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January 1979

Solar Thermal Test Facilities Users Association

Charles J. Bishop

SERI

Solar Energy Research Institute
A Division of Midwest Research Institute

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Golden, Colorado 80401

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FOREWORD

This document addresses activities and accomplishments of the Solar Thermal Test Facilities Users Association (STTFUA) for the period from 1 October 1977 to 31 December 1978. This document was prepared as part of SERI Task 1323, which addresses the management of STTFUA activities.

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Program Coordinator

Approved for:

SOLAR ENERGY RESEARCH INSTITUTE

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ABSTRACT

Highlights of STTFUA activities for the past fifteen months are summarized as follows: in June 1978, SERI awarded the University of Houston a contract to continue operation of the STTFUA for one year; approximately 20 High Temperature scientists met to consider the current status and needs of high temperature research, and to define some of the experiments which might be undertaken; eighty eight Solar Leaders from France, Japan, and the United States participated in a two day annual meeting in April 1978; and a High Temperature Industrial Process Workshop was held September 1978 to examine the use of high temperatures (more than 300°C) for industrial processes.

Fifteen proposals were received and reviewed by the STTFUA. Six were funded, for a total of $86,000, with an additional four proposals presently in the contracting process.

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SECTION 1.0

INTRODUCTION

The Department of Energy (DOE) has funded the construction of two Solar Thermal Test Facilities (STFF) to assist in the development of solar thermal power systems. These facilities are the 5 MW_t Central Receiver Solar Thermal Test Facility (CRSTTF) at Albuquerque, NM, and the 400 kW_t Advanced Component Test Facility (ACTF) at Georgia Institute of Technology, GA.

From discussions of ways to accelerate the advancement of solar thermal energy technology and encourage more university and industry use of the Department of Energy's Solar Thermal Test Facilities, it was determined that an independent Users Association could be effective in providing liaison among experimenters, facility operators, and DOE and in facilitating use of the government-owned facilities by outside experimenters. Furthermore, such an organization could provide an interface with other available solar test facilities, such as the Department of Defense White Sands facility and the French facility at Odeillo, France. This would be done by disseminating information on the facilities through workshops, conferences, and newsletters; by providing funds for data gathering, equipment interface modifications, and other incidental expenses for users and prospective users of the participating STTFs; by establishing straightforward procedures for soliciting and reviewing experiment proposals; and by coordinating test plans and schedules with experimenters and facility operators.

A Solar Thermal Test Facility Users Association (STTFUA) was organized in early 1977. The University of Houston was awarded a contract in June 1977 to support the first six months' operation of the STTFUA and to organize an Association Office. These tasks have been accomplished; the STTFUA is now a functioning entity incorporated in the State of Texas as a nonprofit organization. The Association's Executive Committee has been organized, an Experiments Committee has been organized to review proposals, and Memberships and Publicity Committees have been named. Alvin F. Hildebrandt of the University of Houston was elected President of the Association. The executive committee selected Frank B. Smith as the executive Director for the Association. The Association office has been established and is located in Suite 1507 of the First National Bank Building East, Albuquerque, NM 87108.

The objectives of the STTFUA are:

- to act as the point of contact for users of Solar Thermal Test Facilities (STTF) and as a primary access link between users and operators of STTFs;
- to solicit and review proposals for experiments to be performed on the STTFs, and to make recommendations regarding utilization of STTFs;

- to provide funding for STTF users subject to DOE program approval and funding availability; and

- to disseminate STTF and experiment information on a regular basis.

In September 1977, management responsibility for the STTFUA was transferred to the Solar Energy Research Institute in Golden, CO.

This document summarizes FY78 activities and first quarter activities for FY79. It addressed workshops and conferences held, proposals reviewed and funded, and presentations made. In the future, reports will be issued quarterly.

SECTION 2.0

HIGHLIGHTS

Highlights of STTFUA activities for the past fifteen months are summarized below:

- SERI assumes management responsibility for STTFUA.
- In June 1978, SERI awarded the University of Houston a contract to continue operation of the STTFUA for one year.
- High Temperature Sciences Workshop was held November 1977. Approximately 20 High Temperature scientists met to consider the current status and needs of High Temperature research, and to define some of the experiments which might be undertaken on the STTFs. Proceedings of the workshop are available.
- First Annual Meeting held in April 1978. Solar leaders from France, Japan, and the United States participated. Eighty-eight people attended the two day meeting. Papers on test facility status, proposed experiments for STTFs, and 20 technical papers on Optics, Materials, Energy Conversion and Storage, Industrial Chemical Processes, and Testing/Simulation were presented. Proceedings are available.
- High Temperature Industrial Processes Workshop was held September 1978. The thrust of the workshop was on the use of high temperatures (>300°C) for industrial processes. Representatives from major oil, chemical, basic metal, and aerospace industries, as well as personnel from national labs, universities, and other research organizations, discussed means of using solar thermal energy as a source of the high temperatures. A proceeding will be issued.
- Fifteen proposals received and reviewed: six funded, four in contracting process, four rejected, and one withdrawn. Funded experiments (totaling $88,000) include:

  * T. Lenz & J. Wright (CSU) - Study of NH_3 Dissociation and Use T. Chubb (NRL) as a Storage Medium,
  * A. B. Meinel (Arizona) - Small Scale Flux Reconcentrator Feasibility Study, M. P. Meinel
  * R. Skaggs (LASL) - Reduction of Molybdenite Ores,
  * J. M. Schreyer (Union Carbide) - High Temperature Absorber Coatings,
  * R. Zito & A. B. Meinel (Arizona) - Selective Surface Degradation Mechanisms, and

* R. Gilles (U. of Kansas) - High Temperature Thermodynamic Studies.

Proposals in the contracting process:

* D. Cubicciotti (SAI) - Carbothermic Reduction of Iron Ore,
* M. Antal (Princeton) - Flash Pyrolysis of Biomass,
* G. Mulholland, (NMSU) - Concrete Degradation Studies, and
* A. Ignatiev (U. of Houston) - High Temperature Solar Irradiation Degradation of Black Chrome.

- Working relationships were established with DOD White Sand Solar Facility and CNRS Solar Furnace at Odeillo, France.

SECTION 3.0

CONFERENCES/WORKSHOPS

A primary method of identifying potential uses of the STTFs and potential experiments to be performed on them is to conduct workshops/conferences on applicable topics or technologies. In the past 15 months, 3 such functions were planned and held.

3.1 HIGH TEMPERATURE SCIENCES WORKSHOP

The first STTFUA workshop was held in Albuquerque on November 28-29, 1977. Twenty high-temperature scientists were invited to meet with STTF operators, managers, and other STTFUA representatives to consider the current status and needs of high temperature research and to define some of the types of experimental work which might be undertaken on the solar test facilities. Additional facility requirements were also addressed. Claude Royere and Jean-Pierre Coutures of CNRS (Odeillo) attended and contributed much of the valuable experience they have gained through their years with the French high-temperature solar facilities. A list of attendees and the agenda for the workshop appears in Appendix A. Proceedings of the workshop are available [1].

Possible STTF experiments proposed and discussed by workshop participants included:

- separation of molybdenum from ores (previous work done by Skaggs and Coutures at Odeillo);
- separation of hydrogen from water; both one-step and two-step processes might be considered;
- carbothermic reduction of iron ore at 1200°K (Fe_2O_3 to give Fe) is a process which has been done for thousands of years--currently in large quantities--which uses much energy and much carbon; a significant part of fossil fuel used in the process might be saved through the use of solar energy;
- carbothermic reduction of aluminum at 2300°K; design of experiments is not trivial, and the effort may or may not result in experiments worth doing;
- melting of refractory metals--particularly titanium sponge--an energy-intensive process;
- silica purification--when silica is heated it has been found that it is purified by vaporization, and such purified silica has applications for optical fibers;

- production of carbon monoxide from fossil fuels;
- purification of zirconium;
- manufacture of lime from limestone (i.e., cement processing);
- thermal dissociation of halides;
- testing of refractory materials (protective coatings);
- study of properties of beams--flux distributions, temperatures, etc.;
- study of phase diagrams and vaporization properties of materials at temperatures greater than 2000°K in controlled atmospheres;
- study of thermal properties of materials at high temperatures: transition temperatures, lattice parameters, segregation phemomena, diffusivity, emissivity, reflectivity, conductivity, heat capacity, enthalpy;
- testing of large pieces of machinery, e.g., from nuclear reactors; and
- development of synthetic fuels, such as methanol.

Other observations and conclusions drawn from the workshop include:

- High-temperature scientists typically work with small sample sizes and low total heat. They are therefore unaccustomed to thinking in terms of the kinds of experiments that might be run on the STTFs, which provide hundreds of kilowatts of thermal energy.
- Much basic high-temperature data essential to exploitation of high-temperature solar technological advancements are not now available. The STTFs might be utilized in securing some of these data, but other information might better be obtained from a smaller university with industrial laboratory facilities.
- To advance high-temperature solar technology most effectively, a balanced program is needed to support both experimental work on the facilities and supporting work in laboratories.
- Other facilities, such as the Sandia Radiant Heat Facility, might also be useful in preliminary work leading to development of STTF experiments.
- STTFs are sources of very intensive radiant energy for study of photochemical reactions.

- Energy available from a solar facility does not necessarily have to be used alone but might be used to supplement other heat sources. One might add solar energy to a chemical reaction to give higher temperatures than would be available with either one alone.

- The STTFs provide opportunity for experimental high-temperature studies in an environment free of other electromagnetic radiation.

- For experiments which require a vacuum or environment other than one atmosphere of air, there may be a need for windows or containers capable of withstanding STTF temperatures.

- A major impediment to many large high-temperature industrial processes will be the intermittent nature of solar energy, since most processes must be run continuously and shutdowns are very costly. Here again, however, it may be that new processes can be developed where daily, or even more frequent, shutdowns can be tolerated.

It became obvious during the conference that chemical or mechanical engineers intimately familiar with large industrial chemical processes requiring high temperatures and high heat fluxes were not represented at the workshop. Consequently, it was agreed that another workshop should be considered in 1978. During this workshop these kinds of people might discuss experimental work leading to industrial uses of the STTFs.

3.2 ANNUAL MEETING

The annual meeting of the STTFUA was held in Golden, CO, April 11-12, 1978. There were 88 registrants. The agenda for the meeting appears in Appendix B. Proceedings for the conference are available [2]. The CNRS of France was represented by Professor Michel Rodot, Director of Interdisciplinary Program for Solar Energy Research and Development, who was a luncheon speaker; Claude Royere, operator of the Odeillo facility; and Herbert Budd, Director, CNRS New York. Professor Tetsuo Noguchi, Government Industrial Research Institute, Nagoya, Japan, was also a luncheon speaker. H. H. Marvin, DOE/DST, was the dinner speaker on April 11. G. W. Braun, DOE/DST, talked on Major Solar Power Projects; Paul Rappaport gave an update on SERI; and F. B. Smith, STTFUA, presented UA Plans and Activities. There were 27 technical papers presented which covered updates on the various STTFs, optics, materials, energy conversion and storage, industrial chemical processes, and testing and simulations. The meeting provided an excellent forum for discussion of facility status and interaction between facility experts and potential experiments.

3.3 SOLAR HIGH TEMPERATURE INDUSTRIAL PROCESSES WORKSHOP

As a result of the November 1977 High Temperature Sciences Workshop, it was decided that a workshop involving industrial scientists was appropriate and desirable. Therefore, on September 27-29, 1978, the subject workshop was held at Atlanta, GA. There were about 100 attendees, including 54 from industry,

17 from universities, and 29 from government labs. Table 3-1 lists the organizations which were represented. It is felt that this workshop was a major step in establishing communication between the solar community and the industrial process people. An agenda for the workshop appears in Appendix C.

The objectives of the workshop were:

- to acquaint industrial representatives with possibilities of solar central receivers for industrial process heat;
- to get their views and assess their interests;
- to determine which processes show promise;
- to consider interface with electric power utilities and possibilities of heliostat cost reduction through mass production; and
- to consider next steps, including R&D and experiments on Solar Thermal Test Facilities.

It was organized as a two-way tutorial session: During the first half, solar central technology people discussed the following topics with the industrial users:

- Solar Energy Central Technology Status and Plans;
- Solar Thermal Test Facilities and Furnaces;
- Chemical Conversion and Transmission of Solar Energy; and
- Users Association.

During the second half, the industrial participants provided information about their processes and energy needs and their views on solar energy possibilities and costs. Summary panels were then held involving representatives of both communities which addressed the following topics:

- Chemicals, Fuels, and Process Heat;
- Metals and Oil Recovery;
- Chemicals, Fuels Summary Panel; and
- Cost-Economics Panel.

Some highlights of the subjects covered are described in the following paragraphs.

Overview of Solar Fuels/Chemical Processes--Webb (Aerospace) discussed high-temperature processing of primary metals, chemicals, paper, pulp, petroleum, stone, clay, glass, lime, and cement; 500°F steam for heating asphalt; and possible uses of solar energy to manufacture mobile fuels. Webb suggested that solar energy might be used to reduce flue gas pollutants (CO_2) and produce H_2 and CO at the same time with very good efficiency.

Table 3-1. INSTITUTIONS REPRESENTED AT THE SOLAR HIGH-TEMPERATURE INDUSTRIAL PROCESSES WORKSHOP

INDUSTRY

Aerospace Corporation
Arco Solar, Inc.
Ardev Company
Atomics International
Battelle Pacific
Bethlehem Steel Corporation
Black & Veatch
Cabot Corporation
Cities Services Company
Dow Chemical Company
E-Systems, Inc.
Exxon Research & Engineering
Ford Motor Company
General Atomic Company
General Electric Company
Industrial Research Institute
Institute of Gas Technology
International Nickel Company
J. E. Sirrine Company
Kettering Research Laboratory
Martin Marietta Corporation
McDonnell Douglas Astronautics
Mitre Corporation
Owens Corning Fiberglass
PRC Energy Analysis Company
Rockwell International Corp.
Rocket Research Company
Sanders Associates
SCS Engineers
Shell Development Corporation
Solar North
SRI International
TRW Systems
Union Carbide Corporation
US Borax Research
Veda, Incorporated
Westinghouse Electric
W. R. Grace & Company

GOVERNMENT

Department of Energy
Jet Propulsion Laboratory
Los Alamos Scientific Laboratory
Lawrence Livermore Laboratory
Oak Ridge National Laboratory
Naval Research Laboratory
Sandia Laboratories-Albuquerque
Sandia Laboratory-Livermore
Solar Energy Research Institute
Tennessee Valley Authority
White Sands Missile Range

UNIVERSITIES

Colorado State University
Georgia Institute of Technology
Massachusetts Institute of Technology
Oak Ridge Associated Universities
Princeton University
University of Arizona
University of Houston
University of New Hampshire
Yale University

INTERNATIONAL INSTITUTIONS

CNRS, France
HTGR Institute, West Germany

DOE Chemicals/Fuels Program--Gutstein (DOE) presented a luncheon talk on his views of the U.S. energy situation and DOE plans for a chemical fuels and process heat program.

Solar Central Receiver Technology and Barstow Plant--Hiles (LLL) Presented a review of receivers, heliostats, costs, etc.

European Solar Energy Projects--Salvage (U.S. Representative to European IEA) discussed 8 or 10 European solar projects which are planned, about half of which are central-receiver type.

Chemical Conversion and Transmission--Hildebrandt (U. of Houston) discussed possibilities for transporting solar energy over distances of several hundred kilometers. Kugeler, West Germany, discussed the Eva-Adam System (methane and steam). They have worked on this technology for several years in west Germany. Other systems discussed include methane-carbon monoxide, SO_3/SO_2-O_2, and NH_3/N_2-H_2. Hildebrandt also suggested that solar tower parks equipped with several central receivers which use underground cavern storage to supply 400°C steam might be cost effective by 1985. Networks of these systems could be strung together in the southwestern United States.

Fertilizer--Waggoner (TVA National Fertilizer Development Center) & Treharne, (Kettering Lab) indicated that there is high priority on developing alternate sources for ammonia and nitrogen; 35-40% of energy used by an ammonia plant is at 1500-1750°F. By using entirely new processes which are much less expensive than traditional ones, it may be possible to manufacture some products such as ammonia or nitrogen oxide directly from solar energy plasma. Inputs are air, water, lime or limestone, and sunshine. A 20-year amortization suggests that the cost of solar-produced fertilizer is $750/ton; future cost may be $250/ton, which will be competitive with other processes.

Secondary Oil Recovery--Rogan (McDonnell Douglas) suggested using solar-produced steam at about 500 psi for secondary oil recovery. This will save one third of oil recovered.

Dow Chemical--Mulloy (Dow) noted that Dow generates over 20,000,000 lb of steam per hour and about 20-25% of that is 500-lb steam.

Industrial Chemicals--McBride (Union Carbide) indicated that the three largest chemical consumptions are ammonia, chlorine, ethylene. One-third to one-fourth of the total energy consumed by industry is consumed in converting methane or naphtha from crude oil processing into ethylene.

Steel Production--Laxar (Bethlehem Steel) stated that Bethlehem has a plant in Texas where gas may soon become unavailable. If solar heat could be substituted for gas, they would be quite interested.

Borax--Sprague (Borax) Laxar (Bethlehem Steel) and Beall (Oak Ridge) noted that significant transportation cost savings are possible if Borax can be dehydrated before shipment from the West Coast. The process is not critical, does not require 100% dehydration, and does not have to operate 24 hours a day. They suggested the use of intermittent solar energy for spray-drying of particles. U.S. Borax is interested in the Barstow plant since they use quite

a bit of process steam which could come from a central solar energy receiver. One possible experiment uses hot air from Sanders' receiver in the Georgia Tech facility for processing borax.

Coal Gasification, H_2 Production, Biomass--Antal (Princeton University) Gregg (LLL) Bamberger (ORNL) noted that there are too many promising technologies to discuss here.

Costs--Curto (Mitre) Geoca, (Shell Development) Antal (Princeton University) and others offered widely varying views: Geoca's analysis was that solar energy cannot compete with other fuels for petrochemicals unless totally installed solar energy costs are reduced to less than $\$0.90/m^2$ (in 1976 dollars), assuming a collector effectiveness of 250,000 Btu/sq ft/year. He was also assuming only 4% annual escalation (above inflation) in petroleum costs. Curto's conclusions were that the central receiver is probably the most cost-effective solar energy concept, but his analyses were based on a 40% investment credit; the best markets would be California and Texas where alternative fuel prices are high, insolation is high, and energy demands are large.

General comments made by various participants included:

- The wide scatter in government estimates and data mask practical difficulties of conveyors, pumps, etc.
- Tests could be run more reasonably in a laboratory or solar energy facility smaller than STTFs.
- Experimenters should not attempt multimillion dollar demonstration projects before first doing more fundamental R&D "homework."
- Two scheduled speakers from promising solar application areas, cement-making and gypsum, were unable to attend.
- Too many possibilities may have been considered in a 2-1/2 day workshop; hence, the workshop only "scratched the surface" of most of the possibilities.
- The workshop indicated that there were so many promising solar-using, fuel-saving concepts discussed that if even only a few of them turn out successfully the returns will be great.
- Relatively little is known about high temperature solar processes. Knowledge is inadequate to do reliable designs of test hardware to match the Sandia 5-MW STTF until smaller scale laboratory or small facility investigations are done. Many competent people are prepared to enter into research and experimental work that may not lead to a demonstration-plant next year but could become profitable in the long term.
- Challenges to DOE, SERI, Users Association and government contractors now include looking more closely at the more promising possibilities, continuing the dialogue with industry, sharpening and

verifying technical and cost estimates, and supporting more basic scientific investigation in laboratories and on the STTFs.

Some general suggestions generated at the workshop included:

- Develop a parallel high-temperature process technology capable of interfacing with existing solar technology.
- Create high-temperature heat transfer and transport.
- Create high-temperature thermal storage.
- Industrial process people are concerned primarily with near-term problems, and they probably regard high-temperature solar heat as too long-range for current involvement. A few successful experiments might generate more interest.
- Industrial process engineers and researchers are committed to proprietary work for their companies and they will have to be shown how they will benefit from an association with the STTFUA.
- Some chemical companies (FMC, Dow, Stauffer) are already involved in DOE solar energy programs. It might be possible to reach solar energy groups through process groups; Whaley had some preliminary discussions before the workshop with FMC.
- Publicity and new releases in the following chemical periodicals might reach interested and knowledgeable parties: Chemical and Engineering News, Chemical Week, and Chemical Engineering.
- The primitive position of applications of solar thermal heat to chemical processing requires demonstration of simple energy utilization processes. Chemical processing generally calls for steady and reliable sources of heat. In many processes, tradeoffs exist between use of solar heat and use of pure oxygen.
- Three processes are suggested for further study:
  - * $SO_3(g) \longrightarrow SO_2(g) + 1/2\ O_2(g)$, operated closed cycle with heat delivered to storage;
  - * gas reforming process, run with excess steam to control coking, for example, $CH_4(g) + 2\ H_2O(g) \longrightarrow H_2O(g) + 3\ H_2 + CO$. The H_2 and CO are more valuable than the CH_4, and the process could provide feedstock for a neighboring methanol plant or synthetic liquid fuel plant; and
  - * ammonia dissociation recombination cycle for delivering energy to storage.

- Good laboratory scale work on $CO_2(g) \longrightarrow CO(g) + 1/2\ O_2(g)$ conversion justifies long-term serious effort to effect it, although temperatures required exceed the long-term importance of this reaction.

- Major effort should go into on-tower processing of solids. Simplest processes might be dehydration of gypsum and melting of scrap aluminum.

- A long-term effort could also be put into coal or solid waste gasification, $C(s) + CO_2(g) \longrightarrow 2\ CO\ (g)$.

An agenda for the meeting appears in Appendix C. Proceedings of the workshop will be available in early 1979.

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SECTION 4.0

EXPERIMENTS

The prime function of the STTFUA is to encourage experimentation which utilizes the STTFs. To accelerate this activity, moneys have been set aside to fund promising "proof-of-concept" experiments on the STTFs. To date, the STTFUA has received and reviewed 15 proposals for experiments. Of these, six were funded, four are in the contracting process, four have been rejected, and one was withdrawn. The following sections discuss the proposed evaluation process and describe the funded work in more detail.

4.1 REVIEW PROCEDURE

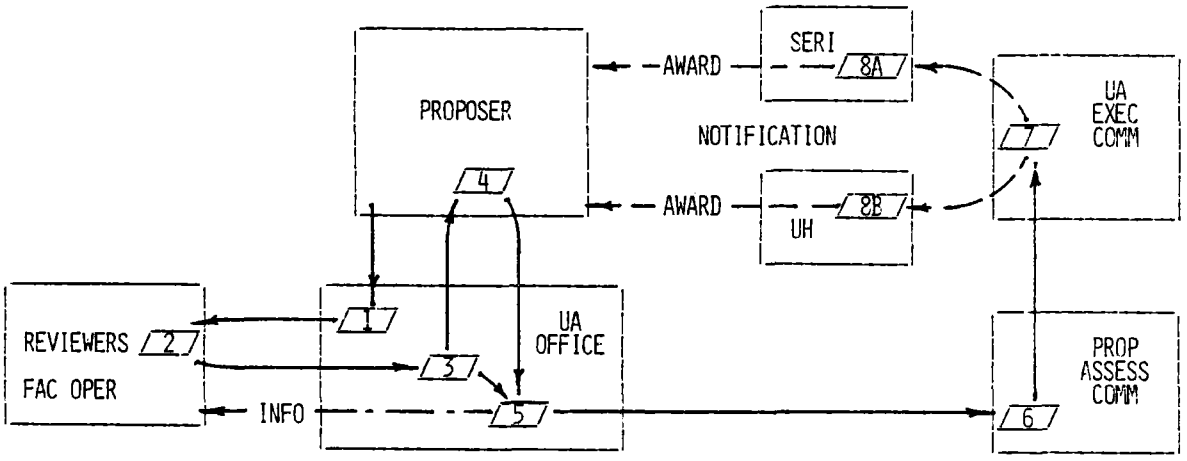
The STTFUA has developed and evolved a peer group review process for proposals submitted to the STTFUA. Several iterations have shown the process to be workable and effective.

The Users Association's Proposal Evaluation Procedure is illustrated in Figure 4-1. After proposals are received by the STTFUA office, (1) they are forwarded to reviewers who are qualified in the disciplines covered by the proposal, and (2) the reviewers send their questions and comments to the STTFUA office. At that point two extra steps are added: (3) reviewers' questions and comments are edited to provide anonymity, and are sent back to the proposer; (4) he then may respond to questions raised by reviewers and provide other additional information if he wishes to do so. The proposer's response then becomes a part of the proposal file (5); it is considered by the Proposal Assessment Committee (6); and their recommendations are forwarded to the STTFUA Executive Committee (7). If the Executive Committee accepts the Proposal Assessment Committee's recommendations, the proposal will either be (8A), funded by a University of Houston subcontract (if less than $10,000) or (8B) (if more than $10,000) forwarded to SERI with a recommendation that a SERI subcontract be issued to the proposer. The entire process from receipt of proposal in Albuquerque to issuance of the subcontract by the University of Houston or a recommendation that SERI award a subcontract is expected to require from 16-20 weeks, unless delayed for further negotiations.

We have found this process to be effective in clarifying uncertainties about the proposal before funding decisions are made.

4.2 CURRENT FUNDED EXPERIMENTS

The project data sheets which follow highlight the present funded STTFUA experiments.



1. PROPOSAL REC., LOGGED, FORWARDED TO REVIEWERS
2. REVIEWERS REVIEW, SEND QUESTIONS & COMMENTS
3. UA OFC EDITS QUESTIONS & SENDS TO PROPOSER
4. PROPOSER RESPONDS WITH FURTHER INFORMATION (OPTIONAL)
5. RESPONSE ADDED TO FILE & FORWARDED
6. COMMITTEE REVIEWS & RECOMMENDS TO EXEC COMM
7. EXEC COMM PRIORITIZES, RECOMMENDS AWARD, NOTIFIES PROPOSER
8. SERI OR UH ISSUES SUBCONTRACT TO PROPOSER

Figure 4-1. PROPOSAL REVIEW FLOW CHART

CONTRACTOR AND ADDRESS	TITLE
University of Kansas Lawrence, KS 66045	High Temperature Thermodynamic Properties
	CONTRACT NO. EI-9-8034-1
PRINCIPAL INVESTIGATOR Name: P. W. Gilles	PERIOD OF PERFORMANCE December 1978 - October 1979
WORK LOCATION University of Kansas	FISCAL YEAR 1979 FUNDING $24,971
CONTRACTING OFFICE SERI Golden, CO	CUMULATIVE FUNDING TO DATE

SUMMARY

OBJECTIVE:

- Study high temperature vaporization phenomena and deduce thermodynamic properties of liquid and solid oxygen alloys of electropositive metals.

APPROACH:

- interaction with Solar Furnace personnel to define temperature measurement technologies and other experiment related problems;
- prepare and characterize samples of alloys;
- modifications of existing test fixtures to use in a solar furnace and of computer codes which control the mass spectrometer; and
- performance of preliminary experiments to debug the equipment.

STATUS:

- New program.

BIBLIOGRAPHY: (Use additional page)

CONTRACTOR AND ADDRESS	TITLE
Los Alamos Scientific Labs Los Alamos, NM	Molybdenite Ore Reduction
	CONTRACT NO. W-7405-ENG-36 D512
PRINCIPAL INVESTIGATOR Name: S. R. Skaggs	PERIOD OF PERFORMANCE August 1978 - October 1979
WORK LOCATION Odeillo, France	FISCAL YEAR 1979 FUNDING $22,000
CONTRACTING OFFICE SERI Golden, CO	CUMULATIVE FUNDING TO DATE

SUMMARY

OBJECTIVE:

- Explore the potential of reducing molybdenite sulfide (ore) to molybdenite oxide using a solar furnace.

APPROACH:

- expose small samples of molybdenite ore to high fluxes in a solar furnace; and
- observe chemical and physical changes to the sulfide ore. Measure amounts of MoO_3 and other species which are produced.

STATUS:

- Experiments performed in the summer of 1976 which exposed a ten gram-sample in the Odeillo Solar Furnace. Results showed excellent separation of molybdenum from silicon and conversion of the sulfide to relatively pure oxide (99+%). In September 1978, samples were treated at Odeillo to perform heuristic studies. Analyses of results have not been completed.

December 18, 1978

CONTRACTOR AND ADDRESS	TITLE Thin Film Material Degradation
University of Arizona Tucson, AZ 85721	CONTRACT NO. P.O. 4208
PRINCIPAL INVESTIGATOR Name: R. Zito, A. B. Meinel	PERIOD OF PERFORMANCE November 1978 - July 1979
WORK LOCATION University of Arizona	FISCAL YEAR 1979 FUNDING $5,000
CONTRACTING OFFICE University of Houston Houston, TX	CUMULATIVE FUNDING TO DATE

SUMMARY

OBJECTIVE:

- Determination of the temperature at which metallic films deteriorate as a result of agglomeration.

APPROACH:

- thin films (1000Å) will be produced and subjected to varying levels of solar flux in and out of vacuum;
- Auger spectroscopy will be used to determine extent and placement of oxygen and nitrogen contaminants in the film; and
- Phase I (funded) covers analysis and design of the proposed experiments.

STATUS:

- New program.

December 18, 1978

CONTRACTOR AND ADDRESS	TITLE
University of Arizona Tucson, AZ	Small Reconcentrators for Sandia STTF
	CONTRACT NO. P.O. 18001
PRINCIPAL INVESTIGATOR Name: A. B. & M. P. Meinel	PERIOD OF PERFORMANCE July 1978 - March 1979
WORK LOCATION University of Arizona Tucson, AZ	FISCAL YEAR 1979 FUNDING $5,000
CONTRACTING OFFICE Houston, TX	CUMULATIVE FUNDING TO DATE

SUMMARY

OBJECTIVE:

- Analyze and develop optional configuration for small-scale flux reconcentrator to use at the 5 MW facility.

APPROACH:

- perform an engineering study of ways to provide small-scale flux reconcentration utilizing a simple, dedicated heliostat at the Sandia STTF;
- examination of different configurations and construction options based on reflector, housing, instrumentation, and support equipment; and
- define most cost effective option.

STATUS:

- Final report due March 1979.

December 18, 1978

CONTRACTOR AND ADDRESS	TITLE
Union Carbide Corporation Nuclear Division Oak Ridge, TN	Plasma Sprayed Coatings
	CONTRACT NO. P.O. XL-9-8019-1
PRINCIPAL INVESTIGATOR Name: J. M. Schrever	PERIOD OF PERFORMANCE November 1978 - February 1979
WORK LOCATION White Sands Solar Furnace and Oak Ridge	FISCAL YEAR 1979 FUNDING $10,000
CONTRACTING OFFICE SERI Golden, CO	CUMULATIVE FUNDING TO DATE

SUMMARY

OBJECTIVE:

- Determine the survivability of plasma-sprayed coatings in a high-temperature (600-800°C) environment.

APPROACH:

- prepare and expose plasma-sprayed absorber coatings to high solar fluxes at 600-800°C in a solar furnace;
- study changes in surface morphology by electron microscopy; and
- study changes in absorptivity and emissivity.

STATUS:

- Experiments performed at White Sands Solar Furnace in December 1978.

CONTRACTOR AND ADDRESS	TITLE
Colorado State University Fort Collins, CO Naval Research Lab (NRL) Washington, DC	Engineering Design Study of Conversion of Solar Energy to Chemical Energy Through Ammonia Dissociation (Contract No. EI-8-1627-1)
PRINCIPAL INVESTIGATOR Name: T. Lenz & J. Wright/T. Chubb	PERIOD OF PERFORMANCE August 1978 - January 1979
WORK LOCATION Colorado State University NRL	FISCAL YEAR 1979 FUNDING $20,693
CONTRACTING OFFICE SERI Golden, CO	CUMULATIVE FUNDING TO DATE

SUMMARY

OBJECTIVE:

- design a solar energy absorber-chemical reactor-heat exchanger for a subsequent test program to study ammonia dissocation using solar energy.

APPROACH:

- design and experiment to test the key components of the proposed system;
- specifically a solar energy absorber--chemical reactor-heat exchanger will be designed; and
- scale of experiment, materials, catalysts, component design, dissociation rate calculations, stress calculations, and control system will be designed.

STATUS:

- Interim Report published 11/15/78; and
- Final Report due January 1979.

4.3 SOLICITATION

During FY78 the mechanism used for experiment funding was the unsolicited proposal. Interested parties were encouraged to submit proposals for experiments using the STTFs. In FY79 (in addition to accepting unsolicited proposals) the STTFUA will issue a solicitation requesting proposals for STTF experiments. The solicitation (scheduled for release in early January 1979) requests proposals with no specific restrictions on the area of research. Criteria established for funding do, however, emphasize solar energy applications. Approximately 4,000 announcements will be mailed to universities and research institutions in the United States. In addition, the solicitation will be advertised in Commerce Business Daily to ensure wide distribution. The due date for proposals is mid-March, and award announcement is to be made by mid-July. Approximately $500,000 will be awarded to selected investigators.

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SECTION 5.0

INFORMATION DISSEMINATION

The dissemination of information regarding solar test facilities, experiments, and the STTFUA is an important function of the STTFUA. This is accomplished through the issuance of conference/workshop proceedings, newsletters, presentations, brochures, and technical papers.

5.1 PROCEEDINGS

The STTFUA has issued two proceedings to date, High Temperature Sciences Workshop (see Section 3.1 [1]), and Annual Meeting (see Section 3.2 [2]). A third proceeding on the High Temperature Industrial Processes Workshop is in work (see Section 3.3).

5.2 NEWSLETTERS

The STTFUA has published two eight-page newsletters. The newsletter, recently named "Focus", addresses such topics as status of proposal review, information about the various experimental test facilities, association membership, proposal submittal, upcoming meetings/workshops, and summaries of recently held meetings. The newsletter is mailed to all association members and is distributed at all STTFUA-approved functions. Publication of the newsletter will continue on either a quarterly or biannual basis, depending on need.

With the recent decision to drop publication of the Sandia publication "STTF Reflections", "Focus" will become the prime source of information regarding solar thermal test facility status and future plans.

5.3 PRESENTATIONS

An important part of information dissemination is presentations made to various organizations regarding the availability of the solar test facilities, their capabilities, and availability of funds to perform experiments. A prime audience is the university community. The pages which follow (see Table 5-1) are compilations of presentations made this past year by various members of the STTFUA. The presentations are aimed at generating additional interest in the utilization of the STTFs.

5.4 OTHER PUBLICATIONS

Early in the establishment of the STTFUA, brochures/flyers were developed to describe the STTFUA and the STTFs and invite membership in the organization. This was later superseded by the newsletters described in Section 5.1.

Table 5-1. STTFUA PRESENTATIONS - 1978

DATE	PLACE	TO WHOM	BY WHOM
1/26/78	Lynn, MA	Bendix Engineers Club	Fred Manasse
2/78	San Diego, CA	Public School Systems	John Russell
2/01/78	Albuquerque, NM	UNM Science & Public Policy Seminar	Frank Smith
2/03/78	Durham, NH	U of NH Economics & Political Science Class	Fred Manasse
3/03/78	San Diego, CA	Solar Thermal Central Power Semiannual Review	Chuck Bishop
4/78	San Diego, CA	Public School System	John Russell
4/11/78	Golden, CO	UA Annual Meeting	Frank Smith & A. Hildebrandt
4/18/78	Washington, DC	US Chamber of Commerce Industrial Energy Users Forum	Frank Smith
4/18/78	Washington, DC	National Association of State Universities & Land-Grant Colleges (NASULGC), Energy & Environment Committee	Frank Smith
4/18/78	Houston, TX	Society of Petroleum Engineers	A. Hildebrandt
5/07/78	Durham, NH	U of NH Sun Day Observance	Fred Manasse
5/11/78	Golden, CO	DOE/DST Advanced Solar Thermal Technology Semiannual Review	Frank Smith
5/13/78	Durham, NH	U of NH Museum of Science	Fred Manasse
5/20/78	Durham, NH	Vocational Technical College	Fred Manasse
6/78	San Diego, CA	Public School System	John Russell
6/12/78	Houston, TX	UH Research Staff	Frank Smith

Table 5-1 (Continued)

DATE	PLACE	TO WHOM	BY WHOM
6/13/78	Houston, TX	Houston Solar Energy Society	Frank Smith
7/19/78	Washington, DC	NASA Office of University Affairs Staff	Frank Smith
7/20/78	Washington, DC	NASULGC, Energy & Environment Committee	Frank Smith
8/03/78	Denver, CO	Solar Repowering Workshop	Frank Smith
8/10/78	Wolfaboro, NH	Gordon Conference on High-Temperature Chemistry	Chuck Bishop
8/11/78	Cambridge, MA	Northeast Solar Energy Center	Fred Manasse
8/25/78	Dearborn, MI	Ford Motor Co. Research Laboratory	Terry Cole
9/21/78	Dallas, TX	Large Solar Central Power Systems Semiannual Review	Frank Smith
9/22/78	Canoga Park, CA	Rockwell Internationl Energy Systems Group	Tom Springer
9/27/78	Atlanta, GA	Solar H-T Industrial Processes Workshop	Frank Smith & A. Hildebrandt
9/29/78	Dearborn, MI	Ford Motor Co. Research Laboratory	Terry Cole
10/03/78	Durham, NH	U of NH Student Energy Coalition	Fred Manasse
10/18/78	Albuquerque, NM	UNM Science & Public Policy Seminar	Frank Smith
10/23/78	Canoga Park, CA	Rockwell International Energy Systems Group	Tom Springer
10/30/78	Madrid, Spain	Temboury & Staff (Center for Energy Studies)	Frank Smith & A. Hildebrandt
10/31/78	Madrid, Spain	Institute for National Technology & Aeronautics (INTA), Carlos Tarifa	Frank Smith & A. Hildebrandt

Table 5-1 (Continued)

DATE	PLACE	TO WHOM	BY WHOM
10/31/78	Madrid, Spain	Construcciones Aeronauticas, S. A. (CASA)	Frank Smith, & A. Hildebrandt
11/03/78	Ansaldo, Italy	Floris & Technical Staff	Frank Smith & A. Hildebrandt
11/07/78	Odeillo, France	Royere & Staff	Frank Smith & A. Hildebrandt
11/08/78	Paris, France	Odeillo Solar Furnace Users Committee	Frank Smith A. Hildebrandt
11/09/78	Paris, France	Electricite de France & CNRS	Frank Smith & A. Hildebrandt
11/09/78	Paris, France	PIRDES Seminar	A. Hildebrandt
11/29/78	Durham, NH	U of NH Faculty Club	Fred Manasse

An announcement regarding the STTFUA was published as part of the Journal of High Temperature Science, Vol. 9, pp. 285-288 (1977).

In December 1978, a package was developed to solicit experiments for FY79 funding. The package included a description of the STTFs, proposal preparation instructions, and proposal review process explanations. This publication will be mailed to more than 4,000 individuals at universities and research institutions. In addition, an announcement will be placed in the Commerce Business Daily (CBD), to ensure wide distribution. See Section 4.3 for a further discussion.

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REFERENCES

1. Proceedings of Facility Operators/High-Temperature Sciences Workshops, Albuquerque, New Mexico, November 28-30, 1977. Available from NTIS.

2. Proceedings of Annual Meeting Technical Sessions, Golden, Colorado, April 11-12, 1978. Available from NTIS.

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APPENDIX A
Agenda
Facility Operators/High-Temperature Sciences Workshops
Solar Thermal Test Facilities Users Association
Albuquerque, New Mexico
November 28-29, 1977

MONDAY, NOVEMBER 28

7:30 Registration - First Floor, Outside Main Ballroom

SESSION I
Chairman - A. F. Hildebrandt, University of Houston

8:45 DOE objectives for STTFs and UA - M. U. Gutstein, DOE

9:00 SERI Objectives for STTFs and UA - C. J. Bishop, SERI

9:15 STTF Funding and Procedures for Proposal Submission and Review - F. B. Smith, UA

9:30 STTF Descriptions - 5-MW Sandia STTF - J. T. Holmes
9:45 - 400-kW Georgia Tech - C. T. Brown

10:00 Coffee Break

10:15 STTF Descriptions - 30-kW White Sands - Richard Hays
10:30 - 1000-kW Odeillo - Claude Royere

10:45 High-Temperature Research and Possible Uses of STTFs - J. J. Margrave, Rice University

11:30 Discussion

12:00 Lunch - Speaker: A. F. Hildebrandt - History of Central Solar Electric Power Generation & Role of UA

1:30 Tour of Sandia Laboratories STTF

SESSION II
Chairman - J. J. Margrave, Rice University

3:30 Panel Discussion on Use of STTFs in High-Temperature Research - Chairman, J. J. Margrave; Panel Members: J. P. Coutures, L. Eyring, J. W. Hastie, G. Rosenblatt, and R. J. Thorn

5:30 Adjourn

6:00 No Host Happy Hour - Main Ballroom

7:00 Dinner - Speaker: P. W. Gilles, University of Kansas - Solar High-Temperature Research

8:30 Subgroup Discussions as Needed

10:00 Adjourn

TUESDAY, NOVEMBER 29

7:30 Breakfast - Continuation of Subgroup Discussions

CONTINUATION OF SESSION II
Chairman - J. J. Margrave

9:00 Results of Subgroup Discussions

9:45 Coffee Break

10:00 Abraham Hertzberg, University of Washington - High-Temperature Solar Machines

11:00 Other Speakers to be Announced

12:00 Lunch - Speaker: J. C. Grosskreutz, SERI - Q&A on SERI Plans and Activities

SESSION III
Chairman - C. J. Bishop, SERI

1:30 Finalization of Results:
List of Possible Experiments and Experimenters
When Experiments Could Be Ready
Development of Proposals
Scheduling
Funding
Suggested Modifications to Facilities

3:00 Summary - Where Do We Go From Here - F. B. Smith

4:00 Adjourn

Facility Operators Meeting has been rescheduled for Wednesday, November 30.

4:15 Brief meeting for Facility Operators to plan agenda for their meeting on Wednesday

APPENDIX A (Continued)
Attendees
Facility Operators/High-Temperature Sciences Workshops
Solar Thermal Test Facilities Users Association
Albuquerque, New Mexico
November 28-29, 1977

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APPENDIX B
Agenda
ANNUAL USERS ASSOCIATION MEETING
Golden, Colorado
April 11-12, 1978

MONDAY, APRIL 10

7:00- 9:00 Preregistration, Holiday Inn--West, Lobby

TUESDAY, APRIL 11

SESSION I - OPENING REMARKS
Chairman - A. F. Hildebrandt, University of Houston

8:30- 8:45 Welcome - Dr. A. F. Hildebrandt

8:45- 9:10 Users Association Plans and Activities - F. B. Smith

9:10- 9:35 Proposal Evaluation and Funding Procedures - Dr. G. P. Mulholland, New Mexico State University

9:35-10:15 Major Solar Power Projects - G. W. Braun, DOE

10:15-10:30 Coffee Break

SESSION II-A - SOLAR FACILITIES
Chairman - J. L. Margrave, Rice University

10:35-11:15 CNRS 1000-kW_t Solar Furnace, Odeillo, France - Claude Royere

11:15-12:00 Sandia 5-MW_t STTF, Albuquerque, NM - John T. Holmes

12:00- 1:15 Lunch, Holiday Inn--West
Speaker: Dr. Michel Rodot, CNRS, France, Initial Applications of Highly Concentrated Solar Energy: Another Look at This Topic

1:15- 1:30 SERI Update - Paul Rappaport, SERI

SESSION II-B - SOLAR FACILITIES
Chairman - J. L. Margrave, Rice University

1:30- 2:15 White Sands 30-kW_t Solar Furnace, White Sands, NM - Richard Hays

2:15- 3:00 Georgia Tech 400-kW_t STTF, Atlanta, GA - Dr. C. Thomas Brown

SESSION III - OPTICS AND SYSTEMS
Chairman - T. Cole, Ford Motor Company

3:00- 3:20 A Single Heliostat Flux Reconcentrator for Materials Sample Testing, Dr. Marjorie Meinel, The University of Arizona

3:20- 3:35 Coffee Break

3:35- 3:55 Secondary Reconcentrator Design of the Sandia STTF, Dr. G. P. Mulholland, NMSU, and L. K. Matthews, Sandia Labs

3:55- 4:15 White Sands 4-kW Solar Furnace, W. C. Hull, NMSU

4:15- 4:35 Tracking Concentrators, Omnium-G Company

4:35- 5:00 Adjourn

5:30- 6:30 Happy Hour, Holiday Inn--West

6:30- 8:00 Dinner, Holiday Inn--West
Speaker: H. H. Marvin, Director, Division of Solar Technology, DOE

EVENING SESSION IV - MATERIALS
Chairman - T. H. Springer, Atomics International

8:00- 8:20 Maximal Operating Temperature for Metallic Films Subject to Deterioration by Agglomeration: A First Principles Calculation, Dr. Richard Zito, The University of Arizona

8:20- 8:40 Selective Coatings for High-Temperature Solar Receivers, Dr. Pat Call, SERI

8:40- 9:00 High Temperature/High Heat Flux Material Testing for Large Solar Flux Applications, L. K. Matthews, Sandia Labs, and Dr. G. P. Mulholland, NMSU

9:00- 9:15 Degradation of Concrete Caused by Concentrated Solar Radiation, Dr. G. P. Mulholland, NMSU

9:15- 9:30 Use of STTFs in the Development of Stable High-Temperature Solar Absorbing Coatings, Dr. J. M. Schreyer, Union Carbide

9:30-10:00 Discussion

WEDNESDAY, APRIL 12

There will be concurrent sessions from 9:00 to 12:00 a.m. on Energy Conversion and Industrial Chemical Processes

SESSION V - ENERGY CONVERSION AND STORAGE
Chairman - R. L. San Martin, New Mexico State University

9:00- 9:20 Engineering Design Study of Conversion of Solar Energy to Chemical Energy through Ammonia Dissociation, Dr. T. G. Lenz, Colorado State University

9:20- 9:40 Experimental Findings on Testing of Honeywell Receiver, W. Oberjohn, Babcock & Wilcox Company

9:40-10:00 Night Storage and Backup Generation with Electrochemical Engines, Dr. G. R. B. Elliott, Los Alamos Scientific Lab

10:00-10:15 Break

10:15-10:35 Sodium Heat Engine, Dr. Terry Cole, Ford Motor Company

10:35-10:55 Thermionic Energy Conversion in Solar Applications, Dr. G. O. Fitzpatrick, Rasor Associates

10:55-11:15 Thermionic Topping of a Solar Power Plant Using Converters Containing LaB_6 Electrodes, Dr. E. K. Storms, Los Alamos Scientific Lab

11:15-11:45 Discussion

SESSION VI - INDUSTRIAL CHEMICAL PROCESSES
Chairman - J. L. Russell, General Atomic Company

9:00- 9:20 Chemical Processes Applicable to a Solar Thermal Test Facility, Dr. John L. Margrave, Rice University

9:20- 9:40 Treatment of Molybdenite Ore Using 2-kW Solar Furnace, Dr. S. R. Skaggs, Los Alamos Scientific Lab

9:40-10:00 Solar-Thermochemical Production of Hydrogen from Water, Dr. K. E. Cox, Los Alamos Scientific Lab

10:00-10:15 Break

10:15-10:35 Results of Recent Research on the Use of Pyrolysis/Gasification Reactions of Biomass to Consume Solar Heat and Produce a Usable Gaseous Fuel, Dr. M. J. Antal, Princeton University

10:35-10:55 Proposed Experiment to Utilize a Solar Facility to Provide Process Heat for the Reaction $C + CO_2 \longrightarrow 2CO$, Dr. D. C. Cubicciotti, SRI International

10:55-11:15 Solar Furnace Measurements of High-Temperature Thermodynamic Properties of Oxygen Alloys of Electropositive Metals, Dr. Robert I. Sheldon, University of Kansas

11:15-11:45 Discussion

11:45- 1:15 Lunch, Holiday Inn--West
Speaker: Prof. Tetsuo Noguchi, Government Industrial Research Institute, Japan, Solar Energy in Japan

SESSION VII - TESTING AND SIMULATION
Chairman - F. Manasse, University of New Hampshire

1:15- 1:45 Thermal Radiation Testing from a Users Viewpoint, Dr. T. M. Knasel, Science Applications, Inc.

1:45- 2:15 A Systems Computer Simulation Model of the Solar Thermal Test Facility, J. F. Coggi, The Aerospace Company

Chairman - A. F. Hildebrandt

2:30- 4:30 Association Business Meeting

4:30 Adjourn

APPENDIX C
Agenda
Solar High-Temperature Industrial Processes Workshop
Atlanta, Georgia
September 27-29, 1978

WEDNESDAY, SEPTEMBER 27, 1978

INTRODUCTORY COMMENTS
Chairman - F. Smith

Georgia Tech - Welcome	J. Walton, GIT
SERI Plans and Programs	K. Touryan, SERI
DOE Plans and Programs	G. Braun, DOE
STTFUA	A. Hildebrandt, U of H
Workshop Plans and Objectives	F. Smith, STTFUA
Solar Possibilities for 500-2500°F	H. Webb, Aerospace Corp.

SOLAR CENTRAL TECHNOLOGY STATUS/PLANS
Chairman - L. Hiles

Barstow, California, 10-MW Solar Electric Pilot Plant	L. Hiles, SLL
Central Receivers	L. Hiles, SLL
High-Temperature Ceramic Receiver	D. Gray, Black & Veatch
Heliostat Development and Costs	W. Wilson, SLL
Sandia Solar Central Power Test Facility	F. Smith, STTFUA
Georgia Tech Solar Test Facility	J. Walton, GIT
Lunch: C. S. Selvage, US Representative to the International Energy Agency Solar Thermal Project, "Solar Central Technology in Europe"	
Visit to Georgia Tech Solar Facility	T. Brown, GIT
White Sands High-Temperature Solar Test Facility	R. Hays, WSSF
Market Analysis of High-Temperature Solar Process Heat	P. Curto, MITRE

CHEMICAL CONVERSION AND TRANSMISSION OF SOLAR THERMAL ENERGY
Chairman - A. Hildebrandt, T. Chubb

DOE Chemical Storage and Transmission Programs	W. Wilson, SLL
Thermochemical Cycles and Distribution of Process Heat	K. Kugeler, HTGR Inst., W. Germany
Interface Methane-Carbon Monoxide Chemical Heat Pipe with Solar Tower: Preliminary Design & Economic Study	J. Richardson/S. Das Gupta, Univ. of Houston

Process Steam End Use for Solar Energy Using Chemical Heat Pipes	J. Flock, GE
Energy Collection & Transport Using the SO_3/SO_2 - Oxygen Thermochemical Cycle, PF_3H_2 as a Possible Thermochemical Fluid	T. Chubb, NRL
NH_3/N_2-H_2 Thermochemical Cycle	T. Lenz, CSU
Ammonia-Hydrogen Sulphate Storage Cycle	W. Wentworth, U of H
Chemical Conversion & Transmission Summary & Discussion	A. Hildebrandt, U of H

CHEMICALS, FUELS, AND PROCESS HEAT - I
Chairman - S. Beall

DOE Programs in Hydrogen Production	C. England, JPL
Solar Central Receiver for Production of Carbon and Nitrogen Oxides	S. Beall/H. Goeller, ORNL
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Hydrogen by Thermochemical Reactions	C. Bamberger, ORNL
Lunch: "DOE Solar Thermal Fuels and Chemicals Program"	M. Gutstein, DOE

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