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INDUSTRIAL ENERGY CONSERVATION

GOVERNMENT AND INDUSTRIAL PERSPECTIVES

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I. GOVERNMENT AND INDUSTRIAL PERSPECTIVES

Up until the last year or two, the attitude of most individual plant operators as well as government officials in developing countries toward industrial energy conservation could be described as ranging from no interest to suspicious. This stemmed in part from some basic confusions surrounding the term "energy conservation." When interpreted as simple curtailment of energy use or cutbacks in the services and amenities derived from the use of energy, industrial energy conservation was regarded as insidious propaganda (some said propagated by the advanced industrial countries) for cutting back on the place of economic development and, in particular, industrial development. Even when interpreted as improvements in the efficiency of energy end-use consumption and the utilization of more plentiful indigenous energy resources, conservation still meant to many decision-makers an abandonment of the traditional commitment to insuring increased availability and access to a variety of affordable energy forms which would be obtained in most developing countries by enlarging centralized energy supply operations. Demonstration of these negative attitudes toward energy conservation was evident in the disdain and suspicion expressed by a number of representatives from developing countries at the World Energy Conferences of 1977 and 1978. Much more significant than these expressions were the economic responses of the industrial energy consumers in developing countries, independent of whether their ownership was held by the government or the private companies. In the period between 1973 and 1979, these organizations took few steps to implement changes in their patterns of energy consumption and fuel utilization. Instead, during this period they elected to pass along fuel price

increases of petroleum products and electricity as increases in the production cost of their products.

The sharp oil price increases of '79- 80, combined with a steady deterioration in the reliability of electricity supply in many developing countries and, in some cases uncertainty in the security of imported oil supplies, contributed to a major reappraisal of industrial energy conservation on the part of both government and owners and managers of primary industries consuming substantial amounts of energy. Increased attention turned to the specific technical interventions associated with improving both the financial and engineering management of electricity and other petroleum based fuels used in industrial production. Energy management practices in energy-intensive industries is now seen (by managers and owners) as complementing rather than competing with supply enhancement. Encouraged by the World Bank, governments have come to regard industrial energy management as a key element in designing a comprehensive national energy policy.

From a government perspective, improved energy management in industry has the following advantages:

1. Energy savings leading to a drop in oil imports, or at least a lowered rate of increase, can be achieved in 1-5 years as opposed to the 4-10 years in converting the production of electricity to the use of coal or hydro, or exploiting new conventional and unconventional resources.

2. The capital investments required are, in general, not as extensive as comparable investments in supply enhancement. And often the associated foreign currency requirements may not be significant, particularly in the cases where improved housekeeping operations or selective replacement of equipment is involved.

3. Industrial output can be more easily maintained and even expanded in key energy intensive industries such as cement, metal processing, and mining essential to the economy in the face of increased energy prices and diminished reliability of supplies of electricity and other energy fuels.

4. Investments in measures to improve energy efficiency or increased industrial use of indigenous fuel has been shown in some studies to lead to the generation of more local employment than equivalent supply options.

5. Industrial energy management measures can lead in the long term to a reduced income elasticity of energy supply in the industrial sector of the economy and free scarce capital and technical resources for other infrastructure development.

But not all of these public benefits translate into private benefits for individual industries or plant operation. The extent to which industries will take actions consistent with these public benefits will depend on the presence or absence of a number of factors including:

1. the final prices charged to industry for different energy fuels and electricity
2. the reliability of energy supplies and electricity on a day-to-day basis
3. intermediate and long-term security of imported as well as domestic energy supplies
4. the presence of mandatory controls affecting industrial energy consumption practices
5. the cost and availability of outside capital for investment in improved energy management
6. the accessibility of industry to energy management technologies and technical information
7. the presence of administered prices for industrial output, and finally,
8. the presence of an historical structure of import substitution-related government subsidies.

While it is true that within the economies in most developing countries industries do not operate in anything like a free markert atmosphere, if there is a substantial divergence between benefits derived to the public sector and benefits that accrue to the industrial sector, the responsiveness of industrial managers and owners in support of the public benefits will develop at a relatively slow pace, and even then only in the presence of con-

siderable prodding by government agencies. In discussing the economics of industrial energy conservation it is well to openly recognize this divergence between public and private benefits.

Judged from the perspective of the owner or managers of individual enterprises, financial investment in energy conservation represents an allocation of capital surplus and/or credits both of which are generally held in short supply. The overall rationalization for such investments is to be found in their ability to insulate industrial production from uncertainties in future prices and reliability of energy. Regarding the first point, the prospect of sharp and unpredictable increases in energy prices makes it difficult to plan future industrial operation efficiently. As to the second, the effect of sudden blackouts of electricity and cut-offs in other fuel supplies is to leave valuable equipment and employees underutilized. Even so one must keep in mind that the effect of all these investments represents, insofar as industry is conserned, an attempt to return to a past status quo, a situation in which reliable supplies of energy were available at predictable prices. Thus the primary motivation for industrial energy management in the minds of industrial managers and owners is basically protectionist in nature. The more narrowly focused nature of these microeconomic benefits can and will lead to priorities in energy conservation somewhat different from that of government.

II. INVESTMENT ANALYSIS OF AN INDUSTRIAL PROCESS HEAT RECOVERY SYSTEM

In order to illustrate the calculation of the economic feasibility of investment in an industrial process heat recovery system in a developing country, a case was chosen for a brewery. Most of the countries in the world produce beer; an even larger number have general food and beverage processing needs which require cooking and pasteurization. Because of the widespread need for such processing, we felt that an industrial process heat recuperator retrofit to a developing country brewery would be a representative example. We have tried to use reasonable estimates of the factors which determine the rate of return on such an investment. The internal rate of return (IRR) and its sensitivity to various changes in the important financial and economic factors is calculated. In this analysis, financial conditions characteristic of developing countries were used. The impact on the IRR of changes in corporate tax rate, depreciation period, investment tax credit, operation, maintenance, tax and insurance costs, fuel price escalation rate, percent equity, fuel cost, debt interest rate, system cost, and system life were examined.

In our example, total annual energy consumption is 9200 barrels of oil, or 55000 GJ. The firing of production processes is about 65% efficient over, and the thermal energy delivered is 36000 GJ. About half this energy is for pastuerization at 65°C, and the remainder for cooking, washing, and other operations. The brewery plant produces 14 million cases of beer annually.

Waste heat recovery systems at a number of points in the plant can be considered. The heat recuperators can capture about 50% of waste heat and cycle this back for preheating. The estimated capital cost of recuperators,

plumbing, electronic controls for a plant-wide installation is $380,000 (1981 US dollars), a system which would recover 4500 GJ of thermal energy. At 65% efficiency, the annual fuel savings is 6900 GJ. In the analysis, we assume a delivered domestic oil price to the industrial customer of $60 per barrel. With the parameters specified above, the annual fuel savings is 12% of total plant requirements and is valued at $69,300. The interest rate of return computed below also depends upon the finance and other economic characteristics of the waste heat recovery system.

The financial and economic parameters for our analysis are shown in Table 1. The capital cost is based on experience with similar heat recovery systems in the United States and elsewhere. Financing terms, inflation rate, industrial marginal tax rate, and other finance parameters are typical of the present economic climate provided for industrial investment in developing countries.

The particular combination of technical, economic, and financial conditions for this waste heat recovery system investment yields an internal rate of return (IRR) of 17%. However, equally important to decisions upon investment is the variation in this rate of return with changes in the technical, economic, and financial factors, particularly factors such as investment tax credits which may be used as instruments of government policy to encourage industrial investments for improved efficiency of energy utilization.

The sensitivity of internal rate of return to the economic and financial parameters specified above is an important factor, especially in our later discussion of public and private benefit of industrial energy management. Roughly listed in order of importance of impact upon the internal rate of

Table 1

ECONOMIC AND FINANCIAL PARAMETERS

FOR INDUSTRIAL WASTE HEAT RECOVERY

Parameter	Value
System	
Capital Cost	$380,000
System Life	15 years
Cash Flow - Year One	$69,300
Cash Flow Escalation Rate	11%
Operating and Maintenance	4% of capital cost
Operating and Maintenance Escalation Rate	8% (equal to inflation rate)
Investment	
Percent Equity	50%
Debt Interest Rate	20% annually
Investment Life	20 years
Depreciation	
Method	Straight line
Percent Initial Investment Allowed	100%
Salvage Value	None
Depreciation Life	7 years
Industrial Taxes	
Marginal Tax Rate	44%
Investment Tax Credit	10%
Analysis	
Method	Conventional cash flow (no sinking fund).
Internal Rate of Return	17%

return, we examine sensitivity to system capital cost, prevailing domestic fuel price, investment tax credit for improved energy efficiency, life of the investment, debt interest rate and percent equity, oil price escalation, operating and maintenance charge, and depreciation period.

The impact of changes in the capital cost on the IRR is substantial (Figure 1). The same is clearly true for the dependence of the IRR on the fuel costs (Figure 2). Since fuel costs will continue to rise over the long term, the competitive position of waste heat recovery will improve. Figure 3 demonstrates the importance of the investment tax credit as a mechanism for encouraging investment in improved industrial energy utilization. Increasing the presently effective investment tax credit from 10 percent to 30 percent for industrial conservation equipment would, in this example, increase the IRR from 17 percent to 28 percent, substantially increase the attractiveness of such an investment. Figure 4 shows the impact of assumed system life on the IRR. The importance of this parameter is clear. If investors decide that a maximum of ten years system life can be used, the IRR will be less attractive than if a longer life is assumed. For industrial heat recuperators, presently available hardware can last twenty years or more, but a somewhat more conservative assumption (15 years) has been used in this analysis. Figure 5 indicates the impact of a change in the debt interest rate on industrial energy technology investments. Establishing a lower effective interest rate (in essence an energy conservation subsidy) would increase the IRR. In this example, lowering the interest rate from about 20 percent to 10 percent would increase the IRR from 17 percent to 22 percent. Figure 6 indicates the dependence of the IRR on the degree of equity financing. For debt/equity ratios below 50 percent the IRR does not vary much with increased equity. Figure 7 demonstrates for this particular

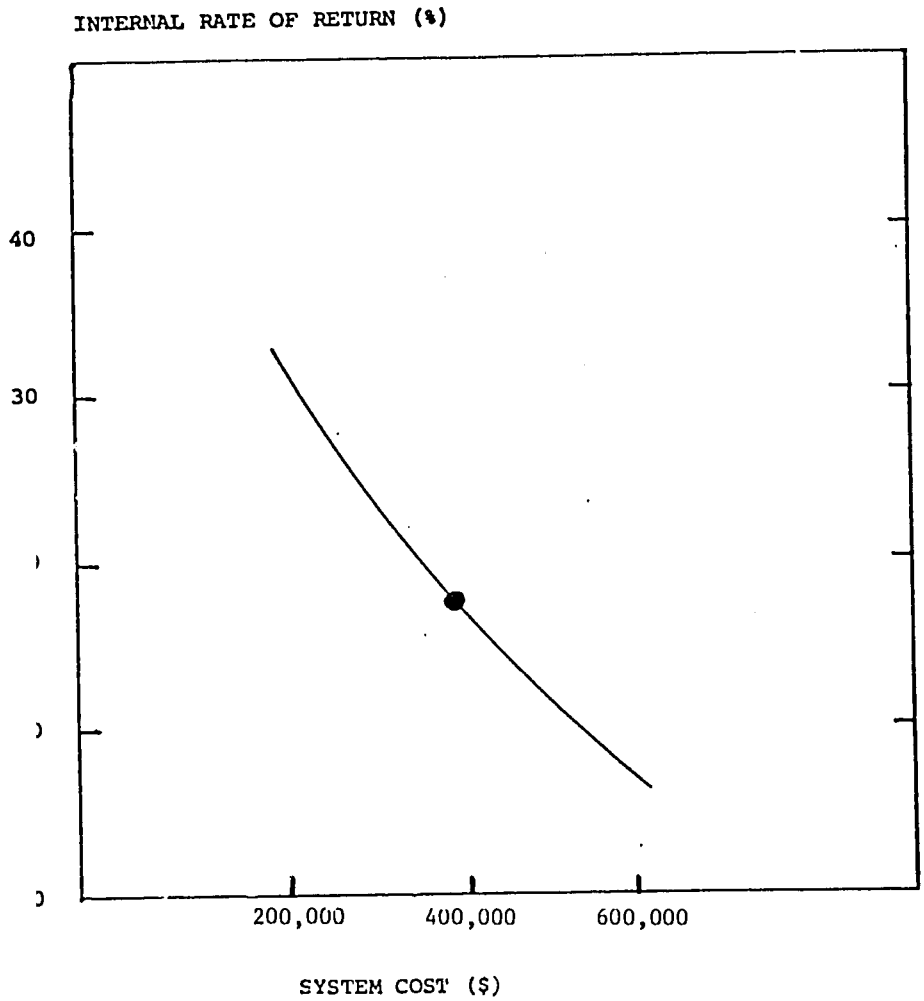


Figure 1. Internal Rate of Return as a Function of System Cost
Industrial Process Heat Case Example.

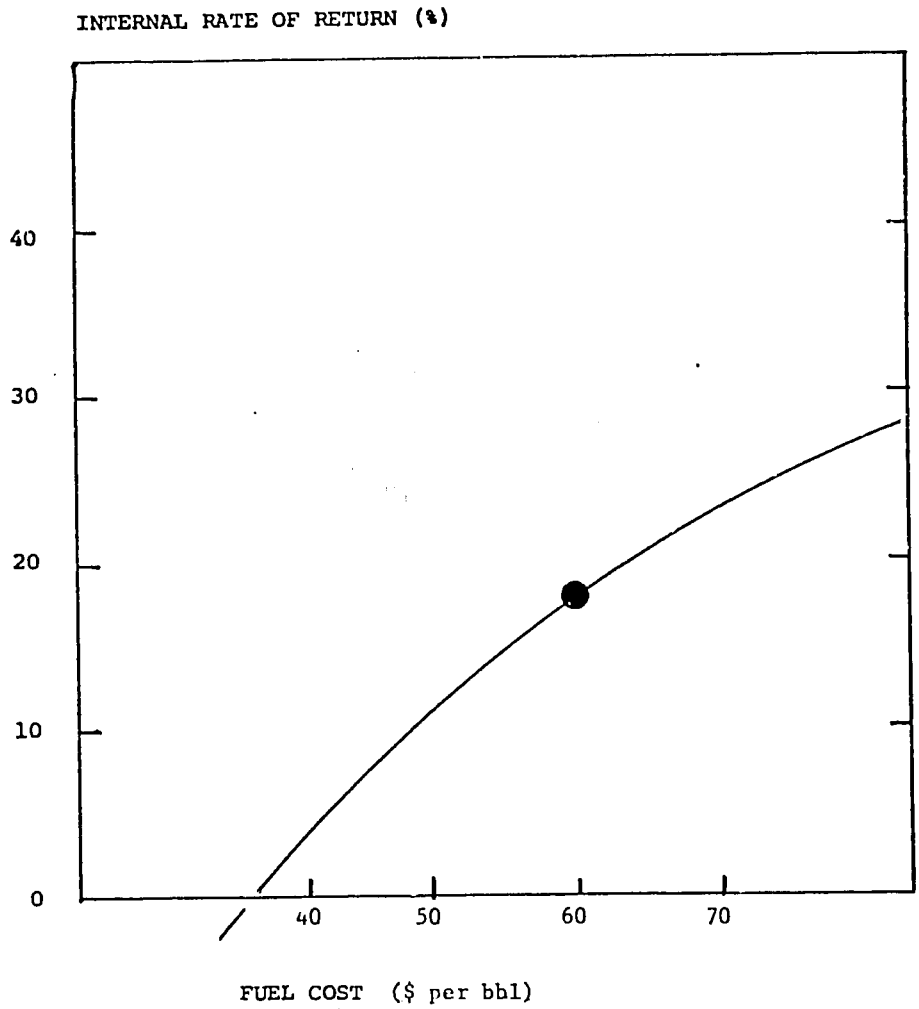


Figure 2. Internal Rate of Return as a Function of Fuel Cost
Industrial Process Heat Case Example.

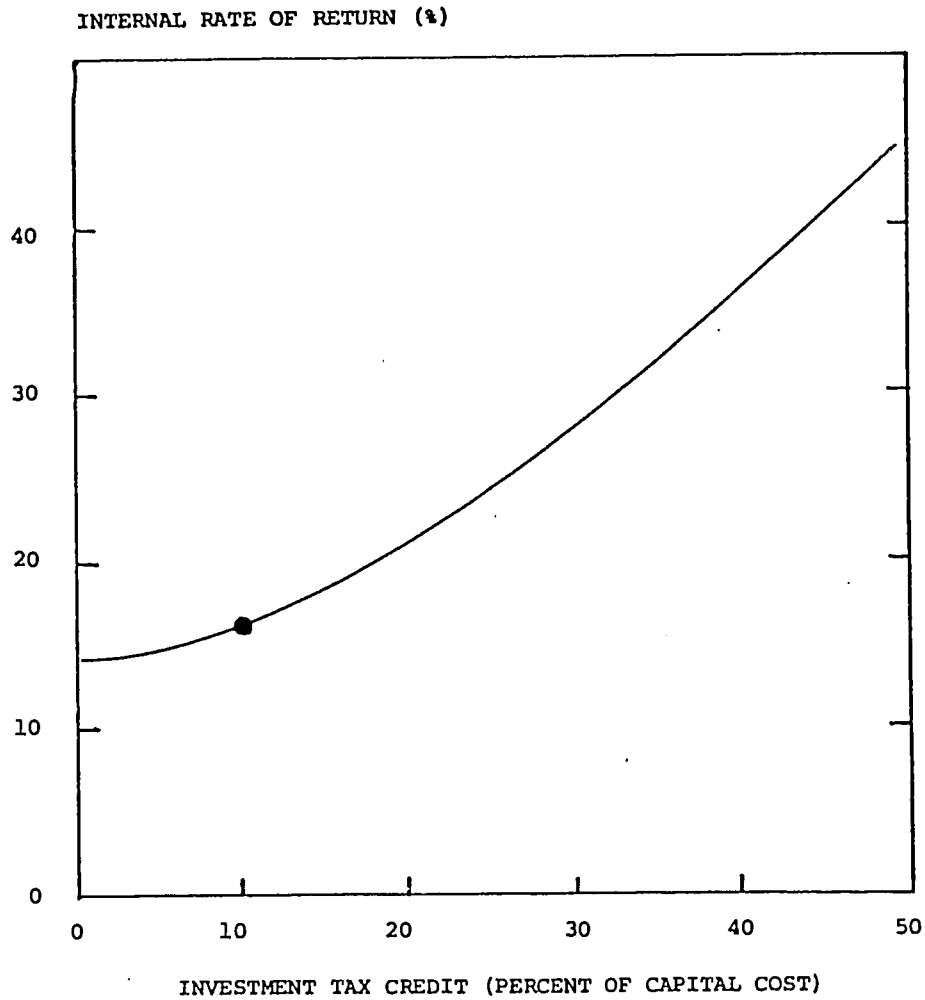


Figure 3. Internal Rate of Return as a Function of Investment Tax Credit Industrial Process Heat Case Example.

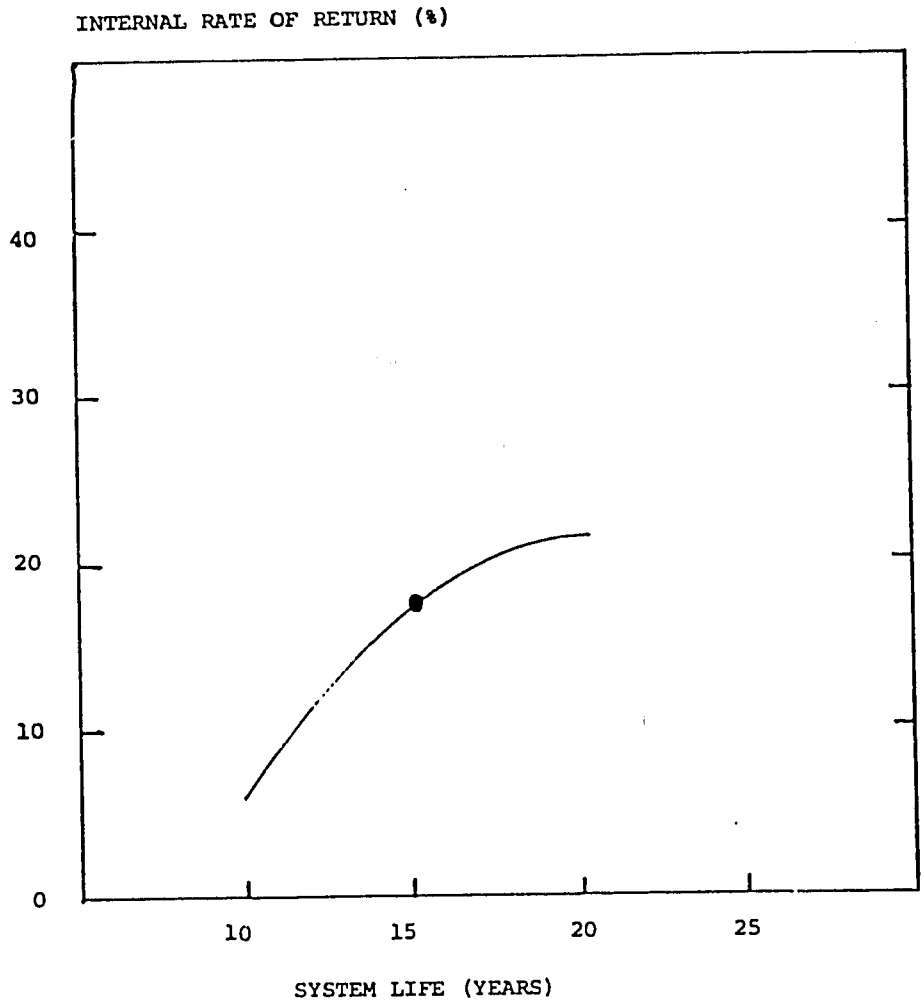


Figure 4. Internal Rate of Return as a Function of System Life
Industrial Process Heat Case Example.

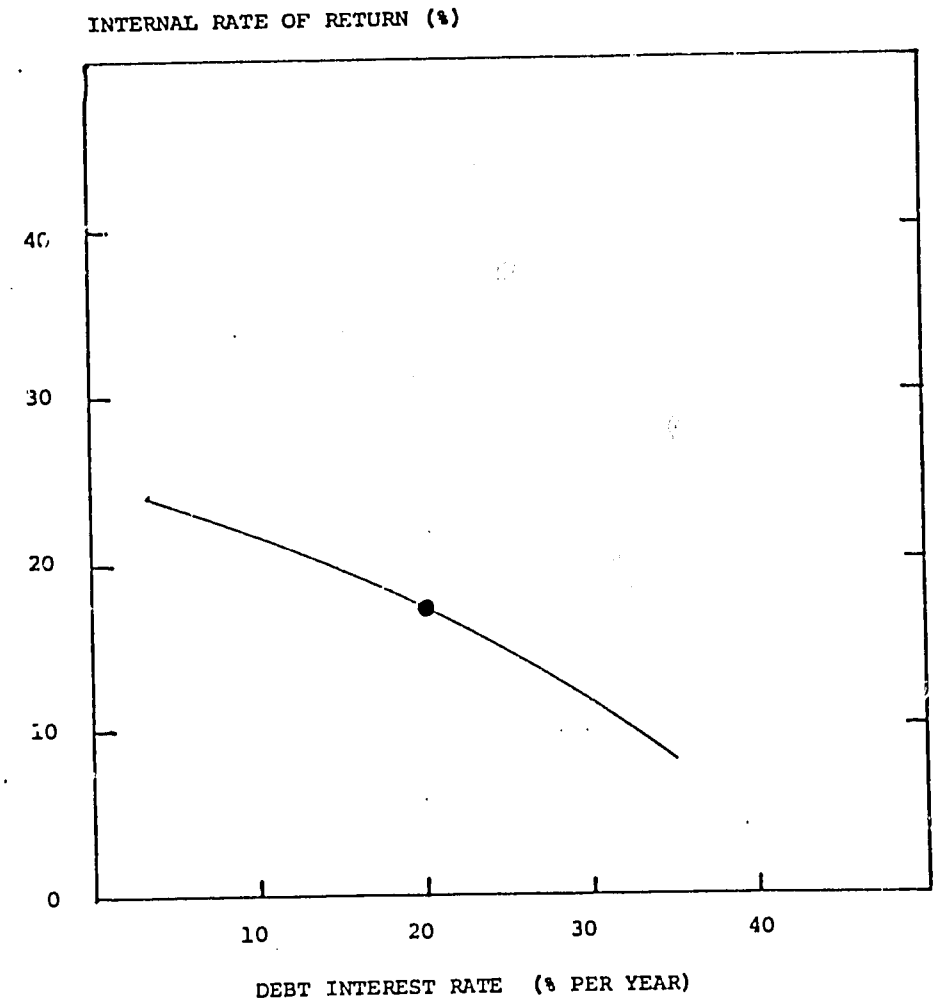


Figure 5. Internal Rate of Return as a Function of Debt Interest Rate Industrial Process Heat Case Example.

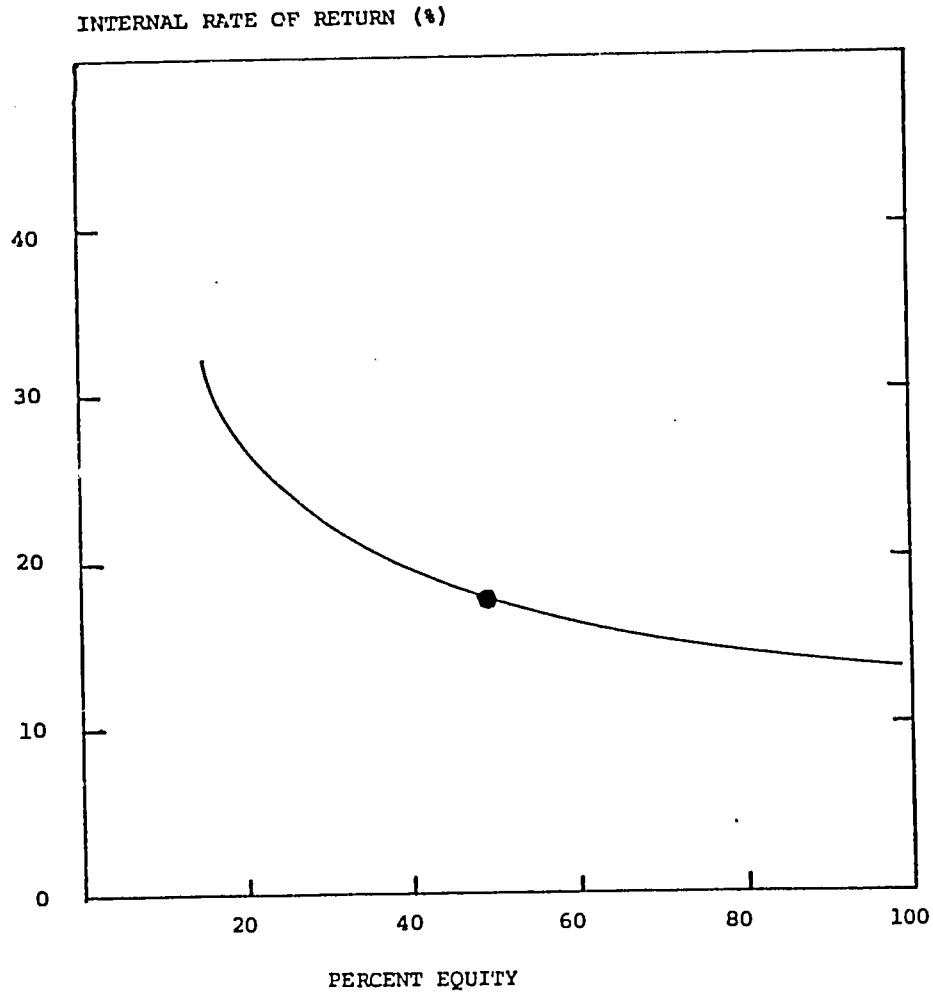


Figure 6. Internal Rate of Return as a Function of Percent Equity Industrial Process Heat Case Example.

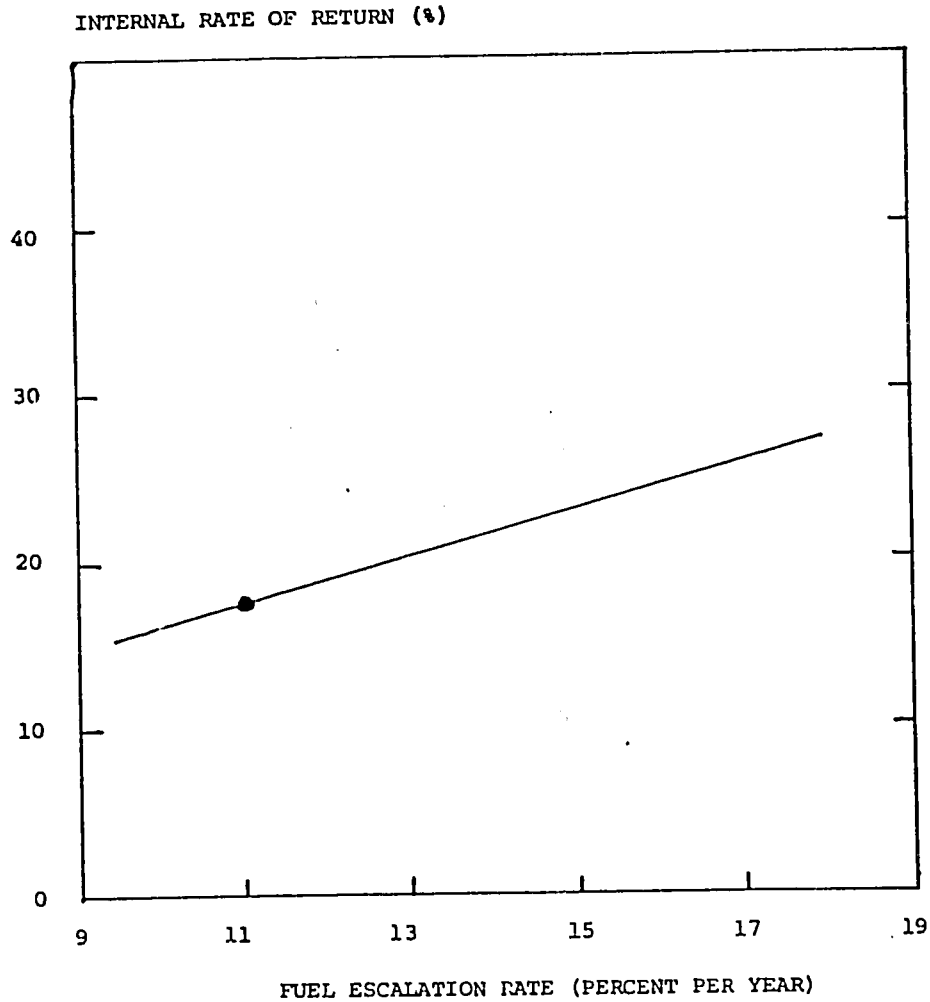


Figure 7. Internal Rate of Return as a Function of Fuel Escalation Rate Industrial Process Heat Case Example.

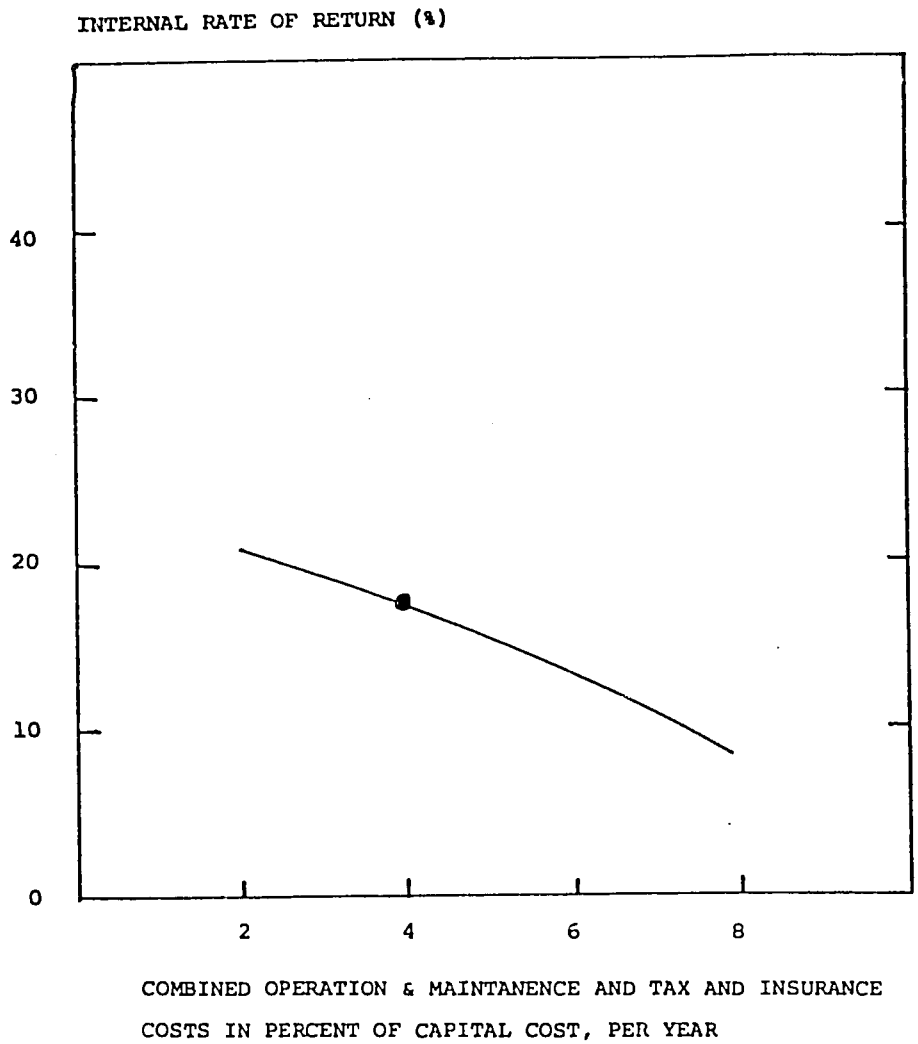


Figure 8. Internal Rate of Return as a Function of Operation, Maintenance

Process Heat Case Example.

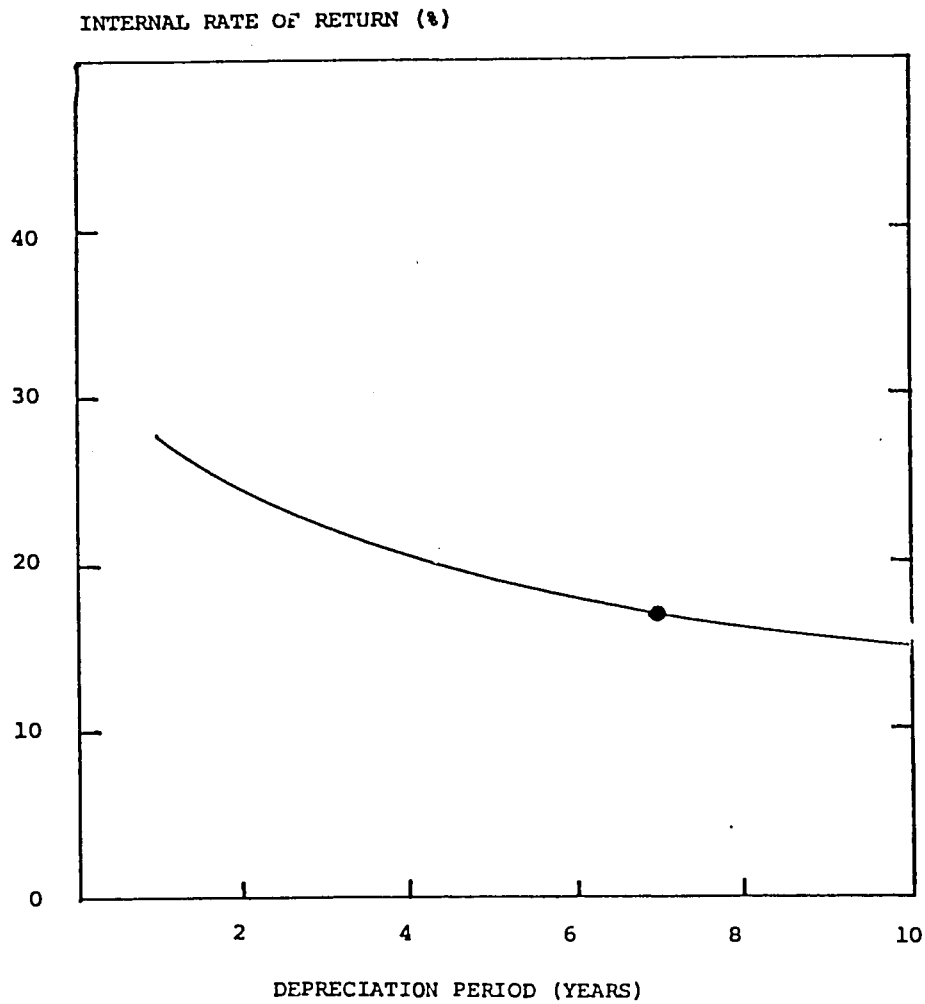


Figure 9. Internal Rate of Return as a Function of Straight Line Depreciation Period Industrial Process Heat Case Example.

example the impact of different fuel escalation rates on the IRR. This behavior depends strongly on the other elements of the financial analysis. Again, increases in the real price of fuel at rates in excess of 3 percent per year will improve the IRR. A doubling of the fuel increase rate from 3 percent to 6 percent per year will result in an increase of the IRR from 17 percent to 22 percent. Figure 8 shows that as O&M costs increase (as a fraction of total capital cost), the IRR will decline, as expected. Property tax can be an instrument of fiscal and investment policy for a government. Figure 9 shows that for depreciation periods below about 7 years (for straight line depreciation) the IRR rises smoothly with declining depreciation. Accelerated depreciation of energy efficient technology investments can be a powerful tool for creating incentives for the use of such technologies.

This example demonstrates the substantial range of returns on investment which can occur for an industrial process waste heat recovery system in a developing country. In particular, the importance of the financial factors governing the investment is manifest. Encouragement of technologies for displacement of oil for process heat production in the developing nation translates directly into policy-mandated shifts in the investment environment for such capital intensive technologies. From the analysis above, the two most significant parameters in the determination of internal rate of return are 1) domestic fuel cost (and its escalation rate) and 2) the investment tax credit (and percent equity). These are, consequently, the most effective instruments of government policy to encourage the improved efficiency of energy utilization in industry. Subsidized loans have somewhat less of an effect upon the rate of return on investment, primarily because the marginal

tax rate is large. The net effect of government policies to set higher prices for oil and, simultaneously, to institute larger investment tax credits for energy-saving industrial technology will be to create substantially higher internal rates of return, a more favorable climate for investment in industrial waste heat recovery.

III. CONCLUSIONS

In Table 2 we identify some significant impacts upon government transactions of a decision by an industrial firm to install heat recuperators. In our analysis the investment decision on the part of the firm has been reduced to the consideration of an internal after-tax rate of return. Should this rate of return exceed the normal rate of return on alternative investments of capital in this business, the firm would be expected to opt for installation of heat recuperators.

From a government perspective before a decision can be made on the appropriate economic signals to be directed to the firm, it must consider what effects the diversion of capital to energy conservation will have on the output of the firm's goods and services. In many developing countries the shortage of capital surplus may force the firm to choose between the use of its capital to reduced use of energy, <u>or</u> to invest the capital in the expanded output of goods and services. If the decision is made to invest in energy conservation the potential for increased production is lessened leading to a loss in the public benefits that accrue from any increase in gross domestic production. On the other hand investment in energy conservation on the part of the firm yields a public benefit in terms of a lowering of domestic oil consumption. In Table 2, we list the value of the direct reduction in oil consumption ($45,000 per year) associated with the choice on the part of the firm to invest in industrial heat recovery systems. However, since capital has been diverted to a "nonproductive" use, there is a concomitant loss in annual production of goods and services which we denote as the primary component of the opportunity cost of capital ($76,000/yr). The values given in Table 2 depend critically upon the incremental capital-to-

Table 2

APPROXIMATE GOVERNMENT IMPACT FOR

INDUSTRIAL WASTE HEAT RECOVERY

Parameter	Capital	Annual
Energy Import Reduction		+ $45,000/year
Opportunity Cost of Capital		- $76,000/year
Incremental Investment Tax Credit (10%)	-$38,000	
Energy Supply Investment Reduction	+ $31,000	

Assumptions: Oil import price $40 per barrel. Opportunity cost of capital taken to be productive capacity with ICOR of 5.

Energy supply investment (refinery plus distribution) amortized is 10 percent of retail oil price.

output ratios used and the extent to which oil prices include shadow pricing. It is apparent that the relative magnitude of the foreign exchange savings of energy conservation and the opportunity costs of capital are two factors that will play a role in setting the levels of subsidies on domestic fuel prices and investment tax credit as instruments of government policy to encourage industrial energy conservation.

Incremental tax credits to encourage industrial energy conservation result in lost revenues to government. These revenues can be recouped if one takes into account that the resultant energy savings permit a reduction of capital outlays for expansion of the energy supply systems. While the figures in Table 2 are merely indicative of the magnitude of such impacts, they point up that it is the relative balance of the annual revenue shifts and these kinds of adjustments which enter into the design of a rationale set of incentives to encourage decisions on the part of individual firms to invest in industrial energy conservation.

The primary conclusions to be drawn from this cursory analysis is that there need be no fundamental incompatability of interest between achievement of private and public benefits in promoting industrial energy conservation if, in the design of incentive measures, government policy takes into account the side effects of energy conservation investments. Reduced foreign exchange expenditures required for oil importation (or, in the case of oil-exporting countries, the opportunity cost of losses in exports) and a slowdown in expansion of energy supply facilities can largely offset any loss of national productive capacity from this deployment of capital.

Another conclusion that follows from our case example is that the dominant instruments of public policy are the cost of fuel to the firm and the size of the investment tax credit going to the firm. The other factors included in the investment analysis proved to be of much less significance. Tariff schedules in almost all developing countries for petroleum products are the products of a complex set of economic and polital factors. In some countries prices reflect international market conditions. In others, fuel oil used in industry is subsidized by government or by higher than usual gasoline prices. Consequently, one should expect that different levels of investment tax credits in fuel prices will be required. For oil-importing developing countries in particular, domestic fuel prices have reflected the escalation of world oil prices. Though there have been attempts to maintain subsidies for specific industrial user groups, and in some countries such subsidies continue, as the percentage of foreign exchange earnings has increased, many of these countries are looking to reduce or eliminate such subsidies. In these countries oil price escalation is likely to follow or top the annual 3% escalation used in our case example. It is noteworthy that if the domestic price of oil rises significantly above the 3% figure, the internal rate of return on energy-saving investment also will rise substantially, thereby reducing or eliminating the need for significant investment tax credits to produce a favorable climate for industrial energy conservation.

On the other hand in oil-exporting developing countries, the domestic oil prices are generally set below the world market. More importantly, annual escalation of fuel prices has been restricted. Such a strategy will lead to low rates of return on investments in industrial energy conservation. Given the social and political constraints upon the upward adjustment of fuel prices in such countries, our analysis suggests that substantial investment tax credits should be directed toward the industrial sector to produce a climate for achieving industrial energy savings.

While the fiscal benefits of improved efficiency of energy utilization in industry are expressible in terms of such measures as rate of return on investment to the industrial firm, shifts in national income flows, and opportunity cost of oil savings, etc., it is evident that before governments can proceed to design comprehensive policies to encourage energy conservation in industry, what is required is a more detailed picture of annual cash flows not only to and from the national energy supply and energy consuming sectors of the economy but to the government itself. A model which incorporates many of these features has recently been developed at the Institute for Energy Research and is discussed in the next section.

IV. ENERGY INVESTMENT ANALYSIS

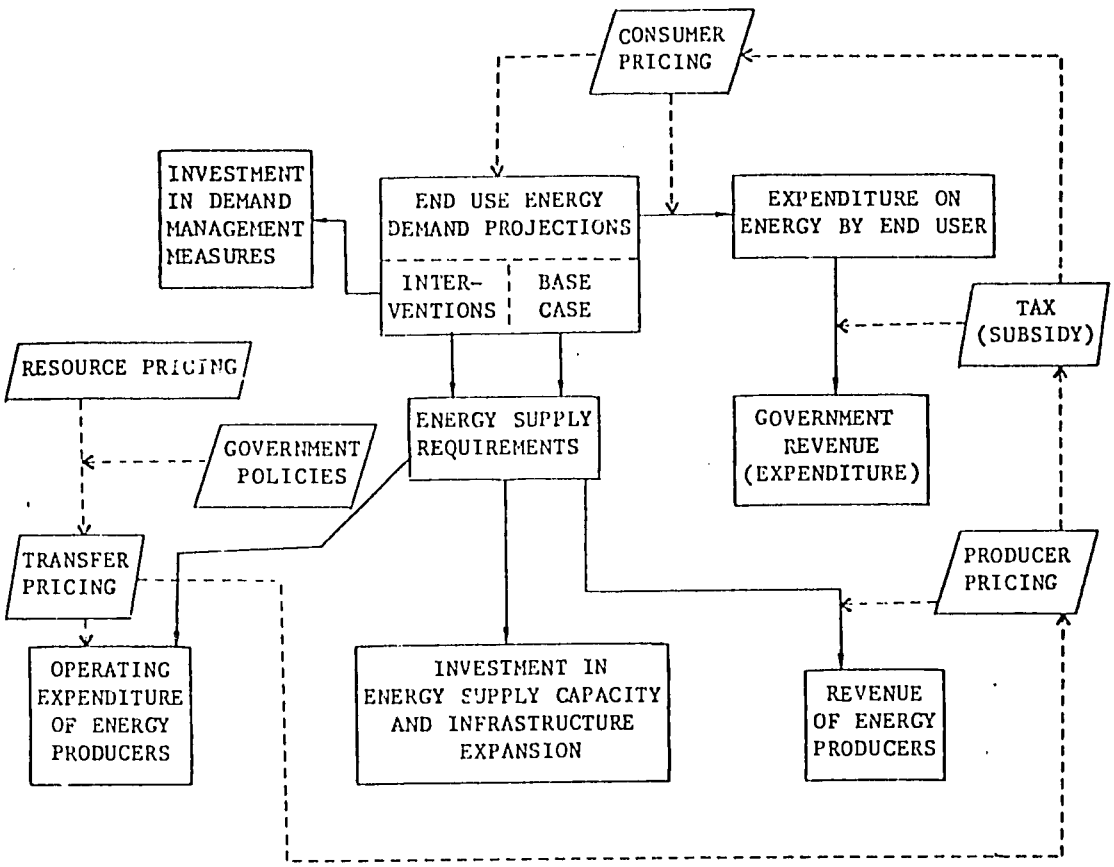
The design of government policy instruments, pricing and taxes, requires a comprehensive framework within which we can examine the impact of alternatives upon various sectors of the economy and upon the overall national income flow. The traditional approach to investment, which was used earlier in this paper, involves the usual concept of cost-benefit analysis and internal rate of return and is often done on an individual project basis. Because of the integrated nature of the energy system, however, each individual investment decision at the subsector level will have a financial impact on other interrelated subsectors as well as an impact on the energy flows among these subsectors. For example, an investment in industry to retrofit oil boilers to coal boilers will have impact on revenue to refineries and their decisions on refinery capacity expansions. It will also affect the total oil imports (or exports) to the country. The Energy Investment Assessment Model (EIAM) shown in Figure 10 was designed to explore the interactions of investments in the energy sector that will be required under a given energy supply-demand balanced scenario. It is in operation at the Institute for Energy Research based on Tunisia data. EIAM incorporates an integrated energy pricing framework which enables one to estimate the ability of alternative pricing schedules for different fuels to recover capital investments and operating expenses. In effect, the model provides an accounting structure which details the energy and revenue stream coming from each major consuming group to each supplier organization on a year-to-year basis. In this way the model provides policy makers with a realistic picture of the inherent restrictions and trade-offs in establishing an integrated investment-energy pricing policy.

The model determines energy supply requirements under a specific set of

FIGURE 10

ENERGY INVESTMENT ASSESSMENT MODEL

SCHEMATIC DIAGRAM



supply strategies and calculates investments necessary to implement a variety of measures affecting additions to supply capacities and infrastructure expansions as determined in the energy balancing procedure. The associated investment requirements in each subsector are converted in the model as streams of yearly revenue requirements (loan payments) based on exogenously determined interest rate and loan terms. The final step is to establish the yearly revenues generated among the energy subsectors on the basis of a comprehensive set of energy tariffs: prices of energy resources, transfer prices that fix prices of energy paid by energy suppliers (e.g., refineries and electric utilities), producers' prices which determine prices received by energy suppliers, and finally consumer prices which are the prices paid by end users (including government taxes and/or subsidies).

The output of EIAM is formalized in a stream of tables which report the following information on a yearly basis for the entire planning period:

1. Energy consumption by end use
2. Cost of energy consumed by each end use
3. Total government taxes and subsidies from energy transactions
4. Revenue received by each energy supplier from sales of energy
5. Expenditure paid by each energy supplier for purchasing energy inputs
6. Capital outlay or revenue requirement in each energy subsector due to energy related investments
7. Implied growth of supply capacities and infrastructure

Table 3, for example, gives incremental changes in revenues and expenditures under a selected pricing policy which leads to the coal conversions noted above. It is this series of year-to-year comparisons over the entire planning horizon which provide the basis for government policy on industrial energy conservation.

TABLE 3

INCREMENTAL REVENUE - EXPENDITURE STATEMENT(1000 RD DOLLARS)
YEARS : 1990

	INCREMENTAL REVENUE (Energy)		INCREMENTAL EXPENDITURE (Investment)		BALANCE	
	DOMESTIC	FOREIGN	DOMESTIC	FOREIGN	DOMESTIC	FOREIGN
ONSUMER						
INDUSTRY	27018.34		505.01	1393.54	26513.32	-1393.54
TRANSPORTATION	32753.09		1031.69	2308.23	31721.40	-2308.23
HOUSEHOLDS	1426.14		143.29	73.81	1282.86	-73.81
MISCELLANEOUS	0.00		0.00	0.00	0.00	0.00
OVERNMENT						
TAXES					-5282.67	
SUBSIDIES					0.00	
NERGY SUPPLIERS						
PETROLEUM	-70630.80	16300.16	0.00	0.00	-70630.80	16300.16
ELECTRICITY	-8956.41	0.00	-216260.06	-54065.02	207303.62	54065.02
WOOD	0.00	0.00	0.00	0.00	0.00	0.00
HYDRO	0.00	0.00	0.00	0.00	0.00	0.00
BAGASSE	0.00	0.00	0.00	0.00	0.00	0.00
COAL	21923.11	-21848.32	0.00	675.96	21923.11	-22524.28
SOLAR	0.00	0.00	0.00	0.00	0.00	0.00