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The Value of Solar Thermal Industrial Process Heat

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March 1986

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FOREWORD

The research and development (R&D) described in this document was conducted within the U.S. Department of Energy's (DOE) Solar Thermal Technology Program. The goal of the Solar Thermal Technology Program is to advance the engineering and scientific understanding of solar thermal technology, and to establish the technology base from which private industry can develop solar thermal power production options for introduction into the competitive energy market.

Solar thermal technology concentrates solar radiation by means of tracking mirrors or lenses onto a receiver where the solar energy is absorbed as heat and either converted into electricity or incorporated into products as process heat. The two primary solar thermal technologies, central receivers and distributed receivers, employ various point and line-focus optics to concentrate sunlight. Current central receiver systems use fields of heliostats (two-axis tracking mirrors) to focus the sun's radiant energy onto a single tower-mounted receiver. Parabolic dishes up to 17 meters in diameter track the sun in two axes and use mirrors or Fresnel lenses to focus radiant energy onto a receiver. Troughs and bowls are line-focus tracking reflectors that concentrate sunlight onto receiver tubes along their focal lines. Concentrating collector modules can be used alone or in a multi-module system. The concentrated radiant energy absorbed by the solar thermal receiver is transported to the conversion process by a circulating working fluid. Receiver temperatures range from 100C in low-temperature troughs to over 1500C in dish and central receiver systems.

The Solar Thermal Technology Program is directing efforts to advance and improve promising system concepts through R&D of solar thermal materials, components, and subsystems, and testing and evaluating the performance of subsystems and systems. These efforts are carried out through the technical direction of DOE and its network of national laboratories that work with private industry. Together they have established a comprehensive, goal-directed program to improve the performance of solar thermal technology and provide technically proven options for eventual incorporation into the nation's energy supply.

To be successful in contributing to an adequate national energy supply at reasonable cost, solar thermal energy must eventually be economically competitive with a variety of other energy sources. Component and system-level

performance targets have been developed as quantitative program goals. The performance targets are used in planning R&D activities, measuring progress, assessing alternative technology options, and making optimal component developments. These targets will be pursued vigorously to ensure a successful program.

This report describes the development of estimates of the value of solar thermal industrial process heat over a temperature range of 250-4000F (121-2204C). Knowing the value of solar thermal industrial process heat will allow an eventual comparison with its cost of production and help identify the markets and technology where solar thermal would be most competitive.

SUMMARY

This study estimated the value of solar thermal-generated industrial process heat (IPH) as a function of process heat temperature. The value of solar thermal energy is equal to the cost of producing energy from conventional fuels and equipment if the energy produced from either source provides an equal level of service. This requirement put the focus of this study on defining and characterizing conventional process heat equipment and fuels.

Costs (values) were estimated for 17 different design points representing different combinations of conventional technologies, temperatures, and fuels. Costs were first estimated for median or representative conditions at each design point. The cost impact of capacity factor, efficiency, fuel escalation rate, and regional fuel price differences were then evaluated by varying each of these factors within credible ranges.

System characteristics were established for a design point by first identifying the median or representative size of the equipment. Capital cost, non-fuel operating and maintenance (O&M) costs, current efficiency, and projected efficiency were then identified for that size. Tradeoffs between capital cost and efficiency were also considered. Current and projected fuel prices were obtained from the Energy Information Administration. System economics were made consistent with the Solar Thermal Technology Five Year Research and Development Plan (U.S. Department of Energy 1984).

The levelized cost of IPH was found to be dominated by the fuel component, which is dramatically affected by the fuel type and its projected price escalation rate. The cost of IPH was found to vary little with temperature within a technology, but showed step function changes when moving from one technology and its temperature range to another. For example, the cost of IPH delivered by an electric furnace was two to four times that for the fossil-fired systems, due largely to the use of a fuel (electricity) that is relatively expensive. The cost of producing IPH actually declined when moving from the temperature range represented by boilers (250F-850F or 121-454C) to the temperature range represented by combustion furnaces (850F-2500F or 454-1371C). This result can be attributed to the fact that the efficiency of generating steam from fossil fuels ranges from 80-90% while the efficiency of

generating hot combustion products from fossil fuels ranges from 90-95%. (Burner efficiencies are near 100%; the range noted includes energy losses associated with water vapor in the combustion products.)

The estimated costs of IPH produced from conventional systems are summarized in Table S.1 for the 17 technology, temperature, and fuel combinations considered. These estimates represent the total cost (fuel plus capital plus O&M) of each system evaluated at its median or representative conditions. The individual cost contributions of fuel, capital, and O&M components were estimated for each case evaluated and are presented in Section 5.0 and Appendix A.

TABLE S.1 Industrial Process Heat Costs

Technology	Temperature	Fuel ^(a)	\$/MMBtu ^(b)	\$/kWh
Boiler	250F (121C)	Coal	10.00	.036
Boiler	250F	Oil	14.90	.051
Boiler	250F	Gas	10.80	.064
Boiler	500F (260C)	Coal	8.90	.023
Boiler	500F	Oil	11.00	.037
Boiler	500F	Gas	14.90	.051
Boiler	850F (454C)	Coal	7.30	.025
Boiler	850F	Oil	11.20	.038
Boiler	850F	Gas	15.10	.052
Combustion Furnace	850F	Oil	8.10	.028
Combustion Furnace	850F	Gas	11.50	.039
Combustion Furnace	1500F (816C)	Gas	11.50	.039
Combustion Furnace	2500F (1371C)	Oil	8.30	.028
Combustion Furnace	2500F	Gas	11.50	.039
Electric Resistor Furnace	2500F	Electricity	48.50	.169
Electric Arc Furnace	2500F	Electricity	31.10	.108
Electric Resistor Furnace	4000F (2204C)	Electricity	41.90	.143

(a) Oil is residual oil.

(b) 1984 dollars levelized in real terms based on a 1995 plant startup and an annual capacity factor of 0.5.

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CONTENTS

FOREWORD.....	iii
SUMMARY.....	v
FIGURES.....	xi
TABLES.....	xii
1.0 INTRODUCTION.....	1.1
2.0 SYSTEM DEFINITION AND APPROACH.....	2.1
2.1 VALUE DEFINITION.....	2.2
2.2 PRODUCT EQUIVALENCY.....	2.2
2.3 SYSTEM BOUNDARY.....	2.4
2.4 IPH PRODUCTION COST FACTORS.....	2.8
3.0 SYSTEM CHARACTERIZATION.....	3.1
3.1 BOILERS.....	3.1
3.1.1 Equipment Size and Design Points.....	3.2
3.1.2 Installed Capital Costs.....	3.4
3.1.3 Non-Fuel O&M Costs.....	3.7
3.1.4 Expected Efficiency Improvements.....	3.7
3.2 COMBUSTION FURNACES.....	3.8
3.2.1 Equipment Size and Design Points.....	3.9
3.2.2 Installed Capital Costs.....	3.10
3.2.3 Non-Fuel O&M Costs.....	3.12
3.2.4 Expected Efficiency Improvements.....	3.13
3.3 ELECTRIC FURNACES.....	3.14
3.3.1 Equipment Size and Efficiency.....	3.15
3.3.2 Installed Capital Costs.....	3.16
3.3.3 Non-Fuel O&M Costs.....	3.16
4.0 SYSTEM ECONOMICS.....	4.1
4.1 LEVELIZED ENERGY COST MODEL.....	4.1
4.2 FUEL COST DATA.....	4.3
5.0 RESULTS.....	5.1
5.1 BASELINE RESULTS.....	5.2
5.2 SENSITIVITY RESULTS.....	5.7
6.0 CONCLUSIONS AND RECOMMENDATIONS.....	6.1
REFERENCES.....	R.1

APPENDIX A: SYSTEM LEVELIZED ENERGY COST CALCULATIONS.....	A.1
APPENDIX B: IPHLEC SPREADSHEET LISTING.....	B.1
APPENDIX C: LEVELIZED ENERGY COST EQUATIONS.....	C.1
APPENDIX D: COMPARING SOLAR THERMAL VALUE WITH ITS COST.....	D.1

FIGURES

1.1	End-Use Industrial Energy Consumption.....	1.2
1.2	Impact of Capacity Factor on IPH Technology Choice.....	1.3
2.1	IPH System Boundaries.....	2.7
4.1	IPHLEC Sample Spreadsheet.....	4.2
5.1	Coal-Fired Boiler IPH Cost.....	5.3
5.2	Residual Oil-Fired Boiler IPH Cost.....	5.3
5.3	Gas-Fired Boiler IPH Cost.....	5.4
5.4	Residual Oil-Fired Furnace IPH Cost.....	5.4
5.5	Gas-Fired Furnace IPH Cost.....	5.5
5.6	Electric Resistor Furnace IPH Cost.....	5.6
5.7	Electric Arc Furnace IPH Cost.....	5.7
5.8	Impact of Fuel Price Escalation Rate on IPH Cost.....	5.8
5.9	Impact of Regional Fuel Price Differences on Boiler IPH Cost.....	5.8
5.10	Impact of Regional Fuel Price Differences on Combustion Furnace IPH Cost.....	5.9
5.11	Impact of Regional Fuel Price Differences on Electric Resistor Furnace IPH Cost.....	5.9
5.12	Impact of Capacity Factor on Boiler IPH Cost.....	5.10
5.13	Impact of Capacity Factor on Combustion Furnace IPH Cost.....	5.11
5.14	Impact of Capacity Factor on Electric Resistor Furnace IPH Cost.....	5.11
5.15	Impact of System Efficiency on Boiler IPH Costs.....	5.12

TABLES

S.1 Industrial Process Heat Costs.....	vii
1.1 System Design Points.....	1.4
2.1 Energy Generation and Application Equipment.....	2.6
2.2 IPH Cost Design Points.....	2.8
2.3 Factors Influencing IPH Production Costs.....	2.8
2.4 Additional IPH Cost Factors.....	2.9
3.1 Conventional IPH Systems.....	3.1
3.2 Number of Installed Industrial Boilers by Category and Capacity Range - 1985.....	3.2
3.3 Capacity Distribution of Industrial Boilers - 1985....	3.3
3.4 Boiler Design Points.....	3.4
3.5 Industrial Boiler Installed Cost Estimates.....	3.5
3.6 Estimated Industrial Boiler Operating Efficiencies....	3.6
3.7 Maximum Expected Boiler Efficiencies.....	3.7
3.8 Representative Industries and Furnace Types.....	3.8
3.9 Furnace Size Ranges.....	3.9
3.10 Furnace Median Sizes.....	3.9
3.11 Estimated Installed Capital Costs.....	3.11
3.12 Estimated Non-Fuel O&M Costs.....	3.13
3.13 Heat of Combustion for Natural Gas and Residual Oil.....	3.15
4.1 System Economic Assumptions.....	4.3
4.2 Fuel Costs and Estimated Escalation Rates.....	4.5
5.1 IPH Systems Evaluated.....	5.1

1.0 INTRODUCTION

The specific objective of this study was to determine the value of solar thermal-generated industrial process heat (IPH) as a function of process heat temperature. Several different solar thermal technologies are being developed that could supply process heat over a wide range of temperatures. Knowing the value of solar thermal IPH (what a process heat user would be willing to pay for it) would allow an eventual comparison with its cost of production and help identify the markets and technologies in which solar thermal would be most competitive.

The diversity of the IPH market makes it difficult to characterize. Application temperatures range from less than 250F to beyond 4000F. Application sizes range from less than 3 Mwt to well over 300 Mwt. End-use industrial energy consumption as a function of temperature and facility size (Mwt rating) is shown in Figure 1.1.

Increasing facility size (capacity) reduces the unit capital component of IPH cost due to economies-of-scale. The wide range of IPH system sizes (more than two orders of magnitude) amplifies the importance of economies-of-scale, especially for the more capital-intensive technologies.

System capacity factor is another distinguishing characteristic which varies dramatically between IPH applications. Some facilities operate around the clock, seven days a week. Others only work a single shift, five days a week. There is an almost endless list of other operating scenarios. The impact of capacity factor on system economics and technology choice is illustrated qualitatively in Figure 1.2. IPH users face numerous fuel/technology options when choosing an energy system. One consideration is the choice between a high capital/low operating cost system (e.g. unit E in Figure 1.2) and a low capital/high operating cost system (e.g. unit B in Figure 1.2). Figure 1.2 shows how this choice would change depending on the capacity factor. Capacity factors ranging from 0.1 to 0.9 were considered in this study.

The diversity of the IPH market and the limited resources associated with this study preclude an exhaustive examination of all the possible combinations of technology, temperature, facility size, capacity factor, and fuel cost. We

FIGURE 1.1. End-Use Industrial Energy Consumption
Source: (Iannucci 1981)

FIGURE 1.2. Impact of Capacity Factor on IPH Technology Choice
 Source: (Electric Power Research Institute 1982)

selected a sampling of IPH systems, but recognize that other equally valid systems could have been chosen.

The process heat temperatures considered in this study range from 250-4000F. This broad temperature range corresponds to the capabilities of three types of conventional process heat technologies (steam boilers, combustion furnaces, and electric furnaces) and also matches well with the current and potential capabilities of parabolic trough, central receiver, and parabolic dish solar thermal systems. Design points were selected within the overall temperature range to match the approximate upper and lower temperature end points of each conventional technology and provide an overlapping point of comparison when moving from a temperature range associated with one type of conventional technology to the adjacent temperature range and technology. Additional intermediate design points were added within the steam boiler and combustion furnace ranges to more accurately determine value as a function of temperature. A third design point was not added within the electric furnace temperature range, however, due to the lack of distinct applications or distinguishing characteristics of electric furnaces at temperatures beyond 2500-3000F. The eight temperature design points evaluated in the study are identified in Table 1.1.

TABLE 1.1 System Design Points

<u>Technology</u>	<u>Temperatures</u>
Steam Boiler	250F, 500F, 850F
Combustion Furnace	850F, 1500F, 2500F
Electric Furnace	2500F, 4000F

The solar thermal IPH values were estimated based on industry-wide characteristics of process heat generation, where possible, rather than focusing on the value of solar thermal IPH for any specific industry. This approach has the advantage of providing results that identify trends that generally apply across a broad market and could be used for making broad decisions regarding solar thermal R&D. The value of solar thermal IPH for any specific industry or specific operator within an industry could be more or less depending on specific fuel costs, financing costs, and process heat technology characteristics.

Many other studies in the past have addressed the value and/or cost of IPH. This study updates previous work by utilizing the latest fuel cost data and incorporating the financial methodology outlined in the Solar Thermal R&D Plan. Future updates should be anticipated as the current data ages.

The following sections (2.0-6.0) of the report describe, in order, system definition and approach, system characterization, system economics, results, and conclusions and recommendations. A full listing of each case analyzed, the levelized energy cost spreadsheet model, levelized energy cost equations, and a discussion of how to compare solar thermal costs with values are provided in Appendices A-D, respectively.

2.0 SYSTEM DEFINITION AND APPROACH

This study estimated the value of solar thermal-generated industrial process heat as a function of temperature. Comparing IPH value across a range of temperatures requires a clear definition of value. Value and cost are defined within the context of an IPH system in Subsection 2.1, Value Definition.

An equitable comparison of dollar costs must also be based on providing comparable service. Ideally, costs would be compared for systems providing an identical level of service, but for most energy systems reasonable comparability must suffice and will not undermine the worth of the evaluation. Comparability of IPH products involves both quality and system boundary issues, which are introduced in the following paragraphs.

The quality of IPH is captured in factors such as temperature, pressure, form (e.g., hot combustion products or steam), availability, and reliability. Here, availability refers to the number and distribution of hours within a calendar year that a system could be counted on to produce IPH. Reliability is defined for the purposes of this study to mean a system's propensity to break down. Each of these quality factors will be discussed in more detail in Subsection 2.2, Product Equivalency.

Although this study focuses on estimating the value of solar thermal IPH by estimating the cost of conventionally produced IPH (since the two are equivalent), the value of these estimates will be recognized only when comparisons can be made with the cost of solar thermal IPH. Accordingly, an attempt has been made to define the product so as to facilitate the eventual comparison. At issue here are the choice of system boundary, separability of energy generation from energy application, and the differences that exist between solar thermal and conventional equipment with regard to the separability characteristic. These issues will be discussed in Subsection 2.3, System Boundary.

After discussing how product equivalency and system boundary issues were handled in this study, the formulation of the general approach to the study will be discussed in Subsection 2.4, IPH Production Cost Factors. The discussion will focus on the factors affecting IPH production costs, their

expected relative importance, and the technology and fuel combinations evaluated.

2.1 VALUE DEFINITION

In general, value is defined by what the customer is willing to pay. The value of solar thermal IPH is equal to what industry is willing to pay for it. The value of solar thermal IPH could be more than, less than, or equal to its cost of production. Economically rational customers will choose the least costly alternative that provides an acceptable level of service. Thus, the value of solar thermal IPH is equal to the cost of the least costly alternative source, given a comparable level of service.

The principal alternatives available to industrial process heat users are primary energy (fossil fuels and purchased electricity) and recovered waste heat. Waste heat recovery was not considered as an alternative in this study for two reasons: 1) In theory, rational industrial entities would have already adopted cost-effective waste heat recovery technology that provides energy at a lower cost than what is available from primary energy sources, and 2) Waste heat characteristics are extremely industry-specific, if not site-specific. The inclusion of waste heat recovery would have required an industry-by-industry analysis, which would have increased the scope of work by an order of magnitude and would have run contrary to the desire to develop industry-wide rather than industry-specific results.

Eliminating waste heat leaves primary energy sources as the principal competition or least-cost alternative to solar thermal. In economic terms, the cost of producing energy from primary sources is the marginal cost of energy if all cost-effective waste heat recovery options have been developed. In other words, the value of solar thermal-generated IPH is equal to the cost of producing IPH from primary energy sources.

2.2 PRODUCT EQUIVALENCY

As described above, IPH products can be characterized by factors such as temperature, form, availability, and reliability. An equitable cost comparison of alternative IPH products must be based on an equivalent level of service. The paragraphs that follow describe how these factors were defined and dealt with in this study.

Since the value of solar thermal IPH was estimated as a function of temperature in this study, it is important to specifically define the temperature reference point. The choice for steam boilers is fairly easy: the reference temperature is the steam temperature as it exits the boiler. Combustion furnaces present a more difficult problem. Possible reference temperatures include the temperature of the flame, the wall, the product, or the furnace. The furnace temperature refers to the bulk average temperature of the atmosphere within the furnace and is often called the oven temperature. This latter alternative was chosen as the reference temperature for combustion furnaces because it conforms with the most commonly accepted furnace reference temperature and corresponds closely with the temperature of a hot air stream that solar thermal technology could supply as a substitute energy form. The reference temperature for electric furnaces is also defined by the furnace or oven temperature for electric resistor furnaces, where heat transfer is an external (largely radiative) mechanism. The product or charge temperature was chosen as the reference temperature for electric arc furnaces. In this type of electric furnace, energy is transferred to the charge directly via electric current and the furnace or oven temperature is of less importance.

Product form refers to the physical and chemical characteristics of the IPH heat-transfer medium. A comparison of conventional and solar thermal IPH systems must be based on creating a heat-transfer medium of similar form or having a similar heat-transfer effect. For example, boilers produce steam as a heat-transfer medium that is easily defined by its temperature and pressure. As a second example, the hot gases of a combustion furnace are characterized by their temperature and chemical makeup. In this case the product form supplied by conventional IPH equipment is different from that supplied by solar thermal equipment. In most cases, where product contamination from combustion gases is not a problem, the chemical difference in form will not create a difference in value. The estimates of solar thermal IPH value presented in this study do not include any benefit that might accrue due to the cleanliness of a solar thermal heat-transfer medium. Where heat-transfer medium cleanliness is important, this incremental value would have to be added. Defining the IPH product form is more difficult for an electric furnace since the energy source (electricity) is not usually thought of as a form of process

heat. This problem is discussed in more detail in the System Boundary subsection that follows.

Availability is a critical issue that affects the comparability of conventional and solar thermal-generated IPH. Availability is defined in this study to mean the number and distribution of hours within a calendar year that a system could be counted on to produce IPH. Except for periodic maintenance, conventional IPH systems are essentially available all of the time. Solar thermal IPH systems have a difficult time matching that capability, even with overnight storage. An inevitable extended period of poor insolation works against the creation of equivalent availability for solar thermal equipment. For these reasons, solar thermal IPH systems are usually designed with conventional equipment as a backup or operating in hybrid. In this situation the value of solar thermal IPH is equal to the sum of displaced energy and variable O&M costs that would have been expended if the solar thermal facility did not exist. Including displaced capital and fixed O&M costs along with displaced energy and variable O&M costs establishes the highest potential value of solar thermal IPH if equivalent availability can be provided. The estimates of value presented in this report correspond to the full displacement of the conventional IPH equipment, unless otherwise noted. The total potential value has also been disaggregated into its fuel, capital, and O&M components for many cases to illustrate their relative contribution to the total.

Reliability has been defined for this study to mean the propensity of the equipment to break down or, conversely, its propensity to perform as designed. The issue of differing reliability between conventional and solar thermal IPH equipment was not explicitly considered in this study. Implicitly, the estimates of IPH value assume there is no difference in reliability between the two technologies that adds or detracts from the value the solar thermal system would otherwise have. If the relative reliability of conventional and solar thermal equipment were judged to be significantly unequal, the estimates of value presented in this report would need to be adjusted.

2.3 SYSTEM BOUNDARY

Several approaches exist for defining the boundary of an IPH system. The selection of an appropriate boundary must consider the characteristics of both conventional and solar thermal equipment. A judicious selection of the

boundary is necessary to properly evaluate the conventional system and/or minimize the work necessary to eventually characterize an equivalent solar thermal system.

An initial issue to consider is the difference between energy generation and energy application. Where possible, it would be best to draw the system boundary so as to include IPH generation but to exclude the application of IPH to the end product being heated. Separation of generation from application has the advantage of avoiding characterization of both conventional and solar thermal application equipment. This is important to the Department of Energy Solar Thermal Program because it removes the necessity of considering unique solar thermal energy application equipment for every application in each industry. This is also important to this study since avoiding industry-specific application equipment maintains the general, industry-wide validity of the IPH value estimates.

Unfortunately, the ability to separate energy production from application varies among conventional IPH equipment. Boilers present no problem; both conventional and solar thermal steam generators focus only on the production of steam and not its application. Although solar thermal technology has the capability of separating the generation of hot gases from their application, combustion furnaces combine energy generation and energy application within a single piece of equipment. Finally, the separation of production and application of energy is certainly possible in an electric furnace, but this would change what could be considered an IPH application (from the solar thermal point of view) to a strict electric power application.

The differences that exist among steam boilers, combustion furnaces, and electric furnaces require a unique approach to defining the system boundary for each technology. The steam boiler boundary quite naturally includes the entire system for generating steam from water via heat transfer from combustion products. The boundary for combustion furnaces includes only the combustion product generation equipment. Defining the boundary in this way requires a segregation of furnace components into energy generation and energy application components (see Table 2.1), but this inconvenience is less of a problem than attempting to characterize a generic furnace. Because furnaces combine energy generation with energy application, they tend to be uniquely designed to meet

the needs of a specific product application. While it is possible to speak of a generic or typical boiler, the concept of a generic or typical furnace breaks down because of their design diversity. This boundary choice also profits from the general advantages cited above for separating energy generation from energy application. Finally, the system boundary chosen for electric furnaces includes both energy generation and application. As noted above, this boundary choice is necessary to maintain the concept of IPH for this technology.

TABLE 2.1 Energy Generation and Application Equipment

<u>Energy Generation</u>	<u>Energy Application</u>
fuel storage	firebox
fuel handling	tube banks
burners	furnace walls
stacks	furnace structure
pollution control	

Figure 2.1 illustrates the system boundaries for the steam boilers, combustion furnaces, and electric furnaces. Again, the boiler systems include all equipment necessary for generating steam from water via heat transfer from combustion products. This includes fuel-storage, fuel-handling, burners, stacks, and pollution control equipment plus the heat-transfer apparatus (firebox, tube banks, boiler walls, and boiler structure) required for transferring heat from the combustion products to the water. The boiler system boundary produces an intermediate IPH medium (steam) which can then be applied to any number of possible end-uses. The combustion furnace system is identical to the boiler system, except the intermediate heat-transfer apparatus and the intermediate IPH medium have been eliminated. The electric furnace system boundary differs from both the steam boilers and combustion furnaces by including the end-use heat-transfer apparatus within the system boundary.

In general, each of the components included within the system boundaries shown in Figure 2.1 was included as part of the capital cost for the systems evaluated. However, several of the components represent relatively minor or

Figure 2.1. IPH System Boundaries

nonexistent costs for certain systems. In addition, the costs of some components (especially pollution control equipment) are occasionally assignable to other parts of the plant and don't represent an incremental cost attributable to the IPH system. A more specific discussion of the equipment included for each system evaluated is presented in Section 3.0, System Characterization.

2.4 IPH PRODUCTION COST FACTORS

The general approach taken to estimate the cost of IPH was to characterize the cost and performance of conventional technologies for various technology, temperature, and fuel combinations. The possible combinations are identified in Table 2.2. Costs were first estimated for median or expected conditions; costs for other conditions were then evaluated by varying the value of some of the more important cost-influencing parameters.

TABLE 2.2. IPH Cost Design Points

<u>Technology</u>	<u>Temperatures</u>	<u>Fuel(s)</u>
Steam Boiler	250F, 500F, 850F	coal, oil, gas
Combustion Furnace	850F, 1500F, 2500F	oil, gas
Electric Furnace	2500F, 4000F	electricity

IPH costs are influenced by a number of factors listed in Table 2.3. Some of these factors directly affect IPH costs (e.g., fuel costs) while others (e.g., equipment efficiency) indirectly affect IPH costs. Many of the factors have a direct interaction with each other. Additional factors affecting those cited in Table 2.3 are listed in Table 2.4.

TABLE 2.3 Factors Influencing IPH Production Costs

Equipment Capital Cost	Equipment Efficiency
Initial Fuel Cost	Fuel Escalation Rate
Initial O&M Rate	O&M Escalation Rate
Capacity Factor	Financing/Economic

TABLE 2.4 Additional IPH Cost Factors

Equipment Capital Cost	- fuel type, equipment efficiency, unit size, product being heated
Equipment Efficiency	- fuel type, unit size, equipment capital cost (quality), product being heated
Initial Fuel Cost	- fuel type, location, energy market dynamics
Fuel Escalation Rate	- fuel type, location, energy market dynamics
Initial O&M	- fuel type, equipment capital cost (quality)
O&M Escalation Rate	- material costs, labor market dynamics
Capacity Factor	- plant and industry-specific
Financing/Economic	- tax rates, depreciation schedule, and tax credits defined by law; discount rate varies with entity, subject to some uncertainty; inflation and economic life subjective, but have little effect on the real cost of energy.

A major premise of the study was that fuel costs are the dominant component of IPH costs. This premise determined which factors were evaluated via parametric investigation and which were fixed at a representative, median value. Initial fuel cost, fuel escalation rate, and equipment efficiency all have a direct bearing on the fuel component of IPH costs. The importance of fuel cost was evaluated by investigating alternative fuels, U.S. average and Southwestern regional fuel prices, and their unique fuel price escalation rates. Details regarding the fuel prices and fuel price escalation rates used in this study can be found in Section 4.0.

Two other non-fuel factors were included in the parametric investigation. A tradeoff between equipment capital cost and equipment efficiency was first considered prior to analyzing the impact of other factors. The cost effect of varying capacity factor was evaluated over a range of 0.1 to 0.9. Any energy system will become dominated by capital costs if the capacity factor drops low enough. Industrial capacity factors vary widely, but tend to range from 0.5 to 0.9.

3.0 SYSTEM CHARACTERIZATION

Conventional IPH equipment characterized in this study included boilers, combustion furnaces, and electric furnaces. The temperature ranges and fuels considered for each technology are shown in Table 3.1.

TABLE 3.1 Conventional IPH Systems

<u>Equipment</u>	<u>Temperature Range</u>	<u>Fuels</u>
Boilers	250-850F	coal, oil, gas
Combustion Furnaces	850-2500F	oil, gas
Electric Furnaces	2500-4000F	electricity

The approach to characterizing each system consisted of the following procedure. The equipment size range (heating capacity, MMBtu/hr) was first identified for a design point (technology, temperature, fuel combination). A median or representative size was then selected based on the population and energy capacity distributions. Capital and non-fuel O&M costs were then estimated for both high-efficiency and low-efficiency units. These data were used in a cost/performance tradeoff between the high capital cost/high efficiency and low capital cost/low efficiency systems. The system yielding the lowest levelized energy cost from this pair was selected to serve as the base case for further parametric investigations. Finally, potential improvements in efficiency within the next 10-15 years were identified. Boiler, combustion furnace, and electric furnace characterizations are described in the following subsections.

3.1 BOILERS

There are two basic classifications of boilers that are distinguished by their heat-transfer configuration. These are the water-tube and fire-tube boilers. Water-tube units produce steam by circulating water through numerous tubes around which hot gases pass. In fire-tube boilers the combustion gases flow thorough tubes that are immersed in water. A third type, or subclassification, of boiler is the cast-iron boiler. The cast-iron boiler is similar in design to the fire-tube boiler in that the combustion gases

pass through the tubes submerged in the water. However, since they are not constructed of steel, as are the fire-tube boilers, cast-iron units are designed to meet different code requirements and usually operate at lower temperatures and pressures.

Generally, cast-iron units are found in the residential and commercial sectors, with some use in industrial plants. Fire-tube boilers are primarily used in commercial and industrial applications. Industrial and utility operations account for the majority of water-tube boiler applications.

3.1.1 Equipment Size and Design Points

Cast-iron boilers dominate both the commercial and industrial sectors in terms of the total number of installed units. Cast-iron boilers constitute almost 57% of the installed industrial boilers. Thirty-five percent of the total industrial boilers are fire-tube, while the remaining 8% are water-tube units. A breakdown of the number of each boiler type by capacity is shown in Table 3.2. As can be seen in the table, the cast-iron boilers have relatively small capacities compared to either fire-tube or water-tube units. As a result, cast-iron boilers contribute only a small portion of the total installed capacity in industrial applications.

TABLE 3.2 Number of Installed Industrial Boilers by Category and Capacity Range - 1985 (Chockie 1984)

Capacity Range (Million Btu/hr)	Water-tube	Fire-tube	Cast iron
< 0.4	---	---	203,715
0.4 - 1.5	4,551	114,759	80,182
1.5 - 10	9,040	60,121	25,877
10 - 25	6,211	15,883	---
25 - 50	12,210	2,864	---
50 - 100	6,686	---	---
100 - 250	4,544	---	---
250 - 500	1,083	---	---
500 - 1000	282	---	---
> 1000	<u>73</u>	<u>---</u>	<u>---</u>
	44,680	193,627	309,774

As shown in Table 3.3, an estimated 71% of the industrial boiler capacity in 1985 was supplied by water-tube units. Fire-tube boilers supplies 23% of the total capacity, while cast-iron boilers accounted for only 6%. The average size of an industrial cast-iron boiler is only 0.59 million Btu/hr. This is significantly less than the fire-tube or water-tube averages of 4.0 and 58 million Btu/hr, respectively.

TABLE 3.3. Capacity Distribution of Industrial Boilers - 1985
(Chockie 1984)

Capacity Range (Million Btu/hr)	Total Capacity (Billion Btu/hr)		
	Water-tube	Fire-tube	Cast-iron
< 0.4	---	---	48.1
0.4 - 1.5	5.4	106.5	61.8
1.5 - 10	41.2	308.8	72.8
10 - 25	102.8	258.4	---
25 - 50	449.8	99.7	---
50 - 100	498.1	---	---
100 - 250	668.8	---	---
250 - 500	356.4	---	---
500 - 1000	212.2	---	---
> 1000	254.7	---	---
	<hr/> 2589.4	<hr/> 773.4	<hr/> 182.7

The three boiler design points initially investigated were 250F saturated steam, 500F saturated steam, and 1000F superheated steam at 1000 psia. Based on discussions with representatives from various boiler manufacturers, the upper temperature design point was lowered to a more standard 850F superheated steam at 850 psia. Fire-tube and cast-iron boilers are both commonly used for supplying 250F steam. A fire-tube design was selected as the design basis over a cast-iron design because of the greater contribution of the former to industrial boiler capacity. Both the middle and upper boiler design points correspond to the capabilities of water-tube boilers. Boiler design point information is summarized in Table 3.4.

TABLE 3.4 Boiler Design Points

<u>Temperature</u>	<u>Pressure</u>	<u>Boiler Type</u>	<u>Capacity</u>
250F	30 psia	Fire-Tube	5 MMBtu/hr (1.46 MWt)
500F	681 psia	Water-Tube	60 MMBtu/hr (17.6 MWt)
850F	850 psia	Water-Tube	60 MMBtu/hr (17.6 MWt)

3.1.2 Installed Capital Costs

The cost estimates for both purchase and installation of industrial boilers were obtained from published reports, discussions with boiler manufacturer representatives, and architect and engineering (A&E) firms. The large variations in site requirements and estimating procedures used by various firms made estimating costs for industrial boilers difficult. Site-specific variables, such as the type and amount of equipment required and the amount of site preparation and building modifications required, can significantly affect the cost estimates. The following estimates were based on an "average" industrial boiler system and should be considered as indicators of the relative economic competitiveness of the three boilers.

Installed costs for the three boilers by fuel type are presented in Table 3.5. The total boiler system installation cost includes the boiler plant, site work, boiler support, general facilities, fuel handling, indirect costs, and environmental controls. Economizers are also included in the cost estimates for higher-efficiency systems. The cost information for the various boiler plants and their associated economizers was obtained from the boiler manufacturers. The estimates for the other system components and installation activities were based on a study of industrial boilers prepared for the EPA (PEDCO 1979).

As can be seen in Table 3.5, the boiler plant represents only about 40% of the total installed cost. The costs of the fuel-handling and boiler auxillary equipment can almost equal that of the boiler plant, particularly for coal-fired units. Boiler auxillary equipment includes such items as heaters, feed pumps, the condensate system, the water-treating system, chemical feed equipment, and the compressed air system. Foundations and supports, duct work, piping, insulation, painting, electrical and buildings make up the site work and facilities category. Indirect costs include those costs that

TABLE 3.6 Industrial Boiler Installed Cost Estimates (PEDCO 1979)
(Costs are in thousands of 1984 dollars)

	250F, 5 MMBtu/hr		500F, 60 MMBtu/hr		850F, 60 MMBtu/hr	
	Oil/Gas (a)	Coal	Oil/Gas (a)	Coal	Oil/Gas (a)	Coal
Boiler	38.00	45.00	400.00	600.00	500.00	700.00
Stack	0.57	0.51	7.59	0.82	9.49	7.95
Boiler Support	13.48	0.09	179.78	81.14	224.70	94.88
Economizer	15.00	15.00	25.00	25.00	25.00	25.00
Coal and Ash Handling	---	34.28	---	458.82	---	532.95
Total Equipment	59.05	100.00	612.35	1169.78	759.19	1360.58
Boiler Installation	4.20	15.30	8.30	204.00	6.30	238.00
Stack Installation	0.31	0.28	4.11	3.41	5.14	3.88
Boiler Support Installation	4.31	1.52	58.50	20.23	73.12	23.60
Economizer Installation	15.00	15.00	25.00	25.00	25.00	25.00
Coal and Ash Handling Installation	---	17.90	---	238.64	---	278.41
Site Work and General Facilities	32.54	41.78	433.83	558.82	642.29	849.82
Total Installation	56.36	91.74	527.74	1048.10	651.85	1218.61
Total Direct (Equipment & Installation)	115.41	192.00	1140.09	2217.88	1411.04	2579.17
Indirect Cost	38.93	61.63	364.83	709.72	451.53	825.33
Total Installed Plant	152.34	254.23	1504.92	2927.60	1862.57	3404.50

(a) Oil/gas boiler costs reflect a multiple fuel firing capability, including the firing of residual oil.

cannot be attributed to specific equipment. These include such items as engineering costs, construction and field expenses, the contractor's fee, startup costs, and performance tests. These costs are generally specified as a percentage of the installed equipment cost items and will vary from one project to another. Boiler indirect costs were estimated to be 32% of direct costs, based on the recommendation provided in the PEDCO (1979) study.

The operating efficiencies of a boiler system depend on a large number of influencing factors. Several studies were undertaken in the late 1970s with the objective of determining the actual and potential operating efficiencies of various commercial and industrial boilers. Efficiency data were obtained for boilers with and without economizers across various operating load conditions. Based on this information, a breakdown of the operating efficiencies for the three boilers selected for this study was developed. This breakdown is presented in Table 3.6.

TABLE 3.6 Estimated Industrial Boiler Operating Efficiencies
(KVB 1977)

Fuel	Fire-Tube Boiler (250F)		Water-Tube Boiler (500F)		Water-Tube Boiler (850F)	
	Base	Max. Econ. Attainable	Base	Max. Econ. Attainable	Base	Max. Econ. Attainable
Gas	79.9	80.1	79.9	81.7	79.9	81.7
Oil	83.7	84.1	83.7	86.7	83.7	86.7
Coal	81.0	81.3	83.3	86.8	83.3	86.8

As can be seen in Table 3.6, an additional 0.3 to 3.5% improvement potential is available using economically justified auxiliary equipment. For this study it was assumed that the maximum economically attainable operating efficiencies were due primarily to the addition of an economizer and/or air heater. The capital and installation costs were adjusted appropriately for the addition of this equipment to the base boiler system. The economizers were estimated to cost approximately \$15,000 for the small fire-tube system and \$25,000 for both water-tube boiler systems. Installation costs were estimated by representatives of several A&E and manufacturing firms to equal the purchase cost of the economizer.

3.1.3 Non-Fuel O&M Costs

The operation and maintenance (O&M) costs of the three boiler systems were based on data presented in Peters and Timmerhaus (P&T)(1982). Correlations presented in P&T indicated that one person would be required to operate the 5 MMBtu/hr boiler while a three-person crew would be required for the 60 MMBtu/hr boilers. Maintenance labor and materials for boilers were estimated as a percentage of initial capital cost per year. P&T recommends 4% of capital per year for "simple chemical processes" and 7% of capital per year for "average chemical processes." Oil- and gas-fired boilers were assumed to be representative of the former and coal-fired boilers the latter.

3.1.4 Expected Efficiency Improvements

The maximum attainable boiler operating efficiencies were identified by KVB (1977) in their study of industrial boiler operations. Their estimates are presented in Table 3.7. These estimates were used as the upper end of the efficiency range considered for investigating the cost impact of varying efficiency.

TABLE 3.7 Maximum Expected Boiler Efficiencies

Fire-tube (250F)

Gas	85.6%
Oil	88.8%
Coal	89.5%

Water-tube (500F)

Gas	86.2%
Oil	89.4%
Coal	90.1%

Water-tube (850F)

Gas	86.2%
Oil	89.4%
Coal	90.1%

3.2 COMBUSTION FURNACES

This section describes the system characterization for combustion furnaces in the 850F-2500F temperature range. Oil-fired and gas-fired furnaces were characterized. Three design points were selected to cover the range of combustion furnace operating temperatures: 850F, 1500F, and 2500F. For each of these temperatures, a "representative" industrial furnace was selected for each of the two fuel types (oil and gas). It would have been preferable to keep the characterization of combustion furnace energy generation equipment free of the specific nature of any single industry, but the diverse nature of combustion furnaces precludes the generic approach. Table 3.8 shows the representative industries and furnace types selected. No representative applications were characterized for coal-fired furnaces at 850F, 1500F, and 2500F or for oil-fired furnaces at 1500F. There are some furnaces that use coal and oil at these temperatures, but not commonly as their primary fuel source.

TABLE 3.8 Representative Industries and Furnaces Types

<u>Temperature</u>	<u>Fuel</u>	<u>Industry</u>	<u>Furnace Type</u>
850F	Coal	None	---
850F	Oil	Petroleum Refining	Natural Draft Fired Heater
850F	Gas	Petroleum Refining	Natural Draft Fired Heater
1500F	Coal	None	---
1500F	Oil	None	---
1500F	Gas	Hydrogen Plant	Steam-Methane Reforming Furnace
2500F	Coal	None	---
2500F	Oil	Pulp & Paper	Lime Kiln
2500F	Gas	Container Glass	Melting Furnace

3.2.1 Equipment Size and Design Points

The combustion furnaces selected to represent industrial process heat applications at the various design points range from 0.8 MMBtu/hr to 726 MMBtu/hr. Table 3.9 shows the size ranges for the design points.

TABLE 3.9 Furnace Size Ranges

<u>Temperature</u>	<u>Fuel</u>	<u>Size Range</u>	
		<u>(MMBtu/hr)</u>	<u>(Mwt)</u>
850F	Coal	None	None
	Oil	0.8-726	0.23-213
	Gas	0.8-726	0.23-213
1500F	Coal	None	None
	Oil	None	None
	Gas	2-695	5.9-204
2500F	Coal	None	None
	Oil	25-450	7.3-132
	Gas	17-63	5.0-18.5

For each design point a "median" size representative furnace was selected to be used as the basis for our cost estimates. The median sizes ranged from 37.5 MMBtu/hr to 275 MMBtu/hr, as shown in Table 3.10.

TABLE 3.10 Furnace Median Sizes

<u>Temperature</u>	<u>Fuel</u>	<u>Median Size</u>	
		<u>(MMBtu/hr)</u>	<u>(Mwt)</u>
850F	Coal	None	None
	Oil	70	20.5
	Gas	70	20.5
1500F	Coal	None	None
	Oil	None	None
	Gas	275	80.6
2500	Coal	None	None
	Oil	100	29.3
	Gas	37.5	11.0

3.2.2 Installed Capital Costs

This section describes the installed capital costs of the representative furnaces. The system boundary was drawn to include energy generation equipment as opposed to energy application equipment. In general, if a corresponding piece of equipment would not be required for the application of solar thermal IPH, then it was also included within the furnace energy generation equipment. For instance, smoke stacks and pollution control equipment were included within the energy generation boundary of a conventional furnace since this equipment would be displaced by a solar thermal system. The following furnace equipment components were included within the energy generation system boundary (not all of these components were required for each system):

- o burners
- o stacks
- o fuel-handling equipment
- o fuel-storage equipment
- o pollution control equipment

The specific costs for each design point are discussed below, and the costs are summarized in Table 3.11 for high-efficiency and low-efficiency burner systems. The costs shown represent the contribution of these components to the full cost of an installed system.

The representative oil-fired or gas-fired furnace at 850F is a 70 MMBtu/hr petroleum refining natural draft fired heater. It is standard practice to use combination oil/gas burners on these furnaces to allow refiners to switch back and forth between oil and gas as their relative prices change. A 70 MMBtu/hr furnace would require 15 burners rated at 5 MMBtu/hr each, assuming an efficiency of 98-100 percent. The installed cost of one burner is \$8700 in 1984\$ (Cherry and Hunter 1980).

In addition to the burners, the stack was included as part of the energy-production equipment. The cost of a box-type fired heater with carbon steel tubes and an absorbed duty of 70 MMBtu/hr is \$900,000 (Matley 1984).

TABLE 3.11 Estimated Installed Capital Costs

<u>Temperature</u>	<u>Fuel</u>	<u>Burner Efficiency (%)</u>	<u>Capital Cost (\$1984)</u>
850F	Coal	---	---
	Oil	98	221,000
		99	221,000
	Gas	99	221,000
		100	221,000
1500F	Coal	---	---
	Oil	---	---
	Gas	99	726,000
		100	722,000
2500F	Coal	---	---
		---	---
	Oil	90	205,000
		99	197,000
	Gas	94	14,300
		100	143,000

The cost of the stack represents about 10 percent of the cost of a fabricated furnace^(a), so a stack cost of \$90,000 was assumed.

The representative gas-fired furnace at 1500F is a 275 MMBtu/hr hydrogen plant steam-methane reforming furnace. On a reforming furnace there are more burners than on a fired heater, but they are smaller. A 275 MMBtu/hr reforming furnace would require 92 or 93 burners at 3 MMBtu/hr, depending on the burner efficiency (100 percent vs. 99 percent). The cost of the burner depends on accessories such as noise abatement and on the burner's ability to handle preheated combustion air. For this study, a purchase cost of \$1,000 per burner was used^(b). The installed cost per burner would be about \$4,800 in 1984\$, based on cost data presented by Cherry and Hunter (1980). Again, the furnace stack was included as part of the energy-production equipment. The cost of a

(a) Personal communication with Harry Deacon, Manager of Furnace Design, Process Division, M. W. Kellogg Company, Houston, Texas. At M. W. Kellogg the "rule-of-thumb" for estimating the stack cost is to use 8-10% of the fabricated furnace cost.

(b) Personal communication with representatives from John Zinc Co., Tulsa, Oklahoma.

275 MMBtu/hr furnace is about \$2.8 million (Matley 1984), so a stack cost of \$280,000 was assumed based on the M. W. Kellogg "rule-of-thumb."

The representative oil-fired furnace at 2500F is a 100 MMBtu/hr lime kiln in the pulp and paper industry. The cost for this application is \$197,000 to \$205,000, depending on the burner efficiency. This cost includes the burner, oil gun, pilot, flame safeguard, controls, pump, piping, and oil storage tank for a 2-week supply.^(a)

The representative gas-fired furnace at 2500F is a 37.5 MMBtu/hr container glass melting furnace. Such a furnace might typically use 16 burners (at about \$9,000 apiece), assuming a burner efficiency of 100 percent, which sealed-in gas burners can achieve.^(b) The low-efficiency case corresponds to actual plants that just inject the gas through a pipe, which results in poorer mixing, air leaks, and an efficiency of only 94%. A cost of \$14,300 was assumed for this low-efficiency case.

3.2.3 Non-Fuel O&M Costs

This section describes the non-fuel O&M costs of the representative furnaces. The specific costs for each design point are discussed below, and the costs are summarized in Table 3.12 for high-efficiency and low-efficiency burners.

The non-fuel O&M costs for 850F oil-fired or gas-fired furnaces are estimated to be 1.4 percent of the initial capital cost per year (Cherry and Hunter 1980). This estimate is based on data from two major West Coast petroleum refineries and was assumed to apply to the 1500F gas-fired furnace as well. The glass melting furnace requires 0.8 kWh of electricity per million Btu of fuel that is burned for circulating air within the surrounding checkerwork. Non-fuel O&M costs for the lime kiln were assumed to be 1% of the initial capital cost per year.

(a) Burner cost (plus cost of associated accessories) from personal communication with Coen Co., Burlingame, California. Storage tank cost from Peters and Timmerhaus (1982).

(b) Personal communication with Glenn Neff, Jr., Combustion Tec, Inc., Orlando, Florida.

TABLE 3.12 Estimated Non-Fuel O&M Costs

<u>Temperature</u>	<u>Fuel</u>	<u>Burner Efficiency (%)</u>	<u>O&M Cost</u>
850F	Coal	---	---
850F	Oil	98 or 99	1.4% of initial capital/year
850F	Gas	99 or 100	1.4% of initial capital/year
1500F	Coal	---	---
1500F	Oil	---	---
1500F	Gas	99 or 100	1.4% of initial capital/year
2500F	Coal	---	---
2500F	Oil	90 or 99	1% of initial capital/year
2500F	Gas	94 or 100	0.8 kWh/MMBtu of fuel burned

3.2.4 Expected Efficiency Improvements

Currently available burners are already at or near 100% efficiency. An assumption of 100% efficiency for gas burners and 99% efficiency for coal and oil burners was made in this study, based on the current burner efficiencies quoted by vendors and A&E firms contacted.

In addition to the burner efficiency, fossil-fueled systems suffer a loss of energy associated with vaporization of the water in the combustion products. The heat of vaporization contained in the water is almost never recovered in practice and represents an inefficiency of application that solar-generated hot air would not suffer. Although we have generally excluded IPH application equipment and application efficiencies from our boundary of analysis for combustion furnaces, the inherent difference between fossil-generated combustion

products and solar-generated hot air requires that water vaporization losses be included in the fossil system efficiency.

The inefficiency associated with vaporizing water in the combustion products is equal to the ratio of the lower heating value (LHV) of a fuel to its higher heating value (HHV). The HHV represents the heat of combustion for a fuel assuming the water in the combustion products has condensed. The LHV represents the heat of combustion when the water remains as a vapor. The ratio of the LHV to HHV depends on the fuel. Values for the LHV, HHV, and the ratio of the two are shown in Table 3.13 for natural gas and residual oil.

3.3 ELECTRIC FURNACES

Electric furnaces have the capability to precisely control the application of heat, to operate in a controlled atmosphere, and can reach temperatures limited only by the characteristics of the charge. Electric furnaces are comprised of four general classifications, each with its own unique heat-transfer mechanism. Resistor furnaces create heat by passing current through a resistive heating element. Induction furnaces create heat by currents developed directly within the charge. Heat is created in an arc furnace by an electric arc which is drawn from an electrode to the charge. Finally, in resistance furnaces, heat is created directly in the charge by passing a current from one electrode to another through the charge. The resistor and arc furnaces were chosen for characterization in this study since they represent two types of indirect heat transfer and would be more similar to the heat-transfer capabilities of a solar furnace than the induction or resistance furnaces.

Standard resistor furnaces operate at a design temperature range of 1000 to 2000F with nickel-chromium-iron alloy resistor heating elements (Baumeister 1982). The softening point of the alloy material at about 2500F limits their use in higher-temperature furnaces. Silicon carbide heating elements are commonly used for heating-chamber temperatures up to about 2800F. Another material commonly used in high-temperature heating elements is molybdenum. Molybdenum elements can be used for temperatures up to 3000F, but only in an artificial atmosphere. Resistor furnaces may operate at temperatures up to about 4000F. At this temperature an inert, reducing, or vacuum operating

TABLE 3.13 Heat of Combustion for Natural Gas and Residual Oil

<u>Fuel</u>	<u>LHV</u> (Btu/lb)	<u>HHV</u> (Btu/lb)	<u>LHV/HHV</u>
Natural Gas	19,719	21,830	0.903
Residual Oil	17,252	18,126	0.952

atmosphere is required to protect the heating elements. Graphite heating elements are commonly used in this temperature range. Water cooling systems are also mandatory at these elevated temperatures to protect the furnace lining.

Electric furnaces operating at around 2500F are generally used for applications such as heat treatment of metals, annealing glass, and firing of vitreous enamel. Typical applications for 4000F resistor furnaces are sintering, heat treating, melting, alloying, graphitization and the firing of silicon nitrides and silicon carbides.

Arc furnaces are either a three-phase or single-phase design. Three-phase furnaces are most commonly used for the melting and refining of steels, while single-phase furnaces are typically used for non-ferrous metals. Although the arc temperature itself can exceed 6000F, the temperature of the molten steel charge is closer to 2800F.

3.3.1 Equipment Size and Efficiency

The electric power ratings of resistor and arc furnaces differ by two orders of magnitude. Resistor furnace sizes range from under 100 kW up to 500 kW (Baumeister 1982). Steel arc furnaces range in size from less than 10 MW up to 100 MW (McGraw-Hill 1985). The median size resistor furnace operating in an inert or reducing atmosphere is about 150 kW for both 2500F and 4000F furnace temperatures, according to furnace manufacturers. Standard atmosphere units are slightly smaller. The median size steel arc furnace has a power rating of about 40 MW (McGraw-Hill 1985).

The operating efficiency of electric furnaces is generally not measured or specified by the manufacturers. The energy required to melt or heat an object varies with the size of the furnace, the thickness of the refractory lining, the rate of melting, and the degree of continuity of furnace operation.

The efficiency of resistor furnaces is around 55%, while the typical steel arc furnace efficiency is about 65%.

3.3.2 Installed Capital Costs

The purchase cost of a 150 kW inert atmosphere resistor furnace operating at 2500F ranges from \$150,000 to \$200,000 depending on the type of instrumentation and cooling system employed.^(a) These costs are based on a 12 cubic foot furnace box. Installation adds an estimated 10% to the capital cost. The purchase cost for a 150 kW inert atmosphere resistor furnace operating at 4000F is actually lower, ranging from \$125,000 to \$135,000. The lower cost is attributable to the much smaller physical capacity (two cubic feet) of the higher-temperature unit. The purchase cost for a 40 MW (90 ton) steel arc furnace is approximately \$2.4 million.^(b) Installation adds about 60%, for a total capital cost of \$3.8 million.

3.3.3 Non-Fuel O&M Costs

The primary maintenance activity for a resistor furnace is the replacement of the heating element. Depending on the mode of operation, this activity will be required at most once a year. The elements were estimated to cost between \$600 and \$1000 per replacement. Labor cost was estimated to run up to about \$1500 per replacement. Additional maintenance is required for replacing the ionization seals, o-rings, vacuum grease, and oil. These items are usually replaced about once a year, depending on the furnace operating mode. Refractory lining replacement is also strongly dependent on the mode of operation. Manufacturers indicated that the annual material costs could range as high as \$8,000 for the 2500F furnace using an inert or reducing atmosphere and about \$5,000 for a 4000F furnace. These costs include the replacement of the heating elements. The difference between the two types of furnaces is attributed to the differences in the type, number and cost of the heating elements. Maintenance labor costs are estimated to be approximately \$2000 per year. Operational labor was assumed to be negligible.

(a) Personal communication with representatives from L&L Specialty Furnaces.

(b) Personal communication with representatives from Lectromelt, Inc.

The single biggest maintenance item for a steel arc furnace is the replacement of the refractory lining. Materials and labor for relining cost about \$.55/ton of steel melted, according to a representative of Lectromelt. All other maintenance activities cost an additional \$.55/ton of melted steel. A 40 MW (90 ton) steel arc furnace was estimated by Judson Steel to require 3.5 full-time-equivalent operators.

4.0 SYSTEM ECONOMICS

Section 2.3 identified two IPH cost production factors (financing/economic assumptions and fuel costs) which will be discussed in more detail here. Section 4.1 describes the levelized costing model used to calculate IPH costs, identifies the financial, economic, and technology-characterizing inputs to the model, and presents the levelized energy cost outputs. Section 4.2 presents the current (\$1984) fuel costs and escalation rates used in the study and discusses the qualifications of the data source cited.

4.1 LEVELIZED ENERGY COST MODEL

A levelized energy cost model (IPHLEC) was developed to facilitate the calculation of IPH costs for the myriad of cases evaluated. The model was developed from equations presented in Doane (1976) and produces results entirely consistent with the levelized energy cost model being used for establishing goals in the 1986-1990 Solar Thermal Five Year Plan. Full documentation of the levelized energy costing equations is available in Doane (1976) or Williams (1985). A listing of the spreadsheet cell contents for IPHLEC and the levelized costing equations are given in Appendices B and C, respectively.

IPHLEC is best described by example. A sample spreadsheet is presented in Figure 4.1. The spreadsheet is divided into four sections: general system description, cost and financial inputs, calculations, and results. Inputs are entered into the first two sections and the model calculates the outputs presented in the latter two sections. The general system description characterizes the design point triplet (technology, temperature, fuel) plus system capacity factor and efficiency. Cost inputs are divided into equipment, O&M, and fuel components.

Each of the general system description and cost inputs may vary from case to case. The fixed-charge rate (FCR) and capital recovery factor (CRF) were fixed for all the cases evaluated.

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.920
Fuel Type:	Gas		

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 70 MBtu/hr
\$/Unit: \$3,157 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$4.30 /MBtu
Fuel Escalation: 4.64 %/year

O&M Cost Inputs

Fixed O&M: \$3,094
Variable O&M Rate: \$0.000 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$220,990
1st Year Fuel Cost= \$2,360,086
1st Year O&M Cost= \$3,094

Present Value of Capital= \$220,990
Present Value of Fuel= \$29,109,209
Present Value of O&M= \$26,341

Annualized Capital Cost= \$32,900
Annualized Fuel Cost= \$3,419,157
Annualized O&M Cost= \$3,094

Results (levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.11 /MBtu	1.0%
Levelized Fuel Cost=	\$11.15 /MBtu	99.0%
Levelized O&M Cost=	\$0.01 /MBtu	0.1%
Levelized Energy Cost=	\$11.27 /MBtu	

FIGURE 4.1. IPHLEC Sample Spreadsheet

General system description, equipment cost, and O&M cost inputs were determined as part of the system characterization described in Section 3.0. Fuel cost inputs are presented in Subsection 4.2. Financial inputs (FCR and CRF) were calculated based on economic assumptions consistent with those given in the 1985-1989 Solar Thermal Five Year Plan (Department of Energy 1984) for an industrial entity. These assumptions are specified in Table 4.1 below.

TABLE 4.1 System Economic Assumptions

1984 Constant Dollars	10% Real Discount Rate
Five Year ACRS Depreciation	50% Income Tax Rate
Plant Built in 1994	10% Investment Tax Credit
Operation Begins in 1995	1% Other Taxes
Twenty Year Life	0% Capital Escalation Rate
5% General Inflation Rate ^(a)	0% O&M Escalation Rate

^(a) An inflation rate assumption was required to convert nominal depreciation credits into real depreciation credits. All other cost components were estimated directly in real terms.

Both intermediate and final results are calculated and presented by IPHLEC. First-year costs, present value, and annualized costs are calculated for capital, fuel, and O&M cost components. These figures are presented in the calculations section of the spreadsheet. Total and component levelized energy costs are presented in the results section.

4.2 FUEL COST DATA

Fuel costs are not only the dominant cost component for most conventional IPH systems, but probably have the highest level of uncertainty. These two factors highlight the necessity for using the best available fuel cost information.

Many sources of fuel price projections by both public and private institutions exist. The source chosen for this study was the Annual Energy Outlook 1984 published by the Energy Information Administration (EIA) (1985). This source has several characteristics which make it a good choice: 1) The

EIA exists, in part, to supply accurate energy-related data for government-sponsored studies such as this one; 2) The EIA has spent considerable resources, well above and beyond the budget for this study, to develop an indepth estimate of future energy prices; 3) The EIA estimates are based on a full macroeconomic model rather than a partial model or no model; 4) The EIA estimates specifically address the industrial sector (among others); 5) The EIA estimates are specific to fuel type; and 6) The EIA provides both U.S. average and regional price estimates based on the same underlying macroeconomic assumptions.

EIA national fuel price projections are developed for "low," "medium," and "high" world oil price scenarios. Regional fuel price projections are only offered for the "medium" world oil price scenario. Fuel price escalation rates implied by EIA estimates and used in this study are shown in Table 4.2. The lower escalation rates shown for coal and natural gas under the "high" world oil price scenario are not misprints, but represent the real price effect of interacting supply and demand for this scenario.

Energy price projections made in support of the National Energy Policy Plan (NEPP) were also considered as an alternative or additional source of data, but were rejected for the following reasons. The latest (fourth) edition of the NEPP was published in 1983. Changes in the world energy situation by 1985 had considerably reduced the validity of the fuel price projections provided in that publication. Unfortunately, the fifth edition of the NEPP was not available in time to be used in this study.

TABLE 4.2 Fuel Costs and Estimated Escalation Rates

Fuel ^(a)	<u>\$1984/MMBtu</u> ^(b)	<u>"Low"</u> <u>Esc.</u> <u>%/yr</u>	<u>"Medium"</u> <u>Esc.</u> <u>%/yr</u>	<u>"High"</u> <u>Esc.</u> <u>%/yr</u>
Steam Coal-U.S. Ave.	1.93	2.00	2.00	1.92
Steam Coal-S.W. Ave.	2.59	-	1.22	-
Residual Oil-U.S. Ave.	4.35	0.90	2.92	5.43
Residual Oil-S.W. Ave.	4.92	-	2.86	-
Natural Gas-U.S. Ave.	4.30	4.56	4.64	4.53
Natural Gas-S.W. Ave.	4.95	-	3.76	-
Electricity-U.S. Ave.	16.66	-0.33	-0.18	-0.14
Electricity-S.W. Ave.	15.62	-	2.26	-

(a) Distillate oil was not specifically analyzed in this study.

(b) 1984 dollars for fuel sold in 1984.

5.0 RESULTS

Estimates of the cost of IPH were calculated for each of the design point triplets (technology, temperature, fuel) listed in Table 5.1. Each of the design points was first evaluated for the baseline conditions established in Sections 3.0 and 4.0. A tradeoff between capital cost and system efficiency was considered to determine the minimum-cost baseline system. Alternative costs were then calculated based on variations of capacity factor, system efficiency, fuel prices (due to regional differences), and fuel price escalation. Over 150 individual cases were evaluated.

TABLE 5.1 IPH Systems Evaluated

<u>Technology</u> <u>Factor</u>	<u>Temperature</u>	<u>Fuel</u> (a)	<u>System Size</u> <u>MMBtu/hr</u>	<u>Baseline</u> <u>Capacity</u>
Boiler	250F	Coal	5	.5
Boiler	250F	Oil	5	.5
Boiler	250F	Gas	5	.5
Boiler	500F	Coal	60	.5
Boiler	500F	Oil	60	.5
Boiler	500F	Gas	60	.5
Boiler	850F	Coal	60	.5
Boiler	850F	Oil	60	.5
Boiler	850F	Gas	60	.5
Combustion Furnace	850F	Oil	70	.5
Combustion Furnace	850F	Gas	70	.5
Combustion Furnace	1500F	Gas	275	.5
Combustion Furnace	2500F	Oil	100	.5
Combustion Furnace	2500F	Gas	37.5	.5
Electric Resistor Furnace	2500F	Electricity	0.51	.5
Electric Arc Furnace	2500F	Electricity	137	.5
Electric Resistor Furnace	4000F	Electricity	0.51	.5

(a) Oil is residual oil.

Baseline estimates of IPH costs will be presented and discussed in this section along with a sampling of the more interesting sensitivity cases. A complete listing of all the cases evaluated is provided in Appendix A. Implications of the results will be discussed in Section 6.0.

5.1 BASELINE RESULTS

Estimates of the cost of IPH from coal-, oil-, and gas-fired boilers are shown in Figures 5.1, 5.2, and 5.3, respectively. The most striking aspect of the three figures is the high cost associated with the 250F systems. For each fuel type, the high cost differential for 250F systems is almost entirely attributable to O&M costs. The system capacity (measured in MMBtu/hr) of the 250F units is 1/12 that of the 500F and 850F units, but the operating labor requirement was found to only vary by a factor of three. The resulting large economies-of-scale for operating labor are evident when comparing the O&M component of 250F systems with 500F and 850F systems. Other cost trends for boilers conformed better with expected values. The smaller capacity 250F boilers have a slightly lower efficiency than 500F or 850F systems, which increases the fuel component of the 250F boiler levelized cost. Levelized capital costs increase with steam temperature (and the corresponding increase in steam pressure) due to the more demanding requirements on boiler tubes. Coal-fired boilers have a much larger capital component than oil or gas systems. Finally, fuel is the dominate cost component for all boiler systems except the 250F coal-fired unit.

IPH cost estimates for oil- and gas-fired combustion furnaces are shown in Figures 5.4 and 5.5, respectively. No coal-fired combustion furnace applications were identified, nor were any predominately oil-fired combustion furnaces identified at 1500F. Capital and O&M costs have become insignificant levelized energy components for oil and gas combustion furnaces because the system boundary only includes energy generation equipment and not energy application equipment.

FIGURE 5.1. Coal-Fired Boiler IPH Cost

FIGURE 5.2. Residual Oil-Fired Boiler IPH Cost

FIGURE 5.3. Gas-Fired Boiler IPH Cost

FIGURE 5.4. Residual Oil-Fired Furnace IPH Cost

FIGURE 5.5. Gas-Fired Furnace IPH Cost

The choice of system boundary also reduces the fuel cost component compared to boiler systems since energy generation efficiency ranges from 90-95%. Boiler system efficiencies, including the application efficiency, ranged from 80-90%. For instance, if the application efficiency were included for each of the gas-fired furnaces, the levelized fuel component would be \$11.75, \$12.67, and \$14.27 at 850F, 1500F, and 2500F, respectively. These levelized fuel costs correspond to system efficiencies of 0.87, 0.81, and 0.72.

The cost of heat supplied by electric resistor furnaces is shown in Figure 5.6. Each of the individual cost components is large relative to the combustion systems. The high fuel charge reflects both the use of a highly priced fuel (electricity) and the relatively inefficient (50-60%) operation of electric resistor furnaces. The inefficiency of these furnaces stems from the cyclic, batchwise nature of their operation and the need for extensive water cooling of furnace walls. Inefficiency can also be tied to their relatively small physical size. A 150 kW resistor furnace has external dimensions of only a

FIGURE 5.6. Electric Resistor Furnace IPH Cost

few feet on a side. A furnace of this size has a much larger ratio of surface area to furnace volume than the typical combustion furnace. This enhances the opportunity for heat transfer through the furnace walls. The small size of resistor furnaces also explains why capital and O&M costs are so high (per MMBtu) relative to other systems. The smallness of the electric resistor furnaces does not allow them to capture economies-of-scale. Finally, capital and O&M costs for the 4000F resistor furnace are lower than costs for the 2500F furnace because the furnace dimensions for the higher-temperature unit are smaller, even though they both have the same KW rating.

The cost of process heat for melting steel in an electric arc furnace is shown in Figure 5.7. Overall, the cost of heat for the electric arc furnace is less than that for either of the electric resistor furnaces, but is still much higher than any fossil-fired system. The capital, fuel (electricity), and O&M contributions to levelized energy cost are all less for the arc furnace than for either resistor furnace. The capital cost reduction (per MMBtu) can be attributed to the large economies-of-scale that exist between the "lab-sized" resistor furnaces and the "industrial-sized" arc furnaces. Arc furnace O&M

FIGURE 5.7. Electric Arc Furnace IPH Cost

costs also benefit from economies-of-scale, but to a lesser extent. The greater efficiency of the arc furnace is evident by its smaller levelized "fuel" component compared to the resistor furnaces.

5.2 SENSITIVITY RESULTS

The variation of IPH cost for different fuel price escalation assumptions is shown in Figure 5.8. EIA projections for residual fuel oil escalation are 0.90%, 2.92%, and 5.43% per year for their low, medium, and high world oil price scenarios, respectively. The range of fuel escalation rates considered has a factor of two impact on the cost of IPH. EIA projections for coal, natural gas and electricity varied little between low, medium, and high world oil price scenarios as was shown in Table 4.3. Therefore, the cost impact of alternative escalation rates for these other fuels was insignificant.

Regional differences in fuel price directly impact the cost of IPH. Figures 5.9, 5.10, and 5.11 show how differences between U.S. average and

FIGURE 5.8. Impact of Fuel Price Escalation Rate on IPH Cost

FIGURE 5.9. Impact of Regional Fuel Price Differences on Boiler IPH Cost (oil-fired costs based on residual oil)

FIGURE 5.10. Impact of Regional Fuel Price Differences on Combustion Furnace IPH Cost (oil-fired costs based on residual oil)

FIGURE 5.11. Impact of Regional Fuel Price Differences on Electric Resistor Furnace IPH Cost

Southwestern average fuel prices impact the cost of IPH for boilers, combustion furnaces, and electric resistor furnaces. The levelized cost of coal, oil, electricity is projected to be higher in the Southwest than for the country as a whole, while the levelized cost of natural gas is expected to be lower in the Southwest than across the nation.

The effect of capacity factor on IPH cost is shown in Figures 5.12, 5.13, and 5.14 for boilers, combustion furnaces, and an electric resistor furnace, respectively. The cost of IPH goes up as capacity factor decreases for all systems and will approach infinity as the capacity factor approaches zero. Capital-intensive systems such as coal-fired boilers and electric resistor furnaces show a more rapid response to a declining capacity factor. The combustion furnace systems are insulated from the effects of the declining capacity factor because only energy generation equipment is included in the system boundary. It should be mentioned that solar thermal systems are likely

FIGURE 5.12. Impact of Capacity Factor on Boiler IPH Cost (oil-fired costs based on residual oil)

FIGURE 5.13. Impact of Capacity Factor on Combustion Furnace IPH Cost (oil-fired costs based on residual oil)

FIGURE 5.14. Impact of Capacity Factor on Electric Resistor Furnace IPH Cost

to be more capital-intensive than any of the conventional systems evaluated in this study and, therefore, would most likely be competitive at higher capacity factors. In other words, solar thermal system costs would increase more rapidly with declining capacity factors than the conventional alternatives.

The impact of improvements in efficiency on IPH cost is shown in Figure 5.15 for coal-, oil-, and gas-fired boilers. Because only 3-4% improvements in efficiency are foreseen, the impact on IPH cost is small compared to the cost impact of most of the other variables evaluated in this study. Even if boiler efficiency improved to 100%, the resulting cost impact would be overshadowed by the cost impact of fuel choice.

FIGURE 5.15. Impact of System Efficiency on Boiler IPH (oil-fired costs based on residual oil)

6.0 CONCLUSIONS AND RECOMMENDATIONS

This section describes the conclusions obtained from this study. A discussion of the implications of the results and recommendations for future IPH applications analyses follows.

Fuel costs were the single largest contributor to levelized energy cost in all but one of the cases evaluated. Only the levelized energy cost for the small-sized (250F) coal-fired boiler was dominated by another (O&M) component. The fuel component of levelized energy cost is (as expected) dramatically affected by fuel type and the fuel's projected escalation rate. Finally, declining capacity factor increases IPH costs more quickly for capital-intensive systems.

Among the more interesting results, the cost of IPH was found to be relatively flat within the temperature range of a single technology (boiler, combustion furnace, electric furnace). Step-function changes in cost occurred when moving from one technology to another. The highest-cost IPH was that provided by electric furnaces. The cost of heat delivered by an electric furnace was two to four times that for a fossil-fired system. This represents a significant difference in cost that cannot be explained by the fact that the system boundary for boilers and combustion furnaces included only energy generation equipment, while the electric furnace boundary included both energy generation and application. The difference in IPH cost between fossil and electric systems is largely due to the expense of electricity compared to coal, oil, or gas. The cost of producing IPH actually declined for combustion furnaces relative to boilers. This can be explained by the fact that the efficiency of generating steam ranges from 80-90% while the efficiency of generating hot combustion gases ranges from 90-95%. Finally, projected levelized coal, oil, and electricity costs were identified as being higher in the Southwest than in the U.S. as a whole. Levelized natural gas prices, on the other hand, are projected to be higher nationally than in the Southwest.

The results of this study imply that the greatest opportunity for solar thermal technology exists near the two endpoints of the IPH temperature spectrum. Extremely high-temperature IPH offers the highest value, if solar

thermal technology can overcome the engineering difficulties. The relatively constant value of IPH from 250-2500F suggests that simple, inexpensive solar thermal equipment targeted at the low-temperature market may have the best chance for economic success.

Additional questions need to be answered before decisions regarding the direction of solar thermal IPH research can be made. The cost of producing solar thermal IPH must now be estimated and compared with its value. Promising IPH markets warrant further investigation to determine if the amount of energy consumed is significant, and which fuel types (and values) solar thermal energy would displace.

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APPENDIX A

SYSTEM LEVELIZED ENERGY COST CALCULATIONS

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.500
 Temperature: 250 F Efficiency: 0.810
 Fuel Type: Coal

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 5 MBtu/hr
 \$/Unit: \$42,583 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$1.93 /MBtu
 Fuel Escalation: 2.00 %/year

O&M Cost Inputs

Fixed O&M: \$14,904
 Variable O&M Rate: \$5.000 Per MBtu

Financial Inputs

FCR: 0.149
 CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$212,917
 1st Year Fuel Cost= \$64,881
 1st Year O&M Cost= \$124,404

Present Value of Capital= \$212,917
 Present Value of Fuel= \$644,518
 Present Value of O&M= \$1,059,123

Annualized Capital Cost= \$31,698
 Annualized Fuel Cost= \$75,705
 Annualized O&M Cost= \$124,404

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$1.45 /MBtu 13.7%
 Levelized Fuel Cost= \$3.46 /MBtu 32.7%
 Levelized O&M Cost= \$5.68 /MBtu 53.7%
 Levelized Energy Cost= \$10.58 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.500
 Temperature: 250 F Efficiency: 0.810
 Fuel Type: Coal

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 5 MBtu/hr
 \$/Unit: \$48,413 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$1.93 /MBtu
 Fuel Escalation: 2.00 %/year

O&M Cost Inputs

Fixed O&M: \$16,944
 Variable O&M Rate: \$5.000 Per MBtu

Financial Inputs

FCR: 0.149
 CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$242,064
 1st Year Fuel Cost= \$64,642
 1st Year O&M Cost= \$126,444

Present Value of Capital= \$242,064
 Present Value of Fuel= \$642,139
 Present Value of O&M= \$1,076,493

Annualized Capital Cost= \$36,037
 Annualized Fuel Cost= \$75,425
 Annualized O&M Cost= \$126,444

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$1.65 /MBtu 15.1%
 Levelized Fuel Cost= \$3.44 /MBtu 31.7%
 Levelized O&M Cost= \$5.77 /MBtu 53.1%
 Levelized Energy Cost= \$10.86 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.100
Temperature:	250 F	Efficiency:	0.810
Fuel Type:	Coal		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	5 MBtu/hr	Unit Cost:	\$1.93 /MBtu
\$/Unit:	\$42,583 /MBtu/hr	Fuel Escalation:	2.00 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$14,904	FCR:	0.149
Variable O&M Rate:	\$5,000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$212,917		
1st Year Fuel Cost=	\$12,976		
1st Year O&M Cost=	\$36,804		
Present Value of Capital=	\$212,917		
Present Value of Fuel=	\$128,904		
Present Value of O&M=	\$313,335		
Annualized Capital Cost=	\$31,698		
Annualized Fuel Cost=	\$15,141		
Annualized O&M Cost=	\$36,804		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$7.24 /MBtu	37.9%	
Levelized Fuel Cost=	\$3.46 /MBtu	18.1%	
Levelized O&M Cost=	\$6.40 /MBtu	44.0%	
Levelized Energy Cost=	\$19.10 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.100
Temperature:	250 F	Efficiency:	0.810
Fuel Type:	Coal		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	5 MBtu/hr	Unit Cost:	\$1.93 /MBtu
\$/Unit:	\$42,583 /MBtu/hr	Fuel Escalation:	2.00 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$14,904	FCR:	0.149
Variable O&M Rate:	\$5,000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$212,917		
1st Year Fuel Cost=	\$38,929		
1st Year O&M Cost=	\$80,604		
Present Value of Capital=	\$212,917		
Present Value of Fuel=	\$386,711		
Present Value of O&M=	\$666,229		
Annualized Capital Cost=	\$31,698		
Annualized Fuel Cost=	\$45,423		
Annualized O&M Cost=	\$80,604		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$2.41 /MBtu	20.1%	
Levelized Fuel Cost=	\$3.46 /MBtu	28.8%	
Levelized O&M Cost=	\$6.13 /MBtu	51.1%	
Levelized Energy Cost=	\$12.00 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.700
 Temperature: 250 F Efficiency: 0.810
 Fuel Type: Coal

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 5 MBtu/hr Unit Cost: \$1.93 /MBtu
 \$/Unit: \$42,583 /MBtu/hr Fuel Escalation: 2.00 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$14,904 FCR: 0.149
 Variable O&M Rate: \$5.000 Per MBtu CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$212,917
 1st Year Fuel Cost= \$90,834
 1st Year O&M Cost= \$168,204

Present Value of Capital= \$212,917
 Present Value of Fuel= \$902,325
 Present Value of O&M= \$1,432,017

Annualized Capital Cost= \$31,698
 Annualized Fuel Cost= \$105,987
 Annualized O&M Cost= \$168,204

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$1.03 /MBtu 10.4%
 Levelized Fuel Cost= \$3.46 /MBtu 34.6%
 Levelized O&M Cost= \$5.49 /MBtu 55.0%
 Levelized Energy Cost= \$9.98 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.900
 Temperature: 250 F Efficiency: 0.810
 Fuel Type: Coal

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 5 MBtu/hr Unit Cost: \$1.93 /MBtu
 \$/Unit: \$42,583 /MBtu/hr Fuel Escalation: 2.00 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$14,904 FCR: 0.149
 Variable O&M Rate: \$5.000 Per MBtu CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$212,917
 1st Year Fuel Cost= \$116,786
 1st Year O&M Cost= \$212,004

Present Value of Capital= \$212,917
 Present Value of Fuel= \$1,160,132
 Present Value of O&M= \$1,804,911

Annualized Capital Cost= \$31,698
 Annualized Fuel Cost= \$136,269
 Annualized O&M Cost= \$212,004

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$0.80 /MBtu 8.3%
 Levelized Fuel Cost= \$3.46 /MBtu 35.9%
 Levelized O&M Cost= \$5.38 /MBtu 55.8%
 Levelized Energy Cost= \$9.64 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.500
 Temperature: 250 F Efficiency: 0.837
 Fuel Type: Coal

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 5 MBtu/hr Unit Cost: \$1.93 /MBtu
 \$/Unit: \$42,583 /MBtu/hr Fuel Escalation: 2.00 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$14,904 FCR: 0.149
 Variable O&M Rate: \$5.000 Per MBtu CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$212,917
 1st Year Fuel Cost= \$62,788
 1st Year O&M Cost= \$124,404
 Present Value of Capital= \$212,917
 Present Value of Fuel= \$623,727
 Present Value of O&M= \$1,059,123
 Annualized Capital Cost= \$31,698
 Annualized Fuel Cost= \$73,263
 Annualized O&M Cost= \$124,404

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$1.45 /MBtu 13.8%
 Levelized Fuel Cost= \$3.35 /MBtu 31.9%
 Levelized O&M Cost= \$5.68 /MBtu 54.2%
 Levelized Energy Cost= \$10.47 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.500
 Temperature: 250 F Efficiency: 0.864
 Fuel Type: Coal

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 5 MBtu/hr Unit Cost: \$1.93 /MBtu
 \$/Unit: \$42,583 /MBtu/hr Fuel Escalation: 2.00 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$14,904 FCR: 0.149
 Variable O&M Rate: \$5.000 Per MBtu CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$212,917
 1st Year Fuel Cost= \$60,826
 1st Year O&M Cost= \$124,404
 Present Value of Capital= \$212,917
 Present Value of Fuel= \$604,235
 Present Value of O&M= \$1,059,123
 Annualized Capital Cost= \$31,698
 Annualized Fuel Cost= \$70,973
 Annualized O&M Cost= \$124,404

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$1.45 /MBtu 14.0%
 Levelized Fuel Cost= \$3.24 /MBtu 31.3%
 Levelized O&M Cost= \$5.68 /MBtu 54.8%
 Levelized Energy Cost= \$10.37 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	250 F	Efficiency:	0.810
Fuel Type:	Coal		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	5 MBtu/hr	Unit Cost:	\$1.93 /MBtu
\$/Unit:	\$42,583 /MBtu/hr	Fuel Escalation:	1.92 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$14,904	FCR:	0.149
Variable O&M Rate:	\$5.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$212,917		
1st Year Fuel Cost=	\$64,324		
1st Year O&M Cost=	\$124,404		
Present Value of Capital=	\$212,917		
Present Value of Fuel=	\$634,946		
Present Value of O&M=	\$1,059,123		
Annualized Capital Cost=	\$31,698		
Annualized Fuel Cost=	\$74,581		
Annualized O&M Cost=	\$124,404		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$1.45 /MBtu	13.7%	
Levelized Fuel Cost=	\$3.41 /MBtu	32.3%	
Levelized O&M Cost=	\$5.68 /MBtu	53.9%	
Levelized Energy Cost=	\$10.53 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	250 F	Efficiency:	0.810
Fuel Type:	Coal		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	5 MBtu/hr	Unit Cost:	\$2.59 /MBtu
\$/Unit:	\$42,583 /MBtu/hr	Fuel Escalation:	1.22 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$14,904	FCR:	0.149
Variable O&M Rate:	\$5.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$212,917		
1st Year Fuel Cost=	\$80,018		
1st Year O&M Cost=	\$124,404		
Present Value of Capital=	\$212,917		
Present Value of Fuel=	\$747,731		
Present Value of O&M=	\$1,059,123		
Annualized Capital Cost=	\$31,698		
Annualized Fuel Cost=	\$87,828		
Annualized O&M Cost=	\$124,404		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$1.45 /MBtu	13.0%	
Levelized Fuel Cost=	\$4.01 /MBtu	36.0%	
Levelized O&M Cost=	\$5.68 /MBtu	51.0%	
Levelized Energy Cost=	\$11.14 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	250 F	Efficiency:	0.837
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	5 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$22,389 /MBtu/hr	Fuel Escalation:	2.92 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$4,478	FCR:	0.149
Variable O&M Rate:	\$5,000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$111,944		
1st Year Fuel Cost=	\$156,209		
1st Year O&M Cost=	\$113,978		
Present Value of Capital=	\$111,944		
Present Value of Fuel=	\$1,670,539		
Present Value of O&M=	\$970,357		
Annualized Capital Cost=	\$16,666		
Annualized Fuel Cost=	\$196,221		
Annualized O&M Cost=	\$113,978		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.76 /MBtu	5.1%	
Levelized Fuel Cost=	\$8.96 /MBtu	60.0%	
Levelized O&M Cost=	\$5.20 /MBtu	34.9%	
Levelized Energy Cost=	\$14.93 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	250 F	Efficiency:	0.841
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	5 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$28,175 /MBtu/hr	Fuel Escalation:	2.92 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$5,635	FCR:	0.149
Variable O&M Rate:	\$5,000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$140,873		
1st Year Fuel Cost=	\$155,466		
1st Year O&M Cost=	\$115,135		
Present Value of Capital=	\$140,873		
Present Value of Fuel=	\$1,662,594		
Present Value of O&M=	\$980,208		
Annualized Capital Cost=	\$20,973		
Annualized Fuel Cost=	\$195,288		
Annualized O&M Cost=	\$115,135		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.96 /MBtu	6.3%	
Levelized Fuel Cost=	\$8.92 /MBtu	58.9%	
Levelized O&M Cost=	\$5.26 /MBtu	34.7%	
Levelized Energy Cost=	\$15.13 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.100
 Temperature: 250 F Efficiency: 0.837
 Fuel Type: Oil

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 5 MBtu/hr Unit Cost: \$4.35 /MBtu
 \$/Unit: \$22,389 /MBtu/hr Fuel Escalation: 2.92 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$4,478 FCR: 0.149
 Variable O&M Rate: \$5.000 Per MBtu CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$111,944
 1st Year Fuel Cost= \$31,242
 1st Year O&M Cost= \$26,378
 Present Value of Capital= \$111,944
 Present Value of Fuel= \$334,108
 Present Value of O&M= \$224,569

Annualized Capital Cost= \$16,666
 Annualized Fuel Cost= \$39,244
 Annualized O&M Cost= \$26,378

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$3.80 /MBtu 20.3%
 Levelized Fuel Cost= \$8.96 /MBtu 47.7%
 Levelized O&M Cost= \$6.02 /MBtu 32.1%
 Levelized Energy Cost= \$18.79 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.100
 Temperature: 250 F Efficiency: 0.837
 Fuel Type: Oil

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 5 MBtu/hr Unit Cost: \$4.35 /MBtu
 \$/Unit: \$22,389 /MBtu/hr Fuel Escalation: 2.92 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$4,478 FCR: 0.149
 Variable O&M Rate: \$5.000 Per MBtu CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$111,944
 1st Year Fuel Cost= \$93,725
 1st Year O&M Cost= \$70,178
 Present Value of Capital= \$111,944
 Present Value of Fuel= \$1,002,324
 Present Value of O&M= \$597,463

Annualized Capital Cost= \$16,666
 Annualized Fuel Cost= \$117,733
 Annualized O&M Cost= \$70,178

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$1.27 /MBtu 8.1%
 Levelized Fuel Cost= \$8.96 /MBtu 57.5%
 Levelized O&M Cost= \$5.34 /MBtu 34.3%
 Levelized Energy Cost= \$15.57 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.700
 Temperature: 250 F Efficiency: 0.837
 Fuel Type: Oil

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 5 MBtu/hr Unit Cost: \$4.35 /MBtu
 \$/Unit: \$22,389 /MBtu/hr Fuel Escalation: 2.92 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$4,478 FCR: 0.149
 Variable O&M Rate: \$5.000 Per MBtu CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$111,944
 1st Year Fuel Cost= \$218,692
 1st Year O&M Cost= \$157,778

Present Value of Capital= \$111,944
 Present Value of Fuel= \$2,338,755
 Present Value of O&M= \$1,343,251

Annualized Capital Cost= \$16,666
 Annualized Fuel Cost= \$274,709
 Annualized O&M Cost= \$157,778

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$0.54 /MBtu 3.7%
 Levelized Fuel Cost= \$8.96 /MBtu 61.2%
 Levelized O&M Cost= \$5.15 /MBtu 35.1%

Levelized Energy Cost= \$14.65 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.900
 Temperature: 250 F Efficiency: 0.837
 Fuel Type: Oil

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 5 MBtu/hr Unit Cost: \$4.35 /MBtu
 \$/Unit: \$22,389 /MBtu/hr Fuel Escalation: 2.92 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$4,478 FCR: 0.149
 Variable O&M Rate: \$5.000 Per MBtu CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$111,944
 1st Year Fuel Cost= \$291,176
 1st Year O&M Cost= \$201,578

Present Value of Capital= \$111,944
 Present Value of Fuel= \$3,006,971
 Present Value of O&M= \$1,716,145

Annualized Capital Cost= \$16,666
 Annualized Fuel Cost= \$353,198
 Annualized O&M Cost= \$201,578

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$0.42 /MBtu 2.9%
 Levelized Fuel Cost= \$8.96 /MBtu 61.8%
 Levelized O&M Cost= \$5.11 /MBtu 35.3%

Levelized Energy Cost= \$14.50 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.500
 Temperature: 250 F Efficiency: 0.863
 Fuel Type: Oil

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 5 MBtu/hr
 \$/Unit: \$22,389 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$4.35 /MBtu
 Fuel Escalation: 2.92 %/year

O&M Cost Inputs

Fixed O&M: \$4,478
 Variable O&M Rate: \$5.000 Per MBtu

Financial Inputs

FCR: 0.149
 CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$111,944
 1st Year Fuel Cost= \$151,503
 1st Year O&M Cost= \$113,978

Present Value of Capital= \$111,944
 Present Value of Fuel= \$1,620,210
 Present Value of O&M= \$970,357

Annualized Capital Cost= \$16,666
 Annualized Fuel Cost= \$190,309
 Annualized O&M Cost= \$113,978

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$0.76 /MBtu 5.2%
 Levelized Fuel Cost= \$8.69 /MBtu 59.3%
 Levelized O&M Cost= \$5.20 /MBtu 35.5%
 Levelized Energy Cost= \$14.66 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.500
 Temperature: 250 F Efficiency: 0.868
 Fuel Type: Oil

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 5 MBtu/hr
 \$/Unit: \$22,389 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$4.35 /MBtu
 Fuel Escalation: 2.92 %/year

O&M Cost Inputs

Fixed O&M: \$4,478
 Variable O&M Rate: \$5.000 Per MBtu

Financial Inputs

FCR: 0.149
 CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$111,944
 1st Year Fuel Cost= \$147,237
 1st Year O&M Cost= \$113,978

Present Value of Capital= \$111,944
 Present Value of Fuel= \$1,574,596
 Present Value of O&M= \$970,357

Annualized Capital Cost= \$16,666
 Annualized Fuel Cost= \$184,951
 Annualized O&M Cost= \$113,978

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$0.76 /MBtu 5.3%
 Levelized Fuel Cost= \$8.45 /MBtu 58.6%
 Levelized O&M Cost= \$5.20 /MBtu 36.1%
 Levelized Energy Cost= \$14.41 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	250 F	Efficiency:	0.837
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	5 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$22,389 /MBtu/hr	Fuel Escalation:	0.90 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$4,478	FCR:	0.149
Variable O&M Rate:	\$5.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$111,944		
1st Year Fuel Cost=	\$125,606		
1st Year O&M Cost=	\$113,978		
Present Value of Capital=	\$111,944		
Present Value of Fuel=	\$1,145,064		
Present Value of O&M=	\$970,357		
Annualized Capital Cost=	\$16,666		
Annualized Fuel Cost=	\$134,499		
Annualized O&M Cost=	\$113,978		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.76 /MBtu	6.3%	
Levelized Fuel Cost=	\$6.14 /MBtu	50.7%	
Levelized O&M Cost=	\$5.20 /MBtu	43.0%	
Levelized Energy Cost=	\$12.11 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	250 F	Efficiency:	0.837
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	5 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$22,389 /MBtu/hr	Fuel Escalation:	5.43 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$4,478	FCR:	0.149
Variable O&M Rate:	\$5.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$111,944		
1st Year Fuel Cost=	\$203,617		
1st Year O&M Cost=	\$113,978		
Present Value of Capital=	\$111,944		
Present Value of Fuel=	\$2,687,003		
Present Value of O&M=	\$970,357		
Annualized Capital Cost=	\$16,666		
Annualized Fuel Cost=	\$315,614		
Annualized O&M Cost=	\$113,978		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.76 /MBtu	6.2%	
Levelized Fuel Cost=	\$14.41 /MBtu	70.7%	
Levelized O&M Cost=	\$5.20 /MBtu	25.5%	
Levelized Energy Cost=	\$20.38 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	250 F	Efficiency:	0.837
Fuel Type:	Oil		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 5 MBtu/hr
\$/Unit: \$22,389 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$4.92 /MBtu
Fuel Escalation: 2.86 %/year

O&M Cost Inputs

Fixed O&M: \$4,478
Variable O&M Rate: \$5,000 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$111,944
1st Year Fuel Cost= \$175,548
1st Year O&M Cost= \$113,978

Present Value of Capital= \$111,944
Present Value of Fuel= \$1,868,246
Present Value of O&M= \$970,357

Annualized Capital Cost= \$16,666
Annualized Fuel Cost= \$219,443
Annualized O&M Cost= \$113,978

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.76 /MBtu	4.8%
Levelized Fuel Cost=	\$10.02 /MBtu	62.7%
Levelized O&M Cost=	\$5.20 /MBtu	32.6%
Levelized Energy Cost=	\$15.99 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	250 F	Efficiency:	0.799
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 5 MBtu/hr
\$/Unit: \$22,389 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$4.30 /MBtu
Fuel Escalation: 4.64 %/year

O&M Cost Inputs

Fixed O&M: \$4,478
Variable O&M Rate: \$5,000 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$111,944
1st Year Fuel Cost= \$194,107
1st Year O&M Cost= \$113,978

Present Value of Capital= \$111,944
Present Value of Fuel= \$2,394,106
Present Value of O&M= \$970,357

Annualized Capital Cost= \$16,666
Annualized Fuel Cost= \$281,211
Annualized O&M Cost= \$113,978

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.76 /MBtu	4.0%
Levelized Fuel Cost=	\$12.84 /MBtu	68.3%
Levelized O&M Cost=	\$5.20 /MBtu	27.7%
Levelized Energy Cost=	\$18.81 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	250 F	Efficiency:	0.801
Fuel Type:	Gas		

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	5 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$28,175 /MBtu/hr	Fuel Escalation:	4.64 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$5,635	FCR:	0.149
Variable O&M Rate:	\$5.000 Per MBtu	CRF:	0.117

Calculations (all costs are in 1984 dollars)

Capital Cost=	\$140,873
1st Year Fuel Cost=	\$193,622
1st Year O&M Cost=	\$115,135
Present Value of Capital=	\$140,873
Present Value of Fuel=	\$2,388,128
Present Value of O&M=	\$980,208
Annualized Capital Cost=	\$20,973
Annualized Fuel Cost=	\$280,509
Annualized O&M Cost=	\$115,135

Results (levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.96 /MBtu	5.0%
Levelized Fuel Cost=	\$12.81 /MBtu	67.3%
Levelized O&M Cost=	\$5.26 /MBtu	27.6%
Levelized Energy Cost=	\$19.02 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.100
Temperature:	250 F	Efficiency:	0.799
Fuel Type:	Gas		

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	5 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$22,389 /MBtu/hr	Fuel Escalation:	4.64 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$4,478	FCR:	0.149
Variable O&M Rate:	\$5.000 Per MBtu	CRF:	0.117

Calculations (all costs are in 1984 dollars)

Capital Cost=	\$111,944
1st Year Fuel Cost=	\$38,821
1st Year O&M Cost=	\$26,378
Present Value of Capital=	\$111,944
Present Value of Fuel=	\$478,821
Present Value of O&M=	\$224,569
Annualized Capital Cost=	\$16,666
Annualized Fuel Cost=	\$56,242
Annualized O&M Cost=	\$26,378

Results (levelized constant 1984 dollars)

Levelized Capital Cost=	\$3.80 /MBtu	16.8%
Levelized Fuel Cost=	\$12.84 /MBtu	56.6%
Levelized O&M Cost=	\$6.02 /MBtu	26.6%
Levelized Energy Cost=	\$22.67 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	250 F	Efficiency:	0.799
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 5 MBtu/hr
\$/Unit: \$22,389 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$4.30 /MBtu
Fuel Escalation: 4.64 %/year

O&M Cost Inputs

Fixed O&M: \$4,478
Variable O&M Rate: \$5.000 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$111,944
1st Year Fuel Cost= \$116,464
1st Year O&M Cost= \$70,178

Present Value of Capital= \$111,944
Present Value of Fuel= \$1,436,464
Present Value of O&M= \$597,463

Annualized Capital Cost= \$16,666
Annualized Fuel Cost= \$168,726
Annualized O&M Cost= \$70,178

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$1.27 /MBtu	6.5%
Levelized Fuel Cost=	\$12.84 /MBtu	66.0%
Levelized O&M Cost=	\$5.34 /MBtu	27.5%
Levelized Energy Cost=	\$19.45 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.700
Temperature:	250 F	Efficiency:	0.799
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 5 MBtu/hr
\$/Unit: \$22,389 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$4.30 /MBtu
Fuel Escalation: 4.64 %/year

O&M Cost Inputs

Fixed O&M: \$4,478
Variable O&M Rate: \$5.000 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$111,944
1st Year Fuel Cost= \$271,750
1st Year O&M Cost= \$157,778

Present Value of Capital= \$111,944
Present Value of Fuel= \$3,351,749
Present Value of O&M= \$1,343,251

Annualized Capital Cost= \$16,666
Annualized Fuel Cost= \$393,495
Annualized O&M Cost= \$157,778

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.54 /MBtu	2.9%
Levelized Fuel Cost=	\$12.84 /MBtu	69.3%
Levelized O&M Cost=	\$5.15 /MBtu	27.8%
Levelized Energy Cost=	\$18.53 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.900
 Temperature: 250 F Efficiency: 0.799
 Fuel Type: Gas

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 5 MBtu/hr Unit Cost: \$4.30 /MBtu
 \$/Unit: \$22,389 /MBtu/hr Fuel Escalation: 4.64 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$4,478 FCR: 0.149
 Variable O&M Rate: \$5.000 Per MBtu CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$111,944
 1st Year Fuel Cost= \$349,392
 1st Year O&M Cost= \$201,578

Present Value of Capital= \$111,944
 Present Value of Fuel= \$4,309,391
 Present Value of O&M= \$1,716,145

Annualized Capital Cost= \$16,666
 Annualized Fuel Cost= \$506,179
 Annualized O&M Cost= \$201,578

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$0.42 /MBtu 2.3%
 Levelized Fuel Cost= \$12.84 /MBtu 69.9%
 Levelized O&M Cost= \$5.11 /MBtu 27.8%
 Levelized Energy Cost= \$18.38 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.500
 Temperature: 250 F Efficiency: 0.828
 Fuel Type: Gas

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 5 MBtu/hr Unit Cost: \$4.30 /MBtu
 \$/Unit: \$22,389 /MBtu/hr Fuel Escalation: 4.64 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$4,478 FCR: 0.149
 Variable O&M Rate: \$5.000 Per MBtu CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$111,944
 1st Year Fuel Cost= \$187,308
 1st Year O&M Cost= \$113,978

Present Value of Capital= \$111,944
 Present Value of Fuel= \$2,310,255
 Present Value of O&M= \$970,357

Annualized Capital Cost= \$16,666
 Annualized Fuel Cost= \$271,362
 Annualized O&M Cost= \$113,978

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$0.76 /MBtu 4.1%
 Levelized Fuel Cost= \$12.39 /MBtu 67.5%
 Levelized O&M Cost= \$5.20 /MBtu 28.4%
 Levelized Energy Cost= \$18.36 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	250 F	Efficiency:	0.856
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 5 MBtu/hr
\$/Unit: \$22,389 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$4.30 /MBtu
Fuel Escalation: 4.64 %/year

O&M Cost Inputs

Fixed O&M: \$4,478
Variable O&M Rate: \$5.000 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$111,944
1st Year Fuel Cost= \$181,181
1st Year O&M Cost= \$113,978

Present Value of Capital= \$111,944
Present Value of Fuel= \$2,234,686
Present Value of O&M= \$970,357

Annualized Capital Cost= \$16,666
Annualized Fuel Cost= \$262,485
Annualized O&M Cost= \$113,978

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.76 /MBtu	4.2%
Levelized Fuel Cost=	\$11.99 /MBtu	66.8%
Levelized O&M Cost=	\$5.20 /MBtu	29.0%

Levelized Energy Cost= \$17.95 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment type:	Boiler	Capacity Factor:	0.500
Temperature:	250 F	Efficiency:	0.799
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 5 MBtu/hr
\$/Unit: \$22,389 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$4.30 /MBtu
Fuel Escalation: 4.56 %/year

O&M Cost Inputs

Fixed O&M: \$4,478
Variable O&M Rate: \$5.000 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$111,944
1st Year Fuel Cost= \$192,481
1st Year O&M Cost= \$113,978

Present Value of Capital= \$111,944
Present Value of Fuel= \$2,358,027
Present Value of O&M= \$970,357

Annualized Capital Cost= \$16,666
Annualized Fuel Cost= \$276,973
Annualized O&M Cost= \$113,978

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.76 /MBtu	4.1%
Levelized Fuel Cost=	\$12.65 /MBtu	67.9%
Levelized O&M Cost=	\$5.20 /MBtu	28.0%

Levelized Energy Cost= \$18.61 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	250 F	Efficiency:	0.799
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	5 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$22,389 /MBtu/hr	Fuel Escalation:	4.53 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$4,478	FCR:	0.149
Variable O&M Rate:	\$5.000 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$111,944
1st Year Fuel Cost=	\$191,874
1st Year O&M Cost=	\$113,978

Present Value of Capital=	\$111,944
Present Value of Fuel=	\$2,344,642
Present Value of O&M=	\$970,357

Annualized Capital Cost=	\$16,666
Annualized Fuel Cost=	\$275,401
Annualized O&M Cost=	\$113,978

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.76 /MBtu	4.1%
Levelized Fuel Cost=	\$12.58 /MBtu	67.8%
Levelized O&M Cost=	\$5.20 /MBtu	28.1%
Levelized Energy Cost=	\$18.54 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	250 F	Efficiency:	0.799
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	5 MBtu/hr	Unit Cost:	\$4.95 /MBtu
\$/Unit:	\$22,389 /MBtu/hr	Fuel Escalation:	3.76 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$4,478	FCR:	0.149
Variable O&M Rate:	\$5.000 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$111,944
1st Year Fuel Cost=	\$203,625
1st Year O&M Cost=	\$113,978

Present Value of Capital=	\$111,944
Present Value of Fuel=	\$2,332,939
Present Value of O&M=	\$970,357

Annualized Capital Cost=	\$16,666
Annualized Fuel Cost=	\$274,026
Annualized O&M Cost=	\$113,978

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.76 /MBtu	4.1%
Levelized Fuel Cost=	\$12.51 /MBtu	67.7%
Levelized O&M Cost=	\$5.20 /MBtu	28.2%
Levelized Energy Cost=	\$18.48 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.868
Fuel Type:	Coal		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 60 MBtu/hr
\$/Unit: \$48,132 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$1.93 /MBtu
Fuel Escalation: 2.00 %/year

O&M Cost Inputs

Fixed O&M: \$202,153
Variable O&M Rate: \$1.250 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$2,887,897
1st Year Fuel Cost= \$726,549
1st Year O&M Cost= \$530,653

Present Value of Capital= \$2,887,897
Present Value of Fuel= \$7,217,408
Present Value of O&M= \$4,517,746

Annualized Capital Cost= \$429,938
Annualized Fuel Cost= \$847,754
Annualized O&M Cost= \$530,653

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$1.64 /MBtu	23.8%
Levelized Fuel Cost=	\$3.23 /MBtu	46.9%
Levelized O&M Cost=	\$2.02 /MBtu	29.3%
Levelized Energy Cost=	\$6.88 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.868
Fuel Type:	Coal		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 60 MBtu/hr
\$/Unit: \$47,314 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$1.93 /MBtu
Fuel Escalation: 2.00 %/year

O&M Cost Inputs

Fixed O&M: \$198,721
Variable O&M Rate: \$1.250 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$2,638,869
1st Year Fuel Cost= \$757,076
1st Year O&M Cost= \$527,221

Present Value of Capital= \$2,638,869
Present Value of Fuel= \$7,520,660
Present Value of O&M= \$4,488,528

Annualized Capital Cost= \$422,639
Annualized Fuel Cost= \$883,374
Annualized O&M Cost= \$527,221

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$1.61 /MBtu	23.1%
Levelized Fuel Cost=	\$3.36 /MBtu	48.2%
Levelized O&M Cost=	\$2.01 /MBtu	28.8%
Levelized Energy Cost=	\$6.98 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.100
Temperature:	500 F	Efficiency:	0.868
Fuel Type:	Coal		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$1.93 /MBtu
\$/Unit:	\$48,132 /MBtu/hr	Fuel Escalation:	2.00 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$202,153	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$2,887,897		
1st Year Fuel Cost=	\$145,310		
1st Year O&M Cost=	\$267,853		
Present Value of Capital=	\$2,887,897		
Present Value of Fuel=	\$1,443,482		
Present Value of O&M=	\$2,280,382		
Annualized Capital Cost=	\$429,938		
Annualized Fuel Cost=	\$169,551		
Annualized O&M Cost=	\$267,853		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$8.18 /MBtu	49.6%	
Levelized Fuel Cost=	\$3.23 /MBtu	19.5%	
Levelized O&M Cost=	\$5.10 /MBtu	30.9%	
Levelized Energy Cost=	\$16.50 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.100
Temperature:	500 F	Efficiency:	0.868
Fuel Type:	Coal		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$1.93 /MBtu
\$/Unit:	\$48,132 /MBtu/hr	Fuel Escalation:	2.00 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$202,153	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$2,887,897		
1st Year Fuel Cost=	\$435,929		
1st Year O&M Cost=	\$399,253		
Present Value of Capital=	\$2,887,897		
Present Value of Fuel=	\$4,330,445		
Present Value of O&M=	\$3,399,064		
Annualized Capital Cost=	\$429,938		
Annualized Fuel Cost=	\$508,652		
Annualized O&M Cost=	\$399,253		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$2.73 /MBtu	12.1%	
Levelized Fuel Cost=	\$3.23 /MBtu	38.0%	
Levelized O&M Cost=	\$2.53 /MBtu	27.8%	
Levelized Energy Cost=	\$8.48 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.700
Temperatures:	500 F	Efficiency:	0.868
Fuel Type:	Coal		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$1.93 /MBtu
\$/Unit:	\$48,132 /MBtu/hr	Fuel Escalation:	2.00 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$202,153	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$2,887,897
1st Year Fuel Cost=	\$1,017,168
1st Year O&M Cost=	\$662,053

Present Value of Capital=	\$2,887,897
Present Value of Fuel=	\$10,104,371
Present Value of O&M=	\$5,636,429

Annualized Capital Cost=	\$429,938
Annualized Fuel Cost=	\$1,186,856
Annualized O&M Cost=	\$662,053

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$1.17 /MBtu	18.9%
Levelized Fuel Cost=	\$3.23 /MBtu	52.1%
Levelized O&M Cost=	\$1.68 /MBtu	29.1%
Levelized Energy Cost=	\$6.19 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.900
Temperatures:	500 F	Efficiency:	0.868
Fuel Type:	Coal		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$1.93 /MBtu
\$/Unit:	\$48,132 /MBtu/hr	Fuel Escalation:	2.00 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$202,153	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$2,887,897
1st Year Fuel Cost=	\$1,307,788
1st Year O&M Cost=	\$793,453

Present Value of Capital=	\$2,887,897
Present Value of Fuel=	\$12,991,335
Present Value of O&M=	\$6,755,111

Annualized Capital Cost=	\$429,938
Annualized Fuel Cost=	\$1,525,957
Annualized O&M Cost=	\$793,453

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.91 /MBtu	15.6%
Levelized Fuel Cost=	\$3.23 /MBtu	55.5%
Levelized O&M Cost=	\$1.68 /MBtu	28.9%
Levelized Energy Cost=	\$5.81 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.885
Fuel Type:	Coal		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 60 MBtu/hr
\$/Unit: \$48,132 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$1.93 /MBtu
Fuel Escalation: 2.00 %/year

O&M Cost Inputs

Fixed O&M: \$202,153
Variable O&M Rate: \$1.250 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$2,887,897
1st Year Fuel Cost= \$712,593
1st Year O&M Cost= \$530,653

Present Value of Capital= \$2,887,897
Present Value of Fuel= \$7,078,769
Present Value of O&M= \$4,517,746

Annualized Capital Cost= \$429,938
Annualized Fuel Cost= \$831,470
Annualized O&M Cost= \$530,653

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$1.64 /MBtu	24.0%
Levelized Fuel Cost=	\$3.16 /MBtu	46.4%
Levelized O&M Cost=	\$2.02 /MBtu	29.6%

Levelized Energy Cost= \$6.82 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.885
Fuel Type:	Coal		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 60 MBtu/hr
\$/Unit: \$48,132 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$1.93 /MBtu
Fuel Escalation: 2.00 %/year

O&M Cost Inputs

Fixed O&M: \$202,153
Variable O&M Rate: \$1.250 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$2,887,897
1st Year Fuel Cost= \$699,938
1st Year O&M Cost= \$530,653

Present Value of Capital= \$2,887,897
Present Value of Fuel= \$6,953,063
Present Value of O&M= \$4,517,746

Annualized Capital Cost= \$429,938
Annualized Fuel Cost= \$816,704
Annualized O&M Cost= \$530,653

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$1.64 /MBtu	24.0%
Levelized Fuel Cost=	\$3.11 /MBtu	46.0%
Levelized O&M Cost=	\$2.02 /MBtu	29.9%

Levelized Energy Cost= \$6.76 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.868
Fuel Type:	Coal		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 60 MBtu/hr
\$/Unit: \$48,132 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$1.93 /MBtu
Fuel Escalation: 1.92 %/year

O&M Cost Inputs

Fixed O&M: \$202,153
Variable O&M Rate: \$1.250 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$2,887,897
1st Year Fuel Cost= \$720,305
1st Year O&M Cost= \$530,653

Present Value of Capital= \$2,887,897
Present Value of Fuel= \$7,110,228
Present Value of O&M= \$4,517,746

Annualized Capital Cost= \$429,938
Annualized Fuel Cost= \$835,165
Annualized O&M Cost= \$530,653

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$1.64 /MBtu	23.9%
Levelized Fuel Cost=	\$3.18 /MBtu	46.5%
Levelized O&M Cost=	\$2.02 /MBtu	29.6%
Levelized Energy Cost=	\$6.83 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.868
Fuel Type:	Coal		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 60 MBtu/hr
\$/Unit: \$48,132 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$2.59 /MBtu
Fuel Escalation: 1.22 %/year

O&M Cost Inputs

Fixed O&M: \$202,153
Variable O&M Rate: \$1.250 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$2,887,897
1st Year Fuel Cost= \$896,056
1st Year O&M Cost= \$530,653

Present Value of Capital= \$2,887,897
Present Value of Fuel= \$8,373,206
Present Value of O&M= \$4,517,746

Annualized Capital Cost= \$429,938
Annualized Fuel Cost= \$983,514
Annualized O&M Cost= \$530,653

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$1.64 /MBtu	22.1%
Levelized Fuel Cost=	\$3.74 /MBtu	50.6%
Levelized O&M Cost=	\$2.02 /MBtu	27.3%
Levelized Energy Cost=	\$7.40 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.867
Fuel type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$24,603 /MBtu/hr	Fuel Escalation:	2.92 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,476,191		
1st Year Fuel Cost=	\$1,809,644		
1st Year O&M Cost=	\$387,548		
Present Value of Capital=	\$1,476,191		
Present Value of Fuel=	\$19,352,822		
Present Value of O&M=	\$3,299,411		
Annualized Capital Cost=	\$219,769		
Annualized Fuel Cost=	\$2,273,175		
Annualized O&M Cost=	\$387,548		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.84 /MBtu	7.6%	
Levelized Fuel Cost=	\$8.65 /MBtu	78.9%	
Levelized O&M Cost=	\$1.47 /MBtu	13.5%	
Levelized Energy Cost=	\$10.96 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.867
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$23,792 /MBtu/hr	Fuel Escalation:	2.92 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$57,100	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,427,500		
1st Year Fuel Cost=	\$1,874,505		
1st Year O&M Cost=	\$385,600		
Present Value of Capital=	\$1,427,500		
Present Value of Fuel=	\$20,046,471		
Present Value of O&M=	\$3,282,830		
Annualized Capital Cost=	\$212,520		
Annualized Fuel Cost=	\$2,354,651		
Annualized O&M Cost=	\$385,600		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.81 /MBtu	7.2%	
Levelized Fuel Cost=	\$8.96 /MBtu	79.7%	
Levelized O&M Cost=	\$1.47 /MBtu	13.1%	
Levelized Energy Cost=	\$11.24 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.100
Temperature:	500 F	Efficiency:	0.867
Fuel Type:	Oil		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$24,603 /MBtu/hr	Fuel Escalation:	2.92 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$1,476,191
1st Year Fuel Cost=	\$361,929
1st Year O&M Cost=	\$124,748

Present Value of Capital=	\$1,476,191
Present Value of Fuel=	\$3,870,564
Present Value of O&M=	\$1,062,047

Annualized Capital Cost=	\$219,769
Annualized Fuel Cost=	\$454,633
Annualized O&M Cost=	\$124,748

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$4.18 /MBtu	27.5%
Levelized Fuel Cost=	\$8.65 /MBtu	56.9%
Levelized O&M Cost=	\$2.37 /MBtu	15.6%
Levelized Energy Cost=	\$15.20 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.300
Temperature:	500 F	Efficiency:	0.867
Fuel Type:	Oil		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$24,603 /MBtu/hr	Fuel Escalation:	2.92 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$1,476,191
1st Year Fuel Cost=	\$1,085,786
1st Year O&M Cost=	\$256,148

Present Value of Capital=	\$1,476,191
Present Value of Fuel=	\$11,611,693
Present Value of O&M=	\$2,180,729

Annualized Capital Cost=	\$219,769
Annualized Fuel Cost=	\$1,363,905
Annualized O&M Cost=	\$256,148

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$1.39 /MBtu	11.9%
Levelized Fuel Cost=	\$8.65 /MBtu	74.1%
Levelized O&M Cost=	\$1.62 /MBtu	13.9%
Levelized Energy Cost=	\$11.67 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.700
 Temperature: 500 F Efficiency: 0.867
 Fuel Type: Oil

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 60 MBtu/hr Unit Cost: \$4.35 /MBtu
 \$/Unit: \$24,603 /MBtu/hr Fuel Escalation: 2.92 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$59,048 FCR: 0.149
 Variable O&M Rate: \$1.250 Per MBtu CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$1,476,191
 1st Year Fuel Cost= \$2,533,501
 1st Year O&M Cost= \$518,948
 Present Value of Capital= \$1,476,191
 Present Value of Fuel= \$27,093,950
 Present Value of O&M= \$4,418,094
 Annualized Capital Cost= \$219,769
 Annualized Fuel Cost= \$3,182,445
 Annualized O&M Cost= \$518,948

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$0.60 /MBtu 5.6%
 Levelized Fuel Cost= \$8.65 /MBtu 81.2%
 Levelized O&M Cost= \$1.41 /MBtu 13.2%
 Levelized Energy Cost= \$10.66 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.900
 Temperature: 500 F Efficiency: 0.867
 Fuel Type: Oil

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 60 MBtu/hr Unit Cost: \$4.35 /MBtu
 \$/Unit: \$24,603 /MBtu/hr Fuel Escalation: 2.92 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$59,048 FCR: 0.149
 Variable O&M Rate: \$1.250 Per MBtu CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$1,476,191
 1st Year Fuel Cost= \$3,257,359
 1st Year O&M Cost= \$650,348
 Present Value of Capital= \$1,476,191
 Present Value of Fuel= \$34,835,079
 Present Value of O&M= \$5,536,776
 Annualized Capital Cost= \$219,769
 Annualized Fuel Cost= \$4,091,715
 Annualized O&M Cost= \$650,348

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$0.46 /MBtu 4.4%
 Levelized Fuel Cost= \$8.65 /MBtu 82.5%
 Levelized O&M Cost= \$1.37 /MBtu 13.1%
 Levelized Energy Cost= \$10.49 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.881
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$24,603 /MBtu/hr	Fuel Escalation:	2.92 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,476,191		
1st Year Fuel Cost=	\$1,780,887		
1st Year O&M Cost=	\$387,548		
Present Value of Capital=	\$1,476,191		
Present Value of Fuel=	\$19,045,285		
Present Value of O&M=	\$3,299,411		
Annualized Capital Cost=	\$219,769		
Annualized Fuel Cost=	\$2,237,052		
Annualized O&M Cost=	\$387,548		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.84 /MBtu	7.7%	
Levelized Fuel Cost=	\$8.51 /MBtu	78.6%	
Levelized O&M Cost=	\$1.47 /MBtu	13.6%	
Levelized Energy Cost=	\$10.82 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.874
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$24,603 /MBtu/hr	Fuel Escalation:	2.92 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,476,191		
1st Year Fuel Cost=	\$1,754,990		
1st Year O&M Cost=	\$387,548		
Present Value of Capital=	\$1,476,191		
Present Value of Fuel=	\$18,768,340		
Present Value of O&M=	\$3,299,411		
Annualized Capital Cost=	\$219,769		
Annualized Fuel Cost=	\$2,204,522		
Annualized O&M Cost=	\$387,548		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.84 /MBtu	7.8%	
Levelized Fuel Cost=	\$8.39 /MBtu	78.4%	
Levelized O&M Cost=	\$1.47 /MBtu	13.8%	
Levelized Energy Cost=	\$10.70 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.867
Fuel Type:	Oil		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$24,603 /MBtu/hr	Fuel Escalation:	0.90 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$1,476,191
1st Year Fuel Cost=	\$1,455,118
1st Year O&M Cost=	\$387,548

Present Value of Capital=	\$1,476,191
Present Value of Fuel=	\$13,265,310
Present Value of O&M=	\$3,299,411

Annualized Capital Cost=	\$219,769
Annualized Fuel Cost=	\$1,558,138
Annualized O&M Cost=	\$387,548

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.84 /MBtu	10.1%
Levelized Fuel Cost=	\$5.93 /MBtu	72.0%
Levelized O&M Cost=	\$1.47 /MBtu	17.9%
Levelized Energy Cost=	\$8.24 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.867
Fuel Type:	Oil		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$24,603 /MBtu/hr	Fuel Escalation:	5.43 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$1,476,191
1st Year Fuel Cost=	\$2,358,858
1st Year O&M Cost=	\$387,548

Present Value of Capital=	\$1,476,191
Present Value of Fuel=	\$31,128,329
Present Value of O&M=	\$3,299,411

Annualized Capital Cost=	\$219,769
Annualized Fuel Cost=	\$3,656,322
Annualized O&M Cost=	\$387,548

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.84 /MBtu	5.1%
Levelized Fuel Cost=	\$13.91 /MBtu	85.8%
Levelized O&M Cost=	\$1.47 /MBtu	9.1%
Levelized Energy Cost=	\$16.22 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.867
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.92 /MBtu
\$/Unit:	\$24,603 /MBtu/hr	Fuel Escalation:	2.86 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,476,191		
1st Year Fuel Cost=	\$2,033,682		
1st Year O&M Cost=	\$387,548		
Present Value of Capital=	\$1,476,191		
Present Value of Fuel=	\$21,643,210		
Present Value of O&M=	\$3,299,411		
Annualized Capital Cost=	\$219,769		
Annualized Fuel Cost=	\$2,542,203		
Annualized O&M Cost=	\$387,548		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.84 /MBtu	7.0%	
Levelized Fuel Cost=	\$9.67 /MBtu	80.7%	
Levelized O&M Cost=	\$1.47 /MBtu	12.3%	
Levelized Energy Cost=	\$11.98 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.817
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$24,603 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,476,191		
1st Year Fuel Cost=	\$2,277,964		
1st Year O&M Cost=	\$387,548		
Present Value of Capital=	\$1,476,191		
Present Value of Fuel=	\$28,096,316		
Present Value of O&M=	\$3,299,411		
Annualized Capital Cost=	\$219,769		
Annualized Fuel Cost=	\$3,300,183		
Annualized O&M Cost=	\$387,548		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.84 /MBtu	5.6%	
Levelized Fuel Cost=	\$12.56 /MBtu	84.5%	
Levelized O&M Cost=	\$1.47 /MBtu	9.9%	
Levelized Energy Cost=	\$14.87 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.799
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$23,792 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$57,100	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,427,500		
1st Year Fuel Cost=	\$2,329,282		
1st Year O&M Cost=	\$385,600		
Present Value of Capital=	\$1,427,500		
Present Value of Fuel=	\$28,729,274		
Present Value of O&M=	\$3,282,830		
Annualized Capital Cost=	\$212,520		
Annualized Fuel Cost=	\$3,374,530		
Annualized O&M Cost=	\$385,600		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.81 /MBtu	5.3%	
Levelized Fuel Cost=	\$12.84 /MBtu	84.9%	
Levelized O&M Cost=	\$1.47 /MBtu	9.7%	
Levelized Energy Cost=	\$15.12 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.100
Temperature:	500 F	Efficiency:	0.817
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$24,603 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,476,191		
1st Year Fuel Cost=	\$455,593		
1st Year O&M Cost=	\$124,748		
Present Value of Capital=	\$1,476,191		
Present Value of Fuel=	\$5,619,263		
Present Value of O&M=	\$1,062,047		
Annualized Capital Cost=	\$219,769		
Annualized Fuel Cost=	\$660,037		
Annualized O&M Cost=	\$124,748		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$4.18 /MBtu	21.9%	
Levelized Fuel Cost=	\$12.58 /MBtu	65.7%	
Levelized O&M Cost=	\$2.37 /MBtu	12.4%	
Levelized Energy Cost=	\$19.11 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.300
Temperature:	500 F	Efficiency:	0.817
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 60 MBtu/hr
\$/Unit: \$24,603 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$4.30 /MBtu
Fuel Escalation: 4.64 %/year

O&M Cost Inputs

Fixed O&M: \$59,048
Variable O&M Rate: \$1.250 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$1,476,191
1st Year Fuel Cost= \$1,366,778
1st Year O&M Cost= \$256,148

Present Value of Capital= \$1,476,191
Present Value of Fuel= \$16,857,790
Present Value of O&M= \$2,180,729

Annualized Capital Cost= \$219,769
Annualized Fuel Cost= \$1,980,110
Annualized O&M Cost= \$256,148

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$1.39 /MBtu	8.9%
Levelized Fuel Cost=	\$12.56 /MBtu	80.6%
Levelized O&M Cost=	\$1.62 /MBtu	10.4%
Levelized Energy Cost=	\$15.58 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.700
Temperature:	500 F	Efficiency:	0.817
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 60 MBtu/hr
\$/Unit: \$24,603 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$4.50 /MBtu
Fuel Escalation: 4.64 %/year

O&M Cost Inputs

Fixed O&M: \$59,048
Variable O&M Rate: \$1.250 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$1,476,191
1st Year Fuel Cost= \$3,189,149
1st Year O&M Cost= \$518,948

Present Value of Capital= \$1,476,191
Present Value of Fuel= \$39,334,842
Present Value of O&M= \$4,418,094

Annualized Capital Cost= \$219,769
Annualized Fuel Cost= \$4,620,256
Annualized O&M Cost= \$518,948

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.60 /MBtu	4.1%
Levelized Fuel Cost=	\$12.56 /MBtu	86.2%
Levelized O&M Cost=	\$1.41 /MBtu	9.7%
Levelized Energy Cost=	\$14.57 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.900
Temperature:	500 F	Efficiency:	0.817
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$24,603 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,476,191		
1st Year Fuel Cost=	\$4,100,335		
1st Year O&M Cost=	\$650,348		
Present Value of Capital=	\$1,476,191		
Present Value of Fuel=	\$50,573,369		
Present Value of O&M=	\$5,536,776		
Annualized Capital Cost=	\$219,769		
Annualized Fuel Cost=	\$5,940,329		
Annualized O&M Cost=	\$650,348		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.46 /MBtu	3.2%	
Levelized Fuel Cost=	\$12.56 /MBtu	87.2%	
Levelized O&M Cost=	\$1.37 /MBtu	9.5%	
Levelized Energy Cost=	\$14.40 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.840
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$24,603 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,476,191		
1st Year Fuel Cost=	\$2,215,591		
1st Year O&M Cost=	\$387,548		
Present Value of Capital=	\$1,476,191		
Present Value of Fuel=	\$27,327,012		
Present Value of O&M=	\$3,299,411		
Annualized Capital Cost=	\$219,769		
Annualized Fuel Cost=	\$3,209,821		
Annualized O&M Cost=	\$387,548		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.84 /MBtu	5.8%	
Levelized Fuel Cost=	\$12.21 /MBtu	84.1%	
Levelized O&M Cost=	\$1.47 /MBtu	10.2%	
Levelized Energy Cost=	\$14.52 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.862
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$24,693 /MBtu/hr	Fuel Escalation:	4.64 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$1,476,191
1st Year Fuel Cost=	\$2,159,044
1st Year O&M Cost=	\$387,548

Present Value of Capital=	\$1,476,191
Present Value of Fuel=	\$26,629,571
Present Value of O&M=	\$3,299,411

Annualized Capital Cost=	\$219,769
Annualized Fuel Cost=	\$3,127,899
Annualized O&M Cost=	\$387,548

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.84 /MBtu	5.9%
Levelized Fuel Cost=	\$11.90 /MBtu	83.7%
Levelized O&M Cost=	\$1.47 /MBtu	10.4%
Levelized Energy Cost=	\$14.21 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.817
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$24,693 /MBtu/hr	Fuel Escalation:	4.56 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$1,476,191
1st Year Fuel Cost=	\$2,258,890
1st Year O&M Cost=	\$387,548

Present Value of Capital=	\$1,476,191
Present Value of Fuel=	\$27,672,905
Present Value of O&M=	\$3,299,411

Annualized Capital Cost=	\$219,769
Annualized Fuel Cost=	\$3,250,449
Annualized O&M Cost=	\$387,548

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.84 /MBtu	5.7%
Levelized Fuel Cost=	\$12.37 /MBtu	84.7%
Levelized O&M Cost=	\$1.47 /MBtu	10.0%
Levelized Energy Cost=	\$14.68 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.817
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$24,603 /MBtu/hr	Fuel Escalation:	4.53 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,476,191		
1st Year Fuel Cost=	\$2,251,761		
1st Year O&M Cost=	\$387,548		
Present Value of Capital=	\$1,476,191		
Present Value of Fuel=	\$27,515,825		
Present Value of O&M=	\$3,299,411		
Annualized Capital Cost=	\$219,769		
Annualized Fuel Cost=	\$3,231,998		
Annualized O&M Cost=	\$387,548		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.84 /MBtu	5.7%	
Levelized Fuel Cost=	\$12.30 /MBtu	84.2%	
Levelized O&M Cost=	\$1.47 /MBtu	10.1%	
Levelized Energy Cost=	\$14.61 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	500 F	Efficiency:	0.817
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.95 /MBtu
\$/Unit:	\$24,603 /MBtu/hr	Fuel Escalation:	3.76 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$59,048	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,476,191		
1st Year Fuel Cost=	\$2,389,671		
1st Year O&M Cost=	\$387,548		
Present Value of Capital=	\$1,476,191		
Present Value of Fuel=	\$27,378,483		
Present Value of O&M=	\$3,299,411		
Annualized Capital Cost=	\$219,769		
Annualized Fuel Cost=	\$3,215,866		
Annualized O&M Cost=	\$387,548		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.84 /MBtu	5.7%	
Levelized Fuel Cost=	\$12.24 /MBtu	84.1%	
Levelized O&M Cost=	\$1.47 /MBtu	10.1%	
Levelized Energy Cost=	\$14.55 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.500
Temperature: 850 F Efficiency: 0.868
Fuel Type: Coal

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 60 MBtu/hr
\$/Unit: \$56,019 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$1.93 /MBtu
Fuel Escalation: 2.00 %/year

O&M Cost Inputs

Fixed O&M: \$235,278
Variable O&M Rate: \$1.250 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$3,361,111
1st Year Fuel Cost= \$726,549
1st Year O&M Cost= \$563,778

Present Value of Capital= \$3,361,111
Present Value of Fuel= \$7,217,408
Present Value of O&M= \$4,799,758

Annualized Capital Cost= \$500,388
Annualized Fuel Cost= \$847,754
Annualized O&M Cost= \$563,778

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$1.90 /MBtu 26.2%
Levelized Fuel Cost= \$3.23 /MBtu 44.3%
Levelized O&M Cost= \$2.15 /MBtu 29.5%
Levelized Energy Cost= \$7.28 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.500
Temperature: 850 F Efficiency: 0.868
Fuel Type: Coal

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 60 MBtu/hr
\$/Unit: \$55,200 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$1.93 /MBtu
Fuel Escalation: 2.00 %/year

O&M Cost Inputs

Fixed O&M: \$231,841
Variable O&M Rate: \$1.250 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$3,312,014
1st Year Fuel Cost= \$757,076
1st Year O&M Cost= \$560,341

Present Value of Capital= \$3,312,014
Present Value of Fuel= \$7,520,660
Present Value of O&M= \$4,770,499

Annualized Capital Cost= \$493,078
Annualized Fuel Cost= \$883,374
Annualized O&M Cost= \$560,341

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$1.88 /MBtu 25.5%
Levelized Fuel Cost= \$3.36 /MBtu 45.6%
Levelized O&M Cost= \$2.13 /MBtu 28.9%
Levelized Energy Cost= \$7.37 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.100
Temperature:	850 F	Efficiency:	0.868
Fuel Type:	Coal		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$1.93 /MBtu
\$/Unit:	\$56,019 /MBtu/hr	Fuel Escalation:	2.00 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$235,278	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$3,361,111
1st Year Fuel Cost=	\$145,310
1st Year O&M Cost=	\$300,978
Present Value of Capital=	\$3,361,111
Present Value of Fuel=	\$1,443,482
Present Value of O&M=	\$2,562,394
Annualized Capital Cost=	\$500,388
Annualized Fuel Cost=	\$169,551
Annualized O&M Cost=	\$300,978

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$9.52 /MBtu	51.5%
Levelized Fuel Cost=	\$3.23 /MBtu	17.5%
Levelized O&M Cost=	\$5.73 /MBtu	31.0%
Levelized Energy Cost=	\$18.47 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.100
Temperature:	850 F	Efficiency:	0.868
Fuel Type:	Coal		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$1.93 /MBtu
\$/Unit:	\$56,019 /MBtu/hr	Fuel Escalation:	2.00 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$235,278	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$3,361,111
1st Year Fuel Cost=	\$435,929
1st Year O&M Cost=	\$432,378
Present Value of Capital=	\$3,361,111
Present Value of Fuel=	\$4,330,445
Present Value of O&M=	\$3,681,076
Annualized Capital Cost=	\$500,388
Annualized Fuel Cost=	\$508,652
Annualized O&M Cost=	\$432,378

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$3.17 /MBtu	84.7%
Levelized Fuel Cost=	\$3.23 /MBtu	35.3%
Levelized O&M Cost=	\$2.74 /MBtu	30.0%
Levelized Energy Cost=	\$9.14 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.700
 Temperature: 850 F Efficiency: 0.868
 Fuel Type: Coal

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 60 MBtu/hr Unit Cost: \$1.93 /MBtu
 \$/Unit: \$56,019 /MBtu/hr Fuel Escalation: 2.00 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$235,278 FCR: 0.149
 Variable O&M Rate: \$1.250 Per MBtu CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$3,361,111
 1st Year Fuel Cost= \$1,017,168
 1st Year O&M Cost= \$695,178

Present Value of Capital= \$3,361,111
 Present Value of Fuel= \$10,104,371
 Present Value of O&M= \$5,918,440

Annualized Capital Cost= \$500,388
 Annualized Fuel Cost= \$1,186,856
 Annualized O&M Cost= \$695,178

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$1.36 /MBtu 21.0%
 Levelized Fuel Cost= \$3.23 /MBtu 49.8%
 Levelized O&M Cost= \$1.89 /MBtu 29.2%
 Levelized Energy Cost= \$6.48 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.900
 Temperature: 850 F Efficiency: 0.868
 Fuel Type: Coal

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 60 MBtu/hr Unit Cost: \$1.93 /MBtu
 \$/Unit: \$56,019 /MBtu/hr Fuel Escalation: 2.00 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$235,278 FCR: 0.149
 Variable O&M Rate: \$1.250 Per MBtu CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$3,361,111
 1st Year Fuel Cost= \$1,307,788
 1st Year O&M Cost= \$826,578

Present Value of Capital= \$3,361,111
 Present Value of Fuel= \$12,991,335
 Present Value of O&M= \$7,037,123

Annualized Capital Cost= \$500,388
 Annualized Fuel Cost= \$1,525,957
 Annualized O&M Cost= \$826,578

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$1.06 /MBtu 17.5%
 Levelized Fuel Cost= \$3.23 /MBtu 53.5%
 Levelized O&M Cost= \$1.75 /MBtu 29.0%
 Levelized Energy Cost= \$6.03 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.885
Fuel Type:	Coal		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$1.93 /MBtu
\$/Unit:	\$56,019 /MBtu/hr	Fuel Escalation:	2.00 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$235,278	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$3,361,111		
1st Year Fuel Cost=	\$712,593		
1st Year O&M Cost=	\$563,778		
Present Value of Capital=	\$3,361,111		
Present Value of Fuel=	\$7,078,769		
Present Value of O&M=	\$4,799,758		
Annualized Capital Cost=	\$500,388		
Annualized Fuel Cost=	\$831,470		
Annualized O&M Cost=	\$563,778		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$1.90 /MBtu	26.4%	
Levelized Fuel Cost=	\$3.16 /MBtu	43.9%	
Levelized O&M Cost=	\$2.15 /MBtu	29.7%	
Levelized Energy Cost=	\$7.21 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.901
Fuel Type:	Coal		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$1.93 /MBtu
\$/Unit:	\$56,019 /MBtu/hr	Fuel Escalation:	2.00 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$235,278	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$3,361,111		
1st Year Fuel Cost=	\$699,938		
1st Year O&M Cost=	\$563,778		
Present Value of Capital=	\$3,361,111		
Present Value of Fuel=	\$6,953,063		
Present Value of O&M=	\$4,799,758		
Annualized Capital Cost=	\$500,388		
Annualized Fuel Cost=	\$816,704		
Annualized O&M Cost=	\$563,778		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$1.90 /MBtu	26.6%	
Levelized Fuel Cost=	\$3.11 /MBtu	43.4%	
Levelized O&M Cost=	\$2.15 /MBtu	30.0%	
Levelized Energy Cost=	\$7.16 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.500
 Temperature: 850 F Efficiency: 0.868
 Fuel Type: Coal

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 60 MBtu/hr
 \$/Unit: \$56,019 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$1.93 /MBtu
 Fuel Escalation: 1.92 %/year

O&M Cost Inputs

Fixed O&M: \$235,278
 Variable O&M Rate: \$1.250 Per MBtu

Financial Inputs

FCR: 0.149
 CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$3,361,111
 1st Year Fuel Cost= \$720,305
 1st Year O&M Cost= \$563,778

Present Value of Capital= \$3,361,111
 Present Value of Fuel= \$7,110,228
 Present Value of O&M= \$4,799,758

Annualized Capital Cost= \$500,388
 Annualized Fuel Cost= \$835,165
 Annualized O&M Cost= \$563,778

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$1.90 /MBtu 26.3%
 Levelized Fuel Cost= \$3.18 /MBtu 44.0%
 Levelized O&M Cost= \$2.15 /MBtu 29.7%
 Levelized Energy Cost= \$7.23 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.500
 Temperature: 850 F Efficiency: 0.868
 Fuel Type: Coal

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 60 MBtu/hr
 \$/Unit: \$56,019 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$2.59 /MBtu
 Fuel Escalation: 1.22 %/year

O&M Cost Inputs

Fixed O&M: \$235,278
 Variable O&M Rate: \$1.250 Per MBtu

Financial Inputs

FCR: 0.149
 CRF: 0.117

Calculations (all costs are in 1984 dollars)

Capital Cost= \$3,361,111
 1st Year Fuel Cost= \$896,056
 1st Year O&M Cost= \$563,778

Present Value of Capital= \$3,361,111
 Present Value of Fuel= \$8,373,206
 Present Value of O&M= \$4,799,758

Annualized Capital Cost= \$500,388
 Annualized Fuel Cost= \$983,514
 Annualized O&M Cost= \$563,778

Results (levelized constant 1984 dollars)

Levelized Capital Cost= \$1.90 /MBtu 24.4%
 Levelized Fuel Cost= \$3.74 /MBtu 48.0%
 Levelized O&M Cost= \$2.15 /MBtu 27.5%
 Levelized Energy Cost= \$7.79 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.867
Fuel Type:	Oil		

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	2.92 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$73,254	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117

Calculations (all costs are in 1984 dollars)

Capital Cost=	\$1,831,349
1st Year Fuel Cost=	\$1,809,644
1st Year O&M Cost=	\$401,754
Present Value of Capital=	\$1,831,349
Present Value of Fuel=	\$19,352,822
Present Value of O&M=	\$3,420,358
Annualized Capital Cost=	\$272,643
Annualized Fuel Cost=	\$2,273,175
Annualized O&M Cost=	\$401,754

Results (levelized constant 1984 dollars)

Levelized Capital Cost=	\$1.04 /MBtu	9.2%
Levelized Fuel Cost=	\$8.65 /MBtu	77.1%
Levelized O&M Cost=	\$1.53 /MBtu	13.6%
Levelized Energy Cost=	\$11.22 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.867
Fuel Type:	Oil		

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$29,705 /MBtu/hr	Fuel Escalation:	2.92 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$71,293	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117

Calculations (all costs are in 1984 dollars)

Capital Cost=	\$1,782,322
1st Year Fuel Cost=	\$1,874,505
1st Year O&M Cost=	\$399,793
Present Value of Capital=	\$1,782,322
Present Value of Fuel=	\$20,046,471
Present Value of O&M=	\$3,403,662
Annualized Capital Cost=	\$265,344
Annualized Fuel Cost=	\$2,354,651
Annualized O&M Cost=	\$399,793

Results (levelized constant 1984 dollars)

Levelized Capital Cost=	\$1.01 /MBtu	8.8%
Levelized Fuel Cost=	\$9.96 /MBtu	78.0%
Levelized O&M Cost=	\$1.52 /MBtu	13.2%
Levelized Energy Cost=	\$11.49 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.100
Temperature:	850 F	Efficiency:	0.867
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	2.92 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$73,254	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,831,349		
1st Year Fuel Cost=	\$361,929		
1st Year O&M Cost=	\$138,954		
Present Value of Capital=	\$1,831,349		
Present Value of Fuel=	\$3,870,564		
Present Value of O&M=	\$1,182,993		
Annualized Capital Cost=	\$272,643		
Annualized Fuel Cost=	\$454,635		
Annualized O&M Cost=	\$138,954		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$5.19 /MBtu	31.5%	
Levelized Fuel Cost=	\$8.65 /MBtu	52.5%	
Levelized O&M Cost=	\$2.64 /MBtu	16.0%	
Levelized Energy Cost=	\$16.48 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.300
Temperature:	850 F	Efficiency:	0.867
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	2.92 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$73,254	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,831,349		
1st Year Fuel Cost=	\$1,085,786		
1st Year O&M Cost=	\$270,354		
Present Value of Capital=	\$1,831,349		
Present Value of Fuel=	\$11,611,693		
Present Value of O&M=	\$2,301,676		
Annualized Capital Cost=	\$272,643		
Annualized Fuel Cost=	\$1,363,905		
Annualized O&M Cost=	\$270,354		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$1.73 /MBtu	14.3%	
Levelized Fuel Cost=	\$8.65 /MBtu	71.5%	
Levelized O&M Cost=	\$1.71 /MBtu	14.2%	
Levelized Energy Cost=	\$12.09 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.700
 Temperature: 850 F Efficiency: 0.867
 Fuel Type: Oil

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity: 60 MBtu/hr		Unit Cost: \$4.35 /MBtu	
\$/Unit: \$30,522 /MBtu/hr		Fuel Escalation: 2.92 %/year	
O&M Cost Inputs		Financial Inputs	
Fixed O&M: \$73,254		FCR: 0.149	
Variable O&M Rate: \$1.250 Per MBtu		CRF: 0.117	

Calculations (all costs are in 1984 dollars)

Capital Cost= \$1,831,349
 1st Year Fuel Cost= \$2,533,501
 1st Year O&M Cost= \$533,154

 Present Value of Capital= \$1,831,349
 Present Value of Fuel= \$27,093,950
 Present Value of O&M= \$4,539,040

 Annualized Capital Cost= \$272,643
 Annualized Fuel Cost= \$3,182,445
 Annualized O&M Cost= \$533,154

Results (levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.74 /MBtu	6.8%
Levelized Fuel Cost=	\$8.65 /MBtu	79.8%
Levelized O&M Cost=	\$1.45 /MBtu	13.4%
Levelized Energy Cost=	\$10.84 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.900
 Temperature: 850 F Efficiency: 0.867
 Fuel Type: Oil

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity: 60 MBtu/hr		Unit Cost: \$4.35 /MBtu	
\$/Unit: \$30,522 /MBtu/hr		Fuel Escalation: 2.92 %/year	
O&M Cost Inputs		Financial Inputs	
Fixed O&M: \$73,254		FCR: 0.149	
Variable O&M Rate: \$1.250 Per MBtu		CRF: 0.117	

Calculations (all costs are in 1984 dollars)

Capital Cost= \$1,831,349
 1st Year Fuel Cost= \$3,257,359
 1st Year O&M Cost= \$664,554

 Present Value of Capital= \$1,831,349
 Present Value of Fuel= \$34,835,079
 Present Value of O&M= \$5,657,723

 Annualized Capital Cost= \$272,643
 Annualized Fuel Cost= \$4,091,715
 Annualized O&M Cost= \$664,554

Results (levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.58 /MBtu	5.4%
Levelized Fuel Cost=	\$8.65 /MBtu	81.4%
Levelized O&M Cost=	\$1.40 /MBtu	13.2%
Levelized Energy Cost=	\$10.63 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.881
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	2.92 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$73,254	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,831,349		
1st Year Fuel Cost=	\$1,780,887		
1st Year O&M Cost=	\$401,754		
Present Value of Capital=	\$1,831,349		
Present Value of Fuel=	\$19,045,285		
Present Value of O&M=	\$3,420,358		
Annualized Capital Cost=	\$272,643		
Annualized Fuel Cost=	\$2,237,052		
Annualized O&M Cost=	\$401,754		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$1.04 /MBtu	9.4%	
Levelized Fuel Cost=	\$8.51 /MBtu	76.8%	
Levelized O&M Cost=	\$1.53 /MBtu	13.8%	
Levelized Energy Cost=	\$11.08 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.894
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	2.92 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$73,254	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,831,349		
1st Year Fuel Cost=	\$1,754,990		
1st Year O&M Cost=	\$401,754		
Present Value of Capital=	\$1,831,349		
Present Value of Fuel=	\$18,768,340		
Present Value of O&M=	\$3,420,358		
Annualized Capital Cost=	\$272,643		
Annualized Fuel Cost=	\$2,204,522		
Annualized O&M Cost=	\$401,754		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$1.04 /MBtu	9.5%	
Levelized Fuel Cost=	\$8.39 /MBtu	76.6%	
Levelized O&M Cost=	\$1.53 /MBtu	14.0%	
Levelized Energy Cost=	\$10.95 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.867
Fuel Type:	Oil		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	0.90 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$73,254	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$1,831,349
1st Year Fuel Cost=	\$1,435,118
1st Year O&M Cost=	\$401,754
Present Value of Capital=	\$1,831,349
Present Value of Fuel=	\$13,265,310
Present Value of O&M=	\$3,420,358
Annualized Capital Cost=	\$272,643
Annualized Fuel Cost=	\$1,558,138
Annualized O&M Cost=	\$401,754

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$1.04 /MBtu	12.2%
Levelized Fuel Cost=	\$5.93 /MBtu	69.8%
Levelized O&M Cost=	\$1.53 /MBtu	18.0%
Levelized Energy Cost=	\$8.50 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.867
Fuel Type:	Oil		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	5.43 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$73,254	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$1,831,349
1st Year Fuel Cost=	\$2,359,898
1st Year O&M Cost=	\$401,754
Present Value of Capital=	\$1,831,349
Present Value of Fuel=	\$31,128,329
Present Value of O&M=	\$3,420,358
Annualized Capital Cost=	\$272,643
Annualized Fuel Cost=	\$3,656,322
Annualized O&M Cost=	\$401,754

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$1.04 /MBtu	6.5%
Levelized Fuel Cost=	\$13.91 /MBtu	84.4%
Levelized O&M Cost=	\$1.53 /MBtu	9.3%
Levelized Energy Cost=	\$16.48 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.867
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.92 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	2.86 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$73,254	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,831,349		
1st Year Fuel Cost=	\$2,033,682		
1st Year O&M Cost=	\$401,754		
Present Value of Capital=	\$1,831,349		
Present Value of Fuel=	\$21,643,210		
Present Value of O&M=	\$3,420,358		
Annualized Capital Cost=	\$272,643		
Annualized Fuel Cost=	\$2,542,203		
Annualized O&M Cost=	\$401,754		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$1.04 /MBtu	8.5%	
Levelized Fuel Cost=	\$9.67 /MBtu	79.0%	
Levelized O&M Cost=	\$1.53 /MBtu	12.5%	
Levelized Energy Cost=	\$12.24 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.817
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$73,254	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,831,349		
1st Year Fuel Cost=	\$2,277,964		
1st Year O&M Cost=	\$401,754		
Present Value of Capital=	\$1,831,349		
Present Value of Fuel=	\$28,096,316		
Present Value of O&M=	\$3,420,358		
Annualized Capital Cost=	\$272,643		
Annualized Fuel Cost=	\$3,300,183		
Annualized O&M Cost=	\$401,754		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$1.04 /MBtu	6.9%	
Levelized Fuel Cost=	\$12.56 /MBtu	83.0%	
Levelized O&M Cost=	\$1.53 /MBtu	10.1%	
Levelized Energy Cost=	\$15.12 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.799
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$29,705 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$71,293	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,782,322		
1st Year Fuel Cost=	\$2,329,282		
1st Year O&M Cost=	\$399,793		
Present Value of Capital=	\$1,782,322		
Present Value of Fuel=	\$28,729,274		
Present Value of O&M=	\$3,403,662		
Annualized Capital Cost=	\$265,344		
Annualized Fuel Cost=	\$3,374,530		
Annualized O&M Cost=	\$399,793		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$1.01 /MBtu	6.6%	
Levelized Fuel Cost=	\$12.84 /MBtu	83.5%	
Levelized O&M Cost=	\$1.52 /MBtu	9.9%	
Levelized Energy Cost=	\$15.37 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.100
Temperature:	850 F	Efficiency:	0.817
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$73,254	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,831,349		
1st Year Fuel Cost=	\$455,593		
1st Year O&M Cost=	\$138,954		
Present Value of Capital=	\$1,831,349		
Present Value of Fuel=	\$5,619,263		
Present Value of O&M=	\$1,182,993		
Annualized Capital Cost=	\$272,643		
Annualized Fuel Cost=	\$660,037		
Annualized O&M Cost=	\$138,954		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$5.19 /MBtu	25.4%	
Levelized Fuel Cost=	\$12.56 /MBtu	61.6%	
Levelized O&M Cost=	\$2.64 /MBtu	13.0%	
Levelized Energy Cost=	\$20.39 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.300
Temperature:	850 F	Efficiency:	0.817
Fuel type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$73,254	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,831,349		
1st Year Fuel Cost=	\$1,366,778		
1st Year O&M Cost=	\$270,354		
Present Value of Capital=	\$1,831,349		
Present Value of Fuel=	\$16,857,790		
Present Value of O&M=	\$2,301,676		
Annualized Capital Cost=	\$272,643		
Annualized Fuel Cost=	\$1,980,110		
Annualized O&M Cost=	\$270,354		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$1.73 /MBtu	10.8%	
Levelized Fuel Cost=	\$12.56 /MBtu	78.5%	
Levelized O&M Cost=	\$1.71 /MBtu	10.7%	
Levelized Energy Cost=	\$16.00 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.700
Temperature:	850 F	Efficiency:	0.817
Fuel type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$73,254	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,831,349		
1st Year Fuel Cost=	\$3,189,149		
1st Year O&M Cost=	\$533,154		
Present Value of Capital=	\$1,831,349		
Present Value of Fuel=	\$39,334,842		
Present Value of O&M=	\$4,539,040		
Annualized Capital Cost=	\$272,643		
Annualized Fuel Cost=	\$4,620,256		
Annualized O&M Cost=	\$533,154		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.74 /MBtu	5.0%	
Levelized Fuel Cost=	\$12.56 /MBtu	85.1%	
Levelized O&M Cost=	\$1.45 /MBtu	9.8%	
Levelized Energy Cost=	\$14.75 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.900
Temperature:	850 F	Efficiency:	0.817
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$73,254	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,831,349		
1st Year Fuel Cost=	\$4,100,335		
1st Year O&M Cost=	\$664,554		
Present Value of Capital=	\$1,831,349		
Present Value of Fuel=	\$50,573,369		
Present Value of O&M=	\$5,657,723		
Annualized Capital Cost=	\$272,643		
Annualized Fuel Cost=	\$5,940,329		
Annualized O&M Cost=	\$664,554		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.58 /MBtu	4.0%	
Levelized Fuel Cost=	\$12.56 /MBtu	86.4%	
Levelized O&M Cost=	\$1.40 /MBtu	9.7%	
Levelized Energy Cost=	\$14.54 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.840
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$73,254	FCR:	0.149
Variable O&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,831,349		
1st Year Fuel Cost=	\$2,215,591		
1st Year O&M Cost=	\$401,754		
Present Value of Capital=	\$1,831,349		
Present Value of Fuel=	\$27,327,012		
Present Value of O&M=	\$3,420,358		
Annualized Capital Cost=	\$272,643		
Annualized Fuel Cost=	\$3,209,821		
Annualized O&M Cost=	\$401,754		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$1.04 /MBtu	7.0%	
Levelized Fuel Cost=	\$12.21 /MBtu	82.6%	
Levelized O&M Cost=	\$1.53 /MBtu	10.3%	
Levelized Energy Cost=	\$14.78 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.862
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	4.64 %/year
D&M Cost Inputs		Financial Inputs	
Fixed D&M:	\$73,254	FCR:	0.149
Variable D&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,831,349		
1st Year Fuel Cost=	\$2,159,044		
1st Year D&M Cost=	\$401,754		
Present Value of Capital=	\$1,831,349		
Present Value of Fuel=	\$26,629,571		
Present Value of D&M=	\$3,420,358		
Annualized Capital Cost=	\$272,643		
Annualized Fuel Cost=	\$3,127,899		
Annualized D&M Cost=	\$401,754		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$1.04 /MBtu	7.2%	
Levelized Fuel Cost=	\$11.90 /MBtu	82.3%	
Levelized D&M Cost=	\$1.53 /MBtu	10.6%	
Levelized Energy Cost=	\$14.47 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Boiler	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.617
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	60 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$30,522 /MBtu/hr	Fuel Escalation:	4.56 %/year
D&M Cost Inputs		Financial Inputs	
Fixed D&M:	\$73,254	FCR:	0.149
Variable D&M Rate:	\$1.250 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$1,831,349		
1st Year Fuel Cost=	\$2,258,880		
1st Year D&M Cost=	\$401,754		
Present Value of Capital=	\$1,831,349		
Present Value of Fuel=	\$27,672,905		
Present Value of D&M=	\$3,420,358		
Annualized Capital Cost=	\$272,643		
Annualized Fuel Cost=	\$3,250,449		
Annualized D&M Cost=	\$401,754		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$1.04 /MBtu	6.9%	
Levelized Fuel Cost=	\$12.37 /MBtu	82.8%	
Levelized D&M Cost=	\$1.53 /MBtu	10.2%	
Levelized Energy Cost=	\$14.93 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.500
 Temperature: 850 F Efficiency: 0.817
 Fuel Type: Gas

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 60 MBtu/hr Unit Cost: \$4.30 /MBtu
 \$/Unit: \$30,522 /MBtu/hr Fuel Escalation: 4.53 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$73,254 FCR: 0.149
 Variable O&M Rate: \$1.250 Per MBtu CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$1,831,349
 1st Year Fuel Cost= \$2,251,761
 1st Year O&M Cost= \$401,754

Present Value of Capital= \$1,831,349
 Present Value of Fuel= \$27,515,825
 Present Value of O&M= \$3,420,358

Annualized Capital Cost= \$272,643
 Annualized Fuel Cost= \$3,231,998
 Annualized O&M Cost= \$401,754

Results
(levelized constant 1984 dollars)

Levelized Capital Cost= \$1.04 /MBtu 7.0%
 Levelized Fuel Cost= \$12.30 /MBtu 82.7%
 Levelized O&M Cost= \$1.53 /MBtu 10.3%
 Levelized Energy Cost= \$14.86 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Boiler Capacity Factor: 0.500
 Temperature: 850 F Efficiency: 0.817
 Fuel Type: Gas

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs Fuel Cost Inputs
 Capacity: 60 MBtu/hr Unit Cost: \$4.95 /MBtu
 \$/Unit: \$30,522 /MBtu/hr Fuel Escalation: 5.76 %/year

O&M Cost Inputs Financial Inputs
 Fixed O&M: \$73,254 FCR: 0.149
 Variable O&M Rate: \$1.250 Per MBtu CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$1,831,349
 1st Year Fuel Cost= \$2,389,671
 1st Year O&M Cost= \$401,754

Present Value of Capital= \$1,831,349
 Present Value of Fuel= \$27,378,483
 Present Value of O&M= \$3,420,358

Annualized Capital Cost= \$272,643
 Annualized Fuel Cost= \$3,215,866
 Annualized O&M Cost= \$401,754

Results
(levelized constant 1984 dollars)

Levelized Capital Cost= \$1.04 /MBtu 7.0%
 Levelized Fuel Cost= \$12.24 /MBtu 82.7%
 Levelized O&M Cost= \$1.53 /MBtu 10.3%
 Levelized Energy Cost= \$14.80 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Furnace	Capacity Factor:	0.500
Temperatures:	850 F	Efficiency:	0.942
Fuel Type:	Oil		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	70 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$3,157 /MBtu/hr	Fuel Escalation:	2.92 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$3,094	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$220,990
1st Year Fuel Cost=	\$1,943,158
1st Year O&M Cost=	\$3,094
Present Value of Capital=	\$220,990
Present Value of Fuel=	\$20,780,657
Present Value of O&M=	\$26,341
Annualized Capital Cost=	\$32,900
Annualized Fuel Cost=	\$2,440,888
Annualized O&M Cost=	\$3,094

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.11 /MBtu	1.3%
Levelized Fuel Cost=	\$7.96 /MBtu	98.5%
Levelized O&M Cost=	\$0.01 /MBtu	0.1%
Levelized Energy Cost=	\$8.08 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Furnace	Capacity Factor:	0.100
Temperatures:	850 F	Efficiency:	0.942
Fuel Type:	Oil		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	70 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$3,157 /MBtu/hr	Fuel Escalation:	2.92 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$3,094	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$220,990
1st Year Fuel Cost=	\$388,632
1st Year O&M Cost=	\$3,094
Present Value of Capital=	\$220,990
Present Value of Fuel=	\$4,156,131
Present Value of O&M=	\$26,341
Annualized Capital Cost=	\$32,900
Annualized Fuel Cost=	\$488,178
Annualized O&M Cost=	\$3,094

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.54 /MBtu	6.3%
Levelized Fuel Cost=	\$7.96 /MBtu	93.1%
Levelized O&M Cost=	\$0.05 /MBtu	0.6%
Levelized Energy Cost=	\$8.55 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.900
Temperatures:	850 F	Efficiency:	0.942
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	70 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$3,157 /MBtu/hr	Fuel Escalation:	2.92 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$3,094	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$220,990		
1st Year Fuel Cost=	\$3,497,684		
1st Year O&M Cost=	\$3,094		
Present Value of Capital=	\$220,990		
Present Value of Fuel=	\$37,405,183		
Present Value of O&M=	\$26,341		
Annualized Capital Cost=	\$32,900		
Annualized Fuel Cost=	\$4,393,599		
Annualized O&M Cost=	\$3,094		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.06 /MBtu	0.7%	
Levelized Fuel Cost=	\$7.96 /MBtu	99.2%	
Levelized O&M Cost=	\$0.01 /MBtu	0.1%	
Levelized Energy Cost=	\$8.03 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.500
Temperatures:	850 F	Efficiency:	0.942
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	70 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$3,157 /MBtu/hr	Fuel Escalation:	0.90 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$3,094	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$220,990		
1st Year Fuel Cost=	\$1,562,476		
1st Year O&M Cost=	\$3,094		
Present Value of Capital=	\$220,990		
Present Value of Fuel=	\$14,244,014		
Present Value of O&M=	\$26,341		
Annualized Capital Cost=	\$32,900		
Annualized Fuel Cost=	\$1,673,097		
Annualized O&M Cost=	\$3,094		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.11 /MBtu	1.9%	
Levelized Fuel Cost=	\$5.46 /MBtu	97.9%	
Levelized O&M Cost=	\$0.01 /MBtu	0.2%	
Levelized Energy Cost=	\$5.57 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.942
Fuel Type:	Oil		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity:	70 MBtu/hr
\$/Unit:	\$3,157 /MBtu/hr

Fuel Cost Inputs

Unit Cost:	\$4.35 /MBtu
Fuel Escalation:	5.43 %/year

O&M Cost Inputs

Fixed O&M:	\$3,094
Variable O&M Rate:	\$0.000 Per MBtu

Financial Inputs

FCR:	0.149
CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$220,990
1st Year Fuel Cost=	\$2,532,893
1st Year O&M Cost=	\$3,094

Present Value of Capital=	\$220,990
Present Value of Fuel=	\$33,424,952
Present Value of O&M=	\$26,341

Annualized Capital Cost=	\$32,900
Annualized Fuel Cost=	\$3,926,082
Annualized O&M Cost=	\$3,094

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.11 /MBtu	0.8%
Levelized Fuel Cost=	\$12.81 /MBtu	99.1%
Levelized O&M Cost=	\$0.01 /MBtu	0.1%
Levelized Energy Cost=	\$12.92 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.942
Fuel Type:	Oil		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity:	70 MBtu/hr
\$/Unit:	\$3,157 /MBtu/hr

Fuel Cost Inputs

Unit Cost:	\$4.92 /MBtu
Fuel Escalation:	2.86 %/year

O&M Cost Inputs

Fixed O&M:	\$3,094
Variable O&M Rate:	\$0.000 Per MBtu

Financial Inputs

FCR:	0.149
CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$220,990
1st Year Fuel Cost=	\$2,183,726
1st Year O&M Cost=	\$3,094

Present Value of Capital=	\$220,990
Present Value of Fuel=	\$23,240,029
Present Value of O&M=	\$26,341

Annualized Capital Cost=	\$32,900
Annualized Fuel Cost=	\$2,729,765
Annualized O&M Cost=	\$3,094

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.11 /MBtu	1.2%
Levelized Fuel Cost=	\$8.90 /MBtu	98.7%
Levelized O&M Cost=	\$0.01 /MBtu	0.1%
Levelized Energy Cost=	\$9.02 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.903
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	70 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$3,157 /MBtu/hr	Fuel Escalations:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$3,094	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$220,990		
1st Year Fuel Cost=	\$2,404,517		
1st Year O&M Cost=	\$3,094		
Present Value of Capital=	\$220,990		
Present Value of Fuel=	\$29,657,222		
Present Value of O&M=	\$26,341		
Annualized Capital Cost=	\$32,900		
Annualized Fuel Cost=	\$3,483,526		
Annualized O&M Cost=	\$3,094		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.11 /MBtu	0.9%	
Levelized Fuel Cost=	\$11.36 /MBtu	99.0%	
Levelized O&M Cost=	\$0.01 /MBtu	0.1%	
Levelized Energy Cost=	\$11.48 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.100
Temperature:	850 F	Efficiency:	0.903
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	70 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$3,157 /MBtu/hr	Fuel Escalations:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$3,094	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$220,990		
1st Year Fuel Cost=	\$480,903		
1st Year O&M Cost=	\$3,094		
Present Value of Capital=	\$220,990		
Present Value of Fuel=	\$5,931,444		
Present Value of O&M=	\$26,341		
Annualized Capital Cost=	\$32,900		
Annualized Fuel Cost=	\$696,705		
Annualized O&M Cost=	\$3,094		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.54 /MBtu	4.5%	
Levelized Fuel Cost=	\$11.36 /MBtu	95.1%	
Levelized O&M Cost=	\$0.05 /MBtu	0.4%	
Levelized Energy Cost=	\$11.95 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.900
Temperature:	850 F	Efficiency:	0.903
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	70 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$3,157 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$3,094	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$220,990		
1st Year Fuel Cost=	\$4,328,131		
1st Year O&M Cost=	\$3,094		
Present Value of Capital=	\$220,990		
Present Value of Fuel=	\$53,383,000		
Present Value of O&M=	\$26,341		
Annualized Capital Cost=	\$32,900		
Annualized Fuel Cost=	\$6,270,347		
Annualized O&M Cost=	\$3,094		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.06 /MBtu	0.5%	
Levelized Fuel Cost=	\$11.36 /MBtu	99.4%	
Levelized O&M Cost=	\$0.01 /MBtu	.0%	
Levelized Energy Cost=	\$11.43 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	850 F	Efficiency:	0.903
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	70 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$3,157 /MBtu/hr	Fuel Escalation:	4.56 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$3,094	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$220,990		
1st Year Fuel Cost=	\$2,384,373		
1st Year O&M Cost=	\$3,094		
Present Value of Capital=	\$220,990		
Present Value of Fuel=	\$29,210,289		
Present Value of O&M=	\$26,341		
Annualized Capital Cost=	\$32,900		
Annualized Fuel Cost=	\$3,431,030		
Annualized O&M Cost=	\$3,094		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.11 /MBtu	0.9%	
Levelized Fuel Cost=	\$11.19 /MBtu	99.0%	
Levelized O&M Cost=	\$0.01 /MBtu	0.1%	
Levelized Energy Cost=	\$11.31 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Types:	Furnace	Capacity Factor:	0.500
Temperatures:	850 F	Efficiency:	0.903
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	70 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$3,157 /MBtu/hr	Fuel Escalations:	4.53 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$3,094	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$220,990		
1st Year Fuel Cost=	\$2,376,858		
1st Year O&M Cost=	\$3,094		
Present Value of Capital=	\$220,990		
Present Value of Fuel=	\$29,044,482		
Present Value of O&M=	\$26,341		
Annualized Capital Cost=	\$32,900		
Annualized Fuel Cost=	\$3,411,554		
Annualized O&M Cost=	\$3,094		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.11 /MBtu	1.0%	
Levelized Fuel Cost=	\$11.13 /MBtu	99.0%	
Levelized O&M Cost=	\$0.01 /MBtu	0.1%	
Levelized Energy Cost=	\$11.24 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Types:	Furnace	Capacity Factor:	0.500
Temperatures:	850 F	Efficiency:	0.903
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	70 MBtu/hr	Unit Cost:	\$4.95 /MBtu
\$/Unit:	\$3,157 /MBtu/hr	Fuel Escalations:	3.76 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$3,094	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$220,990		
1st Year Fuel Cost=	\$2,522,430		
1st Year O&M Cost=	\$3,094		
Present Value of Capital=	\$220,990		
Present Value of Fuel=	\$28,899,510		
Present Value of O&M=	\$26,341		
Annualized Capital Cost=	\$32,900		
Annualized Fuel Cost=	\$3,394,526		
Annualized O&M Cost=	\$3,094		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.11 /MBtu	1.0%	
Levelized Fuel Cost=	\$11.07 /MBtu	99.0%	
Levelized O&M Cost=	\$0.01 /MBtu	0.1%	
Levelized Energy Cost=	\$11.19 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	1500 F	Efficiency:	0.903
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	275 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$2,593 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$9,982	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$713,075		
1st Year Fuel Cost=	\$9,446,318		
1st Year O&M Cost=	\$9,982		
Present Value of Capital=	\$713,075		
Present Value of Fuel=	*****		
Present Value of O&M=	\$84,982		
Annualized Capital Cost=	\$106,160		
Annualized Fuel Cost=	\$13,685,282		
Annualized O&M Cost=	\$9,982		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.09 /MBtu	0.8%	
Levelized Fuel Cost=	\$11.36 /MBtu	99.2%	
Levelized O&M Cost=	\$0.01 /MBtu	0.1%	
Levelized Energy Cost=	\$11.46 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.100
Temperature:	1500 F	Efficiency:	0.903
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	275 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$2,593 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$9,982	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$713,075		
1st Year Fuel Cost=	\$1,889,264		
1st Year O&M Cost=	\$9,982		
Present Value of Capital=	\$713,075		
Present Value of Fuel=	\$23,302,103		
Present Value of O&M=	\$84,982		
Annualized Capital Cost=	\$106,160		
Annualized Fuel Cost=	\$2,737,056		
Annualized O&M Cost=	\$9,982		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.44 /MBtu	3.7%	
Levelized Fuel Cost=	\$11.36 /MBtu	95.9%	
Levelized O&M Cost=	\$0.04 /MBtu	0.3%	
Levelized Energy Cost=	\$11.84 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.900
Temperature:	1500 F	Efficiency:	0.903
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	275 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$2,593 /MBtu/hr	Fuel Escalation:	4.64 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$9,982	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$713,075		
1st Year Fuel Cost=	\$17,003,372		
1st Year O&M Cost=	\$9,982		
Present Value of Capital=	\$713,075		
Present Value of Fuel=	*****		
Present Value of O&M=	\$84,982		
Annualized Capital Cost=	\$106,160		
Annualized Fuel Cost=	\$24,633,507		
Annualized O&M Cost=	\$9,982		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.05 /MBtu	0.4%	
Levelized Fuel Cost=	\$11.36 /MBtu	99.5%	
Levelized O&M Cost=	\$0.00 /MBtu	.0%	
Levelized Energy Cost=	\$11.42 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	1500 F	Efficiency:	0.903
Fuel Type:	Gas		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	275 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$2,593 /MBtu/hr	Fuel Escalation:	4.56 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$9,982	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$713,075		
1st Year Fuel Cost=	\$9,367,179		
1st Year O&M Cost=	\$9,982		
Present Value of Capital=	\$713,075		
Present Value of Fuel=	*****		
Present Value of O&M=	\$84,982		
Annualized Capital Cost=	\$106,160		
Annualized Fuel Cost=	\$13,479,045		
Annualized O&M Cost=	\$9,982		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.09 /MBtu	0.8%	
Levelized Fuel Cost=	\$11.19 /MBtu	99.1%	
Levelized O&M Cost=	\$0.01 /MBtu	0.1%	
Levelized Energy Cost=	\$11.29 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	1500 F	Efficiency:	0.903
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 275 MBtu/hr
\$/Unit: \$2,593 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$4.30 /MBtu
Fuel Escalation: 4.53 %/year

O&M Cost Inputs

Fixed O&M: \$9,982
Variable O&M Rate: \$0.000 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$713,075
1st Year Fuel Cost= \$9,337,658
1st Year O&M Cost= \$9,982

Present Value of Capital= \$713,075
Present Value of Fuel= *****
Present Value of O&M= \$84,982

Annualized Capital Cost= \$106,160
Annualized Fuel Cost= \$13,402,533
Annualized O&M Cost= \$9,982

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.09 /MBtu	0.8%
Levelized Fuel Cost=	\$11.13 /MBtu	99.1%
Levelized O&M Cost=	\$0.01 /MBtu	0.1%

Levelized Energy Cost= \$11.22 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	1500 F	Efficiency:	0.903
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 275 MBtu/hr
\$/Unit: \$2,593 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$4.95 /MBtu
Fuel Escalation: 3.76 %/year

O&M Cost Inputs

Fixed O&M: \$9,982
Variable O&M Rate: \$0.000 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$713,075
1st Year Fuel Cost= \$9,909,548
1st Year O&M Cost= \$9,982

Present Value of Capital= \$713,075
Present Value of Fuel= *****
Present Value of O&M= \$84,982

Annualized Capital Cost= \$106,160
Annualized Fuel Cost= \$13,335,636
Annualized O&M Cost= \$9,982

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.09 /MBtu	0.8%
Levelized Fuel Cost=	\$11.07 /MBtu	99.1%
Levelized O&M Cost=	\$0.01 /MBtu	0.1%

Levelized Energy Cost= \$11.17 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	2500 F	Efficiency:	0.942
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	100 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$2,050 /MBtu/hr	Fuel Escalation:	2.92 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$2,050	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$205,000		
1st Year Fuel Cost=	\$2,775,940		
1st Year O&M Cost=	\$2,050		
Present Value of Capital=	\$205,000		
Present Value of Fuel=	\$29,686,653		
Present Value of O&M=	\$17,453		
Annualized Capital Cost=	\$30,520		
Annualized Fuel Cost=	\$3,486,983		
Annualized O&M Cost=	\$2,050		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.07 /MBtu	0.9%	
Levelized Fuel Cost=	\$7.96 /MBtu	99.1%	
Levelized O&M Cost=	\$0.00 /MBtu	0.1%	
Levelized Energy Cost=	\$8.04 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.100
Temperature:	2500 F	Efficiency:	0.942
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	100 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$2,050 /MBtu/hr	Fuel Escalation:	2.92 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$2,050	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$205,000		
1st Year Fuel Cost=	\$555,189		
1st Year O&M Cost=	\$2,050		
Present Value of Capital=	\$205,000		
Present Value of Fuel=	\$5,937,331		
Present Value of O&M=	\$17,453		
Annualized Capital Cost=	\$30,520		
Annualized Fuel Cost=	\$697,397		
Annualized O&M Cost=	\$2,050		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.35 /MBtu	4.2%	
Levelized Fuel Cost=	\$7.96 /MBtu	95.5%	
Levelized O&M Cost=	\$0.02 /MBtu	0.3%	
Levelized Energy Cost=	\$8.33 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.900
Temperature:	2500 F	Efficiency:	0.942
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	100 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$2,050 /MBtu/hr	Fuel Escalation:	2.92 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$2,050	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$205,000		
1st Year Fuel Cost=	\$4,996,691		
1st Year O&M Cost=	\$2,050		
Present Value of Capital=	\$205,000		
Present Value of Fuel=	\$53,435,976		
Present Value of O&M=	\$17,453		
Annualized Capital Cost=	\$30,520		
Annualized Fuel Cost=	\$6,276,570		
Annualized O&M Cost=	\$2,050		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.04 /MBtu	0.5%	
Levelized Fuel Cost=	\$7.96 /MBtu	99.5%	
Levelized O&M Cost=	\$0.00 /MBtu	.0%	
Levelized Energy Cost=	\$8.00 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	2500 F	Efficiency:	0.942
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	100 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$2,050 /MBtu/hr	Fuel Escalation:	0.90 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$2,050	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$205,000		
1st Year Fuel Cost=	\$2,232,108		
1st Year O&M Cost=	\$2,050		
Present Value of Capital=	\$205,000		
Present Value of Fuel=	\$20,348,591		
Present Value of O&M=	\$17,453		
Annualized Capital Cost=	\$30,520		
Annualized Fuel Cost=	\$2,390,138		
Annualized O&M Cost=	\$2,050		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.07 /MBtu	1.3%	
Levelized Fuel Cost=	\$5.46 /MBtu	98.7%	
Levelized O&M Cost=	\$0.00 /MBtu	0.1%	
Levelized Energy Cost=	\$5.53 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	2500 F	Efficiency:	0.942
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	100 MBtu/hr	Unit Cost:	\$4.35 /MBtu
\$/Unit:	\$2,050 /MBtu/hr	Fuel Escalation:	5.43 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$2,050	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$205,000		
1st Year Fuel Cost=	\$3,618,418		
1st Year O&M Cost=	\$2,050		
Present Value of Capital=	\$205,000		
Present Value of Fuel=	\$47,749,932		
Present Value of O&M=	\$17,453		
Annualized Capital Cost=	\$30,520		
Annualized Fuel Cost=	\$5,608,689		
Annualized O&M Cost=	\$2,050		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.07 /MBtu	0.5%	
Levelized Fuel Cost=	\$12.81 /MBtu	99.4%	
Levelized O&M Cost=	\$0.00 /MBtu	.0%	
Levelized Energy Cost=	\$12.88 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	2500 F	Efficiency:	0.942
Fuel Type:	Oil		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	100 MBtu/hr	Unit Cost:	\$4.92 /MBtu
\$/Unit:	\$2,050 /MBtu/hr	Fuel Escalation:	2.86 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$2,050	FCR:	0.149
Variable O&M Rate:	\$0.000 Per MBtu	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$205,000		
1st Year Fuel Cost=	\$3,119,608		
1st Year O&M Cost=	\$2,050		
Present Value of Capital=	\$205,000		
Present Value of Fuel=	\$33,200,041		
Present Value of O&M=	\$17,453		
Annualized Capital Cost=	\$30,520		
Annualized Fuel Cost=	\$3,899,664		
Annualized O&M Cost=	\$2,050		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.07 /MBtu	0.8%	
Levelized Fuel Cost=	\$8.90 /MBtu	99.2%	
Levelized O&M Cost=	\$0.00 /MBtu	0.1%	
Levelized Energy Cost=	\$8.98 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	2500 F	Efficiency:	0.903
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 38 MBtu/hr
\$/Unit: \$3,813 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$4.30 /MBtu
Fuel Escalation: 4.64 %/year

O&M Cost Inputs

Fixed O&M: \$0
Variable O&M Rate: \$0.045 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$142,988
1st Year Fuel Cost= \$1,288,134
1st Year O&M Cost= \$7,391

Present Value of Capital= \$142,988
Present Value of Fuel= \$15,887,798
Present Value of O&M= \$62,926

Annualized Capital Cost= \$21,287
Annualized Fuel Cost= \$1,866,175
Annualized O&M Cost= \$7,391

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.13 /MBtu	1.1%
Levelized Fuel Cost=	\$11.36 /MBtu	98.5%
Levelized O&M Cost=	\$0.05 /MBtu	0.4%
Levelized Energy Cost=	\$11.54 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	2500 F	Efficiency:	0.849
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 38 MBtu/hr
\$/Unit: \$381 /MBtu/hr

Fuel Cost Inputs

Unit Cost: \$4.30 /MBtu
Fuel Escalation: 4.64 %/year

O&M Cost Inputs

Fixed O&M: \$0
Variable O&M Rate: \$0.045 Per MBtu

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$14,299
1st Year Fuel Cost= \$1,370,065
1st Year O&M Cost= \$7,391

Present Value of Capital= \$14,299
Present Value of Fuel= \$16,898,329
Present Value of O&M= \$62,926

Annualized Capital Cost= \$2,129
Annualized Fuel Cost= \$1,984,871
Annualized O&M Cost= \$7,391

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.01 /MBtu	0.1%
Levelized Fuel Cost=	\$12.08 /MBtu	99.5%
Levelized O&M Cost=	\$0.05 /MBtu	0.4%
Levelized Energy Cost=	\$12.14 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Furnace	Capacity Factor:	0.100
Temperature:	2500 F	Efficiency:	0.903
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	38 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$3,813 /MBtu/hr	Fuel Escalation:	4.64 %/year
D&M Cost Inputs		Financial Inputs	
Fixed D&M:	\$0	FCR:	0.149
Variable D&M Rate:	\$0.045 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$142,988
1st Year Fuel Cost=	\$257,627
1st Year D&M Cost=	\$1,478
Present Value of Capital=	\$142,988
Present Value of Fuel=	\$3,177,560
Present Value of D&M=	\$12,585
Annualized Capital Cost=	\$21,287
Annualized Fuel Cost=	\$373,235
Annualized D&M Cost=	\$1,478

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.65 /MBtu	5.4%
Levelized Fuel Cost=	\$11.36 /MBtu	94.3%
Levelized D&M Cost=	\$0.05 /MBtu	0.4%
Levelized Energy Cost=	\$12.05 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Furnace	Capacity Factor:	0.900
Temperature:	2500 F	Efficiency:	0.903
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	38 MBtu/hr	Unit Cost:	\$4.30 /MBtu
\$/Unit:	\$3,813 /MBtu/hr	Fuel Escalation:	4.64 %/year
D&M Cost Inputs		Financial Inputs	
Fixed D&M:	\$0	FCR:	0.149
Variable D&M Rate:	\$0.045 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$142,988
1st Year Fuel Cost=	\$2,318,642
1st Year D&M Cost=	\$13,304
Present Value of Capital=	\$142,988
Present Value of Fuel=	\$28,598,036
Present Value of D&M=	\$113,267
Annualized Capital Cost=	\$21,287
Annualized Fuel Cost=	\$3,359,115
Annualized D&M Cost=	\$13,304

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.07 /MBtu	0.6%
Levelized Fuel Cost=	\$11.36 /MBtu	99.0%
Levelized D&M Cost=	\$0.05 /MBtu	0.4%
Levelized Energy Cost=	\$11.48 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	2500 F	Efficiency:	0.903
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity:	38 MBtu/hr
\$/Unit:	\$3,813 /MBtu/hr

Fuel Cost Inputs

Unit Cost:	\$4.30 /MBtu
Fuel Escalation:	4.56 %/year

O&M Cost Inputs

Fixed O&M:	\$0
Variable O&M Rate:	\$0.045 Per MBtu

Financial Inputs

FCR:	0.149
CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$142,988
1st Year Fuel Cost=	\$1,277,343
1st Year O&M Cost=	\$7,391

Present Value of Capital=	\$142,988
Present Value of Fuel=	\$15,648,369
Present Value of O&M=	\$62,926

Annualized Capital Cost=	\$21,287
Annualized Fuel Cost=	\$1,838,052
Annualized O&M Cost=	\$7,391

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.13 /MBtu	1.1%
Levelized Fuel Cost=	\$11.19 /MBtu	98.5%
Levelized O&M Cost=	\$0.05 /MBtu	0.4%
Levelized Energy Cost=	\$11.37 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	2500 F	Efficiency:	0.903
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity:	38 MBtu/hr
\$/Unit:	\$3,813 /MBtu/hr

Fuel Cost Inputs

Unit Cost:	\$4.30 /MBtu
Fuel Escalation:	4.53 %/year

O&M Cost Inputs

Fixed O&M:	\$0
Variable O&M Rate:	\$0.045 Per MBtu

Financial Inputs

FCR:	0.149
CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$142,988
1st Year Fuel Cost=	\$1,273,317
1st Year O&M Cost=	\$7,391

Present Value of Capital=	\$142,988
Present Value of Fuel=	\$15,559,544
Present Value of O&M=	\$62,926

Annualized Capital Cost=	\$21,287
Annualized Fuel Cost=	\$1,827,618
Annualized O&M Cost=	\$7,391

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.13 /MBtu	1.1%
Levelized Fuel Cost=	\$11.13 /MBtu	98.5%
Levelized O&M Cost=	\$0.05 /MBtu	0.4%
Levelized Energy Cost=	\$11.30 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Furnace	Capacity Factor:	0.500
Temperature:	2500 F	Efficiency:	0.903
Fuel Type:	Gas		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	38 MBtu/hr	Unit Cost:	\$4.95 /MBtu
\$/Unit:	\$3,813 /MBtu/hr	Fuel Escalation:	3.76 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$0	FCR:	0.149
Variable O&M Rate:	\$0.045 Per MBtu	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$142,988
1st Year Fuel Cost=	\$1,351,302
1st Year O&M Cost=	\$7,391
Present Value of Capital=	\$142,988
Present Value of Fuel=	\$13,481,880
Present Value of O&M=	\$62,926
Annualized Capital Cost=	\$21,287
Annualized Fuel Cost=	\$1,818,496
Annualized O&M Cost=	\$7,391

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.13 /MBtu	1.2%
Levelized Fuel Cost=	\$11.07 /MBtu	98.4%
Levelized O&M Cost=	\$0.05 /MBtu	0.4%
Levelized Energy Cost=	\$11.25 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Electric Furnace	Capacity Factor:	0.500
Temperature:	2500 F	Efficiency:	0.550
Fuel Type:	Electricity		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	150 kWe	Unit Cost:	\$0.06 /kWh
\$/Unit:	\$1,283 /kWe	Fuel Escalation:	-0.18 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$10,000	FCR:	0.149
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$192,500
1st Year Fuel Cost=	\$66,590
1st Year O&M Cost=	\$10,000
Present Value of Capital=	\$192,500
Present Value of Fuel=	\$559,328
Present Value of O&M=	\$85,136
Annualized Capital Cost=	\$28,658
Annualized Fuel Cost=	\$65,699
Annualized O&M Cost=	\$10,000

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.044 /kWh or \$12.78 /MBtu	27.5%
Levelized Fuel Cost=	\$0.100 /kWh or \$29.30 /MBtu	63.0%
Levelized O&M Cost=	\$0.015 /kWh or \$4.46 /MBtu	9.6%
Levelized Energy Cost=	\$0.159 /kWh or \$46.54 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description				
Equipment Type:	Electric Furnace	Capacity Factor:	0.100	
Temperature:	2500 F	Efficiency:	0.550	
Fuel Type:	Electricity			
Cost and Financial Inputs (all costs are in 1984 dollars)				
Equipment Cost Inputs		Fuel Cost Inputs		
Capacity:	150 kWe	Unit Cost:	\$0.06 /kWh	
\$/Unit:	\$1,283 /kWe	Fuel Escalation:	-0.18 %/year	
O&M Cost Inputs		Financial Inputs		
Fixed O&M:	\$10,000	FCR:	0.149	
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117	
Calculations (all costs are in 1984 dollars)				
Capital Cost=	\$192,500			
1st Year Fuel Cost=	\$13,318			
1st Year O&M Cost=	\$10,000			
Present Value of Capital=	\$192,500			
Present Value of Fuel=	\$111,866			
Present Value of O&M=	\$85,136			
Annualized Capital Cost=	\$28,658			
Annualized Fuel Cost=	\$13,140			
Annualized O&M Cost=	\$10,000			
Results (levelized constant 1984 dollars)				
Levelized Capital Cost=	\$0.218 /kWh or \$63.91 /MBtu	55.3%		
Levelized Fuel Cost=	\$0.100 /kWh or \$29.30 /MBtu	25.4%		
Levelized O&M Cost=	\$0.076 /kWh or \$22.30 /MBtu	19.3%		
Levelized Energy Cost=	\$0.394 /kWh or \$115.51 /MBtu			

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description				
Equipment Type:	Electric Furnace	Capacity Factor:	0.100	
Temperature:	2500 F	Efficiency:	0.550	
Fuel Type:	Electricity			
Cost and Financial Inputs (all costs are in 1984 dollars)				
Equipment Cost Inputs		Fuel Cost Inputs		
Capacity:	150 kWe	Unit Cost:	\$0.06 /kWh	
\$/Unit:	\$1,283 /kWe	Fuel Escalation:	-0.18 %/year	
O&M Cost Inputs		Financial Inputs		
Fixed O&M:	\$10,000	FCR:	0.149	
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117	
Calculations (all costs are in 1984 dollars)				
Capital Cost=	\$192,500			
1st Year Fuel Cost=	\$39,954			
1st Year O&M Cost=	\$10,000			
Present Value of Capital=	\$192,500			
Present Value of Fuel=	\$335,597			
Present Value of O&M=	\$85,136			
Annualized Capital Cost=	\$28,658			
Annualized Fuel Cost=	\$39,419			
Annualized O&M Cost=	\$10,000			
Results (levelized constant 1984 dollars)				
Levelized Capital Cost=	\$0.073 /kWh or \$21.30 /MBtu	36.7%		
Levelized Fuel Cost=	\$0.100 /kWh or \$29.30 /MBtu	50.5%		
Levelized O&M Cost=	\$0.025 /kWh or \$7.43 /MBtu	12.8%		
Levelized Energy Cost=	\$0.198 /kWh or \$58.04 /MBtu			

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description				
Equipment Type:	Electric Furnace	Capacity Factor:	0.700	
Temperature:	2500 F	Efficiency:	0.550	
Fuel type:	Electricity			
Cost and Financial Inputs (all costs are in 1984 dollars)				
Equipment Cost Inputs		Fuel Cost Inputs		
Capacity:	150 kWe	Unit Cost:	\$0.06 /kWh	
\$/Unit:	\$1,283 /kWe	Fuel Escalation:	-0.18 %/year	
O&M Cost Inputs		Financial Inputs		
Fixed O&M:	\$10,000	FCR:	0.149	
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117	
Calculations (all costs are in 1984 dollars)				
Capital Cost=	\$192,500			
1st Year Fuel Cost=	\$93,226			
1st Year O&M Cost=	\$10,000			
Present Value of Capital=	\$192,500			
Present Value of Fuel=	\$783,040			
Present Value of O&M=	\$85,136			
Annualized Capital Cost=	\$28,658			
Annualized Fuel Cost=	\$91,978			
Annualized O&M Cost=	\$10,000			
Results (levelized constant 1984 dollars)				
Levelized Capital Cost=	\$0.031 /kWh or	\$9.13 /MBtu	21.9%	
Levelized Fuel Cost=	\$0.100 /kWh or	\$29.30 /MBtu	70.4%	
Levelized O&M Cost=	\$0.011 /kWh or	\$3.19 /MBtu	7.7%	
Levelized Energy Cost=	\$0.142 /kWh or	\$41.62 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description				
Equipment Type:	Electric Furnace	Capacity Factor:	0.900	
Temperature:	2500 F	Efficiency:	0.550	
Fuel type:	Electricity			
Cost and Financial Inputs (all costs are in 1984 dollars)				
Equipment Cost Inputs		Fuel Cost Inputs		
Capacity:	150 kWe	Unit Cost:	\$0.06 /kWh	
\$/Unit:	\$1,283 /kWe	Fuel Escalation:	-0.18 %/year	
O&M Cost Inputs		Financial Inputs		
Fixed O&M:	\$10,000	FCR:	0.149	
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117	
Calculations (all costs are in 1984 dollars)				
Capital Cost=	\$192,500			
1st Year Fuel Cost=	\$119,862			
1st Year O&M Cost=	\$10,000			
Present Value of Capital=	\$192,500			
Present Value of Fuel=	\$1,006,791			
Present Value of O&M=	\$85,136			
Annualized Capital Cost=	\$28,658			
Annualized Fuel Cost=	\$118,257			
Annualized O&M Cost=	\$10,000			
Results (levelized constant 1984 dollars)				
Levelized Capital Cost=	\$0.024 /kWh or	\$7.10 /MBtu	18.3%	
Levelized Fuel Cost=	\$0.100 /kWh or	\$29.30 /MBtu	75.4%	
Levelized O&M Cost=	\$0.008 /kWh or	\$2.48 /MBtu	6.4%	
Levelized Energy Cost=	\$0.133 /kWh or	\$38.88 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description				
Equipment Type:	Electric Furnace	Capacity Factor:	0.500	
Temperature:	2500 F	Efficiency:	0.500	
Fuel Type:	Electricity			
Cost and Financial Inputs (all costs are in 1984 dollars)				
Equipment Cost Inputs		Fuel Cost Inputs		
Capacity:	150 kWe	Unit Cost:	\$0.06 /kWh	
\$/Unit:	\$1,283 /kWe	Fuel Escalation:	-0.18 %/year	
O&M Cost Inputs		Financial Inputs		
Fixed O&M:	\$10,000	FCR:	0.149	
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117	
Calculations (all costs are in 1984 dollars)				
Capital Cost=	\$192,500			
1st Year Fuel Cost=	\$73,249			
1st Year O&M Cost=	\$10,000			
Present Value of Capital=	\$192,500			
Present Value of Fuel=	\$615,261			
Present Value of O&M=	\$85,136			
Annualized Capital Cost=	\$28,658			
Annualized Fuel Cost=	\$72,268			
Annualized O&M Cost=	\$10,000			
Results (levelized constant 1984 dollars)				
Levelized Capital Cost=	\$0.044 /kWh	or	\$12.78 /MBtu	25.8%
Levelized Fuel Cost=	\$0.110 /kWh	or	\$32.23 /MBtu	65.1%
Levelized O&M Cost=	\$0.015 /kWh	or	\$4.46 /MBtu	9.0%
Levelized Energy Cost=	\$0.169 /kWh	or	\$49.47 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description				
Equipment Type:	Electric Furnace	Capacity Factor:	0.500	
Temperature:	2500 F	Efficiency:	0.600	
Fuel Type:	Electricity			
Cost and Financial Inputs (all costs are in 1984 dollars)				
Equipment Cost Inputs		Fuel Cost Inputs		
Capacity:	150 kWe	Unit Cost:	\$0.06 /kWh	
\$/Unit:	\$1,283 /kWe	Fuel Escalation:	-0.18 %/year	
O&M Cost Inputs		Financial Inputs		
Fixed O&M:	\$10,000	FCR:	0.149	
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117	
Calculations (all costs are in 1984 dollars)				
Capital Cost=	\$192,500			
1st Year Fuel Cost=	\$61,041			
1st Year O&M Cost=	\$10,000			
Present Value of Capital=	\$192,500			
Present Value of Fuel=	\$512,718			
Present Value of O&M=	\$85,136			
Annualized Capital Cost=	\$28,658			
Annualized Fuel Cost=	\$60,224			
Annualized O&M Cost=	\$10,000			
Results (levelized constant 1984 dollars)				
Levelized Capital Cost=	\$0.044 /kWh	or	\$12.78 /MBtu	29.0%
Levelized Fuel Cost=	\$0.092 /kWh	or	\$26.86 /MBtu	60.9%
Levelized O&M Cost=	\$0.015 /kWh	or	\$4.46 /MBtu	10.1%
Levelized Energy Cost=	\$0.151 /kWh	or	\$44.10 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description				
Equipment Type:	Electric Furnace	Capacity Factor:	0.500	
Temperature:	2500 F	Efficiency:	0.550	
Fuel Type:	Electricity			
Cost and Financial Inputs (all costs are in 1984 dollars)				
Equipment Cost Inputs		Fuel Cost Inputs		
Capacity:	150 kWe	Unit Cost:	\$0.06 /kWh	
\$/Unit:	\$1,283 /kWe	Fuel Escalation:	-0.33 %/year	
O&M Cost Inputs		Financial Inputs		
Fixed O&M:	\$10,000	FCR:	0.149	
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117	
Calculations (all costs are in 1984 dollars)				
Capital Cost=	\$192,500			
1st Year Fuel Cost=	\$65,498			
1st Year O&M Cost=	\$10,000			
Present Value of Capital=	\$192,500			
Present Value of Fuel=	\$544,033			
Present Value of O&M=	\$85,136			
Annualized Capital Cost=	\$28,658			
Annualized Fuel Cost=	\$63,902			
Annualized O&M Cost=	\$10,000			
Results (levelized constant 1984 dollars)				
Levelized Capital Cost=	\$0.044 /kWh or	\$12.78 /MBtu	27.9%	
Levelized Fuel Cost=	\$0.097 /kWh or	\$28.50 /MBtu	62.3%	
Levelized O&M Cost=	\$0.015 /kWh or	\$4.46 /MBtu	9.8%	
Levelized Energy Cost=	\$0.156 /kWh or	\$45.74 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description				
Equipment Type:	Electric Furnace	Capacity Factor:	0.500	
Temperature:	2500 F	Efficiency:	0.550	
Fuel Type:	Electricity			
Cost and Financial Inputs (all costs are in 1984 dollars)				
Equipment Cost Inputs		Fuel Cost Inputs		
Capacity:	150 kWe	Unit Cost:	\$0.06 /kWh	
\$/Unit:	\$1,283 /kWe	Fuel Escalation:	-0.14 %/year	
O&M Cost Inputs		Financial Inputs		
Fixed O&M:	\$10,000	FCR:	0.149	
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117	
Calculations (all costs are in 1984 dollars)				
Capital Cost=	\$192,500			
1st Year Fuel Cost=	\$66,884			
1st Year O&M Cost=	\$10,000			
Present Value of Capital=	\$192,500			
Present Value of Fuel=	\$563,481			
Present Value of O&M=	\$85,136			
Annualized Capital Cost=	\$28,658			
Annualized Fuel Cost=	\$66,186			
Annualized O&M Cost=	\$10,000			
Results (levelized constant 1984 dollars)				
Levelized Capital Cost=	\$0.044 /kWh or	\$12.78 /MBtu	27.3%	
Levelized Fuel Cost=	\$0.101 /kWh or	\$29.52 /MBtu	63.1%	
Levelized O&M Cost=	\$0.015 /kWh or	\$4.46 /MBtu	9.5%	
Levelized Energy Cost=	\$0.160 /kWh or	\$46.76 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Electric Furnace	Capacity Factor:	0.500
Temperature:	2500 F	Efficiency:	0.550
Fuel Type:	Electricity		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity:	150 kWe
\$/Unit:	\$1,283 /kWe

Fuel Cost Inputs

Unit Cost:	\$0.05 /kWh
Fuel Escalation:	2.26 %/year

O&M Cost Inputs

Fixed O&M:	\$10,000
Variable O&M Rate:	\$0.000 /kWh

Financial Inputs

FCR:	0.149
CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$192,500
1st Year Fuel Cost=	\$81,430
1st Year O&M Cost=	\$10,000

Present Value of Capital=	\$192,500
Present Value of Fuel=	\$825,800
Present Value of O&M=	\$85,136

Annualized Capital Cost=	\$28,658
Annualized Fuel Cost=	\$96,998
Annualized O&M Cost=	\$10,000

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.044 /kWh	or	\$12.78 /MBtu	21.1%
Levelized Fuel Cost=	\$0.148 /kWh	or	\$43.26 /MBtu	71.5%
Levelized O&M Cost=	\$0.015 /kWh	or	\$4.46 /MBtu	7.4%
Levelized Energy Cost=	\$0.206 /kWh	or	\$60.50 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Electric Arc Furnace	Capacity Factor:	0.500
Temperature:	2500 F	Efficiency:	0.640
Fuel Type:	Electricity		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity:	12800 kWe
\$/Unit:	\$295 /kWe

Fuel Cost Inputs

Unit Cost:	\$0.06 /kWh
Fuel Escalation:	-0.18 %/year

O&M Cost Inputs

Fixed O&M:	\$0
Variable O&M Rate:	\$0.010 /kWh

Financial Inputs

FCR:	0.149
CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$3,776,000
1st Year Fuel Cost=	\$4,883,282
1st Year O&M Cost=	\$576,338

Present Value of Capital=	\$3,776,000
Present Value of Fuel=	\$41,017,417
Present Value of O&M=	\$4,906,690

Annualized Capital Cost=	\$562,155
Annualized Fuel Cost=	\$4,817,890
Annualized O&M Cost=	\$576,338

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.010 /kWh	or	\$2.94 /MBtu	9.4%
Levelized Fuel Cost=	\$0.086 /kWh	or	\$25.18 /MBtu	80.4%
Levelized O&M Cost=	\$0.010 /kWh	or	\$3.01 /MBtu	9.7%
Levelized Energy Cost=	\$0.106 /kWh	or	\$31.13 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Electric Arc Furnace	Capacity Factor:	0.100
Temperature:	2500 F	Efficiency:	0.640
Fuel Type:	Electricity		

Cost and Financial Inputs

(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 12800 kWe
\$/Unit: \$295 /kWe

Fuel Cost Inputs

Unit Cost: \$0.06 /kWh
Fuel Escalation: -0.18 %/year

O&M Cost Inputs

Fixed O&M: \$0
Variable O&M Rate: \$0.010 /kWh

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations

(all costs are in 1984 dollars)

Capital Cost= \$3,776,000
1st Year Fuel Cost= \$976,656
1st Year O&M Cost= \$115,268

Present Value of Capital= \$3,776,000
Present Value of Fuel= \$8,203,483
Present Value of O&M= \$981,338

Annualized Capital Cost= \$562,155
Annualized Fuel Cost= \$963,578
Annualized O&M Cost= \$115,268

Results

(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.050 /kWh	or	\$14.69 /MBtu	34.3%
Levelized Fuel Cost=	\$0.086 /kWh	or	\$25.18 /MBtu	58.7%
Levelized O&M Cost=	\$0.010 /kWh	or	\$3.01 /MBtu	7.0%
Levelized Energy Cost=	\$0.146 /kWh	or	\$42.88 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Electric Arc Furnace	Capacity Factor:	0.100
Temperature:	2500 F	Efficiency:	0.640
Fuel Type:	Electricity		

Cost and Financial Inputs

(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 12800 kWe
\$/Unit: \$295 /kWe

Fuel Cost Inputs

Unit Cost: \$0.06 /kWh
Fuel Escalation: -0.18 %/year

O&M Cost Inputs

Fixed O&M: \$0
Variable O&M Rate: \$0.010 /kWh

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations

(all costs are in 1984 dollars)

Capital Cost= \$3,776,000
1st Year Fuel Cost= \$2,929,969
1st Year O&M Cost= \$345,803

Present Value of Capital= \$3,776,000
Present Value of Fuel= \$24,610,450
Present Value of O&M= \$2,944,014

Annualized Capital Cost= \$562,155
Annualized Fuel Cost= \$2,890,734
Annualized O&M Cost= \$345,803

Results

(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.017 /kWh	or	\$4.90 /MBtu	14.8%
Levelized Fuel Cost=	\$0.086 /kWh	or	\$25.18 /MBtu	76.1%
Levelized O&M Cost=	\$0.010 /kWh	or	\$3.01 /MBtu	9.1%
Levelized Energy Cost=	\$0.113 /kWh	or	\$33.09 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Electric Arc Furnace Capacity Factor: 0.700
 Temperature: 2500 F Efficiency: 0.640
 Fuel Type: Electricity

Cost and Financial Inputs
 (all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 12800 kWe
 \$/Unit: \$295 /kWe

Fuel Cost Inputs

Unit Cost: \$0.06 /kWh
 Fuel Escalation: -0.18 %/year

O&M Cost Inputs

Fixed O&M: \$0
 Variable O&M Rate: \$0.010 /kWh

Financial Inputs

FCR: 0.149
 CRF: 0.117

Calculations
 (all costs are in 1984 dollars)

Capital Cost= \$3,776,000
 1st Year Fuel Cost= \$6,836,595
 1st Year O&M Cost= \$806,873

Present Value of Capital= \$3,776,000
 Present Value of Fuel= \$57,424,384
 Present Value of O&M= \$6,869,365

Annualized Capital Cost= \$562,155
 Annualized Fuel Cost= \$6,745,047
 Annualized O&M Cost= \$806,873

Results
 (levelized constant 1984 dollars)

Levelized Capital Cost= \$0.007 /kWh or \$2.10 /MBtu 6.9%
 Levelized Fuel Cost= \$0.086 /kWh or \$25.18 /MBtu 83.1%
 Levelized O&M Cost= \$0.010 /kWh or \$3.01 /MBtu 9.9%
 Levelized Energy Cost= \$0.103 /kWh or \$30.29 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Electric Arc Furnace Capacity Factor: 0.700
 Temperature: 2500 F Efficiency: 0.640
 Fuel Type: Electricity

Cost and Financial Inputs
 (all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 12800 kWe
 \$/Unit: \$295 /kWe

Fuel Cost Inputs

Unit Cost: \$0.06 /kWh
 Fuel Escalation: -0.18 %/year

O&M Cost Inputs

Fixed O&M: \$0
 Variable O&M Rate: \$0.010 /kWh

Financial Inputs

FCR: 0.149
 CRF: 0.117

Calculations
 (all costs are in 1984 dollars)

Capital Cost= \$3,776,000
 1st Year Fuel Cost= \$8,789,908
 1st Year O&M Cost= \$1,037,408

Present Value of Capital= \$3,776,000
 Present Value of Fuel= \$73,831,350
 Present Value of O&M= \$8,832,041

Annualized Capital Cost= \$562,155
 Annualized Fuel Cost= \$8,672,203
 Annualized O&M Cost= \$1,037,408

Results
 (levelized constant 1984 dollars)

Levelized Capital Cost= \$0.006 /kWh or \$1.63 /MBtu 5.5%
 Levelized Fuel Cost= \$0.086 /kWh or \$25.18 /MBtu 84.4%
 Levelized O&M Cost= \$0.010 /kWh or \$3.01 /MBtu 10.1%
 Levelized Energy Cost= \$0.102 /kWh or \$29.81 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description				
Equipment Type:	Electric Arc Furnace	Capacity Factor:	0.500	
Temperatures:	2500 F	Efficiency:	0.670	
Fuel Type:	Electricity			
Cost and Financial Inputs (all costs are in 1984 dollars)				
Equipment Cost Inputs		Fuel Cost Inputs		
Capacity:	12800 kWe	Unit Cost:	\$0.06 /kWh	
\$/Unit:	\$295 /kWe	Fuel Escalation:	+0.18 %/year	
O&M Cost Inputs		Financial Inputs		
Fixed O&M:	\$0	FCR:	0.149	
Variable O&M Rate:	\$0.010 /kWh	CRF:	0.117	
Calculations (all costs are in 1984 dollars)				
Capital Cost=	\$3,776,000			
1st Year Fuel Cost=	\$4,664,628			
1st Year O&M Cost=	\$576,338			
Present Value of Capital=	\$3,776,000			
Present Value of Fuel=	\$39,180,816			
Present Value of O&M=	\$4,906,690			
Annualized Capital Cost=	\$562,155			
Annualized Fuel Cost=	\$4,602,164			
Annualized O&M Cost=	\$576,338			
Results (levelized constant 1984 dollars)				
Levelized Capital Cost=	\$0.010 /kWh or	\$2.94 /MBtu	9.8%	
Levelized Fuel Cost=	\$0.082 /kWh or	\$24.05 /MBtu	80.2%	
Levelized O&M Cost=	\$0.010 /kWh or	\$3.01 /MBtu	10.0%	
Levelized Energy Cost=	\$0.102 /kWh or	\$30.00 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description				
Equipment Type:	Electric Arc Furnace	Capacity Factor:	0.500	
Temperatures:	2500 F	Efficiency:	0.700	
Fuel Type:	Electricity			
Cost and Financial Inputs (all costs are in 1984 dollars)				
Equipment Cost Inputs		Fuel Cost Inputs		
Capacity:	12800 kWe	Unit Cost:	\$0.06 /kWh	
\$/Unit:	\$295 /kWe	Fuel Escalation:	+0.18 %/year	
O&M Cost Inputs		Financial Inputs		
Fixed O&M:	\$0	FCR:	0.149	
Variable O&M Rate:	\$0.010 /kWh	CRF:	0.117	
Calculations (all costs are in 1984 dollars)				
Capital Cost=	\$3,776,000			
1st Year Fuel Cost=	\$4,464,715			
1st Year O&M Cost=	\$576,338			
Present Value of Capital=	\$3,776,000			
Present Value of Fuel=	\$37,501,638			
Present Value of O&M=	\$4,906,690			
Annualized Capital Cost=	\$562,155			
Annualized Fuel Cost=	\$4,404,928			
Annualized O&M Cost=	\$576,338			
Results (levelized constant 1984 dollars)				
Levelized Capital Cost=	\$0.010 /kWh or	\$2.94 /MBtu	10.1%	
Levelized Fuel Cost=	\$0.079 /kWh or	\$23.02 /MBtu	79.5%	
Levelized O&M Cost=	\$0.010 /kWh or	\$3.01 /MBtu	10.4%	
Levelized Energy Cost=	\$0.099 /kWh or	\$28.97 /MBtu		

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Electric Arc Furnace	Capacity Factor:	0.500
Temperature:	2500 F	Efficiency:	0.640
Fuel Type:	Electricity		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 12800 kWe
\$/Unit: \$295 /kWe

Fuel Cost Inputs

Unit Cost: \$0.06 /kWh
Fuel Escalation: -0.33 %/year

O&M Cost Inputs

Fixed O&M: \$0
Variable O&M Rate: \$0.010 /kWh

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$3,776,000
1st Year Fuel Cost= \$4,893,166
1st Year O&M Cost= \$576,338

Present Value of Capital= \$3,776,000
Present Value of Fuel= \$39,895,762
Present Value of O&M= \$4,906,690

Annualized Capital Cost= \$562,155
Annualized Fuel Cost= \$4,686,144
Annualized O&M Cost= \$576,338

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.010 /kWh	or	\$2.94 /MBtu	9.7%
Levelized Fuel Cost=	\$0.084 /kWh	or	\$24.49 /MBtu	80.5%
Levelized O&M Cost=	\$0.010 /kWh	or	\$3.01 /MBtu	9.9%
Levelized Energy Cost=	\$0.104 /kWh	or	\$30.44 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Electric Arc Furnace	Capacity Factor:	0.500
Temperature:	2500 F	Efficiency:	0.640
Fuel Type:	Electricity		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 12800 kWe
\$/Unit: \$295 /kWe

Fuel Cost Inputs

Unit Cost: \$0.06 /kWh
Fuel Escalation: -0.14 %/year

O&M Cost Inputs

Fixed O&M: \$0
Variable O&M Rate: \$0.010 /kWh

Financial Inputs

FCR: 0.149
CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$3,776,000
1st Year Fuel Cost= \$4,904,851
1st Year O&M Cost= \$576,338

Present Value of Capital= \$3,776,000
Present Value of Fuel= \$41,321,956
Present Value of O&M= \$4,906,690

Annualized Capital Cost= \$562,155
Annualized Fuel Cost= \$4,853,661
Annualized O&M Cost= \$576,338

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.010 /kWh	or	\$2.94 /MBtu	9.4%
Levelized Fuel Cost=	\$0.087 /kWh	or	\$25.37 /MBtu	81.0%
Levelized O&M Cost=	\$0.010 /kWh	or	\$3.01 /MBtu	9.6%
Levelized Energy Cost=	\$0.107 /kWh	or	\$31.32 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Electric Arc Furnace Capacity Factor: 0.500
 Temperature: 2500 F Efficiency: 0.640
 Fuel Type: Electricity

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 12800 kWe
 \$/Unit: \$295 /kWe

Fuel Cost Inputs

Unit Cost: \$0.05 /kWh
 Fuel Escalation: 2.26 %/year

O&M Cost Inputs

Fixed O&M: \$0
 Variable O&M Rate: \$0.010 /kWh

Financial Inputs

FCR: 0.149
 CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$3,776,000
 1st Year Fuel Cost= \$5,971,516
 1st Year O&M Cost= \$576,338

Present Value of Capital= \$3,776,000
 Present Value of Fuel= \$60,558,700
 Present Value of O&M= \$4,906,690

Annualized Capital Cost= \$562,155
 Annualized Fuel Cost= \$7,113,202
 Annualized O&M Cost= \$576,338

Results
(levelized constant 1984 dollars)

Levelized Capital Cost= \$0.010 /kWh or \$2.94 /MBtu 6.8%
 Levelized Fuel Cost= \$0.127 /kWh or \$37.18 /MBtu 86.2%
 Levelized O&M Cost= \$0.010 /kWh or \$3.01 /MBtu 7.0%
 Levelized Energy Cost= \$0.147 /kWh or \$43.13 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type: Electric Furnace Capacity Factor: 0.500
 Temperature: 4000 F Efficiency: 0.550
 Fuel Type: Electricity

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity: 150 kWe
 \$/Unit: \$953 /kWe

Fuel Cost Inputs

Unit Cost: \$0.06 /kWh
 Fuel Escalation: -0.18 %/year

O&M Cost Inputs

Fixed O&M: \$7,000
 Variable O&M Rate: \$0.000 /kWh

Financial Inputs

FCR: 0.149
 CRF: 0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost= \$143,000
 1st Year Fuel Cost= \$66,590
 1st Year O&M Cost= \$7,000

Present Value of Capital= \$143,000
 Present Value of Fuel= \$559,328
 Present Value of O&M= \$59,595

Annualized Capital Cost= \$21,289
 Annualized Fuel Cost= \$65,699
 Annualized O&M Cost= \$7,000

Results
(levelized constant 1984 dollars)

Levelized Capital Cost= \$0.032 /kWh or \$9.49 /MBtu 22.7%
 Levelized Fuel Cost= \$0.100 /kWh or \$29.30 /MBtu 69.9%
 Levelized O&M Cost= \$0.011 /kWh or \$3.12 /MBtu 7.4%
 Levelized Energy Cost= \$0.143 /kWh or \$41.92 /MBtu

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description				
Equipment Type:	Electric Furnace	Capacity Factor:	0.100	
Temperature:	4000 F	Efficiency:	0.550	
Fuel Type:	Electricity			
Cost and Financial Inputs (all costs are in 1984 dollars)				
Equipment Cost Inputs		Fuel Cost Inputs		
Capacity:	150 kWe	Unit Cost:	\$0.06 /kWh	
\$/Unit:	\$953 /kWe	Fuel Escalation:	-0.18 %/year	
O&M Cost Inputs		Financial Inputs		
Fixed O&M:	\$7,000	FCR:	0.149	
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117	
Calculations (all costs are in 1984 dollars)				
Capital Cost=	\$143,000			
1st Year Fuel Cost=	\$13,318			
1st Year O&M Cost=	\$7,000			
Present Value of Capital=	\$143,000			
Present Value of Fuel=	\$111,866			
Present Value of O&M=	\$59,595			
Annualized Capital Cost=	\$21,289			
Annualized Fuel Cost=	\$13,140			
Annualized O&M Cost=	\$7,000			
Results (levelized constant 1984 dollars)				
Levelized Capital Cost=	\$0.162 /kWh	or	\$47.47 /MBtu	51.4%
Levelized Fuel Cost=	\$0.100 /kWh	or	\$29.30 /MBtu	31.7%
Levelized O&M Cost=	\$0.053 /kWh	or	\$15.61 /MBtu	16.9%
Levelized Energy Cost=	\$0.315 /kWh	or	\$92.39 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description				
Equipment Type:	Electric Furnace	Capacity Factor:	0.300	
Temperature:	4000 F	Efficiency:	0.550	
Fuel Type:	Electricity			
Cost and Financial Inputs (all costs are in 1984 dollars)				
Equipment Cost Inputs		Fuel Cost Inputs		
Capacity:	150 kWe	Unit Cost:	\$0.06 /kWh	
\$/Unit:	\$953 /kWe	Fuel Escalation:	-0.18 %/year	
O&M Cost Inputs		Financial Inputs		
Fixed O&M:	\$7,000	FCR:	0.149	
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117	
Calculations (all costs are in 1984 dollars)				
Capital Cost=	\$143,000			
1st Year Fuel Cost=	\$39,954			
1st Year O&M Cost=	\$7,000			
Present Value of Capital=	\$143,000			
Present Value of Fuel=	\$335,597			
Present Value of O&M=	\$59,595			
Annualized Capital Cost=	\$21,289			
Annualized Fuel Cost=	\$39,419			
Annualized O&M Cost=	\$7,000			
Results (levelized constant 1984 dollars)				
Levelized Capital Cost=	\$0.054 /kWh	or	\$15.82 /MBtu	31.4%
Levelized Fuel Cost=	\$0.100 /kWh	or	\$29.30 /MBtu	58.2%
Levelized O&M Cost=	\$0.018 /kWh	or	\$5.20 /MBtu	10.3%
Levelized Energy Cost=	\$0.172 /kWh	or	\$50.33 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Electric Furnace	Capacity Factor:	0.700
Temperatures:	4000 F	Efficiency:	0.550
Fuel Type:	Electricity		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	150 kWe	Unit Cost:	\$0.06 /kWh
\$/Unit:	\$953 /kWe	Fuel Escalation:	-0.18 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$7,000	FCR:	0.149
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$143,000		
1st Year Fuel Cost=	\$93,226		
1st Year O&M Cost=	\$7,000		
Present Value of Capital=	\$143,000		
Present Value of Fuel=	\$783,060		
Present Value of O&M=	\$59,595		
Annualized Capital Cost=	\$21,289		
Annualized Fuel Cost=	\$91,978		
Annualized O&M Cost=	\$7,000		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.023 /kWh or	\$6.78 /MBtu	17.7%
Levelized Fuel Cost=	\$0.100 /kWh or	\$29.30 /MBtu	76.5%
Levelized O&M Cost=	\$0.008 /kWh or	\$2.23 /MBtu	5.8%
Levelized Energy Cost=	\$0.131 /kWh or	\$38.31 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Electric Furnace	Capacity Factor:	0.900
Temperatures:	4000 F	Efficiency:	0.550
Fuel Type:	Electricity		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	150 kWe	Unit Cost:	\$0.06 /kWh
\$/Unit:	\$953 /kWe	Fuel Escalation:	-0.18 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$7,000	FCR:	0.149
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$143,000		
1st Year Fuel Cost=	\$119,862		
1st Year O&M Cost=	\$7,000		
Present Value of Capital=	\$143,000		
Present Value of Fuel=	\$1,006,791		
Present Value of O&M=	\$59,595		
Annualized Capital Cost=	\$21,289		
Annualized Fuel Cost=	\$118,257		
Annualized O&M Cost=	\$7,000		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.018 /kWh or	\$5.27 /MBtu	14.5%
Levelized Fuel Cost=	\$0.100 /kWh or	\$29.30 /MBtu	80.7%
Levelized O&M Cost=	\$0.006 /kWh or	\$1.73 /MBtu	4.8%
Levelized Energy Cost=	\$0.124 /kWh or	\$36.31 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Electric Furnace	Capacity Factor:	0.500
Temperature:	4000 F	Efficiency:	0.500
Fuel Type:	Electricity		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity:	150 kWe
\$/Unit:	\$953 /kWe

Fuel Cost Inputs

Unit Cost:	\$0.06 /kWh
Fuel Escalation:	+0.18 %/year

O&M Cost Inputs

Fixed O&M:	\$7,000
Variable O&M Rate:	\$0.000 /kWh

Financial Inputs

FCR:	0.149
CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$143,000
1st Year Fuel Cost=	\$73,249
1st Year O&M Cost=	\$7,000

Present Value of Capital=	\$143,000
Present Value of Fuel=	\$615,261
Present Value of O&M=	\$59,595

Annualized Capital Cost=	\$21,289
Annualized Fuel Cost=	\$72,268
Annualized O&M Cost=	\$7,000

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.032 /kWh	or	\$9.49 /MBtu	21.2%
Levelized Fuel Cost=	\$0.110 /kWh	or	\$32.23 /MBtu	71.9%
Levelized O&M Cost=	\$0.011 /kWh	or	\$3.12 /MBtu	7.0%
Levelized Energy Cost=	\$0.153 /kWh	or	\$44.85 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Electric Furnace	Capacity Factor:	0.500
Temperature:	4000 F	Efficiency:	0.500
Fuel Type:	Electricity		

Cost and Financial Inputs
(all costs are in 1984 dollars)

Equipment Cost Inputs

Capacity:	150 kWe
\$/Unit:	\$953 /kWe

Fuel Cost Inputs

Unit Cost:	\$0.06 /kWh
Fuel Escalation:	+0.18 %/year

O&M Cost Inputs

Fixed O&M:	\$7,000
Variable O&M Rate:	\$0.000 /kWh

Financial Inputs

FCR:	0.149
CRF:	0.117

Calculations
(all costs are in 1984 dollars)

Capital Cost=	\$143,000
1st Year Fuel Cost=	\$61,041
1st Year O&M Cost=	\$7,000

Present Value of Capital=	\$143,000
Present Value of Fuel=	\$512,718
Present Value of O&M=	\$59,595

Annualized Capital Cost=	\$21,289
Annualized Fuel Cost=	\$60,224
Annualized O&M Cost=	\$7,000

Results
(levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.032 /kWh	or	\$9.49 /MBtu	24.1%
Levelized Fuel Cost=	\$0.092 /kWh	or	\$26.86 /MBtu	68.0%
Levelized O&M Cost=	\$0.011 /kWh	or	\$3.12 /MBtu	7.9%
Levelized Energy Cost=	\$0.135 /kWh	or	\$39.48 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Electric Furnace	Capacity Factor:	0.500
Temperature:	4000 F	Efficiency:	0.550
Fuel Type:	Electricity		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	150 kWe	Unit Cost:	\$0.06 /kWh
\$/Unit:	\$953 /kWe	Fuel Escalation:	-0.33 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$7,000	FCR:	0.149
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$143,000		
1st Year Fuel Cost=	\$65,498		
1st Year O&M Cost=	\$7,000		
Present Value of Capital=	\$143,000		
Present Value of Fuel=	\$544,033		
Present Value of O&M=	\$59,595		
Annualized Capital Cost=	\$21,289		
Annualized Fuel Cost=	\$63,902		
Annualized O&M Cost=	\$7,000		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.032 /kWh or	\$9.49 /MBtu	23.1%
Levelized Fuel Cost=	\$0.097 /kWh or	\$28.50 /MBtu	69.3%
Levelized O&M Cost=	\$0.011 /kWh or	\$3.12 /MBtu	7.6%
Levelized Energy Cost=	\$0.140 /kWh or	\$41.12 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description			
Equipment Type:	Electric Furnace	Capacity Factor:	0.500
Temperature:	4000 F	Efficiency:	0.550
Fuel Type:	Electricity		
Cost and Financial Inputs (all costs are in 1984 dollars)			
Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	150 kWe	Unit Cost:	\$0.06 /kWh
\$/Unit:	\$953 /kWe	Fuel Escalation:	-0.14 %/year
O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$7,000	FCR:	0.149
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117
Calculations (all costs are in 1984 dollars)			
Capital Cost=	\$143,000		
1st Year Fuel Cost=	\$66,884		
1st Year O&M Cost=	\$7,000		
Present Value of Capital=	\$143,000		
Present Value of Fuel=	\$563,481		
Present Value of O&M=	\$59,595		
Annualized Capital Cost=	\$21,289		
Annualized Fuel Cost=	\$66,186		
Annualized O&M Cost=	\$7,000		
Results (levelized constant 1984 dollars)			
Levelized Capital Cost=	\$0.032 /kWh or	\$9.49 /MBtu	22.5%
Levelized Fuel Cost=	\$0.101 /kWh or	\$29.52 /MBtu	70.1%
Levelized O&M Cost=	\$0.011 /kWh or	\$3.12 /MBtu	7.4%
Levelized Energy Cost=	\$0.144 /kWh or	\$42.14 /MBtu	

INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY

General System Description

Equipment Type:	Electric Furnace	Capacity Factor:	0.500
Temperature:	4000 F	Efficiency:	0.550
Fuel Type:	Electricity		

Cost and Financial Inputs (all costs are in 1984 dollars)

Equipment Cost Inputs		Fuel Cost Inputs	
Capacity:	150 kWe	Unit Cost:	\$0.05 /kWh
\$/Unit:	\$953 /kWe	Fuel Escalation:	2.26 %/year

O&M Cost Inputs		Financial Inputs	
Fixed O&M:	\$7,000	FCR:	0.149
Variable O&M Rate:	\$0.000 /kWh	CRF:	0.117

Calculations (all costs are in 1984 dollars)

Capital Cost=	\$143,000
1st Year Fuel Cost=	\$81,430
1st Year O&M Cost=	\$7,000

Present Value of Capital=	\$143,000
Present Value of Fuel=	\$825,800
Present Value of O&M=	\$59,595

Annualized Capital Cost=	\$21,289
Annualized Fuel Cost=	\$96,998
Annualized O&M Cost=	\$7,000

Results (levelized constant 1984 dollars)

Levelized Capital Cost=	\$0.032 /kWh or	\$9.49 /MBtu	17.0%
Levelized Fuel Cost=	\$0.148 /kWh or	\$43.26 /MBtu	77.4%
Levelized O&M Cost=	\$0.011 /kWh or	\$3.12 /MBtu	5.6%
Levelized Energy Cost=	\$0.191 /kWh or	\$55.88 /MBtu	

APPENDIX B

IPHLEC SPREADSHEET LISTING

B1: 'INDUSTRIAL PROCESS HEAT LEVELIZED ENERGY COST SUMMARY
 A2: '-----
 B2: '-----
 C2: '-----
 D2: '-----
 E2: '-----
 F2: '-----
 G2: '-----
 H2: '-----
 C3: ' General System Description
 A5: 'Equipment Type:
 C5: 'Furnace
 E5: 'Capacity Factor:
 G5: (F3) 0.5
 A6: 'Temperature:
 C6: '850 F
 E6: 'Efficiency:
 G6: (F3) 0.99
 A7: 'Fuel Type:
 C7: 'Oil
 A8: '-----
 B8: '-----
 C8: '-----
 D8: '-----
 E8: '-----
 F8: '-----
 G8: '-----
 H8: '-----
 C9: ' Cost and Financial Inputs
 C10: '(all costs are in 1984 dollars)
 A12: 'Equipment Cost Inputs
 E12: 'Fuel Cost Inputs
 A14: 'Capacity:
 B14: (F0) 70
 C14: 'MBtu/hr
 E14: 'Unit Cost:
 G14: (C2) 4.35
 H14: '/MBtu
 A15: '\$/Unit:
 B15: (C0) 3157.14
 C15: '/MBtu/hr
 E15: 'Fuel Escalation:
 G15: (F2) 2.92
 H15: '%/year
 A18: 'O&M Cost Inputs
 F18: 'Financial Inputs
 A20: 'Fixed O&M:
 C20: (C0) 3094
 F20: 'FCR:
 G20: (F3) 0.148875688
 A21: 'Variable O&M Rates:
 C21: (C3) 0
 D21: 'Per MBtu
 F21: 'CRF:
 G21: (F3) 0.117459625
 A22: '-----

```

B22: '-----
C22: '-----
D22: '-----
E22: '-----
F22: '-----
G22: '-----
H22: '-----
D23: 'Calculations
C24: '(all costs are in 1984 dollars)
A26: 'Capital Cost=
D26: (C0) +B14*B15
A27: '1st Year Fuel Cost=
D27: (C0) +B14*8760*G5*(1+G15/100)^11/G6*B14
A28: '1st Year O&M Cost=
D28: (C0) +C20+C21*B14*8760*G5
A30: 'Present Value of Capital=
D30: (C0) +D26
A31: 'Present Value of Fuel=
D31: (C0) *(1+G15/100)/((+0.1-G15/100)*D27*(+1-((+1+G15/100)/1.1)^20)
A32: 'Present Value of O&M=
D32: (C0) +D28*8.513563717
A34: 'Annualized Capital Cost=
D34: (C0) +D30*G20
A35: 'Annualized Fuel Cost=
D35: (C0) +D31*G21
A36: 'Annualized O&M Cost=
D36: (C0) +D32*G21
A37: '-----
B37: '-----
C37: '-----
D37: '-----
E37: '-----
F37: '-----
G37: '-----
H37: '-----
D38: '    Results
C39: '(levelized constant 1984 dollars)
A41: 'Levelized Capital Cost=
D41: (C2) +D34/(B14*8760*G5)
E41: '/MBtu
F41: (P1) +D41/D45
A42: 'Levelized Fuel Cost=
D42: (C2) +D35/(B14*8760*G5)
E42: '/MBtu
F42: (P1) +D42/D45
A43: 'Levelized O&M Cost=
D43: (C2) +D36/(B14*8760*G5)
E43: '/MBtu
F43: (P1) +D43/D45
A45: 'Levelized Energy Cost=
D45: (C2) +(D34+D35+D36)/(+B14*8760*G5)
E45: '/MBtu

```

APPENDIX C

LEVELIZED ENERGY COST EQUATIONS

The levelized energy cost (LEC) methodology developed for IPHLEC and used in this study was derived directly from basic equations presented in The Cost of Energy From Utility-Owned Solar Electric Systems (Doane 1976). This appendix documents the development of the LEC equations from the equations presented in Doane (1976).

$$\text{Capital Recovery Factor (CRF)} = k/[1-(1+k)^{-n}] \quad (\text{Doane, p. III-9})$$

$$k = \text{discount rate} = 10\%$$

$$n = \text{plant economic life} = 20 \text{ years}$$

$$\text{CRF} = 0.11746$$

$$\text{Fixed Charge Rate (FCR)} = \{\text{CRF}[1-t(\text{DPF})-\text{ITC}]/[1-t]\} + B \quad (\text{Doane, p. E-4})$$

$$t = \text{marginal income tax rate} = 50\%$$

$$\text{DPF} = \text{depreciation factor} = 0.61868$$

$$\text{ITC} = \text{investment tax credit} = 10\%$$

$$B = \text{property and other taxes} = 1\%$$

$$\text{FCR} = 0.14888$$

The depreciation factor is the present value of future depreciation credits, expressed as a fraction of initial capital. This fraction was calculated based on the Accelerated Cost Recovery System (ACRS) five year property tables. The calculation is summarized below. Depreciation credits are specified in nominal terms by the ACRS tables for each year of depreciable life. The nominal dollar credits are first deflated by an assumed inflation rate of 5% per year to convert them to real dollar credits. The present value of the year by year real dollar depreciation credits is then calculated by discounting each credit by 10% per year. The total present value of real dollar tax credits is reduced by an additional 5% according to tax laws governing ACRS depreciation.

<u>YEAR</u>	<u>NOMINAL ACRS</u> <u>CREDIT</u>	<u>REAL ACRS</u> <u>CREDIT</u>	<u>PRESENT VALUE</u> <u>OF CREDIT</u>
1	0.15	.14285	.12987
2	0.22	.19955	.16491
3	0.21	.18141	.13629
4	0.21	.17277	.11800
85	0.21	.16454	.10217
		<u>TOTAL</u>	.65125
		<u>ADJUSTED TOTAL</u>	.61868

Present Value of Capital Investment (CIPV) =

$$(1+g_c)^p \sum_t \{CI_t [(1+g_c)/(1+k)]^j\} \quad (\text{Doane, p. III-11})$$

g_c = real capital escalation rate - 0 %

p = first year of commercial operation
(1995) minus the price year (1984) = 11

CI_t = capital investment in year t

j = year of capital investment (1994)
minus first year of commercial
operation (1995) plus one = 0

$$CIPV = CI_{1994}$$

Present Value of O&M (OMPV) =

$$(1+g_{om})^p OM_0 ((1+g_{om})/(k-g_{om})) [1 - ((1+g_{om})/(1+k))^n]$$

(Doane, p. III-12)

g_{om} = real O&M escalation rate + 0%

OM_0 = annual O&M cost in price year
(1984) dollars

$$OMPV = 8.51356 OM_0$$

Present Value of Fuel (FLPV) =

$$(1+g_{f1})^p FL_0 ((1+g_{f1})/(k-g_{f1})) [1 - ((1+g_{f1})/(1+k))^n]$$

(Doane, p. III-12)

g_{f1} = real fuel escalation rate

FL_0 = annual fuel cost in price year

(1984) dollars

$$FLPV = (1+g_{f1})^{11} FL_0 \left(\frac{(1+g_{f1})}{(0.1-g_{f1})} \right) \left[1 - \left(\frac{(1+g_{f1})}{(1.1)} \right)^{20} \right]$$

$$\text{Annualized Capital Cost (ACC)} = (FCR)(CIPV)$$

$$\text{Annualized O\&M Cost (AOMC)} = (CRF)(OMPV)$$

$$\text{Annualized Fuel Cost (AFC)} = (CRF)(FLPV)$$

$$\text{Levelized Capital Cost (LCC)} = \text{ACC}/\text{annual energy output}$$

$$\text{Levelized O\&M Cost (LOMC)} = \text{AOMC}/\text{annual energy output}$$

$$\text{Levelized Fuel Cost (LFC)} = \text{AFC}/\text{annual energy output}$$

$$\text{Annual Energy Output} = \text{system capacity (MMBtu/hr or kW)} \times \text{times}$$

$$8760 \text{ hours per year} \times \text{system capacity factor}$$

$$\text{Levelized Energy Cost} = \text{LCC} + \text{LOMC} + \text{LFC}$$

APPENDIX D

COMPARING SOLAR THERMAL VALUE WITH ITS COST

This study has estimated the value of industrial process heat for varying combinations of technology, application temperature, fuel type, thermal efficiency, capacity factor, initial fuel cost, and fuel escalation rate. The usefulness of this information will be greatly enhanced once the cost of producing solar thermal IPH is estimated and compared with its value. This appendix establishes some ground rules which should govern the comparison.

An equitable comparison of dollar costs must be based on providing a comparable service and must be calculated based on identical system level characteristics and financial modeling assumptions. Comparable service involves quality and system boundary issues which were discussed in Section 2.0. A solar thermal system should include the necessary equipment to produce an IPH medium of identical or nearly identical characteristics for comparison with steam boilers and combustion furnaces. For comparison with an electric furnace, the solar thermal system should include the necessary equipment to produce an identical or nearly identical application of heat.

Concentrator, receiver, transport, steam generator, and solar- related balance-of-plant equipment would be required for the boiler system comparison. Storage would also be required for each solar thermal system except for comparisons at lower capacity factors. Combustion furnace comparisons would require the same equipment as for steam boilers, minus the steam generator. Electric furnace comparisons would require an end-use energy application heat exchanger in place of the steam generator.

The appropriate value of solar thermal energy to be used for comparison with its estimated cost of production depends on the nature of the specific application being investigated. If some combination of solar thermal storage and/or flexibility in the timing of plant operations precludes the necessity of having a fossil-fired backup for the solar system, then the cost of solar thermal IPH should be compared to the full cost (capital + O&M + fuel) of the conventional system. However, if the application dictates that a fossil-fired backup would be required for the solar thermal system, then the cost of solar thermal IPH should be compared to cost of the fuel and variable O&M components of the conventional system.

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