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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 (TASE) 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 300°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 [illegible] which exist today will influence the year 2000, but that significant developments [illegible] expected to occur over the forthcoming twenty years.

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

- [illegible]
- [illegible] of solar collector technologies for high temperature ([illegible]) process heat applications;
- Definition of a prospective concentrating collector technology for future process heat applications;
- Characterization of a complete solar industrial process heat system for manufacture;
- Definition and characterization of the manufacturing plant and operations required to fabricate, assemble and package the solar system for distribution; and
- 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 288°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, evacuated tube, line-focusing, point-focusing, and heliostat power tower. The parabolic trough line-focusing collector was chosen for characterization. It is the [illegible] in current industrial applications and commercialization efforts. It offers considerable flexibility for matching with process heat [illegible] and for installation. The parabolic trough collector both needs [illegible] technological improvements. Its requirement for large unit [illegible] reflective surface shaped to a parabolic configuration will offer [illegible] opportunity for new and sophisticated materials and manufacturing processes. It also offers a comparison of alternative materials for the basic [illegible] (e.g., glass vs. metal vs. plastic). The basic elements of a parabolic trough collector consist of the reflector material, reflector [illegible] receiver insulation, [illegible]

[illegible] It is the first four of these elements which most uniquely define the parabolic trough collector and which account for the variability in materials and manufacturing processes.

Reflector Materials: 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 glasses, 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 ap[illegible], the heat transfer method (steam, hot air, direct process, hot wat[illegible] the nature of the process with respect to its use on a continuous or [illegible] basis. Components such as collectors, heat storage, heat [illegible] equipment, and controls must be matched to the process heat [illegible] to provide efficient integration of the systems. Some of the [illegible] special design to be used in the solar system while others [illegible] used in all types of industrial applications.

[illegible] of Manufacturing Plant

[illegible] parabolic trough collectors would have to be a [illegible] to produce a profitable and competitively priced unit. A [illegible] million square feet of collector [illegible]

[illegible] used elsewhere. The larger plants are more likely to carry [illegible] manufacturing processes. A plant capable of producing ten million [illegible] of collector would certainly contain several manufacturing operat[illegible].

The p[illegible] characterized in this study is considered to be a large capacity [illegible] that manufactures parabolic trough collectors. It could easily add other types of line-focusing and point-focusing collectors to its producti[illegible]. 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 mass production 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, sun-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 fuels, and labor.

[illegible] Residuals from the Manufacturing Plant

[illegible] actual environmental residuals for the plant depend on the [illegible] process. If this plant were characterized as following existing [illegible] manufacturing plants models, then the residuals would be [illegible]. Operations such as glass making, electroplating and silvering are not [illegible] being conducted in the solar industry, but are being performed by [illegible] specialty industries. The proposed scale of operation with [illegible] process and material requirements indicated, would probably [illegible] processes [illegible]. Such operations require more energy and [illegible] residuals. The totality of the manufacturing [illegible] light [illegible]

[illegible]

[illegible] primary residuals produced from the glass making operation are air pollutants. [illegible] are generally the products of combustion and vaporization of [illegible] ingredients. Certain of these pollutants must be reduced by the [illegible] scrubbers, bag houses, venturi cyclones, or electrostatic precipitators. The pollutants include sulfur oxides, nitrous oxides, organics, hydrogen fluoride, hydrogen chloride, carbon monoxide and particulates. 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 overspray is required to either neutralize the liquids or remove silver or copper from the waste water. Ammonia fumes are the main contaminant of air in this process. Venting the fumes is the usual procedure. The liquid residuals from this process originate with the cleaning solutions, stannous 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 [illegible]ization of a solar industrial process heat technology and [illegible] plant for the year 2000 indicate that the technology and the [illegible] would be significantly more sophisticated and expanded than [illegible] in the solar industry today. The solar process heat technology is [illegible] a parabolic trough collector system and to utilize a combination [illegible] materials and components under current development. The [illegible] operations are projected to include glass-making, silvering, [illegible] and plastic forming, which, while standard industrial [illegible] will be additions to or expansions of existing solar manufacturing [illegible] integrated operations for the year 2000 solar facility will [illegible] environmental residuals which will need to be managed and [illegible] local, state and federal environmental standards. The [illegible]

[illegible] to the [illegible] of solar energy utilization.