U.S. Department of Energy

Jal

Fourth Parabolic Dish Solar Thermal Power Program Review

Conference Abstracts

The Huntington-Sheraton Hotel
Pasadena, California
November 30 - December 2, 1982

November 1982

Prepared for
U.S. Department of Energy
Through an Agreement with
National Aeronautics and Space Administration
by
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

U.S. Department of Energy

Fourth Parabolic Dish Solar Thermal Power Program Review

Conference Abstracts

The Huntington-Sheraton Hotel
Pasadena, California
November 30 - December 2, 1982

November 1982

Prepared for
U.S. Department of Energy
Through an Agreement with
National Aeronautics and Space Administration
by
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

FOURTH PARABOLIC DISH SOLAR THERMAL POWER PROGRAM REVIEW
Sponsored by the U.S. Department of Energy

Huntington-Sheraton Hotel, Pasadena, California

November 30 - December 2, 1982

Program

Monday Evening, November 29, 1982

7:30 - 10:00 pm	REGISTRATION (Viennese Room - Patio Foyer) Review Handouts Available Set-up of Exhibits

Tuesday, November 30, 1982

Lee Goodwin tax attorney

also no dep

investment tax credit 10%

depreciation 15-22-21-21-21 5yr

energy tax credit - through '85

15% solar prop credit (not 15% of total)

non qualifying costs • real estate (land)

• cost of financing • energy property wouldn't include transmission eq

• storage + dist not exclusively for solar

~~even~~ if shared such as a ~~sto~~ backup heater

• after 83 doesn't apply to subsidized funds

invest tax credit

• not for space heating systems

BAAstrom

• treat of tax credit repeal is a de facto repeal because investors ~~tried~~ off

• cost sharing makes bd of directors ancy

• licensing fees for small electric high

• industry must be active - ERAB was impressed

Ed Blum

private $ different from govt $

govt high risk - long term - novel - tech adv

pvt low short tried make money?

govt wants to give money

pvt wants more money - only pay you if you're a vehicle for them getting more

• no pressure to invest - lots of other invest opportunities

• how do I know it works

• are you to be trusted • fixed costs, fixed deadlines

• will revenue cover debt (plus 20-50%)?

• pension funds insurance companies want to see successes

• your first project must be good

Phil Huyck

• equip mfg dev and utilities ~~they~~ buy it

12:00 Noon LUNCHEON (Wentworth Room)

1:15 pm SESSION II: ORGANIC RANKINE MODULE 5-8
(Chmn: T. Kiceniuk, JPL)

1:20 pm "Status of The Small Community Solar Power System"
(R. Babbe, Ford Aerospace & Communications Corp.)

1:45 pm "Control System Development for the Small Community Solar Power System"
(G. Fulton, Ford Aerospace & Communications Corp.)

2:10 pm "Test Results For The Small Community Solar Power System"
(R. Pons, Ford Aerospace & Communications Corp. and F. Boda, Ford Aerospace & Communications Corp.)

2:35 pm "Solar Tests of Materials for Protection from Walk-Off Damage"
(L. Jaffe, Jet Propulsion Laboratory)

3:00 pm Wrap-Up

3:10 - 3:30 pm ---- BREAK ----

4:00 pm PANEL DISCUSSION

Industrial Issues Affecting Solar Thermal Dish Development

Introduction:
J. W. Lucas, JPL

Moderator:
John Wilson, Executive Director, Renewable Energy Institute — he pulled this panel together

Panelists:
Eugene Frankel, Science Consultant, House Subcommittee on Energy Development and Applications
Ben Washom, Advanco Corporation
Ed Blum, Merrill-Lynch
P. Huyck, First Boston Financial Corporation
Lee Goodwin, Goodwin & Schwartzstein, Attorneys at Law — tax attorney

Frankel – dish is the last technology needing development
Mod 5
last yr large wind mach
cent re past tech dev
through comm'l

volume of correspondence defending conservation far exceeded defense of solar

systems test at small level is valid concept

ISSUE where to comply
3rd world
"military construction act"
expandable power plants avoid one huge outlay

5:15 pm END OF FIRST DAY'S SESSIONS

5:15 pm STEA Meeting* (Wentworth Room)

6:00 pm RECEPTION (Viennese Room Patio/Foyer)

*(Note: The Solar Thermal Energy Association (STEA) will conduct a separate meeting at the close of technical sessions Tuesday afternoon. Specifics will be announced in the general session Tuesday morning.

best we can hope for is an extension – not an increase

PM 14 Huyck (cont)

institutional & utilities are timid
util can't get ITC
risk takers ask tough question
project for tax bene. only not popular w/ IRS
easy to raise venture capital under $1M
there is a venture capital community with directories
magazines etc
must offer investors or a board a convincing arguments

Wm R. Gould Chmn SCE

SCE policy - all new capacity in 80's by alternate, + renewable energy
will not get locked into the uncertainty of huge projects
(dinosaurs) to do so is to risk your company

263 Wind
63 Solar
36 Geo

2150 MW by 1992. SCE goal — 8 diverse resources, stability through diversity

cogen better than expected can be considered base load
half already firm
21 contracts for 400 MW by 11-82

Wednesday, December 1, 1982

8:00 am — REGISTRATION (Viennese Room - Patio Foyer)

8:30 am — "Results of Brayton Module System Trade Studies"
(T. Nussdorfer, Sanders Assoc.)

8:55 am — "Solarized Advance Gas Turbine Brayton Power Conversion Assembly"
(B. Anson, Garrett Turbine Engine Co.)

9:20 am — "Distributed Solar/Gas Brayton Engine Assessment"
(J. Rousseau, Airesearch Company)

9:45 am — "Prospects for Enhanced Receiver Efficiency"
(W. A. Owen, JPL)

10:10 am — Wrap-Up

10:20 - 10:40 am — ---- BREAK ----

10:50 am — "Progress Report On The Development of the PDC-1 Concentrator"
(F. Sobczak, Ford Aerospace & Communications Corp. & T. Thostesen, Jet Propulsion Laboratory)

11:15 am — "PDC-1 Control System"
(J. Stallkamp, Jet Propulsion Laboratory)

11:35 am — "PDC-1 Optical Testing"
(E. Dennison/M. Argoud, Jet Propulsion Laboratory)

11:55 am — PDC Wrap-Up

12:00 Noon — LUNCHEON (Wentworth Room)

Speaker: William R. Gould,
Chairman of the Board,
Southern California Edison Company

1:30 pm — SESSION IV, Cont.

1:30 pm — "Stirling Module Concentrator"
(T. Hagen, Advanco Corp.)

1:55 pm — "A Transmittance-Optimized, Point-Focus Fresnel Lens Solar Concentrator"
(M. O'Neill, E-Systems Inc.)

Wednesday, December 1, 1982, (cont.):

2:20 pm "Non-Imaging Secondary Concentrators"
(R. Winston, University of Chicago)

2:45 pm Wrap-Up

2:50 - 3:10 pm ---- BREAK ----

(Chmn: K. Terasawa, JPL)

3:20 pm "Solar Thermal Technology: Potential Impacts on Environmental Quality and Petroleum Imports"
(W. Gates, Jet Propulsion Laboratory)

3:40 pm "Implications of Energy Tax Credits on Solar Thermal Industry and Federal Tax Revenues"
(H. Habib-agahi, Jet Propulsion Laboratory)

4:00 pm Wrap-Up

4:15 pm PANEL DISCUSSION

Dish Technology from a Utility/User Perspective

Introduction:
A. T. Marriott, JPL

Moderator:
David Martin, Director for Applied Energy Research and Public Service, University of Kansas, Center for Research, Inc.

Panelists:
J. Bigger, Electric Power Research Institute
M. Anderson, Sacramento Municipal Utility District
J. Stolpe, Southern California Edison Company
P. Steitz, Burns & McDonnell, Architects and Consultants

6:00 pm END OF SECOND DAY'S SESSIONS

Thursday, December 2, 1982

(L. Jaffe, JPL)

An unstructured session to allow a review by foreign visitors of the status of their work in parabolic dish development.

Thursday, December 2, 1982, (cont.)

10:15 am		SESSION VII: PARABOLIC DISH TEST SITE (Chmn: D. L. Ross, JPL)
	10:15 am	Orientation
	10:30 am	Depart Hotel for Bus Trip to Parabolic Dish Test Site at Edwards Air Force Base
	1:00 pm	Tour of Parabolic Dish Test Site: Facility Description Instrumentation Tour and Demonstration
	3:00 pm	Depart Edwards Air Force Base for Return Trip to Hotel
	5:00 pm	Anticipated Arrival Time back at Hotel

END OF MEETING

FOURTH PARABOLIC DISH SOLAR THERMAL POWER PROGRAM REVIEW

WELCOMING REMARKS

C. R. Stein
General Chairman
Jet Propulsion Laboratory

Abstract

Welcome to the Fourth Parabolic Dish Solar Thermal Power Program Annual Review. During the next three days, reports on the many significant accomplishments that have occurred during the past year will be presented by the involved contractors. In addition, we have arranged what should be two outstanding panel discussions.

John Wilson, Executive Director of the Renewable Energy Institute, will lead the first panel, discussing industrial issues affecting solar thermal dish development. Government, industry, and financial perspectives will be represented.

David Martin, Director for Applied Energy Research and Public Service, University of Kansas, Center for Research, Inc., will chair the second panel spotlighting dish technology from a utility/user perspective.

William R. Gould, Chairman of the Board of the Southern California Edison Company, will be the featured luncheon speaker. His comments, from the perspective of one of the largest privately owned public utility companies and a leader in the development of alternate energy, will precede this second panel.

On Thursday, several of our foreign visitors will report on parabolic dish development in their respective countries. This will be followed by a visit to the Parabolic Dish Test Site in the Mojave Desert, about 75 miles from Pasadena, where you can get a first-hand look at the dish hardware in operation.

Nov. 30, 1982
Date of Presentation

STIRLING MODULE COOPERATIVE AGREEMENT

Byron Washom
Advanco Corporation
El Segundo, CA

Abstract

On May 28, 1982, a team of industrial and academic contractors was awarded a Cooperative Agreement with DOE to design, build and test a 25 KW_e, solar only receiver Parabolic Dish Stirling Module. The major subsystems of the module, named Vanguard I, include a United Stirling 4-95 engine; an 11 meter Advanco Concentrator featuring a patented exocentric gimbal mechanism and pedestal foundation; an autonomous module and field control system from Electrospace, Inc.; and an induction generator set from Onan, Inc., a division of McGraw Edison. Other team participants include Modern Alloys as the general contractor, Rockwell International as the system integrator, Southern California Edison as the site and user participant and Winsmith, Rotek, Sumitomo Cycle, Corning Glass Works and Georgia Institute of Technology for the structural and optical analysis.

The paper presented will review the recently completed Task I which consisted of the Market Assessment, Preliminary Design and the Sales Implementation Plan.

The market assessment was predicated by a multi-variate analysis of regional isolation, full avoided costs from local utilities, availability of state energy tax credits and property tax exemption and receptivity from individual utilities. The preliminary design focused on the system integration of numerous subsystems and components to meet the system specifications of a autonomous field of 32 modules. Six critical issues identified in the technical proposal were addressed and reported. The Sales Implementation Plan addressed the requirements and risks associated with the utilization of Third Party Financing through limited partnerships and Purchase Power Agreements under PURPA to build a sufficient volume of commercial sales to warrant a relatively high volume production effort.

The paper will additionally discuss the schedule and events of the remaining two month effort.

$10K/kW ~~[illegible]~~ near

19k/kW noon

Nov. 30, 1982
Date of Presentation

TESTING OF THE UNITED STIRLING 4-95
SOLAR STIRLING ENGINE IN TEST BED CONCENTRATOR

Hans

H. Nelving
United Stirling
Sweden

Abstract

This paper discusses the 4-95 Solar Stirling engine tests in the test bed concentrator at the JPL test site, Edwards Air Force Base. The design of the power conversion unit, available hardware and advanced technology efforts are presented, with a special emphasis on the receiver system. The flux distribution and temperature distribution of the receiver are important parameters influencing the system performance.

The test result evaluation shows maximum module performance and daily performance as well a breakdown of component performance. Characteristics of transient operation are also shown.

The highlights from the testing - 24 kW module power output, 27 percent overall efficiency, 33 percent stirling power conversion module efficiency - indicate the excellent module performance. Consequently, the Solar Stirling engine used in a parabolic dish results in a module competitive with other power generating systems, and especially other solar systems.

July ?? 24kW

does this count parasitics - no and its not

how much after power conditioning

optimized at Edwards

Nov. 30, 1982
Date of Presentation

STIRLING ENGINE CERAMIC HEATER HEAD DEVELOPMENT

Valerie J. Van Griethuysen

Energy Conversion Branch - Air Force Wright Aeronautical Laboratories, Wright-Patterson AFB, OH

Abstract

This paper presents the results of a program sponsored by the Aero Propulsion Laboratory of the Air Force Wright Aeronautical Laboratories to develop a ceramic solar receiver/heater head for a kinematic Stirling engine. Ceramic heat receivers promise to alleviate several limitations characteristic of metallic heat receivers, namely high temperature creep, life and high cost strategic materials. Also, ceramic receivers may allow higher operating temperatures than their metallic counterparts with increased system efficiencies.

The objectives of the program were to determine ceramic types and fabrication processes capable of meeting design requirements and to formulated further development requirements. The paper presents tradeoff analyses describing various ceramic thermal conductivities and engine load requirements, material coefficients of thermal expansion compatability, ceramic utilization for different heater and housing components and how the Stirling engine-ceramic heater head power system will depend on the integration of Stirling engine, ceramic, heat transfer and structural requirements and limitations during design efforts.

Areas identified for further development include low conductivity ceramic materials that have approximately the same coefficients of thermal expansion as silicon carbide, silicon carbides with high and low conductivities, and joining technology of ceramic to ceramic and ceramic to metal combinations.

to develop a ceramic receiver/heater head

Nov. 30, 1982

Date of Presentation

STATUS OF THE SMALL COMMUNITY SOLAR POWER SYSTEM

R. H. Babbe

Ford Aerospace & Communications Corp., Aeronutronic Division
Newport Beach, CA 92663

Abstract

This paper presents a summary of the Small Community Solar Thermal Power Experiment (SCSE). Emphasis is placed on the single power module being tested at the JPL Parabolic Dish Test Site, Edwards AFB, California. The power module consists of a regenerative, air-cooled 20-25 kW_e organic Rankine cycle (ORC) engine/generator unit and a cavity receiver mounted at the focus of the solar concentrator. Toluene is the working fluid and is heated in the receiver to 750°F before expanding across a single-stage axial flow turbine direct-coupled to a permanent magnet alternator (PMA). Other equipment includes a control subsystem designed for unattended operation and an energy transport subsystem utilizing a special inverter for voltage (load) control and conversion of dc to grid-compatible ac power. Tests to date have utilized the 11m diameter JPL Test Bed Concentrator. Automatic control of the operating modes during testing was accomplished by a central minicomputer which also performed the functions of data logging, status monitoring and sending warnings to the operator or performing an emergency shutdown if warranted. Engine control was provided by a local microprocessor designed to make each power module virtually self-sufficient. The capability of the microprocessor is being upgraded to control the concentrator which was previously done at the test site by a separate computer. The typical power output of the module for the initial Edwards tests was about 16 kW_e at 950 W/m^2 direct solar insolation; the net module efficiency at these conditions was 19.5%. Receiver efficiency was greater than 95% and the ORC power conversion unit efficiency (engine/alternator/rectifier) was approximately 23%. The Edwards tests were the first demonstration of control system designed for an unattended plant. The computers maintained stable operation under the most severe transients caused by commanding the closing and opening of a water-cooled door at the entrance of the receiver.

Multiple modules will be joined together electrically to form a Small Community Power Plant. The plans for this phase of the program are described.

Nov. 30, 1982
Date of Presentation

CONTROL SYSTEM DEVELOPMENT FOR THE SMALL COMMUNITY SOLAR POWER SYSTEM

D. G. Fulton

Ford Aerospace & Communications Corp., Aeronutronic Division

Newport Beach, CA 92660

Abstract

The Small Community Solar Thermal Power System is a point-focusing, distributed receiver solar thermal power plant with a distributed digital computer-based control system. This paper describes the operation of the plant control system. Emphasis is on the computer control functions of a single module with test results obtained from the demonstration performed at the JPL Parabolic Dish Test Site at Edwards Air Force Base. The extension of the logic for the control of a multiple-module automatically-controlled plant are also described.

The power plant consists of multiple power modules delivering power to a central collection point where the power is appropriately converted and delivered to the utility interface. Each of the distributed power modules consists of a concentrator (parabolic dish) with a closed-cycle receiver/turbine/alternator assembly located at its focus.

The plant control system has a central computer called the Master Power Controller (MPC) which provides the operator interface and plant control logic. This central computer provides supervisory control of microprocessors called Remote Control Interface Assemblies (RCIAs) which are located at each power module. The MPC implements control of the plant by transmitting mode commands to the RCIA at each power module and the detailed control of each power module is performed by its RCIA.

Results of actual Power Conversion Subsystem (PCS) control are shown, and the applicability of the control system design to autonomous plant control are discussed.

Nov. 30, 1982

Date of Presentation

TEST RESULTS FOR THE SMALL COMMUNITY SOLAR POWER SYSTEM

R. L. Pons and F. P. Boda
Ford Aerospace & Communications Corp., Aeronutronic Division
Newport Beach, CA 92663

Abstract

This paper describes the testing which has been conducted so far on a single organic Rankine cycle (ORC) power module as part of the Small Community Solar Thermal Power Experiment (SCSE) program. The power module consists of an air-cooled, regenerative 20 kW_e turbo-alternator coupled to a cavity-type receiver (boiler), all mounted at the focus of a parabolic dish concentrator. The toluene working fluid circulates in a closed loop system and is heated in the receiver to 750°F before expanding across a single-stage axial-flow turbine which is directly coupled to a permanent magnet alternator. Ancillary equipment, including a complete computer-based plant control system and an electrical transport system with voltage control and grid interface capability, is also operated with the power module. This prototype system is heavily instrumented with 103 performance and diagnostic parameters being recorded and displayed at one second intervals.

Development testing of individual components and Qualification testing of major subsystems began in 1982. Full-up system testing "on the sun" was conducted in February and March of 1982 at the JPL Parabolic Dish Test Site (PDTS) utilizing the 11 meter Test Bed Concentrator (TBC). Although some intermittent cloud cover occurred naturally during the test series, the effects of solar flux transients were successfully demonstrated by the further use of a water-cooled door at the receiver aperture which could be actuated by computer command. Despite the intentionally-induced transients, no boiling instabilities were encountered. Moderate design temperatures allowed the receiver to operate at high (95%) efficiency, even with wind gusts up to 30 mph.

Electrical power output from the module was fed either into a load bank or into the local utility grid. Typical module power output was 16.2 kW_e at 950 W/m^2 direct normal insolation, corresponding to an overall module efficiency (from sun to electricity) of 19.5%. The paper presents computer plots of the more pertinent data in graphical form. These data show the control system to be completely stable with excellent control of fluid temperature, pressure, flow, turbine speed and output voltage.

Nov. 30, 1982

Date of Presentation

Solar Tests of Materials for
Protection from Walk-off Damage

Leonard D. Jaffe

Jet Propulsion Laboratory, California Institute of Technology
Pasadena, CA

Abstract

In parabolic dish solar concentrator systems, walk-off of the spot of concentrated sunlight can be a hazard in case of equipment or other malfunction that causes the concentrator to stop following the sun. The use of protective materials that can withstand exposure to walk-off conditions without active cooling provides certain advantages. A test program to evaluate possible materials was, therefore, carried out. Each test consisted of exposure to concentrated sunlight at a peak flux of about 7,000 kW/m^2 for a time of 15 minutes (if the sample did not melt or fall apart earlier).

Types of materials tested included alumina, zirconia, mullite, silica, silicon carbide, graphite, aluminum, and copper. Of these, the only material that neither cracked nor melted was grade G90 graphite, a somewhat expensive premium grade. Grade CS graphite, a much cheaper commercial grade, cracked half-way across in each test, but did not fall apart. With proper design this grade should probably perform satisfactorily as a walk-off shield. Both of these grades are medium-grain extruded graphites.

The only other material tested which appeared promising was high-purity slip-cast silica. The one sample available survived six minutes before the test was terminated due to a deficiency in the test set-up. Further testing of similar material is probably worthwhile.

Other grades of graphite and silica tested, and all the samples of alumina, zirconia, mullite, silicon carbide, aluminum, and copper either melted or fractured quickly during the test.

Coatings of white, high temperature paint or boron nitride did not improve the performance of graphite samples. Immersion in water prior to test, simulating rain, also did not affect their performance.

Dec. 1, 1982
Date of Presentation

Brayton Module Development Introduction

Herbert J. Holbeck
Jet Propulsion Laboratory
Pasadena, California

Abstract

Brayton engine technology is uniquely well suited to solar thermal application. The extensive, well developed gas turbine technology base provides an excellent background for solar Brayton development. An air-Brayton engine is readily adaptable for solar or hybrid application since the input air may be heated by any source, and a solar receiver may be placed in series with a combustor with minimum modifications.

The Solar Thermal program plans to utilize two different ongoing engine developments. The Advanced Gas Turbine (AGT) being developed by the Garrett Turbine Engine Company for automotive application will provide high efficiency in the ceramic modification together with the eventual low cost associated with automotive production. The Subatmospheric Brayton Cycle (SABC) engine being developed by the Garrett Airesearch Company for a gas-fired heat pump provides an opportunity for a near-term module. Both the SABC engine for the near-term module and the ceramic AGT engine for the long-term module are based on ongoing engine developments in non-solar programs thereby eliminating the extremely high development costs associated with new engine development. Additionally, both engine developments feature long life and low maintenance.

Brayton engines can readily take advantage of the improvements in efficiency inherent in high-temperature operation. Since air is the working fluid, the operating temperature is limited only by material limits. Metal engines are limited to about 1600°F while an all-ceramic engine could operate up to 2500°F with an efficiency exceeding 40 percent and long operational life.

The presentations in this session will describe some Brayton Module System Study results, descriptions of both the SAGT and the SABC engine programs and a look toward the potential for improvement of efficiency in air Brayton receivers.

Dec. 1, 1982
Date of Presentation

RESULTS OF BRAYTON MODULE SYSTEM TRADE STUDIES

T. Nussdorfer
Sanders Associates, Inc.
Nashua, NH

Abstract

Sanders Associates, Inc. (S/A) has been selected to fulfill the systems integration role for this program, with the responsibility of configuring and testing a Parabolic Dish Module (PDM) for the purpose of converting solar energy to electric power. The PDM consists of a solar concentrator, receiver, Brayton cycle gas turbine, generator or alternator, recuperator, hybrid combustor and any additional subsystem necessary to complete the integration of the power module and meet the JPL/PDM specifications.

An initial phase of this work recently completed involves Trade-off Studies and Performance Analyses of various system configurations. As presented here, this work has culminated in an integrated recommended program that utilizes for its initial experiments, components that are available, or soon to be available. The AiResearch subatmospheric gas turbine has been designated as an interim power plant to be interfaced with one on several competitive collector designs. This first experiment is a vital step toward the long term goal of utilizing the DOE/NASA Advanced Gas Turbine with its predicted high temperature/high efficiency performance for low cost Solar Brayton electric power.

Dec. 1, 1982
Date of Presentation

SOLARIZED ADVANCE GAS TURBINE BRAYTON POWER CONVERSION ASSEMBLY

B. Anson
Garrett Turbine Engine Co
Phoenix, AZ

Abstract

The solar advanced gas turbine Brayton power conversion assembly, SAGT-1A, is being developed by The Garret Turbine Engine Co. and Sanders Associates, Inc. Garrett has designed, fabricated and assembled the engine, generator and solar receiver under DOE/JPL/NASA Contract DEN3-181. Further, all necessary ancillary equipment required for the feasibility tests at the JPL parabolic dish test facility have been completed and their operation verified.

The Brayton engine, SAGT-1, which will be used in the power conversion assembly is approaching completion of its required development for use in SAGT-1A. The engine is derived from the advanced gas turbine, AGT101, now being developed by Garrett and Ford Motor Co. for automotive use under DOE/NASA Contract DEN3-167. To date, the engine has demonstrated operation over its entire speed range to 100,000 rpm and has produced 22 hp during initial performance testing.

Testing of the SAGT-1A power conversion assembly at the JPL parabolic dish test site is planned for early 1983 with initial system operation in late 1982 at Garrett in Phoenix.

Dec. 1, 1982
Date of Presentation

Distributed Solar/Gas Brayton Engine Assessment

Jean Rousseau
AiResearch Manufacturing Company
Torrance, California 90509

Abstract

A 10-ton gas-fired heat pump is currently under development at AiResearch under joint Department of Energy (DOE) and Gas Research Institute (GRI) sponsorship. This heat pump features a highly efficient, recuperated subatmospheric Brayton-cycle engine, which drives the centrifugal compressor of a reversible vapor compression heat pump. The investigations conducted through this program were initially concerned with the integration of this machine with a parabolic dish-type solar collector. Computer models were developed to accurately describe the performance of the heat pump packed in this fashion.

The study determined that (1) only a small portion (20 to 50 percent) of the available solar energy could be used because of a fundamental mismatch between the heating and cooling demand and the availability of solar energy, and (2) the simple payback period, by comparison to the baseline non-solar gas-fired heat pump, was unacceptable (15 to 36 years). The study program was extended to include investigations of a solar-assisted gas-fired cogeneration system. In this arrangement, the subatmospheric Brayton engine produces electrical power and use is made of the engine waste heat at temperatures of up to 400 deg F. Parametric performance and economic data were generated in terms of engine duty cycle and waste heat utilization fraction. The economic analyses show very attractive returns on investment for this sytem.

Dec. 1, 1982
Date of Presentation

PROSPECTS FOR ENHANCED RECEIVER EFFICIENCY

William A. Owen
Jet Propulsion Laboratory
Pasadena, CA 91109

Abstract

Solar receivers are the link between the concentrated solar energy and the engine or process that utilizes the energy. While much time and effort have been expended on developing concentrators and heat engines, comparatively little has been spent on receivers. This is probably due to the perception that they are inherently simple, low cost devices. Recent system studies however emphasize that receivers play just as important a role in system efficiency as the more complex components. Until recently, receivers were designed using conventional heat exchanger techniques. But when these designs were converted into hardware, none performed as well as expected with losses exceeding calculations by 5% to 50%. Closer examination showed up many special problems especially for higher temperature systems. A number of design aspects including cavity shape, use of windows, coatings, surface condition, radiative properties, cavity convection suppression, reflection, wind screens, lifetime, and others need systematic integration into a comprehensive design scheme.

By examining each mode of heat loss, radiation, convection, and conduction, an "ideal" receiver can be developed. This will serve as a baseline to which individual receiver features can be compared. Sensitivity analysis will permit each element of the "ideal" receiver to be examined for overall system effect. With the large number of possible improvements, it is expected that future receivers can be built that will have efficiencies much closer to the "ideal" than achieved to date.

Dec. 1, 1982
Date of Presentation

PROGRESS REPORT ON THE DEVELOPMENT OF THE PDC-1 CONCENTRATOR

I. F. Sobczak and T. Thostesen

Ford Aerospace & Communications Corp., Aeronutronic Division
Newport Beach, CA 92663

Abstract

This paper summarizes the status of the 12 meter parabolic dish concentrator planned for use with the Small Community Solar Thermal Power System under concurrent development by Ford Aerospace for the Jet Propulsion Laboratory. The PDC-1 unit, designed by the General Electric Company, features a plastic reflector bonded to glass reinforced plastic sandwich gores. An elevation-over-azimuth mount fabricated of structural steel and thin-walled tubing is driven by a cable and drum arrangement powered by a pair of variable speed motors. The concentrator was fabricated and erected at the North Edwards Test Site by Ford Aerospace under JPL contract. The reflective panels and the control/tracking subsystem were procured under separate contract by JPL.

U of Iowa
gamma-ray black hole experiment - needed 2 dishes
there wouldn't be
2" of square grout "no
any subsequent settling
fibreglass skins and balsa core

Dec. 1, 1982
Date of Presentation

PDC-1 CONTROL SYSTEM

John Stallkamp
Jet Propulsion Laboratory
Pasadena, CA

Abstract

This paper is a brief description of the control system for the PDC-1 concentrator at the JPL Parabolic Dish Test Site. The control system was designed and fabricated by GE and completed and installed by JPL. It consists of independent channels for controlling elevation over azimuth motions utilizing a start-stop or on-off strategy. The tracking increments are about 0.1^{o} or auto or fire track controlled by photo-resistive sun sensors and about 0.3^{o} or coarse track controlled by position measurements and a calculated sun position. A fast slow speed is provided for going on and off the sun to and from an offset track mode. The unit is automatically detracked from the sun for a variety of control or system failures. Progress to date is described.

Dec. 1, 1982
Date of Presentation

PDC-1 OPTICAL TESTING

Edwin W. Dennison/Maurice J. Argoud
Jet Propulsion Laboratory
Pasadena, CA

Abstract

During the development of the first JPL parabolic dish concentrator (PDC-1), an optical test program was used to determine the image forming characteristics of the reflecting panels and provide data for estimating the concentrator thermal performance. The first optical tests of the prototype panels were made in the JPL 25 ft. space simulator during the summer of 1981. Twelve of the final concentrator panels were tested outside of the panel storage building at night during the spring of 1982. The final tests were made on the fully assembled concentrator at the JPL Parabolic Dish test site in October-November 1982.

All of the performance tests were based on measurements of the optical imaging characteristics of reflecting panels illuminated by a real or virtual point source of light. Two diagnostic optical techniques were used to determine the relationship between the image quality and the mechanical properties of the reflecting surface.

These optical tests were effective for evaluating the performance characteristics of the PDC-1 panels and also proved to be of great value in the development of a successful panel installation procedure.

A cold water cavity calorimeter will be used for the final evaluation of the concentrator. However, all of the data now available indicates that the PDC-1 will have satisfactory imaging characteristics.

Dec. 1, 1982
Date of Presentation

STIRLING MODULE CONCENTRATOR

T. Hagen
Advanco Corporation
El Segundo, CA

Abstract

Advanco Corporation and the United States Department of Energy (DOE), on May 28, 1982 signed a Cooperative Agreement for the design, manufacture and test of a "solar only" parabolic dish-Stirling system known as Vanguard I. As a result of this agreement, a Project effort has developed that combines the extensive research and industrial experience of several participants to develop and produce the Vanguard I, solar energy, electric-generating module that will technically and economically penetrate the small community market as well as the electrical utility market. The design of the Vanguard I dish-Stirling engine system features low risk, simple fabrication and assembly, and minimum cost. Due to the fully self-contained nature and relatively simple size of each power generation module, this solar technology lends itself to rapid commercialization. The concept combines United Stirling's DSAB 4-95 Solar II Stirling engine; Jet Propulsion Laboratory's (JPL) developed mirror facets which form the reflective surface of the dish (concentrator), Rockwell/Advanco's low-cost exocentric gimbal mount with the needed structural stiffness to assure tracking accuracy; a low-cost pedestal foundation; and an automatic un-manned concentrator control system. This report is a summary of the results achieved by Advanco on the concentrator during the performance of the interface design effort of the Vanguard I program.

Dec. 1, 1982
Date of Presentation

A TRANSMITTANCE-OPTIMIZED, POINT-FOCUS FRESNEL LENS SOLAR CONCENTRATOR

M. J. O'Neill
E-Systems, Inc., Energy Technology Center
Dallas, TX

Abstract

E-Systems is currently developing a point-focus Fresnel lens solar concentrator for high-temperature solar thermal energy system applications. The concentrator utilizes a transmittance-optimized, short-focal-length, dome-shaped refractive Fresnel lens as the optical element. This unique, patented concentrator combines both excellent optical performance and a large tolerance for manufacturing, deflection, and tracking errors.

Under Jet Propulsion Laboratory (JPL) funding, E-Systems has completed the conceptual design of an 11-meter diameter concentrator which should provide an overall collector efficiency of about 70% at an 815 C (1500 F) receiver operating temperature and the 1500X geometric concentration ratio (lens aperture area/receiver aperture area).

In this paper, a review of the Fresnel concentrator development program will be presented, including a description of the concentrator, summary of its expected performance, results of optical and thermal analyses of the collector, a discussion of manufacturing methods for making the lens, and test results for the prototype lens panel (provided testing is completed prior to the conference). Based upon the excellent performance and low cost potential demonstrated for the linear version of the same Fresnel lens over the past five years, E-Systems remains confident that this new point-focus solar concentrator should offer high performance and good cost effectiveness.

Dec. 1, 1982
Date of Presentation

NON IMAGING SECONDARY CONCENTRATORS

Roland Winston/Joseph O'Gallagher
University of Chicago
Chicago, IL.

Abstract

Secondary concentrators deployed at the focal plane of a parabolic dish can significantly increase the system concentration ratio or alternatively decrease the tolerance requirement. Several trumpet shaped radiation flow line concentrators were tested with the JPL Test Bed Concentrator at the Parabolic Dish Test Site in the Mojave Desert. Primary flux inside an 8 inch diameter circle was redirected into 5 1/2 inches with an efficiency exceeding 96%. A power gain of 30% was observed.

Dec. 1, 1982
Date of Presentation

CHAIRMAN'S INTRODUCTORY COMMENTS FOR ECONOMICS SESSION

Katsuaki Terasawa
Jet Propulsion Laboratory
Pasadena, CA 91109

Abstract

The most pervasive characteristics inherent in R&D projects are risk and uncertainty. At the beginning of a R&D project neither the technological characteristics of what is to be developed, the magnitude of the effort required, nor the economic profitability of the project if it is technologically successful can be accurately predicted. In deciding whether or not to undertake a particular R&D project, a private profit-making firm will examine that rate of returns are sufficient compensation for bearing the risks of the R&D, the firm will invest in the project. If the returns are insufficient, the firm will not invest. With one important modification, the Federal government should use an identical criterion in selecting the R&D projects which will receive public support. Since the Federal government exists to serve the interest of society, federal participation in R&D should be based on a comparison of the risks to society and the return to society. Thus, the Federal government should support R&D projects for which there is a divergence between either the private and social rates of return, and/or the private and social levels of risk. Federal participation in the R&D process should be limited to projects which, when compared to their expected level of benefits, exhibit excessive risks to potential private investors but acceptable risks to society as a whole.

The first paper, "Solar Thermal Technology: Potential Impacts on Environmental Quality and Petroleum Imports", examines the benefits and impacts of the solar thermal program to society from this perspective.

Once the desirability of federal participation has been established, it is also necessary to determine if direct funding of R&D is the most effective form of federal stimulation. Tax incentives, regulatory actions, and other forms of federal intervention should also be considered as potential forms of federal assistance.

The second paper, "Implications of Energy Tax Credits on Solar Thermal Industry and Federal Tax Revenues," will address this issue focusing upon the tax credits.

Dec. 1, 1982
Date of Presentation

SOLAR THERMAL TECHNOLOGY: POTENTIAL IMPACTS ON ENVIRONMENTAL QUALITY AND PETROLEUM IMPORTS

W. R. Gates
Jet Propulsion Laboratory
Pasadena, California 91109

Abstract

The Jet Propulsion Laboratory has ongoing responsibility for assessing the benefits and impacts associated with the successful development of cost-competitive solar thermal energy technologies. The purpose of this task is twofold: to determine if justifications exist for federal participation in the development of solar thermal technologies in a changing environment; and to assist the Technical Program Integrator in managing the R&D effort by identifying high payoff research areas. This presentation will summarize the results for part of the work conducted by JPL during FY 1982.

Projecting the economic market potential of solar thermal technologies is the first step in the JPL benefit assessment. Utility simulation has been used to determine the value and economic market potential of solar thermal technologies. In 1982, a significant effort was devoted to refining the utility simulation capabilities. The primary modifications include updating and regionalizing the utilities used in the simulation, and reoptimizing the conventional generating capacity as solar penetration increases. A number of conclusions can be drawn from the results of this refined utility simulation. In particular:

- If the shift toward coal-fired power plants continues as projected, the early 1990's economic market potential is limited for solar thermal electric systems in the southwest and south central regions, assuming utility ownership.

- Early markets for solar thermal electric systems will be provided by third-party investors (assuming extension of the federal energy tax credit), remote site electric applications (islands), agricultural irrigation, and grid-connected applications in specific utilities with characteristics particularly favorable to solar thermal systems.

- Exploiting these early markets can help establish a solar thermal industry which can compete in a coal-dominated utility environment.

- Storage can substantially increase the net value and economic market potential of a solar thermal power plant.

Dec. 1, 1982
Date of Presentation

IMPLICATIONS OF ENERGY TAX CREDITS ON SOLAR THERMAL INDUSTRY AND FEDERAL TAX REVENUES

H. Habib-agahi
Jet Propulsion Laboratory
Pasadena, California 91109

Abstract

The impact on the solar thermal electric industry and Federal tax revenues of extending the Federal energy tax credit beyond 1985 was examined in this study. The emphasis was on the effect of third-party ownership as investor-owned and municipal utilities do not qualify for the energy tax credit. A financial model for third-party financing of solar thermal power systems was developed for this analysis. Primary conclusions are:

- Without extension of the Federal energy tax credit, near-term private investment in solar thermal electric systems in unlikely.

- With extension of the Federal energy tax credit beyond 1985, the expected return on investment to third-party owners is sufficient to encourage a near-term market for solar thermal electric systems. These early markets will enable the solar thermal industry to adopt more efficient production techniques which are the result of increased output. Consequently, solar thermal system costs are expected to drop significantly.

- When the solar thermal capital costs drop sufficiently, the anticipated return on equity will encourage private participation in the solar thermal industry without the energy tax credit.

- If the energy tax credit is retained, the present value of the net direct impact on Federal income tax revenue for systems installed before the capital costs drop is negative.

- When capital costs drop enough so that the expected return to equity becomes sufficient to encourage private investment without the energy tax credit, government revenues will increase.

Dec. 1, 1982
Date of Presentation

INTERNATIONAL SESSION

L. D. Jaffe
Jet Propulsion Laboratory
Pasadena, CA

Abstract

There is significant interest outside the U. S. A. in parabolic dish solar thermal power systems. This informal session has been arranged to help inform Annual Review participants of some of the pertinent work that is under way in other countries.

Dec. 2, 1982
Date of Presentation

MOLOKAI

80 → 16 ORC

81 → 24 sterling

$$\begin{array}{r} .296 \\ 81 \overline{)24.00} \\ \underline{162} \\ 780 \\ \underline{729} \\ 51 \end{array}$$