCU is a directly illuminated STM 4-120 Stirling engine with a mechanical swash-plate. Peak system output has been measured at 21.8 kWe. The dish permits easy maintenance of the PCU by lowering it to ground level. The engine has a measured 41% peak efficiency and has a hybrid gas burner. The Phase II dish has been redesigned and achieves a facedown stow that reduces hail damage and soiling rate. SAIC feels the Phase II system can reach its performance target of 24.6 kWe.

Steve Trimble - Allied Signal Dish/Brayton Project. One unique advantage of the project's use of a Brayton engine is that they will get high volume production costs because the engine is also being developed for industrial automotive applications. The automotive industrial unit is predicted to have 100,000 units per year production at the turn of the century, whereas the solar unit is estimated at 1000 units per year. For the solar unit, Allied Signal de-rated the automotive industrial unit from 50 kWe to 25 kWe by reducing operating temperature from 1800 F to 1500 F and also reducing the engine speed to increase lifetime. The turbogenerator used in the engine has air bearings, reducing maintenance cost. The generator is a random, hi-frequency unit that permits variable engine speed. The concentrator manufacturer has not yet been selected. The receiver is a simple design consisting of an annular air-cooled cylinder. Allied Signal estimates 28% solar-electric efficiency for the system and predicts a cost of $2500-$3000/kW installed.

This is a three-phase project. Phase I involves: receiver development, system integration, on-sun testing at Sandia, acquiring field reliability data on the turbogenerator units, and selection of a commercialization team. The commercialization plan focuses first on the Arizona solar mandate that requires ½-1% of the state's total energy production (250-300 MW) to be from solar sources.

Peter Heller - DISTAL II Dish Systems. By the end of the year, the three Distal I systems installed at the PSA will reach 30,000 hours of operation. The three new Distal II systems have an 8.5-m dish and a SOLO V161 engine. The Distal II project objective is routine operation of an improved Distal I design. One improvement is an increase in the power output to 10 kWe. System optimization will be complete by the end of the year and then long term operation and data reduction and evaluation will begin. The systems will be fully automated, starting in the morning and shutting down in the evening without requiring operator intervention.

Sector 3: START Missions (Michael Geyer, Sector Leader)

Patricia Cordeiro - Brazil START Mission. Brazil's Centro de Pesquisas de Energia Electrica (CEPEL), similar to EPRI in the US, was host to the START mission. Briefings on all 3 technologies were provided at the workshop, two potential sites were visited, and resource information was reviewed. SOLERGY was also demonstrated. Brazil has an installed capacity of 55.5 GW (93% hydroelectric), and a consumption of 296 TWh/yr. After the current hydroelectric projects are complete, thermal power additions will be needed. Brazil is undergoing restructuring, de-regulation, and privatization. The business climate is good and inflation has been controlled (currently less than 10%, and predicted to stabilize at 5%). Clear sky conditions are best in the Sao Francisco valley. CEPEL has been collecting global radiation data since 1979. The START team analyzed 2 years of data with SERIQC and found 10-15% missing, and less than 2% bad. Unfortunately, the two-year period analyzed in 1991-1992 included the effects of Mt. Pinatubo, so more DNI data is needed for systems performance predictions.

The German company Flagsol performed a detailed feasibility study of an 80 MWe SEGS plant with fuel oil backup for Brazil in 1990. The cost was estimated at $114/MWh, partly due to high import taxes, and Brazil chose to not proceed based upon the high cost. During the START mission, Brazil showed interest in a Dish/Stirling demonstration. Initial cost estimates are $90-130/MWh. The cost of a Power Tower will be roughly 12% higher in Brazil ($131/MWh) than in the US ($117/MWh) for the same capacity factor because of the different insolation and latitude. These cost estimates for the troughs, dish systems, and towers cannot be directly compared because of different assumptions used in the analysis. Privatization will actually increase the cost of electricity in Brazil because of the government subsidy for fuel oil. The START team believes that STE can increase Brazil's firm capacity and protect itself against climatic fluctuations by expanding its predominately hydroelectric system. The START team recommends the collection of more resource data and further analysis of existing data (e.g. Janauba), the re-evaluation of the Flagsol study, comparison of technologies on a consistent basis, and promotion of solar thermal in addition to other renewables. Group discussion following Patricia's presentation focused on the importance of providing the information that is desired by the candidate countries, such as net present value, rather than LEC.

The Brazilian representative, Eduardo Serra, requested a SolarPACES review of a 6 MWh/day solar project for irrigation in response to a GEF request after the project was submitted for funding. Patricia Cordeiro will coordinate the review, to be completed by year-end. (A copy of the completed review is attached.)

Michael Geyer - Jordan START Mission. Jordan had high level political interest in the START mission. The Jordan START mission report is intended to provide information to potential IPP project developers. In Jordan, 3% of population is not grid connected and is spread over 41% of the land area. Most of Jordan's power is generated by steam plants using high sulfur content #6 fuel, although some gas turbines exist. The load has dual peaks, one near noon, one 3 hours after sunset. Currently 1.3 GWe of utility capacity is installed and Jordan wants the first IPP to be connected in the year 2000. Generation costs range from 2.4 cents/kWh for base load plants to 6 cents/kWh for peaking plants. Jordan gets the #6 fuel for 15% below the market value from Arab neighbors. The high sulfur content fuel causes plant emissions that are 20 times the levels allowed in Europe. The market price of power ranges from 4-6 c/kWh, depending upon voltage. As in Brazil, privatization will raise prices in Jordan because of current subsidization. The insolation of 2700 kWh/m2 is on par with Barstow and is one of the best in the world. Potential sites include one near Al Quwayra that is close to road, railway, and a substation. Another potential location is Aqaba that has the advantage of reduced cost of fuel handling and shipping for a hybrid plant, so was recommended by the START team for the first plant. The investors will be called upon to select the solar technology and take the risk. A 30 MW PHOEBUS tower, a Molten Salt Power Tower from the Solar Two consortium, and a SEGS plant, all hybrid, will probably be proposed in response to Jordan's RFQ. With a number of economic assumptions, the START team found the optimal

debt/equity fractions to be 54.8% equity and 45.2% debt. The actual turn-key costs of Jordan's last 130 MW conventional plant was $90 million, leading to a solar plant cost of $167 million. With a market value of electricity of 4.5 c/kWh and a return on investment of 20% over 20 years, this leads to a required World Bank grant of $70 million.

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

Tom Williams - Commercial Development. Tom Williams presented the status of activities in Sector 4: Market Barriers and Opportunities. The objective of this work is to help understand the commercial issues associated with getting the technology into the market: current market requirements; market barriers; current and future opportunities. Tom described then the activities of the last meeting (brainstorming, identifying best opportunities, voting on best, and identifying participants). Top activities from barriers included increasing public awareness; understanding energy policies; understanding tax issues; preference within utilities for status quo; roadshows; address green market opportunities; solar enterprise zones; building awareness with policy makers, etc. Activities for market requirements included understanding developing country requirements; understanding remote power requirements; identifying promising sites; better definition of near term technology; literature reviews of market research. Regarding status, we need to develop detailed action plans for activities and secure commitments of teams. Current ongoing investigations include remote market requirements and tax equity work by Hank Price; much more is needed and Tom passed out a list of who had volunteered to support each of the activities. Geyer pointed out that there is now a European Solar Industry Foundation to lobby for solar within the EU; Geyer also indicated he has some funding that could support activities in Europe.

Scott Jones - Life-Cycle Assessment of STE Power Stations. Scott Jones then presented Gerhard Weinrebe's material on Life Cycle Assessment of a SOLGAS Hybrid Solar Power Plant. The assessment studied 4 metrics: material requirement; gross energy requirement; global warming potential; and acidification potential. An example compared requirements for providing a MJ of heat from SOLGAS vs. from gas. A database provides the input for materials, etc. Gross energy requirement analysis showed SOLGAS was about 2% of that for gas! Likewise global warming potential is 30 times higher for the gas over solar. Acidification is also about 8 times less for solar. Blanco indicates that some elements have not been reviewed and we should treat data cautiously. Meike indicated that some data refinement is required for accuracy.

Michael Geyer – SOLWIN. SOLWIN is intended to offer a simple, windows-based tool that can be used by solar non-experts. Performance analyses will be based upon average monthly values (a total of 12 months x 24 hours = 288 values) for insolation, ambient temperature, etc. The user would be able to model different types of conventional solar and hybrid plants. The program is written in the Delphi language. The PSA hired a company to help with the program. There will also be a financial package that will be less standardized since financing, special incentives, and tax structure can vary greatly in different countries.

Next Meeting:

March 3 and 4, Task I & III, Almería, Spain, hosted by PSA.

Task I Meeting Action Items (all designated 9709-#):

1. Coordinate Colon Solar review - Blanco
2. Coordinate Brazilian GEF proposal review - Cordeiro
3. Finalize 1998 START mission decision - Tyner

Appendix A: Meeting Agenda

IEA/SolarPACES Task I: Electric Power Systems

Task I Meeting

Albuquerque, New Mexico, USA
Tuesday, September 16, 1997

Agenda

08:00		**Introduction and Opening Remarks (Craig Tyner, Operating Agent)**	
	10 min	Status of Program of Work	C. Tyner
08:15		**SECTOR 1: Central Generation Systems (Wolfgang Meike)**	
	15 min	KJC Operations and Maintenance Study	G. Cohen, KJC, USA
	30 min	Solar Two Project and Receiver Design	R. Litwin, Boeing, USA
	15 min	TSA Status	P. Heller, DLR, Spain
	15 min	DISS Project Status	M. Blanco, PSA, Spain
	15 min	THESEUS Project Status	P. Heller, DLR, Spain
	15 min	Colon-Solar Project	M. Blanco, PSA, Spain
10:00		BREAK	
	15 min	Hybrid Solar-Fuel Power Plants	O. Popel, IVTAN, Russia
	15 min	Industrial Co-Generation Study	K. Hennecke, DLR, Koln
10:45		**SECTOR 2: Distributed Generation Systems (Tom Mancini)**	
	15 min	NREC Dish/Brayton Project	S. Rawlinson, Sun♦Lab, USA
	20 min	Australian Activities	W. Stein, PP, Australia
	15 min	KSPS Evaluation	T. Mancini, Sun♦Lab, USA
	20 min	U.S./German Dish Stirling Project	R. Diver, Sun♦Lab, USA
11:55		LUNCH	
12:50		**SECTOR 2: Distributed Generation Systems (con't)**	
	20 min	SAIC Utility-Scale Joint Venture Project	K. Beninga, SAIC, USA
	20 min	Allied Signal Dish/Brayton Project	S. Trimble, AS, USA
	15 min	Distal II Dish Stirling Systems	P. Heller, DLR, Spain
13:45		**SECTOR 3: START Mission Reports (Michael Geyer)**	
	15 min	START Mission to Brazil	P. Cordeiro, Sun♦Lab, USA
	15 min	START Mission to Jordan	M Geyer, DLR/PSA
	15 min	1998 START Mission Discussion	C. Tyner, Sun♦Lab, USA
14:15		**SECTOR 4: Market Barriers/Opportunities (Tom Williams)**	
	30 min	Commercial Projects Development	T. Williams, Sun♦Lab, USA
	15 min	Life-Cycle Assessment of STE Power Stations	S. Jones, Sun♦Lab, USA
	15 min	SolWin Software Development	P. Heller, DLR, Spain
15:15		**Additional Business, Action Items (Tyner)**	
15:30		**ADJOURN AND LEAVE FOR AIRPORT**	

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Appendix C: Discussion of IEA Meeting on Global Climate Change, Paris, September 15-16, 1997 (Greg Kolb)

Statement of Trip Purpose:

Participate in the *Workshop on the Role of Electric Technologies in Measures to Mitigate Greenhouse Gas Emissions* at IEA Headquarters and present an invited paper that describes the current and future prospects for solar thermal electric technology. This information will be submitted to the United Nation Framework Convention on Climate Change to be held in Kyoto, Japan in December, 1997.

Abstract:

The International Energy Agency invited their SolarPACES group (Solar Power and Chemical Energy Systems) to participate in the *Workshop on the Role of Electric Technologies in Measures to Mitigate Greenhouse Gas Emissions* at IEA Headquarters in Paris, France. Gregory Kolb (SunLab) represented SolarPACES at the workshop and presented a paper that summarized the current and future prospects of solar thermal electric technology. The objective of the workshop was to identify opportunities for the application of electric technologies conducive to the mitigation of climate change. The workshop was attended by 63 electricity specialists from 20 countries, the United Nations, and other international organizations. The content of the papers included advances in electric technologies that could be used to reduce greenhouse gases within the following sectors: industrial, transportation, buildings and appliances, and power generation. The detailed papers will be summarized within a much simpler 25-page document appropriate for policy makers and will be submitted for discussion at the United Nations Framework Convention on Climate Change to be held in Kyoto, Japan in December 1997.

IEA Electric Technologies Workshop, 15-16 September 1997

The focus of the *Workshop on the Role of Electric Technologies in Measures to Mitigate Greenhouse Gas Emissions* was the identification of opportunities for the application of electric technologies conducive to the mitigation of climate change that are commercially available at present or can be reasonably anticipated to become commercially available by 2025. A 25-page summary report of the workshop, designed for policy makers, will be published and made available at the third session of the Conference of Parties (COP-3) to the United Nations Framework Convention on Climate Change (UNFCCC), in Kyoto, December 1997.

The workshop sessions covered the following areas:

- Role of electric technologies
- Benefits, barriers, and opportunities for deploying climate friendly electric technology
- Transportation sector electric technologies
- Industrial sector electric technologies
- Building and appliance sector electric technologies
- Conventional power generation technologies
- Renewable power generation technologies

A detailed proceedings of the 32 papers presented in the above sessions will be published by the IEA and should be available in early 1998. The general themes of the presentations are summarized below:

More electricity usage is more "part of the solution" to global warming than "part of the problem." This was stated several times by IEA directors and data was presented from China to support this statement: as electricity share increases in China, energy intensity [i.e., (unit of heat) ÷ (gross domestic product)] decreases. It was also stated many times that converting from thermal to electric end-use applications is generally more efficient (e.g. electric cars are 50 to 75% more efficient than gasoline cars and electric-arc furnaces are more efficient than thermal-blast furnaces). The mantra of the workshop was "we should try to reduce MegaJoules (heat), not MegaWatthours (electricity)!"

- Venture capitalists are risk adverse and will only invest in new technologies that have a maximum of 2 significant risks.
- Greenhouse friendly, large hydro and nuclear power should not be discounted and need reevaluation.
- Fossil power plants will be the dominate generation technology in the near term. Improvement in plant efficiencies and increased use of natural gas will help curb CO_2.
- Renewable power plants are seen as a long-term contributor to the solution.
- There was general concern about the global trend of reduced R&D budgets to develop new technologies.

The workshop was attended by 63 electricity specialists from 20 countries, the United Nations, the European Commission, UNIPEDE (an organization of European electric companies), and the European Bank Reconstruction & Development (EBRD).

My paper, entitled *Solar Thermal Electricity* (attached), summarized the current and future prospects for technology being developed, under the auspices of the IEA SolarPACES, in the USA and Europe. Mr. Per Lekander, a renewables specialist who is the IEA representative for SolarPACES, was unable to attend the workshop because of prior work commitments. I was concerned that his absence would jeopardize the proper characterization of what I presented in the condensed 25-page summary report to be delivered to Kyoto. I found him in his office at IEA headquarters to discuss this matter with him. He apologized for not being able to attend the workshop and stated that Debra Justus at the IEA would be responsible for condensing my paper for the Kyoto report. I introduced myself to Ms. Justus and offered to review her written input to the Kyoto report. I imagine that no more than 1 paragraph would be devoted to the discussion of solar thermal technology in the Kyoto report. Further discussions with Ms. Justus indicated that she was aware of SEGS trough technology but knew nothing about solar power towers and dish-Stirling. She is not a renewables specialist. Rather, her expertise is energy policy analysis. I raised this concern with the SolarPACES executive committee.

Appendix D: Brazilian GEF Proposal Review

Appendix E: Presentation Summaries