

Industrial energy efficiency in developing countries: present situation and scope for new initiatives

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Abstract

The manufacturing sector in developing countries accounts for a steadily increasing share of world energy consumption and global greenhouse gas emissions. This paper is based on a study on policies to stimulate improvement of energy efficiency in the industrial sector in developing countries. The paper highlights developments in respect of the efficiency of industrial energy use in Africa, Asia and Latin America. The paper begins to outline some salient features of energy and technology use in four energy-intensive industries. Subsequently, recent policy initiatives and institutional development in support of rational use of energy (RUE) in industry are considered. The paper concludes with national policy priorities in developing countries on industrial energy conservation and opportunities for international cooperation.

1. INTRODUCTION

This paper gives an overview of some highlights of the research project entitled: *Strategies and Instruments to Promote Energy Efficiency in Developing Countries*. The project falls into the theme called 'Sustainable Solutions' of the Dutch National Research Programme on Global Air Pollution and Climate Change (NOP/MLK). The project is financed by the NOP/MLK and by ECN and has been carried out jointly by ECN, ENDA, IEI and TERI. The study sets out:

- to make an assessment of policy strategies and instruments implemented in developing countries to promote more efficient use of energy in the industrial sector;
- to put forward recommendations on effective external assistance to improve the institutional framework and to enhance local capabilities to design and implement

measures and programmes to effectively stimulate efficient use of energy in the industrial sector of developing countries.

Although NOP/MLK is a national programme, the solution for global environmental problems is strongly dependent on the extent to which countries, especially but not only in the developing world, succeed in managing the crucial problems of:

- demographic developments
- eradication of poverty
- making economic development more environmentally compatible (with implications for both life style and production patterns).

These problems are of global relevance, but solutions have to be found at regional and national level. The Rio summit showed that these problems should be treated in a framework of international cooperation as wealth is distributed very unevenly across the world.

Sustainable solutions to the greenhouse effect necessarily have to address the energy issue. A growing energy demand results in a rapidly growing contribution to global CO₂ emissions [1]. The industrial energy demand in the developing world is already quite large and is bound to rise fast. In fact, the industrial sector is the most important energy end-use sector, accounting for almost one half of the final demand for commercial energy in the developing world. Typically, energy intensity of production in developing-country manufacturing plants is substantially higher than in their counterparts in OECD member states. It can be inferred that developing-country industry encompasses vast energy conservation potential. Besides, compared to other major final demand sectors - notably the residential and transportation sectors - actors in the industrial sector, if operating under competitive market conditions, tend to be more sensitive to market signals and government interventions.

The collaborative endeavour has adopted a diagnostic approach. Based on a survey of literature and existing knowledge with the participating institutes of their respective local situation, patterns of industrial energy use and policy instruments deployed to stimulate industrial energy efficiency are reviewed for three developing regions, i.e. Africa, Asia (excluding Japan), and Latin America.

The emphasis is on four country cases per region and four industrial subsectors per country. The decision was prompted by the size and the heterogeneity of the industrial sector, the vastness of the developing world at large, constraints of data availability and resource limitations for conducting this study. Special attention has been given to a selection of energy-intensive industrial subsectors, i.e., cement, iron and steel, aluminium, and pulp and paper.

As for the geographical coverage of the developing countries the emphasis is put on:

- for Africa: Cameroon, Senegal, Tunisia, and Zimbabwe;
- for Asia: Bangladesh, (Republic of) Korea, India, and Thailand;
- for Latin America: Bolivia, Brazil, Costa Rica, and Mexico.

In making this geographical choice it has been attempted to select a sample of four countries per region with a fair extent of representativity for the respective development regions in terms of size (large and small countries), industrial development phase, and geographical dispersion within the region.

2. PRESENT SITUATION

2.1. Sector findings

Introduction

This section describes the results of a comparison between technology and typical levels of specific energy consumption prevalent in selected manufacturing industries of developing countries and industrialized nations. This comparison and the information on which it has been based have been described extensively in the regional reports [2-4], the in-depth report on cement manufacturing [5] and energy consumption and production technology in industrialized countries [6].

Iron and steel

Specific energy consumption (SEC, i.e average energy use per unit of physical output) in steel production plants in developing countries takes on a wide range of values. For some developing-country plants it is comparable with SEC values prevalent in industrialized countries, whereas in others it is more than double. Part of this variation will undoubtedly be caused by difference in technology and operational practices. Furthermore, differences in energy carriers used, differences in the output structure within the industrial subsector among other local circumstances play a role. In developing countries, a major ongoing development is the upsurge in electric steel making from scrap. In part, new electric furnaces replace antiquated open-hearth furnaces, while on the other hand these contribute to capacity expansion. Dry coke quenching can be used instead of the traditional quenching with water. It improves coke quality, and reduces energy consumption (by recovery of heat) and dust emissions. Yet in a situation of large technological backlog, this would not be a technology to start with to improve energy efficiency. Several simpler and more cost-effective measures would be possible. Furthermore, continuous casting equipment is installed in an increasing number of production facilities. These technologies have proved to be reliable in various business environments prevalent in both industrialized and developing countries. The new production routes for steel still in the development stage are unsuitable for technology transfer projects, simply because they are not ready for production yet. Significant R&D-efforts are necessary to commercialize these concepts.

Aluminium

For aluminium production the difference in specific energy consumption between developing and industrialized countries is fairly small. Regional differences in SEC are as large as 7%, although differences between specific countries or plants can be 20% or more. Energy consumption in aluminium production depends strongly on the resource used. Aluminium can be produced from pretreated ore (alumina) in which the metal oxide is already freed from the ore matrix. In this case 'only' the electrolysis from alumina to aluminium has to take place. If the starting point is the raw ore, treatment is necessary, accompanied by significant environmental effects. Energy conservation options in developing countries will be similar to those in the industrialized world on many occasions. This is mainly so because of the predominance of transnational companies in the aluminium industry, also in developing countries. Developments with significant

impacts on energy consumption like the use of inert electrodes or the development of entirely new processes have not progressed far enough for wide scale implementation.

Cement

Differences in specific energy consumption between developing countries and OECD member states can be as large as 30%. Some clear options exist to improve this situation. The most important energy conservation measure is undoubtedly to blend clinker with a higher proportion of additives for cement making. In many developing countries additives are sparsely used. Energy conservation is roughly proportional to the amount of additives. Use of additives may not require special equipment. Rather information is needed about operational practice and characteristics of blended cements. A second important action is the change from the wet process to the dry process. This avoids the evaporation of water from the mix, which saves a significant amount of heat. In countries where national companies active in the cement sector are technologically backward, outside assistance - both financially and technically - may be needed. Furthermore, the use of a so-called precalciner has proved to improve energy efficiency and to be cost-effective.

Energy consumption data indicate elevated electricity consumption in developing regions. In OECD countries, significant improvement has been achieved in efficiency of grinding and mixing techniques. In many cases these technologies may be eligible for transfer to facilities which use older, less efficient equipment. The production of cement is also very suitable to use low-quality fuels such as waste products (e.g. tyres) and (cheap) coal. An advantage of the cement production is that residual material from such fuels can be used as additive.

Pulp and paper

The subsector 'manufacture of paper and paper products' poses special difficulties when comparing energy efficiency and technology based on figures on a national level. Quality of the output (different types of paper), type of resources used, level of integration of process steps (pulping, paper making), and the extent of waste utilization severely limit the drawing of conclusions on the technology employed based on energy consumption data only. On the energy supply side, installation of efficient solid fuel (wood residues/coal) boilers or cogeneration units seems possible at least in a number of cases in the investigated countries. Reduction of steam requirements by installation of improved pressing techniques, covering of evaporation area and insulation of process equipment may further reduce specific energy consumption. The development of small-scale chemical recovery units (to be used in chemical pulping process) would be beneficial to numerous small-scale paper manufacturing facilities.

Conclusions

There is ample scope for energy conservation in developing countries in iron and steel, cement production and most likely also in the pulp and paper, while developing-country energy conservation potential in aluminium production appears limited. Much of the typically high SEC values in the South, as compared to the North, can be explained by dated technology, smaller scale, differences in intra-industry output patterns, as well as differences in quality of raw material and fuel inputs. Although part of the underlying factors may prove hard to change. Yet special attention on the part of policy makers is in order. Table 1 summarizes areas in which a role can be played by external assistance.

Table 1
Technology transfer possibilities in studied sectors.

Sector	Technology transfer possibilities
Cement	<ul style="list-style-type: none"> - information and training on raising the share of additives - (conversion to) dry process - precalciners - efficient grinding equipment
Iron and steel	<ul style="list-style-type: none"> - electric furnaces - continuous casting - dry coke quenching
Aluminium	data point at relatively small differences in SEC between the OECD area and the developing world
Pulp and paper	<ul style="list-style-type: none"> - dual fuel boilers (e.g. biomass/coal) - small scale chemical recovery units - efficient pressing equipment - insulation measures - cogeneration equipment and legislative and regulative experiences

2.2. Regional issues

Africa

With the notable exception of Tunisia, the countries in the African region still focus almost exclusively on energy supply policy issues. The limited number of energy efficiency measures taken are quite recent and appear hesitant. These largely concern surveys of current efficiency levels and the scope for improvement. To date, only a few countries have to date ventured beyond the reconnaissance stage and then only marginally.

Effective institutional settings for the formulation of longer-term energy policies/strategies are conspicuously absent. Most regional economic cooperation organisations, such as SADC, ECOWAS and ECCAS, do not appear to give much specific attention to energy demand management issues, while even regional cooperation on energy supply has still made moderate advances. In some African countries, mainly in energy exporting countries, a line ministry is responsible for energy policy issues. In several other countries energy policy making is entrusted to energy directorates within a ministry or to national (inter-ministerial) energy councils. However, energy supply security and energy tariff issues are the dominant preoccupations. Besides, severe budget restrictions prevail on policy implementation.

In most African countries energy prices are still below economic costs. Hence, industrialists lack the proper incentives to investigate possibilities for improvement of energy efficiency. Furthermore, given the generally poor information infrastructure and the lack of capable energy service companies, transaction costs to African entrepreneurs for obtaining reliable information on feasible, low-investment-cost options to improve energy productivity are high. As a result, little awareness exists of the vast energy conservation potential that can be realised - even with the existing, largely dated capital stock.

Moreover, presently available capabilities to cash in on energy savings at low investment costs from upgrading operational practices and energy monitoring procedures are limited at both management and workfloor level.

Present conditions in the product markets of most African industrialists do not encourage much effort on their part to invest in energy efficiency improvement. Even if energy prices are raised to a level reflecting full economic costs, poor market prospects may inhibit other necessary outlays to cater to short-term product demand. On the continent, international cooperation is lacking and domestic markets are small. In addition, reliability of public energy supply facilities is poor, occasioning both costly production discontinuities and part-load production as well as the need for captive power systems. This unfavourable business environment severely hampers efforts to achieve higher energy efficiency.

Asia

The pursuit of industrialisation policy for economic development created a pressure to increase commercial energy consumption in Asia. Along with increasing rates of urbanisation, the switch from non-commercial to commercial energy use became more pronounced.

The enactment of energy conservation legislation and the establishment of implementing agencies has been made in Indonesia, Malaysia, Philippines, Thailand, Pakistan, and Sri Lanka. These countries have developed programmes to conduct regular training courses, seminars and the establishment of pilot projects to demonstrate the viability of energy conservation measures. Although oil taxes were levied in net oil importing countries, the conservation programmes and measures had limited access to these funds other than for their administrative requirements.

Amongst the countries studied in Asia, the Republic of Korea seemed most impressive in pursuing a national energy conservation programme. The "Rationalization of Energy Utilization Act" placed energy conservation as a very high priority on the government agenda. The energy conservation strategy falls into four broad categories: information dissemination and regulation, financial incentives, research, development and demonstration (RD&D), and structural changes. In addition, the financial assistance made possible through the setting up of the Petroleum Business Fund has been instrumental in making the national effort a relative success.

As for India, there has been some improvement over the years in the efficiency of use of commercial energy in several sectors of the economy. However, these efficiency improvements have been inadequate to make a visible impact on the pattern of growth of demand for commercial energy. It is, however, hoped that the comprehensive National Energy Efficiency Programme (NEEP) in the Eighth Plan, which is to coordinate and organize, existing and, new efforts/activities on energy conservation in the different sectors of the economy for achieving targeted energy savings may prove successful.

In Thailand, more recently, with the privatisation of the electricity sector, the promulgation of the Energy Conservation Law and the implementation of the Demand Side Management Programme, the strategy to conserve energy has gained further strength and potential.

As for Bangladesh, the Energy Monitoring and Conservation Centre conducts energy audits and holds training programmes and seminars. The success of this unit has been reasonable given the limited resources.

In Asia, a number of barriers were found to the implementation of energy conservation policies. The key barriers were:

- inadequate energy pricing policy
- lack of information
- lack of innovative financial incentives
- socio-cultural barriers.

The importance and dynamism of small and medium-scale industries is one of the distinguishing features of the manufacturing sector in Asia. Also, in parts of India and China that are undergoing fundamental reforms in the manufacturing sector, this is the most dynamic subsector. Because of these developments, streamlined information dissemination to this sector may prove very effective.

Governments of many energy-importing Asian countries -including notably China and India - have revised energy pricing policies rather drastically, bringing energy prices charged to industrial users more in line with long-term marginal cost of energy. In Korea, energy prices have played a significant role in determining the energy intensity in the manufacturing sector. The high energy intensity in manufacturing sector during the 1980s has been the result of a combination of lower energy price with lower capital investment for efficiency improvement. Another example of the crucial role of energy pricing is that analysis indicated that the DSM programme has limitations in the market without rationalizing the energy price in Korea [7]. In Thailand, it is observed that the energy prices were still low, representing only a small fraction of their total cost. In Bangladesh, the price of natural gas has been unrealistically low which did not provide an incentive for conserving energy.

A point that warrants mentioning is that with the exception of the newly industrialised countries of East Asia, the DCs continue to be trapped in a technology-import spiral: imported technology into developing countries seldom reaches its design capacity and its performance is more unstable and decreases much faster over its operational life than is usually the case in industrialised countries [8].

Latin America

After the second world war, Latin America had a long period of continued economic growth. Import substitution policies induced industrialization and urbanization, changing the economic and social situation of the region. These policies led to economic development, but they brought in severe economic distortions as well. Trade balances ran a deficit most of the time, the tax regime was unable to finance public expenditures and government policies were strongly oriented to foster industrialization and urbanization, at the expense of rural activities. The outcome of these imbalances was inflation, economic instability and profound social inequalities. Despite large inter-country disparities the economic situation of *all* Latin American countries deteriorated rapidly in the 1980's. The *lost decade* slowed down the industrialization process, and reduced the per capita GDP. More recently, economic reforms, relaxed debt obligations and opening markets present a changed picture that warrants a cautious optimism

Latin America has a mixed energy profile. The region has large energy resources, exporting a substantial surplus of oil (and, increasingly, Colombian coal as well). There is no reason to believe that a major disruption in energy supply can occur in the future, although a large change in oil price could be extremely harmful to non-exporting countries. The intensity of energy consumption per unit of GDP showed a worrisome trend in the

1980's: *energy intensity either increased or remained constant*, save in the Brazilian case where it tended to decrease slightly. It is important to remark that this occurred together with stagnant per capita energy consumption. Undoubtedly, pricing policy played an important role in this process. Domestic availability of low cost fuels induced energy prices in the region to be kept at a relatively low level. More seriously, political or macroeconomic considerations led to price distortions through cross-subsidies or readjustments below inflation rates, hampering the emergence of energy-efficient behaviour.

From the environmental point of view, the Latin American picture is relatively favourable thus far. Latin America largely uses hydropower for electricity generation and biomass for fuelling industry and households. Transportation however is a major consumer of oil and oil products. This situation places regional emissions per unit of GDP below industrial countries' emission levels. Nevertheless, there are signs that GDP growth is likely to boost inefficient use of fuels in the region, if no appropriate policies are enforced. In this circumstance, emissions will have a substantial increase, rapidly deteriorating the environment.

The manufacturing sector has grown relatively fast in Latin America until the 1970's. The debt crisis dramatically changed that trend: the share of industry in the regional GDP dropped from 37.1% in 1980 to 31.3% in 1991. This process has substantially changed the structure of value added, since distinct industries have reacted differently to the economic crisis. Globally, the region has moved towards more energy-intensive industries (chemicals and basic metals), taking advantage of its large natural resource base to generate a trade balance surplus that could pay for its external debt. Traditional industries such as food and textiles showed a reduced share in the regional industrial output.

Industry is the main energy consumer in Latin America. The economic crisis cut the rate of growth of energy consumption in the manufacturing sector; but as soon as the economy recovers, this rate will increase once again, as the Brazilian and Mexican experiences indicate. Average industrial energy intensity is similar in large and small countries of the region, irrespective of large differences among countries regarding the structure of their manufacturing output.

Generally, the energy crisis, particularly the second oil shock, has greatly increased Latin American government's awareness of the important role of policies for the rational use of energy. In a first step, policies were set up at sector level; by the late 1980's, agencies were established for energy policy design and implementation. Education, dissemination of technical information and auditing are basic components of the regional approach to energy conservation; financial support and tax incentives have been less successful. More recently, the regional movement towards the elimination of energy subsidies is likely to have a very substantial impact on the pattern of energy use in industry.

3. POLICY OPPORTUNITIES

3.1. Policy priorities in developing countries

From the cases studied, we may derive a few conclusions of a general character. Important opportunities exist to improve energy efficiency in the industrial sector. However, effective use of these opportunities requires consistent, lasting government policies. Government action is required in a multifold way, which would adjust the classical intervention patterns while adding important new dimensions. In fact, significant success has been achieved in some cases by government agencies acting as negotiators between parties that would remain isolated otherwise, and effectively establishing a network of firms and laboratories. Also significantly, other actions failed when such a network could not be established. The role of government in fostering the rational use of energy may cover a broad range of activities and should present a set of features.

First, the traditional functions of government as regulator remain in force, particularly in the energy sector. In this respect, *special attention should be given to pricing policy*. Price distortions have been a common feature in the cases studied, leading to inefficient energy use patterns. Such distortions often originated from ad-hoc policies to fight inflation and appease dissatisfaction by holding public prices down; in other cases, they have reflected particular policies. In any case, their impact has been negative from the point of view of the financial health of the energy sector and public finance on the one hand and rational energy use on the other. Another task of major importance is the setting-up of a *mission-oriented, coordinating agency* for the rational use of energy, suitably empowered and endowed. Other traditional objects for regulation concern externalities of diverse sorts, among which environmental impacts closely touch on the theme of this conference.

Second, government policy should be consistent with long-term projects for economic development and with a drive towards overall efficiency. As important, policy should be perceived as *sound, consistent and durable* to gain credibility and effectiveness. Credibility is not an easy condition to achieve, but its absence has been the underlying factor in several programme failures. In particular, energy efficiency should be approached in the context of economic efficiency.

Third, traditional government functions like education and strengthening of research institutions are important elements in a strategy for enhancing energy efficiency in the economy. By themselves, however, they may fail to achieve their goals. Government has thus to take on a *fourth* function: that of acting as a negotiator and *mediator* between parties, for effective interaction and networking and the setting up of realistic goals. This is of particular importance for information diffusion, technological capacitation and design of efficiency standards.

A *fifth* traditional mode of government intervention, i.e. credit incentives to conservation projects, has been less successful for reasons of inadequate design. This does not preclude it as a valid mode of action. However, *considerable care has to be exercised in its design* so that it may achieve its goals. Furthermore, in many developing countries the scarcity of public funds suggests that these actions be taken with international support.

The above description has touched upon a few policy priorities directly linked to government functions, as perceived by this study. However, they do not exhaust the list of needs for action. These include, besides the above:

- *Improving awareness of decision makers and the general public.* There is much scope for making the general public aware of the importance of behavioural change toward energy conservation and good equipment maintenance. General education and targeted mass media information are major modes to sensitize the population. This is relevant to energy conservation in industrial plant and office facilities, as well as in many other areas. On the other hand, policy makers must be aware of the importance of Rational Use of Energy policies in the first place.
- *Bridging the technical information gap.* In particular in developing countries, reliable information on technical options to improve industrial energy efficiency is in short supply, either about substantial changes requiring large investments, such as change in production process or major retrofits, or actions like "good housekeeping" and minor retrofit measures such as improving insulation, burners, heat recovery and introduction of process control equipment. This implies the need for extensive *training* activities, *audits* and general *technical assistance* to industry. To this end, existing educational and research institutions should be strengthened; energy services companies (ESCOs) may be of invaluable help in auditing and other technical assistance to industry.
- *Improving the availability of energy-efficient equipment.* Another major hurdle to technical improvements is unavailability of energy-efficient devices in developing-country markets. This may relate to lack of demand from industrial users. Less energy-efficient plant equipment may be preferred because of ignorance, or because it is cheaper or robust (withstanding poor maintenance, bad energy quality or other unfavourable conditions). Other reasons might be high transportation costs (bad roads, small markets, poor port handling) and import protection of the country concerned.
- *Improving technological capabilities.* Introducing improved hardware is not sufficient to improve general productivity and energy efficiency. In developing countries, rated capacities of plant equipment may never be achieved, while equipment performance tends to deteriorate much quicker than in industrialised countries. On the one hand, this relates to harsh operating conditions. On the other, to low technological capabilities of both management and workers. In transferring technologies to the developing world, much more emphasis on the soft side of technology use, and on long-term issues, needs to be put. This suggests that technology transfer schemes (e.g. BOT and BOOT) should be designed with much greater care than has been the norm.
- *Improving access to finance.* Economically and socially justified investments for energy conservation in developing countries face a scarcity of financial resources. Several lines of action can be pursued: capital market development, improving business climate for private investment (e.g. franchising, joint-ventures, foreign investments) and introducing special credit lines to investments in rational use of energy in industry. The latter line of action needs much prudence and care to avoid diversion to other uses, insufficient or ineffective use, and biases in favour of large, energy-intensive industrial facilities. In targeting energy-intensive industry, a trade-off has to be made between better energy conservation results and introducing biases in favour of big energy users.
- The items above point to the importance of *networking*. It has been found (e.g. in Brazil) that effective interaction of government agencies, teaching and research

institutions, user as well as equipment producer firms may bridge several gaps through synergy and induce efficiency-seeking behaviour.

3.2 Institutional implications

To implement energy conservation programmes, government interventions as well as energy utility actions are necessary. However, it is of crucial importance that the general policy context is consistent with the programme aims. Macroeconomic, trade and industrial policies should be sound and coherent, and perceived as such. Past experience suggests that, generally, interventions of a closed command-and-control type are less effective in achieving energy efficiency goals than those obtaining voluntary commitment of targeted energy users.

Past experience also shows that RUE programmes designed to cope with an emergency have often proven inadequate for lack of *adequate data* and a *legislative structure*. A clear legislation differentiates between the main energy sources and provides clear responsibilities, rights and obligations to the important actors: government, industry and trade. In developing countries, laws on basic energy end-use data collection in industry and standards and regulations for energy using equipment have proven to be useful for the design of effective energy policy making and interventions.

The cases also suggest the importance of a *national coordinating agency* for RUE activities. Irrespective of the exact institutional framing of an energy policy agency (at arm's length of the ministry or as a part of the ministry), this should have resources and power adequate to the task; it should also take into account the position of other actors in the energy field, and use them as much as is adequate; these include, among others: *ESCOs*; *utility-based DSM agencies*; *private industry associations*; *E-cells* (energy management and conservation cells within industrial companies).

A national energy conservation agency or institute (ECA) can perform, among others, the following functions in the field of industrial energy conservation:

- training target groups: ESCOs, E-cells, DSM agencies, industrial bodies, ministries
- initiating, monitoring and evaluating industrial audits, using ESCOs and DSM agencies
- demonstration programmes to disseminate feasible energy-efficient options and technologies with a large replication potential
- gather data and identify plants with best energy-efficiency performance that may be widely replicated
- encourage private-public partnerships to achieve conservation goals set at branch and plant levels, based on info from abroad and national 'best practices programmes'; standards setting and equipment labelling can also follow this approach
- information campaigns (in cooperation with branch associations and ESCOs)
- educational campaigns, in cooperation with the education ministry
- technical management of special credit line programmes (in cooperation with appropriate financial institutions).

ECAs have to be government-sponsored as many activities cannot be completely commercialised. On the other hand, complete or partial cost recovery for activities with a commercial character should be given serious consideration, as the willingness of clients to pay gives important feedback information on the societal usefulness of the institute's activities.

Nonetheless, the capacity to pay (for instance of small-scale enterprises) should also be taken into account. A source for government funding could be an indirect tax on energy, notably on fossil fuels. Such a tax should be economy-wide but moderate, so that the competitiveness of national firms in energy-intensive branches vis-a-vis foreign producers will not be seriously affected.

3.3. Opportunities for international cooperation

Analysis of the opportunities for national policies shows that international cooperation has an important role to play in developing countries. Government commitment to a sound, consistent policy to improve energy as well as economic efficiency is a necessary condition for success, but may be insufficient without external help. This is particularly the case in poorer countries, or those with an incipient industrial basis, but in most or all cases cooperation will be beneficial. We see the following opportunities for useful international cooperation:

Strengthening the capabilities of energy policy agencies, particularly at the national level. In most developing countries, energy policy is poorly coordinated. Programmes for the rational use of energy are often ad-hoc and lack continuity; agencies have to use staff that has little formation in the required analytical skills. Furthermore, information gathering on energy use is most often insufficient to design and target specific actions. The situation is particularly critical in Africa, but in many Asian and Latin American countries there is also ample scope to improve technical capabilities of agency staff to design, implement, monitor and evaluate integrated energy strategies.

Assistance could take the form of training the technical staff at such agencies, either on the job or through traineeships abroad; interchange of experiences with well-developed institutes would be another mode of cooperation. Support for this could come through well-designed bilateral arrangements or through multilateral organizations like regional development banks or regional energy organizations.

Strengthening national regulatory agencies. Globally, important new developments are taking place in the energy supply industry, with consequences on energy regulation. Several aspects of a RUE policy also have implications for energy regulation: demand-side management, stimulus to co-generation and to independent generation can be rational from a societal point of view, but require important and delicate changes in the way industry is regulated. Here, cooperation might be more effective through experience interchange, given the wide variation in national contexts.

Strengthening other relevant agents, such as research institutions, E-cells and ESCOs. These agents have important functions in a consistent RUE policy; the former are important components of training programmes and the development of technological capability. The latter are crucial for a vigorous programme of auditing and technical assistance to industries. Cooperation could be done through *participation in national training programmes, and assistance to national networks.*

Facilitating the access to information on energy-efficient technology. This is an important component of several lines of cooperation. Up to date knowledge of efficient options requires systematic access to information not readily available in developing countries (and perhaps elsewhere as well). This line of action might take e.g. the form of a multilaterally managed data base on existing technologies.

Assistance to design and fund credit lines of adequate design to foster industrial energy efficiency. We have seen that financial incentives may fail for poor design or lack of funds. Cooperation should aim at a three-pronged goal: to identify viable projects in need of funding, to design effective financial stimuli and to devise ways to fund the actions.

Facilitating transfer of energy-efficient technology. As argued above, this should go beyond the simple process of equipment acquisition, installation and operation to include 'soft' aspects of technical know-how, aiming at an effective capacitation of the receiving end. Given the two-sided nature of such exchanges, and since firms who own transferable technology have little interest in going beyond the usual arrangements, cooperation of international organisms would be important in facilitating this process.

International networking. A careful survey of the short list above indicates that an important role for international co-operation will be to *stimulate the interchange of experiences*, and more broadly to *foster networking* at both local and international levels. Information interchange could be done through the creation of a world-wide information centre; other possible interchange channels are international seminars and networks of institutions. Each has its own virtues and limitations. Possibly, a world-wide information centre will be adequate for managing a data base on efficient technology, but fail in other respects. Seminars are useful for exchanging views but have little continuity. Networks may be the best bet for ensuring continuity and depth; but they are slow to build, and easy to break: they require continuing attention and support. In our view, effective co-operation will require thoughtful use of all three channels.

3.4. Concluding remark

This study has corroborated the presumption that a vast energy conservation potential exists in developing-country industry. Some highly effective energy efficiency actions have been identified, while warranted policy measures and institutional frameworks have been outlined. The study outcomes suggest that, given a conducive general policy framework, cooperation between North and South in expediting industrial energy efficiency programmes might well rank among the most effective lines of action to implement the Framework Convention on Climate Change and Agenda 21.

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