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Project Summary

Preliminary Assessment of the Use of Heat Transfer Fluids for Solar Thermal Energy Systems

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This report contains a preliminary assessment, based on available data, of the extent to which various materials will be used as heat transfer media in solar energy systems and of mechanisms for their release to the environment. The emphasis is on solar thermal energy systems for industrial, agricultural and electrical production applications over the next 5-10 years. The study provides an assessment of consequences associated with transport and fate of the materials in the environment, identifies available pollution control techniques, and cites areas where further research may be required.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Over the next 5 to 10 years, the potential exists for widespread deployment of concentrating solar thermal energy systems using high molecular weight hydrocarbons, silicone oils, and other heat transfer agents. The use of such materials could result in significant insult to the environment if leaks, spills, or other releases occurred. The purpose of the present study is to assemble background information on the anticipated use of heat transfer fluids in solar energy systems and to determine pathways by which fluids could enter the environment.

The report describes the types of concentrating solar energy collectors that are likely to be used during the 1980s and 1990s and the conventional energy systems which they may replace. Emphasis is placed on solar collectors operating at temperatures above 100°C, because they frequently require special heat transfer fluids.

The study determined the extent to which solar energy development would result in increased production of heat transfer fluids. It also identified the rates at which leaks and spills could occur during the manufacture, transport, use, and disposal of these fluids and compared these rates with those for general use of heat transfer fluids. In addition, the study analyzed transport mechanisms for fluids once they entered the environment and existing techniques for controlling fluid release. The study did not examine the toxicity of heat transfer fluids.

Findings and Conclusions

Estimates of Solar Thermal System Development

It is projected that the primary United States markets for solar thermal applications will require approximately 6.5 x 10^{17} joules (0.62 quads) of energy annually in the latter half of the 1980s. Of this, the greatest demand is expected for supplying electricity to displace peak-load gas and oil units. Some demand is anticipated in southern California for enhanced oil recovery. During the 1990s, it is estimated that solar thermal applications will supply 1.2 x 10^{18} joules of electric power and 1.0 x 10^{18} *joules of industrial* process heat (IPH). Siting of these facilities will be predominately in the

Southwest and Hawaii, although some plants may be installed in the South and Southeast.

During the 1980s and 1990s, it is expected that water and water/glycol-based heat transfer fluids will be displaced by hydrocarbon and silicone oils as the chief heat transfer fluids. Some electric generating stations may use molten salts or liquid sodium.

The extent to which solar thermal energy development will place a strain on current production of heat transfer fluids is dependent upon the types of fluids used and upon how rapidly the energy technology is deployed. The projected demand of 1.0×10^{18} joules for IPH in the 1990s would require quantities of commercially available, non-aqueous heat transfer fluids (such as Dowtherm and Therminol) that are one or two orders of magnitude above present-day production capacities for any one fluid. However, the quantity of heat transfer fluid is only a fraction of today's production rates for more common materials such as the glycols. In either case, it is anticipated that the ten-year lead time available to increase production before widespread deployment of solar systems should allow for orderly development of new manufacturing facilities to meet demand.

Source of Spills

Heat transfer fluids can enter the environment as a result of leaks and spills. In terms of volume, the annual spillage or leakage of heat transfer fluids in the 1980s will be small. The greatest loss of fluid is expected to occur during fluid transfer and transport, situations for which containment of large spills may be difficult. Since most solar systems will be located in the Southwest while many heat transfer fluid producers are in the East, the spillage rate during transport may be above average.

Heat transfer fluids can enter the environment as a result of leaks and spills. In terms of volume, the annual spillage or leakage of heat transfer fluids in the 1980s will be small. For 1990, it is estimated that annual spillage rates on the order of 16,000 kg/year will occur from manufacture, transfer, use, and storage operations. Thus, spillage of *all* heat transfer fluids used for solar systems in 1990 would be comparable to the annual spillage at an oil refinery which processes 100,000 barrels per day.

Spillage and leakage are expected to account for less than 20 percent of the volume of fluid lost during the life cycle of a solar power site. Most of this loss will be from storage facilities, where spills can be controlled with containment structures.

It is concluded that a relatively small volume of fluid will be released from the use of solar energy for industrial process heat or moderate power applications. For the fluids which will be used in the 1980s, no engineering problems were found in this study that could not be addressed and solved by careful attention to potential environmental effects during design, operation, and maintenance of solar thermal systems.

Environmental Transport and Fate

The potential for migration in the environment varies depending on the heat transfer fluid being used. A majority of the solar system designs being considered for the near term make use of fluids such as water or water-glycol mixtures which are quite mobile in the environment.

The other principal fluids-- silicone and organic hydrocarbons--are generally quite low in mobility. However, data related to environmental mobility are incomplete or unknown for a number of materials that have been proposed.

In many cases, heat transfer fluids can be disposed of readily by standard techniques. However, the lack of toxicity data for some fluids suggests that the use of special disposal techniques (e.g., secured landfills) may be indicated by future research. Inert, inorganic fluids such as silicones will need to be confined in containers, since they are not amenable to biological or thermal degradation.

Heat transfer fluids tend to be high molecular weight, non-volatile compounds and mixtures. Therefore, air pollution is not generally a significant factor in evaluating potential environmental impact. The fluorocarbons are an exception to this rule. However, fluorocarbons have been considered only in a few designs of large-scale or high-temperature systems, and potential impacts are thus expected to be low.

Recommendations

Based on the findings of this study, a number of areas were identified where incomplete knowledge exists of the factors influencing the impact of heat transfer fluids on the environment. The areas described below are considered to be the most important ones to address in further research on the use of these fluids in solar energy systems.

It is recommended that specific studies be instituted to explore toxic effects and migratory potential of those materials judged to be primary candidates for use as heat transfer fluids. Toxicity studies of the actual fluids, as well as of their major constituents, are needed. Migration effects should be evaluated by octanol-water partitioning and soil column leaching determinations for those materials for which such data are non-existent.

Since few of the solar system designs that have been proposed have reached the demonstration stage, periodic studies to reevaluate environmental impact potential need to be continued. This is particularly true since the environmental effects of currently proposed fluids vary widely, and since widespread deployment of any given system may occur rapidly if the demonstration phase is successful. A continuing program to evaluate potential for environmental insult should be planned to parallel the demonstration efforts.

Since the evaluation of potential environmental impact is nearly always only a secondary objective of solar energy research and development programs and sponsoring agencies, EPA should consider continuing support of timely studies that focus on that aspect. This would provide assurance that environmental effects are properly considered, while allowing the developer to focus attention on system development.

Finally, a study is needed of the impact of pollution control and environmental monitoring on design, siting, and operation of solar energy systems. This exercise would include cost-benefit analyses and an evaluation of impact on projected deployment schedules that result from applicable laws and regulations. Such an analysis may be critical to shaping environmental policy and to arriving at overall economic analyses for an industry which currently appears to have only marginal profit potential.

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The complete report, entitled "Preliminary Assessment of the Use of Heat Transfer Fluids for Solar Thermal Energy Systems," (Order No. PB 83-170 597; Cost: $10.00, subject to change) will be available only from:
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