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INDUSTRIAL ENERGY CONSERVATION IN DEVELOPING COUNTRIES*

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I. Introduction

In nearly all developing countries, there are many opportunities to conserve energy. Experience and analysis have confirmed that developing countries can improve energy efficiency in almost all sectors of the economy, and that reducing the energy bill is normally more attractive than investing additional resources to increase domestic energy supplies. Experience has also shown that energy conservation and demand management can produce results faster than actions to increase supply, which is particularly true for the industrial sector. In most developing countries, industry is the largest single consumer of commercial energy. Therefore, energy conservation policy, as the most important componenet of energy demand management should be a critical element of an overall national energy strategy.

Energy consumption at national level is affected by many factors: the size of the population, gross domestic product per capita, the structure of the economy including the energy intensity of different sectors of the economy, climate, consumer's behaviour, etc. To implement a successful energy conservation policy, all these factors need to be taken into account. This analysis should include the reasons for low energy intensity. It needs to identify the sectors of the economy having the greatest impact on energy consumption and identify the measures which can provide the greatest economic benefit.

Specific measures for a national energy conservation programme vary from country to country, but it is possible to classify categories of aims and measures which can be used to carry out a successful conservation programme in any country. In most cases the twin goals are: raising energy efficiency and replacing costly fuel sources, such as oil, with cheaper ones.

The measures are:

a. Economic-financial such as soft loans and credits, subsidies, taxes, pricing policy, tariffs and special payment conditions, direct capital allocation;

b. Institutional-organizational such as awareness and information campaigns, appropriate institutions, training programmes, laws and regulations, energy conservation target

and standards, information systems, organization of supervision and control, inspection including limitations, prohibitions and penalties;

c. Technical measures such as plant surveys, energy housekeeping analysis, waste energy reuse and co-generation, energy system (heat, steam, electricity) improvements and process modification, provision of technical assistance, etc.

The same classification could also be used to identify the barriers and constrains hampering conservation implementations. The potential for the measures varies not only from country to country, but in many cases from region to region within the country. It also varies across the consuming sectors by type and size of energy user. It is important to define the sectors where the greatest impact can be achieved with a reasonable amount of effort and to design a strategy using all available policy tools to meet desired targets.

II. The Role of Industrial Energy Conservation in Developing Countries

II.1. Why Industrial Energy Cosnervation Programme

In the developing countries the industrial and power sectors offer the largest and most easily captured energy conservation potential. Energy conservation is a cheap, quick and relatively easy way for most developing countries to stretch energy supply, reduce energy costs and save foreign exchange. Thus, energy conservation could be conceived as replacement of supply so it must compete with the supply side enhancement.

To consider advantages of conservation efforts the following needs to be taken into consideration:

- investment in energy conservation at the margin in many cases provide better economic attractiveness than to invest in energy supply. Technically proven, cost-effective conservation techniques and processes can save developing countries an estimated 10 to 30 percent of industrial sector energy consumption and 10 to 25 percent of power sector energy consumption;

- by improving energy efficiency, the developing countries depending on energy imports can positively affect balance of payments or debt problems and consequently to improve industrial competitiveness;

- energy conservation can extend the availability of energy resources that are depleatable;

- investment in energy conservation can often be implemented in small increments and is therefore flexible at a time when energy outlook is uncertain and capital stock needed to extend supply is not available;

- energy conservation reduces the environmental consequences of energy production and use in a way which is consistent with energy policy objectives. so, in most cases conservation investments can be appreciated as zero discharge projects;

- conservation is able to lessen the impact of thightening energy markets and able to impose the overall supply-demand balance;

- sustained effort in energy conservation can also improve the use of noncommercial energy resources such as work which will ameliorate complex social-environmental problems such as deforestation.

Despite these advantages, economic and financial benefits, industrial and other energy consumers are often very slow of investing in energy conservation measures. Many factors can be identified hampering these implementations, such as:

- to implement conservation policy is a complex process which needs a continuous harmonization of many factors for a not specially spectacular aim, so the "bureaucratic efficency" is low;

- energy represents a relatively samll part of operating cost, so that energy conservation is often not considered priority especially when existing facilities have operated well and virtually there is no reason to change;

- lack of awareness at all levels of government and industry management about the profitability and benefit of conservation measures. Only widespread information campaigns embedded in a well coordinated national energy programme can improve the situation;

- the possible interruption of production while implementing conservation measures;

- the complexity of energy conservation projects from the point of view of economic evaluation and the risks involved in adopting technological innovations;

- the low visibility of these investments which normally consist of a large number of separate small items often without more desirable production increases;

- the economic climate is not especially favourable for these measures in developing countries, it is difficult to generate internally sufficient financial resources;

- there are countries with significant participation of public sector, where the emphasis is put on expanding production rather than on improving energy efficiency.

All of these advantages offered and difficulties to be overcome by an appropriate conservation program justify the existence and emphasize the importance of the industrial energy conservation.

In addition there is a special characteristic of energy conservation activity being crucial for the developing countries, namely that market forces alone are not enough to achieve the state of energy conservation which is desirable for a country. To define the exact benefit of conservation measures an integrated approach must be applied containing different component of comparison of the energy supply side with the demand side, economic calculations showing clearly the profitability of different saving opportunities, taking into consideration at national/regional level the cost in foreign currency for importing fuels, and so on. Only by this kind of complex analysis it can be proven that energy conservation projects are in general profitable, mainly because fuel saved in this way is considerably cheaper than fuel produced from new resources.

To judge properly, the role of energy conservation of a developing country, it must also be taken into account that there is a widespread evidence, that mainly developing economies are expanding exploration and development of depleatable energy resources and these countries must concentrate more on the potential of conservation and renewable energy resources as exotic but uneconomic alternatives and because the known stocks of depleatble energy resources among developing countries suggest a limited base to promote economic growth and development.

II.2. Potential for Energy Conservation

In nearly all developing countries there is great potential to conserve energy. Experience and analysis have confirmed that developing countries can improve energy efficiency in virtually all sectors of the national economy and to implement a successful energy conservation policy, all these possibilities need to be taken into account. Careful analysis must be carried out to identify the sectors of the economy having the greatest impact on energy consumption and identify the measures which can provide the greatest economic benefic.

The potential for conservation varies across the consuming sectors by type and size of energy user, so it is important to determine those domains where the greatest benefit can be achieved with a reasonable amount of effect and to design a strategy using all available policy tools to meet designed targets.

The main factors that determine the potential for energy savings in developing countries are the amount of energy used in the industrial sector. the structure of each industry, the type and age of the processes used, the energy efficiency of these processes and the fuel used.

From the point of view of conservation potentials industrial energy consumers can be classified into two groups. The first group comprises the energy intensive industries in which energy costs represent a large share of total production costs (15-50 %). These industries are iron and steel. and other metallurgy, building materials, chemicals including fertilizer and food processing; these account for about half of the total commercial energy consumed in industry in the developing countries. For these industries changes in the cost of energy have a crucial impact on the cost of production and profitability. Recent experience has shown that 4-12 % is the potential efficiency improvement which can be achieved by "small investment measures" i.e. mainly by improving plant energy housekeeping, and 15-25 % is the potential energy savings by larger investments such as retrofitting. waste heat recovery, combined heat and power, process changes and controls etc. The second group of industrial users comprises a multitude of medium size and small energy consumers. The potential energy savings for this group as a whole are also substantial and the appropriate strategy towards this group is to facilitate the flow of information on techniques for improving energy efficiency and to ensure that financial-economic measures provide proper signals.

To assess correctly the country's potential for industrial energy savings some information are substantial:

- detailed country energy balances, by sector and by source of energy, according to different types of fuel:
- industrial data including product and process pattern, characterized by the economic output acieved;
- estimates on energy consumption performance by industry and by product and by source of energy in term of physical qualities or/and economic outputs e.g. energy consumption per unit of output;
- set of references with which to compare energy consumption performance, namely the deviation from some international standards.

Because severe shortages of data in most developing countries, it is very difficult to estimate the potential savings precisely.

III. Barriers and constraints to energy conservation

The barriers, constraints and limitations to save energy in the industry are many times underestimated in efforts to start industrial conservation programme. It is important to identify at the start of the programme these factors which could jeopardise the saving efforts. In general constraints can be overcome by a sustained, continuous effort e.g. the lack of professionals for energy conservation can be overcome for immediate relief by hiring some specialists from abroad and for longer term by focusing on energy conservation education and organizing adequate training. Barriers are mostly institutional such as destoring price systems and outdated taxation systems, and these barriers can sometimes akwardly persistent and difficult to remove. Limitations, such as geographical location, the climate, available mineral resources, etc. are imposed on a country and not much can be done.

There are three main groups of barriers and constraints:

a./ Financial-economic barriers, which are typical for developing countries:

- Domestic energy prices below economic cost.
  Pricing can be a strong barrier if prices for fuels and electricity are subsidized. The situation is even worse when pricing structure i.e. the prices of different fuels relative to each other in a country is distored relative to the price structure in the international markets and in relation to supply and demand conditions in the country concerned. The pricing of fuels and electricity should reflect medium and long term acquisitions costs, i.e. opportunity costs, which is a pre-requisite to promote the efficient use of energy in the industry. Subsidies to fuels act as a major barrier to energy savings, so it is necessary to introduce innovative pricing systems which reflect the economic system and the general pricing policy of the countries. Major factors to be considered are:

  - Existing distortions in energy prices should be reduced progressively in order to discourage non-economical substitutions between products. Fuel diversification should be considered as a positive factor for energy conservation effects, where prices reflect the opportunity costs.

- Pricing of energy products used by industry and export oriented activities shouuld reflect the real costs, taking into account the general level of energy prices in the international market in order to preserve the competitiveness of the country.

- Pricing of energy product used by the general population should be compatible with the level of basic goods and services. There is here a social constraint related to the average income of the population, especially in rural areas and the level of unemployment in the ocuntry.

- Limited availability of funds to carry out energy efficient investments. Suppliers of capital may also be unaware of the pay-off from energy saving investments with short payback time and high returns. This barrier emphasizes the need for measures such as awareness campaigns, priority (but not subsidized) credit lines, equipment leasing and other financial easements.

  - The competition between investments in production capacity and energy efficiency improvements. There is often a bias in favour of the first category even though investments in conservation technology may have higher rate of return.

  - Strong financial barrier could be if most production activities in the region are state owned. They often suffer financial deficits due to inefficiencies and long approval procedures related to budget funding. A special barrier for many developing countries is found in large, energy intensive industries that are partially or fully government-owned. Management is commonly more oriented towards increasing production that to improving efficiency. Government directives may be in this case a necessary measure. Either directly or through representatives on the board of directors the government may have to produce such managements to initiate energy conservation measures. The situation in such industries is even worse when pricing is based on a cost-plus profit principle so that it can pass on any inefficiencies to its customers without a direct economic penalty. Of course, on the longer term the economy of the country is penalized for the inefficiencies in its economcy. But this knowledge is mostly not an incentive for bureaucrats to take action to do away with these roadblocks on the way to improved efficiencies.

- An other tipical barrier is that even with motivated managements, many companies will not have qualified engineers or equipment to carry out energy audits. Many plants, wiht capital-intensive processes, will lack the instrumentation to assess and monitor energy balances.

b./ Institutional-management barriers existing in developing countries are more or less typical and they are able to block an energy saving policy. The most important barriers and constraints are:

- Absence of departments or other institutional agencies in a government with a clear responsibility for designing and implementing energy policies or programmes and little legislative or regulatory framework supporting energy management responsibilities. Energy policies often focus only on supply side considerations.

- Lack of awareness in government, companies and individuals of the importance of energy conservation and the opportunities which exist for making savings.

- Lack of interest of government officials and professionals because they feel that energy efficiency considerations do not deserve any significant priority.

- Technical know-how may be inadequate to start the tasks of desioning and implementing energy conservation actions.

- Income disparities and social considerations may require subsidizing of energy prices or even rationing to provide poor consumers with basic energy needs.

- The lack of knowledge is an important general constraint, first of all the lack in methodology knowledge: at government level how to design, start up and implement and energy conservation programme. At enterprise level how to identify energy conservation projects and if identified, how to manage a project and how to evaluate it. In transport at enterprise level how to maintain equipment properly, at driver level how to drive economically and how to maintain the car etc.

- Barriers also can be find in the legislation: all laws and regulations pertinent to energy use must be reviewed. Laws affecting the economies of energy conservation projects must also be examined. Some laws and regulations will need amendments, new ones will need to be promulgated. The degree of intervention is directly dependent on the economic system.

c./ Technical barriers are:

- Non-availability of suitable energy efficiency equipment and of energy measuring instrumentation or monitoring facilities.

- It is generally agreed that in developing countries the difficulty of technology transfer is often due to the availability of adequate skilled personnel and to the complexity of the technology itself. This could be overcome by strenghtening technical cooperation, and regional centers are likely to play a major role in the future.

- The rapid progress in technology and advanced processes may cause some uncertainty regarding energy conservation projects, especially when important investments have to be undertaken.

- The lack of confidence in new techniques not yet proven on an industrial basis is also considered as major constraint in developing countries.

- In many ways the lack of coordination between national research and development institutions and the industrial sector is a factor which explains partly the weakness of the contribution to energy conservation activities.

- The presence of adequate local consulting and engineering firms is also considered a pre-requisite condition to encourage participation of local enterprises in energy conservation programmes and to increase interest of countries to do so.

- The interest in the promotion of cogeneration projects as a mean to energy savings, as well as technical, legal and economical constraints to implement these projects can also be considered as a technical barrier.

The precise identification of these barriers and constraints is a vital part of the activities involved by the designing phase of the national industrial energy conservation programme. Based on the appropriate identification of barriers the measures can be determined to overcome them.

For the identification of barriers and constraints a national industrial energy survey could be very useful, because the relative importance and the role of the barriers can be easily revealed by analyzing the survey data thoroughly (see Chapt. IV).

IV. Developing Industrial Energy Conservation Programme

The development of a national industrial energy conservation programme needs a special logistic for being successful. A successful programme generally has three phases: design, start-up and implementation and monitoring. All these phases need appropriate institutional network, which is able to support and execute the necessary actions at national, regional and enterprise levels. These levels need again special consideration, because the measures realizing the conservation programme vary according to the competency of the management belonging to the different levels. The realization of the programme is carried out by implementation of the measures in three dimensions: financial/economic, institutional/management and technical. As the main aims of the measures are to overcome barriers and constraints hampering the rational use of energy in the industry, the classification of the measures is identical with that of the barriers.

The design phase is (or ought to be) initiated by an existing government agency (eg. ministry of industry or ministry of energy) and involves: national industrial energy survey providing comprehensive data base of industrial energy use. Based on this knowledge it is possible to identify the barriers to energy savings and to design measures to overcome them.

The phase of start-up involves the finalization of the programme, i.e. the appropriate selection of the different measures, the actions necessary to implement these measures successfully e.g. recruit and train auditors, conduct test audit, establish financing channels etc. At the end of the start-up phase some measures, mainly institutional and financial ones are already accomplished or need to be under way, e.g. setting up appropriate organizations, launching awareness and information campaigns.

The implementation and monitoring phase comprises the execution and tuning the conservation programme by setting up conservation targets and standards and conducting auditing programme, training managers etc. These activities - which also mean application of measures - are usually the work of the energy conservation center being generally responsible for the continuous monitoring and evaluation of the project results and for the assessment of the overall conservation policy in the industry.

The experience indicates that developing a comprehensive industrial energy conservation programme the following recommendations should be taken into consideration:

- the implementation of an effective energy conservation policy requires a special governmental organization to conduct and supervise the underlying policy analysis, to guide and develop specific government initiatives and to ensure that the programme is carefully evaluated;

- the technical side of an energy conservation programme relies on the availability of adequate technological infrasturcture for the implementation of energy saving measures. This infrastructure should be capable of producing technical solutions domestically or the capacity to assimilate them from other countries through technology transfer;

- economic incentives for the energy sector, such as taxes, tariffs, subsidies, have a fundamental importance for implementing the energy conservation measures needed for a national programme;

- energy conservation programmes need to be assessed and evaluated periodically once they are under way to ensure that policy objectives are being met with a maximum of effectiveness.

Recent years a number of developing countries have initiated programmes to promote energy conservation. However, the general conclusion is, that despite these energy conservation efforts, only a fraction of the tremendous energy conservation potential has been captured, especially for projects that require complex, techno-economic and financial assessment. It is due to the result of numerous technical, economic, financial, institutional and policy barriers which affect the ability and willingness of energy users to make energy conservation investments.

IV.1. Energy Conservation Center

From the lessons learned from well running energy conservation programme it is apparent that an entity dedicated solely to industrial energy conservation is justified to develop comprehensive programme. This entity could be called as an "energy conservation centre", having special autonomy, advising the Government, questioning prevailing habits, removing barriers, motivating market forces for industrial energy

conservation and initiating specific energy conservation actions when not driven by market forces. The center's scope of action comprises the following main fields:

- the firts task in developing a successful energy conservation programme is to establishd an adequate data base which describes all of energy related features of the economy. Even a simple sector level analysis requires a large quantity of data. The quantity and quality of data are of vital importance and, therefore, all energy related information must be carefully checked for its reliability and consistency;

- the identification of the potential at national level for energy conservation, even with a simple computer nodel. is of great assistance in defining and choosing different economic projections which include a supply and demand balance, price projections and other socio-economic conditions;

- comparative analysis is needed to maki it possible to select the most effective energy conservation measures, rank them in order of priority and to evaluate the long-term impact of energy conservation measures on economic development;

- in designing a national energy conservation programme careful attention must be paid to energy savings which can be achieved by changes in the structure of industry. Growth in less enegy intensive sectors may overtake growth in industrial sector with a high energy intensity. These structural changes must be taken into acount when establishing the order of priority of energy conservation measures and allocation capital to them.

The center's responsibilities can be classified into four categories: planning; monitoring and follow-up; awareness and information; and technical assistance.

The center also provides services to clients and is able to offer and optimization of all required resources with respect to specific project involving technical, institutional and management and financial ones. To accomplish this goal the activities need to be focused on:

- collection of site-specific energy, technical and economic-financial and institutional-management data and information with a view to perform a present situation assessment;

- to carry out a feasibility study to define the possibilities of improvement of the status quo and to meet the new requirements;

- definition of the options for energy conservation measures and determination of all actions required in achieving the defined energy conservation objectives.

IV.2. Measures to be Considered

Developing countries show great variation in their approaches to and magnitudes of industrial conservation policy effort. Their response times have in general been much longer than those of developed countries, and there is also greater reliance on nonmarket, administrative measures reflecting both the structure of the economies and a different approach to economic management. To overcome barriers hampering the rational use of energy in industry a well balanced approach to design and implementation policies is normally necessary involving financial/economic, institutional/management and technical issues and measures. The main task of the Energy Conservation Center is to select and initiate appropriate conservation measures. The most important items are:

- financial/economic measures:

  - apply grants, which are effective to improve economy of the investment in the industry. loans with low interest rates (soft loans), which have many of the characteristics of grants. The effectiveness of grants and soft loans have been widely debated, although in many countries they form the major part of incentive programmes;

  - tax incentives, which are not always successful, and it is not used widely in the developing countries although it is easy to implement and the application process is fairly easy for companies;

  - set up appropriate pricing (price systems) for fuels and electricity, apply the economic costs as basis for the prices, avoiding destorted price structure relative to the price structure in the international markets and in relation to supply and demand conditions in the country concerned (destortion could be due to subsidies, taxes, import duties etc.);

- implement new approach to financing energy conservation investments such as hared-savings arrangement, joint venture arrangement between an energy user and external investor, energy service agreement, variable payment loan and other forms of third party financing.

- <u>institutional and management measures:</u>

  - analyze existing institutions and recommend changes and a comprehensive review of legislation and regulations including pricing policy and proposal for modification;

  - establish institutions providing services for engineering, audit and consulting support outside plants to implement conservation measures especially in-depth energy auditing at enterprise level. waste energy recovery and for continuous monitoring and suprvision of energy management issues;

  - initiate, organize and execute awareness campaign for government. companies and individuals about the importance of energy conservation and about the opportunities which exist for making savings;

  - set up department or other institutional agencies at government level (in government) with clear responsibility for design and implementing energy policies and for legislative and/or regulatory measures supporting energy management issues;

  - establish and operate advisory service to provide information about available conservation programmes, technologies and techniques, this service is in addition to an energy conservation center;

  - introduce coherent and comprehensive energy efficiency standards for energy consuming equipmnet (e.g. refrigerators, hot water heaters, transport vehicles), besides introduction advertisement campaigns are to be conducted by issuing booklets and guiders;

  - set up independent working group, specialized team for adequate planning and decision making at national and regional or local and enterprise level;

  - establish organization structure responsible for development and conduct national energy survey on an adequate data base, which will be responsible for the identification of the constraints and barriers to energy savings and their possible removal.

- technical measures:

  - at national level assure availability of suitable energy efficient equipment and of energy measuring instrumentation or monitoring facilities, considering import and price restraints;

  - energy housekeeping analysis, including fuel or energy carrier leaks, insulation problems, burners adjustment, dirty surfaces, improper operating pressure and temperature;

  - waste energy reuse, such as flue gas heat recovery and other recuperative energy transformation;

  - cogeneration can be applied in many cases as bottoming cycle, or as waste heat recovery for low temperature heat demand;

  - energy systems (heat, steam, electricity) improvements and process modification including load management to manage power peaks and installation of load shedding equipment;

  - improved maintenance and retrofitting especially at electrical systems, e.g. installation of variable speed control, correction of power factor, installation of high efficiency motors, lighting, transformers etc.;

  - provisions of technical assistance to overcome the lack of knowledge and technical expertise about possible energy efficiency possibilities or measures;

  - improve arrangements for technological innovation and dissemination.

The specifics of national energy conservation programmes vary from country to country, so measure-mix offering best results will also vary. It is the responsibility of the energy management to determine and correct from time to time the list of measures to be applied to achieve the optimum conservation outcome.

IV.3. Enterprise/Factory Level Conservation Issues

As it is stated in para II.2. the energy intensity of an industrial sector depends primarily on the structure, as some industries consume large amounts of energy per unit of output, and energy consumption per unit of output also varies with the process used, the efficiency of any process also depends on the fuel used, the age of plant, operating/maintenance practices and operator skills. The low income developing countries have relatively high energy intensity of their industries and often only one or two energy intensive industrial subsectors consume more than 50 % of the total industrial energy demand. In these cases it its worthwile to concentrate on these subsectors, because significant energy savings could be achieved by implementation of few measures. The most important industries and possible technical measures are:

- metallurgy (iron, steel and non-ferrous metal), where the technical measures would be:
  - reuse for energy purposes of blast furnace gases;
  - reducing the energy demand of hot rolling through technological improvements and by increasing furnace efficiency;
  - increasing the load factors in high voltage aluminium arc furnaces;
  - implementation of computer aided process control at blast furnaces and steel production with special attention paid to higher energy efficiency from monitoring and controlling energy flows;
  - reuse of waste materials which represent in the metallurgical sector for processes such as iron and steel making, alumina and aluminium as well as other non-ferrous metal production, represents a large indirect energy saving potential.
- chemicals, in which the main technical issues are:
  - optimization of fuel mix in the production of energy consuming chemical products such as caustic soda, fertilizers, PVC etc., which are the components of the typical pattern of production in developing countries' chemical sector;
  - introduction of continuous computerized monitoring systems to improve energy housekeeping with special regard to the peakload handling of processes in chemical plants;

- re-use of flash steam heat at condensation, waste heat recovery from various cooling systems and stack gas waste heat recovery systems etc.;

- building materials; glass, tiles, brick making and cement production are the most promising industries from the point of view of energy conservation in the building materials sector, where the potential technical issues are:

  - improvement of grinding processes in the cement industry by updating control systems, increase the combustion efficiency in rotary kilns with improved combustion control systems and applying new insulation materials;
  - the introduction of new processes logistics in lime production to apply the wider use of pre-crushing and reduce energy losses in cooling and transport;
  - the improvement of waste heat recovery in the glass industry along with the better preparation of raw materials and computerized process control for furnaces;
  - improvement of drying and application of sophisticated combustion control techniques in furnaces for bricks and tiles.

- food processing industries; the most important sub-sectors are sugar, breweries and spirit production which are typical in developing countries, where the generally applicable technical measures are:

  - the improvement of drying appliances and processes by the more sophisticated design and operation of the devices;
  - waste heat recovery in condensers, dryers and other latent heat utilization technology;
  - the implementaiton of minor modifications in sterilizing processes especially in the production of milk and condensed milk;
  - upgrading, monitoring and controlling processes, especially with the use of modeling techniques for different technologies.

- the waste and by-product utilization for energy purposes is not sector specific in the economy, but it also has a typical set of technical measures:

  - the introduction of technologies to prepare different wastes for energy use. In many cases, only very simple devices or processes are needed;

- in many industries there is a huge potential to use residues and wastes for energy purposes, which need special technical expertise and economically attractive techniques;
- manufacturing monitoring, control and automation equipment for different energy intensive processes, wider application of micro-processor based control equipment to improve energy efficency and enhance the availability, reliability and flexibility of industrial plant performance. Improved controls and instrumentation should have an immediate and strong effect on waste reduction, increasing saving. Sophisticated process control equipment could achieve large waste reduction without and/or a very modest modification to existing technologies.

- housekeeping and operational improvement: it is a comprehensive summary of measures to reduce energy consumption that can be taken by plant engineer or plant operator at little or no cost in a short time, such as:

  - regular control of efficency of boilers, including measures on fuel consumption, flue gas temperature and CO/CO2 content, combustion air temperature, etc.;
  - control of compressed air systems including temperature reduction of the aspirated air, compressor maintenance, etc.;
  - control of steam or hot water systems, including condensate leak, water or steam leak, damaged or missing insulation etc.;
  - others, such as heat recovery on wet gas steams recirculation on drying systems, improve economizer of boilers, condensing heat recuperating systems of both direct and indirect type, etc.;

- waste heat and recovery and reuse:

  - flue gas waste heat recovery of boilers and kilns, turbines etc., which represent relatively high temperature source of energy, methods and devices to reuse these waste energies;
  - process steam condensate and refrigeration condensers, cooling zones of kilns and dryers outlet represent low temperature heat sources and its utilization needs more sophisticated economic/technical analysis.

- electric system improvements; it contains load management measures and energy saving study on:

  - electric motors for heating and ventilation systems;

- lighting which many times could be connected to more efficient high intensity lamps;
- reactive power consumption and its compensation, the necessary capacitive power for compenstion;
- variable speed drives improve the operation of large fans and pumps by matching their speed to power demand.

- process modification and cogeneration which does not need necessarily substantial change in the processes applied by the production technologies, but mainly contains components of minor modification, such as:

  - change of burners;
  - increasing cooling capacity;
  - installation of mixing fans to the preheating zone etc.

Cogeneration, which generally provides significant potenntial for savings, denotes any form of joint production of electrical or mechanical energy and useful thermal energy, either by producing electricity first and using the exhausted thermal energy for other purposes (topping systems), or using thermal energy from a waste stream to produce power (bottoming system). Cogeneration benefits arise primarily from the higher overall efficiencies in a combination process compared with the cost of producing the needed power and heat through separate processes, so primary fuel cost can be reduced substantially, typically between ten and thirty percent.

For the improvement of plant/factory energy management the electricity load demand, peak load shedding and timing have vital importance. Plant level conservation issues need to involve offers to overcome load management problems. Some technical measures for this purpose may be:

- the improved design, production and operational conditions for fans, pumps and ventilators which could also result energy savings;

- improved load control and peak load shedding by sophisticated specialized technologies, widespread application both for small industrial consumers and for regional grids;

- upgrading lighting systems to help easing the peakload electricity demand.

To develop i.e. to design, implement and re-adjust successful industrial energy conservation programme is a very complex activity, the conservation objectives must be determined on the basis of the overall economics of production. To achieve economic patterns of energy consumption in the longer term, developing countries need to reassess their industrialization strategy. Choices involve not only basic technology, but also the subsectoral mix of industries that is best suited to the country's resources and comparative advantages. But to achieve these aims generally they need exogenous assistance.

V. The Role of International Cooperation to Improve Industrial Energy Efficiency in Developing Countries

A gap exist in the developing countries with respect to the actual industrial energy conservation development and the potential energy saving in different sectors of their economies. The main aim of the transfer of experience is to bridge that gap, so the basic objective is to provide valuable asssistance at country/regional/enterprise level to implement conservation measures. Most international development asssistance agencies have increased their efforts to assist developing countries in industrial energy rationalization. They are helping developing countries to make preliminary analyses of potential energy savings, to develop appropriate policy measures and prepare, appraise, implement and supervise individual energy-saving projects. These institutions can assist developing countries:

A. At governmental level (national, regional institutions):

- analysis, identification, selection, development and control of energy conservation opportunity;
- mobilization of government, industrial, institute and financial resources;
- assistance in all information, consultancy, training and project development tasks leading to the development, application, production, installation and proliferation of energy conservation projects, measures and other policy issues.

Financial/economic efficiency is a central objective of energy and conservation planning, so it is in many developing countries in the front-end of conservation assessment. Assistance provided by international cooperation should focus on the most vital topics, such as:

- fuel and energy prices, including the problem of subsidies. Pricing policy should be based on the complex analysis of all factors involved in this issue: economic subsidies initialized by the social-policy;
- set up proper system for taxes and tariffs, which should be established in such a way that they would contribute to the clear formulation of accomplishment of energy conservation policy;

- assistance to overcome economic/financial barriers and constraints such as: limited availabilitv of funds to carry out energy-efficiency investments, lack of simple shour-term financing for energy efficient equipment changes, insufficient funding of enterprises and government to invest in reducing energy costs and improving energy efficiency;

- providing analytical framework to evaluate alternative conservation opportunities against each other and against other investment opportunities in the energy sector. This type of consultancy consists of ansers to questions, such as: how an analyst compares the value of different economic life spans, wht type of evaluation methods and criteria are available, how to access the evaluation criteria, how inflation and exchange rate affect the project evaluation etc.;

- initiate innovative approaches to financing energy conservation investments, initiate special financial arrangements sich as third party financing etc.

Assistance concerning institutional/management issues should include:

- define the rules, responsibilities and mood of operation of government agencies, especiallv to avoid overlapping the roles of central, state or local authorities;

- many developing countries have a national energy conservation programme and some form of an energy conservation center, but consultancy is needed for setting up and refining data banks, that include data on the country's energy balances, industrial products and process mix, specific energy consumption;

- developing and/or strenghtening this organization to identify, regulate and monitor the energy rationalization programme;

- supervision of the design, startup and implementation and monitoring phases of the programme to ensure that its objectives are coherent and are efficiently executed;

- initiating studies of the feasibility and economic attractiveness of suggested measures that require more investment and detailed expert analysis;

- initiating studies to understand properly reasons for inadequate planning and decision-making structure, to modify unfavourable legislation and regulations, to review pricing policies and propose modifications;

- setting up appropriate institutional structure for recruiting and training auditors and to develop auditing programme;

- initiating international cooperation in demonstration and dissemination of energy efficient technology and equipment;

- initiate and establish institutional bodies to design awareness and information responsibilities including carrying out promotional campaigns for energy saving actions in all media, preparing energy conservation manuals for the most important industrial subsectors, collecting and disseminating statistical information on energy use, and organizing seminars and conferences on energy conservation.

B. Assistance provided by international cooperation for the developing countries at enterprise level (firm level, including specialized institutions, e.g. research institutes) would be:

- set challenging but realistic goals to reduce enercy costs within defined time schedules;

- define priorities necessary to achieve to goals which mean the appropriate allocation of resources;

- assign management and supervisor responsibility for achieving the goals and implementation of conservation policy measures;

- monitor the progress of implementation of conservation measures and conservation policy programme in term of budget, schedule and accopmlishment;

- periodically evaluate the cost-benefits of different conservation measures and update programme goals;

- compare the return on investment on conservation investment with the economic figures of other planned investments;

- continue to lead and support the programme over the present period of years to insure results.

The beneficiaries of these cooperations are the governments, responsible institutions for indutrial energy conservation and different energy consuming enterprises of the subject countries. The advantages gained by the assistance are:

- easy access to all available energy conservation related information on an international, national, sub-regional, regional basis in order to facilitate cost effective allocation of plant, human, financial and development resources;

- precise identification of credible short, medium and long term requirements and justify technological and project development expenses in engineering, production, marketing and other services;

- determination of market opportunity and size, competitiveness and all other relavant factors to the development and industrialization of energy conservation technologies including economies of scale, standards, maintenance, logistics, management etc;

- easy realization of transfer of technologies and engage in bilateral and/or multilateral conservation cooperative research and development and coproduction programmes in order to ensure cost-effectiveness and acceptable market share;

- objective definition of methods of market penetration whether by direct sales, technology transfer or various investments e.g. joint ventures are the better options;

- attain higher levels of coordination between governments, institutes, universities as well as regional and international organizations in order to develop collaboration in the use of all available energy conservation resources.

To produce and gain these benefits an interactive and iterative process is required between all participants. The assistance to improve industrial energy rationalization programmes provide considerable economic benefits to developing coutries in both short and long terms. These ber fits include not only reducing a country's energy import bills but also improving the international competitivenes of its industrial products