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INDUSTRIAL INTERFUEL SUBSTITUTION
PHASE I REPORT:

MODEL DEVELOPMENT AND CASE STUDY
EXECUTIVE SUMMARY

Energy Systems Group*

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EXECUTIVE SUMMARY

INDUSTRIAL INTERFUEL SUBSTITUTION PHASE I REPORT

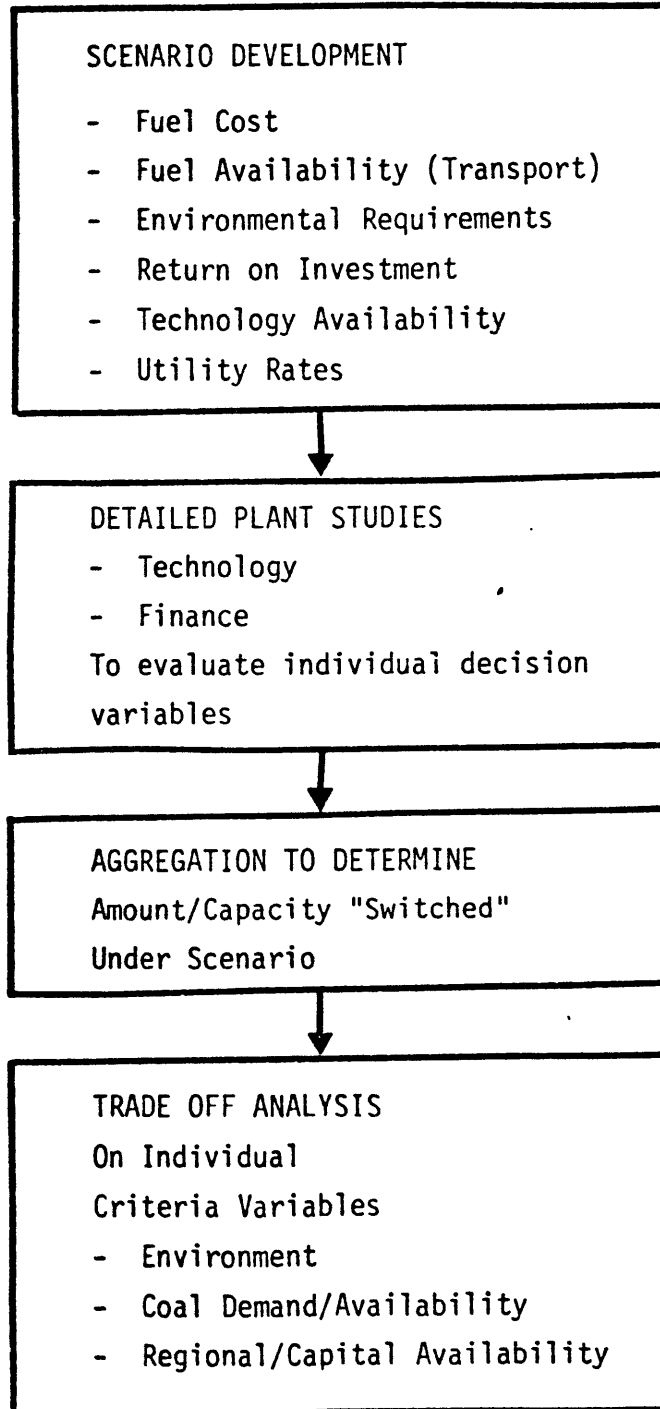
Model Development and Case Study Executive Summary

Coal played a major role as both an industrial and utility boiler fuel until the 1950s. The decades of the fifties and sixties saw a dramatic decline in coal as a boiler fuel in industry and in utilities because of the relatively lower cost of oil and the concern for environmental quality associated with coal combustion. The decade of the seventies began with a major change in the relative economics of coal, oil, and natural gas. Oil became expensive and occasionally scarce; natural gas because of curtailments became, for some industries, an intermittent energy source; coal was again looked to as a fuel for utilities and for industry. The change from oil-based fuels to coal-based fuels in the industrial sector has not, however, proceeded as rapidly as expected through the seventies and early eighties. The supply systems are no longer in place in many regions and the scarcity of capital provides an impediment to switching.

The purpose of the study reported here is to develop a set of tools for evaluation of the potential for industrial interfuel substitution, most specifically in boiler fuels from oil to coal. A new approach to the evaluation of regional interfuels analysis has been developed which builds upon detailed, plant-specific energy economic analyses; these are then aggregated to the industry and finally to the regional level. It is important to note that the tools and the basic theoretical structures are not all new. Existing tools are used in new ways which allow decision makers both in industry and government to evaluate better specific strategic fuels options. Figure 1 shows the flow of research studies in

FIGURE 1

REGIONAL ANALYSIS



the regional analysis. It includes evaluation of scenarios for fuel cost, fuel availability, environmental requirements, technologies availability, and economic parameters. These are evaluated in detailed plant studies which are then aggregated to the regional level at which a series of trade-off analyses between attributes can be carried out to evaluate the possible market for coal or the regional economic and environmental impact of significant coal conversion.

The tools developed in Phase I of this activity have included planning/analysis models of fuel use including, significantly, cogeneration. They also include economic/financial models at the plant level as well as a set of data bases for combustion and cogeneration technologies. Finally, as was indicated above, a framework for industry aggregation has been developed. Regional impacts are evaluated using an EPA approved air quality modeling structure modified for this effort and regional and transport impacts can be evaluated for the region given knowledge of fuel demands. Each of these components is discussed in greater detail in the main report which follows.

The results of the Phase I activity have been of two types. The first type, the testing of the individual components of the model and pairs of the models run together was performed, successfully. The modeling structures function as designed and are now available for use in and further effort for evaluation of interfuel substitution potential for industry in a specific region. The second set of results from the Phase I activity was the development of a set of general conclusions or screening criteria concerning the possibilities for interfuel substitution, specifically coal for oil, within a given region. These form a pre-screening set of criteria and are discussed here in summary

form only. Chapter 4 of the report which follows discusses in greater detail each of the general conclusions put forth at this time.

The conclusions are presented in a hierarchical fashion; the decision for an industry to move to an alternative fuel can be depicted as a set of sequential steps. The discussion which follows attempts to capture the major points associated with those steps.

In all considerations of the potential for fuel switching from coal to oil the first set of criteria are at a macro level.

- o The industry must be located in a region where it is environmentally feasible to burn coal.
- o The industry must be located in a region where coal supplies are available at a reasonable cost with high reliability.
- o Related to the individual industry, if the facility is existent and the decision is to switch from oil to coal, storage capacity for coal must be available on site.

The decision on a plant-by-plant basis then is made on the following criteria. Given commercially available technology for fossil fuel combustion,

1. For thermal loads greater than 500×10^6 Btu/hr

Coal steam raising dominates oil

2. In the range of $100 - 500 \times 10^6$ Btu/hr the following favor coal over oil:

Greater size

Greater absolute cost differential between oil and coal

Lower capital investment

Lower discount rate

Greater load factor

Having evaluated the potential for coal as a fuel, it is possible to evaluate the economic viability of coal cogeneration. Two general conclusions can be drawn concerning coal-fired cogeneration.

- o If coal is a feasible and economic option within an industry, cogeneration will increase the attractiveness of the investment.
- o If cogeneration is chosen, increased economic advantage is gained from raising steam at high temperature and pressure.

These conclusions are drawn from the extensive discussion in Chapter 4 and Appendix B to the main report.

The curves of on Figures 2 and 3 present the minimum difference between coal and oil fuel costs necessary to reach a break even point between oil and coal systems on a before-tax basis. These figures show how this relationship changes as a function of size, load factor and discount rates. Cogenerated electricity has been priced at electric utilities coal-fired plants fuel avoided costs.

The report also covers briefly a potential way for assessing the economic viability of coal in a modified form such as coal water slurries. Given the possibility of a coal-based liquid substitute for residual oil that can be burned in an existing, modified oil boiler, the conclusions above concerning coal boilers will obviously hold. The size threshold for economic viability will be significantly reduced in each of the above categories. Those factors which have the largest impact on the relative economics of a coal-based liquid substitute are the following:

- o The absolute cost differential between oil and the coal-based liquid substitute
- o Capital cost of boiler retrofit
- o Boiler derating and consequently

FIGURE 2
OIL/COAL FUEL COST DIFFERENTIAL

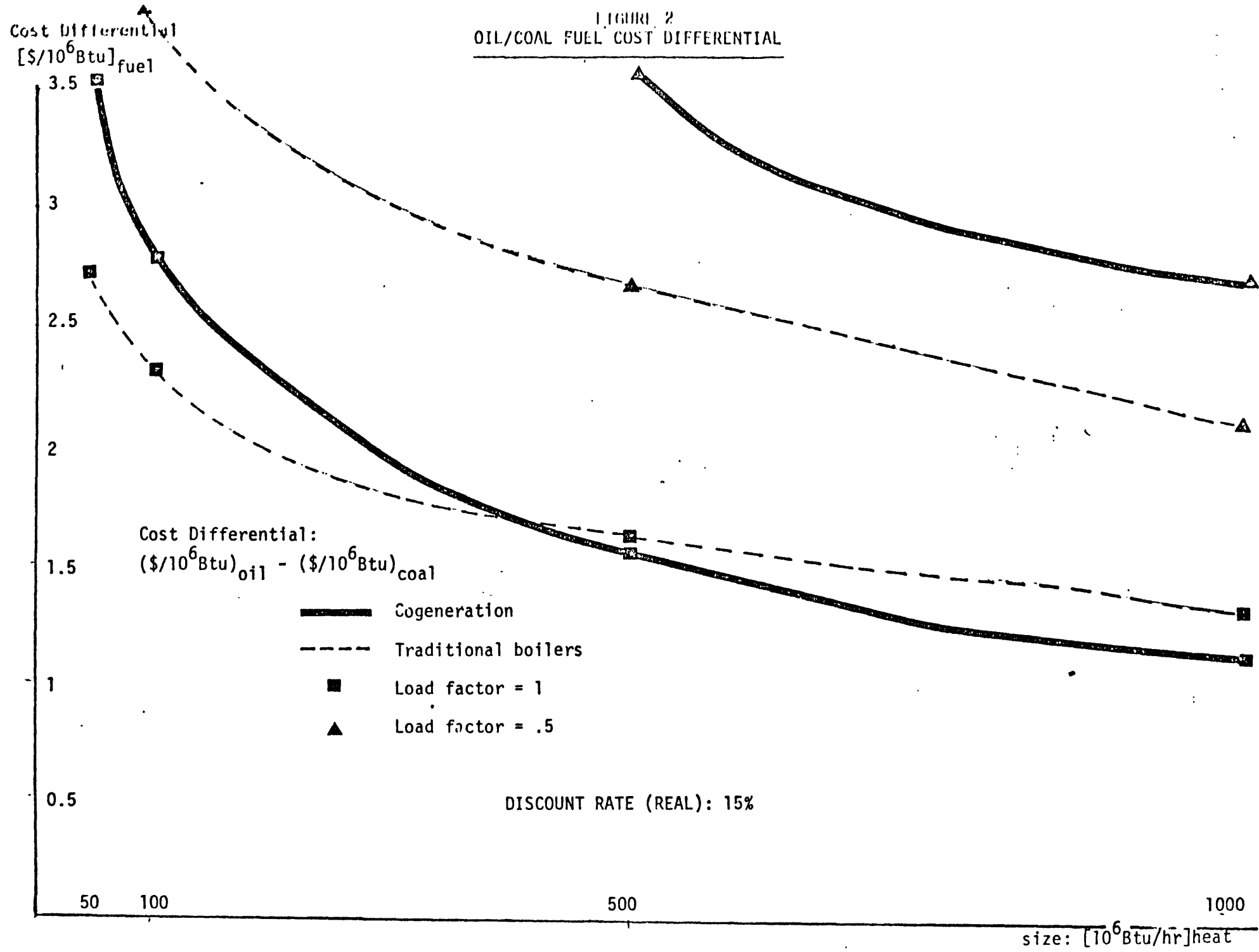
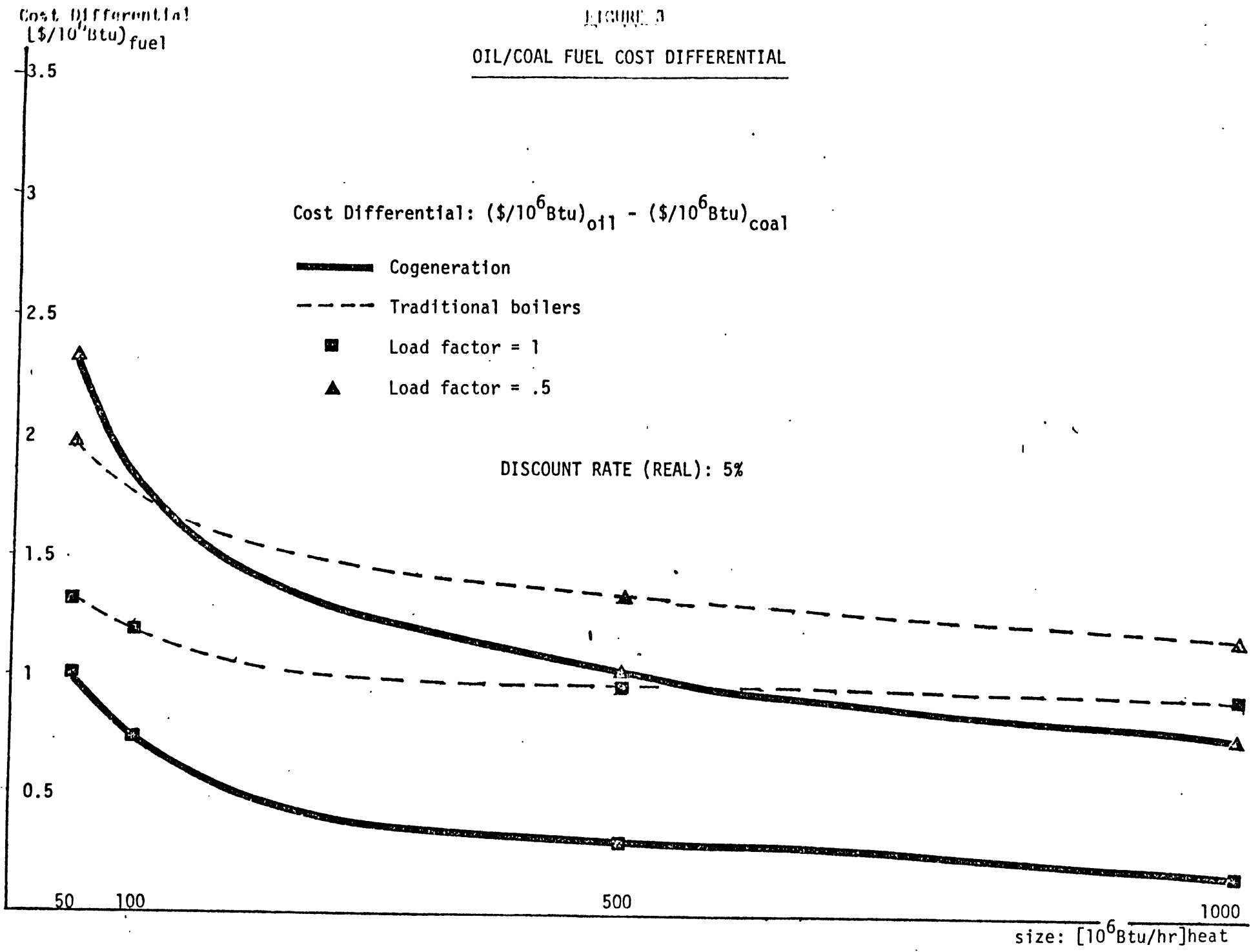


FIGURE 3

OIL/COAL FUEL COST DIFFERENTIAL



- o Additional (new) boilers to be put on line.

To a much lesser extent due to the (expected) low capital intensity of the process steam cost, the following two considerations might be of some relevance:

- o size of the boiler system
- o the load factor of the systems.

The conclusions listed above have been derived from the work of this project. They are general in nature and as a result subject to the rule of exception. For every conclusion stated, we have been able to identify at least one situation in which it does not hold. This aside, however, we have found that the overall conclusions are of considerable value in summarizing the potential for interfuel substitution. Most simply stated, large installations with high load factors have positive economic potential for interfuel substitution inasmuch as those are the best conditions for capital intensive systems, with large economies of scale. Relative economics declines with size and load factor. In these cases, if coal is attractive as a boiler fuel option, cogeneration using coal will also be attractive and will add to the total net present value of the investment; the more, the higher the value assigned to cogenerated electricity and the higher the power installed per unit process heat; it will however always break even if cogenerated electricity is valued at electric utilities coal-fired plants fuel costs. Cogeneration will not make a difference between an unattractive coal investment and one that becomes economically attractive, except in medium size systems, unless electricity is priced higher than coal-fired plants fuel cost.

Finally, in Figure 4, the economic viability of a physically derived coal-based liquid substitute for residual oil, to be burned in

retrofitted oil boilers, can be evaluated as a function of that fuel cost differential with respect to oil, assuming a retrofit cost and a boiler derating factor.

In conclusion, the Phase I report which follows has developed a set of compatible analytic tools for use in a regional interfuel substitution activity, the regional analysis being started at a plant level and then aggregated. The modeling systems developed have been successfully tested both individually and as a whole. The next phase will be to take modeling and aggregation structures into the field to apply them in a given region to test their generalizability and to test their basic underlying conclusions discussed above, as well as to test the effectiveness of the pre-screening curves developed.

FIGURE 4

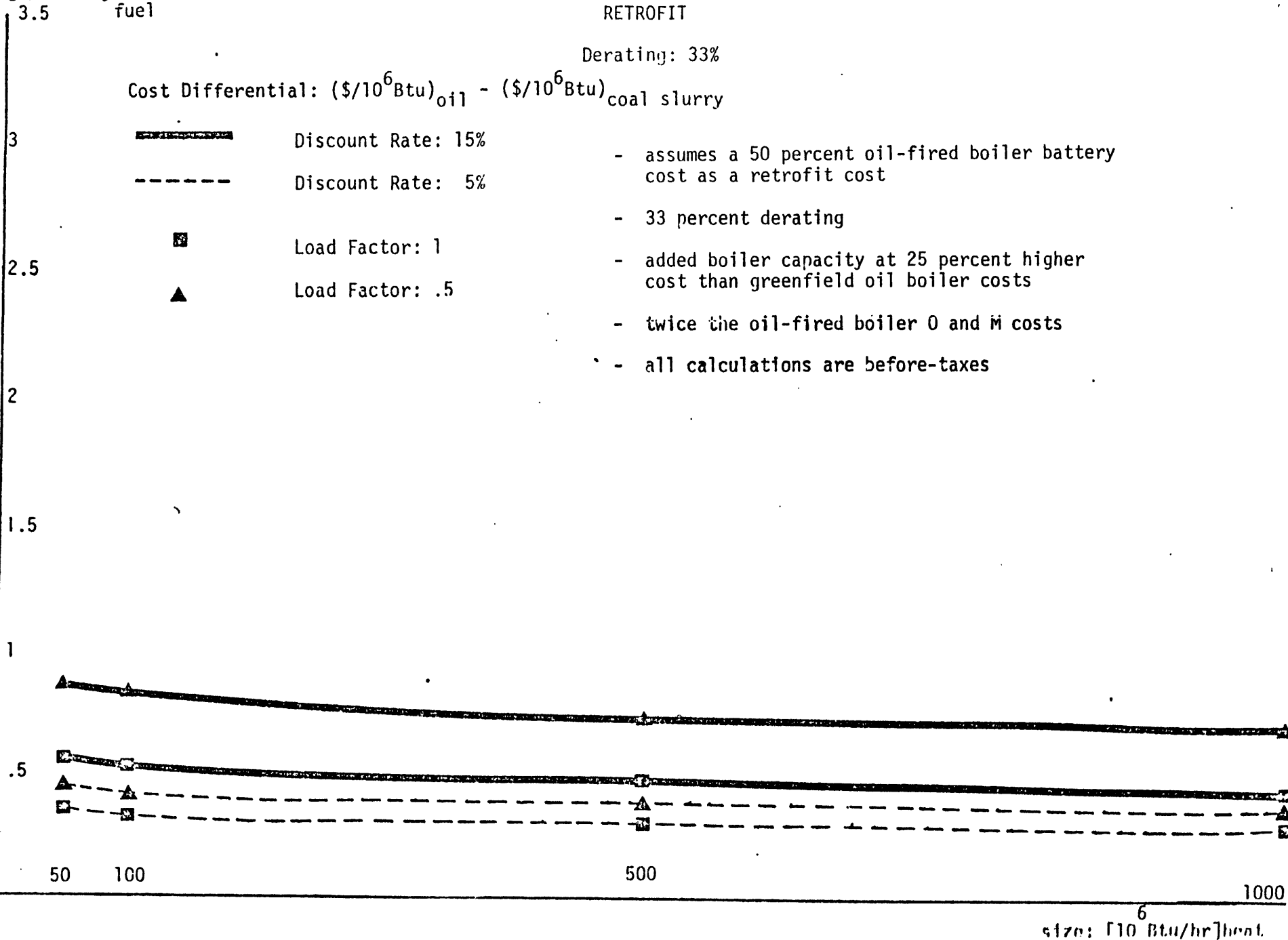
Cost Differential

[\$/10⁶ Btu)

OIL/PHYSICALLY OBTAINED COAL BASED RESIDUAL OIL SUBSTITUTE FUEL COST DIFFERENCE
RETROFIT

Derating: 33%

Cost Differential: $(\$/10^6 \text{ Btu})_{\text{oil}} - (\$/10^6 \text{ Btu})_{\text{coal slurry}}$



- assumes a 50 percent oil-fired boiler battery cost as a retrofit cost
- 33 percent derating
- added boiler capacity at 25 percent higher cost than greenfield oil boiler costs
- twice the oil-fired boiler O and M costs
- all calculations are before-taxes

size: [10⁶ Btu/hr] heat