Quarterly Progress Report

First Quarter Fiscal Year 1992

DOE Solar Industrial Program

Submitted by

National Renewable Energy Laboratory
Golden, Colorado

Sandia National Laboratories
Albuquerque, New Mexico

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FOREWORD

The research and development described in this report were conducted within the U.S. Department of Energy's Solar Thermal Technology Program. Quarterly reports for the Program are prepared jointly and describe the work of both major field laboratories, the National Renewable Energy Laboratory and Sandia National Laboratories, and their contractors. This report specifically describes the work included in the Solar Industrial Program. A companion report is prepared for the Solar Thermal Electric Technology.

EXECUTIVE SUMMARY

The Program continued a high level of activity on a wide variety of fronts this quarter. Although some changes have occurred in external circumstances, these have not fundamentally altered the basic strategy in any of the current technology areas.

One important management event was the completion of a draft of the Multi-Year Program Plan. After review within the Program staff, this document will be circulated within both DOE management and industry for comment.

Emphasis has been placed this quarter on strengthening interactions with industry and with other government agencies. The industrial component development program in water detoxification, which was begun in response to the DOE Solar Detoxification Initiative, began to bear fruit this quarter with the Phase I reports from the various contractors. A number of important cooperative research and development agreements are under negotiation, especially in advanced materials. The FY 1991 contracts on Prefeasibility Studies in Process Heat have all been placed, and plans are being made to initiate another round for FY 1992 after review of the first round at SOLTECH '92.

In the government agency arena, the Tri-Agency Soil Decontamination Project continued to advance on schedule. In addition, plans are coming together to develop a joint effort in water detoxification with the Air Force Civil Engineering Laboratory in Florida. On the downside, DOE Environmental Restoration and Waste Management (EM) has decided not to pursue further joint work at the Field Experiment site in Livermore. Although this will necessitate moving the test equipment, it will not cause a major setback in the project. EM staff suggested that the Industrial Program approach their organization through the Integrated Demonstration Program, and plans are underway to organize that effort.

On the whole, the Program continues to advance its role: working closely with industry to promote the application of solar technology in the U.S. industrial base. The number of industrial contacts and the breadth of this activity are already large and continue to grow. This has begun to be translated into an increased base of support, although efforts in this area will need to continue unabated.

MANAGEMENT STATUS REPORT

Structure of the Solar Industrial Program

The Solar Industrial Program is structured to focus on a number of opportunities for commercialization of the solar technology while maintaining a baseline of research and development which is essential to achieving the long-term technological goals. The following elements constitute work under the Solar Industrial Program: Systems and Market Assessment; Technology Development, and Technology Transfer.

Field Management--Structure and Responsibilities

The lead responsibility for the implementation of the Solar Industrial Program is assigned to the National Renewable Energy Laboratory (NREL) in Golden, Colorado. The two field laboratories, NREL and Sandia, are responsible for implementation of the research, development, and commercial application of the solar technologies. Activities are conducted both in-house at the laboratories and through subcontracts placed with private industry, other research organizations, and universities. In order to provide a clear delineation of management responsibilities for each programmatic activity, a lead responsibility is assigned for each of the current categories.

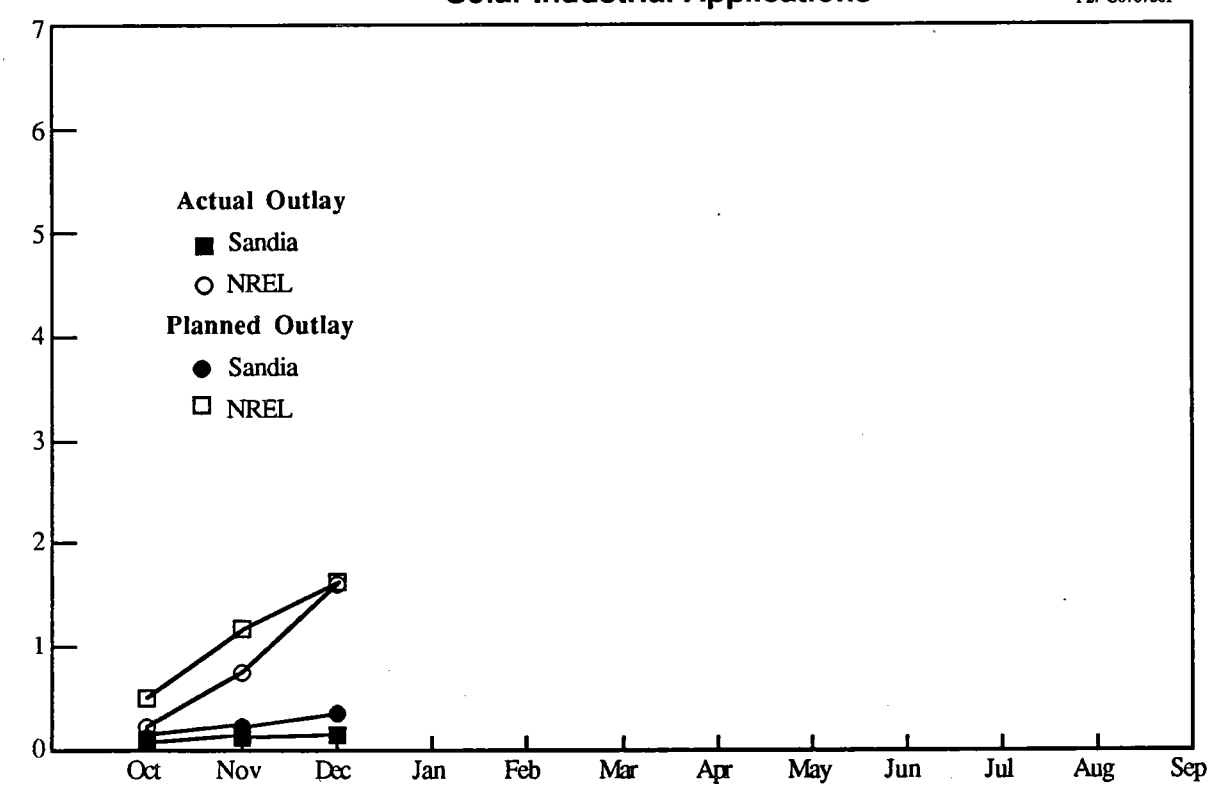
SOLAR THERMAL TECHNOLOGY PROGRAM
WORK BREAKDOWN SCHEDULE

PROGRAM ACTIVITY	LEADER
Solar Industrial Program Management	J. Anderson, NREL
Systems and Market Assessment	T. Williams, NREL
Solar Detoxification Systems	H. Link, NREL C. Tyner, SNL
Process Heat	R. Hewett, NREL P. Klimas, SNL
Advanced Applications	A. Lewandowski, NREL

Resource Summary

BUDGET STATUS

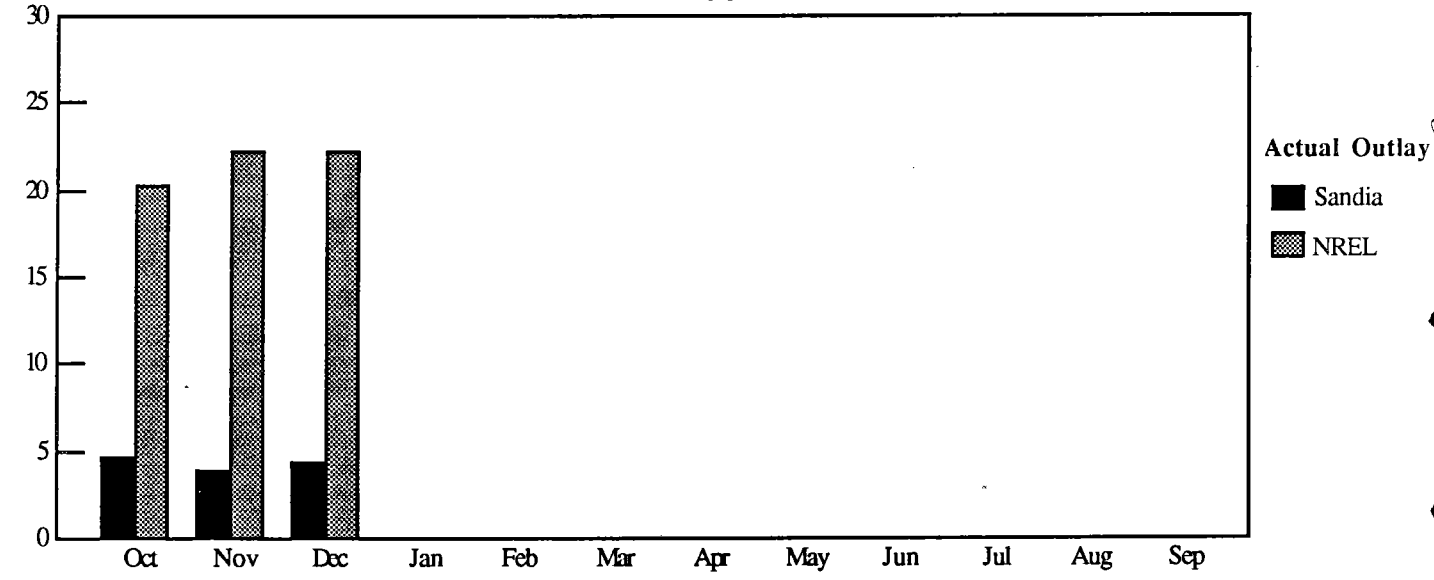
Solar Industrial Applications



FISCAL YEAR 1992

MANPOWER STATUS

Solar Industrial Applications



FISCAL YEAR 1992

Solar Industrial Subcontracts
Procurement Plan and Status Summary

Task	Specific Contract Subject	Contractor	Lab Contract Number ($K)	Present Contract Value ($K)	Prior Year Funds ($K)	FY 1992 Funds	Period of Performance	Contract Type	Major Reports	Project Monitor
Sol. Detox.	Photocatalysis	Univ. of Colorado	NREL 10105-01	$34	$34	--	11/90 - 01/92	Univ.	--	D. Blake
Sol. Detox.	Ordering Agreement	United Engineers	NREL 10123-01	$35	$35	--	01/91 - 12/91	Ind.	--	A. Laxson
Sol. Detox.	Design/Fab. Mobile Solar Detox. Unit	ECOVA Corp.	NREL 10093-01	$454	$454	--	06/91 -	Ind.	--	A. Laxson
Sol. Detox.	Design/Fab. Mobile Solar Detox. Unit	Radian	NREL 10093-02	$100	$100	--	09/91 -	Ind.	--	A. Laxson
Sol. Detox.	Design/Fab. Solar Receiver	Science Applications	NREL 10094-03	$210	$210	--	09/91 -	Ind.	--	I. Parent
Sol. Detox.	Modeling High-Temp Waste Dest.	Col. School of Mines	NREL 11224-01	$40	$40	--	09/91 -	Univ.	--	M. Nimlos
Sol. Detox.	Solar Process Heat Prefeasibility Studies	EA Engineering, Science & Technology	NREL 11131-04	$29	$29	--	12/91 -	Ind.	--	R. Hewett
Sol. Detox.	Lab Treatability Testing & Analytical Serv.	ECOVA Corp.	NREL 11092-01	$99	$99	--	12/91 -	Ind.	--	D. Blake
Sol. Detox.	Solar Process Heat Prefeasibility Studies	United Solar Technologies, Inc.	NREL 11131-01	$35	$35	--	11/91 -	Ind.	--	R. Hewett

Solar Industrial Subcontracts
Procurement Plan and Status Summary

Task	Specific Contract Subject	Contractor	Lab Contract Number ($K)	Present Contract Value ($K)	Prior Year Funds ($K)	FY 1992 Funds	Period of Performance	Contract Type	Major Reports	Project Monitor
PH	Solar Process Heat Prefeasibility Studies	Industrial Solar Technology Corp.	NREL 11131-02	$39	$39	--	11/91 -	Ind.	--	R. Hewett
Sol. Detox.	Solar Detox.	Board of Regents, U of AZ	NREL 10035-01	$64	$64	--	11/91 -	Univ.	--	D. Blake
AA	High Flux Applications	U. of Chicago	NREL 6-06019-2	$200	--	$70	08/90-01/92	Univ.	--	A. Lewandowski

KEY

PH = Solar Process Heat
AA = Advanced Applications
Sol. Detox. = Solar Detoxification Systems
NOTE - This list contains subcontracts exceeding $25,000.

Major Milestone Schedule

The major milestones for each program task are summarized below in chronological order and by task reference. This set of major milestones forms the basis for reporting and tracking progress in this Quarterly Progress Report.

Laboratory--Date		Activity-Task Reference	Descriptive Title
Fiscal Year 1992			
First Quarter, FY 1992			
NREL	November, 1991	B1.1	Document results of testing of improved photocatalyst in laboratory and outdoor tests.
NREL	October, 1991	C.1	Participate in the Annual Conference and Exhibition of the Water Pollution Control Federation.
NREL	December, 1991	C.2	Complete development of a brochure publicizing the High Flux Solar Furnace and its availability for use by non-NREL organizations for research and development.
Second Quarter, FY 1992			
NREL	February, 1992	A1	Data base of successful solar heat systems established.
NREL	March, 1992	A2	Solar heat current capabilities and improvement targets report.
NREL	January, 1992	B1.2	Initiate co-funded catalyst development with a major industrial supplier.
NREL	March, 1992	B1.3	Select photoreactor configuration(s) that will be developed into prototype(s).
NREL	March, 1992	B1.6	Select the photoreactor configuration(s) that will be tested at the field experiment.
NREL	February, 1992	B2.1	Document status of low temperature photocatalysis process. This will report on the state of development of the photocatalytic process and the status of elimination of by-products.

Laboratory--Date		Activity-Task Reference	Descriptive Title
Fiscal Year 1992			
Second Quarter, FY 1992 (Continued)			
NREL	March, 1992	B2.2	(M) Complete reactor design for the Tri-Agency project.
NREL	January, 1992	B4.1	Establish procedures and fee structure for use of the High Flux Solar Furnace by external users.
NREL	February, 1992	C3	(M) Participate in SOLTECH '92.
Third Quarter, FY 1992			
NREL	May, 1992	B1.4	(M) Complete testing of first-generation photoreactor and trough concentrators.
NREL	May, 1992	B1.5	Select partner and site for the first deployment of the pilot-scale, mobile treatability unit.
NREL	June, 1992	B1.7	(M) Complete Phase I testing at the field experiment.
SN	June, 1992	B1.8	Complete testing of controls for once-through and recirculating configurations.
NREL	June, 1992	B2.3	Summary report by University of Dayton on work on the photothermal destruction of hazardous compounds and measurement of absorption spectra of compounds at high temperatures.
NREL/SN	May, 1992	B3.1	Complete materials for a joint DOE/industry presentation on solar process heat.
SN	June, 1992	B3.2	Select awards for cost-shared technology development projects.
NREL	May, 1992	B4.2	Initiate cooperative effort in materials processing with industrial partner.

Laboratory--Date		Activity-Task Reference	Descriptive Title
Fiscal Year 1992			
Third Quarter FY 1992 (Continued)			
NREL	June, 1992	B4.4	Evaluate threshold pumping power and slope efficiency of laboratory-scale laser crystals and identify scale-up issues.
NREL	June, 1992	C4	Participate in the ECO World '92 International Renewable Energy Conference and Exhibition.
Fourth Quarter, FY 1992			
NREL	July, 1992	A3	Market projection for detoxification technologies.
NREL	July, 1992	A4	(M) Improved projection of Solar Process Heat market penetration and impact on U.S. energy consumption.
NREL	September, 1992	A5	Market potential and research directions for advanced industrial processes.
NREL	July, 1992	B1.9	Begin Phase II testing at the field experiment.
NREL	August, 1992	B1.10	Document results of the photoelectrochemical laboratory testing on the destruction of organic compounds.
NREL	September, 1992	B1.11	Report on the results of the first year of treatability testing.
NREL	September, 1992	B2.4	(M) Complete Tri-Agency reactor fabrication and checkout.
NREL	July, 1992	B3.3	Document the results of the FY 1991 solar process heat prefeasibility studies, including lessons learned.

Laboratory--Date		Activity-Task Reference	Descriptive Title
Fiscal Year 1992			
Fourth Quarter, FY 1992 (Continued)			
NREL	September, 1992	B3.4	(M) Complete selection of winners for the FY 1992 prefeasibility studies.
NREL	September, 1992	B3.5	Document results of Program efforts to initiate new system projects.
NREL	September, 1992	B4.3	(M) Compare the quality (physical characteristics) of diamond-like carbon films produced in the solar furnace with ones produced by using conventional methods. Use results to define program strategy in this area.

(M) Major milestones tracked by the Office of Industrial Technology.

Major Milestone Status

B1.1 Document results of testing of improved photocatalyst in laboratory and outdoor tests. (NREL)

Scheduled Completion November, 1991
Actual Completion November, 1991

The milestone that documents results of the evaluation of improved catalysts was completed in November, 1991. The report then was revised, expanded, and resubmitted in December. Initial laboratory results indicated that a factor-of-three improvement in the performance of Degussa TiO_2 was achieved by heat treatment of the material. Subsequent tests performed outdoors did not reproduce the promising results achieved in the laboratory. Experiments are currently underway to assist researchers in understanding the variation between the laboratory and outdoor results. The objective of these tests is to be able to understand the key parameters in heat treating that affect performance and to be able to control these parameters so that a catalyst of consistent performance can be produced in large quantities.

C.1 Participate in the Annual Conference and Exhibition of the Water Pollution Control Federation.

Scheduled Completion October, 1991
Actual Completion October, 1991

The milestone was completed on schedule and as planned. Staff participated in the Annual Conference and Exhibition of the Water Pollution Control Federation.

C.2 Complete development of a brochure publicizing the High Flux Solar Furnace and its availability for use by non-NREL organizations for research and development.

Scheduled Completion December, 1991
Actual Completion Rescheduled to April, 1992

This milestone has been rescheduled to April, 1992.

TECHNICAL STATUS REPORT

A. SYSTEMS AND MARKET ASSESSMENT

Objective

The overall objective of this task for FY 1992 is to provide data and projections that support DOE in directing the development of solar industrial technologies and in identifying the applications with the greatest national benefits. This task will support these objectives by:

- Developing a better understanding of the expected performance and cost of solar industrial processes;
- Characterizing market size, performance criteria, and competing technologies which dictate the hurdles that solar industrial processes must meet to be competitive;
- Projecting the potential penetration of these markets by solar technologies; and
- Identifying research and development and other activities which can move solar industrial technologies closer to widespread commercial applications.

Accomplishments

- **Staff cooperated with Pacific Northwest Laboratory on assessment of gas-phase detoxification.**

  Staff from the Pacific Northwest Laboratory evaluated the economics of gas-phase solar detoxification for the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) as part of the preliminary feasibility assessment for the field test of the Department of Defense, the Department of Energy, and the Environmental Protection Agency. To support their effort, NREL staff provided Pacific Northwest Laboratories with available reports and consultation. NREL also provided a technical review of preliminary results of analysis from the Pacific Northwest Laboratory, answered remaining questions, identified problematic areas, and gave recommendations on areas for improvement. Pacific Northwest Laboratories will be making recommendations to USATHAMA on the potential of gas-phase solar detoxification. The results of Pacific Northwest Laboratory's evaluation will form part of the basis for the Department of Defense's decision to proceed with the field testing of gas-phase detoxification for the Department of Defense, the Department of Energy, and the Environmental Protection Agency. (NREL)

- **Cost of the photon study was updated and will be checked by a subcontractor.**

  Revised figures were generated for an FY 1991 study comparing the cost of ultraviolet photons from solar and electric sources. These new figures show cost of ultraviolet photons as a function of cost for solar collectors for different locations in the United States. The results indicate that at current cost levels trough concentrators can compete with electric ultraviolet lamps in the Southwest. On the other hand, nonconcentrating collectors compare favorably to electric lamps throughout most of the United States and outperform troughs for all locations. Because the comparison of the cost of photons from various sources is critical in assessments of systems for ultraviolet detoxification of water, a second study has been initiated to provide an independent assessment of the issue. A subcontract is now in place with Solar Kinetics Incorporated to compare the cost of ultraviolet light from electric lamps and solar sources. (NREL)

- **The implications of results from the field experiment on system cost were assessed.**

  Last fiscal year, cost projections were made for a treatment unit of 100,000 gallons per day at the Livermore site. Using recent information on the cost and performance of the field experiment, researchers updated these cost projections. In addition, further projections were made concerning the cost of an improved system that would employ nonconcentrating photoreactors. Results of these cost studies placed the cost projections based on 1990 technology at $14 per kgal., in close agreement with the projections from last year ($16 per kgal.). However, the distribution of these costs was somewhat different, with the solar array now accounting for a smaller fraction of the total than previously estimated. These studies assist in defining those research areas that are likely to have the largest impact on the cost competitiveness of solar detoxification systems. (NREL)

- **Concepts for integrated storage, photodestruction, and backup were identified.**

  Several process schemes designed to address the options for incorporating a unit for solar detoxification of water into a system of 24 hours per day were outlined as part of a system analysis to develop realistic operating scenarios for solar units. The ideas generally fall into two categories: combining overnight storage into the photoreactor itself and providing tankage or alternate treatment units to handle the flow when the solar unit cannot operate. Currently, additional concepts are being solicited from researchers at NREL and Sandia. These concepts will be the basis for a revision of the systems-assessment study produced in FY 1991. (NREL)

- **A new process model was developed to account for effects of recirculation.**

  A new reactor model has been developed to analyze the data obtained at the solar detoxification field test. Previous test reactors at NREL and Sandia have operated under either one-pass or differential-pass (low pollutant conversion per pass through the reactor) conditions. Both of these regimes can be described by simple mathematical models. However, the high rate of destruction achieved at the field experiment has necessitated a more detailed analysis of the reactor system. For the conditions of these tests (solar noon, pH 5, 0.1 wt percent), the initial rates of destruction per pass were 94 percent at 10 gpm and 58 percent at 30 gpm--both of which are higher than the differential assumption. Researchers at Sandia first demonstrated that a more representative model could describe several phenomena seen at the field test. Subsequent analysis at NREL has confirmed the Sandia model and formed a basis from which to model other modes of operation. The model shows that the behavior of the system at different flow rates can be predicted by using the same kinetic parameters for the reactor (Figure 1). This new model is more representative of the conditions at the field system and will allow researchers more accurately to extrapolate field-test data to other conditions. (NREL/SNL)

- **A preliminary investigation of the market was conducted for solar-produced silicon carbide.**

  A preliminary investigation was conducted on the economic viability and market impacts for solar-produced silicon carbide. Silicon carbide represents an example of a specific niche market for solar-produced materials. A process for solar-based silicon carbide production has been demonstrated at NREL's High Flux Solar Furnace and appears to have two distinct advantages over the conventional process currently in use. The first advantage of the solar process is displacement of large amounts of electricity used in the conventional process. The second advantage is that the solar process may be able to produce a finer, higher quality product in fewer processing steps than the conventional process. Although the evaluation is considered preliminary at this point, the results indicate that the solar process could be competitive with the conventional process based on savings in energy cost alone. If the solar process can produce a higher-quality product which allows significant reduction of costs for materials processing, the overall impact could be to cut the total manufacturing cost substantially. (NREL)

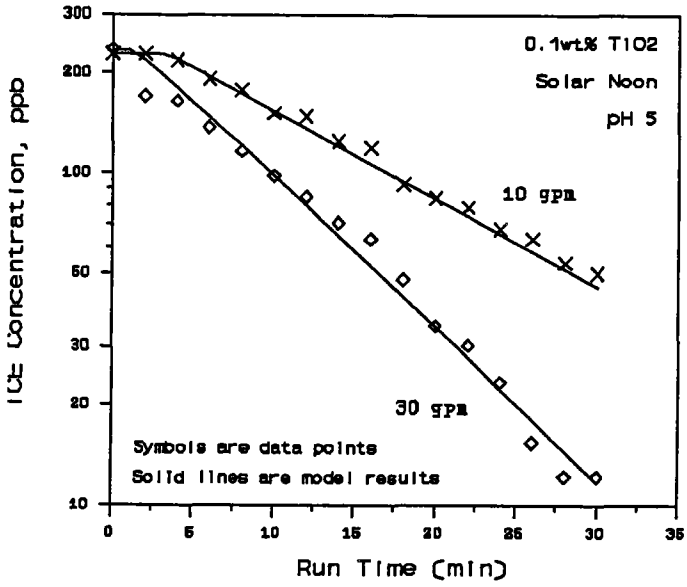


Figure 1. Destruction of trichloroethylene with the solar detoxification system at Lawrence Livermore at 10 gpm and 30 gpm. The solid lines are based on results of the mathematical model describing the behavior of the system, and the symbols are data points. In both cases, the same reaction kinetics were used.

- **A review was conducted on potential issues involving the solar heat market.**

  Two recent studies conducted on the market potential of solar-heat technologies have been reviewed as preparation for expanding this work for the current year. Several areas of improvement based on the review have been identified.

  - Market potential should account for feasibility issues (such as land availability and system integration).

  - The basis for postulating reductions in the costs of solar-heat technology over time should be better defined.

  - A better basis is required for gauging end-user acceptance of the technology in order to predict how quickly solar thermal will enter the market.

  In conducting a literature review, an alternative model for market penetration that was used by Science Applications International Corporation in an analysis of wind-energy systems was identified. This model may be of some benefit in addressing the third identified issue. A draft of a Statement of Work for a contracted study to improve market estimates of solar-heat systems has been prepared. (NREL)

Planned Activities for Next Quarter

- A Statement of Work will be issued for a market study of solar-heat systems.

- A data base will be established for successful solar-heat systems (Milestone A.1).

- The current capabilities and targets of improvement for solar heat systems (milestone A.2) will be documented.

- Evaluation will continue on the options for twenty-four-hour operation of solar systems for detoxification of water.

- The final results of the assessment of gas-phase detoxification by Pacific Northwest Laboratories will be reviewed, and key investigative areas will be identified for improving the economic competitiveness of the technology.

- Work will continue on updating the FY 1991 system costs for solar detoxification of water, and on performance projections and options to improve the economic competitiveness of solar detoxification of water in comparison to other technologies. A formal paper on the results of the revised system will be initiated.

- Support will be provided, as needed, to DOE in an upcoming value-based planning exercise.

B. TECHNOLOGY DEVELOPMENT

1. Water Detoxification

Objective

The objectives for research on water detoxification are closely tied to establishing and building a strong relationship with one or more industrial partners. The technical goals to be pursued with these partners include:

- Refining understanding of the chemical and physical processes which can be altered to improve the performance of the system;
- Demonstrating improved catalytic materials in the field; and
- Moving advanced reactors (concentrating and one-sun) to the field.

Accomplishments

General/Programmatic

- **A cooperative agreement is being developed with the Degussa Corporation.**

  The Degussa Corporation is one of the world's largest producers of hydrogen peroxide and also is producer of one of the best titanium dioxide catalysts, P-25. An agreement was reached between representatives of that company and NREL to investigate the applicability of solar detoxification in treating waste water from one of Degussa's plants. These investigations are currently determining exposure times required to treat methanol, formaldehyde, dichloroethane, and formate, which are the principal contaminants in the wastewater. The effect of the addition of peroxide on decomposition rates also is being investigated. Based on results from these tests, Degussa has sent NREL samples of the wastewater, which is currently being tested. If these tests are positive, Degussa has indicated interest in defining a cooperative agreement for additional research. This cooperative agreement could lead to development of effective systems for treating certain types of industrial wastewater. (NREL)

System Deployment

- **Engineers completed batch-slurry experiments on Livermore's groundwater.**

  Engineers at NREL and Sandia National Laboratories completed an extensive series of experiments at the solar detoxification field experiment in Livermore, California. The experiments were designed to investigate the effect of acidity (pH), flow rate, and catalytic loading on the destruction of trichloroethylene (TCE) in Livermore's groundwater. Figure 2 shows the results of preliminary analysis, which indicates the maximum allowable rate of flow through two drive strings--two-hundred and forty feet of reactor--to maintain destruction of TCE from an initial concentration of 200 ppb to a final concentration of 5 ppb, the discharge limit set by the Environmental Protection Agency for drinking water. As seen in the figure, reducing the level of bicarbonate, achieved by lowering the pH of the fluid, significantly enhances the performance of the process. In addition, the figure indicates that the performance increases by increasing the catalytic loading for the range tested and reproduces results seen previously outdoors and in the laboratory. Velocity through the reactor does not influence the performance.

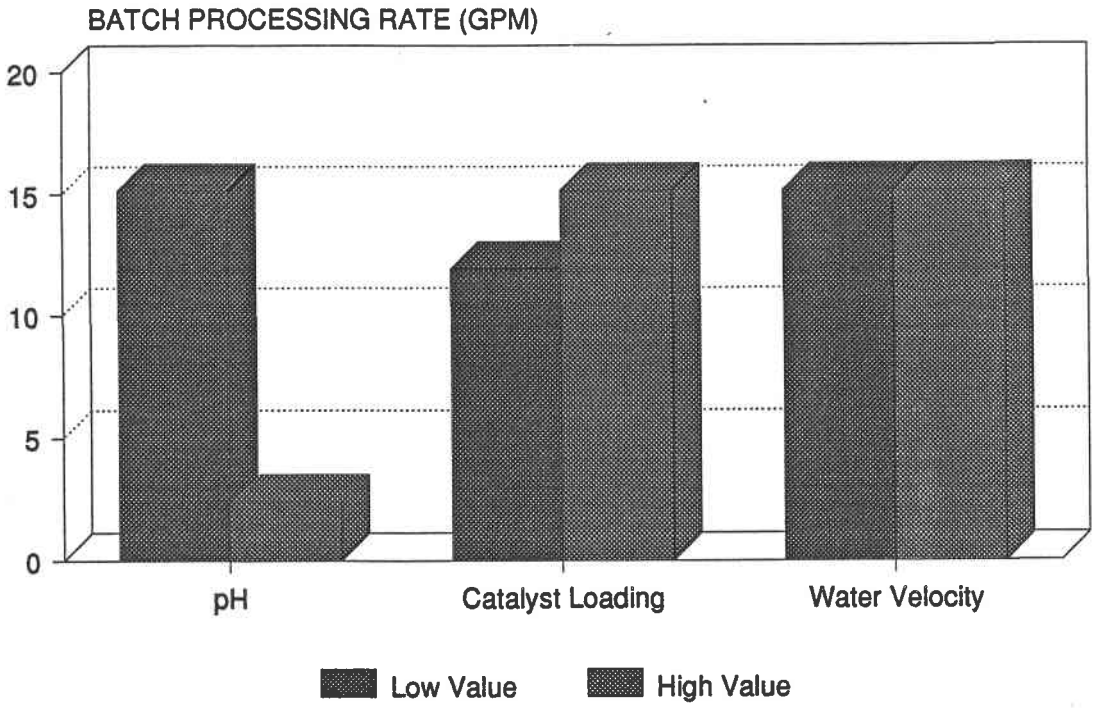


Figure 2. Batch processing rate for destruction of TCE from 200 ppb to 5 ppb involving two drive strings.

Results from the Livermore field experiment will be used by engineers at NREL and Sandia for designing future demonstrations of the solar detoxification process. (NREL/SNL)

- **Radian completed a conceptual design for a second mobile treatment unit.**

Personnel from Radian, Inc., presented their conceptual design for a mobile solar detoxification unit. This marked the completion of Phase I of their subcontract for conceptual design of the unit. Radian's design has a number of advantages over a similar unit which is currently located at the solar detoxification field experiment in Livermore, California. Advantages of Radian's design include increased flexibility for adapting with various photoreactor configurations, simpler appearance, and increased weatherability. The new design makes use of a one-sun solar array which could easily be integrated onto the mobile skid and could make transportation and setup simple. NREL personnel will make a decision early in January on whether or not to proceed with Phases II and III of the subcontract, which involves the detailed design and fabrication of the mobile unit. (NREL)

Component Engineering

- **A report summarizing engineering experiments on solar detoxification of water was prepared.**

A report was prepared to document the engineering experiments on solar detoxification of water. The report summarizes the experiments conducted to date with the large system of outdoor troughs at Sandia. The report will go through peer review and will be finalized next quarter. (SNL)

- **Subcontractors are continuing work on innovative photoreactors.**

  Subcontracts for the development of innovative photoreactors are continuing. Industrial Solar Technology, along with its industrial partner, TDA, Inc., have completed the detailed design for a full-scale prototype photoreactor. The prototype is scheduled to be delivered next quarter. Measurement Technology Northwest (MTNW) presented the results of Phase I of the subcontract. MTNW developed a method by which the titanium dioxide (TiO_2) catalyst is supported in a "streamline" configuration. This configuration resulted in a very low pressure drop across the reactor while maintaining good contact with the fluid. Initial results indicated that the fixed catalytic configuration yielded slightly better than half the performance of a similarly sized slurry reactor. MTNW has been given permission to proceed with Phase II of the subcontract and will focus on applying the streamline approach to the design of a one-sun reactor. A third subcontract, awarded to Science Applications International Corporation (SAIC), is nearing completion of Phase I. The results will be presented early next quarter, and a decision will be made on whether or not SAIC should proceed to develop Phase II of its reactor design. Researchers at the University of Florida have completed Task I of their subcontract on developing a non-concentrating photoreactor. Task I consisted of outdoor testing of a titanium-dioxide slurry reactor. Final analysis of the results will be completed early in January. (NREL)

- **Industrial Solar Technology completed Phase I of its subcontract on low-cost concentrators.**

  Industrial Solar Technology has completed Phase I of its subcontract for the development of a low-cost concentrator for use in solar detoxification systems. Industrial Solar Technology has taken advantage of the relaxed optical requirements associated with using photoreactors that are larger than the receivers used in thermal applications. The modifications have included: increasing the number of concentrator rows per drive system; using fewer and less-accurate support ribs; using fewer rivets; and using coiled aluminum instead of levelled aluminum sheets. Additionally, Industrial Solar Technology had developed a portable layout jig for locating trough foundations and has refined and simplified the installation and alignment of the trough foundation as well as the process of assembling the trough. A detailed report of the work on Phase I has been completed and includes the design study, the plan for the manufacturing process, and a drafted operations and maintenance manual for the design. The work to date has reduced the cost to less than $65 per square meter. This amount approaches the goal of $50 per square meter. Such low costs clearly would enable solar troughs to provide ultraviolet photons less expensively than electric lamps in most areas of the U.S. (NREL)

- **Engineers developed innovative methods for testing optical characteristics of line-focus concentrators.**

  Work on an optical characterization system for line-focus concentrators is proceeding. Once completed, the system will be used to characterize the optical quality of the prototypes of low-cost concentrators. The system uses a line-scan camera for data acquisition and has been successfully implemented for a relatively small number of scans. Minor problems with software are currently being resolved. Following the development of the data acquisition module, engineers will develop a module for data processing and presentation to make the completed system simple to use and to simplify interpretation of the results. In addition to its use in the innovative concentrator work, industry could use the instrument to monitor optical changes in quality in existing installations of line-focus concentrators or as a tool for quality assurance during manufacturing. (NREL)

- **Experiments on settling rates of a catalyst were conducted.**

Tests were performed on Degussa's P-25 titanium dioxide to measure settling rates in deionized water and in tap water. The tests were conducted with a large tank filled with 750 gallons of water and 0.1 wt% titanium dioxide. Samples were taken from five ports mounted at various levels on the tank. The rate of settling is affected by the presence of ions in the water. The ions tend to disrupt the repulsive surface charges between the suspended catalytic particles allowing them to agglomerate. The agglomerated particles settle out faster. The catalyst settled out faster with the tap water than with the deionized water. After four hours of settling, the catalyst loading was approximately 0.0010 percent for tap water and 0.0020 percent for deionized water. After 24 hours the remaining catalytic loadings changed little in relation to the four-hour values. These tests demonstrate the need to develop a process either actively to remove the catalyst from solution or to accelerate the rate of settling. (SNL)

Technology Research

- **The milestone on catalytic heat treatment was completed.**

The milestone that documents results of the evaluation of improved catalysts was completed in November, 1991. A revised and expanded report was completed in December. Initial laboratory results indicated that a factor-of-three improvement in the performance of Degussa TiO_2 was achieved by heat treatment of the material (see Figure 3). Subsequent tests performed outdoors did not reproduce the promising results achieved in the laboratory. Experiments are currently underway to assist researchers in understanding the variation between the laboratory and outdoor results. The objective of these tests is the consistent production of an improved catalyst in sufficiently large quantities for field testing. (NREL)

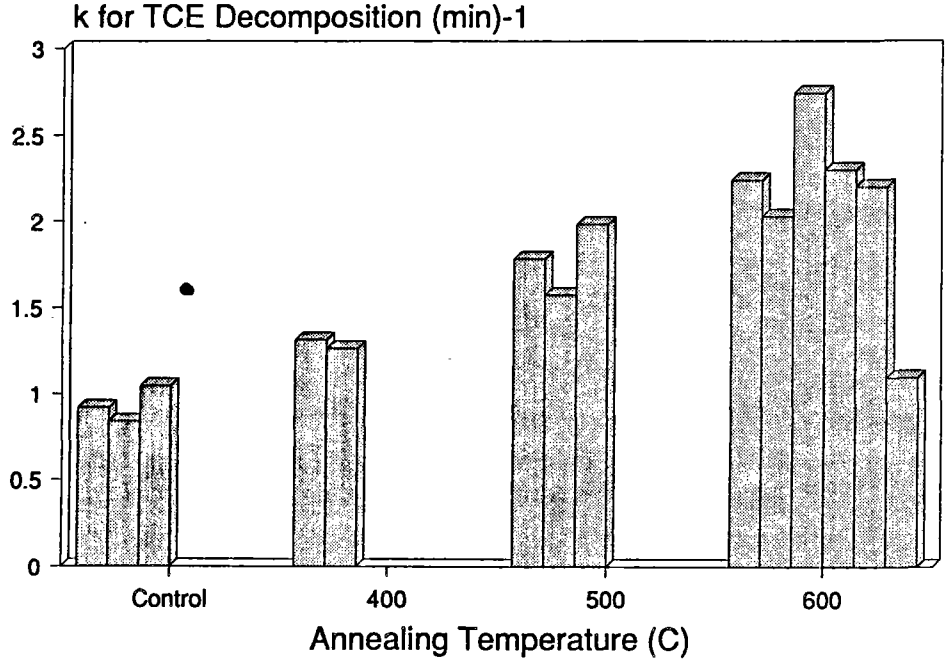


Figure 3. Photocatalytic activity of TiO_2 as a function of annealing temperature. X-ray diffraction analysis has shown a correlation between annealing conditions and the relative fractions of anatase and rutile crystal phases. Scientists think that the mixture of crystal phases is important in explaining the variation in catalytic activity.

- **Research on the removal of heavy metals advanced.**

  Researchers continued studying the photocatalytic reduction of Cr(VI) to Cr(III) with emphasis on the effect of organics (Cr (VI) is a common industrial pollutant regulated by the Environmental Protection Agency). Organics are important in reduction because conduction-band electrons consumed in the reduction of Cr(VI) leave vacancies in the valence band (holes) that must be filled for the process to continue.

  In one series of tests, researchers demonstrated the effects of salicylic acid concentration (between 0 ppm and 2000 ppm) on reduction of Cr(VI) to Cr(III). When no salicylic acid is used, Cr(VI) is reduced very slowly. Adding salicyic acid greatly accelerates the reduction rate and produces optimal reduction at about 300 ppm. Above 1000 ppm salicylic acid, inhibition of the reduction reaction is observed. These results indicate the importance of the organic concentrations.

  Not only is the concentration of the organic important in determining the rate at which Cr(VI) is converted to Cr(III), but so is the type of organic. This condition is exhibited in Figure 4 with Cr(VI) concentration in the pot reactor as a function of illumination time for 11 different organics and no organic. Interestingly, of the 11 tried, only two trends arise. All of the small acids, alcohols, and aldehydes produce reduction rates very similar to what researchers observe when no organic at all is used. However, easily oxidized organics like EDTA, salicylic acid, and citric acid produce very fast reduction. Researchers have not yet determined the cause for the two distinct trends in reduction rate; however, they suspect that direct oxidation is responsible for destruction of the species which produce fast reduction rates, while indirect oxidation dominates for the small acids, alcohols, and aldehydes.

  During the first quarter, researchers also set up and operated a lamp-driven photocatalytic reactor as a small pilot system for continuous reduction of Cr(VI) to Cr(III). As in the batch experimentation, researchers used a suspension of 0.1 wt% TiO_2. Data from this reactor are shown in Figure 5 which is a plot of one minus Cr(VI) conversion (1 - X) as a function of residence time. The linearity of this graph indicates first-order kinetics. In the future, this system will be useful for characterizing reduction kinetics and simulating continuous processes. (SNL)

- **A subcontract was awarded for treatment of effluent from paper mills.**

  A subcontract was awarded to the University of Arizona for work on the photocatalytic treatment of the effluent streams from pulp and paper mills. Arizona researchers will evaluate combinations of membrane filtration, photocatalytic treatment (with and without ozone as an oxidizer), and biological treatment for decolorizing waste streams. The expertise in these areas and contacts with the paper industry will be valuable as the program evaluates the application of solar detoxification of water to industrial process waste streams. (NREL)

- **A subcontract was awarded to study the effect of peroxide on water detoxification.**

  A subcontract was awarded to Project Sunrise, Inc. This company will help to establish the parameters that influence the activity of hydrogen peroxide as an oxidizing agent in the photocatalytic treatment of water. The work will complement NREL's work on the effect of hydrogen peroxide on the destruction of aqueous methanol and formaldehyde, which are of interest to the Degussa Chemical Company. (NREL)

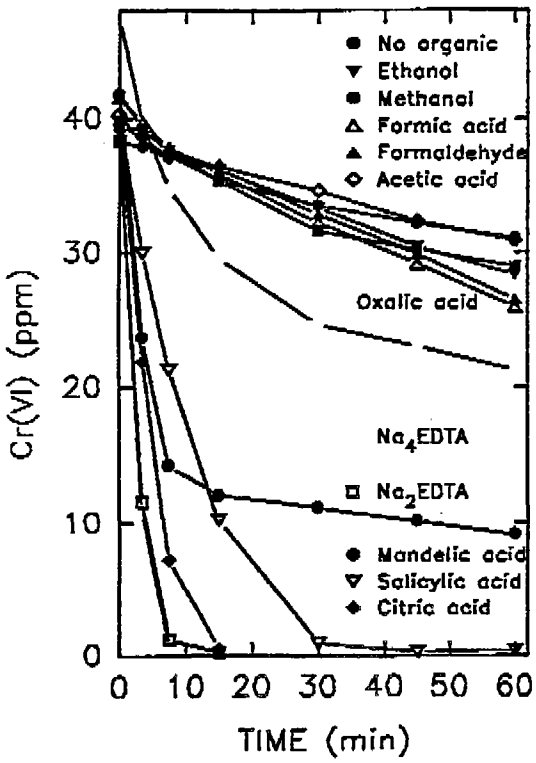


Figure 4. The effect of organic on reduction of Cr(VI) to Cr(III). pH 2, 0.72 mM organic.

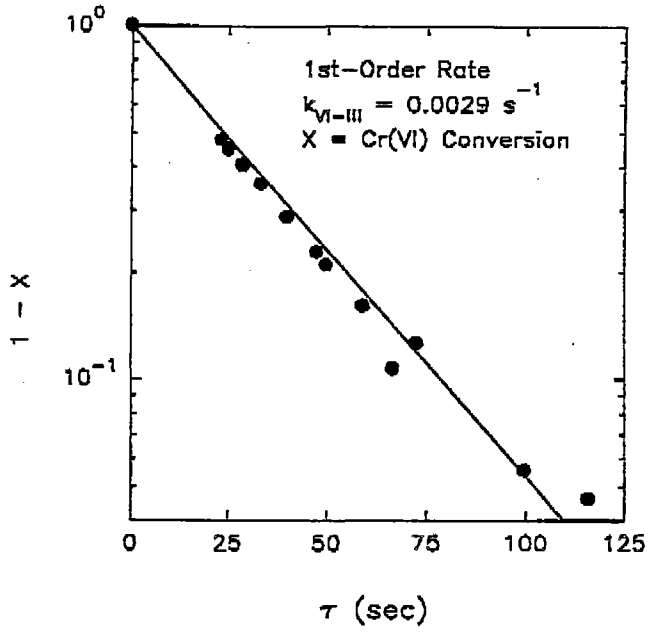


Figure 5. First-order kinetics for the continuous conversion of Cr(VI) to Cr(III). pH 2, maximum flow rate of 800 mL/min.

- **A subcontract on analysis of catalytic surfaces was renewed.**

  Renewal proceedings required to extend the subcontract for analysis of catalytic surfaces at the University of Colorado are underway. This subcontract will continue to analyze new and used photocatalysts that are utilized in both aqueous and gas-phase detoxification and also will begin in-situ kinetic studies and analysis of gas-phase photocatalytic reactions. During the first year of work, significant progress was made in the identification of surface species that may be responsible for changes in catalytic activity. (NREL)

- **A subcontract was awarded for treatability studies.**

  ECOVA of Redmond, Washington, has been awarded the subcontract to do treatability studies on water samples submitted to the Solar Industrial Program by outside parties. ECOVA will provide testing and analytical services to evaluate the applicability of the photocatalytic process of water treatment to contaminated groundwater or process waste-water samples submitted by third parties. ECOVA has in place the necessary permits and procedures for environment, safety, and health. NREL staff will visit ECOVA to work out the details on transmittal of samples, testing, and reporting results. Researchers anticipate that the training of laboratory personnel and the setup of the necessary equipment will occur in January, 1992. (NREL)

- **Degussa-like TiO_2 was produced by Brown University researchers.**

  Researchers at Brown University reported success in producing samples of TiO_2 by a flame-hydrolysis method that duplicates the properties of Degussa's P-25 TiO_2. This is a significant step toward understanding why P-25 is more active than other forms of TiO_2 . Brown scientists also are investigating the deposition of metals on TiO_2 to increase its activity. Samples of these metallized

catalysts have been sent to NREL and the University of North Carolina-Chapel Hill. The Chapel-Hill group will determine if these treated catalysts change the way in which intermediates are formed. NREL scientists will evaluate and compare catalytic activity for TCE destruction.

In other work (funded independently by the National Science Foundation), the Brown University group is developing a method to prepare thin films of pure anatase TiO_2 on a variety of substrates. These have potential application for the preparation of photoelectrodes, and samples will be prepared for testing at NREL. The Brown work is contributing to understanding the structure of TiO_2 and methods for increasing its activity. (NREL)

- **A filterable catalyst was developed.**

A research group at the University of New Mexico made significant progress in the first quarter of FY 1992 toward the development of a filterable titanium dioxide photocatalyst. The material is made from agglomerated Degussa P-25 powder by mixing the powder precursor with titanium isopropoxide. When heated, the titanium isopropoxide becomes titanium dioxide which acts as a glue bonding particles together. To date, the University group has obtained TiO_2 particles (in the range of 50 microns) which rapidly settle out of water. Researchers tested this material for catalytic activity and found it to be comparable to untreated P-25. The University researchers are currently testing the hardness of their granular material to verify its stability in a centrifugal pump. Also, they are developing the capability to generate sufficient quantities of material for testing in Sandia's outdoor reactor. The development of a simple, cost-effective system for removing the catalyst from treated water is essential for the successful deployment of solar detoxification of water. The University's granular material will likely go far to meet this need. The agglomerated titanium dioxide photocatalyst is currently being considered for a patent. (SNL)

- **A collaboration was initiated with the Swiss Federal Institute of Technology.**

A collaboration was initiated with a professor from the Swiss Federal Institute of Technology for large-scale testing of an inexpensive catalyst developed in his laboratory. The catalyst consists of iron supported on clay and uses visible light. It requires hydrogen peroxide as a co-catalyst. Tests in Switzerland showed that the catalyst is very effective for detoxification of water. After limited screening tests in a laboratory at Sandia, this material will be tested in Sandia's large outdoor reactor. If the catalyst works in the large reactor as well as it has in the laboratory, it could represent a significant breakthrough toward increasing energy efficiency and reducing costs. (SNL)

- **A new slurry photoreactor increased system throughput.**

A new photoreactor system designed for use with the high-flux solar simulators and catalyst slurries improved aqueous waste throughput by 50 percent. The new reactor consists of a 0.5 liter reservoir and a quartz and Teflon photoreceiver in which the slurry flow is turbulently directed to the illuminated quartz window. Reactor illumination conditions remained the same, and under identical process conditions, this system treated an aqueous TCE solution in 50 percent less time than the old reactor. This improved efficiency is attributed to better delivery of the catalyst-containing solution to the illuminated portion of the photoreceiver and to better suspension of the catalyst throughout of the system. Faster processing times directly reduce the amount of time required per experiment. These results also indicate that turbulent delivery of the waste-containing catalyst slurry to the photoreceiver increases system performance. (NREL)

- **An X-ray diffractometer analyzed a catalyst's type of crystal.**

- **An X-ray diffractometer analyzed a catalyst's type of crystal.**

  A procedure has been developed to analyze the crystal composition of TiO_2. An X-ray diffractometer was used to measure the relative amounts of anatase and rutile contained in both Degussa P-25 and TiO_2 manufactured by other methods. The result from this procedure agrees well with recently published results that give the anatase and rutile contents of annealed TiO_2 produced from $TiCl_4$ hydrolysis. Researchers can now use this technique to evaluate the effect of heat treatment on catalytic crystal structure. For example, use of this technique demonstrated that significant transformation of anatase to rutile occurred at temperatures well below published values for the onset of this conversion (700°C). Since heat treatment improves catalytic activity, this technique will help to define optimum methods for improving the catalyst. (NREL)

- **New techniques expanded the analytical capability.**

  Gas chromatographic techniques for the analysis of dichloroethylene and methanol were developed to support the photocatalytic decomposition of these compounds in water. The volatility of methanol is significantly decreased in water because of its infinite solubility. The addition of salt to the methanol sample increases the volatility of methanol in water and thus increases sensitivity of the gas chromatography-headspace method for analysis of methanol. The analysis of dichloroethylenes was determined to be similar to the analysis of TCE. (NREL)

- **Studies of treatability began on industrial wastewater.**

  Treatability tests to determine rates of destruction for aqueous dichloroethylene and methanol in the high-flux slurry reactor were completed. This work is part of an effort to establish a cooperative research and development agreement (CRADA) with the Degussa Corporation. Once gas chromatographic techniques for these compounds were identified and implemented, rates of destruction were determined in the solar-simulator, slurry batch reactor. Comparison of destruction rates shows that 1,1-dichloroethylene decomposes with rates that are similar to those of TCE. Methanol decomposes with rates that are an order of magnitude slower than TCE. These preliminary results demonstrate the ability of the aqueous photocatalytic process to destroy a variety of organic compounds.

  As part of the effort to determine the treatability of a waste stream at a plant of the Degussa Chemical Company, a set of experiments was performed to determine the effect of hydrogen peroxide on the rate of the photocatalytic oxidation of methanol in the pot reactors. Researchers ran experiments in which 100 ppm of methanol was treated in the presence of 0, 50, 100, and 1000 ppm hydrogen peroxide at an initial pH 9 ± 0.5. Under these conditions, hydrogen peroxide showed no significant effect on the reaction rate. (NREL)

- **Sonication improved the performance of a catalyst.**

  Sonication of anatase powders in water for short times before use in aqueous photocatalytic decomposition experiments improved rates of destruction of TCE by 20 percent. Reproducibility among identical experiments also was improved. These results were obtained with both Degussa TiO_2 and 100 percent anatase supplied by Titanox. Presumably, sonication increases effective surface area by breaking up agglomerated particles. Thus, this simple physical treatment of the catalyst improved activity by a factor of 1.2 and produced more consistent results. These results could lead to both improved performance and more consistent performance in both experimental and commercial slurry-based systems. (NREL)

- **Effects of groundwater components on destruction efficiency of TCE were determined.**

  The effects of several typical non-hazardous groundwater components on the destruction efficiency of TCE were measured. Tests were conducted in the high-flux reactor with TiO_2 supported on alumina. The basic groundwater mixture contained TCE, carbonate, sulfate, nitrate, chloride, calcium, potassium, and sodium ions. Metals such as zinc, copper, and chromium were added, as required, to this stock solution. Sequential experiments showed that destruction efficiency of TCE was reduced to 65 percent when the basic groundwater components were present (relative to TCE destruction in deionized water). Addition of the metal ions further reduced efficiency to 38 percent. An economical in-situ wash of the catalyst restored destruction efficiency to 76 percent of the original activity. These results, which were obtained with the same supported catalyst over 120 hours of use, demonstrate that the presence of inorganic and metallic components in aqueous TCE solutions reduces catalytic-efficiency approximation about 60 percent; however, a simple in-situ treatment restores catalytic performance to 75 percent of the original activity. (NREL)

Planned Activities for Next Quarter

- Subcontracts for a development of a photoreactor and low-cost concentrators will be completed.
- Preparations will be completed for testing industrial prototypes.
- Phase II of the subcontract for the second mobile unit will begin.
- In-house treatability tests will be completed on Degussa's industrial wastewater.
- Techniques will be developed to analyze chemical components of motor fuels (BTEX), and to begin photocatalytic testing on them.
- Investigations into methods for preparing large, high-quality batches of heat-treated catalysts will be completed, and outdoor tests on the new material will be conducted.

2. Gas-Phase Detoxification

Objectives

The objectives for work on gas-phase detoxification include the following:

- Support of the project for the Tri-Agency, including mini-pilot testing of a high-flux process;
- Advancing the photocatalytic process to a point of decision regarding the range of technical viability;
- Supporting the feasibility study funded by the Department of Defense.

Accomplishments

General/Programmatic

- **Researchers continued active participation in the Tri-Agency Soil Decontamination Project.**

  Staff members continued their participation in the Tri-Agency Project this quarter with both detailed technical contributions and with technical coordination. The Tri-Agency Project is a cooperative project with the Department of Energy, the Department of Defense, and the Environmental Protection Agency. The goal of the project is to demonstrate the use of solar energy to detoxify contaminated soil at an Army facility by 1994.

  A quarterly review of the project was held on October 16 and 17, 1991, in Edgewood, Maryland. The meeting, which was organized and managed by the Technical Coordinator (an NREL engineer), focussed on progress made by Pacific Northwest Laboratories on its economic feasibility study and on MRI's progress on the design of the test loop and reactor for the Mini-Pilot Plant. At this meeting, the Technical Coordinator presented a Technical Management Plan for the Project. This proposal was accepted by the Project Management Council as an overall and technical managerial plan for the project.

  The Technical Coordinator also prepared a critical path chart for the project to help in determining feasibility of completing the project in the allotted time. This schedule should provide a very useful managerial tool for maintaining the project's schedule, for identifying problems, and for identifying the need to reschedule critical events. A drafted version is under review by the project's participants.

  NREL staff prepared the draft of a one-page brochure describing the Tri-Agency Project. This brochure will be useful as handouts at technical and trade meetings, and for distributing to interested parties. It emphasizes the cooperative nature of the project and the fact that it is a demonstration project. Technical jargon was minimized to appeal to as wide a range of audience as possible. The draft is currently under review by the Tri-Agency Management Council.

- **Technical meetings supported the Tri-Agency project.**

  Engineers met with MRI staff in Kansas City to review MRI's design of the test loop and reactor for the Mini-Pilot Plant. This design provides for a flexible testing arrangement that should accommodate a wide range of potential contaminants. This flexibility is required because the site for the demonstration has not been selected; and, therefore, the exact contaminants to be tested are unknown.

Interoffice Memorandum *National Renewable Energy Laboratory*

TO: Distribution

FROM: R. Hewett (NREL) and D. Menicucci (Sandia)

DATE: January 30, 1992

SUBJECT: Draft List of Questions for the Proposed Office of Technical and Financial Assistance (OTFA) Questionnaire

This memorandum documents the draft list of questions that we developed for inclusion in the proposed OTFA questionnaire in response to Tex Wilken's request to both of us in his memorandum dated January 27, 1992.

The questionnaire, to be developed from the list of candidate questions, is to be used as part of a Solar Process Heat Program/OTFA effort to identify and implement collaborative projects.

We independently developed draft lists of questions. Then, we held discussions (by telephone) to remove duplications, etc. Our discussions resulted in the list of questions documented in Attachment I.

If you have any questions or need additional information, please give either of us a call.

Distribution:

NREL

J. Anderson
T. Penny

Sandia

C. Tyner
P. Klemas

DOE/HQ

F. Wilkins

ATTACHMENT I

LIST OF POSSIBLE QUESTIONS FOR
INCLUSION IN THE OTFA QUESTIONNAIRE

Dave —
A few comments,
but I generally OK as
that these are
Paul

(1) Are there any state agencies in your state (i.e., hospitals, universities, recreational facilities, state office buildings, etc.) that have:

- Successfully operating systems/
- Inoperative solar systems?

(2) Do any of the state universities in your state have ongoing solar thermal energy RDT&E programs and/or facilities?

(3) Within the state government structure, identify agencies and departments that use or have the potential to utilize solar process heat technology and the key energy equipment decisionmakers in each.

(4) For the entities identified in (3) above, are the key energy-equipment decisionmakers familiar with solar process heat technology? potentially embarrassing

(5) Does your state have financial incentives in place that serve to promote the use of renewable-energy technology by industry and commerce?

(6) Does your state have an energy plan or policy in place—with one of the objectives being to promote the use of renewable-energy technologies by government, industry, and commerce?

(7) Are there utilities in your state that have programs in place to:

- Demonstrate renewable energy technologies?
- Promote the use of renewable-energy technologies?

If such utilities exist, are there any that would be interested in implementing collaborative cost-shared projects with the Solar Process Heat Program?

(8) In your state, does procuring a renewable-energy technology system present any special problems, compared to procuring a fossil-fuel system? What economic performance criteria are used to procure energy equipment (e.g., life cycle cost competitiveness, etc?)

(9) In your state, for state government agencies, is it possible to negotiate:

- Long-term energy purchase agreements?
- Shared savings contracts?

How do energy equipment decisionmakers feel about third-party financing?

(10) For the next two to five fiscal years, is your state financially able to consider renewable energy initiatives such as: potentially embarrassing

- Cost-shared demonstration projects with the Solar Process Heat Program?
- Tax incentives for the solar industry and/or end users.

(11) Are any legislative initiatives in progress in your state at the present time that are designed to promote/encourage the use of renewable-energy technologies either to conserve energy and/or promote air quality?

(12) What, if anything, is the Public Utility Commission doing in your state to encourage the use of alternative-energy technologies? PUCs don't encourage, they respond

(13) Does your state presently have funds available to participate in co-funded solar projects?

(14) Are data being (systematically) collected in your state regarding energy/fuel use by industry, commerce, and government. If so, are data collected by end-use temperature range?

(15) Is there a solar energy-industries association in your state? If so, is it active (e.g., promoting legislation, etc.)?

(16) Within your state, are there any solar-equipment manufacturers?

Staff engineers also met twice with staff from Pacific Northwest Laboratory to discuss the Laboratory's process feasibility assessment. Under a contract to the U. S. Army Toxic and Hazardous Materials Agency, Pacific Northwest Laboratories is studying the economic feasibility, potential performance, and applicability of solar detoxification of soils. NREL supported the work at Pacific Northwest Laboratories by providing information related to a recently completed report on process economics and also on past experimental programs in which destrucive efficiency and products of incomplete combustion were measured for a number of organic compounds. In economics, Pacific Northwest has determined that solar technologies appear to be cost competitive with the best conventional technologies. In performance, researchers at Pacific Northwest think that required destructive efficiencies can be achieved with solar technologies and that they may also be less susceptible to production of products of incomplete combustion, especially when operating in an off-design condition.

- **Permits for the Mini-Pilot testing were initiated.**

Researchers provided staff of the Environment, Safety and Health Department with information regarding the upcoming test of the Mini-Pilot Plan, currently scheduled to start in May, 1992. Based on this information, the NREL Area Office has notified the Colorado Department of Health of the intent to conduct treatability studies. This activity initiates acquiring the necessary permits for the project.

- **A joint Statement of Work was developed with ECOVA for the photocatalytic process.**

Staff members met with representatives from ECOVA and the E/M Corporation to discuss the vapor-phase detoxification of dilute volatile organic compounds exhausted from paint booths. E/M has plants in nine cities, each with several paint booths that emit the compounds at a concentration of approximately 100 ppm in air. They are faced with state regulations that limit the total mass of volatile organic compounds that they can emit per year. As production increases they begin to bump up against these totals, and they are looking for ways to decrease the quantity of volatile organic compounds in the air stream. Incineration is not an option because the streams are dilute, and large quantities of natural gas would be required. They are looking at carbon for their California plants, but this is very expensive. Since there are on the order of 100,000 paint booths in the country, the potential market for the technology is very large. ECOVA is interested in developing and commercializing the photocatalytic process for several markets--including the paint-booth market. Discussions centered on a cooperative program that would lead to a full-scale demonstration at an E/M plant within 2 to 3 years. A full-scale demonstration will provide the destruction of volatile organic compounds for one 2500 cfm paint booth. If successful, E/M would outfit all its paint booths in the country. A joint Statement of Work for a cooperative research and development agreement has been developed. This Statement of Work is currently under review by ECOVA. (NREL)

Component Engineering

- **Researchers developed the design of the solar detoxification reactor for the Tri-Agency Project.**

Staff from NREL and MRI developed a design for the solar detoxification reactor to be used in the Mini-Pilot test for the Tri-Agency Project. Computer codes were written to determine operating temperatures of the reactor and destruction efficiencies as a function of solar flux levels, waste heating value, and radiative heat loss. The final design was determined, and fabrication of the reactor is proceeding. After MRI researchers fabricate the reactor for the Mini-Pilot Plant, they will ship it to NREL for preliminary testing. This testing will take place in April, 1992, at the Solar Furnace and will involve primarily heating air. Depending on the site selected and the resulting identification of

contaminants to be destroyed, tests on chemical destruction also may be executed. In preparation for these tests, NREL researchers have begun modifying an existing Safe Operating Procedure that will be required before starting the tests. (NREL)

- **Light absorbtion in the Mini-Pilot test was modeled.**

Researchers developed a model for ultraviolet absorption in the design of the reactor of the Mini-Pilot Plant. The objective was to ensure that the reactor's design was such that photons delivered by NREL's High Flux Solar Furnace would be adequately distributed throughout the reactor's volume. Good distribution of photons is important because it is required to provide sufficient opportunity for the reacting species to be exposed to the ultraviolet photons. Researchers modified an existing modeling code for a Monte Carlo receiver/reactor. The code uses as input the detailed intensity distribution delivered by the Solar Furnace. The code predicts the volumetric absorption of photons within the reaction space. Because the composition of the gases in the reactor are unknown, absorption was simulated by assuming the presence of an absorbing gas, chlorine, in various partial pressures in the reaction space. Due to the very high intensity of the Solar Furnace at the focal plane, the model showed that, if the reactor is uniformly filled with an absorbing gas, most absorption will occur at the focal area. If the absorbing gas reacts to a non-absorbing gas at the rear of the reactor, the absorption will be primarily there. Although more detailed information is required on the likely gas composition in the reactor, the results do not indicate any major problems with the existing design of the reactor.

Technology Research

- **Work at the University of Dayton is to focus on compounds and conditions of interest for the Tri-Agency's detoxification program.**

Staff members visited the University of Dayton to review the various types of instrumentation and tests being used to aid in the coordination of work with that of other subcontractors and NREL's in-house program. The Dayton researchers and NREL staff tentatively agreed that work for FY 1992 will emphasize detoxification tests on gas flows that have high concentrations of organic compounds, up to 10,000 ppm; on mixtures, including possible extraneous materials from thermal soil desorption; and on both homogeneous and heterogeneous radical initiators for non-absorbing compounds. The investigations being conducted at the University of Dayton are important to improving the understanding of high-flux, gas-phase destruction of organic compounds. (NREL)

- **Spectral properties of photo-chemical intermediates were measured.**

Scientists at the University of Colorado have measured the absorption spectrum of formaldehyde at elevated temperatures and have compared it to literature spectra. There is only a modest change in the spectrum at higher temperatures. This result contrasts with significant spectral shifts that other materials undergo upon heating. Because these results suggest that spectral shifts cannot be predicted easily, it may not be possible easily to project how much solar-photolytic processes can be improved by increasing temperature. Researchers anticipate that such spectral shifts could improve adsorption in the solar spectrum and would enhance destruction rates. (NREL)

- **Promising catalysts for destroying photocatalytic intermediates were identified and tested.**

A literature search has been done to assess the state of the art in catalysts for destruction of carbonyl chloride in gaseous streams. Research on the photocatalytic destruction of chlorinated ethylenes has shown that under some conditions this toxic gas is produced. Identification of a catalyst for the

strongly favored, but kinetically slow, reaction with water vapor (to produce carbon dioxide and hydrogen chloride) has been an important objective. Granulated activated carbon and high-surface-area alumina were identified by NREL's experimental work to be effective. The search of literature revealed existing foreign patents on both these materials as catalysts for this reaction. The identification of effective catalysts for the destruction of carbonyl chloride ensures that a process can be operated and will not produce this gas as an effluent. (NREL)

- **The effectiveness of TiO_2 for gas-phase, photo-catalytic destruction was determined for a variety of compounds.**

  A literature search was conducted at NREL into the possibility of using heterogeneous, gas-phase photocatalysis to detoxify volatile organic compounds commonly found in industrial gaseous discharges. The compounds included alcohols, ketones, and substituted aromatics. Several articles were found in which these compounds (or compounds with similar characteristics) were photochemically oxidized in the gas phase in the presence of TiO_2 and ultraviolet light.

  A series of preliminary experiments was conducted to learn if photocatalysis can be used to destroy organic solvents of interest to local industries. In these tests, the compounds of interest were entrained in a flow of helium and oxygen, and the mixture was passed over illuminated TiO_2. The starting material and the products were monitored by using NREL's Molecular Beam Mass Spectrometer (MBMS), and the rates of reaction were calculated from these measurements.

  Several experiments were conducted on the photocatalysis of ethanol over TiO_2 to measure the rate of destruction as a function of starting concentration. Ethanol is a solvent which a potential industrial partner is interested in destroying in gaseous effluents. These tests were conducted to determine if rates of reaction for photocatalytic oxidation will decrease with decreasing concentration. The results will be analyzed in the coming weeks and will help with the technical and economic assessment of this process. These tests and analyses will aid interested companies in determining whether or not to use this technology instead of more conventional gas-treatment systems. (NREL)

Planned Activities for Next Quarter

- Preparation will begin for a test plan, safe-operating procedures, quality assurance, quality control procedures, and permitting documents in conjunction with MRI for Mini-Pilot testing.
- Analytical methods will be developed for measuring concentrations of reactants and products in the Mini-Pilot tests.
- Hardware will be prepared for a preliminary air-heating test which is planned at the High Flux Solar Furnace.
- Laboratory work will investigate photolytic destruction of compounds and mixtures identified for the candidate U.S. Army site.
- Low-temperature photocatalytic destruction of compounds exhausted from paint-spraying operations will be explored.
- A paper on high-flux, photothermal destruction of chloronophthalene will be submitted by NREL and Colorado School of Mines to a refereed journal.

- Milestone B2.1, to document the status of low-temperature photocatalysis and elimination of by-products, will be completed.

- Extension for the subcontract to continue work at the University of Dayton will be completed. Dayton will emphasize high-flux, photo-thermal oxidation of the mixture of compounds of interest to the Tri-Agency program.

- An informal technical presentation and discussion among the subcontracted researchers will be held on February 19, 1992, at NREL.

- The next quarterly meeting of the Tri-Agency will gather in January in Kansas City, Missouri.

3. Process Heat

Objective

The overall objective is to bring several new solar systems on-line this year and to lay the groundwork for a larger market in out years. Specific objectives for individual tasks are as follows:

- Establishing a catalog and data base of successfully operating solar process heat systems;
- Identifying and supporting demonstration projects in the Federal sector;
- Supporting collaborative and cost-shared projects with the solar industry;
- Identifying and supporting collaborative projects with State energy offices;
- Providing solar engineering technical support, including some high-priority technology development.

Accomplishments

- **Processing of the FY 1991 subcontracts for prefeasibility studies was completed.**

  The NREL Subcontracts Office completed negotiations with proposed subcontractors and processing the final two of six subcontracts on prefeasibility studies of solar process heat—subcontracts awarded as part of the FY 1991 Solar Process Heat Program. The six studies are as follows.

Subcontractors	Applications	Site	Solar Technology
E. A. Mueller (Baltimore, Maryland)	Solar water heating for buildings owned by the State of Maryland	Maryland	Flatplate or parabolic trough
Conserval Systems (Buffalo, New York)	Ventilation air heating for a large industrial building	Non-sunbelt State	Flatplate
Energy Concepts Company (Annapolis, Maryland)	Solar ice-making system for a remote (non-grid-connected) fishing village in Mexico	Mexico (Gulf of Mexico area)	Parabolic trough
United Solar Technologies (Olympia, New York)	Solar absorption air conditioning for a 30-bed general hospital	Hawaii	Parabolic trough
Industrial Solar Technology (Denver, Colorado)	Solar system for asphalt bulk storage heating	California and/or Florida	Parabolic trough

Subcontractors	Applications	Site	Solar Technology
Bechtel Corporation (San Francisco, California)	Solar absorption air conditioning for an 8000 sq. ft. office building	Hawaii	Parabolic trough

After the studies are completed, for those cases where solar is shown to be technically, economically, and institutionally feasible, the Program will assist the potential end users in translating study results into actual projects for acquisition of solar systems. (NREL)

- **The Program participated in the Renewable Energy Technology Workshop sponsored by the Commonwealth of Virginia.**

  The Commonwealth of Virginia, through the Virginia Department of Mines, Minerals, and Energy (DMME), is in the process of implementing a demonstration program for renewable energy—demonstrating the use of renewable energy technologies in State facilities and operating to encourage use of these technologies in municipal and county-government facilities and in industry and commerce. Staff participated in the Renewable Energy Technology Workshop conducted by the Department of Mines, Minerals, and Energy in Richmond, Virginia, on December 10, 1991. The objective of the workshop was to familiarize Virginia decision-makers on energy equipment and engineers with renewable energy technologies appropriate for use in Virginia—prior to their making applications to the Department of Mines, Minerals, and Energy to implement demonstration projects in renewable energy. The Solar Process Heat Program used participation in the workshop to familiarize the approximately 40 participants with technology in solar process heat: (1) principals of operation; (2) examples of successfully operating systems in applications of interest to Virginia; and (3) capital costs and economics for systems. The Program also presented a pictorial exhibition that showcased successfully operating systems. Staff made Virginia agencies aware that if they are interested in implementing demonstration projects in solar process heat, the Program was willing to assist them, as appropriate, in planning and implementing projects to ensure their success. In late December, 1991, the Virginia Department of Agriculture requested the Program's assistance in participating in Virginia's demonstration program. (NREL)

- **The Program completed plans for participation in SOLTECH '92.**

  The Program completed development of the activities related to solar process heat and to be implemented at SOLTECH '92, a national solar energy conference. SOLTECH '92 is scheduled for February 17 to 20, 1992, in Albuquerque, New Mexico. These activities include: (a) two symposia; (b) two pictorial exhibitions; (c) Proceedings, documenting the presentations given in the symposia; and (d) dissemination of literature documenting successfully operating systems in various applications.

  The two SOLTECH '92 symposia were finalized: session chairpersons, presentations, speakers, and schedule. One symposium is devoted to successful applications of the technology; the other symposium covers results to date in the FY 1991 subcontracts for prefeasibility studies of solar process heat. The Program received commitments to participate from all proposed speakers. Each received a formal letter of invitation. The letter also specified the schedule to be followed by the speakers in submitting presentation materials to be included in the Proceedings.

Staff also completed development of a special promotional flier for SOLTECH '92. It is to be mailed to the targeted audiences of the Program to invite them to attend SOLTECH '92 specifically for the activities related to solar process heat. In early January, 1992, it will be mailed to approximately 500 persons in industry, commerce, government, and education (persons and companies catalogued in the data base on targeted audiences for solar process heat). (NREL)

- **The Program completed design of the proposed traveling exhibit on solar process heat.**

Staff completed development of the conceptual design for the proposed Solar Process Heat Traveling Exhibit for use in technology transfer and outreach. The principle entities in the exhibition are as follows:

- Professional quality, visually attractive, non-technical catalog containing color photographs, schematics, and standardized information about 20 to 25 successfully operating solar process heat systems—the systems covering a variety of applications, markets, types of solar collectors, and geographical areas of the United States;
- Approximately five, one-page colorful fliers—each flier documenting information about one successfully operating solar process heat system (these five will be a subset of the systems documented in the catalog);
- A color video (6 to 10 minutes) that shows five solar process heat systems in operation in various applications, markets, and regions—the video focusing on systems in operation in entities with which non-technical audiences can identify (e.g., schools, motels, etc.);
- Table-top physical models of solar collectors (i.e., flatplate, parabolic trough, and dish); and
- Professional-quality, visually attractive pictorial exhibits of successfully operating systems (and captions).

The Exhibit is designed to be one of the principal means for familiarizing potential end users—and organizations that influence potential users (e.g., State energy offices)—with the technology. In addition, the Program will make it available to State energy offices, DOE entities involved in promoting renewable energy technologies, the Solar Energy Industries Association, and others for use in their market conditioning. (NREL)

- **The Program initiated work to establish and to implement collaborative projects with the Office of Technical and Financial Assistance.**

Project staff, together with the manager for the Solar Industrial Program at the DOE Headquarters, met with senior managers of the Office of Technical and Financial Assistance within the DOE Office of Conservation and Renewable Energy. As a result of the meeting (viewed as an initial meeting by officials of both the Program and Office of Technical and Financial Assistance), officials from the Office of Technical and Financial Assistance agreed that they would like to explore possibilities for working collaboratively with the Solar Process Heat Program and will focus on activities involving State energy offices.

The staff from the Office of Technical and Financial Assistance agreed to conduct internal meetings to identify specific areas that could be the basis for collaborative projects. In addition, they will appoint a person to serve as the focal point for planning and implementing such projects. The officials from the Office of Technical and Financial Assistance also asked the task leader to send them a package of materials regarding solar process heat technology and the Program. The Office of Technical and Financial Assistance also agreed to consider including solar process heat technology as one of the

group's target technologies—technologies that the Office of Technical and Finanical Assistance would emphasize in its programs. (NREL)

- **The Program developed a strategy for responding to requests for assistance in solar resource assessment.**

  Program staff worked with staff in NREL's Technology and Resource Assessment Branch to develop strategy to be used to provide support in solar resource assessment to the California Energy Commission and the California Department of Corrections as part of their efforts to identify State correctional institutions for which solar process heat systems have the potential to be technically viable. The Program will utilize a California-based consultant to do site-specific, solar resource assessments. This strategy will facilitate rapid response to requests for support. The emphasis in the assessment will be on identifying and exploiting use of existing solar radiation and environmental data, rather than on initiating new projects in data collection. This approach also will be utilized in assisting the subcontractors working on prefeasibility studies of solar process heat. (NREL)

- **Support continued for the Foil Division of Gould Incorporated.**

  Gould is in the process of upgrading its sixty-thousand-square-foot solar system that is used to produce hot water for a copper-foil manufacturing process. The upgrade should be completed within a year or two and, when completed, is expected to produce electricity savings worth at least $120,000 per year. The Program will continue to provide technical consulting throughout the course of the project. (SNL)

- **Technical consulting for the California Energy Commission continued.**

  Consulting on a number of activities with the California Energy Commission continued. The first involves the proposed solar project at the prison in San Luis Obispo. Engineers were called to assist in measuring the hot water load at the prison as a prelude to the California Department of Corrections' signing a contact with Besi Corporation to install a third-party-financed solar system. The measurements were used to resolve a dispute between Besi and the Department of Corrections. With the dispute now resolved, the two parties are moving to complete the contract. Efforts are currently underway to assist in issuing a Request for Proposal for a solar system at another California prison. (SNL)

- **Technical support continued for the New Mexico State Energy and Minerals Department.**

  Staff continued to work with the New Mexico State Energy and Minerals Department to provide technical assistance and consulting regarding the use of solar thermal technology in the State of New Mexico. Sandia provided technical consulting regarding the development of the State's comprehensive energy policy.

  A new effort has begun recently in which Program engineers will help in training State of New Mexico engineers on a methodology to identify and to refurbish non-operating solar thermal systems within State institutions. The first refurbishment involves a community college in northern New Mexico. Sandia will assist the State on the techniques to bring the existing non-operational system into production. (SNL)

- **Technical assistance will be provided to the State of Arizona.**

  Engineering consulting will be provided to the Arizona Department of Commerce concerning the refurbishment of an existing, non-operational solar trough system at a school. The system was built in the early 1980s and was never used. It is currently being considered for heating the building space and indoor pool. Sandia will be assisting a local architectural and engineering firm that has been hired to design the modifications, which are expected to be relatively easy. (SNL)

- **Refurbishment continues on the solar system at the Veterans' Administration Hospital in Albuquerque.**

  Engineering assistance continued for the Veterans' Administration Hospital in Albuquerque, New Mexico, to renovate and to return an existing solar system into service. This system, which was installed in 1985, has been shut down since approximately 1986 because it produced excessively hot water and caused pressure and temperature relief valves to open. Last year, Sandia began working with Veterans' Administration engineers to restart the system. One-half of the system operated manually last quarter and is now under automatic operation. Veteran's Administration engineers now are consulting with DOE's Industrial Program about modifying the hot-water system to use the remainder of the solar system. After it is operational, the system could save approximately $12,000 per year in gas usage. (SNL)

- **Testing continued on the ice maker from Energy Concepts.**

  The Department of Energy is continuing to work with Energy Concepts to test the Mini- and Full-Isaac solar ice maker. The testing has followed a plan that was jointly developed by the Department of Energy and Energy Concepts. The results of the tests are being used by Energy Concepts to improve the design of the system. Additional tests may be conducted on the Double-Isaac, a larger version of the Full-Isaac, six of which are listed to be sold to the Mexican government. (SNL)

- **Testing continued on the solar distiller from BSAR.**

  Researchers have been testing the residential solar distiller developed by BSAR. The testing is based on a plan that was jointly developed by DOE and BSAR. The test results will be used by BSAR to improve the design of the system. Tests of the first BSAR model are complete, and suggested changes in design have been implemented by the manufacturer. A new model currently is being assembled for testing next quarter. The testing is expected to continue through the spring of 1992. (SNL)

- **A number of consulting activities continued.**

  On-going projects in technical assistance included: the LBJ Hospital in Samoa; the New Mexico Solar Energy Industries Association; the Solar Weatherization Assistance Program; the Utah Parks and Recreation Department; and the Pennsylvania Energy Office. On-going test and evaluation projects included Pegasus and IST. (SNL)

Technology Assistance in Process Heat

Agency	Service
California Department of Corrections (Sacramento, California)	• Continued assistance in efforts to identify State correctional facilities for which solar has the potential to be technically, economically, and institutionally viable • Solar resource assessment assistance
California Energy Commission (Sacramento, California)	• Continued assistance in support of efforts to identify opportunities for economically viable solar process heat projects in California
American Energy Technology (Green Cove Springs, Florida)	• Solar resource assessment assistance
Virginia Department of Mines, Minerals, and Energy (Richmond, Virginia)	• Assistance in setting up a renewable energy technology workshop for Virginia energy equipment decisionmakers and engineers • Participation in the Virginia Renewable Energy Technology Workshop to familiarize participants with solar process heat technology
Office of Technical and Financial Assistance, DOE Office of Conservation and Renewable Energy (Washington, D.C.)	• Familiarization of senior managers with solar process heat technology and exploration of possibilities for collaborative technology transfer projects
Foltz Engineering (Estes Park, Colorado)	• Assistance in working with base engineers at Fort Carson Army Base (Colorado Springs, Colorado) to interest the Corps of Engineers in selecting a solar ventilation air heating system for a new aircraft hangar under construction at the base
Southern California Gas Company (Los Angeles, California)	• Information on solar absorption air- conditioning
National Rural Electric Cooperative Association (Washington, D.C.)	• Assistance in assessing the technical and economic feasibility of making operational a solar water heating system installed on a headquarters building in 1979 but never placed in operation
Industrial Solar Technology Corporation (Denver, Colorado)	• Solar resource assessment assistance
Shott America (Yonkers, New York)	• Information on Luz parabolic trough solar collectors
BHM (Mongaup Valley, New York)	• Information on dish solar concentrator state-of-the-art
A&R Industries (Colorado Springs, Colorado)	• Information on DOE innovative solar technology programs in research and development targeted for small businesses

Planned Activities for Next Quarter

- Staff will participate in SOLTECH '92.
- Staff will participate in the Atlanta Region Energy Conference Office of Technical and Financial Assistance (within the DOE Office of Conservation and Renewable Energy).
- Technology transfer and outreach will target nine Department of Defense facilities for which solar process heat technology has the potential to be technically, economically, and institutionally viable.
- Completed will be the first (rough draft) of the catalog documenting information about 20 to 25 successfully operating solar process heat systems—the systems will cover different applications, markets, types of solar equipment, and geographical regions.
- Current plans are to continue to provide engineering support to those organizations with which NREL is currently working. Accelerated efforts are planned to identify other opportunities to provide this service and other technology transfer and outreach.

4. Advanced Applications

Objective

The overall objective is to contribute to U.S industrial competitiveness by introducing new and improved materials and innovative processes involving high-flux solar systems. Other contributions include reduction of dependence on imported fuels, as well as the contributions to a cleaner environment that are inherent in augmented use of solar energy. A specific objective is to use collaborative agreements with industrial partners for further commercialization of the technology.

The primary objective of materials research is to develop industrial partners who will support and motivate efforts to conduct technical research of new processes and materials in regard to their technical feasibility and to identify the initial process. The objective of work at the High Flux Solar Furnace is to broaden the current base of support by expanding its role as a user facility for a wide variety of high-flux experiments. The objective of work on solar-pumped lasers is to evaluate the feasibility of the concept and to identify potential applications.

Accomplishments

Materials

- **NREL is continuing negotiations on cooperative research and development agreements with potential industrial partners.**

  Several cooperative research and development agreements are in various stages of negotiations on industrial processes which involve the use of highly concentrated solar flux. Significant progress was made in the development of a cooperative research and development agreement with Brush-Wellman, Inc. Brush-Wellman remains extremely interested and has agreed to proceed with a cooperative research and development agreement. A revised Statement of Work has been generated for review by all parties, and Brush-Wellman is revising the model cooperative research and development document to meet its requirements. A patent disclosure for the solar process has been filed in order to protect that process for development under the cooperative agreement. Coors remains extremely interested in the processing of fine silicon carbide powders for several possible end uses. NREL currently is conducting experiments at the High Flux Solar Furnace to assess the technical feasibility of producing submicron silicon carbide powders in a continuous flow reactor. Coors has agreed to analyze the powders produced and, if sufficient quality is demonstrated, plans to enter into a cooperative agreement to continue development of the process. All NREL's work in this area has been focused on the technical feasibility of the process. (NREL)

- **A meeting was held with DOW Chemical, U.S.A.**

  A meeting was held with the External Programs Manager for DOW Chemical, U.S.A. Mutual interest in a rapid thermal process for cladding cermets to steels was discussed. DOW will undertake an internal investigation to determine the level of technical interest in this or other solar processes. (NREL)

- **Metallization of ceramic materials was demonstrated by using several metals with unique, new optical configurations.**

  Metallorganic paints were airbrushed onto a variety of ceramic tiles involving templates of different geometric designs. The tile surfaces were heated in the High Flux Solar Furnace to pyrolyze the paints and to leave a thin metallic coating. Coatings of gold, palladium and platinum were formed in this way. Samples of metal films were deposited on a nickel strip by translating the strip through the high-flux zone produced by the secondary concentrators. This represents a significant step toward demonstration of a continuous process. It also shows that secondary concentrators can successfully be used to provide a wide range of flux concentrations and can be tailored by design to achieve a desired flux level and distribution. (NREL)

- **Silicon carbide was produced at the High Flux Solar Furnace.**

  On-sun testing continued for the production of submicron silicon carbide powders at the High Flux Solar Furnace. Preliminary results indicate that silicon carbide powders are being produced at significantly lower temperatures than originally anticipated. However, technical problems with the reactor core prevented full characterization of the process. It appears that a new design for the reactor core will be required and may delay the continuation of the work until next quarter. This work is of interest to Coors Ceramics because Coors is looking for new methods for the production of silicon carbide and other high-value ceramic powders. (NREL)

Advanced Concentrators

- **Preliminary experiments with the high-index secondary concentrator were completed.**

  The high-index, non-imaging secondary system designed to achieve a 50,000 concentration at the High Flux Solar Furnace has been installed at the furnace, and numerous preliminary, off-sun experiments were completed. The secondary, fabricated from fused silica with an index of refraction of approximately 1.5, has been designed to deliver over 50,000 suns at a power level of approximately 1 kW. The hardware consists of the secondary and a ballistic calorimeter to measure the output power. Off-sun experiments include the measurement of the rate of temperature rise in the calorimeter fluid with a known electrical power input. In addition, various heat flows through the system were characterized so that appropriate corrections to on-sun measurements can be accomplished. The combination of ultra-high concentration and power levels create a source of energy for solar-pumped lasers of significant output power and potentially very high efficiency. (NREL)

Planned Activities for Next Quarter

- Negotiations on the various cooperative research and development agreements will continue.
- A review paper entitled "Applications of Solar Energy to Surface Modification Processes" will be submitted for publication in the journal, *Materials and Manufacturing Processes.*
- Experiments will continue in materials processing at the High Flux Solar Furnace, including diamond-like coatings, metallization, and silicon carbide production.
- A series of experiments will be conducted with the high index secondary concentrator at the High Flux Solar Furnace to demonstrate flux concentrations over 50,000 suns.

C. TECHNOLOGY TRANSFER

Objective

Objectives for technology transfer include the following:

- Integrating industrial cooperation and interaction into all parts of the Program;
- Establishing the Program's reputation as a strong, reliable player in industrial interactions;
- Expanding exhibition projects by targeting new shows for developing technologies (e.g., materials); and
- Identifying new industrial issues potentially applicable to solar technology.

1. Scientific Meetings and Presentations

Engineers from Sandia participated in a workshop sponsored by the City of Albuquerque entitled "Creating a Sustainable Energy Future." The workshop was developed by six city departments, along with a city Energy Conservation Council, to prepare a plan to reduce the city's conventional fuel use by 10 percent by 1995 through using renewable technologies and conservation. Dave Menicucci was an organizer and coordinator in the Energy Education Breakout Session, which developed a plan to educate energy users about alternatives and energy conservation. Dan Alpert participated in the Land Use Breakout Session, which addressed issues of land use related to energy use and renewable energy production.

A talk about solar energy technology was presented to the SENSE Task Force of Albuquerque and Las Cruces, New Mexico. This Task Force is a coalition of city councilors from the two cities. The purpose of the Task Force is to explore alternative energy sources that can be used by municipal utilities. Sandia was invited to this meeting to discuss the current state of solar technology and some issues relating to the generation of electricity. The presentation included an overview of all solar technologies along with a discussion about the pros and cons of tax credits. Special emphasis was placed on the efforts in California and Nevada to incorporate long-term pollution costs in the estimates for new electric generating plants. With the addition of these environmental costs, solar plants like central receivers are among the most cost-effective generating systems.

An invited address about solar energy technology was presented at the Annual Conference of the New Mexico Science Teachers Association. Members of this association include most of the science teachers in the state of New Mexico. This conference attracted approximately 100 attendees, and one of its focuses was on renewable energy. The forty-five-minute talk was very well received, and animated discussion occurred during and after the session. Several teachers asked for additional information regarding solar energy for use in their courses. There was special interest in obtaining a copy of the solar education package that was jointly developed by Dave Menicucci and Sandia's educational outreach program.

Members of the NREL staff attended a meeting sponsored by NASA and held at Purdue University in November, 1991. This conference presented progress made in the design of a plant-based Controlled Ecological Life Support System (CELSS). Such systems first will be used on the space station, and response was solicited on aqueous waste-treatment systems that can handle low levels of organics dissolved in recycled water. The solar-based aqueous detoxification system is attractive for this application, and discussion with NASA researchers indicated interest in developing a solar detoxification system to be used with the existing CELSS experiment at the Johnson Space Center.

A staff member attended the "Workshop on Surface Processing and Applications to Transportation and Utilities Technologies" on December 10 to 12, 1991, in Dearborn, Michigan. The workshop was sponsored by DOE OTT. A plenary paper reviewing progress in advanced solar processing was presented.

An NREL researcher gave an invited presentation to the Colorado Department of Health, Committee on Hazardous Waste Regulation. The committee assembled speakers on technologies in conventional incineration and asked NREL to provide a speaker for the category of "new technologies." The purpose of the meeting, which included the public, was to provide response to the committee so that they can develop regulations in a more informed manner. The presentation focussed on gas-phase technologies in solar detoxification, including the photolytic, photocatalytic, and reforming processes. Potential advantages of solar detoxification were discussed along with applications, recent experience in the laboratory and field, and future plans. The presentation was well received, and several people expressed great interest in the technology and its potential. Most of the discussion following the presentations centered on the reliability of incinerators, especially during upset conditions, and on whether or not boilers and cement kilns burning wastes should be subject to special regulations.

2. Publications Completed in FY 1992

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