ENERGY-ENVIRONMENTAL POLICY IN DEVELOPING COUNTRIES

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ABSTRACT :- Increased energy use is a vital pre-requisite for economic development and LDCs are struggling to meet energy needs at acceptable costs. LDC decisionmakers share the worldwide environmental concerns, but also face other urgent issues like poverty. The difficult dilemma facing the developing countries is how to reconcile development goals -- which will require increased use of energy and raw materials -- with responsible stewardship of the environment. In view of the severe financial constraints that developing countries already face, the response of these countries in relation to environmental preservation cannot extend beyond measures that are consistent with near-term economic development goals. The industrialised countries can afford to substitute environmental protection for further material growth, but the LDCs will need more conventional aid to address local environmental issues, as well as additional concessional funding to participate in solving global environmental problems. Global financing issues may be analysed and resolved through tradeoffs among several criteria including affordability/additionality, fairness/equity, and economic efficiency. The short-term LDC response to energy-environmental problems will be limited mainly to conventional technology based efficiency improvements, conservation and resource development. The industrialised nations should provide financial resources to LDCs and develop the technology to be used in the 21st century. Pilot international funds like the Global Environmental Facility and the Ozone Fund will help LDCs participate in the effort to solve global environmental issues.

INTRODUCTION

Energy became a major international issue in the 1970s, following the oil crisis. More recently, global climate change induced by excessive greenhouse gas accumulation in the atmosphere has emerged as a potential problem that further complicates energy issues. In this paper, we will focus on energy related environmental issues in the developing countries. The development related energy needs of the third world and their financial implications, the potential for better energy management, barriers to reducing greenhouse gas emissions, and financial mechanisms and policies that can improve the performance of developing countries in this respect, will be explored below.

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The experience of the industrialized countries emphasizes that a reliable supply of energy is a vital prerequisite for economic growth and development. For example, the observed trends relating to electricity demand in developing countries (which indicate annual growth rates in the region of 6 to 12 percent) are consistent with the development objectives that these countries all share (Munasinghe 1990b, World Bank 1990). Up to the present time, many developing countries have been struggling with the formidable difficulties of meeting these needs for energy services at acceptable costs. If such needs cannot be met, economic growth is likely to slacken and the quality of life will fall.

Given these already existing handicaps, the growing additional concerns about the environmental consequences of energy use considerably complicate the policy dilemma facing the developing countries. In the past, industrial countries that faced a tradeoff between economic growth and environmental preservation invariably gave higher priority to the former. These richer countries have awakened only recently to the environmental consequences of their economic progress, and only after a broad spectrum of economic objectives have been reached. This model of economic and social development has been adopted by many third world regions. Therefore, until both developed and developing countries find a less material intensive sustainable development path, environmental protection efforts will be hampered.

The developing countries (LDCs) share the deep worldwide concerns about environmental degradation, and some have taken steps already to improve their own natural resource management as an essential prerequisite for sustained economic development. However, they also face other urgent issues like poverty, hunger and disease, as well as rapid population growth and high expectations. The paucity of resources available to address all these problems constrains the ability of LDCs to undertake costly measures to protect the global commons.

The crucial dilemma for LDCs is how to reconcile development goals and the elimination of poverty -- which will require increased use of energy and raw materials -- with responsible stewardship of the environment, and without overburdening already weak economies. The per capita GNP of low income economies (with half the world population) averaged US$290 in 1987, or under one sixtieth of the US value ($18,530). In the two largest developing countries, India and China, per capita GNP was $300 and 290 respectively. Correspondingly, the US per capita energy consumption of 7265 kilograms of oil equivalent (kgoe) in 1987 was 35 and 15 times greater than the same statistic in India and China respectively.

The disparity in both per capita income and energy use among different countries also raises additional issues in the context of current global environmental concerns, and the heavy burden placed on mankind's natural resource base by past economic growth -- fossil fuel related CO_2 accumulation in the atmosphere is a good example. The developed countries accounted for over 80% of such cumulative worldwide emissions during 1950-86 -- North America contributed over 40 billion tons of carbon, Western and Eastern Europe emitted 25 and 32 billion tons respectively, and the developing countries share was was about 24 billion tons. On a per capita basis the contrasts are even more stark, with North America emitting over 20 times more and the developed countries as a whole being responsible for over eleven times as much total cumulative CO_2 emissions as the LDCs. The LDC share would be even smaller if emissions prior to 1950 were included. Clearly, any reasonable growth scenario for developing nations that followed the same material-intensive path as the industrialised world, would result in unacceptably high levels of future greenhouse gas accumulation as well as more general depletion of natural resources.

Up to now, scientific analysis has provided only broad and rather uncertain predictions about the degree and timing of pote tial global warming. However, it would prudent for mankind to buy an "insuran policy" in the form of mitigatory actions reduce greenhouse gas emissions. Ironicall both local and global environmental degra dation might affect developing countries mo severely, since they are more dependent natural resources while lacking the econom strength to prevent or respond quickly increases in the frequency, severity and pe sistence of flooding, drought, storms, and on. Thus, from the LDC viewpoint, an attra tive low cost insurance premium would be a se of inexpensive measures that could address range of national and global environmenta issues, without hampering development effort

The recent report of the Bruntlan Commission (WCED 1987), which has been wide circulated and accepted, has presented arg ments along the theme of sustainable develo ment, which consists of the interaction of tw components: needs, especially those of th poor segements of the world's population a limitations, which are imposed by the abilit of the environment to meet those needs. Th development of the presently industrialize countries took place in a setting whic emphasized needs and de-emphasized limita tions. The development of these societies hav effectively exhausted a disproportionate large share of global resources -- broad defined to include both the resources that a consumed in productive activity (such as oil gas and minerals), as well as environmenta assets that absorb the waste products of ec nomic activity and those that provide irr placeable life support functions (like th high altitude ozone layer). Indeed, some ana lysts argue that this development path ha significantly indebted the developed countrie to the larger global community.

The division of responsibility in th global effort is clear from the above arg ments. The unbalanced use of common resourc in the past, should be one important basis which the developed and developing countrie can work together to share and preserve wh remains. The developed countries have alrea attained most reasonable goals of developmen and can afford to substitute environmenta protection for further growth of materia output. On the other hand, the developi countries can be expected to participate the global effort only to the extent that th participation is fully consistent with an complementary to their immediate economic an social development objectives.

In the context of the foregoing, this paper identifies critical energy-environmental issues, using examples from the highly capital intensive and pivotal power sector to illustrate specific points. It also explores some policy implications, constraints and opportunities at the national and global level for both the developing countries as well as the wider international community, and examines the role of emerging mechanisms such as the global environmental fund and ozone defense fund, in the allocation of resources for addressing transnational environmental problems.

ELECTRIC POWER NEEDS OF THE DEVELOPING COUNTRIES

Electric power has a vital role to play in the development process, with future prospects for economic growth being closely linked to the provision of adequate and reliable electricity supplies. Figure 1(a) summarises the relationship between GDP, commercial energy, and electricity use in the OECD and developing countries, from 1970 to 1990. Following the oil crises of the last decades, overall energy used per unit of GDP has declined dramatically in the industrialised countries, but dependence on electricity has increased. Based on the OECD example, energy efficiency improvements will continue to reduce the growth of demand for commercial energy in the developing world. However, the 1970-90 trend for electricity demand in LDCs, and the inability of the OECD countries to significantly decouple electricity use from GDP in the past, suggest that the growth-related power needs of the LDC's will increase rapidly in the future. One recent long-run forecast of worldwide electricity consumption up to 2010 is shown in Figure 1(b), with the LDC and Soviet Union-Eastern Europe (SUEE) shares both rising.

In the medium term, assuming no drastic changes in past trends with respect to demand management and conservation, the World Bank's most recent projections indicate that the demand for electricity in LDCs will grow at an average annual rate of 6.6% during the period 1989-99 (Moore 1990). This compares with actual growth rates of 10% and 7% in the seventies and eighties, respectively. Such rates of growth indicate the need for total capacity additions of 384 GW during 1990-99 (see Figure 2), and annual energy consumption of 3844 TWh by 1999. As indicated in Figure 3, the Asia region's requirements dominate with almost two thirds of the total, and coal and hydro are the main primary sources -- both of which have specific environmental problems associated with their use.

The investment needs corresponding to these indicative projections are also very large. Table 1 shows the projected breakdown of LDC power sector capital expenditure in the 1990s. Of a total of $745 billion (constant 1989 US$), Asia (which includes both India and China), again dominates, accounting for $455 billion or over $45 billion annually. In comparison with the total projected annual requirement for LDCs of $75 billion, the present annual rate of investment in developing countries is only around $50 billion. Even this present rate is proving difficult to maintain. Developing country debt which averaged 23% of GNP in 1981, increased dramatically to 42% in 1987 and have not declined significantly since then. In low income Asian countries, outstanding debt doubled, from 8% in 1981 to 16% in 1987. Capital intensive power sector sector investments have played a significant role in this observed increase.

If the developing countries follow this projected expansion path, the environmental consequences are also likely to increase in a corresponding fashion. There is already a growing concern about the environmental consequences at the national level, of energy use in developing countries. At a recent workshop on acid rain in Asia, participants reported on a wide range of environmental effects of the growing use of fossil fuels, especially coal, in the region (Foell 1989). For example, total 1985 sulphur dioxide emissions in Asia were estimated at around 22 million tons, and these levels, coupled with high local densities, have led to acid deposition in many parts of Asia.

The developing countries feel that any attempts to mitigate these environmental effects, however, cannot jeopardize the critical role played by electric power (and more generally, energy) in economic development. Similarly, the allocation of resources to environmental programs in developing countries cannot diminish the resources needed to fund projected expansion of supply. Energy and environmental policymakers in both developing countries and the global community are, indeed, confronted with a formidable dilemma.

THE ECONOMICS OF ENERGY-ENVIRONMENTAL ISSUES

The foregoing discussion has helped to establish a rational and equitable basis for addressing the problems of energy-environmental impact mitigation. In this section we

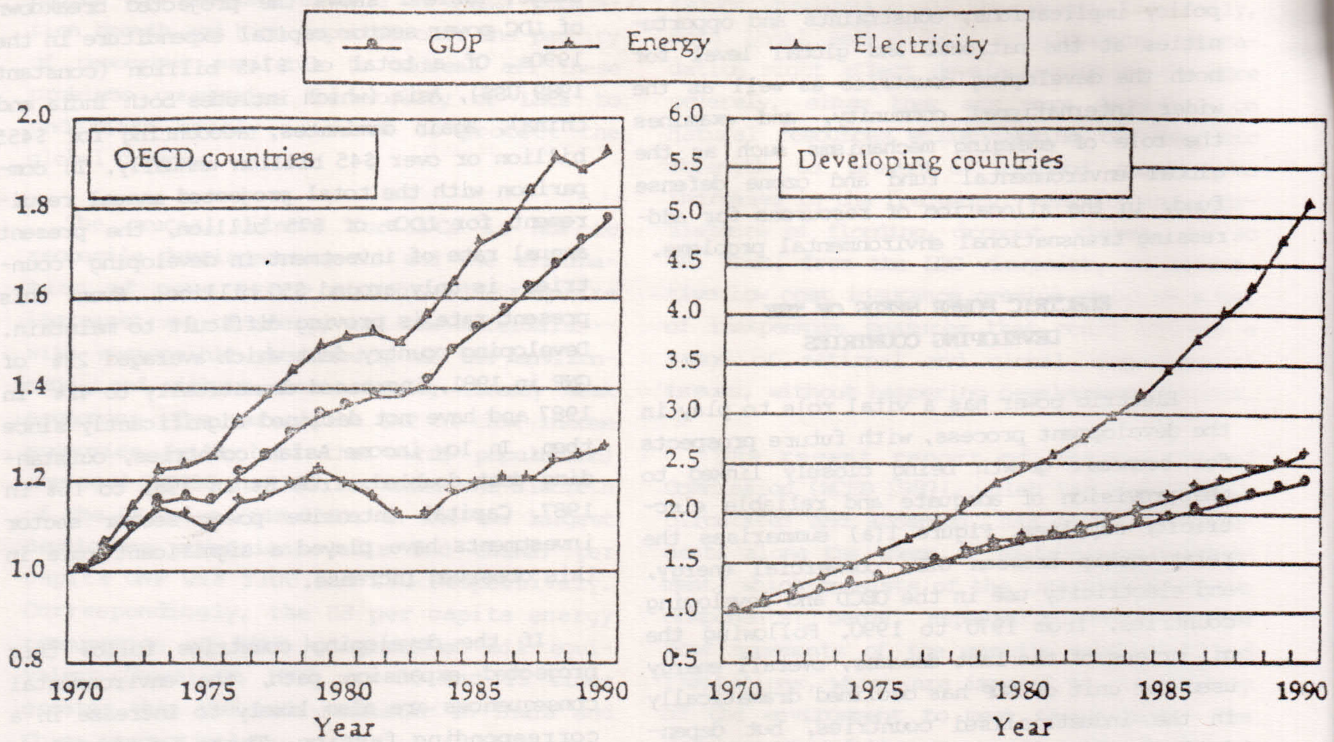


Fig. 1(a) Growth trends for Gross Domestic Product (GDP), energy and electricity (1970–1990). (All values normalized to 1.0 in 1970)

Source: Munasinghe et al. (1991)

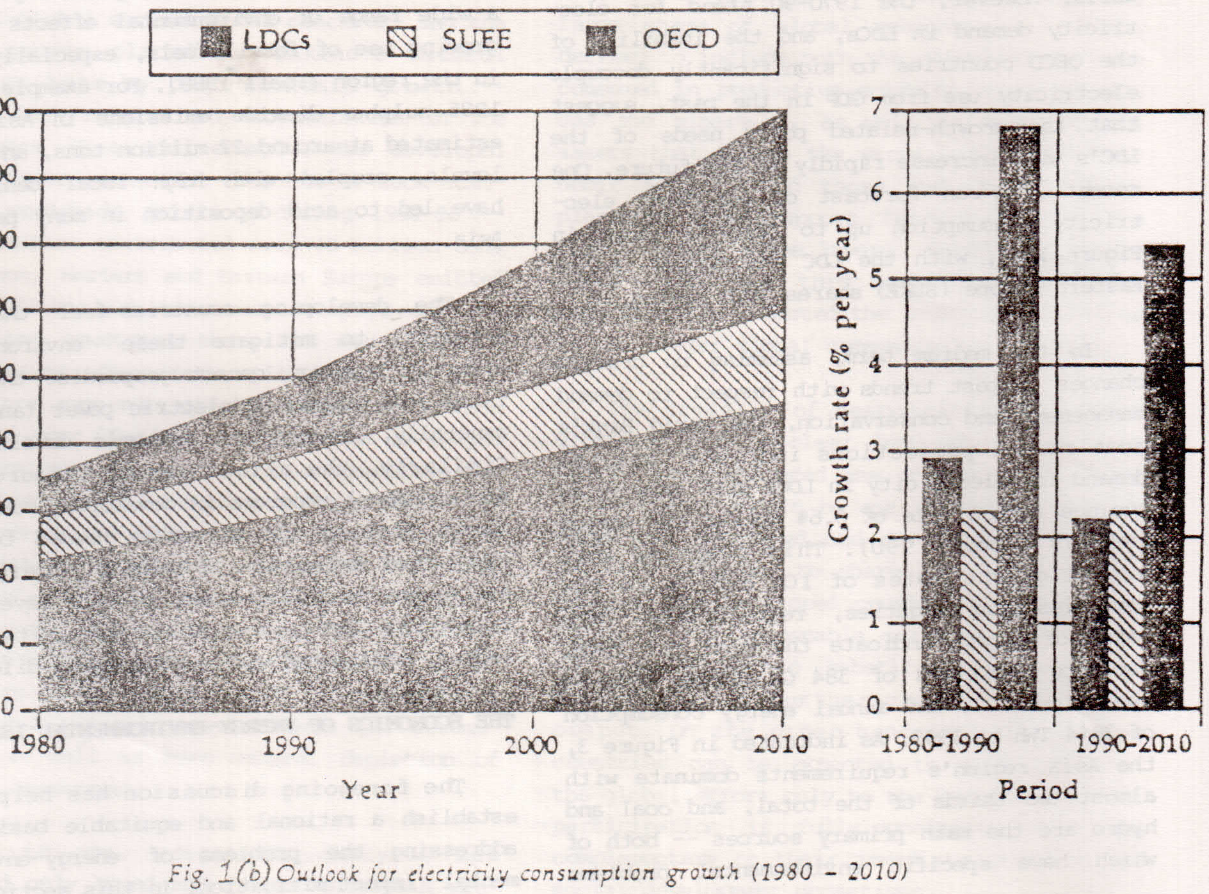


Fig. 1(b) Outlook for electricity consumption growth (1980 – 2010)

Source: Munasinghe et al. (1991)

Table 1
Regional Breakdown of LDC Power Capital Expenditures in the 1990s

	Asia	EMENA*	LAC**	Africa	Total
Generation	277	82	83	6	448
Transmission	39	8	32	2	81
Distribution	100	23	27	2	152
General	39	11	13	1	64
TOTAL	455	124	155	11	745
Percent	61.1	16.6	20.8	1.5	100

* Europe, Middle East and North Africa (Meditarranean region)
** Latin America and the Caribbean

Source: The World Bank

present an economic efficiency framework which ties together the issue of environmental protection with the existing energy sector goals of energy efficiency and economic growth.

It is convenient to recall here that traditionally, the specific prerequisites for economic efficiency have included both (Munasinghe 1990b):

(a) efficient consumption of energy, by providing efficient price signals that ensure optimal energy use and resource allocation; and
(b) efficient production of energy, by ensuring the least-cost supply mix through the optimization of investment planning and energy system operation.

A new issue which has emerged in recent decades as an area of particular concern, is the efficient and optimal use of our global natural resource base, including air, land and water. Since there has been much discussion also about the key role that energy efficiency and energy conservation might play in mitigating environmental costs, it is useful first to examine how these topics relate to economic efficiency. Specific issues dealing with the formulation and implementation of economically efficient energy policies are presented in Section 4.

Major environmental issues vary widely, particularly in terms of scale or magnitude of impact, but most are linked to energy use. First, there are the truly global problems such as the potential worldwide warming due to increasing accumulation of greenhouse gases like carbon dioxide and methane in the atmosphere, high altitude ozone depletion because of release of chlorofluorocarbons, pollution of the oceanic and marine environment by oil spills and other wastes, and excessive use of certain animal and mineral resources. Second in scale are the transnational issues like acid rain or radioactive fallout in one european country due to fossil-fuel or nuclear emissions in a neighbouring nation, and excessive downstream siltation of river water in Bangladesh due to deforestation of watersheds and soil erosion in nearby Nepal. Third, one might identify national and regional effects, for example those involving the Amazon basin in Brazil, or the Mahaweli basin in Sri Lanka. Finally, there are more localised and project specific problems like the complex environmental and social impacts of a specific hydroelectric or multipurpose dam.

While environmental and natural resource problems of any kind are a matter for serious concern, those that fall within the national boundaries of a given country are inherently easier to deal with from the viewpoint of policy implementation. Such issues that fall within the energy sector must be addressed within the national policymaking framework. Meanwhile, driven by strong pressures arising from far-reaching potential consequences of global issues like atmospheric greenhouse gas accumulation, significant efforts are being made in the areas of not only scientific analysis, but also international cooperation mechanisms to implement mitigatory measures.

Given this background, we discuss next some of the principal points concerning energy use and economic efficiency (Munasinghe 1990a). In many countries, especially those in the developing world, inappropriate policies

Figure 2

COMPARISON OF 1989 AND 1999 INSTALLED GENERATING CAPACITIES IN THE LDCs
(GIGAWATTS)

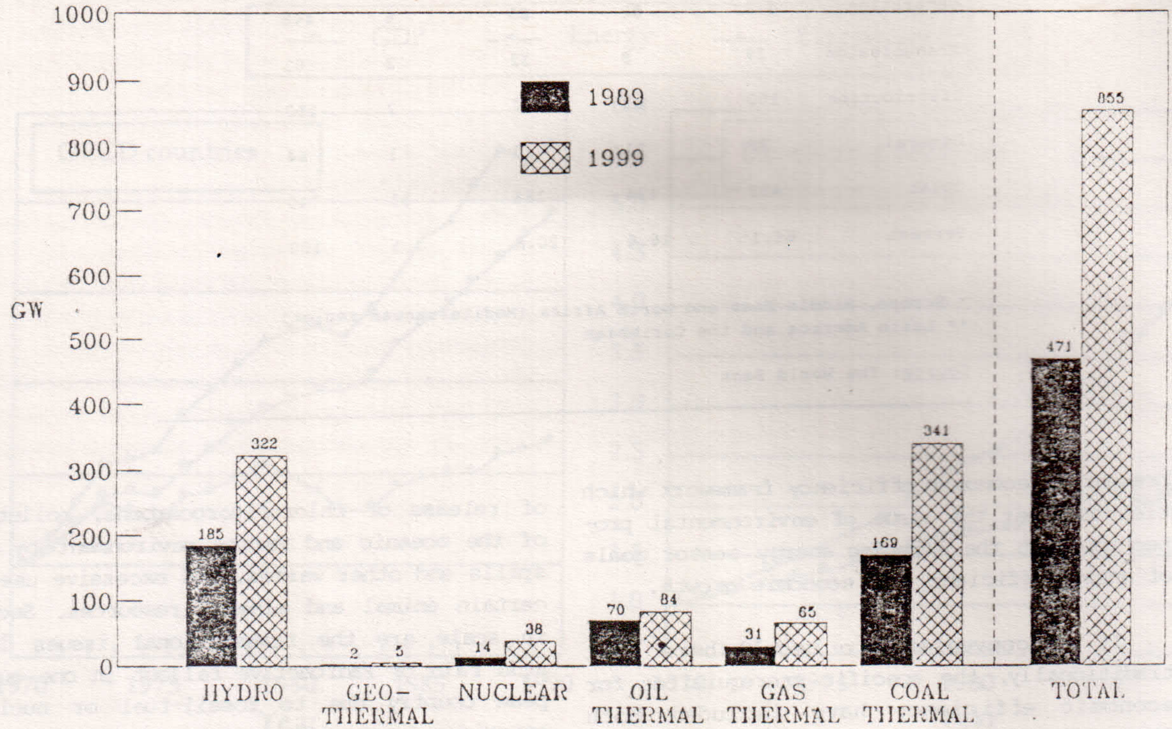


Figure 3

BREAKDOWN BY PLANT TYPE AND REGION OF CAPACITY EXPECTED TO BE ADDED IN THE LDCs IN THE 1990s
(384 GW TOTAL)

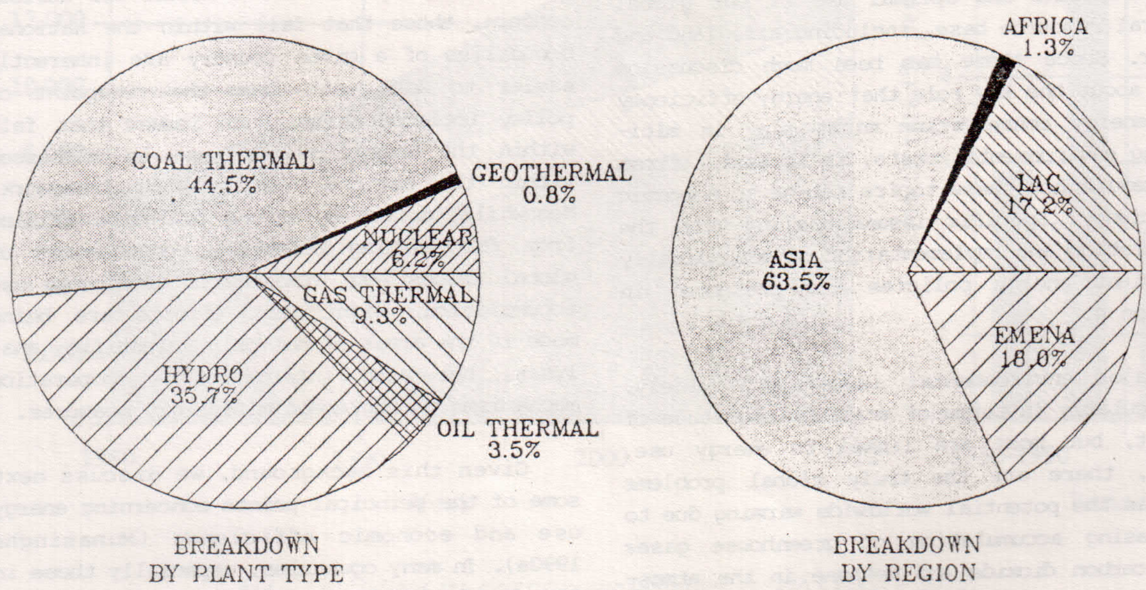
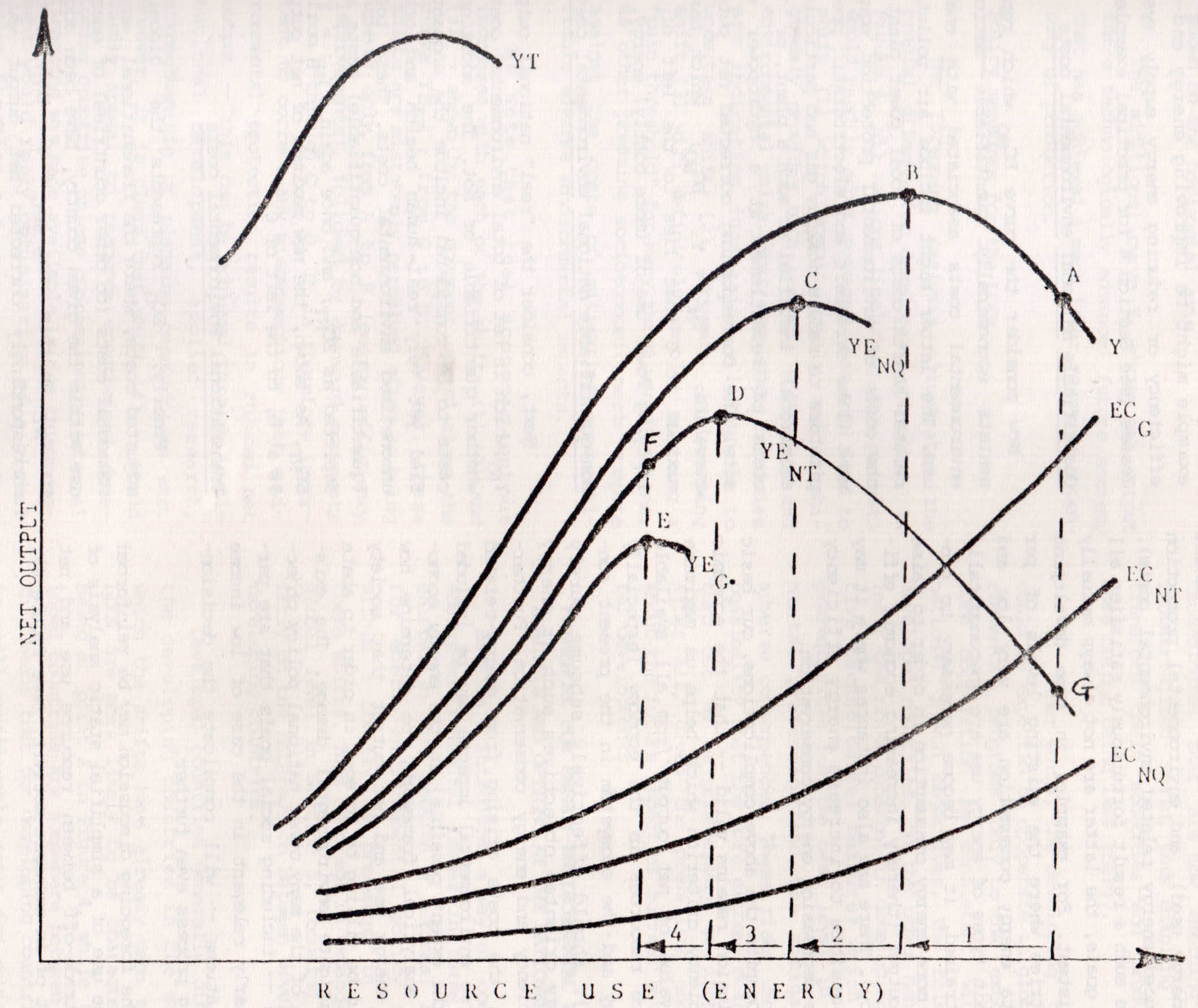


Figure 4



Net output, resource use and environmental cost.
$YE_{NQ} = Y - EC_{NQ}$; $YE_{NT} = Y - EC_{NT}$; $YE_G = Y - EC_G$.

have encouraged wasteful and unproductive uses of some forms of energy. In such cases, better energy management could lead to improvements in economic efficiency (higher value of net output produced), energy efficiency (higher value of net output per unit of energy used), energy conservation (reduced absolute amount of energy used), and environmental protection (reduced energy related environmental costs). While such a result fortuitously satisfies all four goals, the latter are not always mutually consistent. For example, in some developing countries where the existing levels of per capita energy consumption are very low and certain types of energy use are uneconomically constrained, it may become necessary to promote more energy consumption in order to raise net output (thereby increasing economic efficiency). There are also instances where it may be possible to increase energy efficiency while decreasing energy conservation.

Despite the above complications, our basic conclusion remains valid -- that the economic efficiency criterion which helps us maximize the value of net output from all available scarce resources in the economy (especially energy and the ecosystem in the present context), should effectively subsume purely energy oriented objectives such as energy efficiency and energy conservation. Furthermore, the costs arising from energy-related adverse environmental impacts may be included (to the extent possible) in the energy economics analytical framework, to determine how much energy use and net output that society should be willing to forego, in order to abate or mitigate environmental damage. The existence of the many other national policy objectives -- including social goals that are particularly relevant in the case of low income populations -- will complicate the decision-making process even further.

The foregoing discussion may be reinforced by the use of a simplified static analysis of the trade-off between resource use and net output of an economic activity (see Figure 4).

Energy efficiency

Y represents the usual measurement of the net output of productive economic activity in a country, as a function of some resource input (say energy) -- considering only the conventional internalised costs, i.e., not accounting for environmental impacts. Due to policy distortions (for example, subsidized prices), the point of operation in many developing countries appears to be at A, where the resource is being used wastefully. Therefore, without invoking any environmental considerations, but merely by increasing economic and resource use efficiency (i.e., energy efficiency), output as usually measured could be maximized by moving from A to B. A typical example might be improving energy end-use efficiency or reducing energy supply system losses (see Section 4 for practical examples).

Quantifiable national environmental costs

Now consider the curve EC_{NQ} which representats economically quantifiable national environmental costs associated with energy use. The latter might include air pollution related health costs of coal power plant or the costs of environmental protection equipment (like scrubbers and electrostatic precipitators to reduce noxious gas and particulate emissions) installed at such a plant, or the costs of resettlement at a hydropower dam site. The corresponding corrected net output curve is: $Y_{NQ} = Y - EC_{NQ}$; which has a maximum at C that lies to the left of B, implying lower use of (more costly) energy.

Non-quantifiable national environmental costs

Next, consider the "real" national output Y_{NT}, which is net of total environmental costs, whether quantifiable or not. The additional costs to be considered include the unquantified yet very real, human health and other unmonetized environmental costs. These total (quantifiable and non-quantifiable) costs are depicted as EC_{NT}; and once again $Y_{NT} = Y - EC_{NT}$. As shown, the new maximum of net output is at D, to the left of C.

Transnational environmental costs

Finally, EC_G represents the globally adjusted costs, where the transnational environmental costs (to other countries) of energy use within the given country, have been added to EC_{NT}. In this case, $YE_G = Y - EC_G$; is the correspondingly corrected net output which implies an even lower level of optimal energy use.

For example, consider the costs imposed on other countries (such as transborder impacts of a major dam or global climate impacts of carbon dioxide emissions). If it is decided to reduce resource use within this country further in order to achieve the internationally adjusted optimum at E, then a purely national analysis will show this up as a drop in net output, i.e. from D to E. As other countries benefit, this drop in net output may justify compensation in the form of a transfer of resources from the beneficiary countries. Note that the transnational costs imposed by other countries on the nation in question will be a function of regional or global resource use rather than the national resource use shown on the horizontal axis.

The additional curve Y_A shows net output for a technologically advanced future society that has achieved a much lower resource intensity of production.

Policy measures for the LDCs

The foregoing analysis illustrates the crucial dilemma for developing countries. In Figure 4, all nations (including the poorest) would readily adopt measures that will lead to shift (1) which simultaneously and unambiguously provides both economic efficiency and environmental gains. Most developing countries are indicating increasing willingness to undertake shift (2). However, implementing shift (3) will definitely involve crossing a "pain threshold" for many third world nations, as other pressing socioeconomic needs compete against the costs of mitigating nonquantifiable adverse environmental impacts.

We note that real economic output increases with each of the shifts (1),(2) and (3) -- shown by the movement upward along the curve YE_{NT} ; from G to D. However, these shifts are mistakenly perceived often as being upward only from A to B (energy efficiency improvements), followed by downward movements from B through C to D. It is therefore important to correct any misconceptions that environmental protection results in reduced net output -- this can be achieved through institutional development, applied research, strengtheninig of planning capabilities etc. However, it is clear that shift (4) -- would hardly appeal to resource constrained developing countries unless concessionary external financing was made available, since this movement would imply optimization of a global value function and costs that most often exceed in-country benefits. In the foregoing, we have neglected considerations involving reciprocal benefits to the given country due to energy use reductions in other countries.

Therefore, we may conclude briefly that, while the energy required for economic development will continue to grow in the developing countries, in the short to medium run there is generally considerable scope for most of them to practice better energy management, thereby increasing net output, using their energy resources more efficiently, and contributing to the effort to reduce global warming. In the medium to long run, it will become possible for the developing countries to adopt newer and more advanced (energy efficient) technologies that are now emerging in the industrialized world, thus enabling them to transform their economies and produce even more output using less energy.

In other words, the developing countries could be expected to cooperate in global environmental programs only to the extent that such cooperation is consistent with their national growth objectives. The role of the developed countries, on the other hand, is to incur the risks inherent in developing innovative technological measures which are the prerequisites for the next level in environmental protection and the mitigation of adverse consequences. These risks include the possibility that the more extreme measures may turn out to be unnecessary or inapplicable after all, given the prevailing uncertainty about the future impact of current environmental developments.

FRAMEWORK FOR ENERGY-ENVIRONMENTAL POLICY ANALYSIS AND OPTIONS AT THE NATIONAL LEVEL

Section 3 introduced a way of considering energy-environmental issues in terms of four shifts. In this section a rational framework for energy-environmental policy analysis within a country is presented in terms of these shifts. This coverage is expanded to the global level in Section 5, focusing particularly on the interaction between developed and developing countries.

Developed countries generally differ from the developing countries in the extent to which the shifts have already been made. The LDCs are more likely to be characterized as being at point A in Figure 4, while the developed countries are somewhere between C and D. This means that for developing countries there is still considerable scope for environmental improvement by undertaking programs that are consistent with the national objective of increasing overall output. The challenge for national decisionmakers and the international community is to find as many areas as possible where such consistency and complimentarity exist, between growth and environmental protection goals.

Advantages of an Integrated approach

Successful policy analysis, planning and implementation require an integrated approach, because of the complexity of modern society. As summarised in Figure 5, such a decision-making process must deal with a multiplicity of actors, criteria, levels, policy tools, and impediments. The core of this process is the integrated multilevel analysis shown in the middle column. Within a given country, such an analysis may be carried out using a hierarchical framework for integrated national energy planning (INEP), policy analysis and supply-demand management (Munasinghe 1990a).

Although the INEP framework is primarily country focussed, we begin at the global level by recognising that there are many transnational energy-environmental issues. Thus individual countries are embedded in an international matrix, and economic and environmental conditions at this global level will impose a set of exogeneous inputs or constraints on decisionmakers within countries. The next hierarchical level in the Figure 5 focusses on the multisectoral national economy, of which the energy sector is a part. Therefore, energy planning requires analysis of the links between the energy sector and the rest of the economy. Such links include the energy needs of user sectors like industry, transport and agriculture, the input requirements of the energy sector itself, and the impact on the economy of policies concerning energy prices and availability.

The intermediate level of the integrated approach treats the energy sector as a separate entity composed of sub-sectors such as electricity, petroleum, coal, and so on. This permits detailed analysis, with special emphasis on interactions among the different energy subsectors, substitution possibilities, and the resolution of any resulting policy conflicts. The final or micro-level pertains to analysis within the electricity subsector itself. It is at this most disaggregate level that most of the detailed energy resource evaluation, planning and implementation of projects is carried out.

In practice, the many levels of INEP merge and overlap considerably. Thus the interactions of electric power problems and linkages at every level need to be carefully examined. Energy-environmental interactions (represented by the vertical bar) tend to cut across all levels and need to be incorporated into the analysis. Finally, regional and spatial disaggregation may be required also, especially in larger countries.

Turning to the first column in Figure 5, there is an increasing need to ensure multi-actor participation in electricity decision-making (especially of the environmentally concerned public), but this involvement must be effectively structured to avoid paralysis in the sector -- which could result in costly power shortages. The existence of many and often conflicting policy criteria or goals (shown in the second column) is now complicated by pressing environmental considerations.

The INEP conceptual framework facilitates policymaking and does not imply rigid centralized planning. Thus, such a process should result in the development of a flexible and constantly updated energy strategy designed to meet the national goals mentioned earlier. This national energy strategy (of which the investment program and pricing policy are important elements), may be implemented through a set of energy supply and demand management policies and programs that make effective use of decentralized market forces and incentives. To reach the desired goals of sound energy management, a variety of policy instruments are available to decisionmakers, as summarised in fourth column of Figure 5. Since these tools are interrelated, their use should be closely coordinated for maximum effect. Finally, the column five indicates the most important impediments that limit effective policy formulation and implementation.

Policy Tools and Constraints

To achieve the desired national goals the policy instruments available to third world governments, for optimal and energy management include; (a) physical controls; (b) technical methods; (c) direct investments or investment-inducing policies; (d) education and promotion; and (e) pricing, taxes, subsidies and other financial incentives. Since these tools are interrelated, their use should be closely coordinated for maximum effect.

The chief constraints that limit effective policy formulation and implementation are: (a) poor institutional framework and inadequate incentives for efficient management; (b) insufficient manpower and other resources; (c) weak analytical tools; (d) inadequate policy instruments; and (e) other constraints such as low incomes and market distortions.

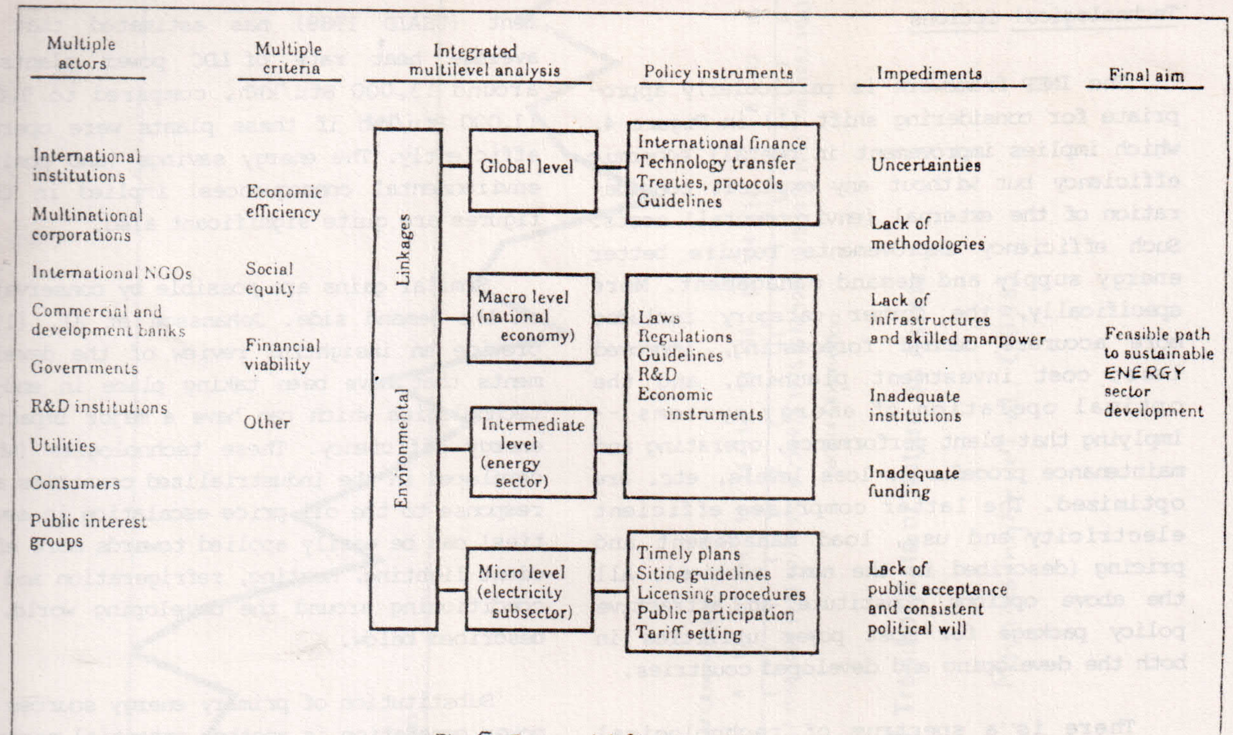


Fig. 5. Framework for decision making

Source: Munasinghe et al. (1991)

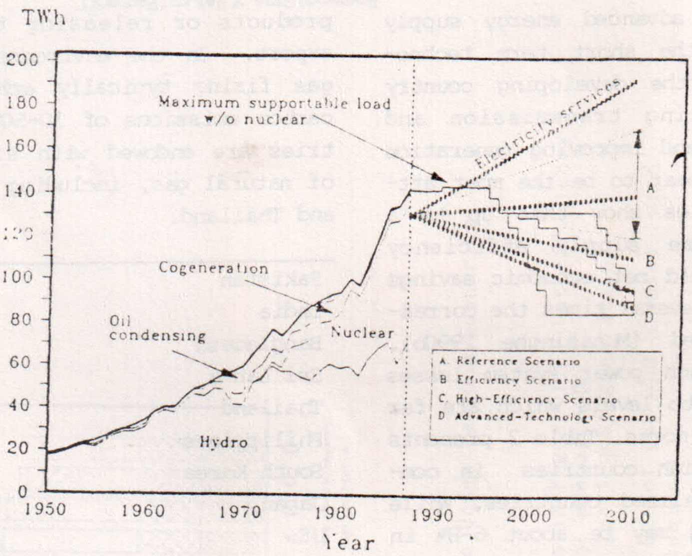


Figure 6. Generation Capability and Load Under Various Scenarios.

Notes:

1. Electricity services = end use efficiency frozen at 1987 level
2. Scenario A = normal penetration of energy efficient end use technologies (vertical arrows show range of uncertainty)
3. Scenario B = high penetration of energy efficient end use technologies that are cost effective and commercialised
4. Scenario C = same as scenario B, but includes uncommercialised newly developed technologies
5. Scenario D = same as scenario C, but includes advanced technologies still in the R&D stage
6. Downward stepped curves indicate generation capability with different options for phasing out 12 nuclear plants

Source: Bodlund et al (1989)

Technological Options

The INEP framework is particularly appropriate for considering shift (1) in Figure 4, which implies improvement in overall economic efficiency but without any explicit consideration of the external (environmental) costs. Such efficiency improvements require better energy supply and demand management. More specifically, the former category includes more accurate demand forecasting, improved least cost investment planning, and the optimal operation of energy systems -- implying that plant performance, operating and maintenance procedures, loss levels, etc. are optimized. The latter comprises efficient electricity end use, load management and pricing (described in the next section). All the above options constitute an attractive policy package for most power utilities in both the developing and developed countries.

There is a spectrum of technological options which the developing countries could potentially utilize in order to improve energy efficiency and thereby reduce environmental effects arising from energy sector activity. These range from simple infrastructural retrofits to the use of advanced energy supply technologies. Among the short term technological options for the developing country power sector, reducing transmission and distribution losses, and improving generation plant efficiencies appear to be the most attractive. Recent studies show that up to a certain point, these supply efficiency enhancing measures yield net economic savings or benefits that are several times the corresponding costs incurred (Munasinghe 1990b). While estimates of such power system losses vary, they all point to levels which are far in excess of accepted norms. Table 2 presents estimates for some Asian countries in comparison with industrialized countries. While acceptable loss levels may be about 6-8% in transmission and distribution as a percentage of gross generation, these losses in third world power systems are estimated to average in the 16-18% range (of which about one third could be theft).

The consequences of reducing these losses can be quite important. On the basis of our previous estimates of capacity requirements, a one percentage point reduction in losses per year would reduce required capacity by about 5 GW annually in the developing countries. The estimated saving in capital investment would be around 10 billion dollars per year. Meanwhile, the Agency for International Development (USAID 1988) has estimated that the average heat rate of LDC power plants is around 13,000 Btu/kWh, compared to 9,000-11,000 Btu/kWh if these plants were operated efficiently. The energy savings (and positive environmental consequences) implied in these figures are quite significant also.

Similar gains are possible by conservation on the demand side. Johansson et al. (1987) provide an insightful review of the developments that have been taking place in end-use technologies which can have a major impact on energy efficiency. These technologies (which developed in the industrialized countries as a response to the oil price escalation in seventies) can be easily applied towards more efficient lighting, heating, refrigeration and air conditioning around the developing world, as described below.

Substitution of primary energy sources in power generation is another potential means of achieving dual benefits. In the developing world, natural gas is the most likely candidate for coal or oil substitution. The economic benefit of natural gas substitution comes from either import substitution for petroleum products or releasing these products for export. On the environmental front, natural gas firing typically achieves reduction in carbon emissions of 30-50%. Many Asian countries are endowed with significant resources of natural gas, including Malaysia, Indonesia and Thailand.

Pakistan	28%
India	22%
Bangladesh	31%
Sri Lanka	18%
Thailand	18%
Philippines	18%
South Korea	12%
Japan	7%
US	8%

* These loss estimates include non-technical losses (i.e. due to deficient metering and theft).

Table 2- Electrical Transmission and Distribution Losses (% of gross generation)*

Sources: The World Bank and USAID

In the longer term, the developing countries will need to rely on more advanced technological options which are currently being developed in the industrialized countries. As we have discussed above, power generation capacity in developing countries is expected

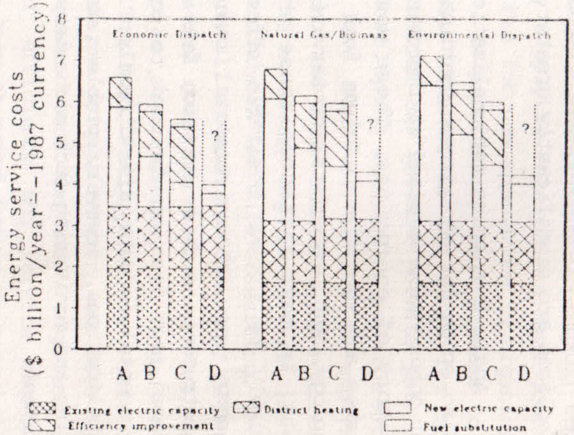


Figure 7. Total Energy Supply Costs Under Various Scenarios.

Notes:

1. Scenarios A to D are the same as in Figure 1.6, but efficiency improvement costs are unknown for scenario D
2. Economic despatch = traditional least cost generation expansion and operation
3. Natural gas/biomass = intensive use of gas and biomass, with coal use banned (to limit CO_2 emissions)
4. Environmental despatch = generation expansion and operation in order of increasing CO_2 emissions per kWh produced

Source: Bodlund et al (1989)

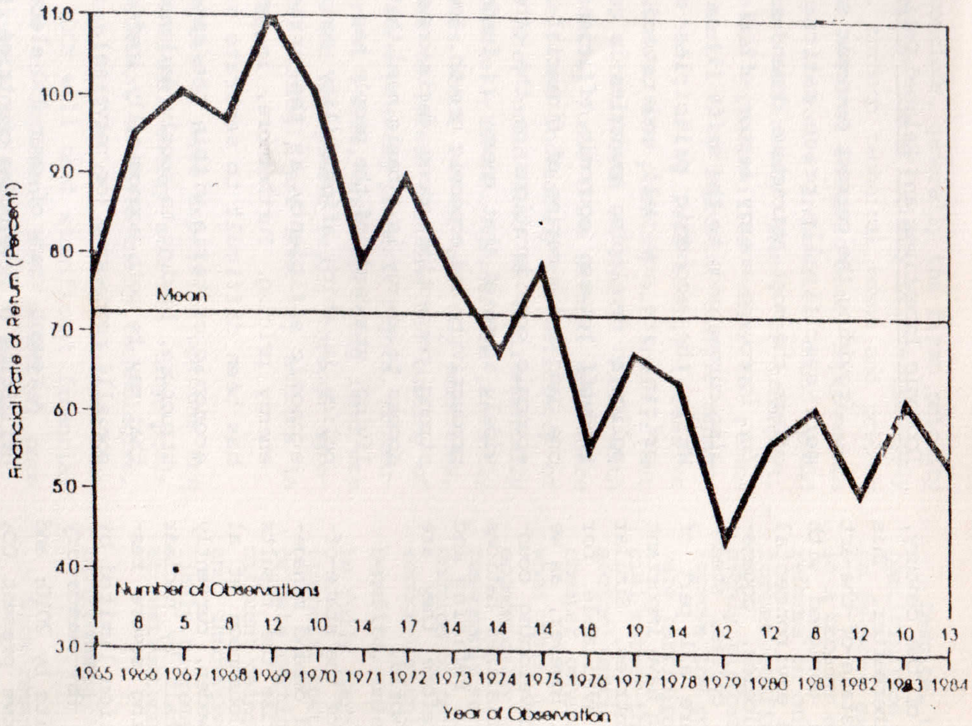


Figure 8 Trend of Rate of Return on Assets.

Source: Munasinghe et al. (1988)

to nearly double by the turn of the century, and will increase further thereafter. This provides opportunities to add state-of-the-art technologies which have been designed with regard to both economic and environmental criteria. Clean coal technologies, cogeneration, gas turbine combined cycles, steam-injected gas turbines etc. are all part of this menu of technologies which have important potential in developing countries. Similar applications will become available for emission control technologies. However, as we have argued previously, the developing countries will look to the industrialized nations to provide the leadership in refining and proving these technologies before they are implemented in the developing world.

As one indicative example of the state-of-the-art in supply planning and demand management possibilities, we summarize the results of a recent Swedish study (Johannson et al 1989). The power sector in Sweden, currently supplied half by hydro and half by nuclear generation, faces the following severe restrictions: (a) hydro expansion limited by environmental constraints; (b) mandatory phasing out of all nuclear units by 2010; and (c) no increase permitted above present CO_2 emission levels. The demand for electricity derived services is projected to increase by 50%, from 1987 to 2010. If end use efficiency remained unchanged, then under this "frozen efficiency" scenario, the electrical load also would increase by 50%, from 129 TWh in 1987 to 195 TWh in 2010, at an average annual growth rate of 1.8%.

The same output of electrical services could be provided, but with steadily declining electricity input needs and load levels -- based on the increasingly energy efficient scenarios A, B, C and D, shown in Figure 6. The corresponding loads in 2010 would be 140, 111, 96 and 88 TWh, respectively. Only options C and D permit the load to be met after all the nuclear plants are retired in 2010. Figure 7 indicates that the total costs of energy supply also fall progressively under the scenarios A through C (some of the costs are undefined for scenario D). In addition, there are three supply scenarios based on different selection rules for generation -- the supply costs rise steadily as we move through the economic despatch, natural gas/biomass, and environmental despatch options. These costs exclude taxes and subsidies, and are based on a 6% discount rate, 1987 world oil and coal prices, and coal equivalent gas prices for steam power generation.

Economic Incentives and Related Options

Providing the correct economic signals, or more specifically price rationalization, offers the most attractive demand-side option for improving energy sector efficiency, that also corresponds to the shift (1) in Figure 4. While the economic principles of energy pricing are now well understood, pricing policy in developing countries is guided by a tradeoff between economic efficiency on the one hand and a series of financial and socio-economic considerations on the other. It is widely accepted that energy is fundamental to productivity and economic growth. However, the strong perception among decisionmakers that access to energy is a basic need that improves living standards of the people has driven a policy in which affordability competes with economic efficiency as the criterion for energy pricing. Furthermore, in practice it has been difficult to separate social and economic criteria within the same pricing structure, leading to poorly designed policies that may be both economically inefficient and socially regressive (or perverse).

A recent study of over 350 electric power util;ities in developing countries (Munasinghe et al 1988) indicates that electricity tariffs have not kept up with cost growth. The operating ratio(defined as the ratio of operating costs before debt service, depreciation and other financing charges, to operating revenue) for the extensive sample studied deteriorated from 0.68 in the 1966-73 period to 0.80 between 1980 and 1985. At the same time, the financial rate of return on fixed assets has decreased steadily from over 10 percent in the mid-1960s to around 5 percent in the mid-1980s (see Figure 8). In some countries these declines are significantly greater.

Apart from price rationalization, there is also scope for applying a coordinated package of other measures aimed at improving the efficiency of energy use. These would include taxes and subsidies based on fuel type, technology, R&D, retrofits, conservation programs etc. In most instances these programs are likely to achieve desirable effects on both energy use and environmental impacts. Fiscal instruments such as emission fees and carbon-based user fees can be used to control environmental impacts more directly. In many LDC applications, however, problems of implementing and monitoring such mechanisms are significant.

To conclude, generally the first priority is to improve the efficiency of energy supply and use, through technical means and pricing energy at marginal economic cost. Improvements in energy intensive industries could yield significant efficiency gains. In transport, considerable opportunities exist to reduce fuel consumption by improving traffic management methods, using less energy intensive travel modes, and phasing out inefficient vehicles. Substitution of fossil fuels with less polluting fuels (like natural gas, where available), and increasing the efficiency of fuelwood use, could also be environmentally and economically sound. Agriculture presently contributes about 14% of all CO_2 emissions, mainly due to forest clearing and burning of wastes. Strengthening property rights, protecting forest lands, and improving land use planning and management (e.g., through agro-ecological zoning), are some key actions in this sector.

Examples of more expensive options are non-conventional energy sources, large-scale reafforestation, advanced energy technologies, and substitution of chlorofluorocarbons (CFCs). LDCs will need significant financial assistance to implement such measures, once the less costly options have been exhausted.

National Level Organizational/Institutional Options

The energy sector in developing countries is typically owned and controlled by the government, and is characterized by large monolithic organizations. While there is some rationale for this centralization, it could be a critical barrier in the path of greater efficiency and improved flexibility. The desperate circumstances of many developing country energy supplying enterprises have generated pressures for new approaches to organizing the sector. In particular, there appears to be considerable interest in the scope for more decentralization and greater private participation. Developing countries power sector officials have been very active in studying this option, and some countries have already prepared the necessary legislative and institutional groundwork for this transition. India plans to install as much as 5000 MW of private power capacity over the 1990-95 period, and similar plas are underway in Indonesia, Malaysia, Thailand, Philippines and Pakistan. In Sri Lanka, a private company has been distributing power since the early eighties and significant efficiency and service improvements have been observed during this period.

Despite these trends, enhanced private participation in the energy sector is likely to be more successful when it is one element in a broader economic package involving policy reforms in other parts of the economy. Market forces confined to the power sector in a highly distorted economy may not necessarily improve the power sector situation since private participants will try to maximize financial rather than economic costs. Thus, private sector participants would make full use of cheaper generation inputs such as coal even when this is potentially detrimental (both economically and environmentally). Even in a reasonably market oriented economy, the introduction of private participation in the energy sector is unlikely to lead to environmental benefits, unless the costs of pollutants can be fully captured (i.e. internalized) in the financial cost to the participant. Thus, while private participation is likely to bring significant gains by the infusion of new capital and innovative management methods, it is likely to remain one of several methods aimed at restructuring the sector.

Environmental Costs

With regard to environmental issues, the national environment in which the utility functions is likely to play an equally important role. Actions of the utility need to be backed up by a set of consistent national policies and legislative support. The development of environmental standards and regulations is likely to (and should) take place outside the utility, and the public needs to understand the importance of a commitment to a program of environmental mitigation.

Our integrated framework also provides an appropriate starting point for consideration of shift (2) in Figure 4, that seeks to incorporate the quantifiable environmental costs. A number of techniques exist for valuing environmental impacts of power projects, and these can be used for incorporating environmental costs into methodologies mentioned above for least-cost planning and estimating LRMC of energy production. However one should be aware of the uncertainties in such estimates and be prepared to perform sensitivity tests where appropriate.

Going beyond the quantifiable environmental costs is of course problematical, but to the extent that these costs are significant an attempt must be made rather than implicitly assuming that these costs are neglible.Non-quantifiable environmental costs can be incorporated in various ways, such as adding new constraints on the optimization that reflect social concerns or absolute environmental standards, or even by using an entirely different methodology than least-cost planning e.g. a type of multi-attribute assessment. This is still within the tradition of INEP, although the various trade-offs would be made explicitly on social-environmental criteria rather than implicitly in economic terms.

GLOBAL ENVIRONMENTAL ISSUES IN THE LDC CONTEXT

The developed and the developing countries are at different points in resolving domestic energy-environmental interactions and this is an important difference which must be taken into account when devising forms of cooperation for solving transnational and global energy-environment problems. Developing countries still have considerable scope for environment-improving activities that are economically attractive for them, e.g., energy conservation and ameliorating the domestic environmental consequences of energy use. These actions will, of course, have positive global environmental benefits also. While no country can be said to have exhausted the potential for shifts (1),(2), and (3),the developed countries are generally closer to D in Figure 4, at which point they need to explicitly consider trade-offs in domestic policy options to improve the global commons.

The foregoing sets the context within which the developing countries are capable of participating in environmental mitigation efforts at the global level. It is quite obvious that LDCs do not have the ability to contribute financially for global environmental cleanup efforts where the measurable benefits to the national economy are too low to trigger investment. Indeed, this paper has argued that many LDC projects which do have positive measurable benefits at the national level are being bypassed on account of capital constraints.

The principle of assistance to developing countries for environmental mitigation efforts, in terms of technology transfer, financial support and other means, is already well established. The Montreal Protocol, which was adopted in 1987 as a framework within which reduction in the consumption and production of certain types of chlorofluorocarbons (CFCs) is to be achieved, recognized the need for global cooperation and assistance to the developing countries. Subsequent Ministerial Conferences on various aspects of global environmental issues have reinforced the idea of protecting the global commons.

Currently, discussions are underway among world bodies and governments to define effective criteria and mechanisms for both generating and disbursing funds to address global environmental issues. While a broad workable agreement will not be easy to reach, global financing issues might be analysed and resolved through a tradeoff involving several criteria: <u>affordability/additionality</u>, <u>fairness/equity</u> and <u>economic efficiency</u>.

First, since LDCs cannot afford to finance even their present energy supply development, to address global environmental concerns they will need financial assistance on concessionary terms that is additional to existing conventional aid. The latter will have to be increased also, to assist developing countries in dealing with local environmental degradation. Second, as noted in the recent Brundtland* Commission report, past growth in the industrialized countries has exhausted a disproportionately high share of global resources, suggesting that the developed countries owe an "environmental debt" to the larger global community. This approach could help to determine how the remaining finite global resources may be shared more fairly and used sustainably. Finally, the economic efficiency criterion indicates that the "polluter pays" principle may be applied to generate revenues, to the extent which global environmental costs of human activity can be quantified. If total emission limits are established (eg., for CO_2), then trading in emission permits among nations and other market mechanisms could be harnessed to increase efficiency.

One specific mechanism that has recently been implemented includes a core multilateral fund of about US$ 1.5 billion - the Global Environment Facility (GEF) - to be implemented as a pilot over the next three years. This fund would finance investment, technical assistance and institutional development activities in four areas: global climate change, ozone depletion, protection of biodiversity, and water resource degradation. A more narrowly focussed Ozone Fund of about US$160 to 240 million has been set up also, to help implement measures to reduce CFC emissions under the Montreal Protocol. Both funds are being managed under a collaborative arrangement between the UNDP, UNEP and the World Bank. In particular, they would fund those investment activities that would provide cost-effective benefits to the global environment, but would not have been undertaken by individual countries without concessions. Thus, these funds are being specifically designed to fill the void which is created by the lack of individual national incentives for those activities which would, nonetheless, benefit us all.

CONCLUSIONS

International pressures to implement environmentally mitigatory measures place a severe burden on developing countries. The crucial dilemma this poses to LDCs is how to reconcile development goals and the elimination of poverty -- which will require increased use of energy and raw materials -- with responsible stewardship of the environment, and without overburdening economies that are already weak. This paper has argued that in view of the severe financial constraints that developing countries already face, the response of these countries in relation to environmental preservation cannot extend beyond the realm of measures that are consistent with near-term economic development goals. More specifically, the environmental policy response of LDC's in the coming decade will be limited to conventional technologies in efficiency improvement, conservation and resource development.

The developed countries are ready to substitute environmental preservation for further economic expansion and should, therefore, be ready to cross the threshold, providing the financial resources that the LDC's need today and developing the technological innovations and knowledge-base to be used in the 21st century by all nations. The Global Environmental Fund and Ozone Fund, presently being established, will facilitate the participation of LDCs in addressing issues at the global level.

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