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Near-Term Viability of Solar Heat Applications for the Federal Sector

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NEAR-TERM VIABILITY OF SOLAR HEAT APPLICATIONS FOR THE FEDERAL SECTOR

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ABSTRACT

Solar thermal technologies are capable of providing heat across a wide range of temperatures, making them potentially attractive for meeting energy requirements for industrial process heat applications and institutional heating. The energy savings that could be realized by solar thermal heat are quite large, potentially several quads annually. Although technologies for delivering heat at temperatures above 100°C currently exist within industry, only a fairly small number of commercial systems have been installed to date. The objective of this paper is to investigate and discuss the prospects for near-term solar heat sales to federal facilities as a mechanism for providing an early market niche to aid the widespread development and implementation of the technology. The specific technical focus is on mid-temperature (100°-350°C) heat demands that could be met with parabolic trough systems.

As the largest energy user in the United States, the federal government represents a large market for the sales of solar heat technology. Federal facilities have several features relative to private industry that may make them attractive for solar heat applications relative to other sectors. Key among these features are specific policy mandates for conserving energy, a long-term planning horizon with well-defined decision criteria, and prescribed economic return criteria for conservation and solar investments that are generally less stringent than the investment criteria used by private industry. Federal facilities also have specific difficulties in the sale of solar heat technologies that are different from those of other sectors, and strategies to mitigate these difficulties will be important in achieving sales.

For the baseline scenario developed in this paper, the solar heat application was economically competitive with heat provided by natural gas. The system levelized energy cost (LEC) was $5.9/MBtu for the solar heat case, compared to $6.8/MBtu for the life-cycle fuel cost of a natural gas case. A third-party ownership case would also be attractive to federal users, since it would guarantee energy savings and would not require initial capital funds from the federal agency. The baseline third-party ownership case appeared to be marginally attractive to investors, with an after-tax return on investment (ROI) of slightly more than 10%.

INTRODUCTION

Solar thermal technologies are capable of providing heat across a wide range of temperatures, making them potentially attractive for meeting end-use energy requirements in industrial process heat applications and institutional heating. Parabolic trough technology can easily supply heat at delivery temperatures of 100°-350°C, and parabolic dish technologies can provide heat at much higher temperatures. A recent study estimated that the potential market for solar industrial process heat could be as high as 3.8 quads in the manufacturing sector by 2030 if a vigorous research and development (R&D) program is pursued (1). Although there are large uncertainties associated with long-range market penetration estimates, a potential energy contribution of several quads is a large payoff for an emerging energy technology. Applications in the commercial sector could also be expected to displace a significant amount of energy if the technology continues to increase in performance and decrease in cost; this could bring the total energy impact of the technology above the quad estimate referenced above.

The vast difference between the potential of many quads of energy contribution and the current realities of the market for mid-temperature solar heat technologies may cause many to wonder whether the technology can ever achieve this promise. One of the prerequisites for success will be the development of niche markets that can support the development of technology, providing industry with the profits and sales volume necessary to achieve reductions in the cost and improvements in the technology performance. While a number of niche markets may exist that could provide these opportunities, the purpose of this paper is to investigate sales to federal facilities as a particular niche market. The investigation has been limited to mid-temperature solar heat applications to limit the scope of the analysis. For convenience in discussing the technology, the term "solar heat" is used in this paper to describe mid-temperature solar thermal applications; the results and discussions in the paper are not applicable to low-temperature (i.e., flat-plate) applications.

As a starting point for discussing the need for a solar heat niche market, some historical perspective is valuable. At the beginning of the 1980s, industrial process heat was an important thrust of the Department of Energy (DOE) solar thermal program, and 17 large-scale demonstration projects were conducted. Declining budgets during the 1980s, coupled with the perception that solar trough technology could be considered commercialized and was therefore not appropriate for DOE program involvement, led to the decision by DOE to eliminate process heat as an R&D program for solar thermal technologies. In 1985, seven of the projects still in operation were transferred to industrial ownership. To date, none of these demonstration projects is in operation (2). Although the demise of these demonstration systems can be attributed both to good reasons (being designed as demonstrations rather than as commercial systems) and bad luck (declines in fossil fuel prices made operation uneconomical due to the high cost of operations and maintenance [O&M] associated with demonstration systems), the fact is that many potential end users saw this as a failure of the technology.

During the 1980s, declines in the price of fossil fuels created a very difficult competitive situation for the fledgling solar heat industry. The state of the industry today for mid-temperature solar thermal products could best be described as early commercialization. The technology has improved since the time of the initial demonstration systems, with a few successful commercial systems installed by a small number of companies. In general, the organizations (or divisions) marketing mid-temperature solar heat systems today are small, and domestic sales for the total industry are probably well under 10,000 m^2/year.

Given the experiences of the last decade, a reasonable question to ask is whether the projections of a viable solar heat industry that we make today are any more to be believed than previous projections that largely have not been fulfilled. Several factors are very different today than they were in the early 1980s. First and foremost, there have now been several successful commercial (not demonstration) solar heat systems that have operated reliably over a period of time. Examples of these systems are the systems installed by Solar Kinetics Inc. in Chandler, Arizona, for Gould, Inc. in 1982 and Industrial Solar Technology's projects at the Paul Beck Recreation Center in Colorado (1985); the Adams County Detention Center in Brighton, Colorado (1986); and the California Correctional Institution in Tehachapi, California (1990). These projects have provided valuable insights into the way systems must be designed and operated to be economically competitive with conventional energy sources. A second factor is that both the performance and cost of solar heat technologies have improved substantially over time, and they are continuing to improve. A third factor is that the DOE/National Laboratory community and the solar industry have both been "educated" by a decade of tough times. It may have been perceived at one time that technology commercialization would be driven by large increases in the price of fossil fuels and be a fairly easy process. It is now recognized that there is nothing easy about the commercialization process. Technology development and commercialization need to be aggressively pursued in a market environment where fossil fuel prices may be highly unstable but cannot be counted on to consistently escalate at high rates over decades of time. Before solar heat technology can be successful in large, multiquad markets, it will first have to prove itself and develop through niche markets.

The approach taken in this paper is to first examine general characteristics of federal facilities and the solar industry to determine whether there is an overlapping of these needs that could generate an attractive niche market. Following this general examination, specifics of the near-term economics of solar heat systems are addressed to determine whether it is practical to expect significant sales in the federal sector markets without technology improvements or subsidies.

SOLAR HEAT INDUSTRY NEEDS IN A NICHE MARKET

The value of a niche market to the solar industry is to provide the early sales of the technology that are critical in reducing system costs. One of the long-standing barriers to solar thermal technologies is that large-scale production is necessary to achieve reasonably priced solar components. For example, by the late 1970s, it was clearly recognized that, even in large-scale commercial operations, changes in the production levels of concentrators could affect the price of concentrators by a factor of two or more, even without changes in the concentrator design (3). In the current industry situation, with very low production levels, increasing sales is even more critical; companies simply cannot survive without enough sales to cover the fixed costs of operating a business.

From the perspective of a solar heat industrial firm, there are a number of characteristics that enhance the attractiveness of a niche market. None of the characteristics are strict criteria that must be met before a given potential sale would be attractive. Rather, they represent a list of desirable features that can be used to discriminate between the attractiveness of different markets. A general description of these characteristics is summarized below.

- <u>High Cost for Competing Energy</u>—While many factors may be included in the decision to buy a solar heat technology, economic competitiveness against other energy sources will always be a major requirement. The cost of competing energy systems provides the energy cost criteria that solar heat must meet to be competitive.

- <u>Repeatability</u>—Ideally, the niche market should be fairly large and fairly homogenous so that one project sale could be a springboard to additional sales. To ensure repeatability, the entire market must also be located in a region with good solar resources.

- <u>Incorporating Noneconomic Factors in the Decision Process</u>—A good niche market would include some of the positive noneconomic characteristics of solar heat technologies in the process of deciding whether to invest in a technology. Examples of these factors are low environmental impacts and positive public perceptions. Incorporating the noneconomic benefits into the decision process would tend to make solar heat systems attractive even when their energy costs are at some positive delta above fossil fuel sources. The specific value of noneconomic factors is subject to much debate, and will vary significantly between users.

- <u>Risk Indifference</u>—New technologies are intrinsically risky. Because they do not have the established operating record of existing technologies, potential users may lack confidence in how well the technology will perform over time. Risk aversion will tend to reduce the energy cost solar heat needs to meet to be competitive. An ideal niche market would be risk seeking, but the market should at least be indifferent to technology risk.

- <u>Capital Availability</u>—Solar heat systems are capital intensive; achieving the benefits of eliminating annual fuel costs comes at a fairly substantial initial investment. Capital availability is a potential showstopper for any solar heat project regardless of how economically attractive the project appears, so general availability of capital funds is a prerequisite for a good niche market. In addition, lower discount rates (which are generally correlated with capital availability) are generally favorable to comparisons between solar and fossil heat sources.

- <u>Long-Term Planning Horizon</u>—Given their capital intensive nature, solar heat systems require long operating periods to be economically competitive against fossil fuel sources. A good niche market would take a long-term (20-30 years) planning perspective on making decisions regarding energy supply. Short-term (5 years or less) planning horizons would virtually eliminate solar heat from any but very high valued application.

- <u>Clear Decision Criteria</u>—Marketing any product is expensive. It is advantageous if the factors important to the end-user in deciding to install a solar heat system are clearly understood by the solar company. A good understanding of the issues involved in making a sale can reduce marketing costs by early identification of applications where the solar heat plant would not be acceptable, and by better targeting the characteristics and design of the heat plant toward the specific needs of the end user.

- <u>Quick Decisions on Sales</u>—One factor which keeps marketing costs low is reaching a quick decision by the end user on installation of the solar heat system. Even if the decision is negative, a quick decision allows the solar company to turn attention to developing a more promising project and will avoid expensive follow-on efforts to structure a successful project.

FEDERAL FACILITY NEEDS

Although the federal government is not often perceived as a business, the needs of the federal government for energy are not unlike those of any large energy-consuming business. Federal facilities require reliable energy sources that are safe, environmentally acceptable, and represent the lowest possible life-cycle cost.

Federal facilities as a whole consume a very large quantity of energy. In FY 1989, this energy consumption totaled 1.92 quads, which represented 2.4% of the total U.S. energy use that year (4). If it is considered as a single entity, the federal government represents the largest use of energy in the nation. A general breakdown of the energy consumption is shown in Table 1. A rough estimate of the potential total market in which solar heat could compete on a technical basis can be developed by adding the nonelectric energy use from buildings and the process energy requirements from general operations. This would translate into a FY 1989 market (of approximately 0.4 quads) in which solar heat systems could theoretically provide the same service as the current energy supply.

Table 1. Breakdown of Energy Use in Federal Facilities FY 1989

Buildings and Facilities	**Quads**
Electricity	0.540
Fuel Oil	0.081
Natural Gas	0.144
Coal	0.040
Other	0.024
Subtotal	0.829
General Operations	
Jet Fuel	0.762
Process Energy	0.130
Other	0.004
Auto Gas	0.041
Distillate/Diesel	0.153
Subtotal	1.090
TOTAL	1.919

Source: Reference 4

From a practical standpoint, the prospective niche market would consist of those federal facilities located within regions with good insolation characteristics. Although accounting for coincidence of facilities with good insolation regions would reduce the size of the potential market substantially, it would still represent a strong niche market for the solar industry. Assuming for the point of argument that practical factors (such as insolation and land availability) reduced the potential market by three orders of magnitude, federal facilities still represent a market for approximately 1 million m^2 of collectors.

On the whole, federal facilities are generally not energy efficient. The government has recognized this problem and has chartered the Office of Federal Energy Management Programs within DOE to promote energy and economic efficiency. There are a growing number of government policies promoting energy efficiency in federal facilities. A recent executive order calls for reductions in energy use in federal buildings by 20% by 2000 (5). This goal could be met by reducing energy demand either by conservation or through use of renewable technologies such as solar heat.

A discussion of how federal facilities are likely to judge the desirable factors for a solar heat niche market are discussed below.

- High Cost for Competing Energy—Federal facilities are neutral on this factor. Energy costs at federal facilities vary, depending on the region and the type of energy used, but these costs are not expected to be significantly different from those of other users of a similar size in the same region.

- Repeatability—Federal facilities score high on this factor because of a high degree of consistency in decision making and the procurement process. Successful solar projects within the federal sector would increase the chances for additional projects.

- Incorporating Noneconomic Factors in the Decision Process—Federal facilities score high on this factor. The economic evaluation process (discussed later in the paper) used in the federal sector gives a preference to renewable energy and conservation projects in recognition of their social benefits (6).

- Risk Indifference—In practice, most federal facilities probably exhibit some risk-averse characteristics, so they would not score well on this attribute. Facility managers value system reliability and are suspicious of technologies with which they may not be familiar. Another factor leading to risk-averse behavior is that federal facilities often have a limited O&M staff, making them concerned about increasing O&M requirements or adding systems requiring specialized O&M expertise.

- Capital Availability—Federal facilities have both positive and negative features with regard to capital availability. On the positive side, the discount rate used in evaluating conservation and renewable projects is generally lower than the rate that would be used in private industry; this increases the attractiveness of solar heat projects. On the negative side, capital availability is often an issue for federal facilities, with large appropriations potentially taking years for approval.

- Long-Term Planning Horizon—Federal facilities usually have long-term missions, and may use planning horizons of up to 25 years in decisions regarding energy supply. This factor is a positive influence for federal facilities as a niche market.

- Clear Decision Criteria—The key decision criteria for evaluating energy investments are clearly spelled out for federal facilities. It should be recognized that satisfying federal criteria for cost-effectiveness does not necessarily guarantee that a project will be developed. Individual facilities are likely to have specific concerns (such as mission impacts or O&M requirements) that may be equally as important as cost-effectiveness in terms of whether a project is actually implemented. For example, if a solar heat application was perceived to have an adverse effect on the reliability of the overall heating system, it would be unlikely to be pursued by the facility. On the whole, decision criteria are more explicit for federal facilities than for most large energy users, and this factor is probably slightly positive.

- Quick Decisions on Sales—In general, this factor is negative. While there is no reason in principal that decisions could not be reached quickly on the sales of solar heat systems to federal facilities, the federal procurement process is complex, often overloaded with many demands, and typically slow, relative to private industry. Novel technologies and new procurement processes are likely to slow the procurement process even further, compared to more standard procurements.

ECONOMIC EVALUATION APPROACH

The critical hurdle that a solar heat system must pass in any application is economic viability with competing energy sources. There are two general approaches possible for installation of solar heat systems in the federal sector, and the approach for evaluating the economic viability is somewhat different in each approach. The first option is direct ownership by the federal government, where the government owns, operates, and maintains the solar heat system. The second option is third-party ownership, in which a third-party owns, operates and maintains the plant, selling the energy produced to the government.

The case of direct ownership has the advantage of potentially being the most cost-effective way for a federal facility to obtain solar heat energy. This type of ownership has the basic advantages and disadvantages as a niche market as outlined in the previous section. The key to cost-effectiveness in this option is for the solar heat system to have a lower life-cycle cost than the alternative energy supply options. Executive orders and legislation provide standard directions for evaluation of the life-cycle cost of energy related investments for Federal facilities, and these approaches are outlined elsewhere (6).

In a third-party case, the plant would be owned and operated by a third party and the heat sold to the federal energy user at a guaranteed discount from the price the user would pay to its current energy supplier. Several contracting options are currently possible that could support this approach, including long-term energy purchase agreements and shared energy savings projects. The third-party approach has the advantage (from the federal agencies' perspective) of removing the technology risk and O&M concerns, because these are now the responsibility of the third-party owner. From the standpoint of the federal facility, this arrangement has no issues related to economic viability, because the contract guarantees savings from the facility's existing utility bills. The economic viability criteria for these cases hinges on whether the investment would appear attractive to the third-party owner of the system. This brings about the principal disadvantage of this arrangement, which is an additional party in the arrangement who needs to receive profit from the transaction. By transferring the technology risk to a third party, the government must also transfer a significant share of the economic benefits of the project; the net result is that savings to the government will be less in this case than in a direct ownership case.

The economic evaluation for both types of ownership options was based on a comparison of a solar heat plant to a natural gas boiler. The solar plant is assumed to operate in a fuel-saver mode, so that no attempt is made to reduce the capacity of the natural-gas-fired system (i.e., the fossil plant is always available to provide 100% of the thermal load). An efficiency of 75% was assumed for the natural gas boiler.

The characteristics of the solar heat plant was based on a recently completed project for the California Correctional Institute in Tehachapi, California. The Tehachapi project was chosen because, as a recent project, it represents currently available solar heat systems. The Tehachapi project was developed under a third-party ownership option and consists of 2,675 m^2 of parabolic trough collectors supplying pressurized hot water at up to 154°C (310°F) (7). The project is located in an area of good insolation near the Mojave desert. The project was completed at a time when the facility was paying about $3.5/MBtu for natural gas, and under terms of the contract, would sell thermal energy to the facility at a fixed discount from the current price of natural gas throughout the life of the project.

The principal assumptions developed on the Tehachapi system are shown in Table 2. All information shown in the table was obtained from telephone conversations with Industrial Solar Technology and the project developer, United Solar Technologies, Inc. The annual energy output used in the analysis is based on the assumption of using a silvered polymer reflector, which would provide approximately 10% more annual energy output than the aluminized reflectors used in the Tehachapi project. For comparison purposes, unit costs developed for long-term goals of solar industrial process heat applications in 1985 are also shown in Table 2 (8). The goals in Table 2 have been updated to 1990 price levels to be more directly comparable to the Tehachapi data. Both the capital cost and O&M cost reported for the Tehachapi plant are significantly better than the DOE cost goals established in 1985, although the estimated annual energy production for the Tehachapi system is lower than the goal. This could reflect conservatism on the part of the developer in estimating annual energy output or may simply represent a cost/performance tradeoff in the design of the system.

Economic assumptions used in the evaluation are shown in Table 3. The natural gas real escalation rate shown in the table is an average value. Actual escalation rates for natural gas prices used in the evaluation varied from year to year in accordance with current federal guidelines for renewable energy project evaluation (9). For the government ownership case, the discount rate is also based on current standards of 4.7% real discount rate, combined with the 5% inflation rate assumed for this analysis. For the private party case, the discount rate used was 10.4%, which is a typical discount rate used by developers of cogeneration systems in which debt financing is used (10).

Table 2. Solar Heat Cost and Performance Assumptions

Assumption	Value for Analysis	1985 DOE Long-Term IPH Goal
Annual Energy Output	2.9 MBtu/m^2	5.1 MBtu/m^2
Capital Cost	$226/$m^2$	$315/$m^2$
Annual O&M Cost	$1.5/$m^2$	$6/$m^2$

The economic model used for evaluating the life-cycle costs was TEAM, a detailed project evaluation cash-flow model (11). TEAM produces several figures of merit that can be used in energy project evaluation. The primary figure of merit used is the real dollar LEC, which is a hypothetical energy cost that would exactly cover all costs of the project (including return on investment) over the lifetime of the project. TEAM also produces net present value and discounted ROI values.

RESULTS

For the government ownership case, installation of the solar heat system appears to be economically attractive. The real dollar LEC results for this case were $6.8/MBtu for the gas-fired case, and $5.9/MBtu for the solar heat case. The total net present value to the government for the project would be $99,000.

For the third-party ownership case, the relevant evaluation perspective is that of the third-party owner, since the economic attractiveness of the contract is effectively guaranteed to the government. In this analysis, the LEC is not a particularly useful figure of merit, because there are revenues to be considered as well as costs. Therefore, a net present value calculation was performed. The results of the analysis were a net present value of $2,000, which is effectively 0 for the magnitude of the project investment. The overall ROI calculated for the project is 10.5%, slightly above the discount rate assumed. These results indicate that the project, as configured, would be marginally attractive to a third-party investor.

Two sensitivity analyses were conducted for the third-party ownership case to determine which of the variables were most important to the economic viability of the project. In each case, the range used in the sensitivity analysis was selected subjectively based on judgements of what reasonably informed investors might consider as possible values for the variable. The results are shown as after-tax ROI values; the hurdle rate for the plant to appear economically attractive to the investors is the discount rate of 10.4%.

Table 3. Economic Assumptions	
	General Assumptions
Variable	**Value**
Inflation Rate	0.05
System Life	25 yrs
Natural Gas Price	$3.5/MBtu
Boiler Efficiency	75%
Gas Escalation (Real)	3.0%
	Government Ownership Assumptions
Discount Rate	9.9%
	Third-Party Ownership Assumptions
Discount Rate	10.4%
Depreciable Life	5 yrs
Investment Tax Credit	10%
Combined Tax Rate	40%
Other Taxes	1%
Discount of Solar Steam Relative to Natural Gas	5%

System life was varied from a low of 15 years to the 30 years assumed as the baseline case. The results of the analysis are shown in Figure 1. Reductions in life expectancy of only a few years result in substantial decreases in the ROI. The difference between a lifetime of 30 years and 25 years decreases the ROI by about 1.2 percentage points.

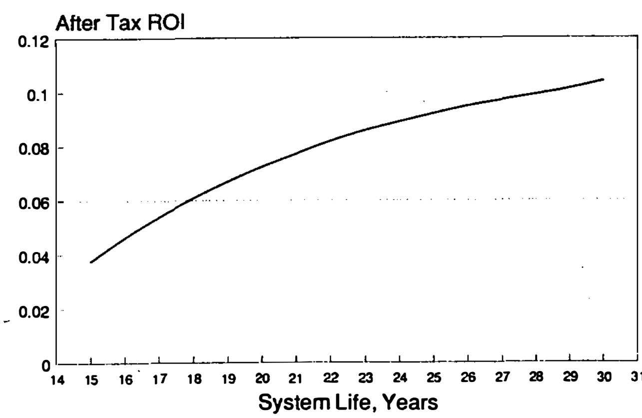

Figure 1. ROI vs System Life (Third Party Financed)

Natural gas escalation rates projected for the next 30 years are subject to large amounts of uncertainty. Given the decline in gas prices that occurred during the last decade, the general perspective of investors is likely to be to expect a lower price escalation than current predictions would indicate. For this reason, the sensitivity analysis included 3 cases with a lower price escalation than the baseline value (including gas prices remaining constant in real terms) and only one case with a higher increase than the baseline. The results of the analysis are shown in Figure 2. The changes in the natural gas escalation rate over the range shown have a fairly substantial impact on the ROI that investors would receive from the plant.

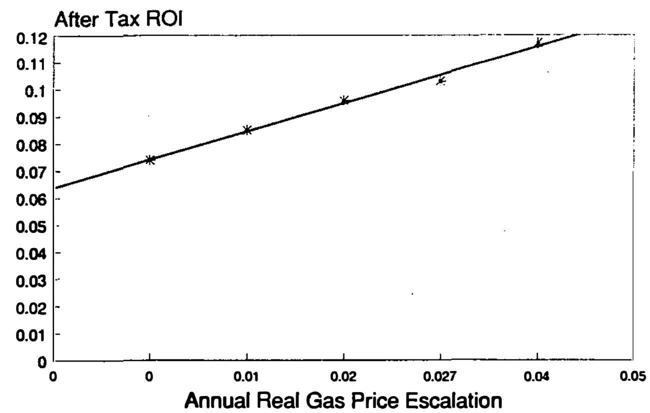

Figure 2. ROI vs Gas Escalation (Third Party Financed)

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this analysis, it appears that the federal sector could be an attractive niche market for solar heat systems in the near term. From the government's standpoint, solar heat systems could be attractive energy sources at federal facilities located in high insolation regions. Pursuing these options would save the government energy and dollars and also provide a stimulus to the solar heat industry. From the industry's perspective, if a niche market could be developed within the federal sector, it could provide a basis for significantly expanded sales and the ability to further move the technology toward widespread commercial use.

Either third-party ownership or direct sales to federal facilities could be attractive mechanisms for project development. Based on the cases evaluated in this study, the economics of third-party ownership would be potentially feasible, although by a slim margin. The economics of direct sales to federal facilities appear preferable. When the risk aversion associated with new technologies is factored in, however, it is likely that third-party ownership options would be the preferred approach in the near term unless other means are used to reduce the perceived risk to the energy users in the federal facilities.

The data used in this study are general enough that it is not warranted to draw conclusions related to whether a large market for solar heat systems is likely to materialize in the federal sector anytime soon. On the other hand, the results are in a promising range, and investigation and feasibility analysis at specific sites appear warranted. If several viable projects could be successfully developed at federal sites, it will significantly increase the prospects that a viable niche market could be developed.

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