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REPORT ON GLOBAL WARMING AND ASSOCIATED IMPACTS

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REPORT ON GLOBAL WARMING AND ASSOCIATED IMPACTS

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Examining the Replacement of coal by natural gas in utility and industrial application

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Introduction

Addressing concerns about the greenhouse effect entails efforts to limit carbon dioxide emissions from fossil fuel use. There are four major categories of interventions to accomplish this: enhancement of energy efficiency; substitution of high-carbon fuels by low-carbon fuels; development and deployment of renewable (non-carbon) energy technologies; and sequestering of carbon dioxide emissions. Many technical options exist in each category. There are, often, additional economic and environmental benefits also associated with the adoption of these options; yet, the national economy does not easily adopt them. At present, the key questions concern not the technologies themselves, but the constraints to their effective incorporation into the economy, the strategies necessary to encourage this incorporation, and the policies required for the implementation of these strategies. This paper addresses these issues in the perspective of devising strategies and accompanying policy interventions that encourage sustainable energy-efficiency practices in the Indian economy. The emphasis here is on the development of capabilities that can internally generate processes that continuously create the need for energy-efficiency enhancement, rather than on periodic technology imports that are inefficiently utilized.

Energy Efficiency in the Indian Economy

In a macroeconomic sense, all economies (including the Indian economy) exhibit a decrease in energy intensity (i.e., the amount of energy required per unit of GDP) with increasing affluence (e.g., per capita GDP). Figure 1 shows this trend for a number of countries; note that energy consumption includes biomass fuels. In the initial stages of development, the decrease is due to the switch from biomass fuels (which are utilized with very low efficiencies) to commercial fuels (which have much higher end-use efficiencies). As industrialization progresses, a simultaneous shift in both fuels and technologies, spurred by reasons of economic efficiency, lowers the energy intensity of the economy. Beyond a per-capita GDP level of about $7,000 (at 1980 prices), structural shifts in the economy result in a decoupling of the energy-GDP link (Janicke et al., 1989), and to a continuing decrease in the energy intensity of the economy.

In the present Indian energy scenario, fossil-fuel use accounts for nearly all energy-related carbon dioxide emissions. Net biomass burning results in 0.59 Tg of carbon dioxide emissions annually, while fossil fuels account for 541.52 Tg (TERI, 1990). In the context of global warming, therefore, it is necessary to examine the commercial energy intensity of the economy, rather than the total energy intensity. Figure 2 shows the commercial energy intensity: despite fluctuations, a relatively steady trend is visible. A sectoral examination provides useful insights: Figures 3, 4, 5 and 6 show the energy intensities of the industrial, transport, agricultural and residential sectors, respectively. In the transport and industrial sectors, a decreasing trend is observed, while in the residential and agricultural sectors, the trend is an increasing one. In the latter sectors, this is largely due to the low-base of energy use, as well as because of the continuing shift from biomass to commercial fuels.

The periodicity of energy-intensity decreases in the industrial and transport sectors needs special attention: the decreases correspond to imports of new technologies which result in a short-term increase in energy-efficiency. However, with time, the energy-intensity rises again, till the next round of liberalisation in the economy when a fresh batch of technologies is imported. This indicates the lack of an internal engine for continual energy-efficiency upgradation. The existing path is clearly economically inefficient.

The Indian Energy Market

Pervasive imperfections in the Indian energy market create many opportunities for cost-effective savings: the absence of competitive markets, skewed price structures, and constraints in access to technologies are the most frequently cited imperfections. However, in these tumultuous times, as the country moves towards the establishment of a market economy, these constraints are weakening; there is a growing acceptance of the market as the most efficient mechanism of capital allocation, and of full-cost pricing (especially in the energy sector) as a necessary precondition for financial stability.

In the move towards encouraging marketisation of the energy sector, the lending of the multilateral development banks, particularily the World Bank, has emphasized the dismantling of barriers to competition, and restructuring of institutional configurations (including privatization of public-sector energy enterprises) so as to establish financial and administrative policy regimes that encourage competition, fair pricing, and technological development; establishment of domestic capital markets; ensure access for all to the market; and promote fiscal, rather than physical controls (World Bank, 1989a; 1989b; 1990a; 1990b). These are aimed at ensuring the establishment of energy markets; it is expected that this process of marketisation would be accompanied by increases in efficiency - of capital utilization, of labor productivity, as well as of energy use.

However, it is important to note that one essential component of an efficient market mechanism is still lacking: the corporate technological capability for responding to price signals and other fiscal incentives (and disincentives) for enhanced energy efficiency. Energy conservation and technology transfer literature is replete with examples of unattained goals because of the lack of response capacities; on the other hand, significant relationships between the strength of technological capabilities of firms and their levels (and trends) of energy efficiency, as well as their ability to respond to fiscal signals (aimed at enhancing energy efficiency) have also been well documented (see, for example, Quazi, 1983; Chantramonklasri, 1985; Lall, 1987; Enos and Park, 1988; Pachauri, Mathur and Natarajan, 1989; Carvalho, 1990).

At present, firms and individuals in the economy do not possess the capability to generate and manage change (Bell, 1990) in a large-scale sense; a history of a regulated economy has rendered this capability redundant. Consequently, new technologies often do not operate at design efficiencies, exhibit a downward trend with time, and undergo drastic reductions in efficiency if external conditions force changes in inputs, operating conditions, or of the product specifications (World Bank, 1988; Kumar and Sharan, 1990)

The process of marketisation is expected to encourage the introduction of new and efficient technologies in the Indian markets. It is feared that if this introduction is not accompanied by the simultaneous development of capabilities within the firms to generate and manage change, the large energy savings potential would not be realized. Moreover, as energy efficiency accompanies other efficiencies, its absence could also mark the large-scale failure of technology-based firms in the marketising economies: possibly spelling doom for the process itself.

Capabilities to Generate and Manage Change

What is this capability? What is necessary to acquire it? And, what would it take to encourage its development across the marketising economies ?

Two issues have to be considered while defining this capability. The first is the ability to exploit a technology efficiently, as well as innovate to enhance its performance. The second is the ability to respond effectively and rapidly to economic signals in the market so as to maintain (and enhance) efficiencies of labor productivity, energy use, and capital utilization.

What does it take to achieve this capability? In the highly regulated electricity industry in India, two companies have consistently maintained operating efficiencies far in excess of the national average, demonstrating a capability to rapidly absorb new technology and often operate it with efficiencies higher than they were designed for. Also, in response to changes in the quality of coal and lignite supplied to them, they have successfully carried out technological modifications that enable them to handle fuel of a substantially different quality than what their plants were originally designed for, and still exceed original design efficiencies (Narayan and Kalia, 1989; Soundarajan, 1990).

In both the companies, the prime reason for the success seems to be their conscious development of a group of professionals who continuously interact with both technology vendors and plant operators. These are highly talented people who monitor plant performance and gain an understanding of the problems that hinder efficient operation through discussions with plant operators. They also follow technological development in the electricity industry, are involved in it by way of their interactions with technology manufacturers to solve present operating problems. Over a period of time, they have acquired the ability to understand what it takes for the technology to operate at its most efficient level, and to engineer cost-effective measures to maintain plant efficiency in the face of changing conditions. Their cumulative experience has also been fed forward to improve the engineering of new projects and the quality of recent technology purchases.

These groups are the link between two important processes in the market: the production of goods, and the development of technology for that production. The surprising fact is that though the need for developing these "human-endowed technological capabilities" (Bell, 1990) seemingly self-evident, they are highlighted in the marketising economies only because of their rarity. The reason is largely economic: these capabilities need a long time (on a business timescale) to show results, and require highly-talented professionals (Soderstrom, 1991). Both these translate to additional costs.

And in economic environments where change is slow and regulated, there is no incentive to invest in these capabilities which leads to decline in performance (World Bank, 1990a; 1990b).

Sustaining the process of marketisation will necessitate the large-scale development of human-endowed technological capabilities to generate and manage change. Their importance is best illustrated by examples from countries that have successfully marketised themselves recently. In Korea, the national electric utility's economic and technical performance improved steadily through the seventies and the eighties, and today compares favorably with that in the industrialized countries (UNCTAD, 1985). Behind this trend lies a record of constant learning and training so as to strengthen its technical, managerial, and engineering skills. This involved a variety of efforts that included an emphasis on the learning and understanding of technology equal to that on the acquisition of goods and services while dealing with foreign consultants and technology vendors; training of large numbers of engineers and operators in overseas plants and engineering design organizations; and internal procedures (including financial incentives) to reinforce learning through interaction of experience and training. A consequence of this process is that the managerial and technical capabilities that were developed have seeded other technology-based firms that have been established in Korea; many of which are already major internationally competitive companies.

Strategies to Sustain Energy Efficiency

Any initiative seeking to encourage energy efficiency would have to incorporate the development of change-managing capabilities that encourage the enhancement and sustenence of energy efficiency in firms in the marketising economies. The development of these capabilities requires, first and foremost, corporate commitment. However, in economies in transition, where, till recently, the development of these capabilities could have been a liability, and where the emerging markets, as yet, do not do not actively necessitate their existence, macroeconomic policies are required to stimulate their expeditious development. The differences in the manner in which the economies of the countries in transition operated prior to marketisation, and the differences in the forces which drive the transition, imply that the actual policies and the instruments used to implement those policies, will be country specific. The overall goals and strategies would, however, be similar.

Opportunity Costs of Capability Development

The first strategy would involve the incorporation of the costs associated with capability development in the overall financial framework of the firm. This implies, first, an acceptance that the absence of human-endowed technological capabilities represents lost opportunities. Second, that an assessment of these lost opportunities is required. Such an assessment could be based on a comparison of performances of firms with and without this capability, particularly in the marketising economies. The goal would be to understand, in economic terms, the opportunity cost of developing this capability, and hence the investment justified in its development. Without minimizing the difficulties involved, and the wide variations expected in the assessments because of firm size, nature of business, level of uncertainty in the market, etc., they would provide an explicit rationale for incorporating investments for capability development in financial planning. Assessments and modified cost-benefit procedures should be encouraged by governments, financial institutions, and multilateral agencies such as the World Bank. The latter's role is important because of its pervasive influence and ability to enable cross-country analyses. The assessments themselves would probably be most effectively carried out by independent bodies, such as industry associations and policy research institutions. In the United Kingdom, the Science Policy Research Unit of the University of Sussex has initiated such assessments; in India, so has the Tata Energy Research Institute.

Financial Incentives

Encouraging firms to develop capabilities to manage change by providing them opportunities to expand into new market segments would be the second strategy. A possible configuration to achieve this goal could be the establishment of venture capital funds to finance projects that involve some inhouse engineering before commercial production can commence. Most marketising economies do not have institutions that provide venture capital; most bankers in these countries are not comfortable with risk-based lending that involves pre-commercial development as well. Three years ago, the U.S. Agency for International Development established a program along these lines in

India. Called PACER (Program for the Acceleration of Commercial Energy Research), it is managed by an Indian financial institution, and provides loans to firms on a profit- (or loss-) sharing basis for the commercial production of energy-efficient technologies. The projects necessarily have to involve some technological development activity: often, it is the adaptation of imported technologies to suit the Indian market; at other times, it is the upgradation of existing technologies, or engineering new technologies for which there is a perceived need. It is too early to evaluate the role of PACER in human-endowed technological capability development in the Indian market; anecdotal evidence suggests a positive correlation in the vast majority of the firms involved in the Program.

Scope and Depth of Technology Transfer

The third strategy would be to deepen the content of technology transfer. Bilateral and multilateral agencies can play a more direct role in financing (through mechanisms that may vary from country to country) the costs of developing the capability to generate and manage change in the recipient firms in the marketising economies. It is important to note that this converts a one-step transfer into a long-term process. Typically, the transfers do provide for some training, but the depth and scope of technology transfer would have to be enhanced if indigenous capabilities are to be developed. In terms of capability development and technology absorption, an alternative route that should be followed, where possible, is to acquire technology from another firm in the marketising world, or in the recently marketised countries. In such cases, the experience of the technology vendor in assimilating and utilizing the technology efficiently is of far greater relevance to the technology recipient. The need and the necessity for developing capabilities to manage technological change are also more forcefully impressed on the recipient (as well as on financial institutions).

Longer linkages; involvement of the recipient firms in problem-solving associated with the technology elsewhere in the world; and possibly their involvement in future technological development, would improve capability building in the marketising economies. This complicates the direct connection between financial transfers and the provision of goods and services, but could still be handled in a financially accountable manner by the incorporation of assessments suggested in the first strategy. The mechanisms could be managed in a manner similar to the technical assistance program of the United National Development Program (UNDP). A necessary corollary of this process is that relationships between transnationals and their licensees in the marketising economies would need to be revaluated. It might be beneficial to both parties to invest in joint ventures rather than outright technology licensing. In this perspective, concerns such as intellectual property rights would have to be addressed by the governments of the marketising economies to persuade the transnationals to have deeper ties with their countries.

Energy Efficiency Standards

The development of a process of evolutionary standards in the marketising economies is the fourth strategy to encourage the development of human-endowed technological capabilities to manage change. Product performance and safety standards are necessary to ensure that products can enter the international market. However, in many instances, it may not be possible to impose a one-step change from existing practices to international standards; the governments may then adopt an evolving set of standards that encourages the development of this capability as the most cost-effective means to maintain compliance with standards. Escalating efficiency standards imposed by government on U.S. appliance manufacturers required firms to innovate or exit. In the process, surviving companies developed engineering expertise which has been repeatedly called upon to meet new technical challenges, including finding alternatives to CFCs while simultaneously ensuring compliance with tougher energy standards for refrigerators (Hallett, 1991). While this non-market -driven technology-forcing has been costly, it has resulted in refrigerators which use 55% less energy than in 1972, and is possibly one of the reasons why Japanese refrigerators have not displaced American refrigerators in the U.S. market.

Education and Training

Finally, the governments of the marketising economies will have to recast their education systems. There is a need to provide advanced and applied technological and managerial training to people in whom the capabilities to manage technological change are to be endowed. To a certain extent, this is available in the Soviet Union at its applied technological institutions. However, their focus would have to widen from technological development alone to technological change. Also, as skills to manage change are acquired cumulatively, they are not easily communicated through traditional pedagogy. Short-term advanced courses for working professionals would need to be designed and established. The industrialized countries have institutionalized this process through courses organized by professional organizations, training institutes, etc. Their experience may be utilized, again with the help of organizations like the World Bank and UNDP, to establish similar structures in the marketising economies. The content of these courses would, however, be best culled from experiences in the marketising economies themselves, or from those in the recently marketised economies.

The ability to mould the process of human-endowed technological capability development in the marketising economies also provides a historic opportunity to ensure that environmental concerns are as deeply ingrained as technological and financial concerns in the thought processes of the people who will actually determine the technological structure of the marketising economies. Incorporating environmental analyses and perceptions in the training processes would contribute greatly in ensuring that responses to change by individual firms protect and enhance both environmental quality and the firm's profitability. Over the economy, it could enmesh global sustainability with market sustainability.

In order to illustrate the mix of strategies required, a case-study is presented here which is presently underway. The Tata Energy Research Institute is involved in this exercise, alongwith Indian manufacturers of refrigerators, compressors, and refrigerants, as well as the Ministry of Environment and Forests, Government of India.

The Indian Refrigerator Industry: Opportunities and Constraints

The Montreal Protocol to ban Ozone Depleting Substances (ODS) is the first international agreement to phase out the production and consumption of an entire class of man-made chemicals in the interest of the global environment. This treaty was established with an understanding of the costs that this phase out would entail. The subsequent London amendments to the Montreal Protocol acknowledged the requirement of special provisions to meet the needs of developing countries. These amendments provide for additional financial resources and access to relevant technologies by establishing a Multilateral Fund to meet the incremental costs of switchover to non-ODS technologies. Although India is not yet a Party to the Protocol, the Government has expressed its commitment to join the Protocol once the London Amendments have been ratified by the Parties to the Protocol.

The Refrigerator Industry in India

The current stock of refrigerators in India is about 7 million; and annual production is of the order of 1.25 million, increasing at over 20 per cent per year. It is projected that the stock and annual production would increase to 32 million and 5 million, respectively, by the year 2000, and to over 110 million and 13 million, respectively, by 2010. At that time, the overall penetration of refrigerators in domestic households would still be less than 60 percent. Currently, all the CFC requirements in India (except those of CFC-113 and halons) are met by domestic production. The total production of CFC-11 and CFC-12 is presently about 4,300 tonnes, and growing at about ten percent per year. The refrigerator industry utilized about 600 tonnes of CFC-11 and CFC-12 in 1990. This consumption is expected to increase to about 3,500 tonnes in 2000, and 9,000 tonnes in 2010 (the year by which complete phase out of ODS is expected in India).

The capacities of refrigerators manufactured in India are generally in the 2.3 to 13.4 cubic feet (65 to 380 liters) range, with the 6.8 cubic feet (165 liters) model being the most popular and accounting for 93 per cent of sales in 1990. The preference for the small refrigerator size is largely due to the limited buying power of individual customers, which is accentuated by a tax structure that imposes a large jump in excise duty for refrigerators larger than 6.8 cubic feet. In the tropical climate of India (with an annual average temperature of about 90 degrees Fahrenheit, and relative humidity greater than 85 percent for at least three months of the year), the main service required of refrigerators is the provision of cold water and ice. Fresh produce and milk are refrigerated, but the requirement for maintaining frozen foods is much less. Compressors are overdesigned so as to accommodate the poor quality of electric supply (with voltage fluctuations ranging from 125 to 270 volts, as against the norm of 220 volts). Consequently, average annual electricity consumption of the 6.8 cubic feet refrigerators is of the order of 500 kWh; about 30 per cent higher than the maximum allowable electricity consumption of U.S. refrigerators of the same size.

Strategies for the Commercialization of CFC-free, Energy-Efficient Refrigerators in India

The unique combination of services required from refrigerators in India, the economic and demographic patterns, and the climate dictate the development of a unique refrigerator technology for India. Thus, the choice of ODS substitutes and accompanying component technologies for Indian refrigerators must be undertaken in response to the Indian situation. The electricity shortages in India, and the present level of electricity consumption of Indian refrigerators also imply that immediate quantum jumps in their energy efficiency are necessary. A three-pronged strategy is would be essential for the development and commercialization of CFC-free, energy-efficient refrigerators in India:

India should immediately launch an evaluation and assessment program for the identification of appropriate substitutes and the accompanying component technologies that are best suited to Indian conditions. The present uncertainty regarding substitutes, and the ten-year delay to which developing countries are entitled in implementing the phaseout, allows India time to make a decision. With this perspective, the appropriate strategy would be to test various substitutes and component technologies under Indian conditions so as to decide on the optimal combination for refrigerator performance in India. This is a developmental activity in which only U.S. and other foreign manufacturers with an active interest in the Indian market would be likely to participate. Other manufacturers with an interest in marketing their products to Indian manufacturers might also participate as part of a marketing effort. Such an activity would allow for the interaction of all manufacturers (of refrigerators, insulation, compressors, and refrigerants), without infringing on their proprietary rights. Intellectual property protection is a critical issue from the perspective of the U.S. manufacturers.

The establishment of evaluation and assessment program would benefit from the involvement of U.S. research and development professionals who are also involved in similar activities. The program could be funded by the Global Environmental Facility, by bilateral funds, as well as by the Multilateral Fund of the Montreal Protocol after India becomes a Party to the Protocol.

The Indian refrigerator manufacturers and research and development organizations should immediately take steps to enhance the energy efficiency of refrigerators. In the United States, the switchover from fiberglass to blown foam was responsible for the initial decreases in electricity consumption; subsequent decreases were largely due to redesigned compressors and heat exchangers and improved control systems. These advances were based on CFC technologies; the U.S. manufacturers presently are addressing more stringent 1993 energy efficiency standards in the face of Montreal Protocol phase out requirements. The Indian compressor manufacturers should also upgrade technology, possibly taking advantage of PACER to import the technology and then adapt it to Indian conditions (by incorporating technologies similar to those used in uninterrupted power supplies, etc.) . Voluntary energy labelling may be considered by refrigerator manufacturers till energy efficiency standards are in place.

The Government of India should institute policies that encourage the development, commercialization, and adoption of energy-efficient refrigerators. These policies include:

(a) incentives for energy-efficient refrigerators (for example, by linking the excise duty to energy efficiency, rather than refrigerator volume or technology);

(b) development of energy-efficiency standards for refrigerators which evolve with time;

(c) initiatives for enhancement of power supply quality; and

(d) potential investments in demand side management (for example, the development and adoption of energy-efficient refrigerators) to redirect limited capital to investments in energy services when such investments prove more cost-effective than obtaining additional capacity exclusively through the purchase of additional generating capacity.

Conclusions

A wide range of issues have to be addressed in order to ensure that a sustainable energy efficiency trend is put into place in developing countries. The establishment of competitive markets and rational energy pricing are two essential features of this process. However, by themselves, they may not be adequate because of the lack of a capability in firms in developing countries to generate and manage the inevitable changes that accompany a market economy. The development of this capability is closely related to the overall ability of countries to develop a economic and intellectual culture based on economic efficiency. It must be stressed again here that energy efficiency accompanies other efficiencies (e.g., of capital and labor) in the economy, and consequently, energy efficiency enhancement strategies are necessarily economic efficiency enhancement strategies as well.

Finally, a caveat is in order: this paper addresses the question of energy efficiency enhancement in India only in the part of the economy that is, "organized", in the sense of individuals and groups being linked to each other through their economic enterprise and its associated rewards. There are large fractions of the population who are, in a real sense, outside the organized economy. These people are generally poor and ill-educated and contribute marginally to the national economy; conversely, they are economically insensitive to market changes and signals. The first aim of developing country policies has been to ensure that these millions are also provided opportunities to join the organized economy. Opportunity structures, the provision of educational and health services, and of financial incentives for this purpose require, and are receiving, much attention; they have, however, not been addressed here.

At the present juncture, the development of human-endowed technological capabilities seems to be the crucial issue in attaining energy efficiency in developing countries.Human-endowed capabilities to generate and manage technological change are as essential to the sustainability of the marketisation process as are the rules that ensure competition and fair pricing. After all, markets are an expression of the aspirations and the endeavors of a people - and if the people are unwilling, or unable to exploit the advantages of a market economy, all policy regimes to ensure market efficiency are pointless; both sides of the market coin need to be equally heavy in order to keep it tossing fairly.

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