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ABSTRACTS

SOLAR INDUSTRIAL PROCESS HEAT CONFERENCE

OAKLAND, CALIFORNIA

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SPONSORED BY:

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FOR

THE U.S. DEPARTMENT OF ENERGY, AIPM SYSTEMS BRANCH

TABLE OF CONTENTS

Page

Contractors Poster Session

CONTRIBUTED POSTER SESSION

An Economic Analysis of a Solar Industrial Process Steam System

D. J. Allen A. C. Gangadharan G. D. Gupta

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ABSTRACT

An economic analysis has been performed to evaluate the economic attractiveness of solar steam systems to process industries. The influence of tax incentives, cost-sharing, capital structure, depreciation method, potential reductions in the costs of solar steam systems, and inflation rates were examined. The analysis was performed using a discounted cash-flow technique. Although traditional methods for the assessment of profitability depend on arbitrarily chosen methods for estimating depreciation as an operating cost, the determination of the profitability of a process through criteria that entail the discounting of cash flows can be made without such subjectivity. In the economic analysis of solar industrial heating systems, a most important variable is the differential between the fuel cost escalation rate and the cost of living inflation rate. This relationship is particularly relevant because such solar projects combine a high capital cost with low operating costs and an "income" generated through the conservation of fossil fuels. From the economic analysis, conclusions are drawn about the tax and capital structures and fuel costs that can be expected to make such projects economically attractive. Additional measures that could enhance the economic viability of solar industrial heat projects are discussed.

NOTES

Screening Potential Industrial Applications of Solar Energy

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ABSTRACT

In this paper a methodology for systematically identifying energy end uses with high potential for solar substitution will be discussed and applied to industrial process heat requirements. The solar energy system is perceived as an intermediary between the energy supply system (sun and weather) and the energy demand system (the end use), each of which is beyond the control of the solar energy system designer. When a good "match" exists between certain critical parameters of the demand system and corresponding characteristics of the supply system, a high level of solar suitability (in the sense of competitiveness with alternative energy sources) is indicated.

Two categories of parameters are defined. Intrinsic parameters depend only on the nature of the application, whereas extrinsic parameters are also sensitive to institutional effects outside the energy supply and demand systems (e.g., tax laws, credit availability, air quality controls). The former type are more easily quantifiable and will be the main focus of the discussion, though the importance of the latter type cannot be underestimated.

Two intrinsic parameters are associated with the spatial characteristics of the insolation. One measures the correlation of the (real or potential) geographic distribution of the end use with the distribution of high insolation. The other is a power density associated with the availability of suitable land for collector deployment. Similarly there are three parameters suggested which refer to the temporal characteristics of the solar energy available at a particular location. Another important intrinsic parameter is process heat temperature.

Extrinsic parameters include availability of venture capital or credit, potential for plant expansion (to avoid retrofit situations), cost of typical alternative energy, and geographical correlation with areas of low air pollution tolerance. Though these properties may be more difficult to quantify, they must be included in a systematic analysis as a supplement to the more quantitiative treatment of the intrinsic parameters.

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ABSTRACT

INDUSTRIAL APPLICATIONS ANALYSIS: MARKET CHARACTERIZATION AND SYSTEM DEFINITION FOR SEVERAL INDUSTRIES

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As solar thermal industrial process heat technology develops, it is increasingly important to identify specific near-term markets for these systems and to define in some detail the performance and cost requirements of these applications in order to direct current efforts in engineering development. This paper presents the results of a cooperative study in market analysis, systems analysis and engineering development as carried out at the Solar Energy Research Institute in 1978 and 1979.

The first step in this analysis was the characterization and ranking of industrial energy markets (by four-digit SIC codes) according to 1976 data on energy demand, plant location and dispersal, process temperature levels and energy intensiveness. Only primary processes using heat at temperatures below 1100°F were considered. Observing this ranking, several industries using energy in the low (550°F) and high temperature (550°F-1100°F) ranges were chosen for further consideration. Industries chosen analysis included paint manufacturing (SIC 2851), baking (2051), fluid milk dairies (2026), non-ferrous die casting (3361), cane sugar refining (2062) and Fullers' earth processing (3295). Four of these industries were selected for in-depth analysis.

In-depth analysis, based on actual site visits to several plants, literature review, consultation, and discussions with trade associations was carried out for fluid milk dairies (2026), baking (2051), die-casting (3361), and cane sugar refining (2062). Information on energy and operating costs, investment criteria,

capital expenditures and the like were obtained in order to produce realistic evaluation criteria for solar systems in a given industry and to support a value analysis for process heat in order to establish cost goals. At the same time, operating information, land availability and process requirements were obtained from plant engineers to allow solar system design and evaluation for specific plants. Using the evaluation routine PROSYS, applicable solar systems, their size, performance and cost were determined for plants in a given industry over most of the United States.

The study concludes with an assessment of the near-term potential for various solar technologies in the selected applications, including appropriate cost and performance goals and desirable technical developments.

A COMPARATIVE ANALYSIS OF SOLAR THERMAL SYSTEMS FOR ON-SITE INDUSTRIAL APPLICATIONS

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The objective of this study is to establish cost and performance estimates of solar thermal systems so that a comparison of their relative merits can be made for on-site industrial applications.

Solar thermal systems are characterized in the analysis by eight generic system configurations. The systems incorporate five different collector types: evacuated tube, parabolic trough, line focus central receiver, parabolic dish, and point focus central receiver. Cost and performance algorithms are developed based on common assumptions and on the most current estimates from manufacturers and researchers of solar components. These algorithms along with solar insolation data are used in a computer simulation to establish costs and performance of the generic solar systems. The simulation is run for nine cities each within one of the United States census regions. The systems are sized to meet industrial demands for electricity and low, medium, and high temperature process heat. Three industrial demand profiles are selected representing one-, two-, and three-shift operations and a wide range of peak power and total annual energy. Collector array size and storage capacity are increased with time to provide a larger fraction of the total energy demand for the near-, mid-, and far term.

The major conclusion of the study is that the point focus central receiver and the parabolic dish appear to be the most promising solar thermal power systems for industrial applications. It is projected that these two concepts will have the lowest long-term energy costs of solar thermal system concepts that are currently on the market and being developed by industry and government. High temperature process heat produced by these two collectors can be attemperated to meet low temperature demands and still have lower energy costs than low temperature collectors.

NOTES

RELIABLE COMMERCIAL TRACKER FOR LINE FOCUSING COLLECTORS

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ABSTRACT

Acurex Corporation has developed a sophisticated uniaxial tracking system with primary application to line-focusing collectors for industrial process heat generation. The patented system consists of a solid-state logic module and sensor, as well as an innovative direct monitoring device. Emphasis was placed on performance, cost, durability, and compatibility with various types of drives and control systems. Tracking accuracies of better than $\pm$ 1/20 degree are typical. By using a special sensor device, cloud tracking was eliminated and labor-intensive installation was minimized. Design criteria and product information are presented in this paper. In addition, the internationally compatible signal interfaces and the priority setting control logic are described. Photographs and drawings demonstrate the operation of the system.

NOTES

Solar-Industrial Heat for New York State - a case study in regional impact on economic viability

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ABSTRACT

New York State offers interesting contrasts in the regional impact on the economic viability of solar heat for industrial processes. A study has been conducted* to identify the economic potential for solar heat in the New York State processing industries, under the assumption of future escalation of fuel prices. In the course of this study it was necessary to identify the particular industries, their process-heat demands and their (regional) locations. New York State has been divided into two solar-performance regions: "Downstate", consisting mainly of the New York City Metropolitan area and "Upstate", the remaining rural and industrial areas. The climatology of these two regions is markedly different, with annual average insolation levels and ambient temperatures having a significant impact on solar performance in the low to intermediate range of industrial application temperatures (below 550°F). Upstate has, for example, been classified nationally along with northern New England in the poorest region of solar collector performance. Of the six most energy-intensive processing industries (nationally), three only are promising for the State. The Primary Metals and Stone, Clay & Glass industries are eliminated from the solar applications, because over 96% of their processes are well above 550°F. The State has virtually no petroleum refining. This leaves only the Food & Kindred Products, Paper & Allied Products and Chemical industries to consider for solar in the State and of these the latter two are located primarily Upstate. Analysis has been carried out on each of these three industries, using the parameters of: heat demand, fuel type, application temperature, process-heat ratio, conventional-fuel system efficiencies and region to determine the State-wide economic potential market for 1985, using scenarios of (oil & nat. gas) fuel price escalations and level of government incentives. The regional effect is paramount in these results. Examples of individual manufacturing plants within each of the three industries have been studied, in order to verify some of the generic characteristics used in the analysis. This included site visits to the plants and discussions with company representatives in each case.

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* Sponsored by New York State Energy Research & Development Authority

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SOLAR PROCESS HEAT
FOR DRYING COAL, PEAT AND WASTE SLUDGE

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ABSTRACT

Large deposits of surface coal exist in Montana and other North West regions of the United States. This coal has a high moisture content which must be removed prior to combustion. Deposits of peat in the North East region of the United States also represent large reserves of low grade fuel which must be dried prior to burning. This peat as well as other low grade sludges must be dried to a moisture content of 10%. Conventional fuels are generally used for this drying process.

The present paper presents an alternative method for drying these fuels using heat gathered by concentrating solar collectors. Heated fluid from the collector bank is circulated through a continuous conveyor type dryer which is used to dry wet bulk materials.

This paper presents a technical description of the system, its operation and applications. Analytical model predictions of the system's performance (using TRNSYS models) are compared with test data from a prototype drying plant.

Estimates of energy required to dry various fuels are also given in the paper, along with estimates of that fraction of solar heat which could be used in the drying process.

Using the solar fraction for various plant site locations, life cycle cost analyses are presented for both the solar and non-solar bulk fuel drying processes.

Results of this project indicate dual advantages of solar drying by (1) limiting the use of conventional fuels, and (2) reducing transportation costs of wet fuels.

The paper concludes by recommending further pilot plant developments in the three following areas: solar thermal drying of coal, expanded development of dried peat as an alternate fuel, and solar heat processing of municipal waste sludge for fuel conversion.

PERFORMANCE AND COST ADVANTAGES OF A SOLAR-ASSISTED INDUSTRIAL HEAT PUMP SYSTEM

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ABSTRACT

The Templifier^{tm} is a rugged, industrial-quality water-to-water heat pump which was developed specifically to produce industrial process hot water at temperatures in the range of 140°F to 220°F without reliance on fossil fuels. This industrial heat pump can use low-temperature (55°-140°F) solar energy and plant waste heat as a source to produce process hot water at rates of 100-thousand to 10-million Btu/hr, at Coefficients of Performance on the order of 3.0 to 6.0.

The ability of the heat pump to operate from a low-temperature source enables the solar collectors to operate at the same low temperature, usually in the range of 60°F to 95°F. It is a characteristic of all solar collectors that the lower collector operating temperature, the greater the amount of available solar energy produced by the collector. Therefore, as versus a "conventional" solar-only system, the solar/Templifier combination enables the collection of an equal amount of usable solar energy with far less solar collector area.

Further, in the Sunbelt region (<4,000 heating Degree-Days), a low-cost, plastic, flat-plate collector panel can be more efficient at collecting solar energy at low temperatures than the more exotic and expensive types of collectors. Such collectors are available and are about 20% less expensive than typical single-glazed flat plate collectors.

This paper analyzes the performance and economics of the Solar-Assisted-Templifier (S-A-T) heat pump system in several typical industrial processes.

One such process, bottling and canning, often requires that a product be consecutively heated then cooled. It is shown that the heat pump can simultaneously extract heat from the cooling bath and supply hot water to the heating bath with solar supplementation.

In processes where waste heat is not available, TRNSYS and SOLCOST computer analyses indicate that, compared to conventional solar-only systems, solar first-cost reductions of up to 50% are achievable by S-A-T systems.

NOTES

SOLAR PONDS FOR INDUSTRIAL PROCESS HEAT

M. Edesess

K. Brown

T.S. Jayadev

SOLAR PONDS FOR INDUSTRIAL PROCESS HEAT

ABSTRACT

SERI IS CONDUCTING A CONTINUING EFFORT IN THE IDENTIFICATION, CHARACTERIZATION AND ANALYSIS OF VARIOUS PROCESS HEATING APPLICATIONS FOR LOW AND INTERMEDIATE TEMPERATURE SOLAR TECHNOLOGY IN THE INDUSTRIAL SECTOR. THE IDENTIFICATION OF THESE PROSPECTIVE APPLICATIONS INCLUDES CONSIDERATION OF FACTORS SUCH AS ENERGY USE, ENERGY INTENSIVENESS, PLANT DISPERSAL, LOCATION, TEMPERATURE LEVELS, CONSERVATION AND COGENERATION POTENTIAL, AND SO ON. ACTUAL SOLAR SYSTEM PERFORMANCE AND COST EVALUATIONS PROVIDE THE FINAL STEP IN "MATCHING" APPLICATIONS AND SOLAR TECHNOLOGY. FOUR INDUSTRIES HAVE BEEN FOUND TO BE PARTICULARLY ENCOURAGING MARKETS: MEAT-PACKING (STANDARD INDUSTRIAL CODE 2011), FLUID MILK DAIRIES (SIC 2026), BAKING (SIC 205) AND READY-MIX CONCRETE (SIC 3272). DATA ON PROCESSES IN EACH OF THESE INDUSTRIES, INCLUDING INFORMATION ON SPECIFIC PLANTS, WAS USED TO PROVIDE INPUT LOAD REQUIREMENTS TO SOLAR POND IPH SYSTEMS. SOLAR PONDS WERE THEN SIZED TO MEET THE SPECIFIC PROCESS HEAT REQUIREMENT OF EACH OF THESE INDUSTRIES. CLIMATE AND INSOLATION DATA USED IN THE SIZING PROCESS REPRESENT CONDITIONS AT EXISTING PLANT LOCALES. A RANGE OF COSTS FOR EACH SOLAR POND IS DEVELOPED. THE LEVELIZED COST OF DELIVERING PROCESS HEAT TO EACH INDUSTRY IS THEN CALCULATED AND COMPARED WITH THE COSTS OF ALTERNATIVES, INCLUDING OTHER TYPES OF SOLAR COLLECTORS.

NOTES

CASE STUDIES OF POTENTIAL SOLAR INDUSTRIAL PROCESS HEAT APPLICATIONS

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ABSTRACT

A series of industrial process heat (IPH) case studies have been performed by the Solar Energy Research Institute (SERI) on selected plants in the food, metal processing, oil production, commercial laundry, and paint industries. The objectives of the studies were to:

- Understand the processes in sufficient detail to identify industrial energy conservation opportunities;
- Investigate the potential for the use of solar energy in these processes;
- Test the usefulness of the solar IPH analysis software developed at SERI (PROSYS) and identify problems in its application;
- Identify conditions unique to the plant process and site that might be favorable or unfavorable to solar applications.

An examination was made of the application of solar energy to the process as it currently existed after energy conservation measures were included. Where possible, the process was then reconfigured or the process heat transfer medium changed to more readily accommodate solar energy (for example, supply solar hot water directly to a process in place of steam-heated water). Once a solar system had been sized for a particular process, a life-cycle economic analysis was performed for the solar system compared to the conventional energy system currently employed for the process.

As an example, one case study was performed on a crude-oil/water separation facility located in central Wyoming. Based on the analysis performed, three potential solar energy systems were examined. Findings indicated that any one of the three solar systems would be a practical supplement to the existing propane energy system. In addition, all three solar systems were cost effective, with payback periods of 6.5 years or less. All were capable of displacing an average of 5.0×10^8 BTU/year, one-third of the energy used in the existing system.

All case studies performed to date are described, including current energy use, potential energy conservation measures, potential solar energy applications, and the life-cycle cost of the solar energy versus conventional systems.

DH:NC

ABSTRACT

GRI'S SOLAR AUGMENTED APPLICATIONS AND INDUSTRY PROGRAM

Vincent B. Fiore

The Gas Research Institute (GRI) is currently sponsoring work at Insights West in the solar area to identify the ten (10) industrial standard industrial classification's (SIC's) "most likely" to offer an opportunity for effective solar energy use in augmenting natural gas in industry. The research is aimed at providing a much needed data base from which GRI can concentrate its efforts on the most likely candidate for commercialization.

Several low temperature solar augmented industrial applications give promise of reducing first cost, a high level of continuous usage, and a better ratio of energy cost savings to capital investment than in the residential and commercial market places. In an overview of the industrial market, Insights West has seen indications that there may well be a significant market for solar energy in vapor degreasers, part washers, drying ovens, and other equipment used in the heat treating, painting and metal fabrication industries. Applications of this type could supplement the natural gas now used as a fuel and make gas available for higher priority energy uses. An analysis to determine the magnitude of this potential, the operating characteristics of likely industrial applications for solar energy, and the matching characteristics of currently available solar energy systems in use or under near-term development is included in the scope of work being performed.

From an initial screening of national data by SIC code and consultation regionally, priorities are being set with GRI staff for field interviews of processed decision influences. Field interviews of over 200 industrial decision makers are taking place and will verify the technical requirements for energy. The major requirements include the temperature of the process, usage pattern and energy consumption. This will determine the technical needs now, the trends for the future and match existing or soon to be available solar hardware with process requirements. Overriding factors are also being sought out which might negate further technical efforts.

The results of the field interviews along with an updated matching of solar hardware and processes will be charted and ranked in a report and include recommendations identifying those applications most suitable for future developmental programs.

NOTES

LONG TERM AVERAGE PERFORMANCE BENEFITS OF PARABOLIC TROUGH IMPROVEMENTS

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Line-focus parabolic trough concentrating collector systems offer significant potential for supplying industrial process heat. With research and development activity the long-term performance of parabolic troughs will improve. An analytical evaluation is underway at SERI to help identify the research and development activities which will most effectively improve long-term parabolic trough concentrating collector performance.

Parabolic trough long-term energy delivery can be increased with a variety of improvements. Several of these potentially attractive improvements are being considered.

1) Selective Surface Coating Improvements.

2) Increased Long-Term Solar Mirror Reflectance.

3) Reduced Concentrator Slope Errors.

4) Evacuated Receivers.

5) Back-Filled Receivers with Low-Conductivity Gases.

6) Heat Mirror Coated Receiver Glazing.

7) High Transmittance Receiver Glazing.

These particular technological advancements were chosen for initial evaluation because realistic goals for these improvements can be identified. Several of the improvements are currently being pursued with substantial R&D while other improvements are receiving little or no R&D.

The methodology employed in this analysis defines the performance increases of the individual technology advancements in a unique manner because it:

- Evaluates the improvements based on the long-term average performance rather than for a single clear day.

- Considers thermal and optical improvements on an equal basis by evaluating parabolic troughs at their optimal concentration ratio.

- Evaluates each improvement over a range of operating temperatures rather than a single temperature.

Long-term average parabolic trough performance will be determined using long-term average radiation correlations. Evaluating the improvements over the long-term has more significance than an evaluation based on a single clear day.

Both receiver improvements and concentrator improvements are being considered. To accurately evaluate improvements of both types the concentration ratio of the parabolic trough must be known. By evaluating parabolic troughs at their optimal concentration ratio (the concentration ratio that best balances optical losses with thermal losses) receiver improvements can be judged fairly against concentrator improvements.

The merits of the individual improvements may vary with the operating temperature of the collector system. Since industrial process heat requirements span a wide temperature range, this analytical evaluation will consider the effect of the improvements over a range of temperatures.

EFFECT OF CLEANING COST ON PROCESS HEAT FROM LINE FOCUS SOLAR COLLECTORS[1]

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ABSTRACT

The effect of operating and maintenance costs on energy produced by solar collector fields is crucial to the penetration of solar process heat into the energy market. In the present paper, a particular recurrent operation, namely--regular collector cleaning is considered to determine its effect upon life cycle and annualized energy costs. A model of minor surface degradation as a function of time is constructed from actual experimental observations at Albuquerque, NM. A first order degradation is fitted to the experimental data. This is used as an input to a systems optimization model of a line focus solar collector process heat installation. To account for collector field locations other than Albuquerque, both the time constant and asymptotic reflection limit of the mirrored surface are varied parametrically.

The effects upon the life cycle and annualized energy costs as functions of cleaning cost per unit of collector aperture and the cleaning interval are considered. Results are presented for

1 This work was supported by the US Department of Energy.
2 Member of the Technical Staff and Division Supervisor, respectively.

two process heat temperatures and several values of degradation limit and time constant. Finally, the equivalent percentage of initial capital investment which should be charged to this facet of O&M costs is given. This information will help in formulating O&M costs to assume in modeling other generic type solar collector fields.

Insights and Experiences

from the

DOE/Sandia Midtemperature Solar

Systems Test Facility

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March 1979

ABSTRACT

Sandia first became actively interested in solar energy in 1972 with a series of system analyses designed to scope the potential impact of solar energy on energy utilization in the United States and to identify hardware design concepts that offer both technical and economic feasibility in utilizing this renewable energy resource. In 1974, this effort reached the hardware stage with the operation of a solar collector test stand. This program has led to the construction of the Department of Energy/Sandia Midtemperature Solar Systems Test Facility (MSSTF). The MSSTF was established to serve as a national engineering evaluation center for midtemperature range component and subsystem development and system integration.

The years of study, design, hardware construction, testing, and evaluation have provided many insights into effective collection and utilization of solar energy. It is vital that these insights of solar technology be shared with those systems designers, component manufacturers, other researchers, potential users, etc., who will be instrumental in the development of a viable solar energy industry in the private, i.e., nongovernmental, sector. It is the purpose of this paper to present some of the more general, fundamental conclusions which have been drawn. Only those insights that can be supported by actual experience in designing, building, and testing hardware components and subsystems will be presented.

NOTES

SOLAR ECONOMIZERS: THE POTENTIAL FOR SOLAR FEED-WATER PREHEATING IN IPH APPLICATIONS

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For efficiency purpose, fossil-fuel fired boilers should be equipped with exhaust flue-gas recuperators (economizers) to preheat the boiler feed-water. But for practical and economic reason dating back to the time of cheap fuel, packaged steam boilers with output up to 400hp do not include economizers. In the cases where the condensate is not returned to the boiler, or when the make-up water supply is large, there is a need for preheating the boiler feed-water. Solar energy can profitably be used for this task.

The object of this paper is to report our analysis of solar economizers (solar feed-water preheaters), a novel solar IPH application with the potential for cost-effective implementation in a number of existing industrial plants. We will also describe the solar collector that we developed for this application.

The paper covers the following aspects:

1- Thermodynamics of boiler feed-water preheating.
2- Optimization of solar collector field for packaged boiler feed-water preheating.
3- Financial evaluation procedures.

The main practical results are:

*- The ATON 3.4x non-tracking cylindroparabolic concentrator is the most cost-efficient collector for solar feed-water preheating applications.
*- The small solar arrays needed for feed-water preheating can be installed even in plants having limited space.
*- The efficiency of the solar collector is, in terms of fuel savings doubled when the feed-water was previously at ambient temperature.
*- The rate of return on the investment for a solar feed-water preheater may be higher than 25%, with paybacks close to 3 years at today's fuel cost.

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LOW TEMPERATURE INDUSTRIAL PROCESS HEAT FROM NON-CONVECTING SOLAR PONDS

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Large scale industrial implementation of solar energy is currently limited by economics. The delivered cost of solar process heat from systems which do not incorporate ponds is high due to complexity and equipment costs. For industrial processes using low temperature heat, (<100°C), the non-convecting solar pond is a low cost alternative. The non-convecting solar pond has potential costs of $10-$15/square meter under favorable conditions. Presently the installed cost of experimental ponds ranges from $40 to $60 per square meter. Combining collection with storage helps to increase the overall cost-effectiveness of solar ponds relative to IPH systems using other techniques.

Presently existing U.S. pond projects in Ohio, New Mexico and Nevada have demonstrated the use of this technology in climates representative of much of the United States. This paper explains the concepts involved in the successful operation of non-convecting solar ponds, their advantages and their disadvantages.

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Sandia/DOE Solar Total Energy Test Facility

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March 1979

ABSTRACT

A solar total energy system is one that provides electrical power generation along with thermal energy for heating and cooling. This concept may be used for a variety of solar applications which include communities, industrial plants, commercial centers and military installations.

Sandia Laboratories, a prime contractor to the United States Department of Energy, has a leading role related to R&D, design, installation, operation and evaluation of solar total energy subsystems and systems. Consequently, Sandia has established the Midtemperature Solar Systems Test Facility (MSSTF) for the DOE at its Albuquerque, New Mexico, site. This experimental installation serves as a national engineering evaluation center.

The MSSTF is comprised of two separate facilities: (1) the collector module test facility which characterizes troughs and dishes and (2) the solar total energy test facility which is used for system and subsystem development as well as operation and maintenance experience on a total energy system.

This paper will consider the solar total energy facility which consists of solar collector fields, fluid transfer system, thermal storage, Organic Rankine Cycle turbine/generator, and computerized control/data subsystems. Supplementary equipment permits independent operation of each module as well as the capability to partially support a nearby 12,000 square-foot Solar Project Building with power, heating and cooling.

The facility will be described, test results will be presented and the future plans for the facility will be outlined.

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PRELIMINARY DEFINITION AND CHARACTERIZATION OF A SOLAR INDUSTRIAL PROCESS HEAT TECHNOLOGY AND MANUFACTURING PLANT FOR THE YEAR 2000

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ABSTRACT

A solar industrial process heat technology and an associated solar systems manufacturing plant for the year 2000 has been projected, defined, and qualitatively characterized. The technology has been defined for process heat applications requiring temperatures of 300°C or lower, with emphasis on the 150°-300°C range. The selected solar collector technology is a parabolic trough collector of the line-focusing class. The design, structure and material components are based upon existing and anticipated future technological developments in the solar industry. The solar system to be manufactured and assembled within a dedicated manufacturing plant is projected to consist of the collector and the major collector components, including reflector, absorber, parabolic trough structure, support stand, tracking drive mechanism, sun-sensing device and control system, couplings, etc. Major manufacturing processes to be introduced into the year 2000 plant operations are glassmaking, silvering, electroplating and plastic-forming. These operations will generate significant environmental residuals not encountered in present day solar manufacturing plants. Important residuals include chemical vapors, acids, toxic elements (e.g. arsenic), metallic and chemical sludges, fumes from plastics, etc. The location, design, and operations of these sophisticated solar manufacturing plants will have to provide for the management of the environmental residuals. In addition, national level evaluations of the economic and environmental impacts of expanded solar technologies will have to account for these new operations for new solar manufacturing plants that may be located at enlarged or new industrial sites across the nation.

June 1979

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THE IMPLICATIONS OF PRESIDENT CARTER'S 20% SOLAR GOAL ON THE DEVELOPMENT OF INDUSTRIAL PROCESS HEAT SYSTEMS

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President Carter, in his June 20, 1979 address, declared that 20% of domestic energy demand will be supplied by solar energy in the year 2000. MITRE estimates that to achieve this goal will require the development of a large solar industry with annual sales of 47 billion dollars and direct and indirect employment of more than one million persons in the year 2000. The cumulative private and public expenditures necessary for reaching this goal could be as high as one trillion dollars over the next twenty years.

MITRE's analysis, which is part of the National Plan for the Accelerated Commercialization of Solar Energy (NPAC), assumes accelerated research and development activities, large (25-30%) investment tax credits through the turn of the century, and elimination of all legal, regulatory, and institutional barriers. The purpose of the study was to determine what would be required to meet the President's goal; the conclusions are sobering and indicate the enormity of the effort necessary to meet this goal.

A large portion of solar energy production will have to be supplied by solar agricultural and industrial process heat (AIPH) systems. The Domestic Policy Review has estimated that solar AIPH systems could displace 0.18 quads of fossil fuel in 1985 and 2.6 quads in the year 2000. MITRE estimates place these potential solar contributions at 0.24 quads in 1985 and 3.4 quads in 2000. This higher estimate translates into annual production requirements of 175 million square feet in 1985 and over 800 million square feet in the year 2000.

Achieving this level of production in 1985 is an almost impossible task. Production capacity will have to grow 250% per year through 1985 in order to meet projected demand, assuming that one million square feet of production capacity is currently in place. Expansion of production capacity at so rapid a rate is unprecedented in peace time. However, in order to satisfy projected demand for over 800 million square feet in the year 2000, production capacity will have to expand at a rate of only 10.8% per year. The difference in requisite capacity expansion for the two time periods indicates some slippage may occur in meeting the 1985 goals without jeopardizing the long range target ow 2.6 - 3.4 quads or approximately 10.4 - 13.6 billion square feet installed by the year 2000.

Further analysis indicates that the capacity of materials suppliers, i.e., glass refractories, copper smelters, steel and aluminum mills, will have to be expanded in order to meet the 2000 goal. Preliminary estimates indicate enough surplus domestic and foreign capacity to meet projected resource demands by solar hardware manufacturers through the year 1990.

Capital requirements are large, between 80 to 100 billion dollars over the next twenty years (in constant, 1976 dollars). The analysis conducted to date indicates that while this amount of capital could be generated by the industrial sector, the effect on the economy could be negative in the short run, with benefits accruing a few years after the turn of the century.

The conclusion of the study is that it will be difficult and expensive task for both the private sector and the federal government to develop a solar industrial process heat market and infrastructure necessary to meet President Carter's goal.

NOTES

SOLAR SUPPLEMENT TO LAUNDRY DRYING

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A demonstration solar laundry drying system has been designed, built, and operated for eight months on a hospital laundry facility in Fort Collins, Colorado. The system consists of 440 square feet of single glazed flat-plate solar collectors and a rock bed storage unit. The collectors heat outdoor air which is then supplied directly to a commercial dryer or to the rock storage. The heat storage is designed to contain the solar heat for periods up to one-half hour while the dryer unit is turned off and is not intended for night time operation.

The laundry operates during the day shift only and the dryers are operated on cycles which average one-half hour on and fifteen minutes off. Therefore one-third or more of the available solar heat can be stored during normal operation.

June 19, 1979
Submitted in response to Call for Papers for the Solar Industrial Process Heat Conference, October 31-November 2, 1979

NOTES

The Potential for Solar Application

for Process Heat in Arizona

Energy Management and Policy Group

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ABSTRACT

At the University of Arizona a survey of the potential for the use of solar energy in process heat applications within the State of Arizona was performed. The study was done for the Arizona Solar Energy Research Commission and examines the technical and economic characteristics of current process heat users within the industrial, commercial and agricultural sectors of the State. A methodology for analyzing the lifetime costs, energy savings, and cost/benefit ratios for applications of solar technology is presented. The analysis is based on the use of an interactive system simulation computer program and life cycle cost methods.

The results presented include a discussion of the technical characteristics of process heat users and the extent of potential fuel displacement, along with an economic evaluation of representative installations. It is found that the incentives offered to the industrial, commercial and agricultural sector by the State and Federal governments play a major role in determining the economic viability of solar implementations.

NOTES

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Parabolic Trough/Flat Plate Collector Performance Comparison

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ABSTRACT

Surveys of industrial process energy requirements that may be met by the use of solar systems have revealed that approximately 1/3 of the energy applications occur between 150° and 600°F with less than 3% occurring below 150°F.

In the interest of identifying the solar technology which would have the greatest near-term impact over the temperature range which spans many process heat applications, performance comparisons have been made between high-quality flat plate and current quality parabolic trough collectors. The results indicate equal performance at temperatures as low as 110°F for approximately equal cost. The tentative conclusion, based on performance and cost, is that it is reasonable to use parabolic troughs for applications at or near the lower applications temperature as well as for 600°F applications.

NOTES

Central Receiver Solar Energy System for an Oil Refinery

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ABSTRACT

The paper discusses the conceptual design of a central receiver solar energy system that will provide practical and effective use of solar energy for an oil refinery currently being designed by Foster Wheeler Energy Corporation for the Provident Energy Company. The refinery will be built 25 miles southwest of Phoenix, Arizona, and is scheduled to be in operation by 1983. The system will be designed to make maximum use of existing solar thermal technology consistent with existing refinery design and operating techniques, will provide for the best possible economics for the application, and will offer the best combination of solar and fossil-fuel energy.

The design is for a baseline system consisting of a tower-mounted, natural-circulation water/steam receiver with a capacity of 18.4 kg/s (146,000 lb/h). A flat-panel absorber generates saturated steam that is superheated to the desired temperature in a separate, oil-fired superheater prior to admission to the main refinery superheated steam headers. Solar energy is concentrated on the receiver by a field of heliostats north of the tower.

Approximately 99,300 MWht (339×10^9 Btu) of energy annually is generated as saturated steam with this baseline conceptual design. Allowing for an oil-fired superheater efficiency of 84 percent and a boiler efficiency of 81 percent, the proposed solar system displaces about 123,000 MWht (420×10^9 Btu) or about 10,700 m^3 (67,400 barrels) per year of the salable residual fuel oil produced by the refinery.

The annual input from the solar plant of 99,300 MWht (339×10^9 Btu) furnishes 20 percent of the annual refinery steam demand (expressed in energy units) of 506,000 MWht (1.73×10^{12} Btu) based on an average steam load of 21.4 kg/s (170,000 lb/h) throughout the year.

CONTRACTORS POSTER SESSION

CONSTRUCTION OF A SOLAR INDUSTRIAL PROCESS STEAM SYSTEM FOR THE JOHNSON & JOHNSON MANUFACTURING PLANT

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Construction of a solar process steam system system for the Johnson & Johnson manufacturing plant in Sherman, Texas is described. The system consists of 11,520 ft^2 of parabolic trough concentrating collectors, a 5,000 gallon flash boiler, and a 25-hp circulation pump. Pressurized water is circulated through the concentrators, heated to 450°F, and flashed to steam in the flash boiler. The steam is then sent directly to a plant steam main. Specific details of the collector installation are given and general construction experience is summarized. This work was performed under contract to the Department of Energy as part of the Solar Production of Industrial Process Steam Program.

NOTES

An Analysis of the Operation of An Industrial Drying Solar System

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California Polytechnic State University, San Luis Obispo, under the Industrial Process Division of the Department of Energy, assisted by TRW (Eenergy Systems Group) of Redondo Beach, and Pacific Gas and Electric Company, has designed, constructed and is operating an industrial hot air raisin and prune drying system at the Lamanuzzi and Pantaleo Drying Plant in Fresno, California. The solar heating system consists of 1951 m^2 (21,000 sq. ft.) of solar collectors, a 396 m^2 (14,000 cu. ft.) rock storage facility, and a heat recovery unit. The system was placed in operation during the drying season from mid-January, 1979, and supplied about 80% of the heating requirements for one drying tunnel.

This paper describes the operations of the system during its first year of operation and compares the actual operation on a day to day basis to a computer simulation program. Maintenance and material problems encountered during the operating season are discussed together with recommended solutions.

Using cost and performance data derived directly from the operation of the system, an economic analysis has been made to determine the cost, per unit energy of the solar system, and its various components. Also an analysis is made of the energy embodied in the system and the length of time required to recapture this "energy cost".

References

(1) California Polytechnic State University, "Research on the Application of Solar Energy to Industrial Drying or Dehydration Processes", (Final Phase I Report-Design, California Polytechnic State University, San Luis Obispo, California, March, 1977).

(2) (Final Phase II Report-Construction, California Polytechnic State University, San Luis Obispo, California, September 1978).

NOTES

SOLAR PRODUCTION OF INDUSTRIAL PROCESS STEAM FOR POTATO FRYING

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ABSTRACT

TRW is developing the application of solar industrial process heat to food processing at the Ore-Ida Foods plant in Ontario, Oregon, under the auspices of the Department of Energy. In the just completed Phase I, conceptual design studies and the detail design of the system were performed. The end use of the energy is steam at 417°F, 300 psi, heating oil through a heat exchanger to fry potatoes.

The conceptual design study reviewed three methods of producing the steam. These included use of a heat transfer fluid and unfired steam generators, a pressurized water system with an unfired steam generator and a pressurized water flash steam system. The economics of the three systems were examined on both a first cost and life cycle cost basis.

The system selected consists of high efficiency, parabolic trough concentrating collectors generating hot water at 480°F feeding a flash tank which generates steam at 417°F. The steam from the flash tank interfaces with the plant process steam through a simple connection into the steam lines. The design of the system is modular such that it can be augmented to provide whatever requirements are desired. Application to any industrial process using fossil-fired boilers to produce steam is easily accomplished.

Current activities include construction of a 10,000 sq ft array of collectors on the roof of the Ore-Ida potato processing plant. Construction will be completed in June 1980. This system is expected to collect 2.6×10^9 Btu of energy which will produce a net of 1.9×10^9 Btu/year of steam, equivalent to 2.3×10^6 cu ft of natural gas. Production schedules in the plant will result in a steam consumption of 1.3×10^9 Btu/year.

NOTES

SOLAR PRODUCTION OF INDUSTRIAL PROCESS STEAM FOR THE LONE STAR BREWERY

by

Danny M. Deffenbaugh

ABSTRACT

The objective of this research and development project is to design, construct, and operate a demonstration system to interface a solar energy conversion system with the present industrial steam process at the Lone Star Brewing Co. This solar energy system will apply solar state-of-the-art components and technology to the industrial process to determine the technical and economic feasibility of producing low pressure steam.

The industrial process at Lone Star Brewery has a steam requirement of 125 psi and 351°F at approximately 50,000 lb/hr. This steam is currently provided by boilers fired with natural gas with diesel fuel burners installed for use as a supplement when required. This brewery is located in San Antonio, Texas where the climate is ideal for solar applications.

The system will be composed of a solar collector array, a closed-loop heat transfer fluid system, an unfired steam boiler, a steam line with a check valve connected to the existing main steam, and a boiler feed line connected to the existing condensate treatment plant. The solar collector array will be 9450 ft^2 of parabolic-trough concentrating solar collectors manufactured by Solar Kinetics, Inc. mounted on a warehouse roof directly above the existing main steam line into which the solar produced steam will be injected. This placement minimizes the piping required to convey the solar heated fluid to the boiler, thereby minimizing the piping cost and maximizing the system performance.

Since this will be a demonstration system, the contribution of energy provided by solar energy will be small by design, so that the interaction with the current process can be investigated without any reduction in industrial production. In addition, special equipment will be installed that would not be necessary in a standard solar process steam system. This equipment will be a data collection system to obtain performance data for a system evaluation.

NOTES

APPLICATION OF SOLAR ENERGY TO THE DEHYDRATION OF ONIONS AND GARLIC
GILROY SOLAR PROJECT - INITIAL OPERATION AND EVALUATION

B. J. Graham, P. D. Sierer, Jr., Trident Engineering Associates, Inc.
David Powell, Gilroy Foods Company, Inc.

* *

The Gilroy Foods Solar Project, Gilroy, California, was constructed during the winter/spring of 1979. The system went into initial operation in mid-June 1979 and full operation in early July 1979. The system is composed of approximately 6000 square feet of evacuated tube collectors. Solar heated hot water at 200°F preheats inlet air to an onion dehydrator, reducing process requirements for natural gas, the normal fuel supply. The paper describes the construction period, the initial test and operation period, and provides a preliminary evaluation of performance for the first few months of full system operation.

NOTES

Systems Analysis of a Solar Industrial Process Steam Concentrating System

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ABSTRACT

The systems analysis of a solar steam system is presented. The solar system is designed to generate industrial process steam at 150 lb/in^2 gage for Dow Chemical Company's Latex Manufacturing Plant located at Dalton, Georgia. The project, funded by the U.S. Department of Energy, is intended to develop a demonstration unit consisting of 10,000 ft^2 of solar collector surface area.

The objectives of the paper are twofold:

- To describe an economic model developed specifically for use in the systems analysis of solar steam systems
- To discuss the systems analysis and optimization of the Dow solar steam system.

The economic model uses the annualized cost of a unit of fossil-fuel displaced by the solar system as the cost-effectiveness parameter. The different factors that must be taken into account in developing this cost-effectiveness parameter are discussed.

The concept selected for the detail systems analysis uses an intermediate heat-transfer fluid in the primary loop. The hot fluid from the solar collectors is taken to a boiler which is utilized for steam generation. The heat-transfer fluid from the boiler is recirculated via a pump through the collectors. Suntec Systems parabolic trough collectors are used in the system.

The design decision parameters considered in the systems analysis include collector orientation, collector spacing, type of heat-transfer fluid, operating temperatures, pipe size, and fluid loop control method. The results of the systems analysis are discussed, and the predicted performance of the designed system is presented.

NOTES

SOLAR AUGMENTED SOYBEAN DRYING

(For: Industrial Process Heat Conference)

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ABSTRACT

The objective of this overall project was to provide for the analysis, design, fabrication, and demonstration of a solar energy system for process drying of soybeans. The system consists of an array of 672 air collectors that preheat the inlet air to existing continuous-flow dryers at the Gold Kist Soy facility at Decatur, Alabama. This experimental system, sponsored by DOE, has been operational since June 1, 1978. Due to soybean process equipment maintenance, a system utilization of only 46.4% was achieved. The 1,215 m^2 (13104 ft^2) system delivered 0.867TJ (822.5 x 10^6 BTU) or 1.3% of the energy requirement for one dryer in the first year of operation. This paper, oriented to Phase III, Performance Evaluation, will describe the facility, the first year of operation and present performance operational, and life cycle cost analyses.

NOTES

DESIGN AND ANALYSIS OF A SOLAR INDUSTRIAL
PROCESS HEAT SYSTEM FOR ERGON, INC.

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This paper describes the design and analysis of a solar process heat system for the ERGON, Inc., Mobile, Alabama, Bulk Oil Terminal. The system will supply process heat (130^{o}F to 190^{o}F) to high-viscosity oils so they can be pumped into and out of the bulk terminal. The system design, selected from 3 candidate approaches, was optimized to deliver the maximum energy at the lowest cost. The detailed design emphasizes simplicity, off-the-shelf hardware, and a standardized layout.

The system consists of 20,160 ft^2 of parabolic trough concentrating collectors that heat a synthetic heat transfer oil to a maximum of 500°F. This hot fluid is then sent directly to existing heat exchangers located within bulk oil storage tanks. This process heat is currently supplied either by 365°F steam or 400 to 500°F heat transfer oil generated in conventional fossil fuel boilers.

Environmental, safety and economic issues concerning the solar energy system are also investigated and reported. This work was performed under contract to the Department of Energy, as part of the Solar Production of Industrial Process Heat (300 to 550^{o}F) Program.

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- ABSTRACT -

TEXTILE DRYING AT WESTPOINT PEPPERELL USING SOLARIZED CAN DRYERS

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A solar process steam system for providing process heat to a textile drying process has been designed and installed at the WestPoint Pepperell MARTEX towel mill in Fairfax, Ala. The system consists of five major subsystems: the collector field, the high temperature water loop, the steam generator, the steam loop, and the process. The collector field consists of 24 parabolic trough, single axis tracking, concentrating collectors. The high temperature water loop is the piping which transports the solar energy from the collector field to the steam generator. The steam generator is a commercially available unfired package boiler. The steam loop is the piping which transports the solar steam to the process, and returns the condesate back to the boiler as feedwater. The process being solarized is a line of "slashers" which use steam heated drying cans to dry the textiles.

The system is designed to generate $380^{o}F$ water at the collector outlet to feed the steam generator. The steam generator will provide 76 psi ($320^{o}F$) steam to the process. Under peak insolation conditions, the system is expected to deliver 1,000 lbs. of steam to the process. Computer simulations using local weather data indicate that the system will deliver about 10^{9} Btus to the process annually.

- ABSTRACT -

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OPERATIONAL RESULTS OF THE LAFRANCE, SOUTH CAROLINA SOLAR PROCESS HOT WATER SYSTEM

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ABSTRACT

Installation of the LaFrance solar energy process hot water system was completed in June 1978 at Riegel Textile Corporation's LaFrance, South Carolina dyeing and finishing plant. The primary objective of this DOE-sponsored project is to evaluate the performance of the solar heated process hot water system used for dyeing fabrics. The ultimate goal is to assess the energy savings and economic potential for solar process hot water for the textile industry and to undertake actions that will promote the utilization of solar energy systems throughout the industry.

The LaFrance solar energy process hot water system consists of three principal hydronic sections. The first is a 6800 square foot solar collector field containing 396 General Electric TC-100 evacuated tube collectors utilizing an ethylene-glycol and water solution that transfers heat through a heat exchanger to the thermal energy storage loop. The second is the thermal energy storage loop which circulates water through an 8000 gallon thermal energy storage tank and transfers energy from the collector loop to the application loop. The third is the application loop which includes an open 1100 gallon atmospheric dyeing tank (dye beck). The dye solution in the third loop is heated to 190°F through a heat exchanger which extracts heat from the thermal energy storage loop.

The LaFrance solar energy system began operation on June 15, 1978. Since then, operation has been continuous, except for brief periods during which either the system automatically shut itself down as a result of an abnormal temperature condition, or it was shut down manually because of the need to make control system adjustments and instrumentation changes.

The operational history of the system is most clearly described in terms of three periods: start-up, operational "shake-down and debug", and routine performance.

The start-up period was characterized by an absence of major problems. However, there were several conditions needing adjustment. For example, a leaky steam valve, a malfunctioning pressure switch and leaking collector fittings were replaced.

During the shake-down period the system atuomatically shut itself off several times as a result of either excessive temperature or pressure. In these occurrences the primary fluid contents of the collector loop were discharged into a holding tank in accordance with a pre-programmed emergency control mode. Subsequent addition of a temperature sensor in the collector loop, plus adjustment of the circuitry controlling the pressure switches and temperature sensors have eliminated this problem.

The third, or performance phase, encompasses a period of thermal energy balance measurements throughout the system. Total system efficiency measurements, together with isolation and measurements of individual losses, were made during this period. Summary data and analyses are presented which give values of system efficiency for a variety of conditions with respect to solar and environmental conditions.

SOLAR PRODUCTION OF LOW PRESSURE STEAM FOR PROCESSING OF ORANGE JUICE

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ABSTRACT

This presentation summarizes the design and analysis of a solar low pressure process steam system for processing orange juice at the Tropicana Industries plant located in Bradenton, Florida. The objective of this project is to evaluate the potential of solar generated steam for supplying a significant fraction of the energy required by the citrus industry for juice processing.

The selection of the specific application, juice processing, and a solar energy system design to provide process steam was based on the following requirements:

- Application which is generally adaptable for a wide spectrum of industries
- Simple system design
- Simple rugged collector with high reliability and potential for low cost mass production
- Design compatible with economic requirements for future low cost solar energy steam systems

The principal use of solar energy is for thawing large blocks of orange juice held in cold storage at -32°C (-25°F). This operation is used five days per week at Tropicana. During weekends the collected energy will be used to remove moisture from a glycol concentrator unit used for cold storage refrigeration.

Since this is a 7 day a week application and can use all the solar energy provided at any time, there is no need for thermal storage. This results in a simpler system design, together with some improvement in overall efficiency.

The system design includes a heat exchanger through which circulates the primary collector loop fluid (water) at 204°C (400°F) to boil water for processing steam in a 66 liter (250 gallon) ASME rated tank. The steam from the solar heated boiler is piped to the thawing/dehumidification processes that are located some 244 meters (800 feet) from the boiler.

The General Electric TC-300 concentrating collector was selected, because it does not require tracking, resulting in a simpler, highly reliable system. The collectors are to be manually adjusted each season, four times per year, to maintain an overall efficiency that is within 2% of that obtained by continuous tracking. The collector area is 929 square meters (10,000 square feet).

Both system performance results based on design analysis and a TC-300 collector performance based on measurements are reviewed.

A CONCENTRATING COLLECTOR SYSTEM DESIGNED FOR THE STAUFFER CHEMICAL CORPORATION IN HENDERSON, NEVADA

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ABSTRACT

Our presentation will describe the major features of a 10,592 ft^2 concentrating collector system which we have designed for the Stauffer Chemical Corporation in Henderson, Nevada, The system is expected to provide a peak saturated steam flow delivery of 1,500 lbm/hr at 368°F. The paper will outline the characteristics and constraints of the proposed site, results of transient computer modeling of the system, and the key hardware problems which were addressed in the design, Interestingly, if selected for Phase-II funding, the project is likely to be the first commercial application using sagged glass reflector surfaces for the concentrating collector modules.

NOTES

Solar Industrial Process Hot Water For Concrete Block Manufacture

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ABSTRACT

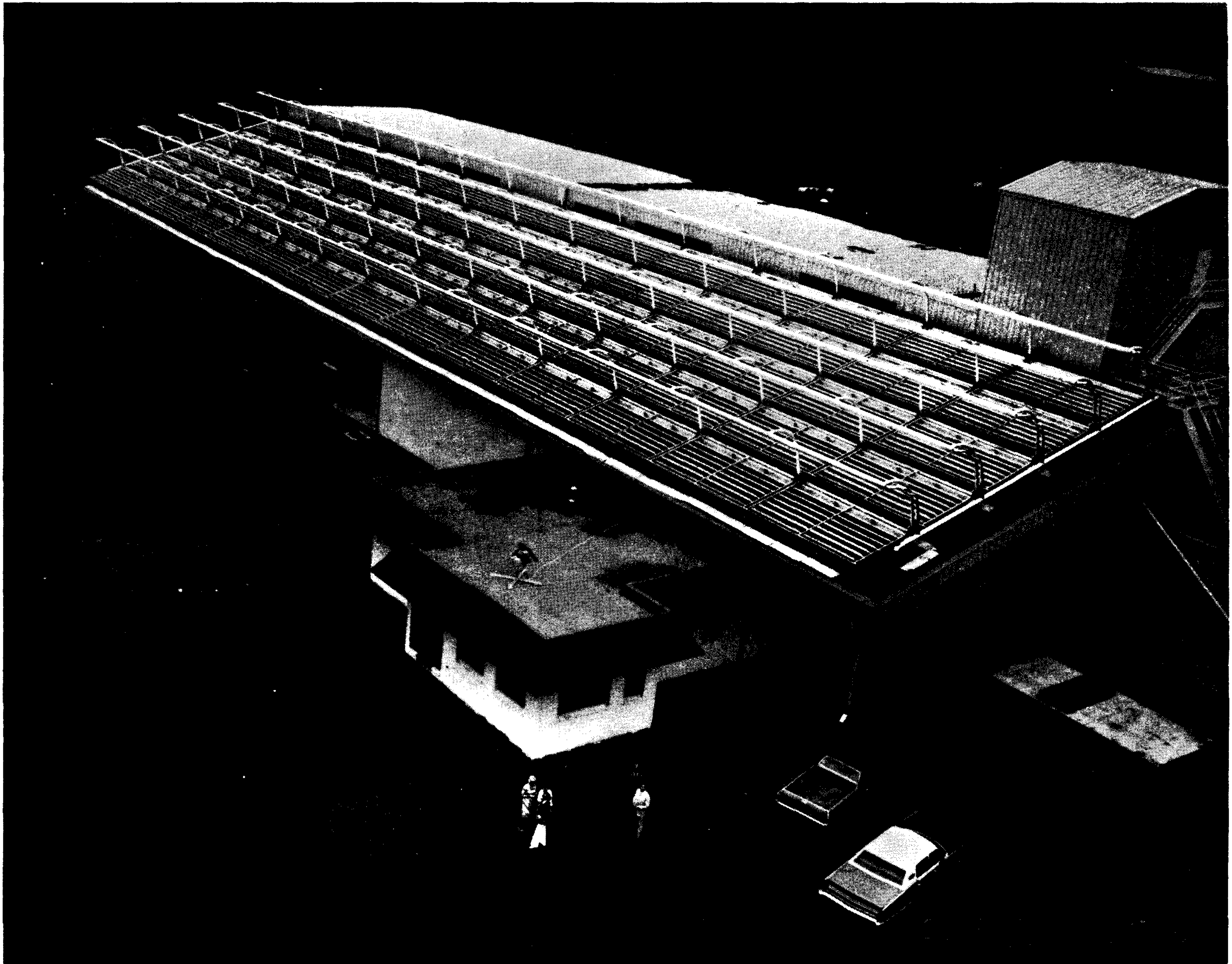
AAI Corporation is currently conducting the Operation and Evaluation Phase of a contract to design, manufacture, and test a solar-assisted hot water system for curing concrete blocks. The collector system consists of 856 meter^2 (9216 ft^2) of AAI's Concentrating Collector. The solar array consists of 70 modular collectors with a concentration ratio of 24 to 1. Each module contains 16 one-foot wide mirror strips which track the sun's movement and keep the reflection concentrated on a fixed receiver. Water circulating through the receiver is heated to 200°F and through a heat exchanger, maintains the desired water temperature.

The collector array is mounted on the roof of the new block manufacturing plant near Harrisburg, Pa., owned by the York Building Products Co., Inc.

Curing of the blocks takes place in an underground, donut-shaped concrete tank which is 120 ft. in diameter and holds 55,000 gallons of hot water. A steel boat, floating in the 180°F water, contains racks of green (uncured) concrete blocks. The high temperature and humidity cure the green blocks within the slowly rotating boat.

Initial testing indicates that the system is operating close to its design goals and will supply over thirty percent of the curing energy.

Modern manufacture of concrete blocks requires large quantities of hot water for curing. It has been estimated that, nationwide, 1,300,000 barrels of fuel oil each year are used for this purpose - using enough oil to heat 1000 homes in the mid-Atlantic area for over 50 years.



ONE YEAR OF OPERATING EXPERIENCE AT THE CAMPBELL SOUP SOLAR HOT WATER FACILITY

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This paper describes the operating experience and performance data gathered over one year of operation of the solar hot water facility at the Campbell Soup Company, Sacramento, California. The facility was designed and installed by Acurex Corporation. At the facility, solar-heated water is used to wash both empty and full soup cans on two of twenty parallel can washing lines.

The design consists of 4,700 ft^2 of single-glazed non-selective flat-plate and 2,880 ft^2 of parabolic-trough concentrating collectors. Water is preheated to 140^{0}F in the flat-plate collectors and then heated to 195^{0}F in the concentrators. Heated water flows into a 20,000 gallon storage vessel where it is pumped to the can-washing line on demand. Operation and maintenance experience is discussed and performance data presented. This work was performed under contract to the Department of Energy as part of the Solar Production of Industrial Process Hot Water Program.

SOLAR ENERGY IN THE OIL PATCH

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ABSTRACT

Southern Union Refining Company's Famariss Energy Refinery will demonstrate that a significant portion of the energy used to generate steam required in the refining of crude oil can be supplied using solar energy. The solar energy system to generate high temperature steam required was designed and is being built by Monument Solar Corporation of Dallas, Texas under a contract with the U.S. Department of Energy.

There is a continual need for high temperature steam at this refinery covering 24 hours each day for 7 days each week. The steam required is approximately 20,000 pounds per hour of 170 psig., 380°F steam. Crude oil is received at the refinery and stored in either "sweet" or "sour" tankage where it is then pumped to the process area in appropriate proportions required for the refining operation. The incoming crude absorbs heat from atmospheric tower overhead vapors, product streams and pump-arounds before final heating in the crude heater.

The solar energy system utilizes parabolic concentrators manufactured by Solar Kinetics, Inc., Dallas, Texas. The solar array consists of 12 modular collector subarrays of 6 collectors each. Each collector is 20 feet long by 7 feet wide with each subarray having an overall length of 120 feet. The receiver is a carbon steel tube with black chrome selective surface, mounted in a pyrex glass jacket for insulation. Oil, under elevated pressure is forced through the interconnecting tubes of the collector array and heated to 500°F and, through a heat exchanger, produces steam at the required 380°F, 170 psig level for the refinery process.

Major subcontractors on this program are Bridgers and Paxton Consulting Engineers, Albuquerque, New Mexico and the New Mexico Solar Energy Institute, Las Cruces, New Mexico.