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PLANT FOR THE YEAR 2000.

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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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Introduction

The US Department of Energy (DOE) is engaged in policy, planning and program efforts to commercialize solar energy technologies for numerous residential, commercial, agricultural, and industrial applications throughout the United States and the world. This project on solar industrial process heat was conducted by Western Energy Planners, Ltd. for the Energy Systems and Economic Analysis Group of Los Alamos Scientific Laboratory (LASL). LASL was the lead DOE national laboratory in FY 1978 for the Technology Assessment of Solar Energy (TASSE) program, with funding from the DOE Assistant Secretary for Environment (ASEV). This study is one of several solar energy technology characterizations prepared by the DOE national laboratories.

The primary objective of the study was to define and characterize qualitatively a prospective solar industrial process heat technology (for temperatures of 500°C and lower) and its associated manufacturing plant for the year 2000. The year 2000 is a key milestone in the DOE solar energy commercialization plan. For both solar utilization planning and environmental assessment, it represents a time distant enough that new economies, new energy technologies, and new environmental perspectives are likely to be in place. Therefore, this study required that solar energy for process heat be examined from a perspective that applications, technologies, and manufacturing methods which exist today will influence the year 2000, but that significant changes are expected to occur over the forthcoming twenty years.

The detailed approach for the study consisted of the following tasks:

1. Review of the state-of-the-art solar technology for industrial process heat applications;
2. Evaluation of solar collector technologies for high temperature (> 500°C) process heat applications;
3. Definition of a prospective concentrating collector technology for future process heat applications;
4. Characterization of a complete solar industrial process heat system for manufacture;
5. Definition and characterization of the manufacturing plant and operations required to fabricate, assemble and package the solar system for distribution; and
6. Identification of the manufacturing requirements (energy, materials, manpower, etc.) and environmental residuals associated with the production of the solar system.

This study has not quantified the requirements and residuals for the solar industrial process heat technology and manufacturing plant. It has only provided the qualitative description of the prospective technology and factory for the year 2000. A qualitative characterization is necessary and desirable if the total environmental assessment of future solar technologies that is sought by DOE/ASEV is to be accomplished.

Industrial Process Heat Applications

The specification of a solar industrial process heat technology applicable to temperature requirements equal to or less than 300°C is based upon independent studies. Process heat constitutes 68.4% of industrial energy use in the United States. Twenty-seven percent of that process heat is at temperatures below 258°C and low pressure steam represents 80% of the steam requirements in industry. Hence, a prime market exists for a moderate temperature, steam-producing solar process heat technology.

Solar Collector Technologies

Five basic solar collector types were examined for the selection of a collector technology suitable for the characterization of current technology and manufacturing procedures, as follows: flat plate, external tube, line focusing, point-focusing, and heliostat power towers. The parabolic trough line-focusing collector was chosen for characterization. It is the first choice in current industrial applications and commercialization efforts. It offers considerable flexibility for matching with process heat requirements and for installation. The parabolic trough collector both needs and offers many technological improvements. Its requirement for large cylindrical reflective surfaces shaped to a parabolic configuration will offer considerable opportunity for new and sophisticated materials and manufacturing processes. It also offers a comparison of alternative materials for the basic elements (i.e., glass vs. metal vs. plastic). The basic elements of a parabolic trough collector consist of the reflector material, reflector support structure, receiver, receiver insulation, and the receiver cover. It is the first four of these elements which most uniquely differentiate the parabolic trough collector and which account for the variability in manufacturing procedures.

Reflector Material: Reflector materials are still being developed by manufacturers and researchers and demand a definite need for a low cost, high efficiency material on a commercial scale of production. The three primary reflector materials are glass, metals, and plastics. Thin glass offers the greatest potential for providing a hard, thin protective coating to a silvered surface. It can be bent to fit a parabolic shape without the need for sagging under heat. However, since the glass is thin, handling presents a difficult problem. Production techniques are required in which the glass is produced, silvered, and placed on a parabolic trough support structure in a continuous operation.

Parabolic Trough Support: The parabolic trough support structure is a major materials item in the collector assembly. The structure offers opportunities for reduction in cost and for fast mass production operations. The material chosen for this study is the Sheet Molding Compound. It represents a low cost production capability and offers a reduction in components (i.e., fittings, etc.) in the assembly. However, it is also representative of materials which will have a tendency to escalate in price as conventional fuel costs increase. It should be recognized that improvements in technology and manufacturing techniques will be required if this material is to be used.

Absorber: The absorber must be able to contain liquid at high pressure (100 - 1000 psia) and at high temperature (300°C and higher). In addition, heat losses at the high temperatures must be minimized. The absorber material selected consists of steel pipe which will be nickel plated, and then black chromed. The steel offers low cost properties and the black chrome process is an established method. However, some black chrome processes will require improvement and better quality control for this material to remain a competitor.

Definition of Solar Industrial Process Heat System

The design and type of solar systems depend on several key factors. Some of these factors include the level of temperature required, the quantity of heat delivered, the tolerance of temperature fluctuations in the process application, the heat transfer method (steam, hot air, direct process, hot water), and the nature of the process with respect to its use on a continuous or intermittent basis. Components such as collectors, heat storage, heat exchange equipment, and controls must be matched to the process heat application to provide efficient integration of the systems. Some of the components require special design to be used in the solar system while others are components used in all types of industrial applications.

Typical Description of Manufacturing Plant

It is assumed that manufacturers parabolic trough collectors would have to be a large scale operation to produce a profitable and competitively priced unit. A plant capable of producing ten million square feet of collector per year would be a large operation. The larger plants are more likely to carry out several manufacturing processes. A plant capable of producing ten million square feet of collector would certainly contain several manufacturing operations.

The plant characterized in this study is considered to be a large capacity plant that manufactures parabolic trough collectors. It could easily add other types of line-focusing and point-focusing collectors to its production activity. A large operation would benefit from having most of the collector manufacturing carried out within the plant. For example, to manufacture parabolic trough support structures it would be advantageous to manufacture all specialty items within the factory to allow for a well-planned manufacturing process.

Based upon the actual design of the collector, it would require several different special components and materials. These include a glass reflector, Sheet Molding Compound, black chromed absorber tubes, sensors and controls, and the tracking drive mechanics. All these items would require an expanded and continuous manufacturing operation, unlike those being carried out in the solar collector industry today.

An analysis of the manufacturing techniques required indicates that the glass making, silvering, and mounting to a parabolic trough shape should be carried out in one continuous process to avoid excessive handling.

Requirements for the Solar Manufacturing Plant

The characterized plant contains a representative sampling of the materials, manpower and energy requirements for a solar manufacturing

operation. Raw materials would be required for the glass making, plastic molding, silvering, and electroplating processes. Structural materials such as steel and aluminum would be required, as well as a large variety of components and parts for the fabrication operations. With the large quantities of raw materials required for the glass operation, it is likely that the plant will require railroad spurs and bulk storage facilities for such items as sand, soda ash, cullet, and lime. Other bulk materials, but used in lesser quantities, include chemical ingredients for silvering, electroplating, painting, and plastics-forming, and components and parts which would be used in the assembly operations (e.g., fasteners, bearings, fittings, hydraulic components, electronic parts, etc.). These materials would require warehousing and an inventory procedure.

Other inputs to the factory operation include electricity, process heat, vehicle fuel, and labor.

Environmental Residuals from the Manufacturing Plant

The actual environmental residuals for the plant depend on the manufacturing process. If this plant were characterized as following existing manufacturing plants models, then the residuals would be negligible. Operations such as glass making, electroplating and silvering are not presently being conducted in the solar industry, but are being performed by other diverse specialty industries. The proposed scale of operation with the small process and material requirements indicated, would probably create minor process residuals. Such operations require more energy and materials than most solar process residuals. The totality of the manufacturing process would be negligible as compared to light industry. The residuals from the manufacturing process are discussed below.

The primary residuals produced from the glass making operation are air pollutants. They are generally the products of combustion and vaporization of raw materials and ingredients. Certain of these pollutants must be reduced by the use of scrubbers, bag houses, venturi cyclones, or electrostatic precipitators. The pollutants include sulfur oxides, nitrous oxides, organics, hydrogen fluoride, hydrogen chloride, carbon monoxide and particulation. The specific pollutants and quantities would vary depending on the properties of the glass.

Electroplating produces both liquid residuals and airborne materials. During the cleaning and electroplating operations, vapors and mist are generated which must be controlled for the safety of workers and for air pollution standards. Mist or vapors originate from hydrochloric acid, alkaline solutions, nickel sulfate and chromic acid. These vapors must be vented out of the building or collected in a liquid solution. Liquid wastes generated from electroplating must also be treated to avoid pollution. Generally the waste material which comes from the processes are: (1) acids or alkaline solutions which must be neutralized, (2) metals which must be precipitated out and recovered, and (3) toxic chemicals which must be reduced to a harmless substance.

The detoxification, chemical reduction, neutralizing and metal recovery operations require that a waste water treatment system be installed at the plant site. The effluent from this plant will need to meet the strict water pollution control standards set by the Environmental Protection Agency.

The silvering operations have few residuals that contaminate the air. However, some minor treatment of the liquids and over-spray is required to

either neutralize the liquids or remove silver or copper from the waste water. Airborne fumes are the main concern of air in this process. Venting the fumes is the usual procedure. The liquid residuals from this process originate with the cleaning solutions, aqueous fluoride and overspray from the chemicals.

Plastic forming has few residuals. During the mixing of the compound and the molding process vapors are released into the air. This necessitates an exhaust system to reduce any harmful effects to the workers. There are no liquid residuals associated with this process besides the insignificant amounts which may occur due to spills.

Conclusion

The findings and projections of this preliminary definition and conceptualization of a solar industrial process heat technology and manufacturing plant for the year 2000 indicate that the technology and the manufacturing would be significantly more sophisticated and expanded than exists in the solar industry today. The solar process heat technology is projected to be a parabolic trough collector system and to utilize a combination of known and projected materials and components under current development. The manufacturing operations are projected to include glass-making, silvering, sheeting, etching and plastic forming, which, while standard industrial technology, will be additive to or expansions of existing solar manufacturing technology. The projected operations for the year 2000 solar facility will contribute to environmental residuals which will need to be managed and controlled in accordance with local, state and federal environmental standards. It is projected that the solar industrial process heat technology and manufacturing plant will be a significant contributor to the growth of solar energy utilization.