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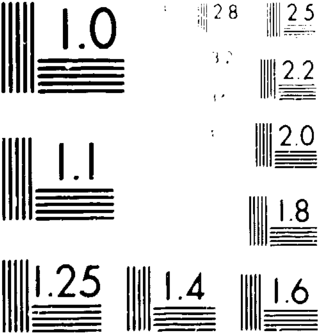
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INTRODUCTION

1. The developing countries are now going through a period of adjustment and decision-making regarding their industrial energy futures. The adjustment is the change from the current heavy dependence on imported oil to an energy future based on increased use of indigenous sources and improved energy management and energy efficiency. It is, therefore, of the utmost importance to recognize the policy options available, the major issues associated with these policy options and the new initiatives which are required to pursue the chosen paths.

2. The interdependence of energy and the industrial sector is of major concern for governments of developing countries in formulating both energy and industrial policies. As industry is the major single market for energy, accounting directly for 30 to 50 per cent of total consumption, developments in industry closely affect the energy sector as developments in the energy sector in turn affect industry. The size and structure of the industry sector determines the amount and to some extent the type of energy needed. Similarly the availability and cost of energy supplies has a major influence on industrial development.

3. In this paper some aspects of the two-way relationship as it affects energy and industry in developing countries are examined. First, energy supply options, with particular reference to biomass and hydropower, are discussed. As energy supplies for industry cannot be divorced from the question of energy supplies to the entire economy, the discussion is necessarily carried out in general terms. Next, possiblities of industrial energy conservation and the substitution of other fuels for oil in the industrial sector are analyzed. Finally some of the implications for energy of likely developments in the industrial sector are considered. Based on this analysis of general energy - industrial policy questions are identified, and programme initiatives proposed.

4. The discussion is conducted on a plane of generality which does not do justice to the heterogeneity of the countries in the developing world with regard to degree of agricultural and industrial development, standard of living, social and physical infrastructure, resource endowments and economic philosophy. This caution must be born in mind particularly in interpreting the applicability of the programme initiatives to countries as diverse as, say, Burundi and Brazil.

I. THE SUPPLY OPTIONS

A. FOSSIL FUELS

The Development of Indigenous Resources

5. The discovery of low cost oil in the Middle East especially after 1950 discouraged the development of more expensive fossil fuel resources in other parts of the world. For all except the most well endowed countries it was cheaper to import than to exploit domestic resources. Now sharply higher prices of all fossil fuels and high import bills encourage the development of hitherto unprofitable indigenous sources of energy.

6. Of all the fossil fuels, oil is the most obvious candidate for domestic development. As an exhaustable form of energy its role in very long term energy strategies may be in doubt but for the nearer term it could make a major contribution. It is the most flexible of all fuels in current use, and the distribution system and oil using technology and machinery is already in place.

7. A large number of oil importing developing countries have some proven reserves or possess attractive geological prospects. Despite these encouraging cirmcumstances and the strong economic incentives provided by higher oil prices, the number of wells drilled in oil-importing developing countries has remained at only 3 per cent of the world total for the past decade. An important question is why oil exploration has remained at such a low level and what action can be taken to remedy the situation.

Expertise and Risk Capital

8. Traditionally the international oil companies provided a large part of the risk capital and the expertise for oil development under contractual and fiscal arrangements concluded with the host government. Part of the international oil companies lack of interest in exploring in the oil importing developing countries in recent years has been due to the existence of attractive possibilities elsewhere, particularly in the United States and Canada. Other reasons include a poor cash flow position which limited the amount of exploratory activity to be undertaken, contractual and fiscal

arrangements which do not provide adequate incentives especially for the typically small fields which are expected to be discovered in this group of countries, and the lack of free access to the crude oil produced. This suggests efforts on behalf of the host governments to develop incentives tailored to new conditions. Examples would be fiscal incentives designed to foster the exporation and development of small fields and efforts to attract new investors such as the smaller independents which have not as yet played a large role in petroleum exploration in oil importing developing countries.

Domestic Natural Gas

9. In those countries with domestic production, gas is an attractive industrial fuel to substitute for petroleum products. It is invariably much cheaper than imported petroleum products and the conversion technology is well established.

10. Reserves of natural gas exist in many developing countries including the oil importers. As in the case of oil, prospects for development hinge on the systematic appraisal of reserves and the incentives offered, including adequate producer prices. The importance of prices is underlined by the amount of gas currently flared because of inadequate incentives for development.

11. Gas development can equally affect the structure of the industrial sector. For those countries with abundant resources, gas can be used as a basis for new fertilizer, methanol and urea manufacturing. It can also be exported in the form of LNG. In all cases these are very large-scale investments which should be preceded by careful resource appraisal and economic feasibility studies.

12. For countries without domestic resources, gas can be imported in the form of LNG. This is, however, unlikely to be a source of alternative fuels for most developing countries. The cost of LNG is not at present substantially lower than oil prices, expensive and complex landing facilities are required, and the minimum quantities shipped are too high for most of the developing countries' industrial needs.

Domestic Coal

13. Coal could be a promising substitute for oil in industrial use. Only a few decades ago coal was a major world fuel with a well-developed international trade providing well over half of total commercial energy consumption. Coal has now been replaced by oil and it is a major industrial fuel only for those countries - China, India, Zambia, Zimbabwe, and the Democratic People's Republic of Korea - which have extensive domestic resources. Imported coal for steam raising is not widely used though several countries import coking coal for use in iron and steel.

14. The advantages of coal are that it is a familiar fuel with a developed technology. It is invariably cheaper than oil on an energy unit basis and it is abundant on a global scale. As in the case of other energy resources, adequate exploration has not been carried out and it is widely believed that current estimates are overly conservative bearing in mind the increase in costs of alternative fuels over the past ten years.

15. On the other hand, the development of a coal industry, or its major expansion, is, as many countries have learned, a complicated exercise dependent on the careful planning of production and transport facilities to assure regular supplies to consuming industries. There is little foreign investor interest in coal so that the major investments required to open new mines and expand old ones must come from domestic sources, in practice largely government. Compared with oil, coal is expensive to transport and difficult and dirty to handle, thus seriously reducing its comparative price advantage. The transport element is particularly important in imported coal. While ocean transport is not expensive on a ton kilometer basis, the costs of inland transports are very much higher thus limiting coal use in practice to coastal regions or to inland situations which are particularly well served by rail links. None of these problems is in and of itself insuperable, but they add up to a formidable list of constraints which require a firm commitment by producing, transporting and consuming entities to overcome.

16. The possibilities for coal use in the industrial sector are quite wide. It can be used in most of the functions undertaken by oil though this involves conversion of existing facilities. Coal has been substituted frequently for oil in cement plants where energy is a large proportion of

total costs. In iron and steel too the trend towards substituting oil for solid fuels in the blast furnace has been checked. There are also some possibilities of developing small-scale coal mines for use in local small industries thus avoiding the heavy burden of transport costs. These could include for example brick works, bakeries, restaurants etc. In some of these cases coal might be substituted for wood rather than oil, and that too could be an advantage.

Other Hydrocarbon Resources

17. Peat and lignite are analogous to coal in the sense that they may be used either on a large scale as part of a modern efficient industrial operation or on a small artisan scale. Peat and lignite have many of the disadvantages of coal and in addition the technology is less well developed and the environmental impacts are less known. These are particularly acute in the case of peat which has a high water content so that large-scale mining or excavation could make extensive changes to local drainage patterns. But in some countries such as Burundi it is the only source of energy so in such circumstances it must be considered as a potential substitute. The in-situ processing of peat to extract energy is an interesting area for study and demonstration.

B. THE HYDROPOWER OPPORTUNITY

World Hydropower Resources

18. Hydropower is among the most promising of the renewable energy resources. It is a clean source of power produced as water turns a turbine as it flows from a higher to a lower elevation. Generally, hydropower systems provide electricity essential for industrial as well as general economic development. It is basically a mature technology which has been neglected until recent fossil fuel price escalations.

19. Although many small hydropower plants were in operation in the latter part of the 19th century, the trend in the 20th century has been to develop large-scale systems. Typical installations of this kind include Boulder Dam

in the United States, the Aswan Dam in Egypt, the Itaipu Dam in Brazil and the Tarbela Dam in Pakistan. Such large undertakings benefit from economies of scale, low and essentially constant operating costs and non-dependence on fossil fuels. They also have multi-purpose uses, primarily for irrigation and flood control. At the time these projects were constructed, the above attributes were the key factors in making them competitive with large-scale petroleum fired power plants using low cost and readily available fuels. In recent years, however, high construction costs, environmental concerns and long delays in planning and construction as well as the difficulty in securing the financing of such large schemes, have reduced the attractiveness of huge dams.

20. By contrast, recent technical advances in water turbine design and efficiency and construction techniques, combined with increasing petroleum fuel costs, have enhanced the competitive position of smaller hydroelectric projects in relation to diesel powered generators of comparable capacity. Smaller plants can be tied to a national or regional grid or serve only a local market. Although the unit cost per installed kilowatt of generating capacity, is higher for small-scale projects, financing is often easier to obtain. These characteristics make small hydropower particularly attractive for developing countries where near-term installation of dispersed electrical energy systems is essential for industrial as well as general economic development.

21. The World Energy Conference (WEC) has periodically published a survey of world energy resources, both potential and developed. In 1974, the World Energy Conference established a Commission on Energy Conservation whose responsibility it was to evaluate the world's energy resources in light of current price escalations. Their most recent data show that currently water provides 23 per cent of the world's electric power. This figure varies from 100 per cent in remote areas to negligible amounts in some Middle East oil rich countries. This contribution has dropped since 1960 when 29 per cent of the world's electricity production was attributed to hydro. The percentage of fossil fuel inputs in electricity production were 71 and 75 per cent in 1960 and 1970 respectively. WEC estimates that by 2020 some 80 per cent of developable hydropower resources will be harnessed.

22. The number of operating hydrosites worldwide is approximately 16 per cent of what is considered to be "reasonably developable" from economic, physical and environmental standpoints. However, exploitable sites are estimated to be only 12 per cent of the total energy that can theoretically be derived from the fall in water of all the world's rivers and streams. Only 9% of the hydro-electric power potential in the developing countries has been developed; in Africa the figure is 1.5%.

23. It must be understood that estimates of hydropower potential are approximate and generally divided into theoretical and practical from the standpoint of economics and engineering. The absence of precise hydrologic and topographical data makes the evaluation of water resources projects only approximate. There is currently a need for the development of methods to evaluate the hydrologic potential of small basins and their rivers either regionally or at the national level.

24. The industrial user of electrical power does not concern himself with the source of generation apart from the reliability of service, adequate capacity and a reasonable tariff. This holds especially true if the industrial user is connected to a national grid, however, if the user is located in a rural area, the source of generation is of fundamental importance because his facility will depend on it. Therefore, the link between industry and the power supplier needs to be developed.

The Question of Scale

25. Hydropower installations come in all sizes and physical configurations. Generally, systems with capacities less than 100 kW are designated as micro-hydro, between 100 kW and 1000 kW as mini-hydro, 1 MW to 25 MW as small hydro and so forth. Head or the difference in elevation between upstream and downstream is a major point of specification. Low head plants, usually less than 20 m, are found along broad rivers or in irrigation structures; high head plants are found in mountain valleys, above 150 m, and usually have some sort of water storage. Pumped storage is a variation of high head plants whereby unused capacity in a power system is used to pump water up into a storage reservoir for use during peak hours.

26. In isolated areas, away from the grid but with hydrological resources nearby, an industrial consumer may find it more expedient and convenient for his own interest to install a diesel generator. From a broader view, however, the development of hydropower could very well be a preferred option, but one involving more complex analysis, consultations and financing.

Some Current Activities in Developing Countries

27. The development of hydropower resources, in most developing countries, is carried out under supervision of the local power authorities or utility. Major programmes to develop small and mini-hydropower resources are underway in Peru (U.S., Federal Republic of Germany), Ecuador (U.S., Federal Republic of Germany), the Philippines (People's Republic of China), Malaysia (World Bank and Asian Development Bank) and several other countries.

28. A good example of co-operation between industry and power authorities can be found in the People's Republic of China. Having built some 90,000 mini and small hydropower plants since 1949, most of them using entirely local resources, a small-scale industry now exists in rural areas for the manufacture of small hydropower components. The large number of plants, the reliance on local resources, the lack of foreign exchange, and social organization made possible the development of a widely dispersed small hydropower industry. Recently has there been a national effort to centralize equipment manufacturing for the purpose of trade.

The Economics of Hydropower

29. The economics of hydropower is dominated by high capital costs, long life and low operating costs. The total annual operating costs are basically constant for hydropower systems irrespective of the percentage of capacity utilized because recovery of the capital investment is the major component of cost. The total annual cost of an unused diesel system for example, that is, with no electricity production, is limited to the cost of recovering that capital investment, which is lower per unit kW output.

However, as electricity is produced, the annual operating cost of the diesel unit increases linearly with fuel consumption. Therefore long-term costs of diesel generation is dominated by the price of fuel.

30. The provision of electric power for an industrial enterprise requires consideration of a variety of options. These options include: extension of the electric power grid; a diesel generator; and if available, hydropower. In many decentralized locations, extension of the grid is not practical or economic. The economic choice between hydro and diesel can be heavily influenced by the load factor. If power is required only a few hours, then a diesel would be favoured. If a 24-hour supply operating at a fixed capacity is required, then the hydropower system is optimal.

31. The capital cost of a hydropower installation is typically dominated by site specific factors such as topography, water storage, choice of turbines and environmental considerations. On the other hand, the capital cost of a diesel installation can easily be determined. This causes uncertainty among those who seek to develop small hydropower sites. In order to develop a cost estimate for typical small hydropower plant it is necessary to send engineers into the field to evaluate the variety of factors which can influence the cost; whereas the cost of a diesel plant can be determined from a manufacturer's catalog.

Resource Evaluation

32. The siting of small hydropower plants requires a unique set of physical advantages such as year-round flow or capacity for storage and a significant drop in elevation. Although these factors and their influence upon the design and economics of small hydropower plants are well known, few efforts have been put into developing methodological approaches to the evaluation of specific mini and small hydropower sites. New work in this area is currently under way.

Project Development

(a) Country and Regional Assessments

33. To carry out assessments, many new technologies which have recently been developed can be used. For example, the use of remote sensing coupled with geographical information systems to monitor agricultural and water resources projects is well known. Although some regional assessments have been carried out, they are not uniform and often do not provide sufficient information to develop a project. Uniform methodological approaches to national assessments, prefeasibility investigations and feasibility studies need to be developed. These methodological approaches should be made available to a variety of possible project proposers on a computerized basis using the latest micro-computer systems and software.

34. Such regional assessments should note the location of both existing and planned industry. The optimal siting of small hydropower plants or extension of the grid should be such as to encourage industrial development where raw materials, energy and skilled labour are available.

(b) The Equipment Manufacturing Question

35. In countries which are well endowed with hydro resources, the development of a large number of small hydropower sites will require a considerable quantity and variety of electro-mechanical equipment. Local manufacture could save scarce foreign exchange since equipment may be half the capital cost. However, the development of only a few, perhaps tens of sites would not encourage local industry to pursue the manufacture of turbines, for example, unless there were exporting opportunities. However, this would presume a neighbouring market with no such manufacturing taking place next door.

36. A rational approach would be the manufacture of this equipment at regional centres owned and operated by local and neighbouring industrial interests. Shared sales, therefore profits, would accrue to participating organizations. Candidate locations for such activity might be, for instance, in the Andean region, the ASEAN region and East Africa. Clearly, trade agreements and the equitable sharing of profits and investments would be required.

(c) The Economic Link to Industry

37. The development of small-scale hydropower could enhance industrial opportunities. On the other hand, large hydropower development is generally carried out by foreign engineering consultants with the equipment of such a size that it must be imported. The smaller the average plant size, the more opportunity there will be for local participation in all phases of the project. This would favour a widespread application of mini-hydro in rural areas linked to the development of rural industry.

38. Additional opportunities exist in small communities to couple industrial units to a local utility through hydropower-produced electricity. The load profile could be adjusted such that community energy use complements industrial energy use thereby increasing the load factor and reducing the kilowatt hour cost. Optimally, most of the industrial use of power should be during the nighttime hours when residential consumption is low.

(d) Software Needs

39. A variety of information and analytical support is necessary in order to organize a small hydropower programme. Initially, during the regional assessment phase, hydrologic and geophysical data must be secured locally or from international agencies such as UNESCO or the World Meteorlogical Organization. Remote sensing data are available from N.A.S.A., however, the interpretation in processing of these data requires skilled people and specialized equipment.

40. The essential information needed is streamflow, preferably on a monthly or daily basis. Techniques have been developed in the US and Europe to synthesize streamflow from scant data. However, many developing countries need better stream flow data and these special techniques for evaluating risk and probability factors can be used by the developing countries with the introduction of the micro-computer and adequately developed software.

C. THE BIOMASS OPPORTUNITY

The Need for an Integrated Approach

41. The use of biomass for energy is as old as human kind and will survive far into the future. Biomass fuels such as wood, straw and dung remain the principal energy sources for millions of rural people. Biomass can be simply defined as plant and animal residues which serve a variety of energy and feedstock needs. These popularly include wood, straw, dung, grasses, municipal solid waste, aquatic plants and a host of agricultural and industrial residues. The key constraints to their economic use is low cost availability and the ability to convert them into a useful energy form that can easily be oxidized. There are a variety of processes which will affect this conversion, the economics of which depend upon technical readiness, internal energy consumption and level of capital investment.

42. Clearly some conversion processes are well known and practiced for millennia. These include the thermochemical process of direct combustion and gasification and the biochemical process of fermentation. More advanced processes, such as liquefaction and lignocellulosic fermentation are still in the development stage. Currently such conversion is possible, but only in small quantities under high technology controlled environments and at high cost. Their application in developing countries, in making a signific... energy contribution, remains to be defined. The processes which can now make the biggest impact are direct combustion of woody biomass, alcohol fermentation, anaerobic digestion and gasification of all sorts of residues.

43. The efficient to use of biomass resources without depleting the natural resources of a region, requires planning and judicious use and production of biological material. The utilization of biomass by industry for substitution of fossil fuels must be carefully managed so as not to deplete the biomass resource and raise its economic value to the point where those who have traditionally depended upon it, will not be able to afford it. For example: if an industrial venture sought to use charcoal, energy plantations should be established so as to insure adequate supply. The iron and steel industry in Brazil has been using charcoal in place of coke for several years. The cultivation and processing is carried out by private interests with an eye towards conserving and expanding the resources. However, in this particular setting there is no competitive use by large local populations for cooking, as would be the case in some African countries.

44. To meet industrial needs through substitution of biomass resources will require an integrated approach to the cultivation, harvesting, conversion and utilization of the feedstock. In order to make such substitution feasible, sufficient quantities of resource material must be available on a sustainable basis at the plant site. This may require co-ordination among parties which do not normally interact, such as ministries of agriculture, forestry, natural resources with ministries of energy, planning and industry. Only an integrated approach at the highest levels with government support can mitigate possible environmental disasters as well as social stress which could result from rapid and severe biomass resource depletion.

The Required Resource Base and its Development

45. For industrial use, the most likely biomass resource at the present time would be wood, bagasse, sugar cane, cassava, stillage and, to a lesser extent, manures and oil bearing plants. For biomass energy to be a real alternative to oil in large scale industrial applications, it will be necessary to have large quantities of biomass feedstock available. This material could come from an "energy farm" devoted exclusively to this purpose. However, the opportunity costs associated with reduced food or export crop production must be assessed. Herein lies the policy decision to be made at the highest levels. The political will must exist in order to pursue a course beneficial to industry but not detrimental for social development.

46. To develop a strategy for biomass resource utilization in industry, a complete survey of industrial energy use and standing biomass must be made. This can be carried out at prefeasibility levels to simply determine what particular biomass-supply-conversion option warrants further investigation. The energy needs of industry must be met but not so as to impact negatively on some sector of society.

The Readiness of Conversion Technologies

47. The major oil price increases of 1973-74 and 1979 have fostered much research in biomass cultivation and conversion technology R&D. Many old processes have been rediscovered, for example gasification, after elaborate research and testing. However, technical readiness of these traditional processes has not advanced appreciably apart from a better understanding of

microbiology in anaerobic digestion and enzyme kinetics in alcohol fermentation. Unfortunately, this research has not yet led to easier or more flexible operation of combustion or gasification systems or biogas plants. Therefore, the success or failure of a biomass energy scheme for industry is based upon a realistic appraisal of what is economically and technically possible. R&D should be encouraged, but if an industrial enterprise wishes to take immediate steps to reduce fossile fuels and substitute a biomass fuel, then only a proven technology can be applied.

48. Technical and economic readiness of such advanced processes as high temperature, high pressure liquefaction, fermentation of lignocellulosics and pure pyrolysis may not be reached for some time. The developing countries may chose to participate in this R&D effort or monitor its progress in other countries.

49. The specific biomass energy conversion system which is chosen will depend on the type of feedstock available, the desired form of energy product, economics and the local operating skills base. For example, wood residues can best be converted to thermal energy via direct combustion and to a low-energy gas via gasification; liquid organic residues can be converted to methane via anaerobic digestion; municipal solid waste can be directly combusted or converted to compost or used as an additive for anaerobic digestion; starch crops may be enzymatically converted to sugar and fermented to alcohols and so forth. These basic well-known processes are among the most viable alternatives. A review of the history of research in biomass conversion will reveal much early work pointing out technical constraints which today have been overcome as a result of recent progress in biotechnology.

50. Applications research of known technologies in fresh environments or with new types of biomass feedstocks should be encouraged. The work could be carried out on a demonstration basis perhaps financially supported by donor organizations and industrial entities.

Economic Uncertainty

51. The economic uncertainity attached to the application of specific biomass energy technology can be reduced by a detailed project analysis of the costs and benefits. It is of critical importance that in such an analysis all costs are considered not just direct accounting costs. Opportunity costs must be considered and shadow pricing may be needed to perform a realistic appraisal. In determining the cost of biomass production and conversion, resource depletion and lost export opportunities must be considered. If energy independence and other general policy matters are of prime importance, then costs may become a secondary factor.

52. In order to provide such a view, improved economic analysis methodologies need to be developed. Traditional techniques were designed to compare similar options. Today we are often faced with having to compare dissimilar options. An example of the latter is the comparative analysis of a high capital cost, low operating cost system with one having low capital costs but high operating costs. Resource depletion might manifest itself differently in the two cases. A life cycle cost approach might be more suitable for such an analysis. Therefore, all costs and benefits must clearly be evaluated in an objective manner.

Large Scale Biomass Projects

53. Perhaps the most successful biomass projects were those developed naturally, through local initiative without foreign expert intervention. Examples include biogas digesters in the People's Republic of China, which served the twin purpose of sanitary waste disposal and energy production. The forces that caused their development was high population density, structured social organization and an appreciation for using every available resource at hand. The absence of these factors at a candidate site for a biogas project should be a cause for concern.

54. Large systems such as wood-fired boilers can be built and run without major regard to the local social conditions because the operating personnel will be trained in the appropriate technology for running the plant.

55. The use of bagasse at sugar mills and fast growing trees in a Philippines rural power project bear this out. Similarly the technical success of the alcohol programme in Brazil indicates what can be done on an industrial scale with well trained staff. On the other hand, the limited success of the small biogas programmes in many parts of the world indicates the importance of taking into account local social conditions when dealing with small-scale rural projects.

56. Perhaps the greatest biomass success has been the forest products industry throughout the world. In the United States, for example, this industry is at least 50 per cent energy self sufficient. However, the difference between an established large industry and village biogas units is clear. Another successful biomass venture is the use of alcohol stillage from rum manufacturing at the Bacardi Distillery in Puerto Rico. The entire plant has been made energy self-sufficient through methane generation from a single large digester with a diameter of 150 feet. Other successful industrial biomass projects include feed lot, and pig and dairy farm digesters.

Socially Responsible Biomass Resource Planning

57. The industrial use of biomass could bring about an ecological disaster or a crisis for the rural poor who depend on local resources. This can be avoided by planning and co-ordination among responsible Government entities. Clearly, industry has the economic power to acquire local biomass resources but in the long term if it does not use these resources for the benefit of all, industry itself will suffer.

58. Small, rurally dispersed industry could benefit to a greater extent than large centralized industry through the use of biomass resources resulting in less depletion. Centralized production of charcoal for example in an unsupervised area would bring wealth to a few small entrepreneurs but could deplete many other biological resources in the area, in particular wildlife. To co-ordinate the rational use of the biomass resource, in-depth investigation of the carrying capacity of the land should be done. Small dispersed industry working together to preserve the biomass resource may be the most effective approach.

Some Practical Approaches

59. To take full advantage of the biomass resource, an integrated approach to all phases of its production and use needs to be taken. A rational procedure includes national and regional biomass assessments, evaluation of storage and delivery systems and industrial energy audits with the objective to match biomass resources to industrial energy needs.

60. Industrial energy needs include heat, mechanical work, electricity and hydrocarbon feedstocks. Generic industries in developing countries include breweries, cement plants, bottling plants, food processors, fertilizer plants, refineries, brick kilns, bakeries, metal industries and a variety of construction activities. Each may have several energy needs, some of which could be supplied through biomass feed stock. For example, in small thermal unit operations, brick kilns, bakeries and food processing, wood or other cellulosic feed stock could be substituted for natural gas. In the larger industries this becomes more difficult because of the large quantity of biomass required and thermodynamics of the process itself. That is to say, not just any feedstock could be substituted for natural gas in cement kilns and fertilizer plants. On the other hand, the use of chicken manure to heat brooder houses, becoming popular in Egypt, is very appropriate. There are no formulas to identify perfect biomass-industry matches. It is a matter of detailed technical analysis.

61. Although a great deal has been written about renewable energy, there is a need for a series of publications on the use of biofuel in generic small-scale industry For example, there is little information on how the various brick kilns are constructed and how alternative fuels can be used. Also there is little information on the proper design of gasifiers with specific feedstock and production rates. This type of practical information is of interest to small industry in developing countries and ways should be found to provide it.

D. THE SOLAR OPPORTUNITY

Some Solar Energy Applications in Industry

62. It is a generally accepted notion that solar energy is presently only of use as a dispersed energy source providing a low quantity of heat for a variety of rural applications. This concept limits the possiblity of its use in industry. One needs only to cite a few examples of application as a supplementary energy form in various industrial processes. Low temperature water 30 degrees to 70 degrees Celcius can be produced in simple thermosyphon water heaters with flat plate collectors, higher temeperatures can be generated with concentrating collectors, to 150 degrees Celcius. This range of temperatures fits a variety of industrial uses such as bottle washing, sanitary uses, boiling, etc. More complex systems use solar energy for refrigeration and cooling with a continuous absorption refrigerator system. Solar distillation via simple stills or flash processes have also been developed. These schemes are known to be economically competitive in remote arid areas far from a grid or water supply. Solar drying is an established practice in the dried fruit and other agricultural industries. Improved dissemination of technical information and economics would foster greater use of these techniques in the developing countries.

Needed Demonstrations

63. A variety of demonstration projects should be undertaken to ascertain the economics of various solar technologies to industry. The solar preheating of fuel oil for a cement plant, heating of water for cooking, washing, sanitation, solar refrigeration for the storage of perishables in remote areas are among some of the possible projects.

Solar Photovoltaic

64. Solar photovoltaic energy sources produce direct current electricity, directly from solar energy; their maintenance requirements are minimal and the demise of a single unit does not shut down the whole system. Unlike all other sources of generated electricity, the cost per unit of electrical energy generated does not depend drastically on the capacity of the photovoltaic energy unit installed. Another important feature of this energy is that the user can be independent of external agencies for fuel and maintenance. All

these advantages make solar photovoltaic energy sources eminently suitable for use in remote areas. Viewed from this perspective, solar photovoltaic energy sources can be highly relevant to developing countries. The use of photovoltaic energy beyond remote locations will depend upon continued cost reduction and its becoming economically competitive with conventional sources.

E. OTHER ENERGY OPPORTUNITIES

65. In addition to the resource opportunities outlined above, there are several others that must be considered by the developing countries in evolving their specific energy plans. This group of opportunities is more limited in terms of the number of developing countries that may be able to take advantage of them, but nontheless these should be given careful consideracion.

(a) Geothermal

66. Geothermal energy can be used as a source of heat for direct use or can be used to generate electricity, both of which have industrial applications. Because of the high cost of drilling and development, geothermal resources tend to be related to large-scale industrial developments. Approximately one dozen developing countries are currently involved in geothermal activities. An equal number have the potential for developing geothermal energy. Those countries which are fortunate enough to be endowed with geothermal resources should pursue the development of this option with proper rcognition of the economic, environmental, and institutional considerations involved.

(b) Wind

67. Wind energy has been used for many years for water pumping, grinding grain and other agricultural uses. These applications have been small-scale and not highly adaptable to industrial use. Wind energy can be used to generate electricity and currently new technologies are being developed for large-scale power generation. These activities could lead to a contribution to the electric power grid. It should be recognized, however, that wind energy is an extremely site-specific source and requires high velocity winds of a constant nature.

(c) Nuclear

68. Nuclear power is another option for the generation of electicity which can be considered by the developing countries. The nuclear option is characterized by the following features: relatively large power sources which must be fed into a grid; the need for a large, highly trained, skilled cadré of people to operate and maintain the facilities; the necessity of making provisions for a safe operation and for sound radioactive waste management; and the requirement for a supporting industrial infrastructure. Several developing countries now have nuclear programmes and a few others are embarking on modest nuclear power activities. It is generally believed that nuclear power will supply less than 10 per cent of the electricity in the developing countries by the year 2000.

69. Fusion power had been a subject of research among several industrialized nations for the past thirty years. Its prospects can best be summed up by the view that the world cannot afford to ignore it in its energy research and it cannot afford to depend on its availability in making future plans.

II. INDUSTRIAL ENERGY MANAGEMENT

A. MANAGEMENT

70. Energy managment has been a primary concern in successful industrial operations for many years. The problem has, however, become more acute in recent years such that energy management is receiving much closer attention from industries and governments.

71. Industrial energy management can be thought of in terms of three main areas:

(a) National Industrial Energy Planning

72. Most developing countries are already engaged in energy planning aiming at optimizing national energy supplies and consumption according to their natural resources, priorities assigned to different consuming sectors, financial considerations, balance of payments and other factors. As pointed

out elsewhere in this paper the central role of industry in the energy problem means that national energy planning is directly and inextricably connected with industrial planning. Sectorial energy planning is an essential part of national energy planning and new concepts and programmes are needed in connection with the development of new industrial structures with special attention to energy availability. The maximum and effective use of indigenous energy sources is an obvious priority for the developing countries in evolving a national industrial plan.

(b) Energy Planning at the Plant Level

73. At this level the purpose is to optimize the use of energy including improvements in the determination and control of plant energy balances; the accomplishment of energy conservation and substitution; preventive maintenance for energy equipment and accessories; diversification of energy sources; optimization of operating schedules, etc.

(c) Means of Facilitating Management

74. Industrial energy managment must include plans and programmes pertaining to the means required for the successful implementation of energy development, utilization and industrialization. Such means include scientific and technological activities; education and training; the creation of the appropriate financial machinery to promote and sustain the energy and industrial development effort; and a legislative, physical and promotional framework to stimulate and support an expansion of energy production, consumption and industrialization.

75. Any significant expansion in energy development and industrialization will clearly require scientific and technological expansion: local science and technology are needed to ensure research and development on energy-related subjects; industrial techology including the energy aspects of process and product engineering; industrial engineering services in support of new industrial initiatives and general information systems for the support of scientific, technological and industrial activities.

76. It is now widely recognized that human resources constitute one of the most significant aspects of industrial development. There is a clear need for planners, managers and operating personnel at all levels capable of handling the issues associated with energy development and industrialization. It is equally clear that the initiative must be taken in the form of training and education programmes to foster the growth of individuals in these areas and many such programmes are underway. The manpower needs might be summed up as follows:

Energy planners and managers (specializing in broad energy planning, programming and management);

Energy economists (specializing in the economics of energy trade, pricing, costing, etc.);

Energy engineers (specially trained individuals at the university level for this profession);

Energy technicians (trained at the intermediate level for a diversity of specialized tasks);

Skilled operators and workers (to produce, handle and operate specialized equipment such as a charcoal kiln biogas generator etc.)

B. CONSERVATION AND SUBSTITUTION

Increasing Energy Efficiency

77. One of the main conclusions to come out of recent studies of industrial energy consumption in developing countries is that there exists a major potential to increase the efficiency with which energy is used. This view is supported by evidence on the differing amounts of energy used in the manufacutre of similar products (such as iron and steel) across countries and, more telling, by the widely varying amounts of energy used in producing similar products by different firms within a country. On the spot inspection of industrial facilities in several developing countries has provided examples of grossly wasteful use of energy.

78. It is estimated, for example, that in the energy-intensive industries (such as iron and steel, aluminum) up to 10 per cent of total energy consumption can be saved through house-keeping improvements alone or other small changes involving minimal investment. The return on these investments is large and the pay back period short.

79. Much larger savings (up to 30 per cent) can be achieved over a longer period (in 2 to 3 years or less) through retrofitting, installation of controls and simple process changes. In the longer run much greater savings can be achieved through the use of entirely new processes (such as the dry in place of wet cement process). Even before energy prices started rising, energy consumption per unit of industrial production was falling due to the introduction of cost minimizing new technologies and equipment. The rise in energy prices has accelerated this process.

Changing Industrial Structure

80. The above examples cover possibilities of using less energy to make units of similar products. Other energy savings in the industrial sector can be achieved by steering the structure of the industrial sector away from energy intensive activities, assuming this shift is consistent with broader policies. There is a wide range of energy intensities in industry and in theory at least it is possible to reduce the amount of energy used per unit of industrial output by changing the mix of the industries which go to make up the industrial sector.

81. The availability of cheap oil before 1973 meant that it was possible for countries without major domestic energy resources to industrialize and even develop energy intensive heavy industry on the basis of imported oil. Japan is an example of such a country among industrial countries and the Republic of Korea and Brazil are examples of developing countries. As costs of imported energy rise, countries without major energy resources will tend to move away from energy intensive industries such as chemicals, plastics, iron and steel, cement, pulp and paper and aluminum in their future industrial strategies for both cost and security reasons. There are some exceptions to this rule however. Because of high transport costs, cement is likely to continue to be produced near consumer markets despite high energy costs. The development of natural gas in some countries could stimulate the establishment of a fertilizer and chemical industry. The energy industries themselves are the most energy intensive of all so that the expansion of domestic energy production will involve increases in industrial energy consumption though hopefully not of scarce and expensive petroleum.

82. For other industries where energy costs are a smaller part of total cost, energy is not likely to nave a decisive influence on industrial development strategies. Planning for industry must after all consider all factors of production.

Some Conservation is Cheap and Rapid

83. A major attraction of conservation as an industrial energy policy is the generally lower cost of a wide range of conservation options in saving energy than in supplying an extra unit of energy, and the short time period in which substantial savings can be achieved. Lead times in supply options are typically long, as are such conservation options as changing the strategy of the industrial sector and introducing entirely new processes. There are however a multitude of other less drastic possibilities which yield a high pay-off in a very short period of time.

Fuel Substitution

84. While the generally higher level of energy costs suggests efforts to conserve all energy, the particularly sharp increase in petroleum prices emphasizes the need to conserve petroleum not only through the means already described but also by substituting more abundant forms of energy. (This may even lead to an increase in total energy use but so long as it is a reduction in total energy costs this strategy will be economically worthwhile.) As we have seen industrial energy conservation consists largely of oil and electricity except in those countries which have exceptional endowments of coal or gas. Increasing the share of electricity is one possiblity especially as many countries have major hydro potential. The extent to which electricity can be substituted for petroleum would depend on the type and weight of functional activities being performed by petroleum in the industrial sector. Not all industrial activities can be satisfactorily carried out using electricity. A recent survey of the industrial sector of Costa Rica suggests that technically one half of all industrial energy use could be provided by electricity. But for this to happen electricity tariffs would have to be reduced to a very low level which could compromise the financial viability of the electricity generating sector. Long term economically feasible substitution would be substantially less.

85. Coal can be substituted in a wide range of industrial activities as witnessed by the virtually complete reliance of India and China on coal use in the centralized industrial sector. Similarly gas can substitute for oil in the industrial sector as in Mexico. Some industries especially those in rural areas may look to wood and charcoal but this could cause major environmental problems if care is not taken to preserve the forest resource base. Solar heating or preheating of water and oil could represent significant savings of petroleum and appear to be currently cost effective.

Economic Incentives

86. Whether the savings of energy in general and oil in particular will be achieved depends on a number of factors. Perhaps the most basic is the economic incentives for conservation.

87. The increase in crude oil prices which took place over the last ten years has led to a steep rise in the prices of petroleum products used by industry. There are several points to notice here. First, the increase in prices in industrial fuels has been more rapid than the increase in prices of petroleum products consumed by other sectors - the household sector where efforts have been made to keep prices down by subsidies and the transport sector where the large tax wedge dilutes the effect of crude oil prices on prices paid by consumers. The industrial sector has therefore had a greater incentive to conserve energy.

88. Second, price experience has differed considerably among countries. Within the developing countries three groupings can be distinguished - those which import all petroleum supplies, producing countries which still import some supplies, and net exporters. In the first group the increase in oil prices has been generally fully passed through to consumers. There was in fact little alternative which would not have had a major unfavourable impact on budgets. This group of countries may not have benefitted from the recent fall in petroleum prices due to the strength of the US dollar which has more than offset the decline in oil prices leading to a continued rise in the price of imported oil in terms of local currencies.

89. The producer importers typically kept the price of domestically produced oil low for some years after 1973 and thus the average price of supplies in these countries including imports were below the average prices of the importing countries and below the average of world prices. The net exporters have typically kept prices well below international levels, despite sharp upward adjustments in recent years.

90. The price experience of other fuels used in the industrial sector is not well documented. Despite recent increases in electricity tariffs the costs of electricity have probably remained constant or even fallen in real terms over the past ten to fifteen years. Prices of coal and gas used by industry have probably also followed this same trend. The incentive to conserve in the industrial sector is therefore much greater in those countries which are obliged to import all their industrial fuels - in practice petroleum - than in the others.

Obstacles to Conservation

91. If high energy prices are a necessary inducement to conserve they may not, however, be sufficient to achieve desired conservation ends in a short period of time. Recent surveys of conservation potential and progress in selected countries indicate that even at high prices there are several obstacles to effective conservation. The incentive offered by high energy costs for example can be more than offset by the high costs of energy efficient equipment due to high import duties or high rates of interest for financing such equipment. In conservation as in other aspects of public policy it is important to maintain consistency. In public policy, there is a generally wide-spread lack of knowledge about energy use and about the technical means of achieving conservation. Even if this knowledge is available, energy conservation may still be a low priority for industrial management due to the presence of other more important technical problems and limited manpower available for their solution. Part of this low priority could be related to the share of energy costs in total costs production. It has been remarked earlier that in a few industries energy costs represent a very high proportion of the total, perhaps between 20 and 30 per cent. These industries therefore have a major incentive to achieve

savings in energy use. For many industries, however, energy counts for only between 3 and 5 per cent of total costs of production. In these conditions it may appear to management that scarce skilled labour and managerial ability are from the point of view of overall economics of operation better deployed in other areas.

92. Another disincentive to achieving energy conservation could be the protected market situation in which many of these industries operate. If there is no competitor it is quite easy to pass on the extra costs of more expensive energy, particularly if these are a small part of total consumer price. These are important obstacles and may have been largely responsible for what appears to have been a relatively modest conservation response to higher oil prices.

The Economies of Substitution

93. The relative prices of different sources of energy are important if substitution for oil is to take place. Generally speaking prices of coal and gas are lower than oil prices largely because they are both domestically produced with little possibility for export. Electricity is typically more expensive on a heat delivered basis than petroleum and this, as well as technical considerations limits its possibilities for substituting for petroleum.

94. Though price differentials between petroleum and other fuels suggest good possibilities for substitution, other non-price factors can serve as obstacles. Retrofitting or installation of new equipment especially with high interest rates may swamp the savings affected by lower energy prices. Furthermore energy supply constraints have been a constant problem in the developing countries. Shortages of coal in India for example have inhibited substitution for petroleum and have even led to increased petroleum consumption on some occasions.

III. POLICY OPTIONS AND MAJOR ISSUES

The Economic and Social Policy Background

95. Although energy planning has attracted much attention in recent years it should be recognized that energy is not an end in itself but a means of achieving wider economic and social objectives. It should be subordinated to overall development planning while recognizing that the changing economics of energy may entail new constraints on overall development policy. The purpose of energy policy is then to identify the most effective policies for the least cost development of the energy sector consistent with general development strategies.

96. In the 1950s and 1960s there was a much greater unanimity about development aims and strategies than there is now. A policy of rapid modern industrialization oriented towards exports or import substitution was followed or aspired to by most countries. These policies were associated with rapid rates of economic growth but in many countries left a legacy of troublesome economic and social problems such as continued high unemployment, excessive urbanization, a backward agricultural sector, costly dependence on food imports, and after the oil price rises of the 1970s, unacceptably high oil import bills for the oil importers among the developing countries. Even the oil exporters, although benefitting from higher oil prices, experienced many of the other problems, and like the oil importing countries, looked to alternative development strategies to help overcome them.

Appropriate Industry Policy

97. The range of possibile development strategies discussed was quite wide and dependent to a large extent on particular characteristics of individual countries. There were however certain common elements. These include greater emphasis on agricultural development, and a decentralization of industrial activities, both to promote rural development and to help rectify the regional imbalances which had grown up during the previous industrialization regime. In addition to these general developmental considerations, the rapid rise in oil prices made energy intensive industrial development based on imported oil much less attractive.

Energy and Industry

98. These developments have important implications both for the amount, the type, and the form of industrial energy which will be used. The structural changes represented by increased agricultural development and by less energy intensive industry could lead to a reduction in the overall energy intensity of the economy. Total energy consumption will continue to rise, but less rapidly than it would otherwise have done. The decentralization of industrial activities could be parallelled in those countries where there is no nation-wide energy distribution system by a decentralization of energy facilities. Finally the development of rural and agro industries could lead to increased use of locally available renewable sources of energy such as wood and crop wastes.

99. The link between energy and industry runs two ways. Industrial development has major effects on the energy sector, but energy sector developments can equally affect industry. The sharp rise in oil prices and oil bills will de-emphasize the share of some energy intensive industries. For those countries with a reasonably developed industrial infrastructure, the growth of new energy technology (such as alcohol fuels in Brazil) could lead to the development of new energy supplier industries. The development of gas reserves to replace oil could give rise to a whole range of industries using gas as a feedstock.

100. The links between industrial development and the energy sector are so close, the financial and other resources needed for energy development so large, and lead times so long, that it is essential to recognize this interdependence formally in the planning process so that industrial and energy sector plans can be made mutually consistent.

Energy Policy Issues

(a) Managing the Resource Base

101. Developing countries are, to varying degrees, well endowed with renewable resources, hydro and biomass. The development of these resources can play a central role in the provision of energy supplies to the industrial sector. However, their development, which are after all renewable only in the limited

sense that they are capable of replacement, must be rationally planned. Elements of this planning include a careful appraisal of the size and quality of the renewable resource base, and an assessment of the optimal rate of development taking into account associated environmental and social costs, and their value in alternative uses. The rapid exploitation of wood fuels for industrial use, for example, could lead to widespread deforestation with severe effects on surface drainage, agricultural productivity and the provision of supplies of wood to other users (the urban and rural poor, builders). One solution would be to oblige the consuming enterprise to provide its own supplies of wood from specially designed areas.

(b) Balance Between Imports and Domestic Supplies

102. The experience of the last ten years has made energy self-sufficiency a very attractive option to energy planners in oil importing countries. The sharp rise in prices of imported oil requires a careful re-appraisal of domestic energy resources to assess which could be economically developed under the new conditions. Some progress has already been made in increasing domestic production of energy in developing countries, and the rate of increase in domestic production is estimated by the World Bank to accelerate in the future.

103. For the individual country the policy issue is the degree of energy self-sufficiency to be achieved. Like flexibility, self-sufficiency comes at a price (represented by subsidies and other encouragements to producers) which rises as the degree of self-sufficiency rises.

104. For many importing countries the choice between imported and domestic fuels may be a de facto choice between commercial fuels (imported) and renewable (domestic). Again this is an area where economic considerations can give some guidance so long as the total costs and benefits of renewables development - including such important benefits as employment of under-utilized labor, foreign exchange savings - are included.

105. Insofar as a drive to self-sufficiency is occasioned by concern over high oil bills, an alternative or supplement to energy self-sufficiency is to use resources to develop the exports necessary to pay for oil imports. The experience of the 1970s indicated the extraordinary economic resilience of those countries that were able to raise export earnings.

(c) Flexibility

106. Flexibility in fuel supply and in fuel using capacity is a valuable protection against physical supply interruptions or unanticipated swings in energy prices. One element in a flexible supply system is a balanced energy research and development programme emphasizing the assessment and feasibility of different supply options for local use. On the industrial user side flexibility can be assured by the installation of multi-fuel using facilities so that the user can change fuel as circumstances dictate.

107. The incorporation of flexibility of a system entails costs which will tend to rise as the degree of flexibility rises. The policy question is: given these rising costs how much flexibility is enough? While part of this question will be answered in the market place there are wide issues of national economic vulnerability which could suggest the desirability of a higher degree of flexibility than that provided spontaneously by individual industrial users.

(d) Energy Supply/Demand Mix

107. Petroleum has proved to be an exceptionally versatile energy source, capable of use not only in the three main consuming sectors of transport, household and industry, but also in a wide variety of processes within the industrial sector. So long as oil was the dominant fuel in the industrial sector there was little risk of incompatability between industrial energy supplies and requirements.

108. The reduced role of oil in industrial use could result in mismatches between supply and demand. In general the properties of the various sources of energy and their suitability for various industrial processes are well known. The weakness here is the lack of knowledge of the relative

importance of the different industrial processes. How large, for example, is the demand for low temperature heating which can be supplied by solar hot water heaters? The answer to this and similar questions will vary from country to country but it needs to be known in general terms if the energy supply system is to be fine tuned to match industrial energy demand.

(c) Role of Conservation

109. There is a major potential for energy conservation in the industrial sector. A large number of opportunities exist in this sector for rapid and cheap methods of energy conservation. In the medium- and long-term, an even wider range of conservation options are available with new processes and equipment.

110. An important policy question is the degree to which national and local governments should intervene in the area of industrial energy conservation. Governments can provide incentives, offer services, and foster conservation in many ways.

111. Industrial energy conservation techniques used in the industrialized countries can be considered for application in the developing countries. Such applications, however, require consideration of factors such as the scale of operations and the specific technological processes.

(f) Energy and Industrial Policy

112. The implications of the development of new types of industrial energy on the location and type of industrial development should be studied. In many developing countries, especially those in the earliest stages of development, industrial activity tends to be centralized, tied to a specific location because of limited infrastructure including energy facilities. The development of new, decentralized forms of energy suggests the possibility of decentralized industry which could promote a more balanced regional development. However, lack of ancillary infrastructure (such as roads) may limit this possibility. It should be noted also that renewable forms of energy are not the only form of decentralized energy. An extensive electric grid and a good road/rail system which can deliver energy to a wide variety of locations could also permit decentralization of industry.

113. An extension of this idea is the promotion of type and size of industry more adapted to these new energy sources. Biomass energies for example are characteristically dispersed and need to be gathered and concentrated before they can be efficiently used in industrial processes. Transport costs for collection therefore loom large in the economics of biomass and limit the size of the facilities and therefore the size and possibly the type of user industry.

114. This raises important questions for industrial policy such as which industries are most suited for decentralization and whether they are sufficiently encouraged (or not discouraged) under present industrial policy regimes.

(g) Policy Implementation

115. The discussion so far of policy issues has been couched in terms of policy aim and decisions. Of equal importance is the means of implementing these policies including the development of domestic energy supplies, the promotion of conservation and the direction of industrial policy, in a mutually consistent manner.

116. Governments have a number of policy instruments at their disposal to influence supply and demand for energy. They can cause prices to be higher or lower than they otherwise would be by taxing or subsidizing various forms of energy. Taxes or higher prices have the effect of discouraging consumption and encouraging production. Subsidies or lower prices discourage production and encourage consumption and therefore are logically inconsistent with conservation and supply development aims. Subsidies on such items as kerosene and rural electrification do, however, serve wide social and economic purposes, which may in the view of policy makers more than compensate the perverse effects on energy development. Nontheless it is important to realize that such subsidies strongly discourage the development of renewable forms of energy. Most industrial fuels bear little or no taxes.

117. High though current prices are, these may still provide insufficient incentive to fulfill energy policy aims due to such reasons as lack of information, training, shortage of capital, price controls in other markets, the complexity and therefore higher cost of setting up a new activity. In this case supplementary government actions will be needed to overcome these obstacles. The issue of who will undertake new energy developments, the sources of finance and the planning and co-ordinating mechanisms especially as they affect the interdependent development must also be decided.

118. Another aspect of energy policy making is to assure the phased development of the energy sector. The energy options described above take varying lengths of time to deploy. Important energy savings can be achieved within the short and medium term (say up to 5 years) and some substitution could be achieved in a similar time frame. Major development of new supplies will normally take longer.

IV. PROGRAMME INITIATIVES

119. The value of this meeting will be measured largely by the programme initiatives which stem from it. The following suggestions are only intended to serve as examples of programme initiatives and to provide a basis for discussion.

Developing Countries Need to Strengthen their Methodologies for Developing and Implementing Energy/Industry Policies

120. Inasmuch as the most relevant experience is within the developing countries, consideration should be given to mechanisms for sharing experience in the integration of development, industrial and energy policies. Workshops, seminars, and other modes may be appropriate.

121. This activity would focus on the process of formulating energy/industry policies including the identification of the major options, the criteria and their relative importance in establishing priorities and making selections among alternative paths, factors involved in gaining understanding and acceptance of new policies, and techniques for modifying policies in the face of significant changes in conditions.

Energy/Industry Policy Decisions Require Better Basic Information

(a) Focused Energy Appraisals

122. To provide a sound base for energy policy formulation, specific energy supply evaluations should be undertaken particularly of renewable resources on a country by country basis. These studies should focus on the availability and current disposition of biomass and water resources, solar insolation, various types of hydrocarbon deposits and their flows into the demand sectors. To have in-depth and accurate evaluations, it is suggested that they be carried out by an expert in that field and not through general enumeration procedures. Specifically, biomass resources should be appraised by a forester with quantitative skills, the water resources by a civil engineer or hydrologist, the hydrocarbon resources by geologists, and so forth. In many cases the data base may not be available locally and a primary data gathering effort may have to be mounted.

(b) Industrial Energy Sector Evaluation

123. In addition to various broad considerations, the preparation of an industry/energy policy requires knowledge of the form, quality and quantity of energy needed by specific industrial sectors. This information should be gathered and analyzed in an energy demand assessment, including energy costs, for the principal industries. For example: in Bolivia one might examine the mining and sugar industries, in Egypt the textile industry, in Kenya the coffee industry, and so forth. Industry/energy policies could then be developed based on energy needs, substitutability of fuels and the availability of local energy resources.

124. In addition, since some of these industries also exist in the developed countries, ways should be sought to learn of industrial energy policy directions and usage in those countries for their possible usefulness to the developing countries. One vehicle for carrying out such evaluations could be the industrial trade association within each country or similar industry bodies operating internationally. Through these groups an analyst could obtain data and access to what some may consider private information.

(c) Plant Energy Audits

125. Effective energy policies and actions at the plant level require a plant energy audit. This audit consists of an analysis of all energy and mass flows going in and out of the plant as well as the process flows within. Cost data for all fuels are part of the audit. In this manner, the efficiency of conversion, associated costs and energy losses can be determined. Once there is a complete picture of the plants energy balance, strategies to improve energy efficiency can be developed. This might include increased insulation around thermal equipment, reduced process schedule which will reduce start-up losses and the use of substitute fuels. Courses of action requiring retrofitting or updating old equipment will require cost/benefit analyses to determine if the additional investment can be recouped in energy cost savings.

126. Documented analysis techniques using the microcomputer, for example, should be developed in such a way that they can easily be applied in local situations. Manuals on general plant engineering of specific processes, cement for example, and showing how energy can be saved, should be developed.

Hydrological resources, which represent an excellent opportunity for meeting increased energy needs, are relatively abundant in the developing countries where only 9 per cent of this potential has been developed.

127. The developing countries should initiate an aggressive major programme to undertake activities which will lead to successful new investments for hydroelectric power installations. These activities should be of an integrated, co-operative nature including: hydrological resource assessments, design and other manuals, technological requirements, engineering, training and linkage with industrialization. It is recommended that those developing countries who are endowed with hydro resources potential take the well defined steps necessary for a successful application for capital investment.

128. As part of this major programme, new institutional structures should be established for:

development and demonstration of hydropower;

training;

setting standards on designs and equipment.

129. The Asian and Pacific Regional Research and Training Center for Small Hydro Power Generation at Hangzhou, People's Republic of China, was established in 1982 and may be a useful model for similar institutions in other regions.

Biomass energy resources are very large and widely distributed and with the development of the necessary technologies could become a significant industrial energy source in the developing countries

130. Therefore it is recommended that concerted action be taken at two levels:

(a) To intensify the research, development and demonstration programmes on biomass energy and its industrial implications in developing countries. This would involve national and regional activities;

(b) The exchange of information and experience on biomass energy development and use through regional and international networks. These networks, consisting of appropriate national institutions, would facilitate the sharing of information and experience on biomass energy policy issues, resource surveys and new technologies.

Provision by developing countries of capital goods and service for the energy sector represents a commercial opportunity and a step toward greater independence

131. The development of energy sources in the developing countries will require significant quantities of materials and equipment. Each country must approach the decision on this matter in the context of its national energy/industry policies including such factors as independence, balance of payments, market size, and capabilities.

132. For example, the expected expansion in small hydropower will require extensive new electro and mechanical equipment which could be manufactured domestically. Similarly, an expansion in bioenergy generation could create an industrial production opportunity for biogas generators and other devices needed in a decentralized energy system or whole new plants in centralized energy systems.

133. This market situation lends itself to a regional trade agreement between developing countries whereby each country would gain an equitable share of his neighbour's markets for specified goods and services for the energy sector.

Industrial energy conservation represents an opportunity to make significant savings at low cost

134. Industrial energy management including the wise and efficient use of energy must be an essential feature of the industrialization of the developing countries. Conservation is no longer seen as a matter of hardship and denial but rather as a means of producing more goods and services with a given amount of energy thus contributing to economic growth. In many instances energy conservation can generate employment; e.g. the increased use of thermal insulation in industrial equipment leads to more work for the insulation manufacturers.

135. It is recommended that a comprehensive, integrated, result-oriented programme on industrial energy conservation be implemented on a national and regional basis. The programme should be comprehensive in the sense that it would include those industrial sectors which account for the largest use of energy and would include most if not all of the countries of the given region. The programme should be integrated to bring together all of the essential elements for an effective activity including education and training of managers, engineers and workers; the preparation of manuals; the methodologies for performing energy audits and assessments; the use of workshops, seminars and plant visits; the creation of information centres; and linkages between organizations and institutions in the participating countries. The programme should be result-oriented so as to focus on achieving a significant improvement in industrial energy efficiency. In this regard it is suggested that the first phase of the programme should be aimed at making a 10 per cent savings in energy as a specific objective coupled with a monitoring and reporting system to measure progress.

136. The developing countries should consider the concept of establishing their own corporate entity for industrial energy conservation. The entity would perform services for client industrial plants on a fee basis. These services would include plant energy audits and recommendations of two types: measures that can be implemented immediately and often amount to a 10 per cent per annum savings, and longer term steps involving investments associated with new processes and equipment. The services provided by the entity would include the training of designated plant personnel during the conservation activity. This approach could be undertaken on an international, regional, or national basis with priority given to industrial sectors chosen by the participating developing countries.