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FOR ASIA AND THE PACIFIC
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PROCEEDINGS OF THE WORKING GROUP MEETING ON ENERGY PLANNING AND PROGRAMMING AND OF THE COMMITTEE ON NATURAL RESOURCES, FIFTH SESSION

ENERGY RESOURCES DEVELOPMENT SERIES
No. 20

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FOREWORD

This publication contains the reports and documents of the Working Group Meeting on Energy Planning and Programming, held at Bangkok from 15 to 21 August 1978 with the financial support of the United Nations Development Programme to review the priority needs of countries of the region in the field of energy resources development, and of the fifth session of the Committee on Natural Resources of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), held at Bangkok from 31 October to 6 November 1978.

It consists of two parts. Part one includes the report and documents of the Working Group Meeting, subdivided into three sections: the report of the meeting, working papers presented by the secretariat, and information papers submitted by Governments and other interested parties.

Part two includes the report and documents of the Committee session, subdivided into three similar sections.

Owing to limitations of space and budget, it has not been possible to reproduce all papers in full; some have been abridged.

EXPLANATORY NOTES

The following symbols have been used:

A stroke (/) indicates a financial year: for example, 1971/72.

A hyphen (-) between dates representing years (1967-1972) signifies the full period involved, including the beginning and end years.

The following abbreviations have been used:

AC	alternating current
DC	direct current
GDP	gross domestic product
GNP	gross national product
J	joule — unit of energy
kcal	kilocalorie equal to 4,187 J
kV	kilovolt
kW	kilowatt
kWh	kilowatt hour
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MW	megawatt (million watts)
MVA	megavolt-ampere
ton	metric ton
tce	tons of coal equivalent (1 tce $= 7 \times 10^6$ kcal or 29.3×10^9 J)

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Part one

WORKING GROUP MEETING ON ENERGY PLANNING AND PROGRAMMING

I. REPORT OF THE MEETING

ORGANIZATION OF THE MEETING

The Working Group Meeting on Energy Planning and Programming was held at Bangkok, Thailand, from 15 to 21 August 1978.

Attendance

Participants attended from the following ESCAP countries: Afghanistan, Australia, Bangladesh, India, Indonesia, Iran, Malaysia, Pakistan, Philippines, Republic of Korea, Singapore, Sri Lanka, Thailand and the Union of Soviet Socialist Republics. An observer was present from the Federal Republic of Germany. The following United Nations organizations and specialized agencies were also represented: the Centre for Natural Resources, Energy and Transport (CNRET), Department of International Economic and Social Affairs, United Nations Headquarters; United Nations Industrial Development Organization (UNIDO); United Nations Development Programme (UNDP); United Nations Environment Programme (UNEP); Food and Agriculture Organization of the United Nations (FAO); and United Nations Educational, Scientific and Cultural Organization (UNESCO). The Asian Development Bank, the Asian Institute of Technology, and the East-West Resource Systems Institute of the East-West Center were also represented.

Opening of the session

In his message, the Executive Secretary of ESCAP stressed the importance of the meeting in terms of reviewing the current and projected energy situations of the developing countries of the region. The meeting had the urgent task of identifying and classifying the immediate and near-future problems of the countries in the energy field, and the opportunities for co-operative action in dealing with those problems, and of updating and re-defining the contribution which ESCAP could best make towards technical assistance and solutions. At the same time, appropriate contributions by other parties could be outlined.

The Executive Secretary expressed the hope that the recommendations arising from the meeting would be clear and practical and would materially assist the Committee on Natural Resources at its fifth session in setting out the ESCAP programme for the period 1980-1981, and indicating the approach to be followed for subsequent years.

He expressed his thanks to UNDP for the contribution of funds to support the attendance of participants from the developing countries.

The representative of UNDP noted the background of the meeting as seen from the viewpoint of UNDP, and, reiterating its desire to support a worth-while regional energy project in line with the wishes of the countries, expressed its good wishes for the meeting in the deliberations on possible activities and priorities. He also urged that the possibilities of inter-country co-operation be fully explored.

Election of officers

The Working Group elected Mr. K. K. Y. W. Perera, Sri Lanka, as Chairman. Mrs. Otima Bordia, India, was elected Chairman of the Drafting Committee.

Adoption of the agenda

The following agenda was adopted:

1. Opening of the meeting
2. Election of officers
3. Adoption of the agenda
4. Energy resources in the region
5. Energy planning and programming: methodology of planning—assessment, development, demand, supply (storage, where relevant, and distribution), foreign trade, administration
   - (a) Problems in meeting energy requirements
     - (i) General
     - (ii) Major consumer groups
     - (iii) Rural sector
   - (b) Measures to encourage efficiency and economy
   - (c) Institutional arrangements
   - (d) Additional requirements
6. Suggested action
   - (a) By countries individually
   - (b) By groups of countries
   - (c) Supporting action required from the international community for inter-country and regional activities
7. Recommendations
8. Adoption of the report
9. Closure of the meeting

ENERGY RESOURCES IN THE REGION

The meeting had before it a background paper, document NR/WGMEPP/1, prepared by the secretariat, which gave details of the different forms of energy resources in each country of the region, as at 1974, with notes on new resources which had been discovered since that time. All resources were expressed in metric tons of equivalent coal, calculated according to United Nations equivalencies. Official figures as provided to the United Nations Statistical Office were given for production of the different forms of energy in each country from 1972 to 1977, and consumption from 1972 to 1976, including fuelwood, again using metric tons of equivalent coal. Net exports or imports by country were given as the differences between the totals of production and consumption, neglecting bunkers and variations to stocks.

Graphs were given illustrating trends in production and consumption of the different forms of energy during the intervening period, and indicating the effects of the large increase in the price of crude petroleum in 1973/74. For the region, the consumption of liquid fuels tended to level off, while consumption of other forms of energy tended to increase. Over-all production tended to increase, apart from a temporary reduction in the production of petroleum in 1975.

The Working Group noted with interest the information presented in the paper.

Several countries outlined major problems in the assessment of resources owing to lack of field data, and in the development of those resources owing to the lack of sufficient numbers of professional staff capable of making acceptable detailed feasibility studies; and internal and external capital constraints. In some countries the physical separation between resource areas and demand areas posed a significant problem, one outstanding case being Malaysia where the sea intervened.

Attention was drawn to the need for international co-operation to enable the hydroelectric resources of international rivers to be developed.

There was general agreement on the need to relate the various forms of energy resources to the regimen of demands in an optimum manner, and that point was extended to subregional groupings. The meeting noted that electricity was now being exchanged between the Lao People's Democratic Republic and Thailand, Thailand and Malaysia, and Malaysia and Singapore, although the amounts were comparatively small. The possibility of interconnexion between Sri Lanka and India was mentioned.

It was hoped that increases in efficiency of utilization of energy, and conservation of energy, would have a significant effect on the availability of energy.

Of the non-commercial sources of energy, it was difficult to see how the very considerable use of wood as fuel could be controlled in the short term, but attempts were being made to encourage more efficient usage. The use of biogas, solar and wind energy was increasing, but there was a need for additional research and development and other measures to encourage appropriate use of those resources. Some geothermal resources not suitable for electricity generation could be used for low-grade heating to reduce the use of premium fuels.

ENERGY PLANNING AND PROGRAMMING

The Group considered two background papers, document NR/WGMEPP/2, "Aspects of demand and supply in the region", prepared by the secretariat, and document NR/WGMEPP/3, "An outline of major issues", prepared by Mr. M. K. Chatterjee, consultant to the secretariat, together with the country papers listed in annex I.

In introducing his paper, Mr. Chatterjee emphasized the importance of a dynamic approach to planning, with continuing review in the light of changing circumstances and data availability. He suggested that the end-use method of demand projection was generally likely to be the most effective, with energy requirements related to desired targets in various development sectors, concentrating on the sectors or products involving the highest energy demand. It would be helpful if agreement could be reached on units to be used. Quite apart from units as such, care was needed to ensure the equivalence of alternative energy forms under consideration, including the effects of location of supply and use.

Adequate assessment of indigenous resources was a basic requirement for sound energy planning. While great importance should be attached to improving efficiency, care was needed to ensure that measures to achieve economy in energy use did not impede desirable development. Suitable institutional arrangements to ensure co-ordinated planning and management were very important.

Against the background of their country papers, the participants outlined the main features of the energy situation in their countries. While there were considerable variations in the resource base and requirements in different countries, in many cases energy consumption patterns were likely to involve a complex mix of resources, both indigenous and imported, at least in the short term. Continuing review would be called for in response to changing availability, cost and potential use of various resources; flexibility was also needed in response to changing strategies for development generally.

While the emphasis in energy programmes and related requirements thus varied from country to country, and would change with time within most countries, a number of issues likely to be of major concern to many countries over the next few years were identified at the meeting. These are summarized below.

INSTITUTIONAL AND LEGAL ARRANGEMENTS AND POLICY FORMULATION

Energy was a basic factor in economic and social development. Petroleum, which in recent times had been the principal source of commercial energy for most countries, had increased rapidly in price in recent years and for many countries was a major component in total imports. Furthermore, the availability of petroleum over the operating life of new projects now under development was subject to increasing uncertainties, and further rises in price with increasing scarcity could be expected.

Institutional and legal arrangements

There was therefore an urgent need for all countries, whether or not they currently had an adequate indigenous energy supply, to adopt institutional and legal arrangements which would ensure a co-ordinated approach to energy policy formulation and planning, and to implementation of programmes. The arrangement should also ensure the integration of energy planning and programming with planning and programming for development generally. The type of institutional arrangements to be adopted could be expected to vary depending on circumstances in different countries, but in all cases should be aimed at providing for the optimum use of resources in the short and long term, in harmony with national development objectives. In countries where there were several ministries with major interests in the exploration, production and use of energy resources, a committee or council at the highest level of government was considered desirable, and should be established, where it did not already exist, as a mechanism for co-ordination at the highest level.

Particularly in the case of assignment of work to the private sector, there was a need for institutional and legal arrangements which ensured that while terms and conditions were such as to attract the necessary capital and technology, national interests in the use and management of resources were safeguarded. In addition to matters relating to the use of resources as such, provision was needed to ensure satisfactory arrangements in relation to the supply of data, enhancement of social well-being, environmental protection etc.

National energy policy

Countries should adopt a broad statement of policy as a framework for formulating and carrying out energy programmes. In spite of the extreme variations in the energy situations of countries in the region, it was expected that in many cases policies might be based on objectives along the following lines.

The over-all basic objective would be the timely provision of energy in appropriate forms and quantities, and at appropriate locations and prices, to enable development goals to be achieved, including goals for human well-being as well as for economic development. At the same time there was an objective to strive for self-sufficiency in energy supply. Within these broad objectives the following subsidiary concerns might commonly apply:

(a) The exploration and development of indigenous energy resources with a view to building up reserves, reducing dependence on energy imports, particularly petroleum, and/or releasing premium fuels for export;

(b) The systematic collection, analysis and presentation of data on resources production, distribution and use of energy, including non-commercial forms of energy, as an essential base for energy planning and programming;

(c) The promotion of efficiency and economy in the production, distribution and use of energy, without inhibiting desirable economic growth and human well-being;

(d) The substitution of oil by other energy forms in electricity generation and industry, and the allocation of natural gas to premium uses, where feasible;

(e) The use of incentives and pricing as a tool to support the policies outlined above;

(f) The adoption of measures to ensure that energy programmes for the rural sector had a priority which matched the emphasis that countries might allocate to rural development, and were integrated with such rural development programmes:

(g) The adoption of practices for project and programme formulation and evaluation which gave due weight to the social and environmental implications of proposals;

(h) The education of the public in the importance of energy as a basic element in development, and in the need for care in its use and management, having regard to the increasing difficulty and cost of providing appropriate energy supplies;

(i) Participation wherever possible in co-operative international programmes of research and development, and information exchange, with a view to widening the energy base and encouraging more effective use and management of energy.

PLANNING AND MANAGEMENT OF ENERGY RESOURCES

Over-all energy planning was an extremely complex matter. Difficulties were compounded by uncertainties in the outlook for the supply of petroleum, the absence of adequate information on indigenous resources in the case of many countries, and uncertainties as to the technical and economic feasibility of widespread use of alternative energy resources such as solar energy. Planning also involved a complex interaction between various facets such as acquisition and analysis of data, application of energy management techniques and observation of their effects, and investigation of re-application of energy management techniques and observation of their effects, and investigation of resources. That in itself normally required extensive capital and other inputs, and should be based on planned priorities for resource use. Furthermore, there was often a wide separation between sources of and demand for energy, whether indigenous or imported. There were also difficulties in determining equivalencies between different forms and grades of energy, which generally had associated differences in flexibility and efficiency of use. Within that broad range of issues a number of more specific requirements were identified.

Required inputs for planning

(a) *Energy data system*

Adequate data on resources, production and consumption were essential as a basis for sound energy programmes. Data on consumption should facilitate identification of the various uses of different forms of energy used in various sectors, and enable determination to be made of specific energy consumption for major products. That might lead to the development of a system of energy accounting in which energy budgets could supplement financial budgets as an input to decision-making on development programmes.

In many developing countries non-commercial energy was of great importance, and could account for up to about half the total energy consumption. It was therefore important that more reliable data be obtained on that form of energy use. Comprehensive data collection on non-commercial energy was virtually impossible, but it appeared that reasonable results could be obtained from detailed data compilation from a number of relatively small areas selected as representative of the over-all situation. The collection, processing and presentation of data was a costly and time-consuming process, and care was needed to ensure that data systems served real needs, and avoided effort on collection of data that had little practical value.

Countries should establish efficient and co-ordinated systems for energy data where that had not already been done.

It was noted that a variety of units and standards for conversion were being used by international authorities such as the United Nations, the World Energy Conference and the Organisation for Economic Co-operation and Development (OECD). The United Nations and OECD were co-operating in endeavours to find agreement on standard units, and to improve processes for the collection and presentation of energy data. In 1967, ESCAP (then ECAFE) had issued a publication entitled *Comprehensive Energy Surveys — An Outline of Procedure* (E/CN.11/753), which had been widely distributed. The use of the international system of units (S.I.) was suggested.

Having regard to the recent increase in importance of adequate data systems, and the advantages of compatibility for interchange of data, it was recommended that the ESCAP secretariat, in consultation with countries and other international bodies, develop proposals for the standardization of units and factors for conversion between energy forms, and for formats for presentation of energy data.

There was also a need for the development of a standard approach to the assessment of reserves of primary energy resources. Again it was recognized that that matter was receiving a good deal of attention in various international circles, and it was recommended that it be included in the work of the secretariat outlined above.

(b) *Demand forecasting techniques*

While adequate data on resources and past consumption were essential for planning, there were still great difficulties in demand forecasting except in the short term. Because of recent drastic changes in the energy supply situation for most countries, common techniques for forecasting on the basis of past trends were open to serious question. Some countries had been able to make effective use of the general relationship between energy consumption and economic development with various techniques, including econometric regression and end-use methods. In most countries improved data systems were needed whatever forecasting technique was used.

Planning and management

(a) *Co-ordinated planning, including optimization of resource use*

Countries faced a variety of combinations of problems, which commonly involved questions of comparison of alternative uses of various forms of energy. For instance, a number of countries had useful resources of natural gas, and had to determine its allocation for such purposes as a fuel in an electricity-generating plant, as a direct source of heat without the conversion losses associated with electricity generation, or as feedstock for petrochemical industries. Some countries were looking to the import of coal as a substitute for petroleum wherever possible, but, apart from questions of plant modification, there were often major requirements for additional infrastructure in terms of handling at ports, and between ports and the point of use.

Overall, there was a need for countries to develop comprehensive plans for energy, in the short, medium and long terms. Furthermore, having regard to the dynamic situation involved, it was necessary to keep such plans under continuing review in the light of changing circumstances and improving data availability.

(b) *Stimulation of efficiency in energy production and use*

While *per capita* use of energy in developing countries of the region was generally far below that in industrialized countries, experience in recent years showed that there was still significant scope for savings in energy consumption through improved efficiency, and this was one of the most cost-effective ways of improving energy availability. Priority in introducing energy-saving techniques should be given to those sectors and/or activities in which there appeared to be the greatest potential. In many countries transport was a heavy consumer of high-grade fuels, and offered considerable scope for savings.

(c) *Optimization of power systems, including reduction of system losses*

Many countries had developed, or were in the process of developing, substantial electricity generation and distribution systems. In many cases, the public had come to expect a high degree of reliability, and in order to achieve this reliability and at the same time provide for unexpected outages and planned maintenance, spare generating capacity had to be provided. Losses in transmission and distribution could also have a serious effect on over-all system efficiency.

As the complexity of systems increased, including different forms and locations of primary energy generation, there were increasing opportunities for achieving high efficiency through system optimization. Some countries were using complex mathematical models for that purpose.

The Working Group noted and endorsed the activity in the ESCAP programme for publication of a study on the optimization of the utilization of electricity-generating plants.

(d) *Demand management*

While it was important to provide the energy necessary for development programmes and for the desirable level of social well-being, it was also important to avoid wasteful use of energy. In electricity systems, considerable economies in capital requirements could be achieved by demand management with a view to improvement of system load factor and efficiency. There was also considerable value in measures to shift consumption from scarce and expensive energy forms into those that were more readily provided. Pricing policies could be a useful tool for various types of demand management, such as encouraging industries to stagger their working hours. Care was needed to ensure that the total effect of any pricing policy was compatible with the over-all objectives.

(e) *Public education*

Particularly in relation to efficiency and economy in the use of energy, but also in relation to other aspects of energy policy, the success achieved depended to a considerable extent on public awareness and acceptance of the importance of the issues involved. Programmes should be developed for the inclusion of appropriate material in school curricula as well as in the public media.

INVESTIGATION AND DEVELOPMENT OF RESOURCES — GENERAL

Investigation and assessment of resources

Programmes for resource evaluation were at the same time an input to planning, and part of planned programmes. Having regard to the urgent need for reduction of dependence on oil, and for expansion of energy supply generally, current levels of exploration for indigenous energy resources were generally inadequate. Experience suggested that in cases in which work was carried out by arrangements with the private sector, care was needed to ensure that government authorities would have appropriate access to all resultant data. Whether programmes were carried out by contract or by government services, there was in some countries a need to strengthen capabilities for planning and supervision of such work.

Project formulation

Many countries lacked the necessary technical and financial resources for the detailed studies necessary for project formulation, with a view to seeking necessary funds, and that was a factor impeding energy development. While technical assistance would be valuable in helping overcome that problem, it was important that any such assistance be coupled with carefully planned training in order to promote national self-sufficiency as quickly as possible.

Apart from the question of available resources for feasibility studies, attention was drawn to the problem of selecting appropriate discount rates to reflect social time preferences.

Besides economic factors, there was now a general recognition of the need to give due consideration to the social and environmental implications of development projects, and energy projects were no exception. Techniques for that purpose were inadequate. Since issues of that type tended to be of greater consequence in industrialized countries, it was recommended that the ESCAP secretariat maintain an awareness of developments in that field, and bring significant matters to the attention of countries in the region.

Funds for development

Energy development was capital-intensive, and, having regard to the current inadequate level of energy availability in many countries, serious problems were envisaged in attracting the capital necessary for proposed development programmes, particularly in relation to competition with other urgent development needs.

Rural energy development

The provision of appropriate energy supplies in rural areas involved particular problems, and in many countries had a special priority as part of general rural development programmes.

Experience showed that the provision of electricity was an important factor in promoting human well-being, not only through economic development associated with pumping for irrigation or energy for rural industries, but also such factors as adequate lighting and power supply for educational and cultural activities, and home crafts at night. However, load density in rural electricity systems tended to be low. Peak loads in rural distribution systems resulted in increased costs, and in some cases could aggravate peaks in the system generally. Hence the provision of electricity supplies through conventional distribution systems were generally not financially viable.

The largest domestic energy requirement was for cooking, and in many instances traditional fuels were wood, agricultural materials and dung. Combustion efficiency was commonly very low, and there were well-known disadvantages associated with the use of those resources.

There were various possibilities for decentralized energy systems in rural areas and others seemed likely to be viable within the foreseeable future. Possibilities, depending on circumstances, included small-scale local hydroelectric or geothermal development, solar and wind energy, energy plantations and biogas. These are referred to more specifically below, but countries should, within the framework of national energy programmes, develop and implement programmes for the provision of rural energy supplies, as far as possible through the matching of local resource endowments and requirements.

SPECIFIC ENERGY RESOURCES AND TECHNOLOGIES

Use of coal

It was expected that coal would be an increasingly important component in the energy systems of many countries. However, available resources were often of relatively low grade, and there was widespread interest in various forms of beneficiation to increase flexibility in use, including use for domestic purposes. Potential for conversion to gaseous or liquid fuels was also a matter of great interest. In selected cases there was scope for co-operative research and development and more generally for information exchange.

Oil shale

A few countries were interested in the technologies and economics of development of oil shale deposits, either for production of high-grade fuels, or for direct use in combustion.

Fuel for transport

In many countries a substantial proportion of total petroleum consumption was used in transport. There was widespread interest in the use of alternative fuels such as LPG, natural gas or fuels synthesized from it such as methanol, particularly where they were in surplus supply, or liquid fuels converted from cellulosic materials. There was an interest in technologies associated with those fuels. Electric traction could also be a suitable alternative in appropriate circumstances.

Geothermal energy

Within the region there was a wide range of experience in exploration and development of geothermal energy, and training courses in geothermal energy were available in Japan and New Zealand, the latter with financial support from UNDP. A number of countries were at an early stage of assessment of geothermal resources, and a sharing of experience in the processes involved would be useful. That might be achieved not only through formal training courses, but also through exchange of personnel.

Biomass

There was already some experience in the region in various forms of harnessing biomass. This commonly took one of two forms — the production of wood for direct combustion either as fuelwood or charcoal, or conversion to liquid fuel. In the former case there would be value in dissemination of information on tree varieties, their habitat, characteristics and expected performance in biomass production, together with exchange of experience as that developed.

With regard to conversion to liquid fuels, there was less experience available within the region in the large-scale production of liquid fuels and in their use.

Biogas

There was extensive experience within the region, but mainly with small plants which were too costly for most individual households. The Group noted that following a recent meeting on biogas development convened by ESCAP, it was expected that a publication on guidelines for biogas development would be issued in 1979. However, a programme of co-operative research and development was needed with a view to a substantial reduction in the cost of small plants, and the evolution of suitable management systems for larger plants to serve rural communities.

Solar energy

The potential importance of solar energy for many countries in the region was stressed. Solar drying was already important for a variety of agricultural products but could be enhanced through the use of more efficient devices currently available. More limited use was being made of solar energy within the region for a variety of other purposes, including desalination.

Having regard to the tropical and subtropical climates over much of the region, and the wastage of food for lack of suitable means of preservation, there was an urgent need for further research and development aimed at improving the viability of the use of solar energy for cooling and refrigeration. Economic conversion of solar energy for water pumping would also make a great contribution to rural development in the region. Households in relatively isolated locations, where the cost of conventional electricity supply was prohibitively high, would benefit greatly from a reduction in the cost of photovoltaic cells which would enable solar energy to meet minimum household requirements at an acceptable cost.

The Group considered that increased efforts should be made to enhance the viability of solar energy and in particular recommended that a significant part of the R and D effort of industrialized countries on solar energy should be directed to the solution of those problems which were of widespread concern to developing countries.

Having regard to the number of international bodies now actively involved in programmes to enhance the use of various forms of renewable energy, and of solar energy in particular, the Group urged the bodies concerned to ensure the maximum possible co-ordination of their activities.

Wind energy

Wind energy was used to a very limited extent in a number of countries in the region, mainly for direct work such as pumping water or grinding grain. There were many forms of windmill, involving the use of local skills and materials. Its use for electricity generation involved a number of special problems, and was much more limited. The need for storage normally associated with intermittent wind energy often added considerably to the over-all cost of a wind-powered water supply. Research and development were being carried out in a number of countries, and should be encouraged, together with information exchange.

Small-scale hydroelectric development

A number of countries were engaged in the development of small-scale hydroelectricity as a component in rural energy development, frequently involving the use of relatively simple construction technologies and equipment, and local skills and materials. Small plants were generally associated with high unit costs, and special efforts were needed to achieve the desired quality of service at an acceptable cost. This form of energy production was attracting increasing interest, and systematic information exchange was desirable.

Energy storage systems

A number of indigenous energy forms, particularly those which were likely to be attractive in rural areas — solar energy, wind energy and small-scale hydroelectric development — were discontinuous in varying degrees, and required some form of storage in order to be used effectively. In view of its implication for rural energy development, that was a problem of great importance, and it was desirable to stimulate intensive research and development, in industrialized as well as developing countries, and to ensure dissemination of information on any new developments for centralized or decentralized applications.

INTER-COUNTRY CO-OPERATIVE PROJECTS

International trade in coal

There was widespread interest in the use of coal as a substitute for petroleum wherever possible, and as a result an increasing trade in coal was likely. That involved a variety of problems such as the matching of boilers and other plant to varying grades of coal which might be expected from different sources, or the processing of coal to achieve desirable standards; the need for facilities for handling coal at ports, and between ports and points of use; the general question of assessing availability of coal for export, and demand, including quantities in relation to specific grades; and measures which might assist in establishing trade in a manner which would be the most beneficial to all concerned.

Interconnexion of electricity systems

There was already a significant interconnexion between Thailand and the Lao People's Democratic Republic, and quite recently a start had been made with an interconnexion between Thailand and Malaysia, and Malaysia and Singapore. Extensions were under consideration. It was recommended that, when requested, ESCAP should assist in studies and/or negotiations to stimulate such interconnexions.

Development of the hydroelectric potential of international rivers

The attention of participants was drawn to the large potential for the development of hydroelectricity on international rivers, and to the progress being made in that connexion in the lower Mekong basin. There was a very large potential for similar developments in some other parts of the region, and special reference was made to the Ganges-Brahmaputra and Salween river systems, in which several countries of the region were involved.

It was recommended that when requested by the countries concerned, ESCAP should assist as far as possible in measures to stimulate a co-operative approach to the development of such rivers.

INTERESTED INTERNATIONAL ORGANIZATIONS

In order to facilitate discussion on action to be taken, the representatives of international organizations and bodies gave brief statements highlighting their current and future activities in the energy field, which are summarized below.

The Centre for Natural Resources, Energy and Transport (CNRET) (see NR/WGMEPP/13) carried out activities within four categories: (a) technical co-operation projects such as the energy surveys and planning conducted in Pakistan and Bolivia, (b) reports to United Nations bodies, (c) non-operational activities in the form of conferences, seminars such as the Group of Experts on Energy Planning in Developing Countries in December 1977 and the Interregional Symposium on State Petroleum Enterprises in Developing Countries in March 1978, and (d) preparation and publication of studies on specific energy issues. The Centre would organize a coal symposium in Poland in September 1979, was co-operating with the Government of Japan in organizing a solar energy seminar in Japan, also in 1979, and, if endorsed by the General Assembly at its thirty-third session, would organize a conference on new and renewable sources of energy in 1981. The Centre's periodic publications included the *Natural Resources Forum* and the *Natural Resources and Energy Newsletter.*

The United Nations Industrial Development Organization (UNIDO) carried out activities on industrialization, including those related to energy. During 1976-1978, UNIDO had issued six studies on iron and steel, fertilizers, petrochemicals, agro-industries, vegetable oils and fats, and leather, in which energy requirements were considered a prime criterion. In 1979 it would undertake a study on energy requirements in industry in developing countries. With regard to non-conventional energy, UNIDO had compiled a publication on the state of the art of solar energy, organized a meeting on solar technology and the possibilities of manufacturing solar equipment and had undertaken operational projects in many countries. In the field of wind energy, it was carrying out an operational project on a wind mill/pumping system. UNIDO had also published a report on the establishment of an industrial and technological information bank and planned to compile a paper on information sources regarding alternative sources of energy.

In the ESCAP region, UNDP was assisting over 50 country projects in the energy sector with a total input of approximately $29 million. Furthermore, there were three approved regional projects receiving over $2.7 million of UNDP inputs. The Regional Bureau of UNDP for Latin America was currently undertaking two main programmes, one being the Central American energy programme designed to assist five countries in several aspects of energy development and planning, and the other, preparatory assistance on new and renewable sources of energy conducted for all Latin American countries consisting of a study of requirements and another of capabilities, as well as a technical seminar in which the studies would be discussed by policy-makers and specialists. The results of that preparatory assistance would be used for the formulation of future programmes.

UNEP was carrying out an in-depth study on interactions between energy programmes and the environment. Within the framework of that study seminars were being arranged on specific energy resources. Detailed work was being carried out on renewable resources such as biogas.

Participants noted information provided on FAO interests in energy related to agriculture.

The Asian Development Bank (ADB) had completed an energy survey for Bangladesh and follow-up action was being considered. The Bank was willing to consider financing energy studies, and was currently considering a study of an energy master plan for Thailand.

The Asian Institute of Technology (AIT) had facilities for academic training in the engineering field (post-graduate programme). A Renewable Energy Resources Information Centre had been established recently for the collection and dissemination of information on several subjects, particularly solar energy. The Division of Energy Technology would be established to admit the first students in January 1980. The views of the Working Group would be useful in drawing up the curriculum of the Division.

The East-West Center provided academic training and fellowships in several fields, including energy (post-graduate programme). The Conference on Asia-Pacific Energy Studies held in July 1978 considered the energy situation of the region, including the uncertainties, research requirements etc., and reached an agreement to establish the non-governmental Asia-Pacific Energy Studies Consortium (APESC) to be serviced by the Resource Systems Institute, one of the institutes of the Center. The Consortium would involve co-operation among institutions in a number of countries in the Asia-Pacific area. It would conduct research on academic and policy matters and provide a network for the exchange of information and personnel. Initially the Institute planned to organize APESC workshops in 1979 on rural energy and indexing methods for various forms of energy.

ESCAP presented document NR/WGMEPP/4, containing the current programme on energy and the medium-term plan.

Current activities of UNESCO (see NR/WGM-EPP/9 and Add. 1) in the energy field concerned technical research and development of solar energy, geothermal energy and biogas (particularly microbiology) with emphasis on their use for low-income groups. As a result of a meeting held early in 1978, an Asian regional network on solar energy had been established. The agency was planning to hold a workshop on solar drying in the Philippines in October 1978.

SUGGESTED ACTION

Having enumerated many proposals for action by countries, as reported earlier in the present document, the Group considered a compilation of possible actions at the inter-country or regional level, based on individual submissions of participants and views expressed during the meeting, and agreed on a number of proposals, as set out in annex II.

Having regard to the increasing number of international bodies taking steps to develop inter-country programmes related to energy generally, and non-conventional energy resources in particular, and the importance of avoiding fragmentation of effort within countries, the Group recommended that countries identify one focal point for communication on energy generally, at the national level. In addition, if desired, subsidiary focal points might be designated for direct contact in relation to specific energy interests such as coal, petroleum or solar energy. The ESCAP secretariat might take this up with all member countries, and advise other international bodies of the outcome.

With regard to information exchange, it was agreed that, apart from various types of meetings, ESCAP should, on a trial basis, institute a system whereby very brief summaries of information likely to be of interest to others would be requested, say, twice a year, from all known centres of activity in member countries on the selected topics, and those summaries compiled and distributed to all the centres concerned. In each case, an address would be given in conjuction with the summary, so that those interested could obtain more detailed information by direct inquiry. It was envisaged that an evaluation of the usefulness of that process would be made after about two years.

With regard to exchange of personnel, it was agreed that while the general understanding would be that costs would be met by the country requesting in-service training, financial support might in some cases be provided through bilateral arrangements, and international funds should be provided to support the activity.

ADOPTION OF THE REPORT

The Working Group adopted its report on 21 August 1978.

Annex I

LIST OF DOCUMENTS

Symbol	*Title*	*Source*
NR/WGMEPP/1	Progress in energy development	ESCAP secretariat
NR/WGMEPP/2	Aspects of demand and supply in the region	ESCAP secretariat
NR/WGMEPP/3	An outline of major issues	M. K. Chatterjee, consultant
NR/WGMEPP/4	ESCAP's energy programme	ESCAP secretariat
NR/WGMEPP/5	1977 review of national energy programmes	International Energy Agency — OECD
NR/WGMEPP/6	Energy programme in the Republic of Korea	Jin-Hi Choi, Republic of Korea
NR/WGMEPP/7 and Corr.1	Energy planning and programming in Singapore	Public Utilities Board, Singapore
NR/WGMEPP/8	Energy planning and programming, Thailand	National Energy Administration, Thailand
NR/WGMEPP/9 and Add. 1	UNESCO's energy activities	V. Kouzminov, UNESCO consultant
NR/WGMEPP/10	Recent energy trends and future prospects	United Nations secretariat
NR/WGMEPP/11	Energy situation in Bangladesh	A. N. Shahadat Ullah, Bangladesh
NR/WGMEPP/12	Country paper, India	Department of Power, Ministry of Energy, India
NR/WGMEPP/13	United Nations activities in energy: the role of the Centre for Natural Resources, Energy and Transport	CNRET
NR/WGMEPP/14	Resources, planning and programming of energy in Afghanistan	Ahmad Shah Arsalan, Afghanistan
NR/WGMEPP/CRP.1	Energy requirements and planning in Sri Lanka	K. K. Y. W. Perera and G. B. A. Fernando, Sri Lanka
NR/WGMEPP/CRP.2	Energy programming and planning in Malaysia	Petroleum Development Unit, Prime Minister's Department, Malaysia
NR/WGMEPP/CRP.3	Indonesia energy outlook	Indonesia
NR/WGMEPP/CRP.4	Technical co-operation on energy policy: two regional experiences of UNDP in Latin America	Alfredo del Valle, Regional Programmes Officer, UNDP
NR/WGMEPP/CRP.5	Australia's energy situation	Department of National Development, Australia
NR/WGMEPP/CRP.6	Preliminary proceedings of the Asia-Pacific Energy Studies Conference	East-West Resource Systems Institute, East-West Center
NR/WGMEPP/CRP.7	Energy and GNP: some thoughts on inter-country comparisons	CNRET
NR/WGMEPP/CRP.8	Energy planning and programming in Pakistan	A. M. Izharul Haque, Pakistan
NR/WGMEPP/CRP.9	Ten-year energy development programme, 1978-1987	Ministry of Energy, Philippines
NR/WGMEPP/CRP.10	Energy and agriculture	FAO

Annex II

PROPOSED REGIONAL ENERGY ACTIVITIES

A. *Already included in the ESCAP programme for 1978-1979*

Expert group meeting on the evaluation of geothermal energy

Working group on efficiency and conservation in the production and use of energy

Study on the optimization of the utilization of electricity-generating plant

B. *Suggested meetings*

Meeting for high-level government officers involved in national energy policy, including methodology of planning, forecasting techniques and programme formulation

Roving seminar on methodologies of energy planning, including forecasting, demand management, inter-fuel substitution, and environmental effects

Seminar on planning, management and economics of energy resources for rural areas

Meeting on arrangements to encourage and manage exploration and development of energy resources

Working group meeting on mini and micro hydroelectric development

Seminar on effective production, transport, storage and use of fuelwood

Seminar on international negotiations and contracts on energy projects and equipment

C. *Mission*

Mission on requirements in the region for training in the energy field

D. *Studies which could be scheduled*

Energy storage systems

Energy pricing and its effects

Production, specifications and use of ethanol and methanol

E. *Co-operative research and development*

Solar energy

Wind energy

Biogas

Biomass

F. *Collection and dissemination of information required on:*

Data collection systems for energy resources, production and end-use consumption

Beneficiation and utilization of coal

Geothermal energy

Environmental implications of energy programmes

Power tariff experiments

G. *Catalytic action needed in:*

Exchange of personnel concerned with institutional arrangements, energy planning and management

Exchange of technical specialists and economists in the energy field

Formal training courses for medium-level personnel in:

(a) Energy utility operation

(b) Energy planning

II. WORKING PAPERS PRESENTED BY THE SECRETARIAT

PROGRESS IN ENERGY DEVELOPMENT

(NR/WGMEPP/1)*

INTRODUCTION

For the second session of the Committee on Natural Resources, held in 1975, a secretariat paper with a similar title was presented. This updated version has generally retained the same structure, although this has meant repeating some of the definitions, and parts of series of historical figures. However, more attention has been paid to the transitional nature of the period since 1973, and to non-commercial sources of energy, for which more information has become available.

Primary forms of energy refer to those occurring in nature and providing the first stage of energy production. Traditional conventional forms of primary energy are coal, lignite and peat (solid fuels), crude petroleum, petroleum from oil shale and bituminous sands and natural gas liquids (liquid fuels) and natural gas; hydroelectricity and nuclear electricity, although not strictly primary energy as defined, are commonly included in this category. The above forms of energy are regarded as commercial energy, and comprehensive statistics on production and consumption are available, as in table 1 which gives world consumption (including direct consumption in industry). Some interesting observations could be made on the figures given in table 1, but they may not necessarily be relevant to countries in the region.

There are other primary commercial forms of energy of minor but increasing importance, which have not been listed separately (up to 1976) but are expected to be separated out in later statistics. These include tidal power, which is usually included in hydroelectricity, and geothermal energy, which is usually included in secondary energy as thermal power station electricity production. In the future, energy from wave action and ocean temperature differentials may be added.

Non-commercial primary forms of energy include fuelwood, agricultural and animal wastes, solar energy and wind energy. These forms are broadly classified as non-conventional sources and statistics on production and consumption are at present available only for fuelwood. Again, some further statistics may become available shortly, particularly where solar or wind energy is used to produce electricity. In the mean time, although the figures for fuelwood are in some cases

* As presented, except that annex I has been amended to include information supplied at the meeting.

Table 1. World consumption of commercial primary energy (in million metric tons of coal equivalent and in kilograms *per capita*)[a]

Year	Solid fuels	Liquid fuels	Natural gas	Hydro and nuclear electricity	Total	Energy per capita		
						World	Developed countries	Developing countries
1965	2,255	1,967	882	116	5,220	1,589	4,710	255
1966	2,293	2,135	963	126	5,517	1,649	4,903	267
1967	2,178[b]	2,267	1,031	129	5,606	1,645[b]	5,014	274
1968	2,286	2,472	1,126	137	6,021	1,734	5,297	294
1969	2,354	2,687	1,232	146	6,419	1,814	5,606	305
1970	2,399	2,934	1,346	154	6,834	1,895	5,901	327
1971	2,382[b]	3,116	1,445	165	7,110	1,936	5,993	344
1972	2,428	3,346	1,526	177	7,477	2,000	6,240	357
1973	2,492	3,596	1,582	185	7,855	2,065	6,460	379
1974	2,540	3,560[b]	1,612	207	7,919	2,044[b]	6,298[b]	390
1975	2,623	3,526[b]	1,633	221	8,003	2,028[b]	6,094[b]	402
Average annual increase percentage	1.52	6.01	6.35	6.66	4.36	2.47	2.61	4.65

Source: *World Energy Supplies, 1971–1975,* United Nations Statistical Papers, series J, No. 20.

[a] In United Nations energy statistics, all primary forms of energy, including primary electric energy, are converted into a common coal equivalent unit on the basis of physical heat content, which is taken as the heat energy they would produce under ideal conditions.

[b] Decrease in amount from previous year.

estimates, when they are combined with the known usage of animal dung in some countries, it becomes apparent that usage of non-commercial forms of energy in some developing countries may account for more than half of total energy consumption. At the present time, the high cost of petroleum products has made these forms of energy more attractive than hitherto, and the percentage of total usage may actually be increasing in some developing countries.

The statistics presented in the various tables in this report are confined to those readily available in a consistent form, and, as noted above, do not give the complete picture. Another gap concerns the usage of animal and human energy. From some case studies in agricultural areas, which may or may not have wide application, a tentative figure of 10 kg of equivalent coal *per capita* has been derived. Such a figure would be significant in the countries with lowest apparent energy consumption *per capita*.

Up to 1973, the main emphasis in exploration was on oil and natural gas, and most of the exploration was carried out by transnational oil companies and other private organizations. Exploration for oil and gas has now been intensified, with Governments taking an increased interest, and at the same time reassessing other indigenous sources of energy, both conventional and non-conventional.

The countries in the ESCAP region are conscious of the need for the systematic assessment and classification of energy resources. Only relatively few countries in the region have large reserves of oil and gas, and again, only a few countries in the region (not necessarily the same ones) have large reserves of coal. However, several of the countries have reserves of oil or coal which, although not large, are significant in relation to their energy requirements. Hydropotential is known to be relatively well distributed geographically within the region, and its importance as a source of electricity production has been recognized. Considerable efforts are being made to assess its potential, particularly in the context of over-all water resources development. A search for nuclear fuels, particularly uranium, is also being carried out in several countries. Good possibilities are seen to exist for some harnessing of wind energy, solar energy and geothermal energy, and the production of energy and fertilizer from agricultural and animal waste is being actively encouraged in several countries.

ENERGY RESOURCES OF THE REGION

In conjunction with the meeting of the World Energy Conference (WEC) in 1974, the United States National Committee of that body obtained updated replies to a comprehensive questionnaire and published the results in a book entitled *Survey of Energy Resources, 1974*. This reference is recommended as a reliable source of information on reserves of commercial energy resources, and selected figures for countries of the region are summarized in annex I. Since 1974, discoveries have been made in some countries, and these are noted in the text.

Production and consumption figures are given in annex II, the information being obtained from the final draft of the United Nations publication *World Energy Supplies, 1972-1976*.

A. SOLID FUELS

In the WEC survey, world resources of coal are given as 10,750 $\times$ 10^9 metric tons, without differentiating between black coal, brown coal and lignite. China is credited with 8.9 per cent of the world resources, and the rest of Asia and Oceania with a further 2.9 per cent. Of this total amount, 1,400 $\times$ 10^9 tons are classed as reserves, and 590 $\times$ 10^9 tons as proved recoverable reserves.

Similarly, figures are given for peat in terms of actual tonnage without reference to calorific value. Total world resources recorded are given as 210 $\times$ 10^9 tons, but many countries were unable to supply data. Figures for proved recoverable reserves were supplied by only four countries, including Bangladesh within the ESCAP region.

The figures for reserves of solid fuels given in annex I for individual countries in the region cover black coal, brown coal and lignite (but not peat), with all the quantities from the tables in the WEC reference converted to standard black coal equivalent (7,000 kcal/kg). It may be noted that in some cases the reference gives information on sulphur content and ash content, both of which affect usability.

Fourteen countries of the region have recorded reserves of solid fuels, and five other countries have advised that they have deposits, but detailed information is not available. Large reserves by world standards are present in Australia, China and India, and moderate reserves are present in Bangladesh, Indonesia, Japan, Pakistan and the Republic of Korea. No recent discoveries have been reported, but in most countries with deposits work is proceeding on proving additional recoverable reserves.

From annex II, it may be noted that solid fuels are being produced in 15 countries, that is, 13 countries with recorded reserves (no production in Bangladesh) and 2 countries, Mongolia and Viet Nam, for which data on reserves are not available. The ratio of annual production to reserves is generally low, except for Japan, where the ratio is substantially above the world average.

B. LIQUID FUELS

The increasing reliance on petroleum as an energy source evident over the past two decades was accompanied by extensive exploration for crude petroleum resources all over the world. The technological advances made in exploration have led to discoveries at greater depths on land and off shore, and improvements in production techniques, including secondary stimulation, have increased the ratio of proved recoverable reserves to total reserves.

Notwithstanding substantial consumption, the amount of proved recoverable reserves of crude petroleum in the world has been increasing, to a figure from the WEC survey of 91.5×10^9 metric tons, or 134.5×10^9 metric tons of equivalent coal[1] (about one quarter of the figure for proved recoverable solid fuels).

Other published figures, converted to metric tons of equivalent coal, are given below for reference, but these have not been shown to be of the same order of reliability as the WEC figure of 134.5×10^9:

World Oil

end 1974 113.8×10^9

end 1975 115.8×10^9 revised to 109.2×10^9

end 1976 110.0×10^9

The Oil and Gas Journal

end 1976 119.8×10^9

end 1977 129.2×10^9

The WEC survey showed that in their assessment of petroleum reserves most countries had neglected liquids obtained from natural gas. Data supplied for the survey (12 countries only, including Australia and New Zealand from within the region) gave proved recoverable reserves of 1.3×10^9 metric tons or 2.2×10^9 metric tons of equivalent coal,[2] indicating that a much greater amount is likely to be proved in the near future.

An accurate appraisal of potential world resources of oil from shales and bituminous sands cannot be made because of the lack of definitive data from most countries. From the WEC survey, an order of quantity of recoverable oil is 100×10^9 tons. Countries in the region which have indicated the possibility of recoverable oil from these resources are Australia, Burma, China, New Zealand and Thailand.

[1] In United Nations practice, one ton of unspecified crude oil is equal to 1.47 tons of standard coal.

[2] In United Nations practice, one ton of unspecified natural gas liquids is equal to 1.67 tons of standard coal.

The figures for reserves of liquid fuels given in annex I for individual countries of the region cover only crude petroleum, the figures for natural gas liquids and oil from shale and bituminous sands being considered incomplete or lacking in reliability. All quantities from the WEC survey have been converted to standard black coal equivalent.

The total for the region is of the order of 14 per cent of the world total. Iran accounts for the major part, but large reserves are also present in China and Indonesia, significant reserves are present in Australia, Brunei, India and Malaysia, and five other countries have recorded reserves.

Since the WEC survey, new discoveries have been made, or additional reserves in known fields have been proved, in Afghanistan, Australia, Brunei, Burma, China, India, Indonesia, Iran, Malaysia, Pakistan and the Philippines, and exploration is continuing in many countries and off-shore areas.

From annex II, liquid fuels are being produced in 13 countries, although only 12 are recorded as having reserves. For Thailand, the minor production is from a field whose reserves are less than 1 million tons of coal equivalent. The ratio of annual production to 1974 indicated reserves is comparatively high in Australia, Burma, Japan and Thailand.

C. NATURAL GAS

The increase in oil exploration activity has resulted in associated and separate finds of natural gas. However, natural gas is still primarily a local fuel in that its greatest exploitation is in areas where the demand is near the supply or can be reached by pipelines. Consequently, natural gas has been somewhat neglected in nations where no ready market exists, and discoveries have been recorded but the amount of reserves has not necessarily been proved. A comprehensive evaluation of world reserves is not feasible at this stage. *The Oil and Gas Journal* gives a figure for the end of 1977 which converts to about 91×10^9 metric tons of coal equivalent, of the same order as reserves of crude petroleum.

The WEC survey figures for recoverable reserves were stated in cubic metres, and in order to obtain amounts of coal equivalent the following heat values were used in the priority indicated: WEC survey, United Nations country averages, 8,900 kcal/cu m. The total reserves for the region comprised about 13 per cent of world reserves, the majority being located in Iran. Large reserves are also present in Australia, China and Pakistan, with lesser amounts in 11 other countries in the region. Several countries, Australia, Bangladesh, Brunei, Burma, India, Indonesia, Iran, Japan, Malaysia and Pakistan, have reported new finds or increases in proved reserves since the WEC survey, and one country, Thailand, which previously had no recorded reserves, has reported a significant new field. Transportation as liquefied natural gas (LNG) seems to be particularly appropriate in the region, and Australia, Indonesia and Malaysia are all proceeding with implementation of this technique to supply major distant markets.

As seen from annex II, natural gas is being produced (not including re-injection or flaring to waste) in 13 of the 15 countries with recorded reserves; no production is occurring at present in Papua New Guinea, the Philippines or the new field in Thailand. The total amount is comparatively small, at 80 million metric tons of coal equivalent in 1977. The general ratio of production to reserves is very low, although it is noted that the ratio in Japan is well above world average.

D. HYDROELECTRICITY

There are technical, economic and in some cases environmental limitations in developing the theoretical potential of the entire stretch of river courses. In most cases, also, it becomes necessary to co-ordinate hydropower development with the development of water resources for other purposes, such as irrigation, water supply for domestic and industrial use, flood control and navigation. Again, where a river system flows through two or more countries, or forms part of the boundary between two countries, there may be protracted delays in reaching development agreements. Comprehensive studies have been undertaken in a few countries of the region, while in other countries the assessment of hydroelectric potential has been carried out in a limited way as part of the studies on over-all water resources development.

The information available for the region is given in annex I. The basis used for the figures is the annual energy available at average river flow (load factor ranging from 30 to 80 per cent) taken from the WEC survey, converted by the United Nations factor of 0.123 tons of equivalent coal per 1,000 kWh, and multiplied by a commonly used figure of 50 years' availability. Additional figures, where available, were obtained from United Nations sources.

Substantial hydroelectric potential exists in all the mainland countries and large islands, and it may be noted that 9 of the countries in the region are in the top 20 countries of the world in amount of hydroelectric resources. In order, these are China, Nepal, India, Burma, Viet Nam, Indonesia, Japan, Papua New Guinea, and Pakistan. Regional resources comprise about 33 per cent of world resources.

Production figures are given in annex II for 1976, indicating a rate of utilization of resources of about 8 per cent. In general, the ratio of developed to potential resources is higher in developed than developing countries, and Australia and Japan are good examples of this.

E. NUCLEAR FUELS

Nuclear fuels include uranium, plutonium which can be derived from uranium, thorium and lithium (possible future use for fusion reactors). At present, only uranium is used as an energy source, and this is only utilized as a fuel in nuclear power stations.

Uranium is widely distributed throughout the world at very low concentration of the order of parts per million. However, assessment of reserves is at present restricted on economic grounds to concentrations above 0.1 per cent. The locations and quantities of such resources in countries without centrally planned economies, where exploration has been carried out, are comparatively well known, but little information is available from countries with centrally planned economies.

Information on reserves of uranium in the region (from International Atomic Energy Agency (IAEA) sources) is given in annex I on the basis of an economic limit of production cost of $66 per kg.

A problem occurs in expressing the energy content in terms of equivalent coal. Since the energy is at present only used to generate electricity, United Nations practice is to take the electrical output and convert back to equivalent coal, as for hydroelectricity, and that method has been used in this report. However, it should be noted that if the actual heat output could be used directly, the evident reserves would increase by a factor of 5. Moreover, in due course it could be expected that breeder reactors would be operating commercially, and the evident reserves would then be increased by a further factor of 60.

Main resources in the region are in Australia, China, India, Japan and the Republic of Korea, representing a sizeable proportion of world resources. Exploration is proceeding in several countries, and new discoveries have been reported in Australia, Bangladesh, the Philippines and Thailand. Significant reserves of thorium are known to be present in Australia, India and Sri Lanka, but at present the market for this resource is small. Lithium is known to occur in Australia, but is also generally present in sea water.

Because of the difficulty in obtaining production figures, the figures for production and consumption of uranium (in nuclear power stations) have been combined with those of hydroelectricity. Countries in the region with nuclear power stations in operation are China, India, Japan, Pakistan and the Republic of Korea.

F. OTHER PRIMARY COMMERCIAL FORMS OF ENERGY

Geothermal energy. The interior of the earth is heated by the slow decay of naturally occurring radioactive elements and escapes to the surface by conduction. However, in some locations the geothermal gradient is much higher than the global average, as a result of:

(a) Active or dormant volcanic conditions;

(b) Regional faulting causing deep fractures;

(c) Very thick layers of sediment.

Ground water permeating to the high temperature areas is heated, and may emerge as steam or hot water or may remain trapped beneath an impermeable layer of rock. These types of sources may be exploited with the current state of technology, higher temperature output for electricity generation, and lower temperature output for domestic and communal heating. In the future, it may become possible to exploit hot, dry rock areas by injecting water or gas.

Statistics are generally available only for geothermal electricity generation. Total installed capacity in 1977 was about 1,000 MW in seven countries, of which two are in the region (Japan, 76 MW, and New Zealand, 192 MW). Construction and/or planning of new installations is under way in India, Indonesia, Japan, New Zealand and the Philippines.

Tidal power. The harnessing of tidal power has been considered from time to time for many years, but present installations (outside the region) are of very minor magnitude. Possibilities exist in several location in the region, particularly Australia, India and the Republic of Korea.

A related possibility is utilization of the small permanent difference in water level between adjacent seas.

Wave energy. Investigations are being carried out into the possibility of harvesting the energy in waves, typical locations being long ocean reaches, cliff-type shores and reefs.

Ocean temperature differentials. Investigations on utilizing ocean temperature differentials are being carried out, and this may eventually be of interest in tropical areas in the region.

G. NON-COMMERCIAL PRIMARY FORMS OF ENERGY

Fuelwood. Most countries in the world have forested areas, and the Food and Agriculture Organization of the United Nations (FAO) has for many years taken an active interest in this subject. However, the reserves of fuelwood as such are rather a matter for speculation, as most forestry operations are directed towards obtaining wood for industry.

The United Nations Statistical Office now includes production of wood and charcoal in the J series of statistical papers, commencing in *World Energy Supplies, 1971-1975.* While most countries are included, many figures given are estimates, but it may be expected that the accuracy of the information will improve steadily. Figures for countries in the region are included in annex II, the conversion ratio used being 4 cubic metres of green wood to 1 ton of equivalent coal (from a joint ESCAP-FAO study). The percentage of consumption of fuelwood to consumption of total commercial energy is 100 per cent or more in 10 countries, Nepal being particularly noteworthy in this respect. In 6 countries, fuelwood used for energy is a very small proportion of commercial energy used.

Agricultural and animal wastes. Selected forms of agricultural waste are traditionally used for energy in many countries in the region, for example, the burning of bagasse to provide power in sugar-mills and controlled burning of other wastes for heating, but over-all statistics are not readily available.

In some countries in the region, cow-dung is burnt for domestic cooking and heating, the major user being India, with an estimated annual consumption of about 40 million tons of coal equivalent. An alternative use for cow-dung, other animal wastes, and to a limited extent agricultural waste, is to produce biogas by anaerobic fermentation, the residue being a valuable fertilizer, and this practice is growing.

A portion of municipal waste is burnt in incinerators in some countries, with or without using the energy output, but in developing countries the calorific value of municipal waste is generally low and may not support combustion.

Solar energy. The solar energy potential in the region is high, but usage is minor, being confined to salt production, which is fairly common, and water heating, mainly in Australia and Japan.

Wind energy. Tropical areas in general have comparatively low average wind velocity, while some may suffer periodic extremely high wind velocities. Temperate areas in general have reasonable average wind velocities.

At present only minor usage is made of wind energy. In Burma, China and Thailand simple hand-made windmills suitable for low wind velocities are used for low head-water pumping, and in rural areas in Australia and New Zealand manufactured windmills are used for water pumping and electricity generation.

TRENDS IN ENERGY PRODUCTION, CONSUMPTION AND TRADE

A. SOLID FUELS

Annex II shows the production of coal in individual countries of the region from 1972 to 1977, and consumption from 1972 to 1976. Differences between the two sets of figures represent imports or exports, subject to allowances for bunkers and adjustments to stockpiles. The trends for the major producers and for the region as a whole are shown in figure I, which also shows regional production and consumption.

During the period, coal production and consumption increased at a rate of about 4.5 per cent per annum, a comparatively fast rate considering the lead time for production. There was a fairly constant net import to the region. However, the regional figures are heavily dependent on the quantities for China, where all production was consumed internally, and in figure I the curves for the region excluding China are

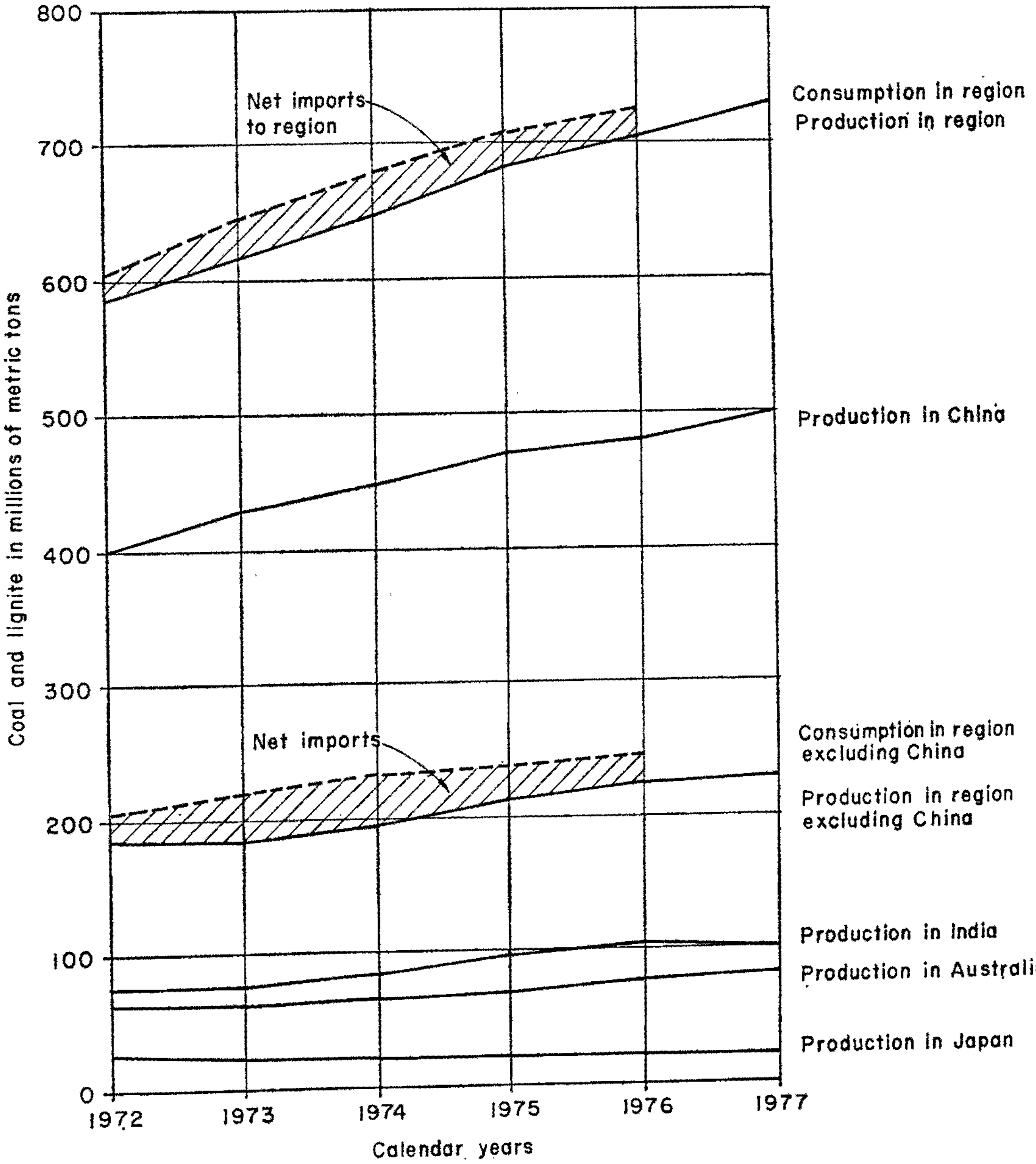

Figure I. Solid fuels production and consumption in the region also given. These indicate that production, after being practically static until 1973, began to increase in response to the rise in oil prices. Consumption also increased, but fewer imports are now required.

Of individual countries, output increased in all producing countries except Burma (steady), Iran and Japan (declined), and New Zealand (steady). Consumption increased in all consuming countries except Bangladesh and Hong Kong (imports reduced), Iran (declined), Japan (imports increased in 1974) and New Zealand (steady).

In addition to increasing production from existing fields, several countries have taken steps towards developing new fields, particularly Australia, India, Indonesia, Pakistan, the Philippines and Thailand. With the continuing favourable economics for both hard coal and lower grades, further expansion of production within the region may be expected.

The major importer in the region was Japan, with about 60 million tons per annum, of which about 24 million tons came from Australia, and this constituted the most significant trade within the region. Bangladesh imported a modest amount from India; the Republic of Korea imported from several sources, including Australia; and Australia exported to several countries outside the region.

In view of the interest shown by some countries with limited or no reserves of coal or oil in the possibility of reducing their dependence on imported oil by planning some future electricity generation in coal-fired plants, it is interesting to note that since 1973 the cost of coal has also increased. Prices are not as well documented as those for oil, particularly in respect of different grades of coal, but in general the prices of the various grades of steaming coal and coking coal lie in a fairly narrow band, so that an average price for these grades, which form the bulk of international trade, may be taken as representative for steaming coal suitable for electricity generation. Table 2 thus gives a reasonable guide, all prices being expressed in United States dollars at the average exchange rates applicable for the years quoted.

Table 2. Representative prices of coal
(in dollars per metric ton)

Country	Price status	Calendar year			
		1973	1974	1975	1976
Australia	Export FOB	16.15	22.10	32.69	43.14
Canada	Export FOB	NA	21.38	36.48	NA
Federal Republic of Germany	Ex-mine, Ruhr region	35.94	45.60	57.86	61.97
Japan	Import CIF	23.31	45.05	54.86	NA
United States of America .	Export CIF Europe	31.52	65.63	72.97	66.96

B. LIQUID FUELS

The production and consumption of liquid fuels in individual countries of the region from 1972 is given in annex II. Further information is given in figure II, which shows the trends for the major producers and the region as a whole. It should be noted that the information given in annex I and figure II for liquid fuels does not carry on from the corresponding information presented in 1975 to the Committee on Natural Resources at its second session, as in the mean time the equivalences between different grades of crude oil and standard coal have been revised. Also, the values given in this report include oil used for non-energy uses.

Total production for the region increased rapidly to 1974, followed by a decline in 1975 and a resumption of the upward trend in 1976. The decline in 1975 was largely influenced by a significant decline in the output of the major producer, Iran, and a minor decline in output in Indonesia, other producers continuing their upward trend throughout the period, as indicated also by the curve of total production excluding Iran. It is noted that Malaysia increased production in 1976, from new fields.

Consumption in Japan fell steadily from 1973 to 1975, followed by a modest increase in 1976. In the mean time, total consumption in the region excluding Japan has continued to increase, and by 1976 equalled that of Japan. Individual countries not affected by other factors in which consumption has not maintained a steady increase during the period are Afghanistan, Bangladesh, Burma, Fiji, Nepal, New Zealand, Sri Lanka and Thailand, each of which reduced consumption in one or both of the years 1974 and 1975.

For the region as a whole, exports overtook imports in 1971, and since then the region has become a significant exporter of more than 100 million tons of

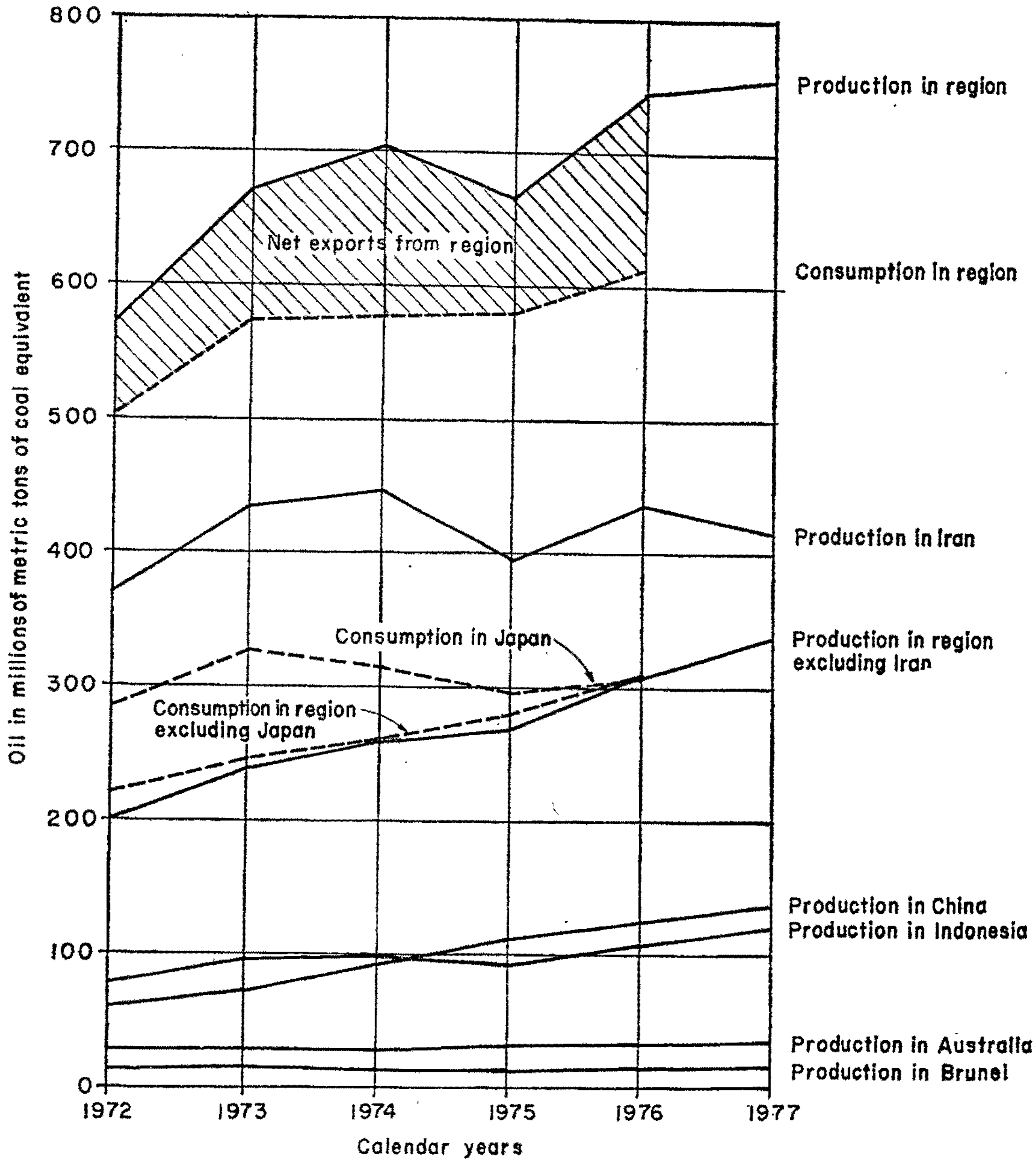

Figure II. Liquid fuels production and consumption in the region

coal equivalent per year. However, such a statement is misleading, as about 93 per cent of Iran's output is exported, while about 97 per cent of Japan's consumption is imported; a better guide is to compare the curves for consumption in the region excluding Japan and production in the region excluding Iran, indicating a fairly balanced condition. Even within this modified grouping, significant quantities are imported by Australia, Hong Kong, India, New Zealand, Pakistan, the Philippines, the Republic of Korea, Singapore, Thailand and Viet Nam and exported by Brunei, China and Indonesia.

The above does not imply that the region is self-contained in terms of trading. Each country with a surplus exports to countries both within and outside the region. Japan imports about one quarter of its supplies from Iran, smaller quantities from Brunei, China and Indonesia and the remainder from outside the region. Most of the other importing countries obtain some part of their supplies from the above four exporters and the remainder from outside the region. There appear to be opportunities for closer co-ordination of trade in this respect, subject to various technical and economic constraints.

The emphasis on government involvement in exploration and production since 1973 has tended to speed up activity on known fields and new discoveries in the region, but some discrepancies have been noticed between increased activity, increased production and economic benefits.

C. NATURAL GAS

Annex II includes the production and consumption of natural gas in individual countries in the region, while figure III shows the trends for the major producers and for the region as a whole. It will be noted that the scale of figure III is 10 times the scale of figures I and II, confirming that natural gas is a small component of commercial energy. For natural gas also, the equivalences of gas from different fields to standard coal have been revised.

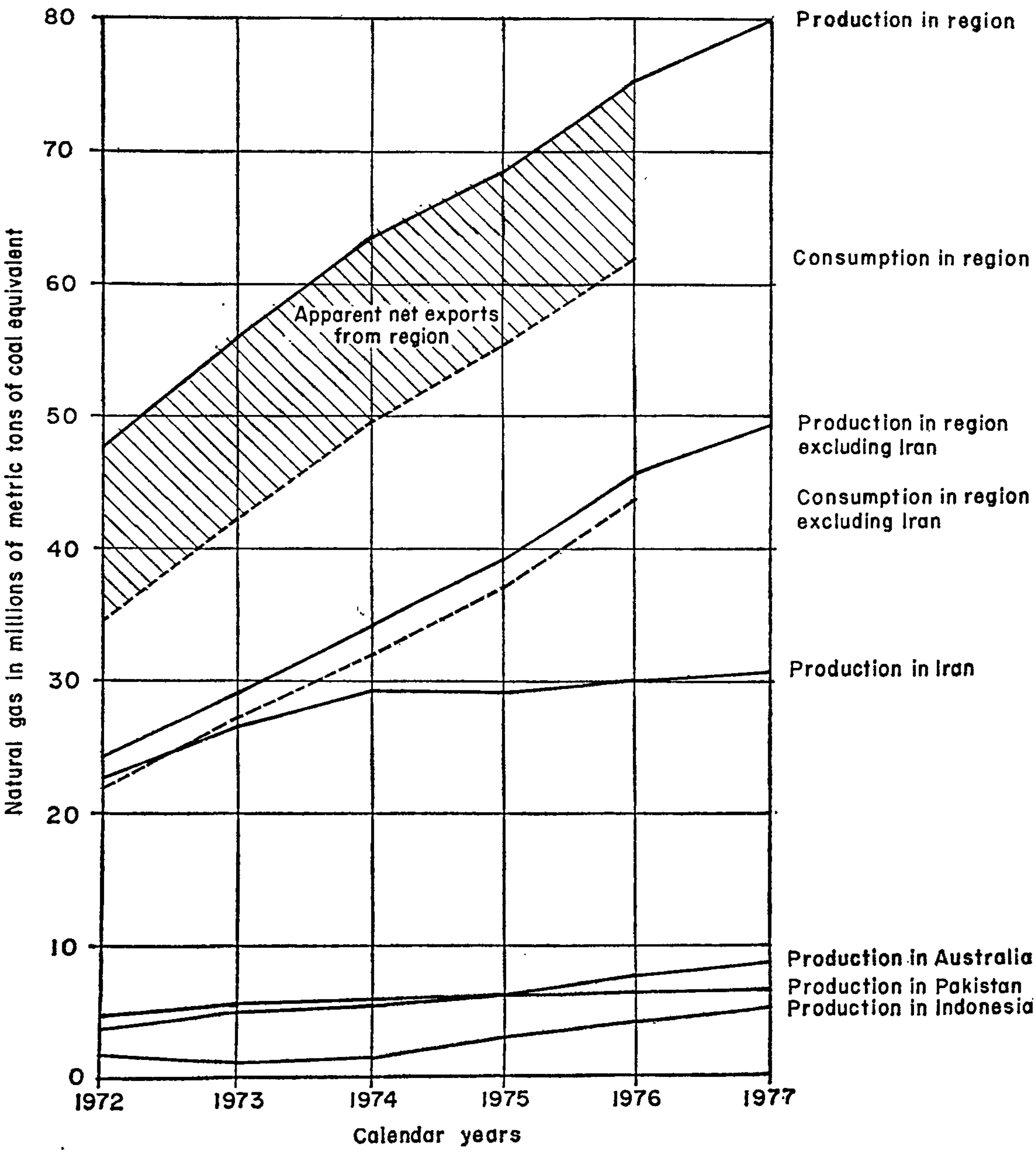

Figure III. Natural gas production and consumption in the region

Production in the region as a whole increased quite rapidly during the period under review, at a faster rate than for other commercial resources, notwithstanding the levelling off of production in Iran in 1975. Of the 12 countries producing natural gas, Australia, Brunei, Indonesia and Pakistan all contributed significantly to the increase, and it is noted that Iran's share of total production declined somewhat, from 50 to 38 per cent. There appears to be a clear indication that countries are working hard to develop this resource.

Consumption in the region as a whole increased during the period at a rate consistent with production, and consumption in individual countries and groups of countries performed similarly. This is not surprising, since most natural gas is consumed locally.

The region as a whole is a net exporter of natural gas, in a defined manner. Export routes consist of Afghanistan to the Union of Soviet Socialist Republics by pipeline, Brunei to Malaysia (Sarawak) by pipeline and to Japan as liquefied natural gas, and Iran to the USSR by pipeline (the major movement). Japan also imports LNG from the United States of America and the United Arab Emirates, and has recently arranged for further imports from within the region (Australia and Indonesia).

As with liquid fuels, the Governments of the countries in the region are taking an active interest in the development of the gas resources and negotiations for export.

D. HYDRO AND NUCLEAR ELECTRICITY

The production and consumption of hydro and nuclear electricity in the region are given in annex II, the quantities not being separated. The amounts of these forms of energy traded between countries are very small, and there is no storage, so consumption in each country is virtually equivalent to production. Figure IV shows production for the region and in selected countries. As for natural gas, the scale for hydro and nuclear electricity is 10 times that used for solid fuels and liquid fuels.

For the region, production dipped in 1973, but this was evidently caused by a decrease in hydro-electric production that year in Japan because of poor weather conditions. In general, a modest rate of increase is apparent.

Hydroelectric production occurred in 20 countries in the region and in all of them, with the exception of Japan, as noted above, and Malaysia, output increased steadily at a modest rate, as indicated for China and India in figure IV.

During the period under review, nuclear production occurred in China, India, Japan, Pakistan and the Republic of Korea, but was significant only in Japan. For that country, the nuclear production is separated out in figure IV, and it is apparent that it is already making a substantial contribution to regional output.

Trade within the region consists of modest amounts of energy exchanged between Bhutan and India, the Lao People's Democratic Republic and Thailand, and Nepal and India. Agreements have also been reported for limited interchange between Malaysia and Singapore and Malaysia and Thailand.

E. REGIONAL PRIMARY COMMERCIAL ENERGY

Figure V summarizes the total production and consumption of solid fuels, liquid fuels, natural gas and hydro and nuclear electricity for the region, and allows a ready comparison to be made between these four components.

Production of liquid fuels and solid fuels have interchanged their position from year to year, while production of natural gas and hydro and nuclear electricity have been small by comparison. Consumption of solid fuels remains well above consumption of liquid fuels. The percentages of the totals for 1976 were as follows:

	Percentage of regional total			
	Solid fuels	*Liquid fuels*	*Natural gas*	*Hydro and nuclear*
Production	45.3	47.8	4.9	2.0
Consumption	50.6	42.9	4.3	2.2

From the regional point of view, the excess of total exports over total imports of energy is increasing, which is a healthy financial condition, and with further development of known and new oil and gas fields and development of more of the coal and lignite resources the over-all condition could continue to improve. This statement disguises the large discrepancy between the finances of the exporting countries and those of the importing countries. However, most of the larger countries have further energy development prospects, which may tend to alleviate their problems, but the same cannot be said of the smaller countries.

F. OTHER PRIMARY COMMERCIAL FORMS OF ENERGY

The future of geothermal energy is bright, and development of this resource will make a welcome contribution in those countries with potential.

No project in the region for development of ocean energy, tidal power, wave energy or temperature differentials, has yet reached the firm planning stage.

G. NON-COMMERCIAL PRIMARY FORMS OF ENERGY

Production and consumption of fuelwood in individual countries is given in annex II and depicted in figure V. The regional total is significant and is

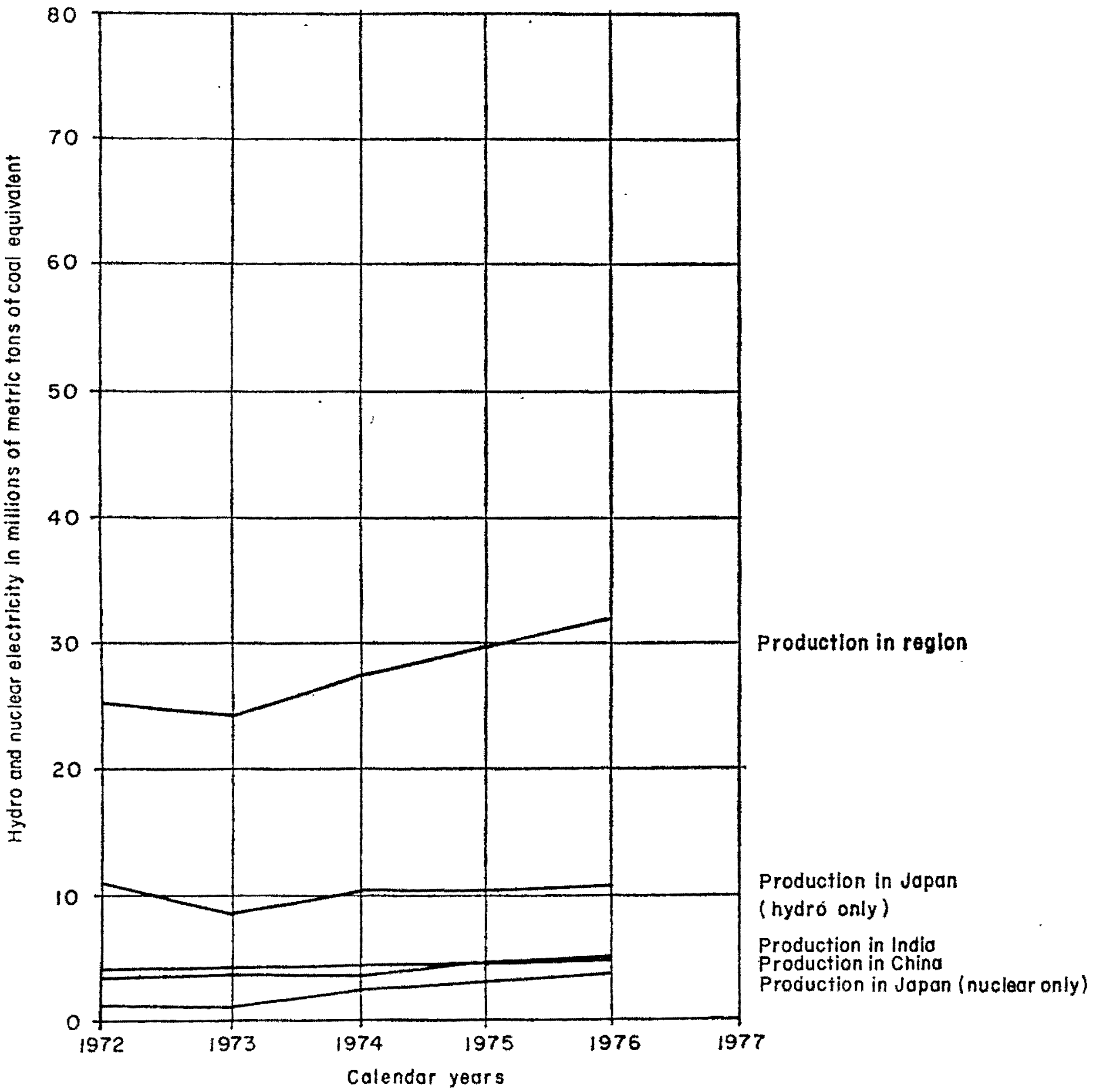

Figure IV. Hydro and nuclear electricity production in the region

likely to continue at about this level. In individual countries, for instance, Indonesia, Iran and the Republic of Korea, government concern about denudation of forest areas has been expressed in directives, but these are difficult to apply in rural areas unless there is some financial inducement to use an alternative source of energy. A government alternative, also under consideration in some countries, is to develop new areas of fast-growing, high energy content species of wood, partly for industrial and partly for domestic consumption. Very little information is available on the production of charcoal, but there is some minor trade between countries, which may be expected to continue and increase to some extent.

There is a perceptible but slow growth of the more effective use of the energy in animal and agricultural wastes. So far, this appears to be confined chiefly to those countries with already established techniques, but may be expected to spread to other countries also.

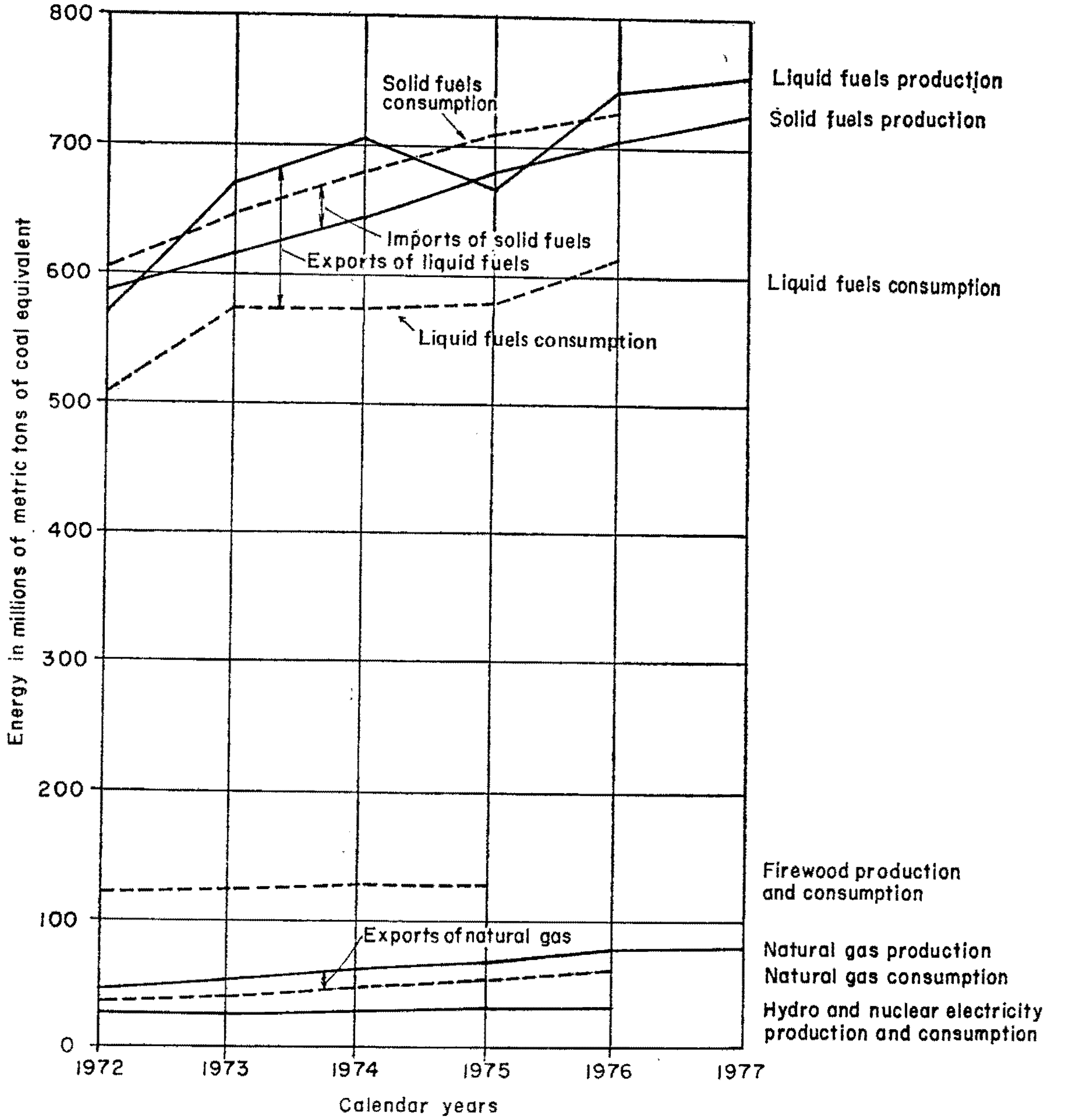

Figure V. Energy production and consumption in the region

Solar and wind energy may be used without restriction, but again it takes time for a rural population not already familiar with the techniques to adopt innovations.

H. SECONDARY ENERGY: ELECTRICITY

Detailed statistics on the electricity industry are given in *Electric Power in Asia and the Pacific.* Although a significant proportion of the region's electricity requirements is made available from primary sources through hydroelectric and nuclear power stations, the greater part of the electricity produced in the region results from the burning of coal, oil or gas in thermal power stations. It is, however, appropriate to note the trend of percentages of generation from the various types of power stations, as in table 3 (which does not include the figures for China). In the 15 years to 1976, the general picture has shown an increase in percentage of generation from steam power stations at the expense of hydro power stations, but the relative proportions now seem to have stabilized. Generation from nuclear power stations is increasing steadily as a percentage, while the internal combustion and gas turbine components remain minor.

Table 3. Electricity generation in the region[a]
(in percentage production by various types of generating station)

Type of station	1961	1966	1971	1972	1973	1974	1975	1976
Hydro	48.2	36.6	27.2	25.6	20.6	22.9	23.2	22.0
Steam	50.5	61.3	68.6	69.9	76.1	71.7	70.9	71.1
Internal combustion	1.3	1.6	2.3	2.4	1.1	1.8	1.7	1.3
Gas turbines	—	0.3	0.3	0.4	0.4	0.4	0.4	0.9
Nuclear	—	0.2	1.6	1.7	1.8	3.2	3.8	4.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Production (kWh × 10^9)	185.9	304.4	579.4	624.8	702.0	705.4	742.1	790.8
Equivalent coal (million metric tons)	22.8	37.4	71.3	76.9	86.3	86.8	91.3	97.3

Source: *Electric Power in Asia and the Pacific.*
[a] By countries reporting.

TRENDS IN COUNTRY POLICIES ON ENERGY

At the time of the second session of the Committee on Natural Resources, in 1975, the effects of the large rise in the price of petroleum were still being digested. Short-term measures directed towards reduction in direct usage of petroleum products, and indirect use in electricity generation, and consisting of a combination of limitation of use, restriction of supplies, exhortation and price changes were giving way to medium-term and long-term measures.

The most obvious results have come from some easing of traffic congestion and speeds, and increase of efficiency of use of energy in factories, while rationalization of the institutional framework related to energy has set the stage for more effective assessment, investigation, production and control of the energy resources available.

During the transition period, several influences have been at work, mostly hampering Governments in the readjustment process. These have included:

(a) The flurry of exploration for petroleum;

(b) The temporary slow-down in the economies of the developed countries;

(c) The temporary high prices for agricultural commodities and selected minerals;

(d) Increases in the cost of manufactured goods;

(e) The medium-term high inflation rates;

(f) The medium-term high interest rates;

(g) Chronic unemployment;

(h) The medium-term scarcity of development funds;

(i) Problems with balances of payments;

(j) Rapid changes in currency relativities.

Dealing with the above problems has absorbed much of the available administrative effort of Governments, and there have been cases, owing to insufficient knowledge of interrelations in the event of a large step change, where easing of one problem has caused strain in another (unexpected) sector. In the circumstances, the efforts of Governments to improve the energy picture are very commendable.

Some interesting general points which have emerged may be noted:

(a) In the short term, there is no direct substitute for petroleum;

(b) Natural gas, where available, should be exploited, and the value of the liquids which are associated with it should not be overlooked;

(c) Liquefied petroleum gas can find a ready market;

(d) Time spent in proving and developing coal fields is a valuable long-term investment;

(e) Peat resources should not be neglected;

(f) Hydroelectric resources may be reassessed for their potential for peaking power;

(g) Exploration for uranium will attract financial backing;

(h) Geothermal prospects become more and more interesting;

(i) Practical devices and technology for low-grade and small-scale use of solar energy, wind energy and biogas are readily available;

(j) High-grade and large-scale use of solar energy and wind energy are not within the reach of developing countries;

(k) Increasing consumption of wood is attracting general attention;

(l) Exotic sources of energy are unlikely to become available for many years.

It has also become apparent that Governments, and people, are not interested in saving energy as such but are vitally interested in saving money. This serves to focus attention on the traditional financial processes involved in comparing alternative projects, including calculation of present worth, cost-benefit ratios, rates of return and cash flows. These approaches have proved their worth in stable economic conditions, with shadow calculations for considering the sensitivity of the results to small changes in the parameters. However, when large changes may take place in base costs, interest rates and internal inflation rates, shadow calculations for sensitivity may yield overlapping ranges. This might leave the decision in doubt, normally leading to delays in agreement within the country and in negotiations with financial institutions. One suggestion that has been made is that in such a case selection should be made in the basis of minimum foreign exchange requirements, in order to reduce the effect of external factors.

Annex I

Commercial primary energy reserves in countries of the ESCAP region

(in millions of metric tons of coal equivalent)

Country or area	Total coal[a]		Crude oil[a] Recoverable	Natural gas[a] Recoverable	Hydro power[a] Assessed	Uranium[c] Recoverable
	In place	Recoverable				
Afghanistan	85	NA	19	188	111	—
Australia	204,800[d]	119,624[d]	427[d]	464[d]	138[d]	2,161[d]
Bangladesh	1,491	517	—	291	40	NA[d]
Bhutan	NA	NA	—	—	65[b]	—
Brunei	—	—	292	402	—	—
Burma	154	NA	8	4	1,384	—
China	1,000,000	NA	2,537	875	8,118	NA
Cook Islands	—	—	—	—	—	—
Democratic Kampuchea	—	—	—	—	175[b]	—
Fiji	—	—	—	—	—	—
Gilbert Islands	—	—	—	—	—	—
Hong Kong	—	—	—	—	—	—
India	81,965	NA[d]	600[d]	126[d]	1,722	190
Indonesia	15,000[d]	5,000[d]	2,140	427[d]	765[d]	—
Iran	385	NA	13,039	7,607	230	—
Japan	7,881	976	5	15	800	50
Lao People's Democratic Republic	—	—	—	—	277	—
Malaysia	400[d]	93[d]	286	600[d]	76[d]	—
Maldives	—	—	—	—	—	—
Mongolia	NA	NA	—	—	NA	—
Nauru	—	—	—	—	—	—
Nepal	NA	NA	—	—	2,680[b]	—
New Zealand	799	119	47	231	339	—
Pakistan	1,801	187	36[d]	579[d]	646	—
Papua New Guinea	—	—	—	43	748	—
Philippines	100[d]	60[d]	NA[d]	7	274[d]	2[d]
Republic of Korea	1,657	622	—	—	61	16
Samoa	—	—	—	—	—	—
Singapore	—	—	—	—	—	—
Solomon Islands	—	—	—	—	—	—
Sri Lanka	—	—	—	—	29	—
Thailand	118	79	NA[d]	158[d]	412[b]	NA[d]
Tonga	—	—	—	—	—	—
Trust Territory of the Pacific Islands	—	—	—	—	—	—
Tuvalu	—	—	—	—	—	—
Viet Nam	NA	NA	—	—	1,077	—

Sources: [a] World Energy Conference, *Survey of Energy Resources, 1974.*

[b] *Electric Power in Asia and the Pacific.*

[c] *Uranium Resources, Production and Demand,* OECD–IAEA, December 1977.

[d] Updated information supplied for the Working Group Meeting on Energy Planning and Programming, 15–21 August 1978.

Note: United Nations conversion factors for reserves of unspecified heating capacity:

Standard coal	: 7,000 kcal/kg or 27,750 BTU/kg or 29.3 MJ/kg
Crude petroleum	: 7.33 barrels or 1 ton = 1.47 tons standard coal
Natural gas	: 1,000 m^3 or 35,400 cu ft = 1.27 tons standard coal
Hydroelectricity	: 1 kW at 0.6 load factor for 50 years = 32.3 tons standard coal
Uranium	: 1 ton natural uranium = 6,500 tons standard coal

Annex II

Production and consumption of energy in countries of the ESCAP region

(in millions of metric tons of coal equivalent)

Country or area	Year	Production					Trade		Consumption					Fuelwood consumed	Fuelwood as percentage of total commercial energy
		Solid fuels	Liquid fuels	Natural gas	Hydro and nuclear electricity	Total commercial energy	Total exports	Total imports	Solid fuels	Liquid fuels	Natural gas	Hydro and nuclear electricity	Total commercial energy		
Afghanistan	1972	0.07	—	3.85	0.06	3.98	3.32	—	0.07	0.47	0.06	0.06	0.66	1.34	203
	1973	0.12	—	3.73	0.06	3.91	3.13	—	0.12	0.52	0.09	0.06	0.78	1.23	158
	1974	0.12	0.01	3.92	0.06	4.11	3.35	—	0.12	0.45	0.13	0.06	0.76	1.41	186
	1975	0.15	0.01	3.95	0.07	4.17	3.29	—	0.15	0.52	0.15	0.07	0.88	1.45	165
	1976	0.16	0.01	3.38	0.06	3.62	2.81	—	0.16	0.53	0.05	0.06	0.81	NA	NA
	1977	0.20	0.01	3.29	NA	NA									
Australia	1972	62.39	24.78	4.06	1.46	92.69	19.60	—	34.32	33.25	4.06	1.46	73.09	0.55	1
	1973	63.63	29.85	5.21	1.48	100.17	22.22	—	35.02	36.25	5.21	1.48	77.95	0.54	1
	1974	66.98	29.85	5.74	1.67	104.24	21.15	—	37.76	37.93	5.74	1.67	83.09	0.65	1
	1975	69.99	31.78	6.39	1.87	110.04	25.66	—	38.35	37.76	6.39	1.87	84.38	0.41	1
	1976	78.03	32.38	7.54	1.92	119.86	29.03	—	41.69	39.68	7.54	1.92	90.83	NA	NA
	1977	81.89	33.15	8.57	NA	NA									
Bangladesh	1972	—	—	0.77	0.05	0.82	—	1.32	0.19	1.13	0.77	0.05	2.14	3.34	156
	1973	—	—	0.91	0.05	0.96	—	1.39	0.48	0.91	0.91	0.05	2.35	3.38	144
	1974	—	—	0.95	0.06	1.01	—	1.18	0.35	0.83	0.95	0.06	2.19	3.42	156
	1975	—	—	0.63	0.06	0.69	—	1.49	0.34	1.15	0.63	0.06	2.18	3.50	161
	1976	—	—	1.07	0.06	1.14	—	1.49	0.33	1.16	1.07	0.06	2.63	NA	NA
	1977	—	—	1.09	NA	NA									
Brunei	1972	—	13.07	0.64	—	13.71	13.21	—	—	0.10	0.40	—	0.50	0.02	4
	1973	—	16.34	3.37	—	19.71	18.10	—	—	0.10	1.51	—	1.61	0.02	2
	1974	—	13.75	6.52	—	20.26	18.02	—	—	0.11	2.13	—	2.24	0.01	1
	1975	—	13.84	8.51	—	22.34	20.05	—	—	0.12	2.18	—	2.29	0.02	1
	1976	—	14.94	11.02	—	25.96	23.44	—	—	0.12	2.40	—	2.52	NA	NA
	1977	—	15.00	11.03	—	26.03									
Burma	1972	0.02	1.42	0.02	0.06	1.52	—	0.21	0.14	1.50	0.02	0.06	1.73	4.59	265
	1973	0.01	1.43	0.03	0.06	1.53	0.17	—	0.08	1.20	0.03	0.06	1.36	4.64	341
	1974	0.01	1.41	0.03	0.06	1.51	—	0.07	0.17	1.34	0.03	0.06	1.58	4.70	297
	1975	0.02	1.43	0.01	0.06	1.51	0.12	—	0.23	1.10	0.01	0.06	1.39	4.75	342
	1976	0.01	1.71	—	0.06	1.78	0.27	—	0.22	1.24	—	0.06	1.51	NA	NA
	1977	0.02	1.91	—	NA	NA									

Annex II *(continued)*

Country or area	*Year*	*Production*					*Trade*		*Consumption*					*Fuelwood consumed*	*Fuelwood as percentage of total commercial energy*
		Solid fuels	*Liquid fuels*	*Natural gas*	*Hydro and nuclear electricity*	*Total commercial energy*	*Total exports*	*Total imports*	*Solid fuels*	*Liquid fuels*	*Natural gas*	*Hydro and nuclear electricity*	*Total commercial energy*		
China	1972	400.00	63.14	3.40	4.06	470.59	6.75	—	399.50	56.64	3.40	4.31	463.84	33.53	7
	1973	430.00	75.34	3.77	4.24	513.35	9.59	—	429.39	66.11	3.77	4.49	503.76	34.04	7
	1974	450.00	95.55	4.00	4.31	553.85	16.26	—	448.97	80.07	4.00	4.55	537.59	34.75	6
	1975	470.00	110.25	4.66	4.55	589.46	25.46	—	468.81	85.73	4.66	4.80	564.00	35.50	6
	1976	480.00	124.95	5.22	4.61	614.78	24.72	—	478.90	101.08	5.22	4.86	590.06	NA	NA
	1977	500.00	139.65	5.86	NA	NA									
Cook Islands	1972	—	—	—	—	—	—	0.01	—	0.01	—	—	0.01	—	—
	1973	—	—	—	—	—	—	0.01	—	0.01	—	—	0.01	—	—
	1974	—	—	—	—	—	—	0.01	—	0.01	—	—	0.01	—	—
	1975	—	—	—	—	—	—	0.01	—	0.01	—	—	0.01	—	—
	1976	—	—	—	—	—	—	0.01	—	0.01	—	—	0.01	—	—
	1977	—	—	—	—	—									
Democratic Kampuchea . .	1972	—	—	—	—	—	—	0.18	0.01	0.18	—	—	0.19	0.95	528
	1973	—	—	—	—	—	—	0.23	—	0.23	—	—	0.23	0.96	417
	1974	—	—	—	—	—	—	0.13	—	0.13	—	—	0.13	0.99	762
	1975	—	—	—	—	—	—	0.13	—	0.13	—	—	0.13	1.01	777
	1976	—	—	—	—	—	—	0.13	—	0.13	—	—	0.13	NA	NA
	1977	—	—	—	—	—									
Fiji	1972	—	—	—	—	—	—	0.27	—	0.27	—	—	0.27	—	—
	1973	—	—	—	—	—	—	0.24	—	0.24	—	—	0.24	—	—
	1974	—	—	—	—	—	—	0.31	0.01	0.30	—	—	0.31	—	—
	1975	—	—	—	—	—	—	0.29	0.01	0.27	—	—	0.29	—	—
	1976	—	—	—	—	—	—	0.23	0.01	0.23	—	—	0.23	—	—
	1977	—	—	—	—	—									
Gilbert Islands	1972	—	—	—	—	—	—	0.01	—	0.01	—	—	0.01	—	—
	1973	—	—	—	—	—	—	0.02	—	0.02	—	—	0.02	—	—
	1974	—	—	—	—	—	—	0.02	—	0.02	—	—	0.02	—	—
	1975	—	—	—	—	—	—	0.02	—	0.02	—	—	0.02	—	—
	1976	—	—	—	—	—	—	0.02	—	0.02	—	—	0.02	—	—
	1977	—	—	—	—	—									
Hong Kong	1972	—	—	—	—	—	—	4.26	0.03	4.24	—	—	4.26	—	—
	1973	—	—	—	—	—	—	4.43	0.02	4.42	—	—	4.43	—	—
	1974	—	—	—	—	—	—	5.14	0.02	5.13	—	—	5.14	—	—
	1975	—	—	—	—	—	—	4.92	0.01	4.90	—	—	4.92	—	—
	1976	—	—	—	—	—	—	5.75	0.02	5.74	—	—	5.75	—	—
	1977	—	—	—	—	—									

Annex II *(continued)*

Country or area	Year	Production: Solid fuels	Production: Liquid fuels	Production: Natural gas	Production: Hydro and nuclear electricity	Production: Total commercial energy	Trade: Total exports	Trade: Total imports	Consumption: Solid fuels	Consumption: Liquid fuels	Consumption: Natural gas	Consumption: Hydro and nuclear electricity	Consumption: Total commercial energy	Fuelwood consumed	Fuelwood as percentage of total commercial energy
India	1972	76.67	10.84	0.85	3.49	91.84	—	16.78	77.88	26.41	0.85	3.49	108.62	26.50	24
	1973	78.97	10.58	0.82	3.86	94.23	—	18.18	79.85	27.88	0.82	3.86	112.41	26.98	24
	1974	85.08	11.01	0.96	3.70	100.75	—	15.92	84.42	27.60	0.96	3.70	116.67	27.54	24
	1975	96.81	12.18	1.22	4.42	114.62	—	12.94	93.64	28.29	1.22	4.42	127.56	28.82	23
	1976	102.16	12.73	1.52	4.68	121.09	—	11.83	97.93	28.80	1.52	4.68	132.92	NA	NA
	1977	99.75	13.86	1.76	NA	NA									
Indonesia	1972	0.18	79.70	1.63	0.16	81.66	65.57	—	0.20	14.10	1.63	0.16	16.09	26.00	162
	1973	0.15	98.43	1.06	0.19	99.83	82.26	—	0.15	16.16	1.06	0.19	17.57	26.75	152
	1974	0.16	99.23	1.50	0.22	101.10	81.12	—	0.17	18.09	1.50	0.22	19.98	27.25	136
	1975	0.21	94.29	3.07	0.22	97.79	72.74	—	0.23	21.52	3.07	0.22	25.05	27.75	111
	1976	0.19	109.08	4.36	0.22	113.85	83.42	—	0.21	25.64	4.36	0.22	30.43	NA	NA
	1977	0.20	121.69	5.00	NA	NA									
Iran	1972	1.00	372.35	23.85	0.48	397.68	367.35	—	1.00	16.01	12.84	0.48	30.33	0.25	1
	1973	1.05	433.01	26.68	0.35	461.10	424.99	—	1.05	19.68	15.02	0.35	36.11	0.27	1
	1974	1.20	444.91	29.72	0.42	476.25	434.95	—	1.20	22.17	17.51	0.42	41.30	0.50	1
	1975	1.00	395.47	29.33	0.42	426.22	381.73	—	1.00	26.58	16.48	0.42	44.49	0.50	1
	1976	0.90	435.78	30.19	0.49	467.36	417.59	—	0.90	30.64	17.74	0.49	49.77	NA	NA
	1977	0.85	415.24	30.72	NA	NA									
Japan	1972	28.13	1.08	3.70	12.01	44.92	—	332.92	75.55	286.27	5.39	12.01	379.22	0.49	—
	1973	22.44	1.06	3.94	10.04	37.49	—	388.35	80.67	327.74	7.39	10.04	425.84	0.37	—
	1974	20.36	1.02	3.92	12.89	38.19	—	383.33	85.59	313.11	9.93	12.89	421.52	0.33	—
	1975	19.02	0.93	3.79	13.70	37.44	—	366.28	80.32	297.84	11.87	13.70	403.72	0.26	—
	1976	18.41	0.89	3.79	15.11	38.21	—	376.66	78.97	306.74	14.05	15.11	414.87	NA	—
	1977	18.14	0.91	4.19	NA	NA									
Lao People's Democratic Republic	1972	—	—	—	0.03	0.03	—	0.22	—	0.25	—	0.01	0.25	0.71	284
	1973	—	—	—	0.03	0.03	—	0.23	—	0.25	—	0.01	0.26	0.71	273
	1974	—	—	—	0.03	0.03	—	0.18	—	0.20	—	0.01	0.21	0.73	348
	1975	—	—	—	0.03	0.03	—	0.18	—	0.20	—	0.01	0.21	0.74	352
	1976	—	—	—	0.03	0.03	—	0.18	—	0.20	—	0.01	0.21	NA	NA
	1977	—	—	—	NA	NA									
Malaysia	1972	—	6.52	0.13	0.14	6.78	—	0.77	0.01	7.09	0.30	0.14	7.55	1.28	17
	1973	—	6.38	0.12	0.14	6.64	—	0.77	0.05	6.91	0.31	0.14	7.41	1.31	18
	1974	—	5.70	0.10	0.12	5.92	—	1.61	0.06	7.04	0.30	0.12	7.53	1.34	18
	1975	—	6.88	0.11	0.12	7.11	0.06	—	0.05	6.57	0.31	0.12	7.05	1.37	19
	1976	—	11.80	0.12	0.12	12.04	4.42	—	0.05	7.13	0.32	0.12	7.62	NA	NA
	1977	—	13.00	0.12	NA	NA									

Annex II *(continued)*

Country or area	Year	Production: Solid fuels	Production: Liquid fuels	Production: Natural gas	Production: Hydro and nuclear electricity	Production: Total commercial energy	Trade: Total exports	Trade: Total imports	Consumption: Solid fuels	Consumption: Liquid fuels	Consumption: Natural gas	Consumption: Hydro and nuclear electricity	Consumption: Total commercial energy	Fuelwood consumed	Fuelwood as percentage of total commercial energy
Mongolia	1972	0.82	—	—	—	0.82	—	0.46	0.82	0.47	—	—	1.28	0.34	27
	1973	0.85	—	—	—	0.85	—	0.47	0.85	0.47	—	—	1.32	0.34	26
	1974	0.91	—	—	—	0.91	—	0.56	0.91	0.56	—	—	1.47	0.34	23
	1975	1.01	—	—	—	1.01	—	0.57	1.02	0.56	—	—	1.58	0.34	22
	1976	1.10	—	—	—	1.10	—	0.64	1.10	0.63	—	—	1.74	NA	NA
	1977	1.26	—	—	—	1.26									
Nauru	1972	—	—	—	—	—	—	0.04	—	0.04	—	—	0.04	—	—
	1973	—	—	—	—	—	—	0.04	—	0.04	—	—	0.04	—	—
	1974	—	—	—	—	—	—	0.05	—	0.05	—	—	0.05	—	—
	1975	—	—	—	—	—	—	0.05	—	0.05	—	—	0.05	—	—
	1976	—	—	—	—	—	—	0.05	—	0.05	—	—	0.05	—	—
	1977	—	—	—	—	—									
Nepal	1972	—	—	—	0.01	0.01	—	0.16	0.02	0.14	—	0.01	0.17	2.18	1,282
	1973	—	—	—	0.01	0.01	—	0.14	0.01	0.12	—	0.01	0.15	2.18	1,453
	1974	—	—	—	0.01	0.01	—	0.13	0.01	0.12	—	0.02	0.14	2.18	1,557
	1975	—	—	—	0.02	0.02	—	0.12	0.01	0.11	—	0.02	0.14	2.18	1,557
	1976	—	—	—	0.02	0.02	—	0.12	0.01	0.11	—	0.02	0.14	NA	NA
	1977	—	—	—	NA	NA									
New Zealand	1972	1.78	0.21	0.32	1.88	4.19	—	5.03	1.79	5.22	0.32	1.88	9.22	0.13	1
	1973	2.03	0.24	0.39	1.88	4.53	—	5.50	2.02	5.74	0.39	1.88	10.03	0.06	1
	1974	2.11	0.24	0.44	1.90	4.69	—	5.99	2.12	6.22	0.44	1.90	10.68	0.06	1
	1975	1.98	0.21	0.47	2.23	4.89	—	5.16	1.97	5.38	0.47	2.23	10.05	0.06	1
	1976	2.03	0.71	1.27	1.99	6.00	—	5.35	2.02	6.07	1.27	1.99	11.35	NA	NA
	1977	2.02	1.04	2.17	NA	NA									
Pakistan	1972	0.88	0.67	4.80	0.49	6.84	—	4.53	0.97	5.12	4.80	0.49	11.37	1.99	18
	1973	0.84	0.64	5.84	0.59	7.91	—	4.35	0.90	4.94	5.84	0.60	12.26	2.05	17
	1974	0.79	0.56	6.20	0.66	8.21	—	4.65	0.87	5.13	6.20	0.66	12.86	2.12	16
	1975	0.92	0.45	6.37	0.66	8.41	—	4.74	0.99	5.12	6.37	0.66	13.15	2.12	16
	1976	0.94	0.45	6.26	0.68	8.33	—	4.78	1.02	5.16	6.26	0.68	13.11	NA	NA
	1977	0.97	0.60	6.29	NA	NA									
Papua New Guinea . . .	1972	—	—	—	0.02	0.02	—	0.63	—	0.64	—	0.02	0.65	1.11	171
	1973	—	—	—	0.02	0.02	—	0.67	—	0.67	—	0.02	0.69	1.14	165
	1974	—	—	—	0.02	0.02	—	0.78	—	0.78	—	0.02	0.80	1.17	146
	1975	—	—	—	0.02	0.02	—	0.74	—	0.74	—	0.02	0.76	1.19	157
	1976	—	—	—	0.03	0.03	—	0.79	—	0.79	—	0.03	0.82	NA	NA
	1977	—	—	—	NA	NA									

Annex II *(continued)*

Country or area	Year	Production: Solid fuels	Production: Liquid fuels	Production: Natural gas	Production: Hydro and nuclear electricity	Production: Total commercial energy	Trade: Total exports	Trade: Total imports	Consumption: Solid fuels	Consumption: Liquid fuels	Consumption: Natural gas	Consumption: Hydro and nuclear electricity	Consumption: Total commercial energy	Fuelwood consumed	Fuelwood as percentage of total commercial energy
Philippines	1972	0.04	—	—	0.28	0.32	—	10.86	0.05	10.86	—	0.28	11.18	5.07	45
	1973	0.04	—	—	0.45	0.48	—	12.00	0.05	11.98	—	0.45	12.48	5.27	42
	1974	0.05	—	—	0.53	0.58	—	11.81	0.08	11.78	—	0.53	12.39	5.36	43
	1975	0.11	—	—	0.56	0.66	—	12.42	0.12	12.41	—	0.56	13.08	5.55	42
	1976	0.16	—	—	0.60	0.76	—	13.62	0.18	13.61	—	0.60	14.38	NA	NA
	1977	0.28	—	—	NA	NA									
Republic of Korea . . .	1972	12.40	—	—	0.17	12.57	—	14.10	12.08	14.42	—	0.17	26.67	1.88	7
	1973	13.57	—	—	0.16	13.73	—	17.47	14.87	16.18	—	0.16	31.20	2.29	7
	1974	15.29	—	—	0.23	15.52	—	16.46	15.68	16.06	—	0.23	31.98	1.79	6
	1975	17.59	—	—	0.21	17.79	—	17.44	17.47	17.55	—	0.21	35.23	1.84	5
	1976	16.43	—	—	0.22	16.65	—	19.93	17.01	19.35	—	0.22	36.58	NA	NA
	1977	17.27	—	—	NA	NA									
Samoa	1972	—	—	—	—	—	—	0.02	—	0.02	—	—	0.02	—	—
	1973	—	—	—	—	—	—	0.02	—	0.02	—	—	0.02	0.02	100
	1974	—	—	—	—	—	—	0.02	—	0.02	—	—	0.02	0.02	100
	1975	—	—	—	—	—	—	0.02	—	0.02	—	—	0.02	0.02	100
	1976	—	—	—	—	—	—	0.02	—	0.02	—	—	0.02	NA	NA
	1977	—	—	—	—	—									
Singapore	1972	—	—	—	—	—	—	3.15	0.01	3.14	—	—	3.15	0.01	—
	1973	—	—	—	—	—	—	4.38	0.01	4.38	—	—	4.38	—	—
	1974	—	—	—	—	—	—	4.09	0.01	4.08	—	—	4.09	—	—
	1975	—	—	—	—	—	—	5.10	—	5.10	—	—	5.10	0.01	—
	1976	—	—	—	—	—	—	5.15	—	5.15	—	—	5.15	NA	—
	1977	—	—	—	—	—									
Solomon Islands	1972	—	—	—	—	—	—	0.03	—	0.09	—	—	0.03	0.04	133
	1973	—	—	—	—	—	—	0.04	—	0.04	—	—	0.04	0.04	100
	1974	—	—	—	—	—	—	0.04	—	0.04	—	—	0.04	0.04	100
	1975	—	—	—	—	—	—	0.05	—	0.05	—	—	0.05	0.04	80
	1976	—	—	—	—	—	—	0.06	—	0.06	—	—	0.06	NA	NA
	1977	—	—	—	—	—									
Sri Lanka	1972	—	—	—	0.11	0.11	—	1.67	0.01	1.66	—	0.11	1.78	1.02	57
	1973	—	—	—	0.09	0.09	—	1.66	0.01	1.65	—	0.09	1.75	1.04	59
	1974	—	—	—	0.14	0.14	—	1.46	0.01	1.46	—	0.14	1.60	1.04	65
	1975	—	—	—	0.14	0.14	—	1.46	0.01	1.46	—	0.14	1.60	1.06	66
	1976	—	—	—	0.14	0.14	—	1.31	—	1.31	—	0.14	1.45	NA	NA
	1977	—	—	—											

Annex II *(continued)*

Country or area	Year	Production: Solid fuels	Production: Liquid fuels	Production: Natural gas	Production: Hydro and nuclear electricity	Production: Total commercial energy	Trade: Total exports	Trade: Total imports	Consumption: Solid fuels	Consumption: Liquid fuels	Consumption: Natural gas	Consumption: Hydro and nuclear electricity	Consumption: Total commercial energy	Fuelwood consumed	Fuelwood as percentage of total commercial energy
Thailand	1972	0.11	0.01	—	0.21	0.34	—	9.84	0.13	9.83	—	0.23	10.18	3.76	37
	1973	0.12	0.01	—	0.23	0.36	—	11.13	0.14	11.10	—	0.25	11.49	3.79	33
	1974	0.16	0.01	—	0.30	0.47	—	10.75	0.19	10.71	—	0.32	11.22	3.87	34
	1975	0.15	0.01	—	0.42	0.58	—	11.31	0.18	11.27	—	0.44	11.89	3.95	33
	1976	0.22	0.01	—	0.45	0.68	—	12.54	0.26	12.49	—	0.47	13.22	NA	NA
	1977	0.19	0.01	—	NA	NA									
Tonga	1972	—	—	—	—	—	—	0.02	—	0.02	—	—	0.02	—	—
	1973	—	—	—	—	—	—	0.02	—	0.02	—	—	0.02	—	—
	1974	—	—	—	—	—	—	0.02	—	0.02	—	—	0.02	—	—
	1975	—	—	—	—	—	—	0.02	—	0.02	—	—	0.02	—	—
	1976	—	—	—	—	—	—	0.02	—	0.02	—	—	0.02	—	—
	1977	—	—	—	—	—									
Trust Territory of the Pacific Islands	1972	—	—	—	—	—	—	0.08	—	0.08	—	—	0.08	—	—
	1973	—	—	—	—	—	—	0.08	—	0.08	—	—	0.08	—	—
	1974	—	—	—	—	—	—	0.09	—	0.09	—	—	0.09	—	—
	1975	—	—	—	—	—	—	0.09	—	0.09	—	—	0.09	—	—
	1976	—	—	—	—	—	—	0.09	—	0.09	—	—	0.09	—	—
	1977	—	—	—	—	—									
Viet Nam	1972	2.00	—	—	0.05	2.05	—	8.77	1.92	8.85	—	0.05	10.82	4.08	38
	1973	2.99	—	—	0.05	3.04	—	8.47	2.77	8.69	—	0.05	11.51	4.08	35
	1974	4.00	—	—	0.05	4.05	—	4.26	3.31	4.95	—	0.05	8.31	4.08	49
	1975	4.25	—	—	0.05	4.30	—	4.10	3.71	4.64	—	0.05	8.40	4.08	49
	1976	5.40	—	—	0.07	5.47	—	0.31	4.80	0.91	—	0.07	5.78	NA	NA
	1977	6.00	—	—	NA	NA									
Regional totals	1972	586.49	573.77	48.01	25.21	1,233.48	59.46	—	606.69	508.44	34.82	25.46	1,175.41	121.16	10.3
	1973	616.79	673.32	55.86	23.98	1,369.95	80.17	—	648.48	574.75	42.34	24.22	1,289.79	123.50	9.6
	1974	647.21	703.24	63.98	27.39	1,441.83	105.79	—	682.00	576.57	49.80	27.64	1,336.01	125.69	9.4
	1975	683.20	667.73	68.49	29.83	1,449.25	79.46	—	708.62	577.28	53.79	30.08	1,369.78	128.52	9.4
	1976	706.15	745.43	75.74	31.57	1,558.89	124.62	—	725.79	614.88	61.80	31.81	1,434.27	NA	NA
	1977	729.01	756.06	80.09	NA	NA									

Source: Final draft of *World Energy Supplies, 1972–1976*, United Nations Statistical Papers, series J, No. 21.

Notes: NA not available; — zero or less than 10,000 tons; figures not available for Bhutan, Maldives and Tuvalu; Okinawa included in Japan.

ASPECTS OF DEMAND AND SUPPLY IN THE REGION

(NR/WGMEPP/2)

HISTORICAL DEVELOPMENT OF ENERGY CONSUMPTION

A. COMMERCIAL ENERGY CONSUMPTION AND ECONOMIC GROWTH

In 1976, energy consumption in the ESCAP region (see table 1) was 1,434 million tons of coal equivalent (tce). Developed countries' energy consumption was 517 million tce. Developing countries consumed 917 million tce of energy, of which 91 million tce in the energy exporting countries, 590 million tce in China, and 236 million tce in energy importing developing countries.[1]

Per capita consumption was 651 kilograms of coal equivalent (kgce) in the ESCAP region as a whole while the developed countries' average was 3,991 kgce. The developing countries average was 442 kgce, while the energy importing developing countries' *per capita* energy consumption was 232 kgce. These figures of *per capita* energy consumption are far below the world averages in the respective categories.

During the period 1960-1976, the total energy consumption of the ESCAP region increased at an average rate of 4.62 per cent per annum. Average annual growth rates during the period on the basis of the above-mentioned subregions were 7.83 per cent in the developed countries and 3.33 per cent in the developing countries, among which 6.36 per cent occurred in the energy importing countries, 9.84 per cent in the energy exporting countries and 1.93 per cent in China. Of individual countries, Afghanistan, Iran, Japan, Papua New Guines, the Republic of Korea, Singapore and Thailand recorded relatively high rates of growth and moderate or low rates were recorded in Burma, China, India and Sri Lanka.

When the period is divided into four parts, that is, 1960-1965, 1965-1970, 1970-1973 and 1973-1976, the following characteristics of the energy consumption growth pattern can be observed.

During 1960-1965, the ESCAP region as a whole recorded a very low rate of growth of energy consumption, averaging 0.38 per cent per annum. However, this low rate of growth was largely due to the decrease in China's energy consumption from 434 million tce in 1960 to 317 million tce in 1965. Energy exporting countries' energy consumption rose at a relatively moderate rate: 4.83 per cent. On the other hand, consumption in energy importing developing countries and developed countries increased by 8.08 per cent and 8.99 per cent respectively.

In the next five years, between 1965 and 1970, the energy consumption of the region as a whole increased by 8.11 per cent per annum. The high rate of growth was led by the developed countries, especially Japan whose annual compound growth rate was 14.2 per cent. Energy exporting countries also recorded a very high growth rate, 15.2 per cent, but for developing countries as a whole the rate was 5.84 per cent per annum.

During 1970-1973, the high growth of energy consumption continued at a slightly reduced level. Annual average growth rates were 7.12 per cent for the region as a whole, 6.79 per cent in developed countries and 7.35 per cent in developing countries.

The most recent period, 1973-1976, is the most interesting in considering the forecast of future demand trends in the region, because energy demand has been affected by the sharp rise in oil prices that occurred in 1973. Energy consumption in the region as a whole increased from 1,290 million tce in 1973 to 1,434 million tce in 1976 at an average annual growth rate of 3.60 per cent, which was about half the rate during the 1970-1973 period. Developed countries recorded minus growth in the 1973-1975 period, but growth continued in the developing countries, including the energy importing developing countries, being 5.73 per cent in developing countries as a whole and 4.19 per cent in energy importing developing countries. If India is excluded from the energy importing countries, the remainder recorded 2.28 per cent growth, substantially less than for the preceding period.

These energy demand changes can be explained in relation to the economic activities in the region, although the information and data are limited and unreliable. It is observed that there is a relatively close relationship between energy consumption and economic growth in the countries selected. For instance, the total gross domestic product (GDP) growth rate increased from 6.26 per cent per annum during 1960-1965 to 8.24 per cent per annum during 1965-1970, while the energy consumption growth rate rose from 8.32 per cent to 10.4 per cent respectively. This general observation is applicable to both developed countries and developing countries, with a few exceptions.

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[1] The definition of the country groupings is as follows:
- Developed: Australia, Japan, New Zealand
- Energy exporting developing: Afghanistan, Brunei, Indonesia, Iran, Malaysia
- China is treated as a special case, since it accounted for a large portion of energy consumption in the region
- Energy importing developing: All other developing countries

Unless otherwise indicated, data are taken from *World Energy Supplies*, United Nations Statistical papers, series J.

Table 1. Commercial energy consumption of countries in the ESCAP region

(in millions of tons of coal equivalent)

Year	Total	Developed countries[a]	Developing countries: Subtotal	Developing countries: Energy exporting[b] countries	Developing countries: China[c]	Developing countries: Energy importing[d] countries	Developing countries: Energy importing countries excluding India
1960	697	154	543	20	435	88	26
Annual growth rate (percentage)	0.38	8.99	−2.75	4.83	6.51	8.08	11.7
1965	710	238	472	25	317	130	46
Annual growth rate (percentage)	8.11	12.1	5.84	15.2	4.68	6.39	11.5
1970	1,049	422	627	52	398	177	79
Annual growth rate (percentage)	7.12	6.79	7.35	6.85	8.15	5.64	6.68
1973	1,290	514	776	63	504	209	96
Annual growth rate (percentage)	3.60	0.20	5.73	12.8	5.40	4.19	2.28
1976	1,434	517	917	91	590	236	103
Average annual growth rate 1960–1976 (percentage)	4.62	7.83	3.33	9.84	1.93	6.36	8.86
Per capita consumption 1976 (kg coal equivalent)	651	3,991	442	443	706	232	254

Sources: *World Energy Supplies,* United Nations statistical papers, series J, Nos. 19 and 21.

[a] Australia, Japan, New Zealand.

[b] Afghanistan, Brunei, Indonesia, Iran, Malaysia.

[c] China is treated separately, since it accounted for a large portion of energy consumption in the region.

[d] All other developing countries.

Change in energy consumption associated with a change in GDP is usually expressed as a ratio, an elasticity coefficient, and this is often used in forecasting energy requirements.[2] Table 2 shows the ratio or elasticity of energy consumption to GDP and the related economic indicators for selected countries. The elasticity ranges in general from 1 to 2. Most studies for developed economies show that the energy/GDP relation is fairly constant and that the elasticity appears to be lower for a higher level of development. Elasticity figures in table 2 for major groups show decreasing trends since 1960, but the values of elasticity for individual developing countries fluctuated considerably from time to time and it seems unlikely that there would be meaningful co-relations between elasticity and *per capita* GDP or *per capita* energy consumption.

One of the main reasons why energy/GDP elasticity is not a satisfactory tool with which to analyse energy trends of developing countries might be that those countries are in the process of evolution from agrarian to industrial production modes and their economic structures are changing rapidly. Also, energy consumption dealt with in the tables is limited to commercial energy. Non-commercial energy consumption, which is not included, is estimated to account for 50 per cent or more of total energy consumption in some developing countries. Consequently, in the countries where non-commercial energy growth is slower than commercial energy growth (in other words, where substitution of commercial energy for non-commercial energy is occurring) the value of apparent elasticity of energy consumption may become larger than the true value if non-commercial energy consumption is taken into account. On the other hand, non-commercial energy consumption may grow faster than that of commercial energy, and the apparent elasticity may be smaller than the true value. Therefore, in order to use energy/GDP elasticity analysis effectively as a tool for forecasting future energy demand for developing countries, there may be a need for accurate assessment of non-commercial energy consumption.

As for sector-by-sector energy consumption, statistical data for developing countries in the region are generally incomplete. However, an attempt may be made to analyse energy demand trends of individual developing countries in relation to the change of GDP composition by sectors and sectoral growth rates. For example, as table 2 illustrates, in countries such as Iran, the Republic of Korea, Singapore and Thailand, where the percentage share of industry in GDP is high and the industry sector grows quickly, the growth rate of energy consumption and the energy/GDP elasticity ratio are also high. On the other hand, countries which are less industralized have slow growth rates of energy consumption. From table 2 it may also be observed that energy input per United States dollar of GDP in such developing countries as India, Pakistan and the Republic of Korea, which have relatively large energy-intensive heavy industry, is higher than in the other developing countries or the developed countries.

[2] For instance, an elasticity of 1.5 for a stated period means that during that period the percentage change in energy consumption was 1.5 times the percentage change in GDP.

B. CHANGE IN COMPOSITION OF ENERGY CONSUMPTION BY ENERGY FORMS

As mentioned above, energy consumption has increased as economic activity has expanded. During the 1960s and early 1970s the composition of energy consumption by different energy forms also changed. As table 3 shows, in the past 16 years, or at least 13 years up to 1973, the percentage use of oil has been increasing. Of the incremental requirement of energy in the region from 1960 to 1973, oil supplies accounted for 79.3 per cent, for developed countries 87.8 per cent, and for energy importing countries (excluding India) 75.9 per cent. The 1960s were a period of abundant, cheap and stable oil supply, and convenience in transportation, storage and utilization of petroleum contributed towards making it a major source of energy consumption in the region.

Looking at secondary energy utilization, total electricity consumption in the region increased at the rate of 9.17 per cent per annum from 1960 to 1976, which exceeds the growth rate of total primary energy consumption. This indicates that for final energy consumption electricity has been preferred in many consumption areas to other energy forms. But this, in turn, resulted in increased dependency on oil in many countries, as major sources of electricity production shifted from a coal or hydro-power base to an oil base in the 1960s.

Table 4 indicates the historical variation of the ratios of energy imports and oil imports to total consumption for developed countries and energy importing developing countries. In 1973, the import oil dependency of energy importing developing countries, excluding India, was 68.1 per cent. For Hong Kong, the Philippines, Singapore, Sri Lanka and Thailand the percentages were extremely high (over 90 per cent). Such a highly oil-dependent energy consumption structure caused energy importing developing countries to be affected severely by the 1973-1974 oil crisis and subsequent developments. If the current status of the energy consumption structure continues, economies and societies in the region will be adversely affected by any chronic world-wide shortage of oil supply. In that sense, the countries in the region, both developing and developed, particularly energy-deficient developing countries, would be in an extremely vulnerable condition.

Table 2. Elasticity of energy demand to GDP in real terms for selected countries in the ECAFE region

Country or area	*Elasticity of energy consumption to GDP*					*Industry in GDP*		*Transportation in GDP*		*Per capita (1975)*		*Energy consumption/ GDP (kgce/$US)*
	1960 to 1965	*1965 to 1970*	*1970 to 1973*	*1973 to 1975*	*1960 to 1975*	*Percentage share to GDP in 1975*	*Growth rate 1960 to 1975*	*Percentage share to GDP in 1975*	*Growth rate 1960 to 1975*	*Energy consumption (kgce)*	*GDP ($US)*	
Developing												
Burma	0.04	2.43	2.51	0.24	0.41	11[a]	2.9[b]	4[a]	2.1[b]	46	96	0.479
Fiji	NA	1.21	0.13	3.93	0.77[c]	15[a]	4.4[c]	7[a]	13.4[c]	505	1,143	0.442
Hong Kong	0.82	1.44	0.42	1.90	1.04	30	NA	6	NA	1,065	1,684	0.632
India	1.77	0.62	3.41	NA	1.42[b]	16[a]	4.6[b]	4[a]	4.5[b]	199[a]	144[a]	1.382[a]
Indonesia	0.26	1.55	0.35	2.98	1.10	30(9)	6.6	4	5.5	184	216	0.852
Iran	1.52	2.13	0.61	0.40	1.23	47(11)	11.5	4	8.2	1,347	1,635	0.824
Malaysia	1.42	1.72	0.74	1.00	1.22	23(5)[d]	NA	5[d]	NA	552	780	0.708
Pakistan	1.49	1.13	0.03	4.83	1.21	17[a]	7.5[b]	7[a]	6.5[b]	188[a]	162[a]	1.160[a]
Philippines	2.25	1.44	1.08	0.46	1.46	21	6.5	2	5.5	308	368	0.837
Republic of Korea	2.17	1.29	0.80	0.71	1.24	30	17.9	6	16.2	998	551	1.811
Singapore	3.35	0.86	2.11	1.54	1.80	26	12.5	11	8.0	2,268	2,523	0.899
Sri Lanka	1.02	1.20	−0.43	−0.82	0.51	15	8.4	8	5.9	119	244	0.488
Thailand	2.54	1.40	2.44	0.34	1.78	20	11.7	6	6.7	284	342	0.830
Subtotal	1.66	1.30	1.12	1.13	1.34					273	252	1.083
Developed												
Australia	1.14	0.75	1.06	3.69	1.05	27(20)	NA	7	NA	6,249	6,319	0.916
Japan	1.02	1.20	0.81	−5.26	0.95	37(35)	NA	7	NA	3,619	4,437	0.816
New Zealand	NA	NA	1.69	NA	NA	NA	NA	NA	NA	3,273	4,337	0.755
Subtotal	1.19	1.25	0.84	−1.82	1.09					3,887	4,652	0.836
Regional total	1.33	1.26	0.91	0.55	1.16					676	743	0.910

Sources: *World Energy Supplies*, United Nations statistical papers, series J, Nos. 19 and 21; *Yearbook of National Accounts Statistics, 1976*; *Statistical Yearbook for Asia and the Pacific, 1970* and *1976*.

Notes: Figures in brackets represent share of manufacturing industry.

[a] 1974 figure.

[b] 1960–1974 figure.

[c] 1965–1974 figure.

[d] 1971 figure.

Table 3. Composition of energy consumption and its increments

(percentages)

Year	Aggregate	Solid fuels	Liquid fuels	Natural gas	Primary electricity	Year	Aggregate	Solid fuels	Liquid fuels	Natural gas	Primary electricity
Total for region						*Developed countries*					
1960 . . .	100	82.2	15.0	1.1	1.7	1960 . . .	100	58.8	35.0	0.7	5.5
1965 . . .	100	67.6	28.3	1.8	2.3	1965 . . .	100	41.1	53.2	1.1	4.6
1970 . . .	100	54.6	40.3	3.0	2.1	1970 . . .	100	29.4	65.8	1.7	3.1
1973 . . .	100	50.3	44.6	3.3	1.8	1973 . . .	100	22.9	72.0	2.5	2.6
1976 . . .	100	50.6	42.9	4.3	2.2	1976 . . .	100	23.7	68.2	4.4	3.7
Increments						Increments					
1960–1973 .	100	12.7	79.3	5.9	2.1	1960–1973 .	100	7.5	87.7	3.3	1.4
1973–1976 .	100	53.5	27.8	13.5	5.2	1973–1976 .	100	154.8	—536.2	307.1	174.3
Energy exporting developing countries						*Energy importing developing countries*					
1960 . . .	100	5.0	70.7	23.6	0.7	1960 . . .	100	70.3	27.2	1.0	1.5
1965 . . .	100	2.9	72.5	23.8	0.8	1965 . . .	100	64.3	31.7	2.0	2.0
1970 . . .	100	1.7	64.5	32.7	1.1	1970 . . .	100	50.0	44.6	2.7	2.7
1973 . . .	100	2.2	68.3	28.3	1.2	1973 . . .	100	47.9	45.8	3.6	2.7
1976 . . .	100	1.5	70.3	27.2	1.0	1976 . . .	100	52.1	41.2	3.7	3.0
Increments						Increments					
1960–1973 .	100	0.8	67.2	30.6	1.4	1960–1973 .	100	31.6	59.3	5.6	3.5
1973–1976 .	100	—0.1	74.7	24.8	0.6	1973–1976 .	100	83.8	6.3	4.6	5.3
China						*Energy importing developing countries excluding India*					
1960 . . .	100	96.6	2.9	0.2	0.3	1960 . . .	100	40.1	55.2	3.3	1.4
1965 . . .	100	94.0	4.6	0.4	1.0	1965 . . .	100	34.9	58.3	5.1	1.7
1970 . . .	100	90.2	8.4	0.5	0.9	1970 . . .	100	21.4	71.8	5.2	1.6
1973 . . .	100	85.2	13.1	0.8	0.9	1973 . . .	100	20.9	70.2	7.1	1.8
1976 . . .	100	81.2	17.1	0.9	0.8	1976 . . .	100	24.2	66.4	7.1	2.3
Increments						Increments					
1960–1973 .	100	14.1	77.1	4.4	4.4	1960–1973 .	100	13.6	75.9	8.5	2.0
1973–1976 .	100	57.4	40.5	1.7	0.4	1973–1976 .	100	70.7	11.9	8.2	9.2

Source: World Energy Supplies, United Nations statistical papers, series J.

C. ENERGY DEMAND CHANGE IN THE POST-OIL-CRISIS PERIOD

The oil crisis and subsequent sharp rises in oil prices in 1973-1974 had serious impacts on the world economy as well as on the energy demand-supply situation. The ESCAP region was not excepted, and the growth in energy demand in the region as a whole, which was 4.85 per cent per annum during 1960-1973, declined to a rate of 3.60 per cent per annum. Energy consumption in the energy importing developing countries, excluding India, declined to 2.28 per cent per annum between 1973 and 1976 against the 1960-1973 growth rate of 10.4 per cent (see table 1).

Similarly, the composition of energy consumption by type was also greatly affected by the new energy situation. In particular, the percentage share of oil consumption to total energy consumption in the region was changed from 44.6 per cent in 1973 to 42.9 per cent in 1976 (see table 3). In the energy importing developing countries, oil's share to aggregate energy consumption decreased from 45.8 per cent in 1973 to 41.2 per cent in 1976, but, for this group excluding India, it decreased from 70.2 per cent in 1973 to 66.4 per cent in 1976.

More clearly, ratios of incremental oil consumption to incremental aggregate consumption declined drastically. For the ESCAP region, oil covered only 27.8 per cent of incremental energy requirements during the 1973-1976 period, while its coverage was 79.3 per cent between 1960 and 1973. For energy importing developing countries, similar changes occurred, but if India is excluded, the extent of change was not as great. This might create problems in substitution for oil by other forms of energy in developing countries with small energy resources.

Table 4. Dependency on imported energy and imported oil in energy importing countries
(percentage share of imported energy to total consumption)

Year	Energy importing developing countries		Energy importing developing countries excluding India		Developed countries		ESCAP total
	Net energy imports/total consumption	Oil imports/ total consumption	Net energy imports/total consumption	Oil imports/ total consumption	Net energy imports/total consumption	Oil imports/ total consumption	Net energy imports or exports/total consumption
1960	26.5	24.9	56.9	50.0	41.0	34.4	0.7 export
1965	28.1	27.1	55.5	54.8	60.5	52.6	3.4 import
1970	42.5	37.9	73.6	69.3	76.9	62.5	7.5 import
1973	44.9	39.7	73.0	68.1	84.2	65.9	0.2 import
1976	43.0	34.9	76.7	64.3	74.4	61.6	3.7 export

Source: Same as table 3.

Note: Net energy imports and oil imports are calculated by the formula
net energy imports = imports — exports — bunkers
oil imports = liquid energy consumption — oil production

These changes in energy consumption trends within the ESCAP region, namely, slow-down in growth and shift from oil to other energy forms, stem from the compounded effects of emergency policy measures with due regard to the oil crisis, the world-wide economic recession following that crisis, price and non-price conservation of energy in each country, and so on. It is almost impossible to set the new trend of energy demand for future medium and long terms on the basis of the trend of energy demand in the region during the period 1974-1976, because the period is too short and data available for future estimates are too scarce. For example, the relation between GDP and energy demand for individual countries has changed from historical relations.

Energy consumption data for 1974-1976 alone are not sufficient to define the quantitative effects caused by the energy crisis and the new energy situation. More detailed analysis with additional data for years 1977 and 1978 should help to indicate the medium- and long-term trends for future energy demand in the region.

ENERGY DEMAND FORECASTING IN THE NEW ENERGY SITUATION

A. NEW TASKS FOR ENERGY DEMAND FORECASTING IN THE NEW ENERGY SITUATION

The oil crisis in 1973-1974 was the dividing line between old and new energy periods. The situation has been drastically changed from a cheap, abundant and stable energy supply era to an expensive and uncertain energy supply era. Because of this change of circumstances, development and adoption of new and innovative methods are needed in forecasting future energy demand for the region as well as for individual countries. The energy demand forecast is the starting point for designing and implementing energy plans and programmes, and it must be geared to the new energy situation. It is, therefore, essential to establish an appropriate energy demand forecasting system that provides accurate and timely information, and may be used for energy policy-making, to provide alternative *scenarios* with different policy options. It is to be hoped that it could be extended to a more sophisticated energy-modelling system, integrating energy demand and supply projections.

B. METHODOLOGY OF ENERGY DEMAND FORECASTING

Most of the developing countries are currently using relatively simple methods for energy demand forecasting. One of these is a simple regression of energy consumption in relation to GDP, based on past data. This macro approach is applicable only if the forecast GDP growth rate for the future period is readily available. In some cases in the past, this has been useful, particularly in short-term forecasting, but, considering the recent evolution in the energy situation and the changing nature of a developing economy's structure, forecasts by extrapolation of historical trends may be inappropriate, as recent experience in several countries has shown. However, if after the transition period a fairly constant trend again appears, this forecast method will again be useful. Already, in some countries, the new (lower) trend has started to appear from 1974.

A second method of forecasting, which some developing countries are using, is the sectoral modelling approach, a micro analysis. Usually, in a sectoral approach primary energy usage is divided into five sectors: residential, agriculture, industry, transportation and commercial. Sometimes, electricity production is treated separately, and in this case, electricity consumption in other sectors normally needs to be clarified. Each sector may sometimes be subdivided further, for instance, industry may be subdivided into steel, chemical, machinery, textiles, etc. For energy-intensive subsectors, separate treatment is considered important. In most cases of this approach, basic units, namely, energy input per production unit (for example, 1 ton of steel production) or energy input per standard household, etc., are useful for the analysis of past performance and for forecasting future demand in each sector. The advantage of this method over the first method is that it is easier to determine the relation between cause and result in the analysis of past performance. However, as forecasts by this method involve a lot of assumptions, either on the economic framework including sector by sector features or on various basic unit values, there may be risks of incorrect subjective judgement by forecasters. This method, which seems to be more precise and accurate than the first, is still not fully reliable.

A third method is input-output modelling or the construction of a micro-economic model of the entire economy. This type of forecasting method attempts to describe the effects of changes in the energy sector on the total economy and the effect of changes in the total economy on the energy sector. For this reason, this method is a useful, effective way of planning energy policy and programmes in relation to national over-all economic planning. Its weakness is that it is extremely data-intensive and requires the estimation of a large number of parameters and technical coefficients. In most cases in developing countries, the input-output table becomes outdated within five years. Therefore, in using such a table, a forecast result may also be outdated without any assumption that inter-sector relationships remained fixed during the forecasting period. Even if an updated table is available, this method tends to be historical rather than predictive. However, with judicious use of parametric adjustments, it can be made sensitive to realistic demand forecasting and to the need for an energy policy-making tool.

The above three methods are now being used in some developing countries in the region. Some other methods, which could be called integrated energy demand-supply modelling rather than energy demand forecasting, are being used in the developed countries, and others are just being proposed in academic society. One of these is the optimization model. The traditional form of this model is a linear programming model with an objective function of minimizing the costs of meeting established demands for energy from known supplies. It is most useful for determining alternative outcomes for changes in supply-demand assumptions. It presents, in short, comparative statistical "snapshots" of alternative situations. A weakness is that the outcome of the models could be dominated by a major assumption in the model structure. Policy-makers also tend to distrust the answers obtained by these models, partly because the models are too large, cumbersome and complex. Another weakness of this method is that it cannot trace the path of the trend between current levels and projected levels.

The econometric simulation model, unlike the optimization model, can show the time-path of development of *scenarios* of policy changes in the energy fields. It attempts to depict the dynamic structure and movement of energy demands. Such models are highly useful for policy analysis, since a new policy can enter into the model as a constraint or parameter, and the effect of the policy can be simulated against the base case. A weakness of this method stems from its historical nature. Because the econometrically fitted parameters used in the model are derived from the observed historical data, economically fitted functions will not represent the future. So, if the situation and circumstances are changed drastically, simulations based upon the model could be misleading. Another weakness is that construction is time-consuming and data-intensive.

A further method uses parametric simulation models. The assumption underlying these models is that, although satisfactory econometrically determined parameters cannot be derived, simulation of the energy demands under assumed parametric values will provide the decision-maker with useful information for bracketing the probable outcomes of policy changes. This type of model has, of course, a major fault in that it is not based upon firm information. But it has many advantages to policy-makers in that it is quick and simple to run, can test many alternative policies, and the boundaries of the decision impacts can be readily determined.

There are thus many methods for forecasting energy demands, from simple regression to fairly complicated energy modelling. Which method the developing countries should adopt is a matter of choice for the decision-makers but may depend upon the current conditions and historical backgrounds of each country. For instance, the degree of development and arrangement of statistical data collection varies from country to country, and in many developing countries in the region can hardly be regarded as satisfactory. Well trained technical experts to develop and establish a complicated energy modelling system are also in very short supply. There is an urgent need for the developing countries to establish advanced systems of statistics and information collection; this will take a long time and considerable effort, including prerequisite training of personnel and, possibly, rearrangement of administrative and institutional systems.

Generally speaking, the choice of forecasting system should be considered with due regard to the limitation of availability of reliable data and information and the availability of well-trained personnel. Needs for energy demand forecasting, from the point of view of the policy-maker, are different among the countries, and the forecast itself may have a different meaning to market economy countries than to centrally planned economy countries.

C. FACTORS AFFECTING ENERGY DEMAND IN THE NEW ENERGY SITUATION

In the new energy situation following the oil crisis and subsequent sharp rises in oil price, energy demand trends are changing, but demand structure itself cannot change completely or drastically in the short term. Rather, it may be appropriate to understand that with residual reflection still coming from historical trends, the adjustment of energy demand to the new situation will gradually become clear as time goes on, and four or five years may be required as a transition period. Therefore, to determine new energy demand trends, with reference to conventional forecasting methods, energy policy planners need to consider factors currently affecting energy demand that were ignored in energy forecasting in the past.

The first important factor is that government policy control, direct or indirect, on energy demands is and/or will be strengthened. In the past, as energy was cheap and readily available, energy demand was generally determined on the basis of economic development plans and/or consumers' free choice in the market place, and supplies simply followed demand. But in the new energy era, that becomes impossible because a major source of energy supplies, oil, has become expensive and scarce. Market forces are not strong enough to meet the new energy situation, which has changed drastically and quickly; and policy planners in most countries are paying attention to energy demand management policies. There is thus a tendency towards strengthening policy control on energy demand, including the selection of specific conservation policy mixes.

The second factor is the price effect on energy demand. One of the most dominant features of the new energy situation is the high price level and increasing cost of production. How the energy demand will respond to a big change in cost is a very important factor in forecasting long-term future demands. Some studies on the price elasticity of energy demands relate to specific fuels or uses (e.g. natural gas, gasoline, fuel oil, residential electricity), but most of them are conducted in the United States and Europe. Almost all of them are based on historical experience and data during earlier periods when energy prices were relatively stable and adjusted downward.

Some results of studies of estimated long-term price elasticity of demand for energy by sector up to 1985 are given below:

Sector	*United States*	*Western Europe*	*Japan*
Residential/commercial .	−0.2 to −0.3	−0.4	−0.3
Industrial	−0.4	−0.3	−0.2 to −0.3
Transportation (gasoline) .	−0.3 to −0.5	−0.3 to −0.4	−0.4
Transportation (other fuels)	−0.2 to −0.4	−0.2 to −0.3	−0.4

Source: Organisation for Economic Co-operation and Development, *Energy Prospects to 1985.*

It may be inappropriate to apply results from those studies to the developing countries, and specific results of price elasticity studies on the basis of the recent development of energy demand in developing countries are required. This kind of analysis is very important for policy-making on energy taxation and energy price regulation. There are many difficulties in studying the price elasticity of developing countries' energy demands, because actual demands in developing countries have often been influenced by various supply constraints and by the direct consumption control caused by short-term measures, for example, import bans on specific equipment, or petroleum rationing. Nevertheless, such studies are urgently needed for long-term energy demand forecasting and policy-making.

The third factor is interchangeability among different energy forms. This is especially important for the forecast of demand for individual energy forms. Since diversification of energy sources became a high priority policy target in almost all energy importing countries, and since oil lost the price advantage it had over other energy forms, shifts from oil to other energy sources have been occurring in the developing countries in the region. Questions for an energy demand forecaster are how much, how far and where those shifts will occur in the future. Like energy-saving effects, substitution effects differ substantially between the short and long term. The short-term effect is mainly based upon the use of existing equipment and appliances with minor modifications. Long-term effects stem from plant replacements and additions, which are on a larger scale and require capital investments. In order to make an accurate and reasonable forecast for future energy balances, it is essential to estimate substitution effects among different energy forms in various sectors.

Some other factors affecting future energy demands are industrial structure changes, supply constraints for economic reasons (e.g. balance of payments problems) or for technical or physical reasons (e.g. troubles in transportation and distribution systems), changes in production mode and/or people's way of life, and even war.

HISTORICAL REVIEW OF ENERGY SUPPLIES

A. CONVENTIONAL ENERGY PRODUCTION

Energy production in the ESCAP region decreased slightly from 713.6 million tce in 1960 to 702.6 million tce in 1965, presumably owing to a reduction in coal production in China. After 1965, the production of conventional energy increased at average annual growth rates of 7.8 per cent, 10.4 per cent and 4.4 per cent during the periods 1965-1970, 1970-1973 and 1973-1976 respectively, bringing the total production to 1,558.9 million tce in 1976 (table 5).

From the details given in table 6, developed countries produced 164.1 million tce or 10.5 per cent of that amount, developing countries, excluding China, 780.0 million tce or 50.0 per cent, and China 614.8 million tce or 39.5 per cent. Of the developing countries, energy exporting developing countries accounted for 76.9 per cent with 622.8 million tce, and energy importing countries for 23.1 per cent with 157.2 million tce. During the period 1965-1970, the production of conventional energy in developing countries of the region, excluding China, increased at an average annual growth rate of 11.9 per cent, which may be split into energy exporting countries at 15.3 per cent and energy importing countries at 3.8 per cent. During the period 1970-1973, energy importing developing countries increased their production at an average annual growth rate of 2.8 per cent, significantly below the annual increase of production in energy exporting developing countries of 15.9 per cent and in the region as a whole of 10.4 per cent. During the period 1973-1976, production of conventional energy in the region increased at an average annual growth rate of 4.4 per cent, in developed countries 4.9 per cent, and in developing countries 3.0 per cent, of which production in energy exporting countries increased at 1.8 per cent, and in energy importing countries at 8.5 per cent, and in China at 6.2 per cent.

Table 5. Production of commercial energy in the ESCAP region

(in millions of tons of coal equivalent)

Years	Total	Developed countries	Developing countries: Subtotal	Developing countries: Energy exporting countries	Developing countries: China	Developing countries: Energy importing countries
1960	713.6	91.1	622.6	121.2	430.2	71.1
Annual growth rate (percentage)	—0.3	2.6	—0.7	9.0	9.2	6.5
1965	702.6	103.7	598.8	186.5	317.9	94.4
Annual growth rate (percentage)	7.8	4.2	8.3	15.3	4.8	3.8
1970	1,020.8	127.4	893.4	379.2	400.7	113.5
Annual growth rate (percentage)	10.4	3.8	11.2	15.9	8.6	2.8
1973	1,369.9	142.2	1,227.7	591.2	513.4	123.1
Annual growth rate (percentage)	4.4	4.9	4.3	1.8	6.2	8.5
1976	1,558.9	164.1	1,394.8	622.8	614.8	157.2
Average annual growth rate 1960–1976 (percentage)	5.1	4.0	5.2	10.8	2.3	5.3

Sources: Same as table 1.

1. Solid fuels

Solid fuels are a basic source of conventional energy in the ESCAP region. They are produced in 15 countries of the region and their total production reached 706.2 million tce in 1976, which accounted for 44.4 per cent of the total regional production of conventional energy (table 6). In 1960, production of solid fuels totalled about 568 million tce, but declined to 471 million tce in 1965 owing to a reduction in solid fuel production in China. After 1965, it increased at average annual rates of 3.0, 4.0 and 4.6 per cent for the periods 1965-1970, 1970-1973 and 1973-1976 respectively.

In 1976, developed countries produced 98.5 million tce of solid fuels while developing countries, excluding China, produced 127.9 million tce (energy importing countries 126.4 million tce and energy exporting countries 1.3 million tce). China is the main producer of solid fuels in the region, and in 1976 produced 480.0 million tce, or 68.0 per cent of the total production

Table 6. Production of energy in the ESCAP region by sources

(millions of tons of coal equivalent)

Year	Total	Solid fuels	Liquid fuels	Natural gas	Hydro and nuclear electricity	Year	Total	Solid fuels	Liquid fuels	Natural gas	Hydro and nuclear electricity
Total for region						*Developed countries*					
1960 . .	713.6	568.4	126.2	7.5	11.4	1960 . .	91.1	80.6	0.8	1.1	8.5
1965 . .	702.6	471.8	201.7	12.4	16.8	1965 . .	103.7	88.7	1.5	2.6	10.9
1970 . .	1,020.8	547.8	416.9	34.4	21.7	1970 . .	127.4	94.9	13.8	5.6	13.1
1973 . .	1,369.9	616.8	673.3	56.0	24.0	1973 . .	142.2	88.1	31.1	9.5	13.4
1976 . .	1,558.9	706.2	745.4	75.7	31.6	1976 . .	164.1	98.5	34.0	12.6	19.0
Developing countries						*Energy exporting developing countries*					
1960 . .	622.6	487.8	125.4	6.4	3.0	1960 . .	121.2	0.9	115.3	4.8	0.1
1965 . .	598.8	382.8	200.2	9.8	6.0	1965 . .	186.5	0.7	179.5	6.1	0.1
1970 . .	893.5	452.9	403.1	28.8	8.6	1970 . .	379.2	0.9	356.0	21.8	0.6
1973 . .	1,227.8	528.7	642.2	46.3	10.6	1973 . .	591.2	1.3	554.2	35.0	0.7
1976 . .	1,394.8	607.7	711.4	63.1	12.6	1976 . .	622.8	1.3	571.6	49.1	0.9
Energy importing developing countries						*China*					
1960 . .	71.1	66.8	2.0	0.9	1.4	1960 . .	430.2	420.0	8.1	0.7	1.5
1965 . .	94.4	83.1	6.0	2.6	2.8	1965 . .	317.9	299.0	14.7	1.1	3.1
1970 . .	113.5	92.1	11.9	4.8	4.7	1970 . .	400.8	360.0	35.2	2.3	3.3
1973 . .	123.1	97.4	12.7	7.6	5.6	1973 . .	513.4	430.0	75.3	3.8	4.2
1976 . .	157.2	126.4	14.9	8.8	7.0	1976 . .	614.8	480.0	125.0	5.2	4.6

Source: *World Energy Supplies*, United Nations Statistical Papers, series J.

of solid fuels in the region. During the period 1973-1976, production of solid fuels increased at average annual rates of 3.8 per cent in developed countries, 10.9 per cent in developing energy exporting countries, 8.8 per cent in energy importing countries and 3.7 per cent in China. The annual average rates of growth in energy importing developing countries are lower than in energy exporting developing countries, even though such energy importing countries as Bangladesh, Pakistan and the Republic of Korea are well endowed with this energy resource. It may be noted that generally solid fuels were produced not only for local use; some countries, such as Australia, China and India, exported a part of their production.

2. Liquid fuels

Liquid fuels are another important source of conventional energy in the ESCAP region. Production was 745.4 million tce in 1976, or 46.9 per cent of the total production of conventional energy in the region (table 6). During the period under review, production of liquid fuels was characterized by high average annual growth rates. The total production of liquid fuels in the region increased at average annual growth rates of 9.8, 15.2, 17.3 and 3.5 per cent during the periods 1960-1965, 1965-1970, 1970-1973 and 1973-1976 respectively. Developed countries achieved very high average annual growth rates of 57 per cent during 1965-1970 followed by 3.0 per cent during 1970-1973, and 3.0 per cent during 1973-1976. During the same periods, developing countries, excluding China, increased their production at average annual growth rates of 14.7 per cent, 15.5 per cent and 1.0 per cent respectively, including energy exporting countries at 14.7 per cent, 15.9 per cent and 1.0 per cent, and energy importing countries at 14.7 per cent, 2.2 per cent and 5.2 per cent. China increased production of liquid fuels at average annual growth rates of 15.2, 17.8 and 21 per cent. However, it may be noted that a significant part of the total production of liquid fuels was exported to countries outside the region.

3. Natural gas

In 1976, natural gas was being produced in 12 countries of the region. The production of natural gas of the region as a whole was only 7.5 million tce in 1960 and increased to 12.4, 34.4, 56.0 and 75.7 million tce in 1965, 1970, 1973 and 1976 respectively (table 6). During the periods 1960-1965, 1965-1970, 1970-1973 and 1973-1976, production of natural gas increased at average annual growth rates of 10.6, 22.0, 17.6 and 10.6 per cent respectively. In 1976, developed countries produced 12.6 million tce or 16.6 per cent of the total natural gas production in the region, developing energy exporting countries 49.1 million tce, energy importing countries 8.8 million tce and China 5.2 million tce or 6.8 per cent.

Especially high average annual growth rates of 29 per cent were recorded in production of natural gas in energy exporting countries during the period 1965-1970. In energy importing countries the rates were moderate at 12.5 per cent annually for the same period.

In 1976, natural gas production accounted for 4.8 per cent of the total production of conventional energy of the region, and it may be noted that part of it was exported outside of the region.

4. Hydro and nuclear electricity

Hydro and nuclear electricity production in the region reached 31.6 million tce in 1976. The production level increased steadily from 11.4 million tce in 1960 to 16.8 million tce in 1965 and 24.0 million tce in 1973 (table 6). In 1976 the production of hydro and nuclear electricity amounted to only 2.0 per cent of the total production of conventional energy in the region.

In the region as a whole, the production of hydro and nuclear electricity has developed at average annual growth rates of 8.0, 5.2, 3.4 and 9.6 per cent during the periods 1960-1965, 1965-1970, 1970-1973 and 1973-1976 respectively. During the same periods, production of hydro and nuclear electricity increased at average annual growth rates of 5.1, 3.9, 0.8 and 12.3 per cent in developed countries, at 14.1, 12.3, 6.5 and 7.7 per cent in developing countries, excluding China, and at 8.0, 5.2, 3.4 and 9.6 per cent in China. An especially high average growth rate of 43 per cent was achieved in energy exporting developing countries during the period 1965-1970, while the share of energy importing countries in total regional hydro and nuclear electricity production increased from 12.2 per cent in 1960 to 23.4 per cent in 1973 and to 22.5 per cent in 1976. Hydroelectricity production is very important for energy importing developing countries and in such countries as the Lao People's Democratic Republic, Nepal, Samoa and Sri Lanka it is effectively the only indigenous conventional energy produced.

B. EXPORTS OF CONVENTIONAL ENERGY

Figures quoted in this section are for recorded exports, and do not include amounts for bunkers, which are actual additional exports, or increases in stockpiles, which are theoretical future exports, as some of the figures for these items are not available.

Exports of conventional energy from the region totaled 603.1 million tce in 1976. Exports increased from 116.4 million tce in 1960 to 183 million tce in 1965, to 374.3 million tce in 1970 and to 586.5 million tce in 1973. Exports increased at average annual growth rates of 9.5, 15.4, 16.2 and 0.9 per cent during the periods 1960-1965, 1965-1970, 1970-1973 and 1973-1976 respectively.

Exports from developed countries increased from 4.9 million tce in 1960 to 36.7 million tce in 1976. Average annual growth rates were 15.1, 17.1, 17.3 and 1.4 per cent during the periods under review. The main conventional energy exporting developed country was Australia, whose exports increased from 4.1 million tce in 1965 to 33.4 million tce in 1973 and 36.1 million tce in 1976.

Energy exporting developing countries increased their exports from 104.1 million tce in 1960 to 532.4 million tce in 1976, at average annual growth rates of 9.1, 15.4, 16.5 and 0.8 per cent during the periods 1960-1965, 1965-1970, 1970-1973 and 1973-1976 respectively.

Exports of conventional energy from energy importing developing countries reached 28.3 million tce in 1973 and 21.2 million tce in 1976. The main conventional energy exporting country was Singapore, with exports of 24.2 million tce in 1973 and 17.3 million tce in 1976. These figures accounted for 88.6 per cent and 81.6 per cent of the total exports from energy importing countries, and were essentially re-exports after processing.

Exports of conventional energy from China decreased from 1.1 million tce in 1965 to 0.8 million tce in 1970. After 1970, China increased exports significantly to 2.7 million tce in 1973 and 12.8 million tce in 1976. Exports increased at average annual growth rates of 50 per cent during the period 1970-1973 and 4.7 times during the period 1973-1976.

C. IMPORTS AND COSTS

In terms of the region as a whole, the dependency on imports of conventional energy is very significant and increased until 1973. The volume of imports rose from 127.0 million tce in 1960 to 631.9 million tce in 1973, then declined to 606.1 million tce in 1976. Imports increased at average annual growth rates of 12.9, 16.2 and 7.6 per cent during the periods 1960-1965, 1965-1970 and 1970-1973 respectively, and decreased by 1.5 per cent during the period 1973-1976.

Developed countries of the region imported 376.9 million tce in 1970, 478.1 million tce in 1973 and 448.7 million tce in 1976. During the period 1965-1970, imports increased by 16.8 per cent annually, while during the period 1970-1973, the annual increase was 6.1 per cent, followed by a decrease during the period 1973-1976 of 2.5 per cent per annum. Japan, the main importing developed country, imported 454.2 million tce in 1973, or 71.8 per cent of the total amount of conventional energy imported by the regional countries.

Energy exporting developing countries reduced their imports of conventional energy from 17.0 million tce in 1970 to 10.4 million tce in 1973, and increased them to 14.4 million tce in 1976.

Energy importing developing countries imported 112.5 million tce in 1970, 143.2 million tce in 1973 and 142.8 million tce in 1976. During the period 1973-1976, the average annual growth rate declined to –0.5 per cent in comparison with an 8.5 per cent increase during the period 1970-1973. China ceased importing conventional energy in 1973.

The energy crisis has seriously affected the balances of payments of energy importing countries of the region. As a result of rising import prices of crude petroleum and petroleum products, the share of crude petroleum imports in the total import bill increased significantly. For countries for which statistical data are available (table 7), the share of petroleum imports to total imports ranged from a minimum of 4.9 per cent to a maximum of 30.5 per cent in 1974, but in the following year the corresponding percentages were 6.5 and 34.0 respectively. The most seriously affected countries of the region were Fiji, Japan, the Philippines, the Republic of Korea, Singapore and Thailand.

D. COMPOSITION OF ENERGY SUPPLIES BY ENERGY FORM

The initial reaction of countries to the oil crisis was to eliminate or reduce consumption of petroleum products wherever it was feasible technically, or to take medium-term measures to ensure a stable supply of crude petroleum and petroleum products, preferably at concessional rates. But modernization of agriculture and industry, as well as development of infrastructure and transport on a new technological level, have called for increasing expenditure of energy. Furthermore, an increase in the gross national product (GNP) of a country seemed to be impossible without more energy supplies, in view of the fact that total energy consumption was closely related to the over-all growth of the economy, since energy was consumed in the process of production of goods and services.

One of the ways of solving the problem was to increase indigenous energy production. For example, some countries of the region have significant resources of solid fuels, liquid fuels, natural gas, and substantional hydroelectric potential.

During the period 1973-1976, Afghanistan increased production of solid fuels at an average annual growth rate of 10.8 per cent, Australia at 8.0 per cent, China at 3.7 per cent, India at 9.0 per cent, Mongolia at 9.3 per cent, the Philippines at 57.0 per cent, the Republic of Korea at 6.6 per cent and Thailand at 23.0 per cent.

During the same period, production of natural gas increased at an annual growth rate of 13.1 per cent in Australia, 49.0 per cent in Brunei, 11.0 per cent in China, 23.0 per cent in India, 60.0 per cent in Indonesia and 3.9 per cent in Iran.

Production of hydro and nuclear electricity increased at an annual growth rate of 13.1 per cent in Australia, 49 per cent in Brunei, 3.1 per cent in China, 23.0 per cent in India, 60.0 per cent in Indonesia and 4.0 per cent in Iran.

The production of liquid fuels increased in Australia, China and India during the period 1973-1976. All oil-exporting countries, excluding Indonesia, decreased their production of liquid fuels.

The above figures show the heavy emphasis being placed on the development of sectors producing indigenous conventional energy so as to make it possible to reduce imports of energy resources.

For many non-petroleum producing countries, a policy of substituting imports of petroleum by indigenous energy and its derivatives, such as coal, natural gas, etc., seems to be possible. Besides serving as a fuel for power generation and industrial heat/steam, coal may also be used as feedstock for the production of fertilizers and smokeless domestic fuels.

E. INFLUENCE OF SHORT- AND LONG-TERM POLICIES AND PRIORITIES

As outlined above, some short- and long-term policies have been planned by the countries in the region to alleviate the consequences of the petroleum crisis. The first step was to minimize imports of petroleum or eliminate them entirely by importing lower-grade petroleum products and replacing petroleum by indigenous energy resources, mainly coal.

Escalation in international oil prices had an immediate effect on taxation of various oil products. In some countries of the region, well-head prices of indigenous crude petroleum remained at a relatively low level compared with the international price of crude oil and the tax was increased.

Special financing terms on a deferred payment basis were negotiated for some imports of crude petroleum, for instance, the investment agreements of India with Iran (about 2.4 million tce of crude oil per year) and Iraq (about 2.8 million tce of crude oil).

Petroleum exploration has now become an important activity in many developing countries of the region even if the risks are high. Recent discoveries of off-shore oil deposits in India and off-shore natural gas deposits in Thailand have indicated profitability of investments in oil and natural gas off-shore prospecting.

Table 7. Share of crude petroleum in the total import bill of selected countries in the ESCAP region

	Unit	1970			1971			1972			1973			1974			1975		
		Total imports	*Petroleum*	*Percentage*	*Total imports*	*Petroleum*	*Percentage*	*Total imports*	*Petroleum*	*Percentage*	*Total imports*	*Petroleum*	*Percentage*	*Total imports*	*Petroleum*	*Percentage*	*Total imports*	*Petroleum*	*Percentage*
Australia	Millions of Australian dollars	4,514.1	218.0	4.83	4,610.8	194.4	4.22	4,309.8	206.9	4.80	5,381.5	195.9	3.64	8,639.1	644.4	7.46	8,514.7	733.6	8.62
Bangladesh	Millions of taka	—	—	—	—	—	—	4,139	—	—	6,762	—	—	8,908	746	8.37	15,611	1,161	7.44
Fiji	Millions of Fiji dollars	90.50	9.98	11.03	111.56	11.69	10.78	131.55	13.07	9.94	174.65	15.62	8.94	219.33	34.49	15.73	221.75	38.51	17.37
Japan	Billions of yen	6,797	805	11.84	6,910	1,066	15.43	7,229	1,190	16.46	10,404	1,627	15.64	18,076	5,509	30.48	17,174	5,830	33.95
Malaysia	Millions of ringgits	4,340	377	8.69	4,434	413	9.31	4,695	177	3.77	6,070	175	2.88	9,954	490	4.92	8,638	559	6.47
Pakistan	Millions of Pakistan rupees	5,479	165	3.01	4,368	192	4.40	5,934	293	4.94	9,788	547	5.59	17,202	1,363	7.92	21,361	2,524	9.22
Philippines	Millions of pesos	7,299	623	8.54	8,525	809	9.49	9,159	939	10.25	12,063	1,123	9.31	24,501	3,873	15.81	27,370	5,169	18.87
Republic of Korea	Billions of won	617.3	39.0	6.32	839.9	61.0	7.26	993.6	81.3	8.18	1,689.0	110.5	6.54	2,781.5	392.1	14.10	3,520.8	615.3	17.48
Singapore	Millions of Singapore dollars	7,534	1,023	13.58	8,664	1,237	14.28	9,538	1,383	14.50	12,573	1,614	12.90	20,405	4,892	23,97	19,271	4,730	24.54
Thailand	Millions of baht	27,009	1,198	4.44	26,794	1,941	7.24	30,875	2,432	7.88	42,184	3,572	8.47	64,044	10,382	16.21	66,835	12,076	18.07

Source: *International Financial Statistics*, vol. XXXI, January 1978.

Under the circumstances of the permanent rise in oil prices, national energy planning in developing countries began to play an increasingly important role, and planning bodies have been established in various countries of the region. For example, the National Fuel Efficiency Service was established under the Government in India. The purpose of this Service is to examine critically the choice of fuel and equipment in different industries on a continuing basis with a view to advising the industries and the Government of various possible solutions from the point of view of national policies as well as techno-economic considerations.

Many developing countries were also faced with the problem of establishing an institutional framework for planning and co-ordination of over-all energy policies. Under existing conditions, attention should be given to working out national and regional energy plans on both short- and long-term bases.

ENERGY SUPPLY PROJECTION METHODOLOGY AND POLICIES

A. NATIONAL ENERGY SUPPLY STRATEGY OF ENERGY IMPORTING DEVELOPING COUNTRIES IN THE NEW ENERGY SITUATION

The international energy supply situation has become more unstable and expensive to the energy importing countries and the problem may get worse in the future. Especially for energy importing developing countries, the securing of stable energy supplies has become a national policy objective of the highest priority.

To achieve the establishment of a secured energy supply structure, the following policy objectives should be achieved. First, to improve the degree of self-sufficiency through accelerating all forms of indigenous production. Secondly, the diversification of energy forms, stressing the development of non-conventional renewable energy sources as well as conventional sources. Thirdly, the diversification of import sources. Because for most energy importing countries it is not easy to achieve self-sufficiency of energy supply, and they will have to continue to rely upon imported energy, it is important to devise a policy to avoid the risks of relying upon one or very few energy supply sources.

Weights of priorities among these three objectives, and target levels in each, may vary from country to country, and will also be different in the short, medium and long term, but all of them should be common policy objectives for energy importing developing countries.

B. METHODOLOGY OF ENERGY SUPPLY PROJECTION

As the starting point of supply planning, energy demands must be forecast as accurately as possible for the short, medium and long term, detailed in each energy form. It is to be hoped that such forecasts will contain various *scenarios* with different demand management policy measures and different assumptions on economic and social conditions in each.

Secondly, before the actual planning of national energy supply, assessment of indigenous energy resources should be carried out. It is an essential element of supply planning to establish the data base on the physical potential of indigenous energy resources. It should be extended further to detailed evaluation of economic feasibility with consideration of various future energy conditions. Such data and information are currently very scarce in the developing countries, and basic surveys and studies on energy resources are urgently needed.

Thirdly, an assessment is required of the availability, stability and cost of imported energy in the future. It is difficult to assess future international energy supply conditions, but it is required in order to analyse cost-benefit ratios of indigenous supplies and to evaluate the feasibility of development projects of indigenous resources.

After the assessment and establishment of the data base is completed, the energy policy planner can proceed with the planning of energy supply for the future.

The first step is to establish criteria for comprehensive evaluation of supply stability and cost and benefit to fix the priorities of various energy supply projects. Some of them may be new development projects while some may be expansion projects and others energy import projects. These criteria should be considered in the context of long-term energy strategy.

The second step is to make simple supply projections to meet the forecast demands starting with the simplest case, based upon the assumption that existing conditions and policies will continue without change. Supply should meet not only the total amount but also the requirement for various energy forms of forecast demands. In the normal case, the level of indigenous supplies is first projected, and then import requirements are determined.

The third step is to consider alternative *scenarios*. Unless the base case projection is a reasonable one from the viewpoint of achieving targets of the long-term national energy strategy such as improving self-sufficiency and diversification of energy supply forms and sources, an alternative supply *scenario* should be projected along with the necessary policy measures. Policy measures and their effects (both plus and minus effects) should be assessed deliberately. For example, a tax incentive or subsidy of high-cost indigenous supply would contribute to improvement of self-sufficiency but governmental finance would be adversely affected. If a high energy price policy is adopted to sustain the profitability of the energy industry, the consumer's welfare, especially the lower income classes, will be affected. For several alternative projections, economic and/or non-economic resources, such as funds, technology and trained manpower, would be required for realization.

Throughout these processes of planning, the criteria for comprehensive evaluation should be followed in order to select the best mix of energy supply sources under given conditions. Various constraints, such as limited availability of economic resources, social acceptance and so on, should be considered at each step of the projections, and, of the several alternatives, the policy-maker must choose the best plan from the over-all point of view, namely, maximum national benefit at minimum cost.

These processes of planning could be operated efficiently and quickly by means of the computerized energy modelling system discussed above, but in most of the developing countries, basic conditions are not sufficiently developed to allow introduction of an advanced sophisticated system. Above all, it is urgently required that the energy resource data base be established as quickly and precisely as possible.

Even before the preconditions for the energy modelling system are completed, it would be possible for developing countries to adopt systematic energy planning in accordance with their status and conditions.

C. SOME CONSIDERATIONS ON CRITICAL SUPPLY ISSUES

1. Indigenous production or import

The top priority policy objective for most energy importing countries is to accelerate indigenous energy production and development. However, in the short or medium term, especially in the transition period, it is expected that a lot of problems will arise.

One of the main purposes in improving the self-sufficiency of energy by accelerating indigenous production is to secure energy supply, and another is to lessen the heavy burden of imported energy costs on the balance of payments. But neither of these purposes is easily attained. For example, new development projects will contain risks such as possible delays in completion, unknown reliability, and unexpected cost increases. Sometimes those risks may be larger than the risks of imported energy supply in the future. Also, problems may arise with balance of payments from the acceleration of indigenous production in the short run, because new development projects require capital goods and technologies, most of which are not available in the domestic markets of the developing countries and have to be imported. For most of the energy importing developing countries, the policy of accelerating indigenous production will be justified because in the long run indigenous supply will be preferable to imported energy in terms of security and cost of supply.

2. Supply diversification policy

The diversification of supply sources and forms should also have a high priority in energy policy. This includes not only expansion of non-oil production, but diversification of oil import sources. However, unless supply programmes are planned and implemented deliberately and harmonized with the demand management programme, friction and confusion in the demand/supply balances of individual sectors or energy forms may occur during the transition period.

For instance, expansion of coal production or imports can be considered as an oil-replacement measure, but it is an important question whether substantial coal demand exists in harmony with the time schedule of the coal supply programme. It may be possible to switch from oil or gas to coal for electricity production and industrial process, but in many cases plants may have to be remodelled or replaced, which would take a relatively long time and require much capital expenditure. The grade of coal available may also be in question. With existing technology, it may not be possible to transport low-grade coal economically, and then its uses may be limited. Construction or expansion of transportation facilities, such as port facilities, railroads, stock yards and so on, for coal requires more space and is more costly than for oil facilities. Environmental problems in production, transportation and utilization of coal should not be ignored. Some of the problems can be solved by development of new technology, for instance gasification or liquefaction of coal. The energy policy planner should devise a coal supply programme with deliberate evaluation of all these factors.

Sufficient attention must be paid to the oil demand/supply balance even if oil demand should be reduced in the long run. The supply diversification policy, if it is effective, will naturally result in reduced growth or actual reduction of oil demand, but reduction rates may be different among the various fractions of petroleum products, such as gasoline, kerosene, diesel oil and fuel oil. For instance, a shift from oil to coal may occur mainly in electricity production and industrial processes, which are usually consumers of heavy oil. In such a case, conversion to coal may result in a drastic reduction in demand for fuel oil, causing either a surplus of fuel oil or a shortage of lighter products. This would have a serious impact on the domestic oil market as well as the refinery production pattern.

As one of the measures to secure oil imports, import source diversification can be pursued. Because gravities and contents of crude oil vary from one source to another, diversification of oil import sources necessitates refineries processing various qualities of crude oil. In order to cope with such a situation, the oil refinery industry may have to make a large investment to remodel plants in order to cope with changed production patterns in spite of the relatively low growth of total oil demand. At the same time, interchange of petroleum products among neighbouring countries should be actively pursued.

The cases mentioned above are examples of demand-supply balancing problems in each energy form. There would be many similar problems in matching demand and supply appropriately without surplus or shortage in each form of energy and in each period, from the short term to the long term.

3. Availability of capital and technology

Generally, essential economic resources such as capital, technology, skilled manpower and management ability, which are required to develop energy resources, are scarce in the developing countries, though the degree of scarcity varies from country to country. In particular, big energy development projects with new innovative technologies have considerable risks and their lead times are fairly long. In most cases, it is difficult to implement them without outside assistance. On the other hand, there is a great need and desire for developing countries to develop their resources themselves.

At the time of decision or choice between various development systems (for example, taking the case of an oil development system, in choosing between a concession-type agreement, a production-sharing agreement with an international corporation, or fully nationalized development using contractors), the policy-makers should evaluate all factors expected for the future, and should determine the choice of system from the point of view of maximizing long-run benefits while achieving short-term objectives. If they rapidly pursue a nationalistic type of development, they may fail to attract the necessary capital and technology.

4. Optimum path from short- to long-term

Many discrepancies may exist between short-term and long-term policy objectives. Basically, planners should focus their attention on long-term objectives, but cannot ignore short-term problems, as they may be extremely important from the economic and social as well as the political point of view. However, decisions on investment, changing of institutional arrangements, pricing and taxation will have long-term effects which might determine the energy demand-supply structure in the future.

The policy planners will need an effective method to find out the optimum path from short- to long-term solutions. A simulation type of energy modelling system would be effective in assessing and selecting options of policies and measures. The introduction of the shadow-price concept may also be important for investment planning or pricing and taxation planning.[3]

D. GENERAL POLICY FRAMEWORK FOR SUPPLY MANAGEMENT

In order to achieve the long-term objective of national energy strategy, securing energy supply through improvement of energy self-sufficiency and diversification of energy supply sources and forms, energy importing developing countries need a long-term energy policy framework.

First, in respect of the energy resources data base, large inputs of money and skilled manpower are needed, and a long lead time is required for basic research and surveys.

Secondly, improvement of technological potentials for energy production should be stressed. Activities in research and development for new technologies as well as in the training of manpower for introduction and adjustment of advanced technologies should be strengthened. Ideally, these activities should be conducted on the basis of a long-term plan for the development of technologies.

Thirdly, the establishment of fund-raising systems should be noted. It might be essential not only to give high priority to energy financing in the government budget but also to make arrangements to give incentives for private investment from both inside and outside the country.

Fourthly, pricing and taxation policy should be clearly stated. In addition, special consideration should be given to new alternative energy supplies which are currently not competitive but may become so.

[3] Shadow price is a price or value worked out with the due regard to unpriced social benefits or losses or resources which are not satisfactorily priced in commercial markets. By using this concept, a planner may be able to develop the optimum solution consistent with both economic and social viewpoints.

AN OUTLINE OF MAJOR ISSUES*

(NR/WGMEPP/3)

INTRODUCTION

The purpose of this paper is to present preliminary information and viewpoints, based on a systematic approach, which could contribute to the drawing up of a regional strategy for a collaborative effort among ESCAP member countries for the optimum energy development in any of them.

Energy use is pervasive throughout the economy of any country. In the current decade, abrupt transitions in cost and availability of energy are having far-reaching effects, particularly on the oil-importing developing countries. It has been a pointer to the harsh reality that energy production and consumption patterns are intimately connected to economic viability, food production, environmental conditions, the lifestyle of the citizens, policy independence and even the international status of each country, both developing and developed.

It is simultaneously a challenge to and an opportunity for the ingenuity of the people of the region to come closer towards a collective attempt at remoulding the future development and use of indigenously available energy resources, while keeping in view complementarity among the countries of the region. Without the vigorous introduction of new supply and conservation technologies, the difference between projected energy demand and supply in some countries may assume ominous proportions. Traditional indigenous supply capabilities developed up to the present, and projected for the near future, appear to be inadequate to overcome the impending demands. Balancing the energy budgets through increased imports of conventional fuels could widen the gap in balance of payments to an apparently unrealistic level in the context of anticipated world production rates of liquid fuels in particular, with a scarcity condition looming large on the horizon.

It is not appropriate for the countries of the ESCAP region to undertake a rigorous programme of energy demand restriction risking a stunted economic growth. The option is open to them also to consider the possibility of a shift in the traditional outlook for energy supply management by considering much wider groupings of countries of the region, wherever technical feasibility and economic complementarily co-exist.

The primary requirement would, therefore, appear to be to organize the essential infrastructure of appropriate institutional development as a nucleus for energy planning and programming, based on an analysis of techno-economic data specially collected for the purpose through systematic effort, culminating in a conscious choice for an optimum solution to the energy problems of each developing country of the ESCAP region.

Production of energy being a long lead item, the developing countries of the region would obviously need to undertake a number of advance actions on their own as well as on bilateral or multilateral bases, drawing on the expertise made available by ESCAP and/or other international organizations to supplement, wherever necessary, the expertise obtainable from indigenous sources. The line of action, broadly speaking, may cover:

(a) Intensive survey of indigenous energy resources followed by selective exploration programmes;

(b) Assessment of demand for total energy over time, broken up into different forms of energy, whether indigenous or imported;

(c) Analysis of the possibilities of replacement of imported energy by indigenous resources to the fullest extent;

(d) Drawing up of a national energy policy based on which a national energy plan could be prepared;

(e) Reinforcing techno-economic research capabilities to make use of existing technology developed elsewhere and/or adapting the technology to suit local requirements.

All the above activities should be initiated by a competent team of experts in energy planning, for which prior training of personnel and proper institutional facilities are prerequisites. It is therefore necessary first to build up a national energy planning unit which could undertake appropriate action in proper sequence.

OBJECTIVES

The Working Group on Energy Planning and Programming has been constituted as a forum for identifying the main issues confronting the developing countries of the ESCAP region and exchanging views on the problems and strategies of energy planning, highlighting policy measures suited to the non-oil producing developing countries in particular and assessing the applicability of various concepts and technologies already in use in the world. In this respect, a review and evaluation of the following items is desirable.

(a) The impact of the new world energy situation on the economies of the energy-deficient developing countries of the ESCAP region;

* This paper was prepared by Mr. M. K. Chatterjee, consultant on energy planning, at the request of the ESCAP secretariat. The views expressed in it are those of the author and do not necessarily reflect those of the United Nations.

(b) Policy measures already taken or planned by individual countries aimed at conserving energy and improving efficiency in the use and augmentation of energy supplies, particularly from indigenous energy resources;

(c) Bottlenecks in the availability of essential inputs of capital, technology and trained manpower;

(d) Institutional arrangements already in vogue at the country level.

As a follow-up measure, the possibilities of co-operation among the developing countries and with the developed countries of the ESCAP region may be assessed in such areas as:

(a) Exchange of information and experience in energy planning production and consumption;

(b) Energy production and consumption technologies which have recently become competitive as a result of the oil price rise on the international market;

(c) Available energy expertise for mutual aid;

(d) Available training facilities in energy planning/production/utilization in different countries within or outside the region and under international/national organizations dealing in energy matters;

(e) The broad magnitude of financial requirements over time for improving or setting up the nuclei for energy planning/programming in each country.

SCOPE

Since the onset of the new world energy situation, a general consensus has evolved on the need for national energy policies and planning. Such a need was particularly felt by the energy-importing developing countries because the effects of the energy crisis on their economies had been extremely adverse, calling for every possible action on a country basis and through collaborative efforts in the ESCAP region as a whole.

The practice of energy policy formulation is of recent origin, being undertaken seriously during the 1960s, and therefore cannot be qualified as a fall-out effect of the energy crisis, although stimulated by it. Following the Hartley Commission's report of the late 1950s, the OECD countries followed up the idea of energy policy planning during the 1960s. In 1967, ESCAP, then ECAFE, issued *Comprehensive Energy Surveys — An Outline of Procedure*[1] in order to assist the countries of the region in assembling data for this purpose. In India, the first ever comprehensive energy survey was carried out between 1963 and 1965, and a fully fledged energy planning unit commenced functioning from then on under the planning commission. These early attempts, prior to the energy crisis, considered in great depth the scope and intricate details of the methodology for comprehensive energy planning through the application of the analytical tool of energy balances as an over-all framework for modelling the future course of events. The methodology and analytical tools are amenable to modifications suiting the needs of individual countries.

Energy policy in each country should reflect to a large extent the over-all development goals, and these can be translated into such objectives as the development of indigenous energy resources, self reliance and rural energy supply. Many developing and developed countries have yet to draw up comprehensive policies appropriate to their situations. In any event, the need for an energy policy has been keenly felt everywhere in order to provide guidelines for energy planners to prepare detailed programmes under the constraints of time, financial and human resources and limited knowledge of energy supply and consumption patterns. This has pointed to the basic need for reliable data on resources, demand aspects and supply possibilities of energy.

RESOURCES, DEMAND AND SUPPLY

Current statistics for resources, production and consumption in countries of the region are included in document NR/WGMEPP/1, and aspects of demand and supply are considered in document NR/WGMEPP/2.

It is emphasized that there still remains considerable lack of clarity in defining energy reserves and resources, particularly on an internationally comparable scale, notwithstanding the efforts of the World Energy Conference, whose latest publication, *Survey of Energy Resources, 1974,* is a significant advance on earlier data. In that publication, resources and reserves have been indicated on the basis of a uniform set of assumptions and definitions. More recent discoveries have been advised in government and company statements, and assessed in various periodicals, but it is by no means clear whether these additions have been stated on a comparable basis. The next report by the World Energy Conference is expected in 1980.

It is possible that extensive drilling carried out by oil companies in the sedimentary areas of many of the countries of the region may have indicated considerable resources of coal although these may not have been reported. Therefore, the result of exploration effort in oil-importing developing countries in particular may be carefully studied for any indications of the existence of coal resources. In developing countries, coal production is likely to be limited to meet

[1] United Nations publication, Sales No. 67.II.F.14.

local demand. The emphasis, therefore, is to be on tapping a simple, low capital cost industry with minimum mechanization. In most of these countries, serious efforts in exploration and development and the linking of technologies, markets, finance and transport facilities through national planning, supported as necessary by international co-operation in the region as a whole, could be the immediate task.

Because of the labour-intensive nature of the coal mining industry in developing countries of the region, the machinery supply problem would not be so limiting a factor, but it would be essential to have an uninterrupted supply of steel or wooden roof support for underground mines, conveyor belts, ventilation equipment, electric cable and explosives. Adequate infrastructure facilities would be required.

In regard to oil and natural gas, most countries have had some experience with transnational companies, and are aware of the costs, time-scale and infrastructure required.

On the other hand, hydroelectric resources are normally developed by government agencies, sometimes with the assistance of consultants. In view of the large untapped potential in several countries in the region, Governments are in a good position to plan future developments.

In the case of nuclear fuels, exploration seemed generally to be in the hands of private companies until recently, and increased government interest may result in further significant finds. Very few of the countries are likely to be able to use nuclear fuels as such, but there are good possibilities for export.

One of the difficulties still apparent, particularly for developing countries, is the lack of reliable data on non-conventional energy resources, and it is necessary to evaluate the availability and effective cost of these forms of energy in considering a policy approach. The use of wood for cooking in many countries, and the use of cow-dung as a fuel and also as an input to biogas plants, are well established. Attemps are being made to use other inputs to produce biogas, but economics must be considered carefully. Solar energy and wind energy are used in some areas only. Geothermal potential needs expert evaluation.

In the short term, energy policies centre around the management of energy demand. The introduction of measures to cut down on wasteful processes, and the stressing of conservation would be a necessary step, in order to use less energy for the same output. Import policies would have to be reassessed, both in the short term, and in the medium and longer terms, related to the survey, exploration and development of indigenous energy resources which it is hoped would gradually assume a larger share of supply.

For any country, the specific policy will be subject to both internal and external constraints, and it is not feasible to evaluate or judge the policy of a particular country. However, general patterns of policy may be sought.

On of the points that is obvious, but should be stressed repeatedly, is the need for realism in assessment of resources, consideration of time-scale for development (and, in some cases, social and environmental acceptance) and in forecasting demand trends. Departures from realism may result in much-magnified variations in incremental demand, and possibly high-cost imports.

ALTERNATIVE ENERGY STRATEGIES

With the dramatic changes in the price of imported energy, the prospects of utilizing indigenous coal resources for balance of payments and security of supply reasons have considerably improved in the region. This factor is now leading many countries in the area to reappraise their energy supply options in both their medium-term and longer-term plans. Earlier optimistic assessments of the additions of nuclear power as a principal substitute for petroleum energy are now being revised downwards in a number of countries in the region. It is now realized that if capital costs, capacity utilization, lead time and capital carrying charges are properly considered, and adequate cost penalties are incorporated in nuclear power development because of its longer-term environmental risks as well as the technological imperative of large-scale generation/utilization of nuclear energy, the result of the analysis is that nuclear power will not be as competitive with coal-fired thermal power and hydroelectric energy as had appeared to be the case some years ago in the developing/developed countries of the region.

It is, however, admitted that if coal is to make a real come-back not only in terms of power generation but also as a substitute for imported oil and gas in countries of the region, it can only succeed in doing so if its technological and environmental properties can be upgraded. It would have to be made into a cleaner, more transportable and more versatile fuel. This requires a vigorous promotion of research and development in coal exploration, mining, beneficiation, transportation, storage and, above all, utilization in power generation as well as industry. The countries with accessible, comparatively inexpensive hydropower have without question given priority to the development of such potential energy resources over nuclear power/thermal power and power generated from imported liquid fuels. However, the choice of the coal option is not available to a few of the countries (with possible coal potential) in the absence of any significant efforts in coal exploration and development so far. This historical neglect can be reversed in a number of cases provided intraregional as well as international co-operation in technical and financial terms are forthcoming. Increased coal production in these developing countries has substantial employment potential and may partially eliminate unemployment where the absorption of surplus manpower assumes considerable importance.

The metal/fuel/raw material nexus had been the basic pattern for industrial development in the past and the industrialization of most of the developing countries in the region may also be based on a similar nexus, and the future role of coal as energy and feedstock in these countries should be viewed in this perspective. The most important use of coal is in the sector of electric power generation. With the price hike for petroleum crude and its products, coal has to fill the gaps immediately for sustaining the supply according to the growth of demand for electric power.

After power generation, the next most important use of coal is as an energy resource and feedstock in the metallurgical industry. A number of countries in the region with growing activities in the metallurgical fields are at present importing coking coal for iron and steel production. In the case of those countries with iron ore outputs considerably greater than their pig iron production, a strong case may be made for the export of finished steel based on indigenous or even imported coking coal, with possible profits from the smelting operations accruing to the source country.

In transportation, which is the next largest consuming sector of energy, the choice could hardly be for reverting to steam locomotives. Where there is a supply of inexpensive coal and where diesel oil is imported, there is a strong argument for the electrification of railways. Although the capital costs of the overhead power supply systems are high, there would be a considerable reduction in the fuel and locomotive maintenance costs.

The use of smokeless fuels from coal for domestic purposes to take the place of wood, dung or kerosene, is gaining ground in the developing countries of the region. In the case of animal wastes, such as dung, and vegetable wastes, it is better to use them as a source of organic fertilizer than to burn them as fuel. The replacement of wood as fuel is extremely important in most of the developing countries of the region which are traditionally denuding their forests and vegetation considerably for fuel purposes to the detriment of their ecology and soil fertility. The production of gas from coal, a technology which goes back to the mid-nineteenth century, for urban illumination, for industrial heat and even for domestic cooking purposes, can make use of indigenous coal resources in these developing countries of the region. The relative economics of gasification of coal via-à-vis the use of either petroleum products, liquid petroleum gas (LPG) and/or natural gas for heating or lighting purposes are improving with the sharp rise in import prices of petroleum crude and its products.

In addition to using coal in the developing countries of the region for public electric supply generation, there is a good case for using it, rather than petroleum products, for industrial purposes. The development of small captive power stations for local industrial complexes has been gaining ground in situations where there are no effective power supply systems developed so far. While the capital costs of small steam units are likely to be higher than for equivalent diesel engines, the combined supply of steam and electricity and the application of a total energy concept would make steam cycles economically attractive in industries that require process steam. Furthermore, such steam plants can be designed to serve a wide range of situations in times of uncertain supplies and prices of imported liquid fuels.

In sum, it appears that particularly for the developing countries in south and south-east Asia, hydropower along with a complementary supply of thermal power from indigenous coal, should take precedence over the import of oil or even the generation of nuclear energy in the next two decades of this century.

If priority is to be accorded to non-conventional energy resources in the region, one would put them in the following order: (a) biogas, (b) solar energy, (c) small windmills with storage batteries, (d) geothermal sources and (e) all others.

INTERCHANGE OF ENERGY IN THE REGION

Although there are many differences between the energy resources position and the needs of the individual countries within the Asia and Pacific region, the future economic prospects of these countries will be signicantly influenced by their capacity to generate a greater share of the total energy requirements from indigenous resources, to be complemented by the interchange of surplus resources from the neighbouring countries. For example, Nepal could be a source of a large quantum of supply of hydropower to northern India; India could supply non-coking coal to meet the needs of nearby countries; Bangladesh could supply natural gas to the north-eastern part of India; and Indonesia could probably find further markets for its oil and natural gas in south-east Asia. Interconnected electricity grids could be established between Nepal-India-Bangladesh, Burma and Thailand, Malaysia and Singapore, and so on. Australia could be, when needed, an exporter of nuclear fuels to the countries of the region. Joint river valley development, for instance of the Mekong

River, could be a large source of hydroelectric power for several countries. Many more examples could be considered if viewed in the perspective of development over the next two decades of the century.

SPECIFIC ISSUES FOR DISCUSSION

In the new energy era, because primary energy supplies (above all, oil supply, which has been one of the major energy sources) have become expensive and uncertain, it is and will be almost impossible for most of the energy-importing countries in the world to maintain the energy demand growth pattern of the past. In particular, energy deficient developing countries have been severely affected by the increased cost of imported oil, and that has caused problems such as large deficits in balances of payments and has contributed to inflation, economic depression and unemployment. In most of those countries, it seems to be extremely difficult to achieve the goals planned for development. Furthermore, if in the future they should face the challenge of reduction of oil supplies similar to the 1973 embargo, or world-wide chronic shortage of oil supplies, with the existing energy demand supply structure maintained, survival of their economies and societies might even be jeopardized. In that sense, the energy issue should be regarded as a question of national security as well as an economic matter.

The main tasks of energy policy, common to most energy importing developing countries, might be: (a) to establish a secured energy supply structure, accelerate indigenous production, diversify import sources and energy forms; (b) to stabilize the energy demand structure, energy conservation and energy demand diversification; (c) to usher in a major, and at places radical, change in the consumption pattern by restructuring the energy consuming sectors in a phased manner over time to match the endowment of indigenous energy resources to the extent technically feasible and economically viable.

In the context of all the previous work carried out so far at the country level, it is extremely important that an overview be taken on the entire energy field in each country and in the region as a whole, to focus on the long-term goal to be achieved over, say, 15 years, and to lay down the direction of thrust in each energy subsector with a tentative time-schedule to achieve the desired goals in a chronological sequence. A few very apparent requirements, which are by no means exhaustive, are listed in the following paragraphs for consideration.

A. ESTABLISHMENT OF DATA AND INFORMATION BASE

1. *Demand studies*

The demand for commercial energy, particularly coal, oil and electricity, could be studied on the basis of the framework of input-output analysis covering a number of sectors, inter-industry studies and end-uses, with coal, oil and electricity balances drawn up on the basis of norms of consumption in energy consuming sectors. Over-all macro-economic co-relations between total energy and GNP, commercial energy and industrial output, non-commercial energy and population growth, etc., could also be studied. There is a need to develop long-term forecasting models, particularly for coal and electricity, with the demand for oil treated as a suppressed demand. Special care is needed for any demand forecast for petroleum over the next 15 years, not only in terms of crude oil, but also in terms of the pattern of consumption of various oil products, both as an energy source and as feedstock for essential industries such as fertilizer production. The forecast of oil demand also needs an independent cost-benefit analysis of the import and use of oil as feedstock, say, for fertilizer production, against producing the same quantum of fertilizer through the use of available indigenous resources as feedstock.

In the context of the energy crisis, substitution, in non-oil producing developing countries, of liquid fuels by indigenous resources such as coal and its products has become more important than in the past. Fiscal policy and technical measures that were considered by each country during the past few years may have to be reviewed for expediting substitution processes.

2. *Energy resources review*

As regards the commercial energy subsectors of coal, oil and gas and primary electricity, data on resources available are expected to be reasonably comprehensive and need only be updated by the information collected by various government agencies. For example, during 1973/74, a stock-taking of the Indian energy resources, on the basis of the then current information, was carried out in detail.

As regards the resources of non-commercial fuels, such as firewood, cow-dung and vegetable waste, there is little systematic data available for ready use and this aspect requires consideration with a view to developing mechanism for the compilation of non-commercial resources data. In this connexion, the consumption data collected through sampling methods from time to time in India may be relevant. A systematic analysis through sample surveys in various countries and the pooling of the results could increase their reliability factor.

Biogas as an energy resource is a relatively new entrant and a lot of interest has been aroused, particularly on gas from cow-dung. A systematic investigation into the availability of biogas as an energy resource in farflung villages, not only from dung but also from vegetable and human wastes, water hyacinth, etc. is worth undertaking.

3. *Supply constraints*

In the present context of power shortage in many developing countries, restraint on the availability of petroleum and its products, and the absence of a proper distribution system of imported and/or indigenous coal resources, supply constraints of energy in adequate quantum, proper content and correct form, are looming. This aspect of energy planning requires a co-ordinated approach so that an integrated system can be built up for better articulation and flow of energy in the over-all sense.

B. DEMAND MANAGEMENT FOR DEVELOPING COUNTRIES

1. *Need for energy demand management*

Energy is not an end in itself, but a means to social and economic ends. Therefore, policy targets for energy demand management, energy saving and diversification should be planned in harmony with other national policy objectives such as economic development, employment, welfare, price levels and balance of payments.

The burden on the energy supply arrangements could be lessened by the introduction of energy saving devices and diversification of sources. Energy conservation through improved efficiency of energy use could hold down the demand for energy, thereby reducing energy input per unit of GDP. By applying conservation techniques, future total energy requirements may be kept lower than the estimates projected from historical trends which had no conservation objective.

Considering the serious situation of international energy supplies in liquid form, both at present and in the future, it might not be enough to tackle the energy problems only by reduction of the total energy requirements in the future. On the demand side, shifts of demand for oil to other energy forms is required. However, in view of the convenience of petroleum in liquid form for transportation, storage and end use, such shifts may not be easily or smoothly attained, especially in countries which depend heavily on imported oil.

Looking at energy problems of the developing countries in the ESCAP region from a completely different angle, *per capita* energy consumption in some of them is still lower than the world average figure for developing countries, not to speak of the world average for all countries. It points to the urgent need in these countries to make rapid strides in the use of energy for a boost to their economic activities. Only higher energy use can ensure for them the achievement of social and economic development goals to meet the demands for an improved standard of living, particularly after countering the additional needs derived from a high rate of increase in population.

However, one redeeming feature is that in many of the developing countries in the region, where economic systems and energy structures have not yet been firmly established, or are now being formulated, there are unrestricted opportunities for constructing an efficient and secured structure, with a rational and consistent demand-supply framework. The main problems seem to concern organizational matters and lack of capital and technology.

In view of all these, and many other considerations, energy demand management can be said to be one of the most important policy areas for the developing countries with scarce energy resources.

2. *General policy framework for energy demand management*

There are several general policies for medium- and long-term energy demand management. Their implementation is normally a pre-condition for achievement of energy saving and diversification in individual sectors.

First, a policy on pricing and taxation of energy products should be established to assist energy saving and diversification. Bearing in mind that price elasticity of energy varies from short-term to long-term and by types of fuels, rational pricing and taxation policy has a great role in the energy policy. In this case, the meaning of the word "rational" includes moderation in the conflict with anti-inflation policies and the protection of the low-income earners, a matter which may be a critical challenge.

Secondly, the establishment of education and information systems on energy might be important. Provision of proper and adequate education and information is essential to influence the behaviour of consumers and industrial managements towards energy saving and energy diversification. It may become possible to eliminate wasteful energy consumption and to choose energy sources from the point of view of long-term rational use.

A third area of energy demand policy in a general sense is the development and adoption of more efficient technologies for energy conversion and utilization. In the developing countries, however, it is important not only to introduce more advanced technologies from the developed countries but to adopt the optimum energy utilization technologies to conform to the specific socio-economic conditions of the individual developing countries. For example, total energy system as a vertical concept, i.e. starting from the highest temperature and pressure for generating by-product electricity in plants where process steam is necessary, should be given serious thought. The industries requiring captive power plants may, if called upon, generate a greater proportion of their electricity requirement within their premises by this process and relieve the grid supply to that extent. This is particularly important for maintaining essential plants within the factory premises to guard against grid failures. Technical feasibility has been established, and economic viability is not much in doubt, but a policy decision regarding the introduction of the concept of total energy requires approval by both the Government and the electrical utility body. Continuous activities for research and development require vast amounts of funds and talented human resources as well as a long period of time, and the application of technologies requires similar economic resources. In order to achieve as much as possible with modest inputs, it is essential to establish efficient and effective institutional arrangements to plan and implement research and development activities.

Fourthly, a policy to promote investment for energy-saving and energy diversification should be stressed. In the short-term, improved operation and maintenance of energy-using facilities and equipment are useful, but in order to attain continuous effects, remodelling, replacement or new installation of energy-using systems and facilities may be required. Considering the capital shortage in the private sector in most developing countries, it may be necessary to give incentives to promote this type of investment through proper pricing and/or taxation on energy products, or by providing low interest loans and/or subsidy and permission for the application of special depreciation methods. In some cases, heavy taxes on usage of undesirable energy facilities might be considered. However, before such policy measures are determined, the total effect in the long run must be scrutinized on the basis of national planning, because additional production of facilities and equipment also requires additional energy.

Fifthly, some remodelling of the economic and industrial structure may be necessary. Above all, the policies should place first priority on development of less energy-intensive and high value-added industries rather than on energy-intensive industries. These policies cannot be generalized because they are highly dependent on specific conditions of individual developing countries and optimum policies would vary from country to country.

However, many of the developing countries in the region are highly populous, and lack of employment opportunities is a chronic socio-economic ailment. In those countries, while choosing between efficient but sophisticated technologies for energy use, a balance has to be struck between labour-intensive and energy-intensive ones, preferably more in favour of the former, under the socio-economic compulsions of meeting the challenge of the unemployment problem. Therefore, in many cases, the option is limited to a conscious choice for a "low-energy system" with an energy profile rising gradually with time.

C. ENERGY DEVELOPMENT AND SUPPLY MANAGEMENT

1. *Development possibilities and problems*

While a periodical review of the energy policy of a country is essential to decide from time to time the magnitude of the development and production efforts required and the investment decisions called for, there are certain fundamental directions of energy policy which may remain invariable under most of the likely future developments. One can glean the trends in energy consumption, say, 15 years hence by tracing the factors which affect the quantity and composition of energy consumption. In a developing economy, energy is used mainly for heating, lighting, the provision of motive power and chemical and metallurgical uses.

The demand for the first three purposes arises in households, industrial enterprises, transport undertakings and commercial operations. The demand for the fourth is by resource-based industries.

In developing countries, household demand for energy for heating will be proportional to population growth. But the preferred sources of energy for this purpose may change as the economy develops. For instance, with growing urbanization, electricity, gas and kerosene will tend to replace non-commercial fuels such as firewood and cow-dung. Household demand for lighting may well have a higher income elasticity than that for cooking, and a gradual change-over to a preferred source such as electricity from kerosene is expected. Household demand for motive power may also be highly income-elastic. Growth in urbanization will tend to increase demand and a change-over from animate to inanimate energy, as could arise in the switch from bicycles to scooters.

The demand for energy for agricultural (including irrigation pumping) operations is mainly for motive power, and this will also gradually change over from animate to inanimate energy.

In the transport sector, energy is used almost entirely for the purpose of providing motive power. As the economy grows, the demand for transportation will most certainly increase.

The demand for energy for industrial operations arises mainly for heating, motive power and feedstock inputs. The structure of industrial production will dictate the level of energy use.

With regard to subsectors, electricity will become the principal form of energy for the purposes of lighting, specific industries (such as electrolysis) and motive power in factories. Coal will be used mainly for heating (including steam-raising in thermal power stations). Oil products are a particularly suitable form of mobile energy with a high energy-to-weight ratio, and the transportation sector would mainly use this source.

The demands for various forms of energy are partly governed by the future conditions of energy supply in each country. Thus, it is necessary to examine the availability of resources for meeting the requirements of various forms of primary energy, the cost of their development and the problems that are likely to be encountered in the development of energy supply industries in the future. The time-scale for development and production will obviously be dictated by the profile and the pattern of demand for various forms of energy to sustain the desired development process for achieving socio-economic goals in appropriate time.

An economy based on coal as its principal source of primary energy will inevitably generate large requirements for rail and, if possible, water transport, because these are low-cost carriers. As an example, coal carriage has amounted to around 40 to 50 per cent of total ton-miles of traffic on Indian railways in recent years.

Even though rail costs of coal per ton-mile are much lower than road transport costs, the delivered cost of coal rises rapidly with distance. In India, at 500 to 750 km from the mine head, the delivered cost may be double the mine head price. Since carriage of oil by rail costs somewhat less than coal, the advantages of substituting coal for oil decrease rapidly with coal transport distances.

Oil and gas may also be transported economically by pipeline if volumes are reasonably large. Under certain circumstances, water transport may be economical. Electrical transmission is a special case, because while the location of a hydroelectric scheme may be fixed, the location of coal or oil-fired plants may be related to costs of physical transportation of full or electrical transmission. The initial price relationships between coal, oil, gas and thermal and hydroelectricity generation, and the relevant transport costs influence not only the optimum volume of investment in transport and energy but also the optimum allocation among the various modes of transport and sources of energy.

The proper balance of petroleum products from refinery through-puts has been an issue in the energy policy of a number of countries, and a sensible energy policy may involve adjustments in both product balance and transportation policy.

Many less developed countries, India for example, are still heavily dependent on non-commercial sources of energy, up to half of the total energy consumption coming from firewood, waste products, and cow-dung. Although no data are available on ton-miles of primitive localized transport such as bullock carts and bicycles, this may account for a large fraction of total traffic.

In the case of India (and some other countries), despite the rapid growth of energy services, energy supply has lagged behind requirements. At times, the lags have constituted serious bottle-necks to industrial growth. For a number of years there was both a shortage of electricity generating capacity and an inadequate distribution system. This led to a cutting-off of supplies in periods of excess demand, to limitations on amounts supplied to individual customers, and to refusals of applications for connexions. To meet the heavy requirements of increasing industrialization, and accommodate a desirable, if not inevitable, shift from non-commercial sources, the share of energy in total investment will probably have to increase over the next decade or two in all the developing countries of the region.

In regard to types, methods, costs and risks of development of energy resources in different countries of the region, only specific case studies could indicate the right choice. However, certain generalized approaches for evolving guidelines may be considered. In the oil deficit countries at the threshold of development, the obvious choice will be for the primary sources of hydroelectricity, coal and, at a much later period, nuclear energy. Hydro investigations and coal exploration should start without delay.

Although high-head, single-purpose hydroelectric projects may produce the cheapest energy, hydrological and geological investigation may take time, not less than five years for a project. Simultaneously large inter-state and inter-country, multipurpose river valley projects such as that on the Mekong River can be investigated and undertaken at the appropriate time with international aid both by way of finance and expertise. For quick results, irrigation-cum-power projects at country levels and micro hydro projects in hilly areas may be given an immediate start, although the cost of energy will be relatively higher. Examples may be drawn from schemes in the north-eastern part of India where new diesel power generation has been totally banned in favour of micro hydro works.

Survey, exploration and exploitation of indigenous coal, lignite and peat resources in most south-east

Asian countries might be intensified as potential long gestation projects for replacement of petroleum and its products. During the intervening period, the import of coking coal for metallurgical purposes and non-coking coal for power generation, industrial heat-raising, domestic cooking, etc. from neighbouring countries under a collaborative arrangement, deserves serious consideration.

Development of nuclear power is a possibility in some of the larger developing countries, but, in order to absorb nuclear energy fully at a load factor above 80 per cent, there are a few essential technical pre-requisites: the load density should be high; continuous processing industries should be predominant, transmission grid development should be adequate, alternative hydro-thermal generation should provide peak load requirements and matching spinning reserves; and stand by capacity should be sufficient for meeting demands during refuelling of reactors and emergency shut-downs. Other pre-conditions, including an assured supply of heavy water and/or enriched uranium and trained manpower, make nuclear energy a heavy investment source.

2. *General policy framework*

In many countries, the price to be paid for the purchase of petroleum and its products in the future will continue to be a significant percentage of the total cost of imports. Furthermore the investment in the energy sector as a whole is a significant proportion of total investment. There is already an indication that these percentages may increase in the future, if shortage in the power sector is to be mitigated, the minimal growth in the consumption of liquid fuel is to be allowed, and if indigenous resources cover some of the incremental requirement of energy. Therefore a well-thought-out investment and pricing policy in each country to suit its needs is imperative.

A common characteristic of energy projects is the lumpiness of investment; with the trend to go in for an increasingly larger size of generating units, accelerated *tempo* of coal mining, complex water collection and storage systems in hydroelectric projects, extensive transportation and transmission facilities and the like, the investment peaks will tend to be larger with time.

Considering the critical role of energy in the infrastructure of economic growth, it may be necessary to insulate energy development at the country levels, and thereby the region as a whole, from the fluctuations in the financial fortunes of various countries. This may be possible only if funding of important energy projects on a country basis and a regional basis is assured, over and above general budgetary support at country levels.

International agencies such as the International Bank for Reconstruction and Development and ADB are evincing more and more interest in the energy sector; and several funds for bilateral aid have been set up in recent years by the oil exporting and other countries. Such interests should be encouraged, preferably in the spirit of complementary effort, to provide a regular flow of funds. Such financing arrangements inculcate financial discipline among those responsible for project formulation and implementation and commercial operation thereafter. Strict appraisal procedures provide a safeguard against inadequate investigation and insufficient examination of the techno-economic aspects while drawing up a project, while the fact that loans have to be serviced generates a greater degree of cost consciousness and attention to financial returns.

If the energy products and services are to perform their proper function without being a drag on the general budgetary support of the developing countries, they must be based on input prices that represent at least approximately the scarcity value of these inputs to their economies. This observation has special relevance to the inputs of capital and foreign exchange of which developing economies are conspicuously and chronically in short supply. Shadow prices for capital and foreign exchange may be recommended in calculating the cost to the economy of providing energy inputs as feedstock, infrastructure and services.

There may be non-price incentives and disincentives also. These may be more in the nature of providing reliable alternative energy sources, which were hitherto not available to the consumers, to set in motion a process of substitution of petroleum and its products wherever technically feasible and economically viable. Institutional credit facilities may also be extended for the installation of new equipment for making a change-over from oil to other sources. The cost of energy inputs being relatively small in certain categories of industries, such as engineering and non-resource-based categories, the change-over may not be difficult even at marginally higher energy cost.

Along with the growth of the economy, the income elasticity of demand will come into play and domestic consumers may opt for cleaner forms of energy such as electricity for lighting homes. The rural population might take to soft coke or even raw coal, given reliable and inexpensive supply, in place of non-commercial fuels, although some regulatory action may also be needed to eliminate cutting down of forests and for using dung as organic manure in the agricultural fields. Propagation of biogas plants based on agricultural by-products, animal and human wastes, etc. may be vigorously pursued.

A selection of aspects which may be given special consideration in this respect, subject to consideration of the balance between requirements and availability of various forms of energy, is given below:

(a) Oil-burning power station boilers to be modified or replaced for burning coal indigenously available or even imported;

(b) Oil-burning industrial boilers to be modified or replaced to use coal, coal gas or producer gas;

(c) Extensive rural electrification to eliminate kerosene as an illuminant;

(d) Electrification of railways where dieselized traction prevails;

(e) Town gas plants based on urban wastes and supply of coal gas where possible may eliminate kerosene, liquefied petroleum gas, etc. for cooking;

(f) Setting up of coal dumps evenly spread throughout the country.

To bring about the above and other changes in the structure of energy supply, technological input of a high order is a prerequisite which many of the developing countries are at present not in a position to provide. Therefore, transfer of technology on an accelerated scale from relatively more developed countries within and outside the region may be an essential requirement for quite some time to come. In this regard, an arrangement of pooling information, technology and expertise within the developing countries of the region may help not only in keeping down the cost but also in the expeditious execution of energy projects.

The energy sector extends to so many diverse forms fuels and technological pursuits that production, transformation, transportation and utilization cover a vast area for research and development work. In most of the developing countries with limited resources of men, material and money for such work, efforts in research and development need to be oriented towards solving problems connected with the transfer, or rather transplanting, of technology already developed elsewhere, rather than undertaking original basic research. The priorities for action should be determined with reference to the nature of the problem, the chances of solving the problems under the constraints of funds and time, and the results of efforts undertaken on similar problems elsewhere. Typical problems are listed below:

(a) Increasing efficiency of production and use of energy of various forms, particularly oil;

(b) Substituting coal, coke or coal gas for oil products;

(c) Developing technologies for the production of cheap, commercial, coal-based fuels for use in the domestic and industrial sectors;

(d) Developing new and non-conventional sources of energy to supplement the fossil fuel supplies.

D. ADMINISTRATION AND MANAGEMENT

The responsibility for the production, generation, transmission, transportation, supply and distribution of energy in its various forms is in general widely dispersed in a number of ministries and departments. Data collection, collation and analysis is also hampered owing to lack of cohesion. All the same, for thorough energy planning, taking into consideration all the aspects and the implications touched upon in the earlier paragraphs, centralized thinking is necessary. The central ministries, departments and research organizations in the countries will naturally go into the matter within their respective jurisdictions and produce well-considered propositions in respective areas.

To enable Governments to take an integrated view of the whole situation, an energy planning unit, with the responsibility for carrying out continuous research and analysis and informing the Government, is required to fill a gap in the organizational patterns existing in most governmental systems. The unit would need to include persons with a good deal of previous experience in energy matters, as it will depend on this for its standing and authority. The members must be numerous enough to permit adequate specialization in the chief types of energy and their uses, and responsible enough to be effective in discussions with senior officials in the various ministries and the industries concerned.

In order to evolve a national consensus on energy policy and adequately to consider the output of the energy planning unit and suggest priority lines of work, it would be desirable to set up an interministerial advisory committee, as energy problems are the concern of many ministries covering both the supplies of energy in all its various forms, the demands for energy for various purposes, and budgetary problems.. Suggested broad terms of reference of such a committee could be:

(a) To review the trends in consumption of energy of various forms and forecasts of future demands;

(b) To consider estimates of available supplies from various energy sources, both indigenous and imported, and establish priorities for developing the different energy sources;

(c) To consider policies for reducing costs of energy.

The committee should normally try to look five years ahead, and concentrate its main attention on the trends of the next three years or so. It may be helpful to have the latest, but less detailed, thinking about trends up to 10 or 15 years ahead, since investment in the energy field needs to be planned far ahead, with the longer-term demand and supply position in mind and to cover adequately the gestation period of large energy projects.

The importance that may be attached to the work of the committee will very much depend on the influence it may exert in the formulation of policies and decisions. If the Government uses it as an important instrument in framing its own policies with regard to investment over the whole field of energy, and as the forum in which various energy projects have to be justified if investment is to be approved, the help and assistance with both information and personnel that the various ministries are likely to give to the work of servicing the committee is likely to be more generous and effective.

Up to the early 1970s, all over the world the trend was to provide energy at the minimum cost since adequacy of supply was not very much in question. But the shortages and uncertainties in oil availability, in addition to its high price, during the past few years have placed adequacy of supply of energy in any alternative form on an equal footing with minimization of energy cost, and this may mean changes from traditional governmental guidelines.

Certain organizational arrangements would facilitate increased government activity and control in the energy field. The interministerial advisory committee suggested earlier could have its power increased to that of a full-fledged energy board which would ensure the integration of the energy plan with the national plan not only at the stage of drafting the plans but at every stage of their implementation. The energy planning unit would become the secretariat of the energy board. If preferred, such a board may also be constituted with autonomous power as a statutory body by an act of Parliament. The following functions of such an energy board are suggested for consideration:

(a) To plan for temporal and spatial development of the entire energy sector in respect of the constituents of energy, namely, coal, lignite, oil, gas, electricity, atomic power, non-commercial energy and non-conventional energy, on a national and sectoral basis;

(b) To optimize the production-mix through system analysis as well as in-depth substitution studies for attaining the optimum solution consistent with the internal and external funds;

(c) To appraise and approve individual energy projects taking into consideration economic and social factors;

(d) To monitor and expedite the progress of sanctioned projects to their fruition;

(e) To determine the investment requirements for the individual components of the energy sector, including energy production, transportation, and equipment manufacture, and to sustain an energy plan as a continuing process in relation to the economic plan of the country;

(f) To evolve and maintain a pricing, tariff and taxation framework, taking into account the scarcity values of individual energy resources and products in the energy economy, and to arbitrate in disputes between supplier and consumer (including different agencies);

(g) To consider the choice of technology in the energy consuming sectors, particularly the energy-intensive industries and transportation, with a view to preempting adverse effects on the energy supply position at a future date;

(h) To control public sector funding for research, development, preinvestment appraisal and detailed investigations and surveys for the production and utilization of any form of energy, their approval and licensing, etc.;

(i) To carry out a continuous review of international trade in energy products in order to be knowledgeable when negotiating production, import and export contracts;

(j) To lay down a set of guidelines for both energy producing and consuming sectors, subject to periodic reviews when new circumstances arise.

The envisaged energy board would have as one of its functions the issuing of final sanction not only for public sector projects, but also for proposals from the private sector, in the context of the over-all needs of the country, and it would issue approval for projects and licences for equipment manufacture. The importation of equipment and energy products should also be a responsibility of the board, and its clearance needed from the angle of suitability as well as local non-availability. However, it is not suggested that the board as such would deliberate on minor issues, or delay worthwhile projects by requesting more and more details. An effective method for delegating responsibility on minor matters to the respective ministries to act in accordance with the guidelines would have to be agreed on with the respective ministers, as members of the board, accountable to the board.

A proper pricing policy for energy would have to be based on an adequate appreciation of the delivered cost of each form of energy over time. The price policy should take into account the interests of the producer, consumer and the nation. The relative prices of energy in different forms and qualities should be such as to enable the production of each in required quantities and prevent wasteful production or import of energy forms in short supply. The approach should also enable the industry to undertake and implement a long-term policy of exploration and technical research to improve the efficiency of production, transformation, distribution and utilization. From the national point of view, energy prices should ensure that the pattern of use of energy is in keeping with the optimum pattern of production plus imports, as determined with reference to the availability and cost. In practice, it is difficult to evolve a pricing system which may work equally satisfactorily from all points of view and prices would have to be determined on the balance of advantages.

While the procedures for price determination will vary with the nature of the energy industry for whose products the price is to be fixed, the Government, through its energy board if set up, will have to determine and indicate, taking into consideration the opportunity cost of investment resources, a reasonable rate of return to be fixed for energy industries as a whole which would serve as the guideline for any committee which is entrusted with the task of price fixing for any form of energy. For example, taking note of the objectives of a rational price policy in the energy sector, the Energy Survey Committee of India in 1965 suggested that energy industries should yield a return of at least 10 per cent on the investment.

The present high level of energy consumption in the more industrialized countries in the world has been accompanied by a great deal of concern about energy and the quality of life, particularly the secondary social costs of such consumption. The burning of fossil fuels in power stations has given rise to increasing air pollution in some areas, but pollution from vehicles may be more acute. The recovery of mineral fuels may cause irreversible damage to landscapes. The nuclear era is bringing with it problems that challenge human capacity to control the technologies that are being introduced.

While many such problems are receiving attention, much confusion exists at the policy level as to how to cope with these issues. The developing countries of the region are fortunately not suffering much from such environmental problems, although some urban conglomerations are already having pollution difficulties. Pre-emptive actions right from the beginning of energy planning by each developing country should be one of the functions of their energy boards.

Put to use judiciously, energy is a silent servant of mankind, and has influenced its life-styles for the better with the growth of civilization. Functionally, energy has three roles to play a factor of production, a process feedstock and a consumer item. Hence, energy is not only a component of the productive process but also an element fundamental to welfare. Unfortunately, there is hardly any realization among the masses in the developing countries of the region about the usefulness and appropriateness of energy in all kinds of economic activities for alleviating the lot of the people.

It would be extremely useful to introduce education courses on various energy forms, their production, transformation and utilization to assist informed public involvement and to generate enthusiasm about energy project, and a concern for efficiency and economy in the use of energy. It is also vitally necessary to upgrade existing training programmes, and develop new ones, to create a pool of trained manpower for the execution of the required works.

CONCLUSION

As an over-all planning strategy evolved through the hard realities of the energy crisis, it has to be recognized that energy planning in the development process demonstrates the need for a holistic approach to large-scale problem-solving at the national level. It is not enough to put the investment funds in a ready-built enterprise without the application of technological innovation, the tools of techno-economic analysis and a significant depth of social perspective.

For alleviating the socio-economic condition of the masses in developing countries at the fastest possible rate, the supply of energy should stretch far and wide. The gains to each developing country individually, and the region collectively, from satisfactory energy policies are so great, and the potential damage from unsatisfactory policies is equally as great, that it is worthwhile devoting financial resources to creating the knowledge and assisting clarification of the issues on which policies must be based.

ESCAP's ENERGY PROGRAMME

(Synopsis of NR/WGMEPP/4)

This document gave a brief review of the activities of the Energy Resources Section of the Natural Resources Division of ESCAP during the period from 1974, and the programme of work for the remainder of 1978 and 1979.

Suggestions for future activities, recommended at various meetings and/or provided by individual countries in answer to a letter of enquiry concerning the agenda of the fifth session of the Committee on Natural Resources, were listed.

III. INFORMATION PAPERS SUBMITTED BY GOVERNMENTS AND OTHER INTERESTED PARTIES

RESOURCES, PLANNING AND PROGRAMMING OF ENERGY IN AFGHANISTAN

(NR/WGMEPP/14)*

by

Ahmad Shah Arsalan (Afghanistan)

A. RESOURCES OF ENERGY

1. *Coal*

The total likely reserves of coal including anticipated and speculative reserves were 200 million tons. Proved, probable and possible reserves were 27 million tons. The exploration programme included development of Dara-i-Suf coal-mine to raise production from 5,000 tons per annum to 175,000 tons per annum by 1982, exploration and development of Sabzak coal-field to raise the annual production from about 3,500 tons to 14,000 tons within a year or so, followed by further increases, and proving and developing new mines in the northern region.

2. *Oil and natural gas*

The total reserves of oil including anticipated and speculative reserves were 25 million tons, of which proved reserves were 10 million tons.

Reserves of all categories of gas equalled 168,000 million m^3, of which proved reserves of gas were 66,000 million m^3.

Exploration by geological prospecting and seismic survey as well as exploratory drilling would be carried out in northern, north-western, western and south-western prospective regions.

3. *Hydroelectric energy*

The total installed hydropower capacity in 1976 was 254 MW. A large development programme had been envisaged and it was anticipated that a total of 497 MW of hydroelectric capacity would be available by 1982.

4. *Nuclear energy*

No nuclear energy was being produced at present. Speculative reserves were estimated to be about 4 tons of uranium.

* Abridged.

5. *Non-commercial sources of energy*

Wood was used extensively as a source of energy for heating in winter and as firewood in ovens. Owing to scarcity and heavy use, this was a fast-dwindling source of energy and could not be relied upon much longer, despite some afforestation schemes.

B. PRODUCTION AND CONSUMPTION OF ENERGY

1. *Coal*

	Present (1975) (tons)	*Projected (1982) (tons)*
Production	145,000	520,000
Consumption		
Industrial	112,100	453,000
Domestic	32,900	67,000
Import/export	Nil	Nil

2. *Oil*

	Present (1976) (tons)	*Projected (1982) (tons)*
Production	10,000	205,000
Consumption	242,700	589,800
Import	232,700	384,000

3. *Natural gas*

	Present (1975) (million m^3)	*Projected (1982) (million m^3)*
Production	3,000	3,400
Consumption		
Fertilizer	50	63
Thermal power ..	76	153
Other	24	24
Export	2,850	3,200

4. *Electricity*

	Present (1975)	*Projected (1982)*
(a) Hydroelectricity		
Installed capacity ..	254 MW	497 MW
Production	532 million kWh	1,047 million kWh
(b) Thermal		
Installed capacity ..	43 MW	332 MW
Production	157 million kWh	555 million kWh
(c) Diesel		
Installed capacity ..	50 MW	54 MW
Production	28 million kWh	26 million kWh
Total installed capacity ..	347 MW	883 MW
Total production	717 million kWh	1,628 million kWh
Import/export	Nil	Nil
Per capita production ..	43 kWh	83 kWh

5. *Electricity consumption in industry*

Consumption of electricity in various industries totalled over 500 million kWh in 1975, as shown below, and is forecast to increase at the rate of 9.4 per cent per annum.

Industry	*Consumption (million kWh)*
Textile	468.58
Cement	12.20
Fertilizer	6.70
Food industries	6.02
Engineering	2.17
Plastic	1.37
Mining	N.A.
Miscellaneous	3.43

C. ENERGY PLANNING AND PROGRAMMING

1. *Major problems and constraints in the development of energy*

The financial resources of the country were very limited.

The absence of adequate professional cadres in the field of energy was a basic problem. There was no comprehensive personal training programme to meet requirements for the development of energy resources.

Transport facilities were lacking. Afghanistan was a land-locked country and the absence of railways was a big hurdle in implementation of energy projects. Also, much needed to be done regarding the expansion and improvement of the road network.

Basic facilities and essential data were particularly needed for the proving of reserves of oil and natural gas and the determination of hydropower potential and assessment of other indigenous sources of energy.

Workshops and laboratories for repair, testing etc., and similar infrastructural facilities, were yet to be developed.

Most of the existing hydroelectric generating capacity was located in or around Kabul, thereby restricting the development of industries, employment opportunities and social amenities elsewhere. There was a need to provide for production and distribution of energy in other regions of the country.

Utilization of the power generated had been a problem owing to lack of satisfactory distribution facilities. Losses had been high, amounting to 40 per cent.

Evaluation and techno-economic studies of thermal power generation by natural gas and coal, including the cost of transmission from the generating centres, were yet to be undertaken.

2. *Institutional arrangements for planning and programming*

The planning and execution of the country's electric power programmes was the responsibility of the Ministry of Water and Power. Under that Ministry, the Electricity Authority was the sole agency responsible for this work. The National Institute of Petroleum and Natural Gas was responsible for development and co-ordination of the production, import, export and distribution of potroleum products and natural gas.

3. *Training*

A comparative picture of the number of persons engaged in 1975 and required by 1982 in the power section alone was:

1975				*1982*			
Total	*High level*	*Medium level*	*Skilled worker*	*Total*	*High level*	*Medium level*	*Skilled worker*
1,212	25	193	993	5,211	198	805	4,208

It was necessary to intensify and expand educational and training programmes in the fields concerning development of energy resources by improving facilities and recruiting more teachers. Further requirements might be met from outside.

4. *Programme of action*

(a) *Action within the country and need for outside assistance*

It had been decided to carry out survey and investigation for resources of oil, gas and coal, and to determine the potential of other sources such as hydro-electricity and nuclear energy. Evaluation of power resources and demand projections for energy were envisaged to be set out as short-term and long-term plans, taking into account requirements of the transport sector, domestic heating in winter, new industries, etc. There will be a need for outside assistance for techno-economic studies of important deposits and energy projects, managerial skill for implementing such projects, and construction and extension of high-voltage electric transmission and distribution networks.

Implementation of small hydro and diesel power stations for stimulating the growth of industries and providing social amenities in remote, under-developed or undeveloped areas of the country had been planned, along with intensification of educational programmes in the fields concerning energy resources. There would be a need for outside assistance in building up facilities and in providing services of experienced teachers on loan.

Improvement in communication facilities and implementation of important road projects providing access to sources of energy had been planned as priority projects.

(b) *Collaboration with neighbouring countries*

Technical co-operation with neighbouring countries and developing countries of the subregion was an important component in the plan of action as envisaged.

(c) *Assistance from international organizations*

In the implementation of an energy plan and a scheme of action, financial aid as well as high-level technical know-how from international bodies were considered essential prerequisites.

AUSTRALIA'S ENERGY SITUATION

(NR/WGMEPP/CRP.5)*

by

The Department of National Development (Australia)

A. ENERGY RESOURCES

In terms of its population and expected future energy requirements, Australia was extremely well endowed with economic resources of black and brown coal, oil shale, and uranium. The main deficit item in the future supply of energy was likely to be oil. On current resource estimates it was expected that domestic self-sufficiency in oil would decrease from about 70 per cent in 1976/77 to about 45 per cent in 1985. In a recent report the resources of non-renewable energy were classified according to feasibility of economic extraction and certainty of geological occurrence. Table 1 summarizes the current resources situation. The resource potential for hydroelectricity is summarized in table 2.

Very large demonstrated resources of oil shale probably contained at least 500 times as much oil as the crude oil identified in Australia to date. These deposits were not currently economic, however, at current oil prices and with existing mining and extraction technology — although development of *in situ* processing techniques appeared to have considerable potential.

Identified resources of natural gas were adequate for the foreseeable future, but, because of their remote location, substantial exports and/or higher prices might be necessary to justify economic development of some large deposits. There were ample resources of black coal to cope with domestic demand and to sustain very large quantities of exports for many years. Brown coal resources were also sufficient to allow considerable increases in production in the future. Known resources of black and brown coals were suitable for many end uses, including coke-making, electricity generation and coal conversion. Also, vast quantities of coal existed that were not economically extractable by existing techniques, but which might be suitable for *in situ* gasification in the future.

Recoverable economic resources of uranium represented more than 17 per cent of the world's low-cost uranium and more than 10 per cent of Australia's demonstrated economic energy resources. There were excellent prospects for the discovery of additional uranium resources. While it was very unlikely that there would be any development of nuclear power generators in Australia before the 1990s, the uranium industry had the potential to become one of Australia's largest export industries (in value terms).

Regional energy resources did, however, vary widely. Excluding oil and petroleum products, there was little trade between the States in energy materials, so that local energy resources had a large influence on the States' patterns of fuel usage.

B. EXPLORATION PROGRAMMES AND PROSPECTS

1. *Petroleum and natural gas*

Seventy distinct unexplored petroleum plays had been identified. The drilling and associated geophysical effort would be costly, and additional expenditure would

* Abridged.

Table 1. Australia's non-renewable identified economic energy resources

Resource	Quantity		Specific energy (10^{15} joules)	
	Demonstrated	Demonstrated plus inferred	Demonstrated	Demonstrated plus inferred
Crude oil and condensate				
In situ	673×10^6 tons	687×10^6 tons	29,700	30,000
Recoverable[a]	284×10^6 tons	287×10^6 tons	12,400	12,500
Sales gas and LPG				
In situ[b]	545×10^9 m^3	590×10^9 m^3	21,000	22,700
Recoverable	327×10^9 m^3	354×10^9 m^3	12,600	13,600
Black coal				
In situ	$36,300 \times 10^6$ tons	$196,000 \times 10^6$ tons	1,040,000	5,600,000
Recoverable[c]	$20,260 \times 10^6$ tons	$110,000 \times 10^6$ tons	580,000	3,125,000
Brown coal				
In situ	$40,930 \times 10^6$ tons	$40,930 \times 10^6$ tons	400,000	400,000
Recoverable	$39,000 \times 10^6$ tons	$39,000 \times 10^6$ tons	380,000	380,000
Uranium				
In situ	346×10^3 tons	439×10^3 tons	195,000	245,000
Recoverable	289×10^3 tons	333×10^3 tons	160,000	185,000
Total				
In situ			1,685,700	6,297,000
Recoverable			1,145,000	3,716,100

[a] Recovery factor for crude oil used for condensate.

[b] Recovery factor of 60 per cent assumed.

[c] Recovery factor calculated for demonstrated resources assumed to apply to inferred resources.

Table 2. Hydro-power resources in eastern Australia (*million kWh/year*)

State	Potential	Installed plus committed
Tasmania	13,000	9,400
New South Wales (including Snowy Mountains area)	5,500	5,000
Queensland	2,500	400
Victoria	1,500	900
Total	22,500	15,700

be required for exploration of off-shore areas. Eight exploration wells were drilled on shore and 13 exploration wells off shore in 1977.

Environmental, sea-bed boundary and aboriginal lands rights questions also limited the availability of Australia's petroleum resources. The Great Barrier Reef area had not been explored since a moratorium was placed on exploration in 1970. Drilling of a major structure in the Timor Sea area had been delayed pending resolution of the sea-bed boundary between Australia and East Timor. Exploration and development activities in central Australia had been essentially suspended since 1972, pending formulation and implementation of the Government's policies with respect to land rights for Aborigines.

Because of depth of water, severe operating conditions, remote locations and the limits of technology, it would probably be some years before private enterprise would be prepared to explore the off-shore areas, and potential petroleum production from these areas was even further into the future. Major future developments over the next decade were likely to be limited to the North-west Shelf (currently the subject of a fessibility, planning and definition study); a scheme for the development of the "wet" gas and oil fields in the Cooper Basin region, and further developments of the off-shore gas and oil fields in the Gippsland Basin.

2. *Oil shale*

Considerable interest had recently centred on the possibility of extracting oil from Australia's vast oil shale resources. Two major options were currently under investigation: mining, followed by surface processing of shale to extract the oil, and *in situ* processing.

Indications were that, owing to the relatively thin oil shale strata and the present state of the technology, only the first method was considered to have advanced to the stage where large-scale, commercial production was feasible before the mid 1980s. However, the method required large volumes of water, left large volumes of spent shale residue on the surface, and also caused air and water pollution problems. The resources contained in the Toolebuc Formation in Queensland were thought to have lower potential for economic exploitation because of geographic location and limited availability of water for mining and processing. Development of *in situ* processing, which required much less water, could improve its economic prospects.

3. *Black coal*

Exploratory drilling continued at an increasing rate, and further high-grade, low-cost resources had recently been delineated. The Joint Coal Board, in co-operation with the Queensland Coal Board, recently completed work on a survey of Australian black coals of conversion potential and a survey of fuel coals. In addition, joint state and commonwealth projects had commenced in order more fully to evaluate the economic potential for coal to oil conversion processes using black and brown coal. Increased attention was also being paid to improving the recovery factor at underground mines, but the greatest improvements in recovery would result from increased use of open-cut mining. With the trend towards deeper open-cut mining (down to 300 m), more coal would be recoverable and as a result the level of demonstrated economic resources and their recoverable fraction would be increased significantly.

4. *Brown coal*

Most of Australia's brown coal resources were located in the Latrobe Valley and the Murray Basin in the south-east region of Australia. Owing to the relatively high water content, and consequently low specific energy content, development of these resources had been mainly confined to their use in on-site power generation. Future exploration and development programmes were likely to be directly linked with electricity demand projections, and possibly their usage for coal-oil conversion if proved economic.

New technology and relative economics might enable "thin" seams (less than 15 m thick) to be economically mined and with the trend towards deeper open-cut mining, thick seams deeper than 200 m could be economically extracted. However, as the open-cut mines in Victoria had increased in depth, problems associated with substantial flows of artesian water, regional subsidence and batter stability had been encountered.

A proposed pilot plant to investigate upgrading brown coal for use in steel-making, using a solvent refining process, could eventually lead to the development of a coal liquefaction plant.

5. *Uranium and thorium*

Exploration, so far, resulted in the discovery of about 17 per cent of the Western world's high-grade uranium resources. Over 90 per cent of identified resources of uranium occurred in seven deposits. Exploration cost per kg of uranium discovered had been extremely low by world standards. However, in the future, more expensive exploration, involving more drilling and the increased use of sophisticated geological models and geochemical and geophysical techniques, would be required.

The bulk of the potentially exploitable resources of thorium occurred in essentially lower-grade accumulations, mostly as monazite. To date, monazite had only been produced as a by-product of sand mining for rutile, ilmenite and zircon; exploration effort for mineral sands had responded generally to changes in the prices of titanium and zircon. Much more monazite was produced than was used and the price of monazite was not directly related to the level of production. Thus there was little direct incentive for exploration. However, monazite tailings dumps would be available as a future source of thorium.

6. *Hydroelectricity*

With the exception of Tasmania, Australia was not well-endowed with hydroelectric resources because of its generally low rainfall and limited areas of high relief. Its hydroelectric resources were confined almost entirely to Queensland, New South Wales, Victoria and Tasmania.

Although hydropower plants currently provided a significant amount of electricity, the relative contribution was bound to decline. Most of the economically favourable sites had been developed and only Tasmania and, to a lesser extent, north Queensland, had any significant undeveloped resources. The relatively small resources remaining elsewhere might in time be developed for peak load power. In addition, environmental considerations would be likely to further reduce the availability of energy from this source. Although hydroelectric developments utilized a non-polluting renewable source of energy, their existence and construction disturbed the landscape, natural water flows, etc.

C. PROCEDURES FOR RESOURCE ASSESSMENT

The basic requirements for any assessment of resources were the fundamental geological, engineering and economic data and the methodology to analyse and assess those data. Currently, there was no single universally accepted classification system for different energy resources, but considerable effort was being directed towards that objective.

1. *Petroleum and natural gas*

The Commonwealth currently had access to off-shore data submitted under the Petroleum (Submerged Lands) Act 1967, off-shore and on-shore data submitted under the Petroleum Search Subsidy Acts, and data obtained in the Northern Territory. It did not, however, have access to unsubsidized on-shore data unless these had been released by the States or companies. This machinery on its own was therefore inadequate for national assessment of petroleum resources.

Late in the 1960s the Bureau of Mineral Resources, Geology and Geophysics (BMR) organized a co-operative system for determining the magnitude of proved and probable recoverable reserves (demonstrated resources) of oil and gas. Under this system, companies supplied figures on initial recoverable reserves, cumulative production, and current remaining reserves for each field. A small group was formed in BMR in 1976 to undertake the assessment of undiscovered resources of oil and gas.

2. *Coal*

Exploration permits in each State laid down specific conditions, and the Mines Department in each State and the Department of the Northern Territory collected detailed results of all exploratory drillings carried out within their boundaries under these permits. In addition, the responsible state departments carried out their own drilling programmes.

3. *Uranium and thorium*

Notification of the discovery of uranium or thorium ores in Australia was required, under the Atomic Energy Act, to the Australian Atomic Energy Commission (AAEC). An independent assessment of the find was made by the Commission from the basic drilling data supplied by the company. The responsible department in each State and the Department of the Northern Territory also had the power to collect detailed results of all exploratory drilling carried out within the various mineral tenements issued. BMR compiled and evaluated data on Australia's identified uranium and thorium resources using published information plus confidential information from individual companies. BMR did not have access to the detailed exploration data collected by State mines departments or by AAEC unless provided under a separate agreement with the companies concerned.

4. *Oil shale*

The responsible department in each State and the Department of the Northern Territory had the power to collect all basic exploration data on oil shale deposits acquired in mineral tenements within their boundaries. BMR compiled published information on oil shale deposits and obtained more detailed data from companies involved in oil shale exploration.

D. AUSTRALIA'S ENERGY PROFILE

1. *Historical review*

During the 1960s and early 1970s Australia experienced rapid economic growth, largely facilitated through extensive development of its abundant natural resources, including energy. Low, and often falling, real energy prices, especially for hydrocarbon fuels, encouraged their extensive usage in manufacturing and transport activities as well as for the production of secondary fuels (including electricity). The national energy intensiveness (as measured by the quantity of energy input for a given value of real output) increased by more than 10 per cent over the period 1960/61 to 1976/77. Demand for primary fuels more than doubled over that period, with demand for petroleum products almost trebling, attaining an estimated energy market share of about 46 per cent in 1976/77.

While the recent increases in world oil prices had imposed considerable burdens on the balance of payments situation in many countries and increased domestic energy and oil prices, there had been offsetting benefits to Australia. World demand and prices for substitute fuels had increased, resulting in very large increases in the value of alternative energy resources and their export. Prospects had greatly improved for healthy long-term growth, particularly in the coal, natural gas and minerals processing industries, while exploration for energy, especially oil, had also increased.

During 1976/77 the value of indigenous primary fuels consumed within Australia was about 5 per cent of the gross domestic product, and direct employment in areas of energy resource development, processing and distribution was around 120,000 persons. Capital expenditures in those areas amounted to about 5 per cent of total gross investment, and approximately 15 per cent of the total value of exports consisted of energy materials.

2. *Demand*

Domestic demand projections were made by the Department of National Development for the period 1976/77 to 1986/87. The total primary energy demand was projected using two different assumptions about the rate of growth of GDP and an assumed rate of growth of real energy prices. The influence of other factors might then be assessed in terms of their influence on the base energy projections.

For given energy prices, the 1986/87 level of energy demand would be some 7 per cent higher if the long-term GDP growth rate was 5 per cent per annum compared with a long-term GDP growth rate of 4 per cent per annum. A high rate of growth of energy demand projected for the latter half of the 1970s was directly attributable to the higher levels of the GDP growth rate for that period, the influence of long adjustment lags and the relatively low increases in real energy prices. The relative influence of those factors was projected to change considerably during the early 1980s with a return to lower rates of energy growth.

The projections, as constructed, excluded any large changes in the pattern of demand for energy in each of the major energy-using sectors. However, possible industrial projects which would be large consumers of energy could have a major effect on the estimates of demand derived from historical analyses. These hypothetical projects included an export-oriented, integrated steel-making plant of several million tons per annum capacity, a large-scale industrial development in the northern part of Western Australia, and a uranium conversion and enrichment plant. The additional consumption requirements would amount to approximately 11 per cent of total primary energy requirements in 1986/87 under the high GDP growth projection.

Neither projection indicated a return to the earlier high levels of energy intensiveness, which were at least partially attributable to the lower real energy prices then prevailing. Some of this change in energy intensiveness might come about by structural shifts in the economy, with an increased proportion of GDP derived from the generally less energy intensive tertiary sector.

Both projections, however, indicated a continuing growth in demand for petroleum products for fuel purposes, especially as the Australian economy recovered from recession and the manufacturing and mining sectors of the economy expanded. In the short term, the lack of readily substitutable alternatives to oil for use in locations away from the major population centres, and for transport, meant that higher oil prices would have only a marginal effect on consumption. The increased demand for oil was also expected to occur over a period when domestic production was expected to decline and when the prices and supply of oil from overseas sources might display increased instability.

Table 3 shows the historical and projected production of primary energy excluding hydroelectricity, and table 4 indicates the expected production of electricity from both hydro and thermal sources. The internal demand for primary fuels is shown in table 5, expressed in joules, on the basis of a long-term rate of growth of GDP of 4 per cent.

E. METHODOLOGY OF PROJECTIONS

1. *Methodology*

Separate demand projections were derived for: transport fuels: (a) motor spirit; (b) other transport fuels; and for non-transport fuels: (c) non-transport feuls other than those used in electricity generation; (d) fuels used in electricity generation.

Table 3. Production of primary energy

	Black coal (million tons)	*Brown coal (million tons)*	*Crude oil[a] (million tons)*	*LPG[b] (million tons)*	*Natural gas (10^9m^3)*	*Wood (million tons)*	*Bagasse (million tons)*	*Uranium oxide (tons)*
1970/71	53.7	23.2	12.9	0.40	2.0	2.4	5.3	0
1971/72	59.3	23.6	16.5	0.66	2.6	2.3	5.9	0
1972/73	66.4	24.1	17.9	0.97	3.7	2.2	5.8	0
1973/74	66.6	26.3	20.1	1.10	4.4	2.2	5.9	0
1974/75	78.2	27.5	20.0	1.17	4.8	1.8	6.2	0
1975/76	77.1	29.2	20.6	1.20	5.4	1.8	6.7	119
1976/77	85.9	31.0	21.2	1.37	6.4	1.7	7.2	486
1977/78	84	31	21.8	1.55	7.4	1.7	7.2	NA
1980/81	100	34	20.7	1.63	9.4	1.5	7.5	NA
1984/85	106	39	18.4	2.66	18.6	1.4	7.8	6,000[c]
1986/87	124	43	16.1	2.66	24	1.3	8.0	9,000[c]

Sources: Australian Bureau of Statistics publications; Department of National Development projections.

Notes: [a] Includes condensates.

[b] Victorian off-shore production only, for years up to 1980/81.

[c] Estimates of feasible production.

Table 4. Production of electricity: total generation
(million kWh)

	1976/77	1977/78	1980/81	1984/85	1986/87
Public thermal	60,725	61,397	73,807	94,818	101,292
Public hydro	13,618	13,379	15,169	15,521	16,312
Private thermal	8,083	NA	NA	NA	NA
Total	82,426	NA	NA	NA	NA

Table 5. Demand for primary fuels
(joules × 10^{15})

Fiscal year	Black coal	Brown coal	Petroleum products	Natural gas	Wood	Bagasse	Hydro-electricity	Total
1960/61	531	146	483	10	62	27	17	1,266
1970/71	654	228	1,066	74	39	50	42	2,154
1971/72	669	237	1,111	102	38	56	42	2,256
1972/73	721	240	1,140	144	36	56	43	2,378
1973/74	729	260	1,245	171	35	56	48	2,544
1974/75	773	273	1,243	191	30	62	54	2,626
1975/76	750	290	1,255	213	29	65	56	2,658
Growth rate 1960/61 to 1975/76 in percentage	2.67	4.33	7.10	—	−4.69	5.15	7.73	5.45
Projected								
1976/77	836	310	1,317	256	28	69	49	2,865
1977/78	833	314	1,348	292	27	69	48	2,931
1978/79	897	326	1,407	323	26	71	50	3,099
1979/80	939	326	1,459	351	25	71	55	3,225
1980/81	985	344	1,508	365	25	72	55	3,353
1981/82	1,027	361	1,555	390	24	72	53	3,482
1982/83	1,073	357	1,598	417	23	73	54	3,595
1983/84	1,116	381	1,607	481	23	74	56	3,737
1984/85	1,173	388	1,606	568	22	75	56	3,888
1985/86	1,227	413	1,649	610	22	76	57	4,053
1986/87	1,292	425	1,691	619	21	77	59	4,184
Growth rate 1975/76 to 1986/87 in percentage	4.78	3.34	2.67	9.89	−2.79	1.32	1.27	4.08

Motor spirit accounted for about two thirds of the consumption of transport fuels in Australia; for this, a detailed mathematical model was used. This model incorporated a motor vehicle demand projection; expected changes in the age, size, fuel economy of motor vehicles (including the effects of vehicle emission control legislation); and vehicle utilization. The motor vehicle demand projections were based on an econometric model, using the same assumption for the rate of economic growth as was used in the total energy demand projection.

Other transport fuels. Demand functions for each of those were estimated using relatively simple econometric methods modified as appropriate in accordance with information supplied by airline, railway, shipping and other transport organizations.

Non-transport fuels, other than those used in electricity generation. Information received from a fuel survey carried out by the Department of National Development and econometric techniques were used to estimate energy demand. A relationship was determined between known energy consumption over the past six years and estimates of economic activity for the relevant non-transport industry groups for six States and Australia. Long-term projections of economic activity by industry groups and for each State were then prepared by the Department and in conjunction with the energy relationships developed above were used to derive projections of energy demand for each industry and State. Those derived energy projections were then compared with corresponding data obtained from the fuel survey. The total energy projections within each non-transport industry group by State were then dissected by fuel type from information supplied by industry.

Fuels used in electricity generation. The growth in demand was projected based on a departmental estimate of 1.225 for the future income elasticity of demand for electricity. The dissection by type of primary fuel requirement was derived from survey information relating to hydroelectric output and the primary fuels mix of the thermal stations. Current levels of thermal efficiency in the generating stations were assumed to be maintained.

Constraint on total. Finally, the projection of total primary energy demand was constrained to conform with a projection derived from an econometric function. The major determinants of the past growth in primary energy demand were estimated from a relationship between total primary energy, economic activity as measured by the GDP and a composite energy price index adjusted for inflation.

2. *Assumptions*

In deriving projections of energy demand, assumptions were made concerning: (a) rate of economic growth; (b) future energy prices; (c) availability of energy supplies; and (d) energy technology.

Rate of economic growth was taken as 4 per cent per annum, with adjustments made for immediate and short-term expectations. Energy demand was also dependent on the energy intensiveness of the economy generally. Structural shifts in the economy were identified on the basis of trends in historical information since 1965: these demonstrated an increasing proportion of GDP being derived from the tertiary and mining sectors.

Future energy prices. The assumptions relating to petroleum product prices were based on the Government's stated policy that the price of indigenous crude oil should be moved in the direction of import parity. The rate of increase in the domestic price of natural gas used in the projections was somewhat less than that for other petroleum products. Coal prices and electricity prices had been assumed to show only slight increases in real terms.

Availability of energy supplies. It was assumed that, with the exception of natural gas in Western Australia and Queensland, there would be no physical constraints on the supply of fossil fuels in the period to 1986/87. Additional gas was expected to become available to potential market areas of Western Australia in 1983/84 with the development of the North West Shelf deposits. The rate of increase in the supply of hydroelectricity was expected to be constrained owing to the lack of sufficient potential sites remaining for economic development.

Energy technology. The projections were generally framed within the constraints of existing energy technology. However, it was expected that as a consequence of rising energy prices the rate of development and implementation of energy-saving technology would increase. It was not expected that developments in presently known, but as yet undeveloped, fuel and energy sources would have a significant impact on demand patterns during the next decade.

F. ENERGY PLANNING AND PROGRAMMING

1. *Introduction*

The concern of an energy policy was not the achievement of energy balance, for that was guaranteed, but the composition or structure of the energy balance sheet: the mix of demands on energy sources, including wasteful uses, and the mix of viable energy supplies. The general goal of Australian energy policy was the achievement of the most desirable energy balance and for the immediate future that meant an energy balance which minimized dependence on crude oil.

2. *Energy objectives*

Six general energy policy targets to which national energy policy was to be directed were listed:

(a) To move crude oil prices received by producers and paid by consumers in the direction of international levels;

(b) To restrain the average rate of growth of energy consumption, particularly in liquid fuels;

(c) To achieve the highest degree of self-sufficiency in liquid fuels broadly consistent with the economic utilization of energy resources;

(d) To ensure that economic oil and gas reserves were developed;

(e) To encourage individual major energy projects to meet overseas demand for energy resources where those projects were economic and would provide an adequate return to Australia;

(f) Substantially to increase energy research and development.

Energy policy analysis was complex and assessments that particular measures would be unambiguously beneficial were rare. To acknowledge and accommodate other national goals the evaluation of energy policy measures in most cases required careful cost/benefit analysis and, frequently, the use of multiple objective evaluation techniques.

3. *Constitutional limitations*

Australia was a federation of six States and responsibility for many functions of government, including energy policy, was shared between the Commonwealth and the States. However, decision-making at those levels could involve different parameters, for example, where the national assessment imputed benefits not reflected in a State treasury's accounts.

The primary responsibility for energy production and distribution within States (i.e. not including off-shore areas) resided with the State governments. This included responsibility for granting on-shore petroleum exploration and production permits, setting of royalty and freight rates, and general responsibility for working conditions. The powers of the Commonwealth in other areas were such, however, that energy projects within a State might be materially influenced by Commonwealth Government policies. The relevant powers of the Commonwealth embraced taxation, the control of foreign investment, the control of exports, and, through the Loan Council, control of the loan programmes of the States and their authorities. The management of off-shore resources was in the process of being clarified.

The States could influence decisions to develop major projects in remote locations by agreeing in particular cases to assist in the provision of infrastructure. The States required the approval of the Loan Council to raise the necessary funds for any substantial contribution.

The responsibility for foreign investment policy lay with the Commonwealth through its constitutional powers over international trade and commerce, foreign affairs, currency and banking. State governments might influence foreign investment within their boundaries by virtue of their responsibility for the issue of mining titles.

State governments or their instrumentalities exercised direct control over the prices of significant energy supply sectors, most notably electricity and gas. Sensitivity to price increases imposed by government authorities and competition between States promoting industrial development had resulted in price structures and marketing practices which in important instances conflicted with the pricing objectives of national energy policies.

Regulations concerning the application and use of fuels were almost exclusively the preserve of State authorities. Most important were regulations governing transport, environmental pollution and industrial safety. Restrictions on fuel specifications to control atmospheric pollution, for instance, had significant energy implications as did regulations concerning vehicle dimensions and axle loadings.

The prime responsibility for protecting the environment and for environmental standards rested with the respective State governments although the Commonwealth Government had asserted a role for itself where Commonwealth decisions (e.g. export controls) or direct financial assistance were involved. Development of the means to implement national energy policies required detailed consultation and negotiation between the two levels of government.

G. MEASURES TO ACHIEVE ENERGY OBJECTIVES

1. *Encouragement of the development and export of surplus energy resources*

In support of its energy target of encouraging the development of major projects to meet overseas demand for energy resources, the Government had decided to phase out the levy on coal exports and to relax controls on foreign investment.

The Commonwealth Government also completed consideration of proposals submitted by the North West Shelf Joint Venture for development of the large gas reserves of the North West Shelf. It reaffirmed that it attached the highest priority to this project, and agreed that approval should be given for the export of 53 per cent of the currently estimated reserves over a 20-year period. The remaining reserves were expected to be adequate to meet the requirements of Western Australia at least until the end of the century.

Exhaustive consideration of the issues and evidence on uranium mining and utilization led the Government to decide that there should be further development of uranium mining and export under strictly controlled conditions.

2. *Energy pricing*

The energy prices to which both consumers and producers react should fully reflect the current and future value of the respective energy resources. In practice that meant moving energy prices towards international parity levels while also ensuring that in general the prices of particular fuels reflected the value to the community of self-reliance which was related to their domestic scarcity or abundance.

The Commonwealth Government did not have complete control over energy prices. It did, however, control the price of indigenous crude oil, and that power could be instrumental in exerting some influence on other domestic energy prices. At present the price of natural gas fell within the province of State governments, while electricity prices were set by State electricity authorities. Domestic coal prices were set by the coal producers, many of which were vertically integrated with the electricity generation industry or with the steel or cement industries.

Regulated prices paid for indigenous crude oil prior to about December 1970 were higher than import parity, but since then, and particularly since the Organization of Petroleum Exporting Countries (OPEC) price increases, had fallen well below the import parity level. This had tended to lead to wasteful use of the limited oil resources, and tended also to discourage exploration for and development of additional oil reserves and the development and use of alternative energy forms. A scheme had been adopted in 1977 which effectively allowed the proportion of "old" oil which would be valued at full import parity gradually to increase, while all "new" oil would be valued at full import parity. The arrangements had increased the amount of crude oil available from presently known fields by increasing the amount of economically recoverable oil, and had directly contributed to a marked increase in petroleum exploration effort.

3. *Energy taxation*

In view of the fact that large mining projects, particularly oil, gas and coal projects, necessarily involved long lead times and large capital investments, taxation incentives had primarily been directed at the supply side of the energy equation. An important provision made recently was that allowable capital expenditure of any petroleum or general mining company on the development of a mine or field would in future be deductible at the rate of 20 per cent of the declining balance. In addition, petroleum exploration and development expenditure was made deductible against income from any source, and subscribers of share capital to companies engaged in off-shore petroleum exploration and development could receive an income tax rebate. The Government also introduced a 5 cents per ton levy on coal production to finance increased coal research, and the funds were now allocated to appropriate coal research projects by the National Energy Research, Development and Demonstration Council.

The policy of moving the prices of indigenous energy resources towards international levels affected the distribution of incomes, i.e. it transferred surpluses previously enjoyed by energy consumers to the producers of energy resources.

4. *Quantitative controls*

Quantitative controls could be applied to both the production and consumption of energy. Their main value was that they were direct: the level of consumption of liquid fuels, for example, could be influenced without relying on the consumers' response to the price mechanism. In general, quantitative measures were inflexible and were costly in their administration, implementation and effects on the allocation of resources within the economy. To date Australia had not introduced any measures of that kind.

5. *Energy conservation campaigns*

An important constraint upon the Government's energy conservation programme was that it should not detract from the attainment of socially desirable objectives such as economic growth and the welfare of the population. Accordingly, the main thrust of the programme was to achieve those national objectives with less use of energy, especially petroleum fuels. This meant, firstly, that energy waste should be eliminated; secondly, that energy should be used more efficiently by development and/or application of improved technology; and, thirdly, that the chains of energy supply should be made more efficient (e.g. natural gas should not be burned in power stations to meet demands satisfied more efficiently when the gas was used directly). Energy conservation measures faced, however, important constraints, such as the characteristics of the existing stock of energy-using capital assets; established practices in energy consuming and supplying industries; prevailing modes of social behaviour, and, in relation to transport, the existing infrastructure and the spatial distribution of work and living places.

H. INSTITUTIONAL ARRANGEMENTS FOR PLANNING AND IMPLEMENTATION

1. *National co-ordination*

A forum for the discussion and resolution of energy matters of mutual interest to the Government and to the State governments existed in the form of the Australian Minerals and Energy Council, consisting of Commonwealth and State Ministers responsible for minerals and energy matters. The Government's energy conservation programme was being promoted under the auspices of this Council. The Commonwealth and the governments of Victoria, New South Wales and Queensland also agreed to enter into an agreement with the Federal Republic of Germany to share the cost of a $3 million study of the economic and technical feasibility of a coal liquefaction project. The National Energy Advisory Committee, established by the Government to advise the Minister for National Development on energy related issues, was a high level body comprising experts from the Government, industry and academic institutions. It had published a number of reports. In May 1978 the Government decided upon the establishment of a National Energy Research, Development and Demonstration Council, an interrelated high-level body, to advise the Minister on energy research and development, particularly regarding the disbursement of funds for such purposes.

2. *Regional co-operation*

On a regional level, Australia strongly supported the formation of a Commonwealth regional consultative group on energy, intended to assist in the identification of the energy problems of individual countries in the region, support the work of national and regional institutions in the research, development and practical application of technologies on alternative sources of energy, mobilize resources for such work and facilitate the exchange of information among Commonwealth countries in the region on energy matters.

Australia's energy export surplus amounted to $600 million in 1976/77 and could be as much as $2,000 million by 1985/86. Most of those energy exports went to the Asian and Pacific region, particularly to Japan.

Australia recognized the urgent need for all countries in the Asian and Pacific region, developed and developing, producer and consumer, to encourage the increased production of energy from all available and potential sources. Australia was prepared to participate in intergovernmental co-operation in the region in order that energy problems could be tackled in a co-ordinated fashion.

3. *International activities*

Australia participated in energy related activities organized under OECD and United Nations auspices and had entered a number of bilateral agreements in the field of energy research and development. Membership of the International Energy Agency was currently under consideration. As an increasingly significant net energy exporter, Australia had an interest in and was in a position to play an active role in continuing energy consultations. Australia's international activities were especially important in respect of uranium.

Australia was also keen to make use of and provide access to its technological base, as well as to benefit from the expertise and experience of other nations through co-operation, and had recently signed agreements on coal and solar energy research and development with other countries.

ENERGY SITUATION IN BANGLADESH

(NR/WGMEPP/11)*

by

A.N. Shahadat Ullah (Bangladesh)

A. INTRODUCTION

Bangladesh had limited energy resources of commercial value, though non-commercial forms of energy were abundant and their share in the total energy use was large. Approximately 70-72 per cent of energy consumed was derived from non-commercial sources. The commercial sources of energy were firewood from reserve forests, hydropower and natural gas; the traditional non-commercial sources were solar heat, wind and river currents which were extensively used for dehydration and transportation. In between these two categories fell twigs, rice straw and hulls and jute sticks, which entered some commercial markets but were mainly consumed in the subsistence sector. Besides these sources of energy, Bangladesh had also significant deposits of coal and peat which were not yet exploited.

B. SOURCES OF ENERGY

1. Forest resources (firewood)

Forest covered 16 per cent of the land surface, and almost the whole of this was in the hands of the Government. The forests were divided about equally between reserve forests and unclassified state forests. The official estimate of use of forest wood as firewood was 135 thousand tons per annum, and this accounted for 57 per cent of total use of forest resources (excluding bamboo) of the reserve forests. The use of firewood from the reserve forests had remained more or less constant over the last few years. Total use of firewood in the country was, however, much higher as its requirement was met from both unclassified state forests and homestead wood lots. Total production of firewood was estimated to be 500 thousand tons per annum, and the potential output on a sustained basis was put at 615 thousand tons, made up of 248 thousand tons from managed forests and 367 thousand tons from homestead areas.

The supply of firewood fell short of demand for three reasons: (a) inaccessibility to hill forests because of difficult terrain; (b) deforestation of more accessible areas owing to shift cultivation and pressure on easily accessible forest resources; and (c) quality of wood. Felling practices caused waste of wood. Emphasis was therefore placed on forest management. The policy was to clear out the natural forest and to replace it with plantation forest, to improve the yield per acre both in quantity and quality by introducing or reproducing the most desirable species which grew fast. Some 33,000 hectares had been planted and the programme was to plant 16,200 hectares a year. The idea was to have three life-cycles of crops, namely of 10, 30 and 60 years, so as to meet diverse demands on forest resources. Firewood would be obtained as a by-product of the plantation programme and ultimately as waste from logging operations and industrial uses. The direct effect of the plantation programme on firewood supply was estimated to be over 12,000 tons for 1985 and would increase as production moved into higher life-cycles.

* Abridged.

Homestead wood lots had traditionally played an important role in meeting fuel needs in the rural areas. Village settlements were camouflaged by homestead trees as cover and gardens and about 25 per cent of homestead land was covered by trees. Photo-interpretation technique supported by field observations indicated that firewood supply from homestead wood lots would be over 260 thousand tons per annum, plus 106 thousand tons from round-wood waste. Dried leaves and twigs accounted for another 1.5 million tons. The total homestead wood lots therefore supplied 1.87 million tons. Taking reserve forests and homesteads together, total supply in energy terms was about half the supply of energy available from traditional non-commercial sources such as jute sticks, rice hulls and straw, and cow-dung. The official programme for homestead wood lots included extension works and distribution of seedlings.

2. Hydrocarbons

Natural gas. Exploration was started as far back as 1910, since when 41 wells had been drilled on-shore. After independence, off-shore exploration was initiated and six foreign companies started work. Except for two companies, the others had abandoned the drilling but one off-shore well had definitely indicated gas. Out of the 41 inland wells, 14 had gas, of which 10 were in production. Presently known recoverable reserves of natural gas were put at 250,000 million m^3. The methane content of gas found was quite high, between 94.3 and 94.5 per cent, and its calorific value varied between 30.3 and 31.4 KJ per m^3. Gas reserves were scattered in the eastern zone of the country over seven fields, but two fields contained over half the known reserves. Exploratory drilling in two new inland locations had been completed and production testing was in progress. The production capacity of the seven known gas fields was 19.3 million m^3 per annum. Statistics of recent production and consumption are shown in table 1.

Table 1. Natural gas production and consumption (thousand m^3)

Year	*Power*	*Urea*	*Industries and commerce*	*Domestic*	*Total*
1970/71	203	231	31	1	466
1971/72	155	111	18	1	285
1972/73	224	399	38	3	664
1973/74	287	447	88	8	830
1974/75	239	201	83	8	531
1975/76	247	450	107	14	818
1976/77	323	433	129	22	907

Oil. Bangladesh had not as yet struck any oil deposit. The only refinery in the country was entirely dependent on imported crude of one million tons per year. In addition, it imported a large quantity of petroleum products to meet domestic needs. Production and import of petroleum products are shown in table 2.

Table 2. Refinery production and import of petroleum products in 1975/76 (thousand tons)

Types	*Refinery production*	*Imports*	*Estimated supplies*
Motor spirit	55.2	0.8	56.0
Kerosene	198.7	152.3	350.0
Diesel oil	137.5	147.0	284.5
Furnace oil	336.4	60.9	397.3
Naptha	59.9	—44.5	15.4
Other	50.7	25.0	75.7
Total	838.4	386.0	1,154.9

During the period 1973/74 to 1976/77, the quantity of crude oil imported had increased from 450,000 tons per year to 1,032,000 tons per year, while the quantity of petroleum products imported had decreased from 510,000 tons to 285,000 tons. The refinery had a capacity of 1.5 million tons per annum, but because of the limitation imposed by demand-mix it was operated below full capacity level so as to keep production of motor spirit and naptha to a minimum. Limitation of internal demand had led to the export of furance oil and naptha at below cost prices. Residual fuel would also be used for a bitumen plant which was under construction. Off-shore drilling was continuing under production-sharing schemes with foreign firms, while extensive inland drilling was also programmed.

3. Coal and peat

In the 1960s a UNDP-supported programme resulted in striking an extensive coal dpeosit in North Bengal at a depth of over 900 m. The estimated recoverable reserve was around 100 million tons. The questions of mining and its economics were examined in a recent energy study and it was concluded that the cost of a ton of coal would be very high not only compared to the most favourable deposit of gas but also compared to furnace oil. The quality of the coal was a weak bituminous grade with an ash content of 25 per cent and a sulphur content of 1 per cent.

Besides coal, Bangladesh also found peat deposits in two areas extending roughly over a total of 55 km^2. On a dry basis the total deposit was estimated at 38 million tons. The areas fell on the west of the Padma-Brahmaputra river complex, the zone that was poor in fuel resources. The economics of recovery were poor for the reasons that the peat was of inferior type, the areas remained submerged from May to October, and the bulk of the deposit lay below the water table. The overriding considerations were that the area generally fell in one of the fertile agro-belts of the country and rehabilitation of the area after stripping was almost impossible. Consumption of coal by sectors is shown in table 3.

Table 3. Consumption of coal by sectors (thousand tons)

Year	*Public sector*[a]	*Brick fields*	*Industries*	*Steamers*	*Commercial*	*Total*
1971/72 . .	93	101	16	12	1	223
1972/73 . .	103	101	33	2	1	240
1973/74 . .	82	112	20	1	1	216
1974/75 . .	112	110	25	1	1	249
1975/76 . .	101	116	29	1	1	248
1976/77 . .	118	117	21	1	1	258

[a] Public sector consumption is mainly for supply of bricks for public works.

4. Hydroelectricity

Bangladesh had a very limited hydroelectric potential. The use of water resources for hydropower was currently limited to the Karnaphuli River in the east. This was a small river and only 80 MW of electricity were generated at present while a generator with a capacity of 50 MW was under installation. The present hydroelectric capacity accounted for less than 10 per cent of installed capacity of electric power in the country. There was hydropower potential of 82.5 MW in the Sangu River, as a multipurpose project. In the north, the Brahmaputra had a potential of 400 MW.

5. Traditional fuel resources

Non-commercial resources played an important role in the rural life of Bangladesh. This category of resources consisted of rice straw, rice hulls, dried leaves and twigs, cow-dung and jute sticks, besides the homestead firewood already considered, and supplied about 54 per cent of total energy consumption.

6. Secondary energy: electricity

The existing total generating capacity of the power system was 875 MW and the system was currently physically broken into two parts by the Ganges-Brahmaputra river configuration. With the addition of the additional hydroelectric generating unit and the integration of the east and west grids into one national grid, the importance of oil-burning units would decline, except for efficient despatch of load and stability of the system. Outside the grid system there were some captive plants, mainly in large industrial units such as fertilizer plants and paper mills.

The major user of electricity was the industrial sector with about 70 per cent of total consumption. The contribution of electricity to total energy consumption was less than 5 per cent, and per capita consumption of electricity was about 20 kWh per annum.

The main thrust of the current programme was the rehabilitation of the west zone power system and early implementation of the interconnector between the west and east grids. Another important element was the extension of distribution facilities, particularly to rural areas for electrification of tube wells and low-lift pumps for irrigation and for improving the quality of life in the villages in general. A Rural Electrification Board, distinct from the Power Board, had been set up recently.

C. ENERGY PLANNING

Bangladesh had evolved a comprehensive frame of reference for the development of the energy sector for the next two decades. The reference frame was contained in the energy study carried out by a consortium of four international firms and completed in November 1976 with UNDP assistance.

The study employed a "dominant strategy" to isolate a delivery system that was least sensitive to extreme but plausible assumptions. The approach was based on system analysis in which the energy sector was seen as a part of the larger economic system and in which not only the internal relationships but also those within the larger system were spelt out by means of mathematical models.

For projection of demand for energy, three models were used, namely, (a) an agricultural model, to determine direct demand of the agriculture sector for energy and its indirect demand through other models; (b) a macro-economic model, consisting of 11 equations which highlighted the major factors of economic growth such as agricultural development, population growth and foreign exchange availability, and described five scenarios to simulate the demand for energy; and (c) an energy input-output model, used to determine energy demand for 21 sectors of the economy for the alternative five scenarios for electric power and other commercial fuels. An important aspect of this study was parametric shift in use of energy to reflect a probable rise in efficiency in energy use. Sectoral demand derived through the macro-economic model together with the agricultural model yielded the aggregate demand for commercial energy for each of the alternative scenarios. Analysis of non-commercial sources of energy was undertaken to make up the national energy demand bill.

Selection of the appropriate delivery system was carried out in two stages, technical feasibility of alternative delivery systems, comprising individual projects, and their economics within the likely and meaningful range of values of economic parameters. The demand **scenarios** were combined with the supply data and the economic parameters in the evaluation of a large number of alternative delivery configurations identifying the major projects The five **scenarios** were subjected to thorough analysis from the points of view of both feasibility and desirability and the mid-**scenario** was adopted, features of which are given in table 4.

Table 4.

Growth rates forecast according to the mid-**scenario** (per cent per annum)

	1974-1984	*1984-1994*
Population	3.2	2.9
Per capita income	1.2	2.6
Fertilizer use	13.9	4.2
Agriculture	2.6	2.7
Industry	9.9	10.8
Commercial energy	7.7	6.6
Electric energy	7.3	8.0

COUNTRY PAPER, INDIA

(NR/WGMEPP/12)*

by

The Department of Power, Ministry of Energy (India)

A. RESOURCES, PRODUCTION AND CONSUMPTION

1. Commercial energy

Coal had been the most important source of commercial energy in India and considerable efforts to assess the availability of coal resources had been made for over a century. The Geological Survey of India and other organizations also involved in detailed exploration had largely identified the areas of coal deposits. Detailed regional explorations were continuing. Indian coals belonged to two geological horizons, namely, Gondwana and Tertiary. The bulk of the reserves belonged to the Gondwana sequence. A breakdown of the reserves of coal by type and categories is given in table 1, which is based generally on seams at least 1.2 m thick, and up to a depth of 600 m. No firm estimates of quantities recoverable were available.

* Abridged.

Table 1. Reserves of coal (million tons)

Type	*Total gross reserves*	*Proved reserves*	*Indicated reserves*	*Inferred reserves*
Prime coking	5,299	3,252	1,586	461
Medium coking	9,376	3,793	4,275	1,308
Semi to weak coking	4,721	1,206	2,600	915
Non-coking coal	63,375	12,326	23,420	27,629
Total for Gondwana coal	82,771	20,577	31,881	30,313
Tertiary coal	902	161	192	549
Lignite	2,100	1,869	202	29
Grand total	85,773	22,607	32,275	30,891

Coking coal constituted about 23 per cent, of which prime coking coal which could be used directly for metallurgical purposes constituted only about 6.5 per cent. The rest of the coking coal had medium to weak coking properties and would need to be blended with prime coking coal for use in the metallurgical industries.

Deposits were distributed very unevenly, mainly in a belt extending from the Damodar Valley in east India to the Sone, Mahanadi and Wainganga areas in central India and the lower Godavary Valley in south-central India. The Damodar Valley deposits accounted for about two thirds of the total Gondwana coal reserves and almost all the coking reserves in the country. The tertiary coal was located mainly in the north-eastern part of India and the bulk of the lignite deposits were located in southern India. Indian coal seams were characterized by extreme thickness of the deposits in several locations and also by high ash content.

At present, about 80 per cent of coal production was from underground mines, the bord and pillar method being most commonly used. Open-cast mining accounted for about 20 per cent, and this percentage was increasing gradually, to an estimated 33 per cent by 1983/84.

The estimated future demand for coal is as follows (in millions of tons): 1978/79: 112.0; 1979/80: 119.0; 1980/81: 130.0; 1981/82: 139.0; and 1982/83: 153.0.

The coal mining industry had been nationalized and all the coking and non-coking coal mines under the ownership of the Government had been brought under a single holding company, Coal India Limited. This had several subsidiary companies which had considerable delegated powers.

The location of the coal deposits underlined the need for developing an efficient and adequate transport system which would ensure the flow of available fuel resources from points of availability to the points of demand.

Oil and natural gas. The known reserves of oil and gas in India were small compared to the reserves of coal. There were a number of sedimentary basins covering an area of 1.4 million km^2 of land and 0.39 million km^2 off shore. The on-shore production wells existing at present were located in the Cambay and Assam-Arakan basins. The Bombay High structure, where production had started recently, was located in the Bombay off-shore basin.

Oil exploration in the public sector had been intensified during recent years. Studies had been carried out for comprehensive evaluation of all sedimentary basins jointly by the Indian Institute of Petroleum Exploration and the Institute of Exploration of Combustible Minerals of the Soviet Union. The studies so far indicated that the total prognostic reserves of hydrocarbons from all the sedimentary basins could possibly be of the order of 6,200 million tons of oil and 6,500 million tons of free gas. The proved reserves as of 1976 were, however, of the order of 144 million tons.

The Oil and Natural Gas Commission and Oil India Limited were the two main organizations engaged in the task of exploration and exploitation of oil and natural gas in India. The production and consumption of petroleum products from 1970 to 1976 is given in table 2.

Table 2. Growth of the petroleum industry (thousand tons)

Year	*Production of crude*	*Refineries input including imports*	*Production of petroleum products*	*Consumption of petroleum products*[a]
1970	6,809	18,459	17,177	18,816
1971	7,185	19,588	18,229	20,706
1972	7,373	19,672	18,204	22,675
1973	7,198	20,518	19,125	23,726
1974	7,490	20,783	19,303	23,023
1975	8,283	21,835	20,438	23,541
1976	8,659	22,762	21,188	24,879
1977[b]	10,185	24,430	22,795	26,518

[a] The difference between consumption and production is made up of imports of petroleum products, less some exports.

[b] Provisional figures provided later.

Since 1976 there had been some increase in the production of crude oil from on-shore fields and off-shore areas and the total indigeneous production was expected to be about 13 million tons in the near future. Further exploration programmes for the period 1978-1983 were envisaged.

Hydroelectric resources. The present knowledge of hydroelectric resources in India was based on a detailed hydroelectric survey carried out during 1953-1960, which placed the hydro potential of the country at 42,100 MW at 60 per cent load factor, based on specific schemes of development in the various basins for which topographical and hydrological information was available. It broadly took into account the limitations imposed by topographical con-sidreations, problems of submergence, water requirements for priority uses such as irrigation, industrial and domestic water supply, and technological as well as economic considerations.

Subsequent studies and investigations indicated a substantial increase in potential. Investigation of the upper reaches of some of the Himalayan rivers had led to the identification of several new sites with sizable potential. The original survey also did not include the considerable seasonal and secondary generation possible at various sites as the possibility of absorbing that energy economically could not be foreseen at the time of the survey, and the potential of several small micro-hydro projects. Further, hydroelectric projects were now being designed to operate at load factors considerably below 60 per cent and thus capacity potential would be higher than 41,000 MW.

By the end of 1977, 15.8 per cent of the hydroelectric potential, as established in the earlier survey, had been developed. By the end of 1983, it was proposed to develop 26 per cent of the earlier total potential. About 29 per cent of the total potential was located in the north-eastern region with small infrastructural development and problems of inaccessibility. The long gestation period for completing hydroelectric projects as well as the large capital expenditure involved in the construction of the projects had been the main reasons for not undertaking a quicker programme of hydroelectric development. However, with better co-ordinated and improved methods of investigation and preparation of project reports for construction, and with experience gained in the construction of large and complex hydroelectric projects, the hydropower development programme was expected to proceed much faster in the coming years.

Nuclear energy. The reasonably well-assured uranium resources in India were about 22,000 tons, with additional inferred reserves of 24,000 tons. Uranium mined in India was slightly more expensive than in many countries since the uranium concentration in the ore was relatively low. There were also large thorium reserves in the country.

Following the first boiling water type nuclear power station of 400 MW at Tarapur, which required enriched uranium as feul, a nuclear power programme based on natural uranium fuel and heavy water-moderated and water-cooled reactors had been initiated. At present, 600 MW of nuclear generating capacity was in operation and another 1,000 MW of capacity was under construction. Proved uranium reserves could sustain about 10,000 MW of installed capacity.

2. Non-commercial fuels

The fuels grouped under this category were fuelwood, dried cattle-dung cakes and agricultural wastes. These fuels were used in the domestic sector, mainly in the rural areas, almost entirely for cooking purposes. Transactions relating to these fuels did not enter the monetized economy and the statistics relating to their availability and consumption were not very firm. The presently available estimates for trends in consumption of these fuels were based on three sample surveys carried out in 1958-1962, 1964 and 1974, which obtained **per capita** norms of fuel consumption and their distribution by types of fuel in urban and rural areas. The estimates of consumption and projection of future demands were based on these norms. The estimated consumption of non-commercial forms of energy in 1970/71 was 123 million tons of firewood, 67 million tons of dung cakes and 38 million tons of vegetable waste.

According to these norms, the Fuel Policy Committee had projected the firewood requirement in 1990/91 to be about 122 million tons and the National Commission on Agriculture had estimated the demand in the year 2000 to be 158 million tons. The availability of cow-dung in India was much in excess of the presently estimated level of its use for energy purposes. It was estimated that the dung yield was about 190 million tons (dry). The consumption of dung cakes for energy was estimated to be about 37 per cent of this amount, the rest being used as farmyard manure or wasted. The position in regard to agricultural wastes was somewhat similar. The availability was in excess of the presently estimated level of consumption of 45 million tons for energy purposes, the balance being used for fodder, compost, etc.

To meet the demand for firewood, a lot of denundation of forests and treelands had been taking place. It had therefore been decided in 1952 that a programme for the development of forestry for meeting the fuel demand of the rural population should be promoted. A scheme of forestry-cum-fuelwood plantation was later formulated but efforts had only resulted in very limited success. The involvement of the people in the growing of trees on farmlands on a large scale had not been forthcoming, and purely governmental efforts suffered owing to inadequacy of funds. The protection of newly planted trees was also a problem. Thus the National Commission on Agriculture recommended a programme of social forestry aimed at provision of protection and recreation benefits for the community, as well as in meeting the fuelwood needs of the communities. Social forestry or farm forestry-cum-fuelwood plantations had been taken up as a modest programme in the States and needed to be further intensified.

3. Non-conventional sources of energy

Solar energy. India received substantial quantities of solar radiation and the number of sunny days in the year was high. An integrated research programme involving several agencies had been undertaken to develop the technology of application of solar energy for various purposes. The research activities were directed towards absorbing the heat energy from solar radiation and using it either directly or by conversion to mechanical energy, and direct conversion into electricity.

The programme of research and product development was funded by the Department of Science and Technology, and the major efforts included data collection, solar collectors, solar water heaters, food grain and milk driers, timber kilns, power plants, water pumping, air-conditioning and refrigeration. Significant progress had been made in these fields and work now in progress was aimed at improving efficiency and reducing the cost.

Applications of solar energy for desalination of sea water and conversion of brackish water into potable water had also been successfully developed. Very high priority had been accorded to development of solar pumps. Laboratory models of pumps had been developed and successfully tested. The basic problem was developing a system which would be technologically simple and economically viable in rural areas. A 10 kW demonstration solar power generation unit had been successfully developed through a project undertaken jointly by India and the Federal Republic of Germany. A co-ordinated programme had been undertaken to develop cheap solar cells for conversion of solar energy into electricity directly.

Geothermal energy. Activities in the geothermal field were directed towards location of promising hydrothermal reservoirs for power generation and other possible uses of the heat energy. Hot springs occurred in several regions of the country, including the north-western Himalayas and along the west coast. Geothermal explorations were in progress in three locations.

After conducting preliminary geological, geophysical and geochemical studies at Puga in the north-west, shallow exploratory drillings were started in 1973. The drill holes established a potential of a few MW of energy at shallow depths. It was also indicated that large geothermal potential existed at greater depths. The proving of this potential would, however, require deep drilling and sizeable investment. The need for development of the Puga geothermal field in the foreseeable future would depend chiefly on the demand for power in the vicinity.

Exploration work in the Parbati Valley in Himachal Pradesh and along the west coast was being carried out with UNDP assistance. The main objective of these investigations was to do geological, geochemical and geophysical surveys in promising areas followed by exploratory and evaluation drilling in one of the areas, and they led to the conclusion that the Parbati Valley was more promising than the west coast. It was proposed to carry out further detailed geophysical surveys in the Parbati Valley during 1978/79 with sophisticated equipment to be supplied by UNDP.

Biogas. The most commonly used organic matter for biogas production in India was cow-dung. Several organizations carried out pioneering work in the field, and considerable work was done to improve the technology. At present, it was estimated that 55,000 biogas plants were in operation. The programme being implemented now was oriented toward establishing small-sized plants (3 to 4 m^3 capacity) to serve the needs of individual families. Consideration was now being given to the establishment of community-type biogas plants, which would involve socio-administrative aspects.

Tidal power. Though India had a very long coastal line, there were only three locations where the tidal range was fairly high, affording possibilities for tidal power generation. A rough estimate based on the report of a United Nations expert indicated that a single basin type development could provide an annual energy potential of 15,000 million kWh with an installation of 7,400 MW in the Gulf of Cambay, and 3,000 million kWh with an installed capacity of 1,200 MW in the Gulf of Kutch. The Sunderbans area could provide an annual energy potential of 3 million kWh. It did not seem likely that tidal power would be important in meeting India's energy needs in the foreseeable future.

4. Electricity supply

The electricity supply industry had made significant progress since independence and the advent of planned development, but in general the over-all power availability had been inadequate to meet the demand. More recently, monitoring of projects had been intensified to remove bottle-necks and the tempo of construction had been increased. Installed capacity is indicated in table 3.

Table 3. Installed generating capacity and gross generation (thousand MW and million kWh)

Year	Installed capacity					Gross generation
	Utility hydro	Utility thermal	Utility nuclear	Non-utility	Total	
1950 (end) . .	0.6	1.1	—	0.6	2.3	7,514
1955 (end) . .	0.9	1.8	—	0.7	3.4	11,872
1960/61 . . .	1.9	2.7	—	1.0	5.6	20,123
1965/66 . . .	4.1	4.9	—	1.2	10.2	36,825
1973/74 . . .	7.0	9.1	0.6	1.8	18.5	72,796
1977/78 . . .	13.1	10.0	0.6	2.2	25.9	98,686

For a typical year, 1976/77, consumption by sectors was of the order of 62 per cent for industry, 14 per cent for agriculture, 10 per cent for domestic, 6 per cent for commercial and 8 per cent for other uses.

B. DEMAND PROJECTIONS

The demand for energy dependend on the pace of economic growth. Factors such as changes in the sectoral growth rates, efficiency of use of energy in different sectors and the shift in usage owing to improvements in technology or new technologies within various sectors of the economy also affected the level of energy demand. The long gestation period of developing energy resources necessitated a reasonable projection of long-term energy demand in order to make arrangements in advance for meeting them, and considerable effort had to be made to arrive at as realistic a demand projection for different forms of energy as possible.

1. End-use method

In an economy where the rate of growth and the levels of production in different sectors were computed by central planning agencies within an elaborate system of plan calculations, it was often more dependable to derive total energy demand by employing the end-use method based on norms of consumption in representative units under major categories of consumption. The norms for energy consumption had to be calculated with reference to past data and some adjustments had to be made to allow for possible shifts in technology and higher levels of efficiency in the use of energy and fuels.

2. Trend method

The past trends also provided guidance for forecasting energy demands; but this was more so in developed market economies which were in a state of stable growth. In India, at certain times in the past, the rates of growth of consumption of different fuels were constrained by transport availability or availability of the fuels themselves. Thus, there was a limitation imposed on the use of the trend method for forecasting energy demand. However, in certain sectors where consumption was fragmented and a representative norm was difficult to find, the trend method was used for forecasting growth. Such sectors were the domestic, commercial and small-scale industries in respect of their consumption of electrical energy.

3. Regression method

The regression method could also be a reasonable guide to determine future rates of growth and patterns of consumption of energy, but this method had not been used very much so far. Attempts were now being made to prepare a regression model for some selected energy sectors. In any case, it was best to cross-check the results obtained through one method with those of another method.

C. ENERGY PLANNING AND PROGRAMMING

1. Planning

Energy planning was undertaken keeping in view the demand estimated at the end of every five-year plan period. The demand beyond this period was also estimated on a tentative basis by using the trend method. For central planning, inter-sectoral models had mostly been used on the basis of input-output relationships worked out periodically, and estimates of energy demands for long-term perspectives had generally been made keeping in view this matrix. The basic objectives of an energy policy evolved as a result of exercises in perspective planning covered adequate energy supply, reliability of energy supply, self-sufficiency in energy resources, conservation of energy, and effects on the ecology and pollution of the environment.

On the basis of the resource availability, the feasibility for development of these resources and the long-term energy demand, an energy policy had been evolved. The steep increase in oil prices in the international market and the consequent changes in the world energy situation affected the energy scene in India. This led to a concentrated effort towards achieving more integrated development and supply of various forms of energy, initiating activities in the field of new sources of energy and formulating a more comprehensive energy policy, the main components of which were:

(a) Coal should be the principal source of energy and therefore its exploration, exploitation and utilization should be accelerated;

(b) The policy for oil should be to reduce imports and maximize indigenous production;

(c) Attempts should be made, wherever technically feasible and economically viable, to substitute other forms of indigenous energy for oil;

(d) The rate of growth of electricity production should be increased, using hydropower and nuclear energy wherever cost effective;

(e) The rural energy needs of the people should be given priority;

(f) New and renewable sources of energy should be developed and increasing use of biogas encouraged.

It had also been found necessary to study the transport system for its energy as well as transportation requirements of fuels so as to plan for the future growth of this sector.

2. Programming

Electricity was the most preferred form of commercial energy and the demand for it had been growing at a rate faster than that for other forms of energy. The consumption of electricity had increased at an average annual rate of about 10 per cent since 1950, increasing to 14 per cent since 1974/75. The next five-year programme for the period 1978 to 1983 was to install a further 18,287 MW of capacity in the utilities, of which hydro would account for 4,565 MW, thermal 12,797 MW and nuclear 925 MW.

The utilities were managed and operated by State Electricity Boards which were autonomous power generating and distributing organizations under the

State governments. Electricity was, however, a concurrent subject under the Constitution of India and both the Government and the State governments were responsible for that subject within the framework of the Central Act. Detailed planning for electricity development was undertaken at the national level by the Central Electricity Authority and the investment programme was approved at the national level. A small proportion involving a capacity of 2,287 MW was not included in the public utility sector.

The Government was also augmenting the effort of the States by setting up large pit-head thermal stations to meet the regional power needs. Large hydroelectric stations which involved complicated civil construction and very large investment were also being taken up for execution by the Central Government.

A significant training programme was being organized for operation and maintenance of power stations as well as for telecommunication, telemetering and load despatching for operating integrated regional grids. Administration and personnel policies were constantly reviewed to provide for motivation and development of skills and project management techniques.

The growth of the electricity industry was supported by a large manufacturing industry, which had been developed in the country both in the public and the private sectors over a period of time.

About 36 per cent of the total number of villages in the country and 58 per cent of the rural population had been covered by electrification. Also 3.3 million pump sets had been energized in the rural areas for irrigation purposes. It was planned in the course of the next five years to increase the coverage of rural electrification to another 100,000 villages and to energize an additional 1.5 million pumps sets.

Coal. The coal industry operated under three principal Acts, which were regulatory legislative measures governing the operation of the coal industry, which had been nationalized since 1973. The coal industry was regulated and organized under the Government, in the Department of Coal under the Ministry of Energy.

The Central Mine Planning and Design Institute, also functioning as a subsidiary of the apex public sector coal company, namely, Coal India Limited, looked after exploration and detailed drilling, co-ordinated research and development projects, and offered expert consultancy services in the planning and design of coal mines.

The coal industry as a whole had to develop rapidly and address itself to tackling problems in four major areas in a co-ordinated fashion: increasing production, developing the transport capacity, beneficiation of coal to gas, and equipment supplies.

Continuous efforts to improve the techniques of coal mining and transport were being made. There had been a steady increase in the output per man-shift in the underground mines and the open-cast mines, but productivity was still low; with increasing mechanization, improvements were taking place and would continue.

Oil. The oil industry operated under the Government in the Ministry of Petroleum and was now almost wholly nationalized. Exploration for and production of crude oil and natural gas were undertaken by the Oil and Natural Gas Commission, except for certain old leases given to two other companies. Refining and distribution were undertaken by another public sector company, the Indian Oil Corporation, set up in September 1964. There was a wholly government-owned undertaking which rendered design, engineering and technical consultancy services in the field of petroleum refining, petrochemicals, fertilizers, chemicals, ocean engineering and systems and specialized services for maintenance.

D. CONSERVATION

In view of the capital-intensiveness of all energy production and distribution, as well as the need to conserve the non-renewable resources, the Government decided that conservation efforts should be made in all energy producing sectors, and set down the specific areas that were to receive attention.

The National Productivity Council conducted studies in two phases in 314 industries comprising engineering, textiles, glass, tea, pharmaceuticals, pulp and paper, and chemical processing. An additional 201 industries were added in the third phase of the study under the aegis of the Petroleum Conservation Action Group. An evaluation indicated a saving of 14.6 per cent of the total annual quantity of furnace oil consumed in these units, and the studies helped in the formulation of short-term and long-term action plans. The National Productivity Council offered professional training in fuel efficiency and conducted two-year intensive training programmes at its institute at Madras, and was also undertaking work in promoting the total energy concept for utilization and recovery of waste heat. Efforts were now being made to conserve diesel oil in the railways and in the State road transport undertakings. This involved an accelerated programme of electrification.

In the coal industry, conservation efforts were being co-ordinated and financial assistance was being given to coal producers for undertaking conservation measures. The conservation of coking coal reserves was of special importance, and the measures taken, or proposed to be taken, included extraction of coal by open-cast, long wall and hydraulic mining, and large-scale adoption of sand-stowing. Also, blanketing and trenching in several coal reserves was being undertaken.

In an effort to conserve electricity, the implications of energy use in buildings were being studied by the Central Building Research Institute. Conservation aspects were given due weight in the choice of construction material for buildings, keeping in view the energy inputs required for their production and transportation, and the need to optimize the use of natural light.

E. INSTITUTIONAL ARRANGEMENTS FOR PLANNING AND CO-ORDINATION

The Indian economy operated within the framework of a national plan, formulated by the Planning Commission in consultation with State governments, which was approved by the National Development Council with the Prime Minister as Chairman and Chief Ministers of States as members. In a planned framework, the growth of different sectors of the economy was determined largely by the objectives set out for the economic development of the country in terms of physical targets and strategies, as also the interrelationships of the sectors. The quantitative framework on which the plan was based was a consistency model of the economy in terms of a set of relationships between different sectors, income and consumption, production and employment, etc.

The energy sector, which was upstream of any productive activity and was an essential input for downstream benefits like welfare, played a very important part in the planned development of the country. The targets for development were set for each of the energy producing sectors, based on the demand assessments, by the concerned ministries in consulation with the Planning Commission. The Ministry of Energy was responsible for the development of the electricity and coal sectors as well as for the over-all co-ordination of energy policy, conservation, development of new sources of energy and progress of energy research. The Ministry of Petroleum was responsible for the production and development of the petroleum industry and the Department of Science and Technology supervised the actual research being undertaken in different energy related fields.

The investment for the development of different sectors was fixed as a result of the planning exercise by the Planning Commission for a five-year period, broken into annual plans. Precise budgetary allocations were made each year, but were reviewed in the light of achievements and revised targets. An Energy Policy Working Group was at present examining the objectives and assumptions of all energy related sectors.

In the five-year plan which had been formulated for the period 1978-1983, the investment programme for the energy sectors of coal, electricity, oil and development of new sources of energy accounted for 30 per cent of the total investment in the planned economy.

F. ENVIRONMENTAL PLANNING AND CO-ORDINATION

Steps being taken to safeguard the environment ranged from legislative measures and a constitutional guarantee, to executive directions and setting-up of a high-level multidisciplinary body of experts to advise the central government and State governments and public authorities on the environmental implications of their developmental activities. Legislation for prevention and control of water pollution had been enacted, and legislation to control air pollution was under consideration.

Applications for industrial licences were scrutinized from the pollution control angle and all projects for power generation involving substantial investment required clearance from the National Committee on Environmental Planning and Co-ordination. The Committee's opinion was also sought on the siting of major industrial units like petrochemical and fertilizer complexes and on the technology to be adopted in those units. Since it was easier to incorporate environmental considerations at the project planning stage than to do it subsequently, steps had been taken by the Committee to issue guidelines to project planners, including guidelines for planning thermal power projects. Similar guidelines would be issued soon for hydroelectric schemes, extractive industries, process industries, road and railway projects, etc.

The Committee also promoted research into environmental and ecological problems covering water pollution, patterns of energy consumption, waste utilization and the like.

G. OUTLOOK FOR ENERGY DEVELOPMENT

In India, keeping in view the prices of imported fuels in the world market, the option of developing indigenous coal and hydropower resources would be followed. In order to optimize the utilization of the available energy resources, adequate transportation back-up as well as the effective operation of an interconnected regional and national grid for transmission of electric power were found to be essential areas of development. The construction of a national 400 kV network was under way during the current five-year plan and skeletal regional grids interconnecting smaller systems were already being operated.

H. REGIONAL CO-OPERATION

Looking at the region as a whole, the survey of energy resources required updating from the point of view of the exploitable potential in the short, medium and long terms. Regional co-operation in exchange of fuels, as well as development of non-conventional and renewable energy sources, particularly for rural energy needs, would appear to be areas requiring much greater attention and concerted effort. Exchange of information, technology and training facilities would be of advantage to all countries of the region.

Any energy development programme required a back-up manufacturing capability, and an assessment of the available manufacturing capability within each country and the region as a whole should be undertaken.

INDONESIA ENERGY OUTLOOK

(NR/WGMEPP/CRP. 3)*

by

Indonesia

A. INTRODUCTION

Indonesia was endowed with an abundance of energy resources. Its total coal resources were conservatively estimated at 15,000 million tons and its natural gas at more than 900,000 million m^3. Geological investigation indicated that an ultimate reserve around 7,000 million tons of oil might be found. It was now producing more than 84.5 million tons of oil per year (1977), of which 15 per cent was consumed internally. Hydropower and geothermal potentials were not yet fully exploited. On the other hand, the level of energy consumption in Indonesia was low, although the rate of growth was high.

B. ENERGY RESOURCES

1. Coal

Coal was abundant in Indonesia, but the quality varied from anthracite to brown coal and lignite. Geological survey estimates of the coal resources amounted to well over 15,000 million tons, most of which were in south Sumatra. In addition to major deposits, numerous other resource areas were known, but the quantity of their reserves was not available. Recently, a loan agreement had been reached with the International Bank for Reconstruction and Development for engineering study of the mining and transportation of coal from Bukit Asam (south Sumatra) to a west Java power plant.

2. Oil

There were very promising reserves both in on-shore and off-shore fields. Since their discovery in 1885 approximately 960 million tons of oil had been produced. Although Indonesia's production today was about 230 thousand tons per day, its proved reserves were increasing; geological investigations had shown that the recoverable reserves were large. An ultimate reserve of around 7,000 million tons had been estimated.

3. Natural gas

The estimate of proved reserves of natural gas as at January 1977 was about 960,000 million m^3. Of this total about 142,000 million m^3 was in the form of associated gas and the balance as non-associated gas.

4. Hydropower

The hydropower potential was estimated at 31,000 MW. Although the prospects for hydroelectric development were large, growth was somewhat constrained by the location of potential sites in the various islands, and by the long lead times involved in construction.

5. Geothermal

Based on surface measurements and exploration drilling in major known fields, the geothermal potential throughout Indonesia was estimated at 1,460 MW of which 890 MW was located in Java. In addition to the major fields, numerous other resource areas had been reported. They were generally too isolated to be considered part of any national or regional development but might well be of importance for small-scale rural electrification. Such units might average 5 MW each, giving a combined total for rural electrification purposes of about 50 MW.

6. Uranium

The Government was conducting two separate geological surveys in Sumatra and Kalimantan. The possibility of a joint venture between Indonesia and France on uranium exploration and production was being negotiated. To date, no uranium deposits had been confirmed, but indications were very promising.

C. INTERNAL DEMAND

During the five-year development plan for 1969 to 1974, the commercial energy demand increased on average at the rate of 11 per cent per annum; and during the first three years (1974 to 1977) of the second five-year plan the rate of increase had been 15 per cent per annum. The breakdown of total domestic energy consumption over the period 1969 to 1977 is given in table 1.

* Abridged.

Table. 1. Total domestic consumption of energy, 1969 to 1977
(million tons of coal equivalent)

	1969	1970	1971	1972	1973	1974	1975	1976	1977
Coal	171	161	192	187	129	149	190	156	178
Oil	8,066	8,656	9,549	10,962	12,766	14,561	16,360	18,420	21,670
Natural gas	1,021	880	1,192	724	1,211	871	1,290	1,499	2,017
LPG	—	1	4	10	20	34	47	55	60
Hydroelectric	146	154	177	159	194	225	244	224	219
Total	9,404	9,852	11,114	12,042	14,320	15,840	18,131	20,354	24,144

Although the above table indicated only an approximation of the total energy profile, neglecting for lack of reliable information such energy resources as charcoal and firewood, it clearly reflected the predominant use of oil and the insignificant role of coal. Oil consumption increased at an average rate of 12.5 per cent per annum whereas consumption of natural gas and coal remained fairly stable. Hydroelectric consumption increased at an average rate of 6.3 per cent per annum.

D. LONG-TERM FORECAST

The close correlation between levels of general economic activity (measured by gross national product) and energy consumption had been used to forecast energy consumption. Correlation coefficients testing this relationship were invariably and reliably high. Total demand for commercial energy had been estimated, relating it to the gross domestic product instead of gross national product. Data of energy consumption from 1970 to 1977 had been used to derive the relation. The rate of growth of gross domestic product was assumed to be 6.5 per cent per year during the projection period 1979 to 1984. With an expected population growth of 2.1 per cent per year, **per capita** income would increase at an annual rate of 4.6 per cent at constant prices. The growth elasticity of energy consumption was calculated to be 1.70 for that period, and gradually decreased to a value of 1.60 for the period 1985 to 1990 and to 1.50 for the period 1991 to 2000. Consequently, the growth rate of commercial energy consumption was anticipated to decrease from 11.5 per cent per year during 1979 to 9.7 per cent per annum at the end of the projection period. Commercial energy consumption in the year 2000 was estimated to be 9.8 times its 1977 level and **per capita** consumption in 2000 was projected to be 6.4 times its 1977 level, or 1,130 kg of coal equivalent. The result of the projection is presented in table 2.

Table 2.

Total domestic consumption of energy, 1978 to 2000
(million tons of coal equivalent)

Year	Energy
1978	27,297
1979	30,815
1980	34,176
1985	57,369
1990	94,000
1995	149,000
2000	237,000

E. MEASURES TO MEET ENERGY REQUIREMENTS

The energy consumption growth rate increased during 1969 to 1977 owing to increasing industry, transportation and standard of living. The main concern was to find measures for reducing the rapid growth of oil consumed internally.

Coal led other energy resources in terms of known reserves, and therefore coal should be used internally as much as possible, allowing for more oil to be exported. An exploration drilling programme would be commenced in east Kalimantan and intensified drilling would be conducted in west Sumatra in addition to the delineation currently under way in south Sumatra. It was decided that coal would be used in future thermal power plants.

Economic utilization of natural gas, both as feedstock to industry or as fuel, was still insignificant. This was due to its remoteness and the lack of a gas distribution system. By developing industrial growth centres which would solve the problem of remoteness it was anticipated that natural gas would play a more important role. Part of the natural gas would be exported in the form of LNG provided techno-economical criteria could be met.

Hydropower and geothermal potentials, being renewable sources of energy, should be very attractive. The State electricity company was promoting micro hydropower plants, ranging in capacity from 25 to 1,500 kW, to speed up electrification in rural areas. Solar energy would also be important in the future. Firewood demand had been increasing steadily in the last decade in spite of the sharp rise in oil consumption. The present deficit of supply would be met by an increase of government activities in promoting firewood plantations by farmers and by establishing plantations of about 5,000 ha per annum.

For encouraging efficient use of energy, the Government imposed more tax on private cars and reduced tax on public vehicles. The structure of domestic energy prices was changed in the direction of providing consumers with incentives for efficient use of fuel.

F. INSTITUTIONAL ARRANGEMENTS

Among planning problems faced in outlining a sound energy policy, the first and foremost was the absence of an energy information system and a national energy data bank. Institutionally, until April 1978, the responsibility for energy was in the hands of several governmental agencies. Coal, oil, gas and geothermal projects had been managed by the Department of Mines while town gas, electricity and hydropower were the concern of the Department of Public Works and Power. Firewood was managed by the Department of Agriculture and nuclear energy by the Atomic Energy Agency. However, in 1976 an interdepartmental Technical Committee on Energy Resources was established to draft an energy policy. In April 1978, the Department of Mines had been renamed the Department of Mines and Energy so as to cover mining and energy except for firewood and nuclear energy.

ENERGY PROGRAMMING AND PLANNING IN MALAYSIA

(NR/WGMEPP/CRP. 2)*

by

The Petroleum Development Unit,
Prime Minister's Department (Malaysia)

A. RESOURCES

The most important energy resources were oil and natural gas. Next in importance was the hydroelectric potential. As Malaysia was in the tropics it could count on an abundant supply of solar energy and forest-based wood resources. Coal, agricultural and animal waste were of minor importance. The uranium potential was as yet unassessed but was not expected to be significant.

The oil reserve was officially estimated to be 137 million tons, while another 103 million tons of additional reserve was inferred. The natural gas reserve was officially estimated at 47,000 million m^3 but a doubling of this reserve might not be far wrong.

The gross hydroelectric potential was 414,000 million kWh per annum and the technical potenial was approximately 123,000 million kWh per annum.

The average daily total of solar energy availability was estimated to be 4.0 kWh per m^2.

Forest covered more than four fifths of the total area. However, there did not appear to be any wide-scale felling of trees for the purpose of obtaining firewood, although some charcoal was made from mangrove trees. On the other hand, logging was a large-scale activity that could provide very large amounts of wood waste which at present was not utilized.

Out of an expected 400 to 500 million tons of coal reserves about 93 million tons were considered to be recoverable.

Other sources of energy such as biogas, fuel from rice husks, coconut husks, etc. had not been investigated. However, palm oil plantations regularly used the palm husks as fuel for steam boilers. No estimates of agricultural waste had been made.

B. PRODUCTION AND CONSUMPTION

Oil had been produced in Malaysia in the State of Sarawak since 1910, and at present oil production was from 10 fields. In due course consumption would exceed production. Vary little of the associated natural gas was consumed locally, but it was expected that later some would be exported as LNG. Production and consumption of crude oil and natural gas and projections up to 1985 are given in tables 1 and 2.

Table 1. Crude oil
(tons per day)

	1975	1977	1980	1985
Production	13,425	24,500	32,830	14,010
Import	7,996	9,854	16,015	24,417
Export	9,227	17,720	23,243	3,535
Consumption	12,194	16,600	22,879	34,882

Table 2. Natural gas
(million m^3)

	1975	1977	1980	1985
Production of associated gas	2,662	3,936	4,106	—
LNG (export)	—	—	—	12,913

* Abridged.

The production of electricity is given in table 3. In 1976, the sectoral consumption was 52 per cent industrial, 29 per cent commercial and public, 13 per cent domestic and 6 per cent mining.

Table 3. Electricity production (million kWh)

	1975	1977	1980	1985
Hydro	1,005	631	2,514	4,235
Thermal	4,783	6,005	6,561	11,057
Total	5,788	6,636	9,075	15,292

C. DEMAND PROJECTION

Malaysia was dependent on petroleum products for more than 90 per cent of its requirements and this percentage was increasing. Demand projections for petroleum products had been made using an econometric model, trend analysis and regression analysis, and the demand was correlated with GDP. A simple equation was then used to project future demands using the GDP figure as the independent variable. The GDP growth was estimated in the Third Malaysia Plan which included a forecast for each economic sector.

D. ENERGY PLANNING

Malaysia did not yet have any comprehensive energy policy. The Petroleum Development Unit, Prime Minister's Department, had been charged with the responsibility of formulating such a policy.

1. Major problems

Demand management. More than a quarter of the petroleum products was consumed for the generation of electricity. Owing to industrial growth and increased standard of living, the rate of growth of electricity consumption was 11 per cent per annum, which was greater than the growth rate of GDP at less than 9 per cent per annum. In the face of dwindling availability of petroleum, this great dependence on petroleum and the increased consumption of electricity with its concomitant use of petroleum products could pose a great problem for the future. The conversion of existing generating plants to use substitute fuels, and the phasing out of old equipment for new, might curb demand for oil.

The Third Malaysia Plan forecast that the share of the industrial sector (manufacturing) in the GDP would rise to 26.2 per cent in 1990 compared to 14.4 per cent in 1975 at an average growth rate of 12.7 per cent per annum compared to the projected over-all GDP growth rate of 8.2 per cent per annum. Most of the energy used in industry was for process heat and it might be difficult to change over from oil to other substitute fuels.

The rural energy demand arose mainly for lighting and cooking, at essential minimum. The demand, therefore, was not amenable to any reduction but might be susceptible to change if an alternative, cheaper source of energy could be provided.

Supply management. Petroleum reserves might be required for export, in order to raise revenue for development, and conservation would be necessary. In any event, indigenous oil could not be depended upon for supply of energy by the 1990s. Malaysia had a considerable amount of gas reserves both associated with oil or from undeveloped gas-fields. Some of this gas had been earmarked for export in the form of LNG, but a large quantity was still available for local consumption. However, the gas-fields were away from the industrial centres and a large investment would be required before the gas could be utilized. A long lead time was also required to implement any programme of a gas grid. The quantity of associated gas might be too small to justify a large investment to carry the gas to the market, but this valuable energy resource was currently being wasted.

All the oil gas reserves were situated off-shore. Floating plants that could convert gas into petrochemicals, fertilizer and methanol could be towed into place to utilize gas from small gas-fields and oil-fields with large production of gas. The floating plants required large investments, the concept was new and uncertainties still persisted regarding their reliability and viability. In the case of methanol, certain changes in the market specifications were required so that the fuel could be blended with gasoline. This again not only required investments and long lead time, but also called for systematic energy planning in an integrated manner.

Indigenous hydro potential remained relatively untapped. According to current plans, in the year 1990, only 30 per cent of the electricity generated might be provided by this source. The problems were environmental and financial. In the case of Sabah and Sarawak, the most feasible hydro site contained valuable coal deposits that would be submerged when a dam was constructed. This hydro site was also far away from the centre of consumption which was Peninsular Malaysia. Thus a larger investment was required in order to transmit the electric power through high-voltage submarine cables to the centre of consumption. Also, in Malaysia, the economic advantage of hydroelectric generation was marginal when compared to thermally generated electricity. Lending institutions used this economic criterion for short-term calculations, although in the long run hydroelectricity should be preferred.

The supply of electricity to rural areas posed several problems. The National Electricity Board envisaged that the distribution network to cater for rural electricity might be completed by the year 2000. Solar photovoltaic cells might provide a small quantity of electricity for lighting only, but the financing arrangements or even viability had not yet been worked out. Biogas utilization required education of the farmers, and relatively few farms could adequately supply the raw materials.

2. Implementation of an energy policy

No measures had so far been taken to improve the energy efficiency in production nor for the minimization of consumption. There was no pricing structure to assist new sources of energy to be brought on stream, nor was there any that would encourage inter-fuel substitutions. An energy policy, however, had been drafted and was waiting approval by the Government. The policy emphasised the identification of energy sources that needed to be developed, the incentives for their development, the conservation policies, the institutional arrangements for its implementation, research and so on. Planning, research and monitoring required manpower of adequate skills to carry them out. Further difficulties might be encountered because of lack of essential data.

If inter-fuel transfer on a large scale were to be made in the future, large investments would be required in order to provide the infrastructure, for instance, the laying of a natural gas pipeline from the east coast of the Malay Peninsula to the west coast. Education and incentives were to be provided for the consumers to enable them to make a charge-over to substitute fuels.

It was in those areas, namely personnel, expertise in energy planning and investment, that Malaysia would look for outside assistance

E. SPECIFIC ACTION

The following steps were envisaged:

(a) An inventory to be made of traditional and of non-traditional and renewable energy resources;

(b) Statistics about the pattern of current energy consumption and the specific energy consumption of industries to be collected;

(c) Identification of potential and techniques for utilizing energy plantations, forest waste, agricultural waste and livestock waste;

(d) Assessment of geothermal possibilities, tidal and mini-hydro potentials, major hydro projects, solar and wind possibilities;

(e) Studies to be made of the use of synthetic fuels from natural gas sources;

(f) Exploration to be carried out for uranium and coal.

There was no single organization for analysing data in order to establish the consumption patterns of final energy usage. With this lack of a centralized unit it was difficult to apply energy conservation measures and inter-fuel substitutions.

F. CO-OPERATION IN ENERGY PLANS AND PROGRAMMES

These was scope for co-operation among countries in the region in the field of energy, particularly in trade. Apart from this, a fruitful area was in the exchange of information on energy utilization and research among member countries. A particular case was information on patterns of energy usage in like industries.

Internationally, there were many areas where assistance could be forthcoming. In addition to the flow of investment from the developed countries, there could be the transfer of technologies, for example, on manufacture of synthetic fuel from agricultural products.

ENERGY PLANNING AND PROGRAMMING IN PAKISTAN

(NR/WGMEPP/CRP. 8)*

by

A. M. Izharul Haque (Pakistan)

A. RESOURCES

1. Coal

The first investigation of coal reserves was made in 1949. In 1960 sizeable new deposits of coal were found in the Lakhra area, increasing the reserves estimated by the Geological Survey of Pakistan to 442 million tons, of which economically recoverable reserves were estimated to be 176 million tons. The coal could be classified as lignite to sub-bituminous, with non-coking or weak coking properties, with low fixed carbon and high sulphur and high ash content, and susceptible to spontaneous combustion if stacked with a depth of about 1.5 m.

2. Oil

Five oil fields were producing oil at present. As at June 1976, the position on these was: original oil in place: 71.5 million tons; oil recovered: 11.4 million

* Abridged.

tons; remaining recoverable oil: 24.4 million tons. Since then, two further fields had been discovered, but figures on reserves were not yet available.

3. Natural gas

Thirteen gas fields had been discovered so far, with original total reserves of 630,000 million m^3. Reservoir studies had not been completed for most of the fields. Taking into account the total production, the balance in July, 1977 was 584,000 million m^3, equivalent to 579 million metric tons of coal equivalent.

4. Hydroelectric energy

The River Indus and its tributaries provided the hydroelectric potential of Pakistan, forming a link between two great natural reservoirs, namely, the snow and glaciers in the mountains and the ground water contained by the alluvium in the Indus Plains. With the implementation of the Indus Waters Treaty of 1960 between India and Pakistan, Pakistan could develop the Indus and three tributaries.

In considering the hydro potential, account must be taken of the high seasonal variation of flows, the use of water from reservoirs for irrigation, having priority over the use for power, and high siltation rates.

The difference between the installed capacity and the firm capacity was large and the firm capacity which could be obtained from the existing or planned reservoirs had a limited lifetime. Almost the entire hydroelectric potential was concentrated in the northern zone. Early assessment of total potential was of the order of 25,000 MW, but an alternative assessment in 1967 placed the economically exploitable potential at 10,000 MW. The present installed capacity was 1,567 MW, and was expected to reach 3,247 MW by 1983.

5. Nuclear energy

In 1960 a uranium prospecting programme was commenced, and several promising areas in various parts of the country had been identified. Detailed geological studies and resource estimation were in progress.

6. Others

In the non-commercial sector, resources such as animal dung, firewood, bagasse, wind, geothermal and solar energy, biogas, etc. required detailed study for an estimate of their potential.

B. EXPLORATION PROGRAMME

1. Coal

The coal at Lakhra varied from 3,894 to 6,887 kcal/kg. Studies were being undertaken to determine the type of mining, the siting and optimum size of a power station and availability of water, together with the cost economics. A coal-fired power station (tentatively 250 MW) had been planned to come into operation in the mid-1980s.

2. Oil and natural gas

Since 1947, 94 exploration wells had been drilled, and oil and gas discovered in 17 wells. Ninety development wells had been completed.

During the Fifth Plan (1978 to 1983), 50 wells were to be drilled by the Oil and Gas Development Corporation in the public sector, comprising 30 development wells and 20 exploratory wells. In addition, in the private sector, 3 or 4 exploratory wells would be drilled per annum by licensees.

3. Hydroelectric energy

A feasibility study was prepared in respect of Kalabagh power station for 8 units of 220 MW, totalling 1,760 MW. A detailed study was under way for a number of sites, to update data and make an economic comparison with thermal and nuclear generation.

4. Nuclear energy

Long-term studies of power requirements, conducted by different international consultants and agencies, concluded that a 600 MW nuclear power station could be constructed in the northern area. Commencement of work on this project had been proposed.

5. Non-commercial energy

The energy resources cell of the Government estimated in 1975 that about 50 per cent of the energy requirements was obtained from non-commercial resources. The survey indicated that 7.22 million tons of coal equivalent were being consumed as follows: firewood: 68 per cent; dung: 21 per cent; cotton stalks: 9 per cent; others: 2 per cent.

6. Non-conventional energy

Biogas project. The energy resources cell initiated a biogas project utilizing animal waste. The project envisaged installation of 100 biogas plants in different parts of the country, mainly in rural areas, of which 55 plants had been installed by June 1978.

Solar energy. Research and development work on solar energy had been conducted by educational institutions, the Council of Scientific and Industrial Research, and the Pakistan Atomic Energy Commission. Work was aimed at developing a number of appliances such as solar water heaters, a solar desalination plant, solar chilling equipment, solar pumps for lift irrigation, photovoltaic cells for rural electric lighting and direct and indirect solar driers.

Solar energy had great utility in rural areas for pumping of water for drinking and irrigation, generation of electricity for domestic use, reclamation of waterlogged areas, and desalination. The conversion of solar energy into electricity by using photovoltaic cells had good prospects for isolated areas, and it was estimated that about 20,000 villages were located in remote areas where the supply of electricity through transmission lines from the grid stations might not be economically viable in the near future. On the basis of a survey, the requirements for a village of 200 familles (1,000 persons) had been identified, totalling 103 kWh per day, of which nearly 58 kWh per day could be met by solar energy and the rest by other sources of energy such as biogas. The electric power supply would be met from a battery charged by solar, wind and biogas generating devices as and when they could. The energy resources cell had prepared a scheme to set up four demonstration centres, one in each province of the country, in order to study the economic and other technical aspects of this project.

Geothermal energy. There were indications that in many locations in the mountainous region high-temperature steam and water were available. Preliminary technoeconomic studies had been carried out, and further work recommended.

Micro hydro stations. The Appropriate Technology Development Organization was working on the installation of micro hydro stations of capacities up to about 15 kW, and some pilot plants had been developed. Efforts were being made to develop indigenous techniques, with simple design and low-cost civil work, to be carried out by the local people.

Wind energy. Six windmills had been installed in the Baluchistan area for lifting water for drinking purposes. Windmills for the generation of electricity were not found to be economical.

C. PRODUCTION, CONSUMPTION, IMPORT AND EXPORT OF ENERGY RESOURCES

Historical data are given in tables 1 to 4.

Table 1. Coal statistics
(million tons)

Year	*Production*	*Consumption*	*Export*
1965/66	1.29	1.45	0.12
1970/71	1.34	1.42	0.05
1973/74	1.21	1.19	0.02
1974/75	1.30	1.25	0.02
1975/76	1.06	1.07	0.02
1976/77	1.20	1.22	0.02

Table 2. Oil statistics
(million tons)

Year	*Production (crude oil)*	*Consumption (oil)*	*Import (crude oil)*	*Import (petroleum products)*	*Export (petroleum products)*
1965/66 . .	0.45	2.16	2.71	0.17	0.68
1970/71 . .	0.46	2.83	3.13	0.39	0.60
1973/74 . .	0.32	2.96	3.25	0.76	0.76
1974/75 . .	0.34	3.41	2.84	1.10	0.37
1975/76 . .	0.33	3.16	0.89	0.90	0.45
1976/77 . .	0.51	3.39	2.92	1.06	0.52

Table 3. Natural gas statistics
(million m^3)

Year	*Production/consumption*
1965/66	1,633
1970/71	3,019
1973/74	4,092
1974/75	4,439
1975/76	4,443
1976/77	4,786

Table 4. Hydro and nuclear generation
(million kWh)

Year	*Hydro*	*Nuclear*
1965/66	1,425	—
1970/71	3,449	1
1973/74	4,141	454
1974/75	4,359	557
1975/76	5,436	565
1976/77	5,183	422
1977/78	7,466	342

D. DEMAND PROJECTIONS

The demand for coal was expected to increase from 1.2 million tons in 1977/78 to 1.7 million tons in 1982/83 at 7.2 per cent per annum. A substantial increase could occur in the mid-1980s if Lakhra coal were used for power generation.

The projected demand for oil was estimated to increase at an annual rate of 4.5 per cent during the period 1977/78 to 1982/83.

The projected demand for gas including use for fertilizer was estimated to increase at an annual rate of 16.6 per cent for the period 1977/78 to 1982/83.

Electric power and energy projections are given in table 5.

Table 5. Projects for electric power and energy

Year	Power demand (MW)	Energy demand (million kWh)
1977/78	2,236	12,154
1980/81	3,034	16,488
1985/86	4,765	25,045
1989/90	6,844	35,972

E. ENERGY PLANNING AND PROGRAMMING

1. Policies involved

Power. The policies involved in respect of development of power in the period 1978-1983 were as follows:

(a) Maximum priority would be given to hydro generation;

(b) Fuel consumption would be conserved by transmitting bulk power to the southern part of the country over extra-high-voltage transmission lines;

(c) Maximum use would be made of coal resources;

(d) Secondary transmission and distribution facilities would be improved to reduce system losses and extend power facilities to the maximum number of consumers;

(e) Village electrification would be accelerated;

(f) Every effort would be made to place the power corporations on a sound financial basis so that at least 30 per cent of the expansion programme was financed through self-generation of resources.

Fuel. In the fuel subsector the policies involved had to deal with diverse and separate products which had several interrelated objectives:

(a) Large resources would be devoted to exploration of new oil- and gas-fields, and development of proven fields;

(b) The Government would permit a freer expansion of gas consumption, in modification of earlier policy of conserving gas reserves primarily for industrial use;

(c) Efforts would be made actively to promote the use of LPG;

(d) Plans for refining crude oil would be reviewed to accommodate the increased availability of indigenous crude;

(e) Arrangements for transportation and storage of oil would be strengthened;

(f) Efforts would continue for development of coal resources;

(g) Research and development of non-conventional sources of energy would continue.

2. Methodologies used in planning

Power. There were two important organizations, namely the Water and Power Development Authority (WAPDA) and the Karachi Electric Supply Corporation (KESC), dealing with generation, transmission and distribution of electricity. While KESC was responsible for the Karachi area and its surroundings, the rest of the country was taken care of by WAPDA. The respective load forecasts were studied and also the historical trends were taken into consideration, and annual rates of growth of 11.6 per cent in the case of WAPDA and 10 per cent in the case of KESC had been projected.

For WAPDA, reserve capacity was 11 per cent of the installed capacity, with spinning reserve equal to the capability of the largest unit on line. The unit size of the largest generator on line was generally in the range of 10 per cent of the maximum demand. Power balances were worked out in respect of the four major market areas after detailed study of the capabilities available for hydro generation and thermal generation.

For the Karachi system the reserves were based on the maintenance schedule for the thermal units, and spinning reserve was equal to the largest unit on line.

The two systems were at present interconnected with three circuits at 132 kV and, in order to effect bulk transfer of power from the northern hydro stations, a 500 kV line had already been constructed part of the way, operated at 220 kV, and by 1983 would be completed to Karachi and operated at 500 kV.

Fuel. For fuel, the first requirement of the planning strategy was to determine the total requirement of commercial energy. Demand projections made by different organizations concerned were critically examined by the Planning Commission and the demand projection was finanlized. Supply projections were also studied in depth, estimates of interfuel substitution were made and investment projections were worked out by the Planning Commission.

F. MEDIUM-TERM ENERGY PLAN FOR 1978-1983

1. Commercial energy

The supply of commercial energy increased from 12.09 million tons of coal equivalent in 1973/74 to

15.50 million tons of coal equivalent in 1977/78 at a growth rate of 6.4 per cent annum. Details are given in table 6. The rate of growth of GDP during this period was 3.1 per cent. **Per capita** consumption of energy went up from 180 kg of coal equivalent to 205 kg of coal equivalent. There was a sharp increase in the supply of hydroelectricity which grew at 15.8 per cent per annum and increased its share of total supply from 14.8 per cent in 1973/74 to 20.8 per cent in 1977/78. This resulted in conserving the use of oil, the share of which in the over-all supply of commercial energy went down from 42.2 per cent to 37.6 per cent during the corresponding period. The shares of gas, nuclear energy and coal declined slightly. The use of LPG increased very sharply but its share in the total supply remained insignificant.

The supply of commercial energy was projected to increase from 15.50 million tons of coal equivalent in 1977/78 to 23.04 million tons of coal equivalent in 1982/83 at a growth rate of 8.25 per cent per annum, against an estimated growth rate of 7 per cent in GDP during the corresponding period.

As a step towards self-sufficiency and reduced dependence on imported petroleum, it was hoped to reduce the share of oil to 34.3 per cent of total supply by 1982/83.

Table 6. Components of energy supply (million tons of coal equivalent)

Type of energy	*1973/74*	*1977/78*	*1982/83*
Natural gas, excluding fertilizer feedstock	4.28	5.42	8.15
Oil, excluding non-energy use	5.10	5.83	7.90
Coal	0.71	0.82	1.15
Hydroelectricity	1.79	3.22	5.62
Nuclear	0.20	0.25	0.17
LPG	0.01	0.06	0.05
Total	12.09	15.50	23.04

Power. The aggregate maximum demand was forecast to increase at a rate of 10.3 per cent per annum during the period, and the installed capacity was expected to increase from 3,510 MW in 1977/78 to 5,765 MW in 1982/83.

In the period 1973/74 to 1977/78 the emphasis had been placed on supplying electricity to the maximum possible number of consumers rather than maximizing the number of villages supplied. It was planned that the coverage of rural population would be further increased.

Fuel. The consumption of oil products was envisaged to increase at an annual rate of 5.4 per cent, which was higher than the rate of growth of 3.9 per cent experienced in the last few years. In order to attract capital for oil and gas exploration, the existing policies and regulations for encouraging foreign companies would be continued. The indigenous production of oil was expected to increase from 0.5 million tons to 1.73 million tons at an annual growth rate of 28.3 per cent. The total refining capacity in the country, which was at present 4.8 million tons, would be increased to 6.8 million tons.

The consumption of natural gas was estimated to increase at an annual growth rate of 11.5 per cent per annum. The gas transmission capacity would be increased by 20 per cent, and a new gas pipeline would be laid to Quetta in the north-west which was at present being supplied with LPG.

2. Energy research

Research and investigation in the field of conventional and non-conventional energy resources was emphasized. The main purpose was to keep abreast of technological developments and to utilize new techniques wherever these were economically viable. The main projects were biogas plants, rural energy research centres, solar and wind energy demonstration units, and research on substitution of fuels.

G. INSTITUTIONAL ARRANGEMENTS

The organizations concerned with the planning and programming of energy were the ministries of Finance, Planning and Provincial Co-ordination, Water and Power, Petroleum and Natural Resources and Science and Technology, and the Atomic Energy Commission.

Over-all planning was carried out by the Planning Division under the Ministry of Finance, Planning and Provincial Co-ordination. The different ministries concerned formulated their own plans based on strategies and objectives set by the Planning Division. The forecasting of load, physical programmes and financial provisions assessed by an Energy Working Group were finalized by the Planning Division, and kept under constant review.

The high-level National Energy Policy Advisory Committee had recently been revived. Its terms of reference were to assess energy rquirements and energy resources, establish the supply and demand balance, formulate a national energy policy, develop and utilize new sources of energy, prepare short- and long-term plans, and recommend a taxation pattern which would best serve the interests of the national energy policy.

Comprehensive legislation was in force governing rights, duties and prices with respect to oil, natural gas and electricity, and measures had been suggested for conservation of energy.

H. EXTERNAL ASSISTANCE

There was a need for consulting services in respect of over-all planning for the energy sector, keeping in view its sensitivity to change in cost of fuels, substitution of fuels, priorities for the development of energy resources and the facilities to be provided. The consultancy services might establish a proper, systematic and organized data collection system for the reserves, production, consumption, export and import of energy resources, scientific analysis of data, and develop formats, flow charts, etc. for furnishing the information on regular bases. Such consultancy services might greatly help in developing energy planning techniques and skills, starting with the layout of a proper organization, delineation of duties and responsibilities, delegation of power, fixing of accountability and identification of a clear-cut line of command in the field of energy planning and management.

There was also a need to develop a mechanism for collecting, compiling and computing statistics of non-commercial energy resources and their availability, consumption, prices, etc. while determining the optimum use of such resources.

The consultancy services might also facilitate exchange of technical experts in the field of energy amongst developing countries of the region and also loan of personnel from developed countries within or outside the region.

TEN-YEAR ENERGY DEVELOPMENT PROGRAMME, 1978-1987

(NR/WGMEPP/CRP. 9)*

by

The Ministry of Energy (Philippines)

A. PRESENT SITUATION

The Philippines was 95 per cent dependent on crude oil for its commercial energy requirements. As oil imports continued to escalate, the country's oil import bill increased dramatically as a percentage of total imports. Before the events of 1973 and 1974, the oil import bill amounted to 13 per cent of total imports. By 1976, crude oil had accounted for almost one fourth of the import bill.

Energy development was characterized by a rapid growth in energy consumption relative to national output. During the 1960s when real GNP was increasing at about 5 per cent a year, commercial energy consumption registered a higher growth rate of almost 10 per cent a year.

Statistical analysis showed that a 1.0 per cent increase in income caused a 1.5 per cent increase in energy consumption while a 1.0 per cent increase in price would generate only a 0.33 per cent decline in energy consumption.

Considerable efforts had been made to locate, survey and explore indigenous energy deposits. For instance, in 1977, 9,000 km of seismic lines were run and 15 wells were drilled in the search for oil and gas, 21 wells were drilled in the proving of geothermal reservoirs and 32 holes were drilled in the search for uranium. A tentative assessment of energy resources is given in table 1.

Table 1. Tentative energy resources
(million tons of coal equivalent)

Resource	*Developed*	*Probable*	*Potential*
Hydroelectric	0.41 per year	3.36 per year	4.66 per year
Geothermal	0.15 per year	2.42 per year	NA
Uranium	—	0.93	NA
Coal	—	28.0	560
Oil	—	NA	NA
Non-conventional	0.04 per year	1.49 per year	98 per year

Development of coal was proceeding as rapidly as possible, and annual production had increased from 39,000 tons in 1973 to 285,000 tons in 1977.

An energy policy had been set out in detail, paying attention to management of demand, the respective roles of the public and private sectors, diversification of indigenous supply sources and diversification of sources of imports.

B. PLANNED ENERGY DEVELOPMENT

There would be some shifts in the structure of demand in the future, notably a reduction in the transport proportion and an increase in the electricity generation proportion. There would also be substantial changes in the mix of energy sources, as shown in table 2.

The assumptions allowed for success in locating new oil fields and getting them into production so that by 1987 domestic oil would account for one third of total oil supply, a fourfold increase in coal reserves and a tenfold increase in coal production, a sixfold increase in installed hydroelectric capacity, and substantial imports of uranium.

Considerable progress in rural electrification, including the use of mini hydro plants, and in harnessing non-conventional energy resources, was also planned.

* Abridged. This publication was issued by the Ministry of Energy in June 1978. Some highlights are given here.

Tabel 2. Energy sources mix, 1977 to 1987
(million tons of coal equivalent and percentage)

	1977		1982		1987	
	Quantity	%	Quantity	%	Quantity	%
Oil						
Electricity generation	3.44	20.6	4.95	19.4	5.47	14.3
Other	12.36	74.1	16.60	64.9	21.08	55.1
Coal	0.16	1.0	1.07	4.1	2.06	5.4
Hydro	0.73	4.3	1.32	5.2	4.67	12.2
Geothermal	—	—	1.13	4.4	1.69	4.4
Nuclear	—	—	—	—	1.29	3.4
Non-conventional	—	—	0.51	2.0	2.01	5.2
Total	16.69	100.0	25.58	100.0	38.27	100.0

ENERGY PROGRAMME IN THE REPUBLIC OF KOREA

(NR/WGMEPP/6)*

by

Jin-hi Choi (Republic of Korea)

A. INTRODUCTION

The demand for energy to sustain an economic growth rate of 10 per cent annually (the average rate for the last 15 years) was expected to grow at an average annual rate of 10 per cent for the next 15 years while supplies of domestic resources were diminishing and dependence on imported energy was rising sharply.

The Ministry of Energy and Resources, which was established in January 1978, set as its primary objective the formulation and promotion of an over-all energy policy for establishing the most economical and feasible relationship between energy demand and supply, institutional development for integrated energy planning, and implementation of a rational programme for the development of indigenous energy resources and imports.

B. ENERGY DEMAND AND SUPPLY

Energy consumption grew threefold between 1961 and 1976, as shown in table 1.

Domestic energy resources were limited to anthracite coal, hydropower, and firewood. In 1961, imports of crude oil and coal accounted for 8.1 per cent and 2.0 per cent respectively of total energy consumption, and by 1977 the respective figures had increased to 60.5 per cent and 4.2 per cent. In 1969, the Goverment enacted a special law for the coal-mining industry, and by using the funds from a tax on oil, supported coal production by executing related projects such as marine and railroad transportation systems, the installation of power lines, etc. As a result, coal mining became active again and coal production increased from 10.4 million tons in 1969 to 16.9 million tons in 1976.

Table 1. Energy consumption, 1961 to 1977
(million tons of coal equivalent)

	Coal	Oil	Hydro	Firewood	Total
1961	6.1	1.5	0.3	11.1	19.0
1971	12.1	21.3	0.6	8.0	42.0
1972	12.3	22.8	0.7	7.8	43.6
1973	15.5	26.7	0.6	7.2	50.0
1974	16.1	26.9	0.9	6.9	50.8
1975	16.9	29.7	0.8	6.7	54.1
1976	19.3	34.0	0.9	6.2	60.4
1977	19.0	39.1	0.7	5.9	64.7

The country's hydroelectric potential was estimated at about, 2,000 MW, concentrated in four main river systems, of which 710 MW had already been developed. Most of the sites were of small size with low heads and required the construction of relatively costly dams to regulate the river flows. Hydropower contributed about 1.1 per cent of total energy in 1977 and was not expected to contribute substantially more in the future.

Total consumption of firewood, largely in rural areas, in 1977 was estimated to be about 6 million tons of coal equivalent which was approximately 9.1 per cent of the total energy supply, well down from 58.1 per cent in 1961.

The western coast, and particularly the Bay of Inchon, experienced very high amplitude tides (8 to

* Abridged.

9 m) and could be suitable for tidal power generation. Total tidal potential had been estimated at about 4,000 MW, but in view of the technical problems and high capital cost involved, the Government proposed to try a pilot plant in 1986 following additional studies.

C. EXPLORATION OF ENERGY RESOURCES

The Government undertook exploration of energy resources through public sector organizations such as the Korea Mining Promotion Corporation, and the Korea Research Institute of Geoscience and Mineral Resources. They had not been able to discover hydrocarbons on shore or off shore, although, in their exploration of the continental shelf, they identified a potential hydrocarbon-bearing area. However, that area could not be fully explored because ratification of the off-shore agreement between littoral countries had been delayed. Although several holes were drilled on shore, no productive wells were discovered. It was expected that an agreement on marine resources development would be drawn up shortly, and systematic exploration would start with intraregional co-operation.

D. DEMAND FORECASTS

In the 15 year long-term energy plan recently formulated by the Korea Development Institute, energy demand was projected to increase at an average annual rate of 10 per cent during the period 1977 to 1991.

The forecasts of energy demand given in table 2 indicated that the energy demand of the industrial and transportation sectors would grow more rapidly than that of other sectors; the industrial sector from 46.5 per cent in 1975 to 62.6 per cent in 1991 and the transportation sector from 10.0 per cent in 1975 to 15.4 per cent in 1991. Therefore, the main thrust of the energy conservation policy was to reduce consumption in the industrial and transportation sectors.

Table 2. Long-term energy demand forecast (million tons of coal equivalent)

Sector	1970	1975	1981	1986	1991
Industrial	15.7	25.1	57.3	98.4	162.7
Transportation	3.9	5.7	11.5	21.8	40.1
Household	16.2	19.0	23.5	30.2	40.4
Others	2.9	4.2	7.0	11.0	16.9
Total	38.8	54.0	99.3	161.4	260.2

E. ENERGY STRATEGY

With limited domestic energy resources, the Republic of Korea had become increasingly dependent on foreign oil to meet the rapid increase in energy demand. Unless counter measures were adopted immediately, the share of domestic energy resources in the total energy supply might continue to diminish from 35 per cent in 1977 to 26 per cent in 1981 and to 9.4 per cent in 1991. Assuming that international supplies were available, it would be necessary to import large quantities of fuel, and the energy supply position might be as indicated in table 3. As an alternative strategy, the country could make greater use of imported bituminous coal and nuclear energy. In the long run, the Republic of Korea would need to develop renewable and inexhaustible sources of energy.

Table 3. Long-term energy supply forecast (million tons of coal equivalent)

	1975	1981	1986	1991
Domestic (except nuclear)	23.3	25.8	28.5	24.5
Nuclear	—	1.8	16.4	40.6
Imports (total)	30.7	70.7	116.5	195.1
Oil	29.7	63.7	88.8	130.1
Gas	—	—	—	7.9
Coal	1.8	8.0	27.7	57.1

A few action points are enumerated below:

(a) The exploration for and development of domestic coal and hydroelectricity should be accelerated and potential tidal power and continental shelf off-shore oil should be explored;

(b) A long-term procurement plan for imported energy should be drawn up. Foreign sources of energy should be diversified;

(c) Industries and utility companies using oil should change over to imported bituminous coal and nuclear fuel, sparing oil more for the transport sector and household use. The commercial sector and that part of the household sector using anthracite coal should convert to oil;

(d) The economy should become more energy-conservation-oriented and steps should be taken to improve energy efficiency at user plants, promote energy conservation in the residential and commercial sectors and develop more efficient energy utilization techniques;

(e) There was an urgent need to pursue a vigorous research and development programme of non-conventional energy sources (solar, wind, geothermal).

ENERGY PLANNING AND PROGRAMMING IN SINGAPORE

(NR/WGMEPP/7)*

by

The Public Utilities Board (Singapore)

A. RESOURCES

Although Singapore was the third largest oil refining centre in the world, it did not have any

* Abridged.

indigenous energy resources of significance. It did, however, have an abundance of solar energy owing to its geographical location a few degrees above the equator, and the intensity of solar radiation on the earth surface was about 1.1 kWh/m^2. The lack of large open spaces was likely to be an inhibiting factor against the widespread use of solar energy on any sizeable commercial scale. However, utilization of solar energy for water-heating purposes had been on the increase in recent months, and solar plate collectors were incorporated in building designs, while installation of solar heaters in existing buildings was currently under way. Solar heating was insufficient on its own to meet the hot water requirements of the buildings and supplementary heating from conventional electrical sources was resorted to.

A small quantity of energy in the form of sludge gas from sewerage treatment processes and waste heat from incineration of city garbage was available. The biogas from the sewerage treatment works was used to drive a small generator, but the quantity of gas available was insufficient to meet the electrical demand of the treatment works. The incineration of city waste or garbage produced a large amount of heat which was recovered to feed boilers and produce steam for electricity generation. The three incinerator units with integrated boilers in the first stage of the incineration project were capable of consuming 400 tons of garbage each per day and of producing 11 MW of electrical power. Consumption of the incineration plant amounted to some 2.5 MW, leaving 8.5 MW for injection into the electricity supply network.

B. PRODUCTION AND CONSUMPTION

1. Commercial energy

Of the total consumption of some 2 million tons of petroleum products in Singapore in 1976, about 55 per cent went towards the generation of electricity, 1.7 per cent towards gas production and the remainder was used for transportation and industries.

Sales of electricity increased from 1,075 million kWh in 1966 to 4,038 million kWh in 1976, in which year the industrial sector accounted for 48.7 per cent (major categories being petroleum refineries, electrical and other metal products, and steel mills and other basic metal industries), commercial 32.3 per cent, domestic 17.4 per cent and other 1.6 per cent. Forecasts for maximum electricity demand, generation and sales are given in table 1.

Sales of LPG from refineries in 1976 were mainly to the domestic sector (63.8 per cent); the remainder went largely to the commercial sector, industry taking less than 10 per cent. Changes in the pattern of consumption were expected, with commercial and industrial proportions gradually increasing, until by 1990 about half of the consumption would be in those sectors. However, total consumption was expected to increase only by 3 to 5 per cent per year.

Table 1. Forecast electricity quantities

Year	Maximum demand (MW)	Generation (million kWh)	Sales (million kWh)
1978	939	5,517	4,855
1980	1,119	6,598	5,806
1985	1,710	10,108	8,895
1990	2,549	15,072	13,264
1995	3,711	21,940	19,307

2. Methodology of forecasts

Forecasts for electricity and gas consumption were made from econometric and regression models based on the assumption of no drastic change in the social and economic structure in the time frame considered. Correlating factors used were GDP, manufactured products, population, non-manufacturing GDP and GDP *per capita.* While the forecasts were considered accurat enough for long-term planning purposes, they were thought to be rather unsatisfactory over the short-term period owing to the inability of the models used to capture, with reasonable accuracy, short-term fluctuations in demand. Ten years of statistical data were used as a base for the forecast. It was felt that perhaps an incremental model using incremental values of independent variables, rather than absolute values, could give a better forecast.

3. Alternative fuels

The import and consumption of fuelwood and charcoal were insignificant, being used mainly for special cooking purposes.

Up to 1983, fuel oil would continue to be used in generating stations, although some boilers were designed for dual fuel firing (gas or oil). For the new power stations, planned for commissioning from 1986, the boilers would also be designed for dual fuels, in that case coal (preferred) or oil.

C. ENERGY PLANNING AND PROGRAMMING

1. Oil

Singapore was dependent on world supplies of primary energy products to meet its increasing demand. It was therefore highly susceptible to market changes in the supply and demand of those primary energy products, and it was prudent to diversify its use of fuels away from oil, as noted above.

2. Electricity

Electricity generation expansion planning was carried out through computer simulation. Data on different plant types and ratings and forecast maximum demand were used to derive an optimum solution for a generation expansion plan which gave the optimum plant mix, timing and size of plants. The major problem faced was the lack of suitable sites for construction of new power stations, taking into account stack height limitations imposed by military and civil aviation authorities and pollution control requirements. The rising cost of capital equipment was a perpetual cause for concern and financial aids, in the form of long-term loans, would continue to be required for large projects like power stations and transmission projects.

The basic electricity tariff had not been changed since February 1974, owing mainly to improvement in system efficiency as a result of commissioning larger generating units and low maintenance and running costs.

It was expected that the development of electric vehicles in the foreseeable future would have an impact on the pattern of electricity consumption although this was not likely to be evident for some years.

3. Gas

Gas production in Singapore was based on naptha as the feedstock. Owing to the very low sulphur content of naptha, atmospheric pollution was minimal. The new gas plants had an efficiency of over 90 per cent and capacity was of the order of 830,000 m^3 per day. Further plants would be installed, with modern distribution equipment.

4. Transportation sector

In the field of transportation, various legislative measures aimed at discouraging private car ownership and uneconomical usage of cars had been instituted. The improvement of the public transport system through the introduction of new routes, new buses and the creation of bus lanes had done much to promote efficiency. Detailed engineering studies on a mass rapid transit system had been going on over the past few years. The use of LPG to power taxis was under study. Currently taxis were powered by diesel engines which left much to be desired in terms of pollution.

D. CONSERVATION

1. Electricity

Conservation measures in the generation of electricity were achieved through the use of a computer optimization programme to maximize generation thermal efficiency. The present domestic tariff structure, which encouraged higher consumption of energy, was being reviewed and would be modified to discourage excessive usage. An in-depth study of the feasibility of introducing load management techniques to shift loads such as air conditioners and water heaters to off-peak periods has been carried out, and indicated the possibility of some savings.

2. Gas

Unaccounted-for gas approached 20 per cent of production in 1976. The major portion of this was due to losses through leaking pipes and joints. Considerable improvement had resulted from a mains leakage control programme. Steps had also been taken to reduce leakage by keeping the gas pressure as low as practicable. More precise control of district pressure was achieved by time control of gas governors, close monitoring of gas pressure by recorders at strategic points and relief of bottle-necks in low-pressure mains. In the future, leak surveillance would be intensified and corrosion-resistant pipes and other methods of pipe protection would also be used.

3. Building design

Energy conservation measures had been introduced in the building industry. Most high-rise complexes were now designed with various sun control devices such as vertical fins, horizontal projections, heat reflecting glass, and minimum glass surface to reduce the amount of heat transfer into the building. Use of more efficient lighting systems and solar energy for water heating contributed towards reducing the energy bill. Many commercial building owners were now more conscious of energy conservation measures and energy audits were being undertaken.

E. ACTIONS SUGGESTED

1. Electricity grid

The interconnexion of the supply grids of adjoining and neighbouring countries was a step that could be taken to improve the energy situation of the region. Immediate advantages that could be gained were an improvement in total generating efficiency, a sharing of spinning reserve and better plant utilization.

2. Regional power pool

The creation of a regional electrical power pool where capital and running cost of generating facilities were shared amongst participating countries was another possibility. Larger and more efficient generating sets could be installed, reducing the cost per unit of electricity generated. The construction of a nuclear plant, for example, could be economically viable on a shared basis, even though it could not be justified for an individual country.

3. Regional co-operation

Co-operation in regional energy supply in time of need was another avenue worth exploring. Exchange of information and statistics and the commencement of dialogues among countries in this region would benefit each and every country.

ENERGY REQUIREMENTS AND PLANNING IN SRI LANKA

(NR/WGMEPP/CRP.1)*

by

K. K. Y. W. Perera and G. B. A. Fernando (Sri Lanka)

A. RESOURCES

1. Hydroelectric energy

The most predominant resource of Sri Lanka was its hydropower potential. There were 103 rivers and streams mostly originating in the central hill country. The developed hydro resources amounted to 329 MW. The total capability and energy potentials were estimated to be 1,592 MW and 6,230 million kWh respectively.

2. Coal, oil, and natural gas

There were no known coal, oil, natural gas or similar resources. Approximately 3 million tons of peat had been discovered in the neighbourhood of Colombo city. The extractable quantity of peat in that area had been estimated to be equivalent to 2 million tons of peat with a calorific value of 2,600 kcal/kg. Other peat deposits might exist but had not been identified and evaluated.

3. Nuclear resources

Monazite sands found in certain areas contained uranium and thorium ore in the form of oxides to the extent of about 10 per cent thorium oxide and 0.1 per cent uranium oxide.

4. Firewood

Firewood and agricultural wastes constituted a major energy resource. The area under forest in Sri Lanka was roughly 0.6 million hectares under proclaimed forests, a similar area of proposed reservations and about 1.8 million hectares under other crown forests. A major portion of firewood became available owing to replanting of rubber plantations under a subsidy scheme. Substantial quantities of fuel were in the form of wood wastes from sawmills, paddy husks, and wastes available from coconut plantations and tea plantations.

* Abridged.

5. Animal and vegetable wastes

Animal waste, primarily cow-dung, was available in the major cattle breeding areas in the northern and southern parts of the country. The total number of cattle and buffaloes was 2.4 million animals. Although the cow-dung was not burnt as an energy source in Sri Lanka, substantial volumes of biogas could be produced by using cow-dung supplemented by vegetable wastes available in substantial quantities throughout the country.

6. Solar energy and other renewable resources

The near equatorial position of Sri Lanka and the topography of the island guaranteed the availability of high solar insolation and reliable wind régimes throughout the year. The average solar intensity had been measured, giving a yearly average over a 10-hour day of about 5 watts per m^2, and a seasonal range from 8 watts per m^2 to 3 watts per m^3. Average annual wind speed measured at 11 stations ranged from 8 km/h to 27 km/h.

There were no known areas for geothermal energy of any significance and the tidal ranges were inadequate for energy production. Favourable ocean thermal gradients appeared to exist off the eastern coast.

B. EXPLORATION PROGRAMMES

1. Hydroelectric energy

Investigations were carried out covering most of the larger rivers with a potential for hydropower and energy. The Mahaweli Ganga, with a drainage area of over 10,000 km^2, accounted for more than 70 per cent of the total hydropower and energy still available for development in the country. The development of the gross power and energy potential of the Mahaweli River basin with other irrigational benefits was being considered.

The identification and proper design of power projects in the Mahaweli and other river basins, with due weight given to the power and energy development aspects was of extreme importance considering that the total resources of hydropower available were moderate. A complete and comprehensive reassessment of all the river basins, including even the small discharges, for irrigation purposes should be carried out, and expert advice and/or foreign consultancy services, in cases where local talents were not sufficient, were needed.

The river flows during monsoon periods reached major flood level while very small flows were available during the dry season, and large reservoirs were needed to make full use of the potential. It was fortunate that two regions received benefit from two different monsoons and the drought period for one region did not coincide with that of the other.

2. Coal, oil and natural gas

Exploration for oil and gas had been conducted in the north-western parts of the country during the last few years but was not successful. Off-shore exploration was presently being carried out in the same region and the results so far obtained were also not convincing. However, the existence of crude oil and gas could not be ruled out and further exploration was required. The lack of equipment, expertise and the large capital investments required to launch a major exploration programme hindered progress in this field. Exploration of these resources as joint ventures with outside agencies was being considered.

3. Nuclear resources

The prospect of using nuclear power, in the absence of another proved alternative after the full exploitation of the hydropower resources, could not be overlooked. To that end it was necessary to give careful consideration to aspects such as manpower training, siting of plant, indigenous resources beneficiation and further exploration.

4. Firewood

The firewood that could be obtained annually from the proclaimed forests, crown forests and other reservations without damage to the ecology had been estimated at less than 0.1 million tons. Wastes from sawmills and coconut cultivations accounted for about 0.5 million tons annually. About 1.0 million tons of firewood were estimated to be available owing to replanting of rubber trees. The current consumption was estimated to be 4.0 million tons annually, about 2.4 million tons of firewood being obtained from unidentified sources. Burning down of forest areas to enrich the soil by the *chena* cultivators caused a major problem in the proper development of this resources. The irregular and irrational exploitation of forests for firewood and timber could eventually cause irreparable damage to the environment and seriously inhibit the development of this energy resource. Indiscriminate felling of trees in the catchment areas in the central hills had to be controlled, as it would otherwise affect the regular inflows into the reservoirs from precipitation.

5. Renewable energy resources

A Rural Energy Centre to demonstrate the social, technical and economic feasibility of harnessing renewable energy resources, was being established by the Ceylon Electricity Board under the aegis of the United Nations Environment Programme and the Government. The harnessing of renewable energy resources, such as solar, wind and biogas, in an integrated manner to produce electricity for the provision of the basic energy needs of a small rural community was being attempted on an experimental basis.

C. PRODUCTION AND CONSUMPTION — RECENT AND PROJECTED

1. Recent consumption

The principal sources of commercial energy were electricity, oil and relatively small quantities of coal. In the domestic sector, and in certain small-scale industries, traditional fuels like firewood, vegetable wastes, etc. were used. The consumption of energy from the main supply sources for the period 1950 to 1975 is given in table 1.

Table 1. Energy consumption 1950 to 1975

Year	*Electricity (million kWh)*	*Oil products (thousand tons)*	*Coal and coal products (thousand tons)*
1950	46.0	206.0	293.0
1960	257.7	535.0	256.3
1965	309.7	620.1	136.7
1970	624.9	893.0	25.0
1973	627.8	963.4	10.0
1974	880.7	764.6	10.0
1975	965.8	731.2	10.0

If the total energy consumed in different forms was represented in terms of a common unit it was found that in the year 1977, the total energy requirements of 10,000 million kWh equivalent were met by petroleum products (28 per cent), hydroelectricity (12 per cent), and firewood and other fuels (60 per cent); the share of coal was practically negligible.

The *per capita* annual energy consumption in 1977 was equivalent to 715 kWh. The consumption of commercial energy in the different sectors of the economy in 1975 was: domestic, 20 per cent; industries, 33 per cent; transport, 40 per cent; and other, 7 per cent. Before the oil crisis, the expenditure on oil imports was about 5 or 6 per cent of the total export earnings of the country. After the oil crisis, that expenditure had gone up to about 13 per cent of the total export earnings.

Tables 2, 3 and 4 show the consumption of fuel in the domestic, industries and transport sectors, respectively, from 1960 to 1975.

Table 2. Consumption of fuel in the domestic sector, 1960 to 1975

Year	*Coal gas (million m^3)*	*Kerosene (thousand tons)*	*Electricity (million kWh)*	*Firewood (million tons)*
1960	7.53	111.3	58.1	3.22
1965	5.89	141.3	75.5	3.50
1970	6.67	218.4	117.1	3.40
1975	2.86	167.8	163.2	4.20

Table 3. Energy consumption in the industries sector, 1960 to 1975

Year	Coal (thousand tons)	Oil products (thousand tons)	Electricity (million kWh)
1960	12.2	129.7	141.9
1965	9.5	129.6	222.1
1970	10.8	181.1	428.2
1975	4.6	151.5	596.0

Table 4. Energy consumption in the transport sector, 1960 to 1975
(thousand tons)

Year	Coal	Gasoline	Auto diesel	Other oil procts
1960	150.0	151.8	94.8	45.2
1965	147.5	129.9	154.7	46.5
1970	19.5	148.0	250.0	83.7
1975	7.1	95.1	245.5	70.8

Table 5. Electrical energy consumption forecast
(million kWh)

Category	1979	1980	1981	1982	1983	1984
Domestic	116	124	133	142	153	163
Small and medium industry	295	332	357	384	414	446
Large industry	420	480	552	634	729	838
Commercial	170	191	206	222	239	258
Bulk supplies	276	293	311	330	350	371
Rural electrification	10	12	14	15	16	17
Street lighting	16	16	17	17	18	18
Investment promotion zone	16	22	38	63	94	125
Transport electrification	—	—	—	15	20	25
Other	2	5	10	15	20	25
Total	1,321	1,475	1,638	1,837	2,053	2,286

2. Demand forecasts

Table 5 shows the electrical energy consumption pattern expected over the period 1979 to 1984.

Large industries scheduled up to 1980 were taken into consideration individually, and beyond 1980 were assumed to increase at the rate of 15 per cent per annum. The rates of growth adopted for the other significant consumption categories were: domestic, 7.0 per cent; small and medium industry, 7.5 per cent; commercial, 8.0 per cent; and bulk supplies, 6.0 per cent.

Energy generation required was calculated with an allowance for losses of 12.5 per cent, and the maximum demand was expected to increase from 307 to 510 MW.

The Ceylon Petroleum Corporation planned its requirements on an assumption that the demand for petroleum products would increase at the rate of 10 per cent per annum. Other estimates had been made which indicated an increase of 5 per cent per annum corresponding to growth of GDP at 5.5 per cent per annum. The demand for auto diesel would be determined by the growth rate of vehicles for transportation. There might be a larger consumption of kerosene, owing to firewood getting more scarce, even in rural areas. Consumption estimates resulted in a total figure for 1982 of 1,168,700 tons of petroleum products.

Estimates for the consumption of firewood had been derived indirectly. The pattern of use of firewood in the future could be predicted but could be influenced by such steps as restrictions on felling of trees, clearing of jungle areas, introduction of more efficient firewood cookers, etc.

D. ENERGY PLANNING AND PROGRAMMING

The medium-term power and energy forecast could be met from planned hydroelectric projects if completed expeditiously. Some thermal additions might become necessary to optimize production.

An oil refinery had been established in 1969. The present production capacity was about 1.8 million tons per year and there were proposals to increase the capacity of the refinery to 2.35 million tons per year by 1980. This capacity was expected to be sufficient till the year 1985. Owing to the high demand for the middle distillates (kerosene and diesel) from the domestic and transport sectors, a suitable conversion process was required to be incorporated in the present refinery complex. Further investigations would be carried out in this respect.

The social need for firewood was so large that the Government had taken special steps for the conservation of forests. At present about 1 per cent of the forest cover was reforested annually. The Government had already taken action to ban unauthorized felling of trees and clearing of proclaimed jungle areas and crown forests with a view to improving the firewood and timber resources and also bringing about an ecological balance. An island-wide tree-planting campaign was launched recently. Also a reafforestation plan in the catchment areas of the Kelani River was under active consideration.

An analysis of the fuels which supplied the energy needs of the rural areas revealed that about 90 per cent of the households used kerosene for lighting and firewood and vegetable wastes for cooking. Only about 10 per cent of the villages out of a total of 25,000 had access to the electrical distribution system. A loan scheme had been introduced to meet the initial capital investment required for electrical installations in rural households. The investment on rural electrification was expected to increase rapidly, mainly for lighting.

It was not considered advisable to encourage the use of electricity for domestic cooking purposes. For urban areas LPG was being advocated, and the continued economic use of firewood in the rural areas would continue.

E. MEASURES TO ENCOURAGE EFFICIENCY IN PRODUCTION AND CONSUMPTION AND CONSERVATION OF ENERGY

Numerous measures to encourage efficiency in production and consumption of energy, conservation and the reduction of demand growth had been implemented. Action had been taken to encourage factory owners to change over to electricity by providing the capital investment needed under a minimum revenue guarantee scheme. The Government also provided subsidies in the case of tea factories for the installation of internal electrical equipment, and this subsidy could be extended to other categories.

Import of motor vehicles for private use had been restricted, and a complete ban on cars with an engine capacity more than 1.5 litres had been imposed. The more energy-efficient railroad transport system needed to be fully utilized and developed for goods and mass transportation. Where appropriate, animal and draught forms of energy should be continued or be substituted for oil-based forms of energy especially in the agricultural and small industries sectors. It was worthwhile to note that bullock carts continued to compete for transportation of goods in the rural sector.

F. INSTITUTIONAL ARRANGEMENTS

There was no specific body to co-ordinate, monitor and plan the demand and supply of the different forms of energy, although independent units were functioning to regulate particular forms of supply. There was also no central body to promote energy conservation methods in the industrial and domestic sectors. The Ministry of Finance and Planning had initiated some exercises towards the development of an over-all energy policy, and it was expected that in due course a central planning unit would be established.

Adequate efforts had yet to be made to promote the use of alternative energy resources and to create an awareness about their potential. A few institutions had initiated work in that respect but there was no co-ordinated effort.

G. ACTIONS SUGGESTED TO IMPROVE THE ENERGY SITUATION

Internally, the proposed energy unit or authority should be responsible for co-ordination of sources of energy, particularly hydroelectricity, and action should be taken to prepare detailed project appraisals and reports on selected hydro projects. Assistance in the form of consultancy services from outside agencies and training of personnel would be useful.

Groups of countries should engage, where possible, in interconnecting electricity grids for transfer and exchange of electrical energy. It would also be useful to have an exchange of information on energy policies and experience with regard to sensitivity of the consumption of different forms of energy to price structures, changes of tariff, etc.

Technical advice by experts for planning over-all energy strategies, as well as training of local personnel in over-all energy programme aspects, were considered very useful. Further, it might be suggested that a data bank on regional energy issues, including experiences of energy management, be established.

ENERGY PLANNING AND PROGRAMMING, THAILAND

(NR/WGMEPP/8)*

by

The National Energy Administration (Thailand)

A. RESOURCES

1. Conventional resources

Hydroelectric potential included 106 possible dam sites that had been reconnoitred, with an estimated potential of 8,935 MW installed capacity and 18,644

* Abridged.

million kWh of energy per annum. In addition, there existed 10 more dam sites on the inter-country rivers with an estimated potential of 12,380 MW installed capacity and 64,992 million kWh of energy per annum. Completed projects, all entirely within the country, had a total installed capacity of 910 MW, while projects under construction were planned to add another 420 MW.

Coal, in the form of lignite, occurred in the northern and southern parts of the country. Extensive explorations were still going on and the known lignite resources had been estimated to be 206 million tons of probable reserves, of which 107 million tons were recoverable, with heat content ranging from 3,300 to 6,000 kcal per kg.

Oil and natural gas were discovered recently off the coast in the Gulf of Thailand. The estimated availability of oil was insignificant. The volume of natural gas was estimated to be 124,500 million m^3.

Bagasse was used extensively as a fuel in sugar-mills.

Two deposits of oil shale occurred, a large one at Mae Sod and a small one at Li interspersed with the lignite deposit. The estimated total reserve was 2,015 million tons of oil shale, with an oil content of 121.3 million tons.

2. Non-conventional resources

The average solar radiation in Thailand was high, varying between 470 $cal/cm^2/day$ and 350 $cal/cm^2/day$.

The wind speed, except in coastal areas and areas of high elevation, was low, with the average annual wind speed ranging from 4 km/h to 14 km/h.

Biogas could be produced from dung from about 4.5 million cows, 5.7 million buffaloes, 3.0 million pigs and about 65.5 million poultry, as well as from human and agricultural wastes, and garbage.

B. ENERGY PRODUCTION AND CONSUMPTION

Apparent energy availability was 120,000 x 10^9 kcal in 1977, of which 21,500 x 10^9 kcal or about 18 per cent was from indigenous sources. A flow chart had been prepared, showing inputs by resource, and consumption by sectors.

1. Energy from indigenous sources

The existing eight hydroelectric stations, with a total installed capacity of 910 MW, produced 3,265 million kWh of energy in 1977, about 9 per cent of total energy availability, and about 29 per cent of all electricity produced.

The three lignite mines, two in the north and one in the south, produced 520 x 10^3 tons, or 2 per cent of total energy availability in 1977.

Bagasse from 40 sugar-mills was used for producing steam. The total production in 1977 was 4.3 x 10^6 tons or 7 per cent of total energy availability.

Paddy husk from rice mills was used for producing steam to operate machinery in the mills. The total production in 1977 was 275 x 10^3 tons or 0.3 per cent of total energy availability.

There had been a marked drop in the use of wood and charcoal, owing to scarcity, high cost and government restrictions. The production in 1976 was about 1.2 million m^3, or 0.5 per cent total energy availability.

2. Energy from external sources

The interchange of electricity with the Lao People's Democratic Republic resulted in 1977 in the import of 177 million kWh and the export of 6 million kWh.

In 1977, 33,877 tons of coal and coke were imported.

Thailand imported crude oil, mainly from the Middle East, and in 1977 this amounted to 8.33 million tons, a 6 per cent decrease from the previous year. It was processed in three refineries whose full capacity was 22,665 tons per day. About 1.4 million tons of finished petroleum products (diesel oil and fuel oil) were also imported. The average growth rate of oil consumption over the past five years was about 8 per cent per annum.

3. Consumption

During the past, consumption of energy had doubled about every five years. The structure of consumption each year was similar: petroleum products, 80-82 per cent; hydro generation, 8-10 per cent; bagasse, 6-7 per cent; lignite, 2 per cent; and fuelwood and paddy husk, about 0.5 per cent each. About 80 per cent of the lignite was consumed for electric generation, 10 per cent for fertilizer production and the rest by railways and tobacco leaf-curing plants. Bagasse and paddy husks were consumed *in situ*. Fuelwood and charcoal were mostly used for household cooking. Consumption of petroleum products by sector in the recent past (1976) is shown in table 1.

C. ENERGY FORECAST

The relationships between the economic variables of population and GDP were found by linear regression analysis and an equation was framed to project energy demand in the future.

Table 1. Consumption of petroleum products by sector in 1976

(million litres)

Type	Agriculture	Construction	Industry	Electricity and water supply	Transportation	Commercial	Total
Gasoline	4.7	5.5	47.3	62.8	1,670.5	172.2	1,963.0
Diesel oil	1,077.5	53.35	490.4	77.2	1,419.8	238.3	3,356.6
Fuel oil	9.4	1.5	1,414.5	1,272.1	81.8	250.9	3,030.2
Kerosene	—	1.4	67.9	—	0.6	216.3	286.2
Jet fuel	—	—	—	—	854.7	—	854.7
LPG	—	—	—	—	—	223.2	223.2

The data used to formulate the equation were based on energy consumption for the past 17 years. This equation was found to be good only in forecasting for a short period, up to five years. For long-term projections, such an equation with its inherent limitations might prove unsuitable, and declining rates of growth were postulated for population, GDP and energy consumption. Energy consumption by sector estimated up to the year 2000 is shown in table 2.

D. ENERGY PLANNING AND PROGRAMMING

1. Supply arrangement

A supply plan was prepared to match the forecast of energy consumption. The programme to meet the electricity demand required the development of various hydro projects, and the installation of fuel oil, natural gas, lignite, nuclear and diesel power plants with a total additional capacity of 3,850 MW between 1978 and 1987.

Table 2. Energy consumption

(10^{12} kcal)

Year	Petroleum products	Hydro-electric	Coal and lignite	Bagasse	Fuelwood	Charcoal	Paddy husk	Natural gas	Total
1974	75,390	7,752	2,159	5,565	413	215	360	—	91,854
1975	79,071	10,572	2,169	5,880	388	130	437	—	98,647
1976	89,120	11,282	2,542	8,372	390	246	379	—	112,331
1977	94,743	11,373	3,039	11,719	394	498	410	—	122,176
1980	128,601	16,026	7,708	14,762	415	565	516	—	168,593
1985	165,042	18,701	10,533	21,691	451	697	758	39,093	256,966
1990	270,520	26,592	11,567	31,871	413	829	1,114	39,093	381,999
1995	396,229	26,595	13,328	46,828	377	986	1,637	39,093	524,983
2000	569,426	26,598	15,678	68,806	345	1,172	2,406	39,093	723,524

Surveys were being carried out to locate new lignite deposits, and production was being expanded.

For petroleum products, since both crude oil and finished products had to be imported, a study was being conducted on the expansion of the refinery facilities to meet the growing demand.

Plans were being made to utilize the natural gas from the Gulf of Thailand. A power station was planned for the south of Thailand, and a pipeline would be laid to Bangkok for town gas and supply to industries.

A small rate of increase was expected in fuelwood, charcoal and paddy husk.

2. Major constraints

The developed hydro potential, in terms of energy, amounted to 22 per cent of inland potential. Shortage of technical manpower, the existence of two governmental agencies and a public sector enterprise having responsibility for developing the hydropower projects, without a clear-cut delineation of authority, posed some problems for further development. Data collection in some politically sensitive areas was also difficult.

Inter-country potential still awaited development. Lack of a collaborative arrangement between neighbouring countries on the investigations of engineering data for the design of projects hindered large-scale development of international rivers, namely the Mekong and Salween. Investment in these projects had to depend on external finance, and it was desirable that financial assistance be obtained for hiring foreign consulting firms to prepare feasibility reports.

Approximately 80 per cent of the energy utilized in the country was from imported crude oil, and it was desirable to use lignite or oil shale as a replacement. However, lignite utilization potential was limited, and the possibility of developing the oil shale deposits was still in the early stages of consideration.

Outside assistance might be necessary to increase efficiency in energy production. Essential requirements in that regard were the training of personnel in energy planning and construction works in the field and the fostering of local consulting engineering firms.

E. INSTITUTIONAL ARRANGEMENTS FOR ENERGY PLANNING AND PROGRAMMING

1. Institutions

There were several governmental organizations involved in planning and carrying out energy programmes. The National Energy Administration was the government department responsible for over-all energy programmes. The Electricity Generating Authority was the public sector organization responsible for electric energy generation and development of electricity generating plants. Both those organizations were under the supervision of the Office of the Prime Minister. The Royal Irrigation Department had jurisdiction over developing irrigation networks, and the schemes were quite often multipurpose projects and included electric power generation. This department worked under the Ministry of Agriculture and Co-operatives. The petroleum industry was under the control of the Ministry of Industry. The unification of the organizations on energy, to function under one ministry, was under consideration.

2. Specific needs

Requirements for improving energy development could be enumerated as follows:

(a) Scholarships for advanced study in energy development and related subjects at universities in developed countries;

(b) Fellowships for training in project appraisal at international financial institutes;

(c) Survey, study and recommendation by an expert team on organization, planning and management of energy resources;

(d) A collaborative effort by the riparian countries on the Salween River to establish a procedure for co-ordination in the investigation of hydrological and geological data;

(e) Experts on supervising energy planning and carrying out feasibility studies in order to attract credit facilities from international financial institutes.

UNITED NATIONS ACTIVITIES IN ENERGY: THE ROLE OF THE CENTRE FOR NATURAL RESOURCES, ENERGY AND TRANSPORT

(Synopsis of NR/WGMEPP/13)

The paper, submitted by CNRET, gave a brief review of recent activities in the energy field, subdivided as follows:

(a) Technical co-operation projects, largely financed by UNDP, covering petroleum (including the establishment of the Petroleum Exploration Institute in India), energy surveys and planning, non-conventional and new sources of energy (including projects on geothermal and tidal power in India and a rural energy centre in Sri Lanka) and electric power (including a project in Indonesia);

(b) Reports on energy trends and problems (see document NR/WGMEPP/10);

(c) Seminars and other meetings (including meetings in India on rural electrification and petroleum refining);

(d) Publications, including *Natural Resources Forum* and *Natural Resources and Energy Newsletter.*

RECENT ENERGY TRENDS AND FUTURE PROSPECTS

(Synopsis of NR/WGMEPP/10)

This report of the Secretary-General was issued as document E/C.7/70 to the Economic and Social Council's Committee on Natural Resources at its fifth session, held at Geneva from 9 to 20 May 1977. It dealt with over-all developments in the world energy situation.

ENERGY AND GNP: SOME THOUGHTS ON INTER-COUNTRY COMPARISONS

(NR/WGMEPP/CRP.7)*

by

The Centre for Natural Resources, Energy and Transport

A. INTRODUCTION

Historically, high energy consumption had generally been associated with industrialization, economic development and high standard of living, since energy use

* Abridged.

and production of goods and services were obviously closely related. The high correlation between the level of economic development of a society and its *per capita* energy consumption was well known, and energy consumption had often been used as a reliable index of a country's economic development.

Energy was not wanted for itself but was used in production of goods and services which were then consumed in the process of improving human living conditions. However, until quite recently, energy was not explicitly considered in many economic development plans since it was considered relatively cheap and abundant either from domestic sources or through imports.

Three different forms of technological progress were related to energy use. Economy-innovations resulted in net saving of energy by, for example, improved combustion of an engine, substitution-innovations led to replacement of human labour with energy, and spectrum-innovations introduced new consumer goods. Most of the past growth in energy consumption had been caused by substitution-innovation, which led to substantial increases in labour productivity.

Table 1. Commercial energy consumption and GNP in 1976

Country or area	Per capita consumption of commercial energy (kg coal equivalent)	Per capita GNP at market prices (US dollars)	Energy consumption per unit of GNP (kg coal/$US)
Australia	6,657	6,100	1.09
Bangladesh	33	110	0.30
Burma	49	120	0.41
China	706	410	1.72
Hong Kong	1,313	2,110	0.62
India	218	150	1.45
Indonesia	218	240	0.91
Iran	1,490	1,930	0.77
Japan	3,679	4,910	0.75
Malaysia	620	860	0.72
Mongolia	1,166	860	1.36
New Zealand	3,617	4,250	0.85
Pakistan	181	170	1.06
Philippines	329	410	0.80
Republic of Korea	1,020	670	1.52
Singapore	2,262	2,700	0.84
Sri Lanka	106	200	0.53
Thailand	308	380	0.81

B. THE ENERGY/GNP RATIO

One measure used to describe the relationship between energy consumption and GNP was the ratio of energy consumption, expressed in common units (such as coal equivalent) to GNP, expressed in dollars. It indicated the energy input required to produce one unit of output, sometimes also referred to as the intensity of energy use.

Numerous detailed studies had found a close relationship between energy consumption and GNP. Table 1 presents cross-sectional data on energy consumption and GNP *per capita* and the energy/GNP ratios for selected countries in 1976. The differences among countries were extremely wide. Countries with the highest energy consumption *per capita* did not have the largest *per capita* GNP, and similarly those with low energy use did not have low levels of income. Comparisons between the developed and the developing countries were also revealing. Thus, the Federal Republic of Germany consumed about 0.8 kg of coal equivalent for each dollar of GNP, the same as, for example, the Philippines at a substantially different level of development. Other factors might affect the use of energy in each country and it was important to bear in mind when making inter-country comparisons that high energy/GNP ratio might not necessarily be an indication of inefficiency or waste.

GNP was measured in monetary terms and expressed in United States dollars at official exchange rates which did not take into account the real purchasing power of national currencies. That tended to increase the differences in GNP *per capita* between developed and developing countries. The major problem with GNP, however, was that it was generally a poor indicator of the performance of an economic system since it combined all transactions regardless of their economic and social impact. For instance, GNP combined the monetary value of goods and services which resulted in environmental damage with those which were needed to control those undesirable effects.

Since GNP was a poor measure of a society's well-being, the question arose whether it was ever meant to be an adequate measure. At best it should probably be used only as a rough indicator of a country's production capacity. Despite its shortcomings, GNP *per capita* continued to be widely used by policy-makers all over the world, owing mostly to the convenience and familiarity of the term.

Countries which derived a large part of their energy requirements from hydropower had their energy/GNP ratio underestimated. This was caused by the fact that in most statistical sources hydropower was converted into coal equivalent on the basis of its theoretical heat energy output, rather than the amount of energy that would have been required at fossil-fueled power plants to produce an equivalent amount of electricity, taking into account conversion losses. An objection to using the latter method was that electricity was used for such purposes as space heating largely because it was cheap and plentiful. If cheap hydropower were not available, the alternative would be fossil fuels used directly.

Practically all statistics on energy excluded non-commercial energy sources which, in many countries, not only developing, contributed a considerable share of the energy supplies of a large portion of the population, especially in the rural areas. Also, draught animals were the principal sources of mechanical energy for agriculture and transportation in many developing countries, and human power in some parts of the world was the only source of mechanical energy which could be considered. The problem was further complicated by the fact that most of the non-commercial fuels were used with a very low end-use efficiency, usually less than 5 per cent, much lower than most commercial fuels. This led in most cases to overstating the importance of non-commercial fuels when these were expressed in equivalent thermal content.

Currently, the only "new" energy source that was making a substantial contribution to energy supplies in a number of countries was solar energy used for water heating, while windmills were in use in some countries. Brazil used gasoline which contained 15 per cent ethyl alcohol produced from the cassava plant, and several countries in the region had biogas plants in operation. To the extent that new energy sources replaced the fossil fuels currently used, or perhaps displaced the potential demand for them, they would have to be included in any serious analysis of energy consumption.

C. EFFECTS OF ECONOMIC DEVELOPMENT

The structure of an economy, and in particular the relative importance of energy-intensive sectors or industries had a major influence on the energy/GNP ratio. Industries producing iron and steel, electricity, cement and chemicals were highly energy-intensive. The larger the share of those industrial sectors in a national economy, as measured, for example, by their contributions to the total output, the higher the energy/GNP ratio. Since agriculture, still the most important sector in the majority of the developing countries, was usually the least energy-intensive, countries with a significant part of GNP produced in that sector tended to be less intensive users of energy.

Relatively less important than the structure seemed to be the general level of development as measured by *per capita* GNP. While most findings tended to indicate that the higher the level of economic development, the lower the necessary energy input per unit of GNP, there was evidence that useful energy input per constant dollar of GNP was approximately constant at any given time in different countries, independent of *per capita* GNP for countries with similar economies.

Because energy was needed only for its ability to perform certain useful functions, the same functions might be performed with varying amounts of energy inputs depending on the efficiencies of the conversion equipment used. These might vary from country to country, between sectors, end-use categories, processes, equipment and fuels used. Such factors as the technical parameters of the capital stock, the degree of maintenance and the intensity of use would have an impact on the efficiency with which energy was used at the various stages in an economy, and this would ultimately affect the energy/GNP ratio of a country. Also, during a downturn in economic activity, there was a tendency to use the most efficient plants or equipment and keep the less efficient ones idle. At the same time, however, economic activity below the optimum capacity level might lead to inefficient energy use. The large differences which existed among countries were striking and could be attributed at least partly to the degree of adoption of more efficient processes or methods of production.

Another factor accounting for at least part of the differences in energy/GNP ratios among countries was the share of final energy consumption which was consumed in the form of electricity. As the share increased, the energy input per unit of GNP tended to rise owing to the conversion losses during generation and transmission. The share of electricity appeared to be increasing as the level of development rose and more electricity was needed to run modern industries. At the same time, consumers' preference for the convenience of electricity and the growing appetite for more appliances that came with higher levels of GNP tended to increase the share of electricity and the energy/GNP ratio.

Countries consuming large amounts of coal tended to have higher energy/GNP ratios because coal, used mostly in generation of electricity, but also in the transport and domestic sectors, burned less efficiently than oil or gas.

Results of recent studies indicated that energy prices relative to other resources, including substitutes and complements, were probably the most important factor influencing the energy consumption of a country, and the higher the country's relative prices of fuel, the lower its energy/GNP ratio.

Since domestic energy consumption was usually defined as the sum of domestic consumption and net energy imports, account should be taken of the invisible trade in energy, i.e. the energy embodied in imported and exported goods. For example, a decision to import petroleum products instead of crude petroleum would result in a decline in direct energy use because of the fuel saved by not refining the crude oil domestically. At the same time, however, it would increase the energy embodied in the imported petroleum products.

Most of the developed countries lay in climatic regions requiring space heating. The majority of developing countries, on the other hand, did not use a large portion of their energy for space heating, except in the higher altitude regions. Consequently, differences in climatic conditions might explain some of the energy/GNP variations, especially since energy used for heating was not for the most part related to a level of GNP.

The size of a country affected to some extent the consumption of energy in the transportation sector which accounted for a substantial share of the energy budget in many nations.

Relative abundance of energy resources and government policy with regard to waste or conservation also played important roles in consumption of energy. The availability of cheap domestic supplies of energy or the ability to afford high-cost energy imports would tend to increase energy/GNP ratios. Such measures as gasoline taxes or fuel economy standards had been found to be very effective tools for improving efficiency in the use of energy in transportation. Other measures included consumer information programmes, energy efficiency labels on appliances, various incentives for efficient heating or cooling of buildings, and low-interest loans for energy conservation improvements. At the same time, government policies with regard to direct or indirect subsidies of energy production and consumption might lead to inefficiencies regardless of the level of energy use.

D. ENERGY AND DEVELOPMENT

Recently, economists and others concerned with energy policy issues had begun to question the necessity for continuation of the historically close relationship between energy consumption and GNP, and the question of "decoupling" of energy consumption and economic development had been raised in a number of countries. The basic policy choices open to policymakers considering a formulation of a national energy plan leading to a less energy-intensive development included restructuring of final demand, substitution of other factors of production for labour, capital and materials, technological improvements, elimination of energy waste and change of consumers' behaviour.

Although there was still a considerable controversy as to whether energy consumption could be substantially lowered without seriously affecting economic development, there were indications that it could be achieved. Perhaps the most significant change over the recent past had been the fact that the question of energy was being approached from the point of view of end-uses of energy instead of stressing primarily increases in energy supplies.

While some developed countries were beginning to show concern that the marginal social cost of energy use might already be approaching marginal social benefit, many developing countries had not yet begun to enjoy any of the benefits of energy use. The value of energy used in those countries for such basic needs as heat or light was much greater than the incremental value of energy consumed in many developed countries. At the same time, however, it had to be borne in mind that average consumption figures hid large disparities within each country.

Inter-country comparisons performed a useful function as long as the various inherent limitations were recognized. Done at a highly disaggregated level of energy use, such comparisons showed alternative ways of achieving the same or similar results with less energy, thus pointing out possible inefficiencies and room for improvement. The cross-sectional method could give some indication as to why energy use varied among countries. Unfortunately, although it might be relatively easy to list the various factors causing those differences, for many of them it would be extremely difficult to separate or quantify the impact they had. At best, it might be possible to estimate the direction of their influence on the total energy use.

TECHNICAL CO-OPERATION ON ENERGY POLICY: TWO REGIONAL EXPERIENCES OF UNDP IN LATIN AMERICA

(Synopsis of NR/WGMEPP/CRP.4)

by

A. del Valle (UNDP)

This paper gave details of two regional UNDP projects in Latin America:

(a) A Central American energy programme, covering Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua, all small countries deficient in indigenous energy resources, but with a rapid rate of growth of primary energy consumption, chiefly imported oil;

(b) Preparatory assistance on renewable sources of energy in Latin America, to explore the possibilities for development and utilization of solar radiation, wind, biomass, biogas and small waterfalls in that region.

UNESCO'S ENERGY ACTIVITIES

(Synopsis of NR/WGMEPP/9)

by

V. Kouzminov (UNESCO)

This paper described the objectives of the UNESCO programme on energy matters, and listed recent and current activities in that field. Included were the Regional Centre for Energy, Heat and Mass Transfer for Asia and the Pacific established in India in 1976, an Asian Working Group on Solar Energy (India, January 1978), a Working Group on Solar Drying (Philippines, October 1978) and a Regional Workshop on Microbiology at the Village Level (Indonesia, January 1979). Reference was also made to support given for a clearing house and information centre for solar energy at the Asian Institute of Technology at Bangkok, Thailand, and the post-graduate training course in geothermal energy conducted annually at Kyushu University in Japan.

ENERGY AND AGRICULTURE

(Synopsis of NR/WGMEPP/CRP. 10)

This paper was a reprint of chapter 3 from *The State of Food and Agriculture 1976* published by the Food and Agriculture Organization of the United Nations, Rome, in 1977 as Agriculture Series No. 4.

1977 REVIEW OF NATIONAL ENERGY PROGRAMMES (IEA)

(Synopsis of NR/WGMEPP/5)

by

International Energy Agency — Organisation for Economic Co-operation and Development

This paper was an extract from the advance summary of a report entitled *Energy Policies and Programmes of IEA Countries, 1977 Review.* The complete report has been published (1978) by the Organisation for Economic Co-operation and Development, Paris.

PRELIMINARY PROCEEDINGS OF THE ASIA-PACIFIC ENERGY STUDIES CONFERENCE

(Synopsis of NR/WGMEPP/CRP.6)

This paper contained the preliminary proceedings of the Asia-Pacific Energy Studies Conference sponsored by the East-West Resource Systems Institute of the East-West Center and held in July 1978 in Hawaii. The complete proceedings have been published (1978), entitled *Report on the Asia-Pacific Energy Studies Conference*, by the East-West Center, Hawaii.

Part two

COMMITTEE ON NATURAL RESOURCES, FIFTH SESSION

I. REPORT OF THE SESSION

A. ORGANIZATION OF THE SESSION

The fifth session of the Committee on Natural Resources was held at Bangkok from 31 October to 6 November 1978.

Attendance

The meeting was attended by representatives of Australia, Bangladesh, China, France, India, Indonesia, Iran, Japan, the Lao People's Democratic Republic, Malaysia, Nepal, the Netherlands, New Zealand, Pakistan, the Republic of Korea, Sri Lanka, Thailand, the Union of Soviet Socialist Republics, the United Kingdom of Great Britain and Northern Ireland and the United States of America. Representatives of the Federal Republic of Germany, Israel and Switzerland also attended, in accordance with paragraph 9 of the terms of reference of the Commission.

The following United Nations bodies and specialized agencies were represented: United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), International Labour Organisation (ILO), Food and Agriculture Organization of the United Nations (FAO), United Nations Educational, Scientific and Cultural Organization (UNESCO) and World Health Organization (WHO). The secretariat of the Committee for Coordination of Investigations of the Lower Mekong Basin was also represented. Representatives of the Asian Institute of Technology (AIT), the Asian Productivity Organization and the International Energy Agency (IEA) also participated.

Opening of the session

In his opening statement, the Executive Secretary pointed out that the session had a special significance in relation to the programme of work and priorities for the development of energy resources. Now that there had been some improvement in the availability of UNDP development funds, the shortage of which had caused deferment of major projects in the energy field, the opportunity had been taken to make a complete review of the priority needs of the countries at the recently held Working Group Meeting on Energy Planning and Programming.

That review had set the stage for consideration by the Committee of the strategy to be adopted in the energy field for the 1980s, followed by detailed consideration of ESCAP's programme in the next biennium, 1980-1981. At the same time, the Committee could consider action that might be taken under technical co-operation among developing countries (TCDC), and by other organizations interested in energy aspects in the region. These were matters of the highest importance, as the availability of energy in its various forms, as appropriate, would have a critical influence on the extent to which over-all development goals were achieved.

He assured the participants that ESCAP and the other members of the United Nations system would do their utmost to follow the directives of the Committee, including support for national and inter-country efforts.

Election of officers

The Committee elected Mr. Pravit Ruyabhorn (Thailand) as Chairman, Mr. S. N. Roy (India) and Mr. Abdul Kadir (Indonesia) as Vice-Chairmen, and Mr. P. P. Shah (Nepal) as Rapporteur.

The Committee appointed a Drafting Committee, with Mr. Nazir Hussain Qureshi (Pakistan) as Chairman.

Adoption of the agenda

The following agenda was adopted:

1. Opening of the session
2. Election of officers
3. Adoption of the agenda
4. Current energy situation
5. Electricity supply
6. Non-conventional energy resources
7. Improvements in conservation and efficiency in the production and use of energy
8. Development and management of energy resources
   (a) Major issues for the 1980s
   (b) Proposals for action
9. Activities of ESCAP in the appraisal, development and management of natural resources
   (a) Energy resources (other than those activities referred to above)
   (b) Mineral resources
   (c) Water resources
   (d) Remote sensing, surveying and mapping

10. Activities of other international bodies in the appraisal, development and management of energy resources
11. Programme of work and priorities in the appraisal, development and management of natural resources, 1980-1981, in the context of the medium-term plan, 1980-1983
    (a) Energy resources
    (b) Mineral resources
    (c) Water resources
    (d) Remote sensing, surveying and mapping
12. Consideration of the agenda and arrangements for subsequent sessions of the Committee
13. Other business
14. Adoption of the report

CURRENT ENERGY SITUATION

The Committee had before it document E/ESCAP/NR.5/4 on progress in energy development. The original version of the document had been discussed at the Working Group Meeting on Energy Planning and Programming, and annex I had been amended as a result of that discussion. Three country papers presented at that Meeting were circulated to the Committee. In addition, seven new country papers were presented.

The Committee commended the secretariat on its paper and requested that both the data and the analysis be revised in the light of the more recent information submitted by participants.

From the statistics of commercial energy resources of the region, including recent discoveries, 19 of the 36 members and associate members listed had reserves of coal, 14 had reserves of oil, 16 had reserves of natural gas, 23 had hydropower potential and 8 had uranium ore. However, those reserves were not evenly distributed and, of the five different types of commercial resources, 6 countries had all five, 7 countries had four, 2 countries had three, 6 countries had two, and 3 countries had one. Although it appeared that 12 members and associate members had no reserves, two of those, Hong Kong and Singapore, were special cases, and the remaining 10 were all small island countries, and such resources as they had were too small to be shown on the scale used for larger countries.

In the case of production and consumption, there was again a big disparity in scale, so that the bulk of production and/or consumption occurred in four countries for solid fuels, six for liquid fuels, four for natural gas, three for hydropower and one country for nuclear power. The general trend of the statistics showed that, notwithstanding the transient slow-down caused by the energy crisis, both production and consumption, in small countries as well as large ones, was increasing. In spite of concern regarding the outlook for liquid fuels, consumption of those fuels had increased at a faster rate than solid fuels in 1976.

The main points in relation to the energy situation in individual countries were presented as follows.

Australia was well-endowed with economic resources of black and brown coal, natural gas and uranium, and had appreciable quantities of oil and hydropower. There were also large reserves of oil shale, but their development was not economically attractive at present. There were problems, particularly with some of the natural gas fields, in the large physical distances between deposits and markets. Known reserves of liquid petroleum were relatively small and, under energy policies recently formulated, steps were being taken to conserve existing supplies and encourage further exploration and development. As a reflection of the Government's increasing concern with energy matters, a Department of National Development had been set up with specific responsibility for the further development of a national energy policy which would deal in a co-ordinated way with all energy forms.

The production, processing, distribution, and export of energy materials played a very significant role in the development of the economy. The projection of future production growth rates must take into account both internal demand, which was related to GDP and was expected to tend towards lower growth rates in the future, and external demand, which was somewhat less predictable. Account must also be taken of the possibility of the establishment of large energy-intensive industries, such as mineral processing, near the energy sources. Econometric models were used, and being further developed, to obtain the best possible predictions in each demand sector.

China. Rational use of all energy resources was being promoted in China as a basic component in the over-all programme of modernization.

Coal was the major fuel, and in the first six months of 1978 production was 300 million tons, an increase of 19.7 per cent over the same period in 1977. Production exceeded requirements, with a surplus for export. An annual increase of 30 to 40 million tons was planned for the next 10 years to 1987. Special attention was given to geographic distribution of coal production and about one third of the total production came from some 20,000 small mines, each producing from tens of thousands to hundreds of thousands of tons per year. Such mines were being developed as power and industrial centres where appropriate.

Petroleum was also being exported and off-shore and on-shore exploration was being intensified with a view to development of new oil and gas fields for energy production and for an expansion of the petro-chemical industry, particularly for fertilizer production. There was also a vigorous programme of hydroelectric development, involving large-, medium- and small-scale plants.

Great attention was being paid to the utilization of low-grade fuels, peat, lignite and oil shale, and the use of residual heat from industrial processes was being encouraged. Development of biogas units was continuing, and possibilities for use of other energy sources, including geothermal, solar and nuclear energy, were being investigated.

India. The most important indigenous commercial energy resource in India was coal, and it was noted that whereas up until the energy crisis in 1973 the proportion of usage of coal to total energy usage had been declining, from that time onward production had increased rapidly, at about 8.6 per cent per annum, compared with about 3.5 per cent in the preceding years. Some oil was produced, but the major part was imported; and, heartened by recent discoveries, the exploration programme was being stepped up. A recent survey of the use of non-commercial energy had shown that it amounted to about 59 per cent of the total energy consumption in terms of heat content, and 40 per cent in terms of useful energy. Supply and demand in that sector were therefore receiving particular attention in energy planning.

Indonesia. Although the country had an abundance of energy resources, commercial energy use was currently based mainly on petroleum. Increasing use of firewood was causing erosion problems on many islands and in particular on Java.

Close attention was therefore being paid to the development of other resources of energy, conservation aimed at energy efficiency and saving in all sectors, and optimization of energy utilization, so that each type of energy resource could be used for purposes for which it would be best suited.

In some cases much more investigation would be required, as for many areas data were still scarce.

Although the consumption of energy *per capita* was still low, it was increasing rapidly, which posed a problem in forecasting demand, as it was necessary to consider structural changes in utilization as well as the relation of energy consumption to GDP. A recent estimate indicated that consumption of commercial energy in the year 2000 would be nine times the consumption in 1978.

Recently the former Ministry of Mines had been reorganized to form the Ministry of Mines and Energy, so as to strengthen co-ordination of the national energy programmes.

Japan. Over-all consumption of energy decreased from 1973 to 1975 owing to the economic recession and the adoption of measures for energy conservation, and had since increased at a modest rate. Consumption by the domestic and commercial sectors was increasing, concurrent with the increasing use of household appliances and the construction of large buildings and underground commercial areas. For the foreseeable future, there would be considerable dependence on imported oil, and some difficulties seemed likely. In that connexion, great national efforts were being made in energy conservation through administrative and legislative measures and also in new energy developments, including accelerated research and development and stimulation of co-operation between the public and private sectors.

Malaysia's most important commercial energy resource was oil, followed by potentially important reserves of natural gas and hydroelectricity. More than 90 per cent of current commercial energy supply came from petroleum. There were little data on the use of non-commercial energy, but it was believed to be between one fourth and one half of the total. However, there was very great potential for use of timber residue, the total from logging, rubber-tree replanting and coconut and oil palm residues being about 21 x 10^6 tons per annum. With effective use, those resources could exceed current consumption of petroleum. One of the main difficulties in the past had been the lack of a comprehensive energy policy, and steps were being taken to frame and implement suitable procedures. Based on present official estimates of reserves, energy demand was expected to exceed indigenous petroleum supplies by 1990. Although there was considerable hydroelectric potential, its development in some cases might be impeded by conflicts in land use.

Nepal had very large potential for hydroelectric development, which could benefit its neighbours as well as itself, but large developments took a long time to finalize and implement. In the mean time, medium-size projects were being developed and, more recently, in view of the fact that two thirds of the population lived in the hilly areas, a serious effort was being made in the development of mini and micro hydro plants to provide electricity for domestic, small-scale industries and irrigation uses in the rural areas. This was being planned and carried out with the active participation of the people of the locality. In addition, the current consumption of fuelwood was very high, comprising about 87 per cent of the total energy consumption, which was resulting in severe denudation of forest areas. Special attention was now being given to afforestation programmes, and incentives were also being provided to encourage *panchayats* (village administrations) to undertake that work.

New Zealand had recently reorganized its institutional arrangements on energy, and a new Ministry of Energy incorporated the work of three separate former departments. In an endeavour to reduce New Zealand's high dependence on imported oil (60 per cent in 1973) the Government had implemented policies to encourage the substitution of oil by indigenous energy resources and the more effective use of all forms of energy. The main elements of the programme were increased government involvement in petroleum exploration; increased exploration for coal and geothermal energy and the development of new coal mines; the greater use of renewable resources for electricity generation; incentives, penalties and mandatory requirements to encourage energy conservation and the use of indigenous resources; the use of pricing to encourage wise use of energy; and increased efforts in energy research and development.

The transport sector consumed 75 per cent of the oil used, and a large plant based on natural gas was proposed to provide methanol for mixing at a rate of 15 per cent with gasoline. A large off-shore natural gas field was expected to be in production in 1979, and the coal situation was improving, particularly with the recent proving of a large new lignite field (2,000 million tons).

Public participation in energy policy formation had been promoted by the publication of an energy goals and guidelines discussion document.

Pakistan had very low *per capita* energy consumption and was deficient in coal and oil, but had reasonable resources of hydroelectricity and natural gas. There had been great dependence on non-commercial energy sources. The position had improved recently, with the discovery of new oil and gas fields and further investigation of the coal possibilities, but significant imports of oil were still required and would continue to be needed in the future to support the growing population and improve the standard of living. Development work was proceeding on non-conventional resources, and an over-all energy policy was being prepared to cover development, production and consumption.

The Republic of Korea had insufficient energy resources for its purposes, and in addition to importing oil would soon be importing coal. In view of the rapidly increasing demand as a result of continuing industrialization, a national energy plan had been formulated to stabilize the demand and supply of energy, and to develop and utilize domestic resources, particularly hydroelectric resources, in an optimum pattern. Nuclear power production was expected to increase, and attention was being given to tidal power and other renewable energy resources.

Sri Lanka's major indigenous energy resource was hydroelectric potential, and developments were proceeding within the constraint of capital availability. An expert committee appointed to review the power and energy situation had forecast a rate of growth of energy demand of 10.4 per cent per annum. That rate might vary owing to the development of the free-trade zone and the establishment of large industries and would be reviewed twice a year. The institutional framework had been improved by the creation of the separate Ministry of Power and Highways.

Thailand. The main indigenous energy resources were lignite, oil shale, natural gas and hydropower, but no development had yet taken place with regard to oil shale. The known reserves of lignite had recently been extended and production was increasing, while development of the recently discovered natural gas deposit was in its early stages. Most of the hydropower prospects within the country had been investigated, and several developed, but as yet no effective development had taken place on the international rivers, which had a large potential.

Consumption of energy consisted of 19 per cent from indigenous energy resources, including fuelwood and agricultural waste, and 81 per cent from imported petroleum products. The average growth rate of energy from indigenous sources during the past five years had been about 16 per cent per annum, while the corresponding rate for imported petroleum products was about 8 per cent per annum. Even though natural gas would make a substantial contribution from the end of 1981, actual quantities of imports of petroleum products would continue to rise, to a tentative forecast figure in the year 2000 of about six times the actual imports in 1977.

The representatives of France, the Netherlands and the United Kingdom, referring to developments in the regional countries, noted that high rates of growth of energy consumption resulting from population increase and the trend towards increasing industrialization would require the application of considerable amounts of capital and expertise.

Particular attention was drawn to the real possibilities for increase in utilization of renewable sources of energy and the importance of efficiency and economy in the energy sector in order to avoid unnecessarily high costs.

The representative of the Netherlands emphasized the importance of the establishment of national focal points, as they already existed in some member countries, as a tool for the development of national energy policy. ESCAP could help with systematic information exchange, and through promotion of international standards as well as exchange of power and commercial fuels.

In the United Kingdom special emphasis was being placed on support for energy activities, and technical assistance could be provided, particularly in relation to off-shore petroleum development. Such assistance could be provided as aid in some cases.

ELECTRICITY SUPPLY

The Committee considered documents on four aspects of the subject.

Document NR.5/15 contained the proceedings of the Seminar and Study Tour on Electricity Distribution Systems in Urban Areas and Their Integration with Transmission Systems, held in Tokyo and other locations in Japan from 30 May to 14 June 1977 with the financial support and technical assistance of the Japanese Government. It was attended by participants from 17 countries. Country papers had highlighted local activities in electricity supply, and 10 reports had been presented by experts from the host country, covering both technical and socio-economic aspects of urban electrification. The Study Tour had included relevant installations in a number of cities in Japan. Recommendations of the Seminar included items on the framing of regulations for standards of security of supply and of reliability, the production of guidelines on periodic checks of installations and equipment, and collection and exchange of information on aesthetic aspects, safety procedures, multipurpose underground ducts, training courses, computer codes and computerized billing.

The Committee recorded its appreciation to the Government of Japan for the provision of host facilities and funds to support the Seminar and Study Tour, which had been of considerable practical value to participants.

Document NR.5/1 on peak-load coverage with particular reference to gas turbines and hydroelectric plants was a study in depth carried out by a consultant with the financial support of the Government of Switzerland. After consideration of power system and load characteristics and a brief section on demand management, followed by the delineation of the need for peaking plant, the study described in detail several arrangements of gas turbines and other thermal plants, pumped-storage schemes, conversion of existing facilities to include pumped-storage, and low capacity factor conventional hydro facilities. A suggested set of guidelines was given for reaching decisions on the need for peaking plant, and the choice of the type of plant.

The Committee expressed its appreciation to the Government of Switzerland for funding the study, which had been of widespread interest.

The latest of the biennial publications "Electric power in Asia and the Pacific, 1975 and 1976", prepared by the secretariat (NR.5/14), was presented. A brief general review of the situation in the region was followed by notes on individual countries and 16 statistical tables. The statistical figures and illustrations indicated that in many countries the effect of the energy crisis on power production had been a pause during 1974 in the long-term rate of growth, followed by what might become a further relatively constant but lower rate of annual increase. The full effect of the energy crisis on generation plant installation programmes, however, did not yet seem to have worked its way through into construction schedules. The Committee noted that a survey of the usefulness of the publication, and of possible improvements, would be made in conjunction with the next issue.

The Committee also took note of document NR.5/7, an information note on operating characteristics of existing high voltage direct current links.

The highlights of electricity development in individual countries were presented as follows.

Bangladesh. The electricity system was divided into two geographical sections by the main river system; that brought problems in co-ordination and investment, which would be alleviated in due course when construction of a proposed interconnexion was implemented by 1982. For the country as a whole, the installed generating capacity was 875 MW, about half being fuelled by natural gas. The available capacity was about 600 MW, as many of the machines were old. Hydro potential was relatively small unless agreement could be reached on the development of international rivers. Load growth in recent years had averaged about 11 per cent, and it was forecast that at least that growth rate would continue until 1985. The availability of electricity in the rural sector, especially for water pumping, was being increased, assisted by a loan from the United States Agency for International Development (USAID). The Asian Development Bank and the United Kingdom were providing financial support for the long overdue rehabilitation of the urban electrification systems in the two main cities of the country. Similar assistance was needed to maintain, rehabilitate and extend the distribution systems.

China. The 10-year plan for 1976-1985 called for the country's generating capacity to be approximately doubled. In selecting the sizes and sites of the hydro and thermal stations, attention was being given to the geographical distribution of supplies. While state finances were used for large- and medium-sized power stations, local authorities had been encouraged to construct small power stations for local use, and the total number of these was now over 80,000. A significant feature of the electrical industry was the active encouragement of worker participation in improving operation and minimizing losses. In some thermal power stations, coal substitutes such as bone coal and oil shale were used. Factories were encouraged to use all waste heat, in some cases for generating supplemental electricity.

India. With a current installed capacity of 26,000 MW, and with about 40 per cent hydro units, India had a five-year plan which envisaged the installation of a further 18,500 MW. In recent years demand had been growing at a rate of 12 to 14 per cent per annum. The size of units in both hydro and thermal stations was progressively increasing, and new coal-fired stations located at the pit-heads with capacities of the order of 2,000 MW were being installed for more economic thermal power generation. Individual units up to 200 MW thermal and 165 MW hydro were manufactured locally, and action was being taken to extend manufacturing capabilities to 500 MW and 250 MW respectively. The highest voltage in the transmission system was 400 kV, but as the national grid developed over the next few years it might be necessary to install some direct current links to assist transient stability of the physically large system.

A serious problem was that, although energy consumption *per capita* was low and should be increased, the capital investment required was rapidly becoming a major part of the national budget, and capital constraints were very real. One possibility was to increase subtransmission and distribution voltages, but further study was required of the over-all cost.

In order to improve capabilities in construction and operation of power stations, new training programmes were being developed and it was expected that there would, in the near future, be possibilities for the training of personnel from other countries.

An important aspect of planning for the electricity industry concerned the methods to be used for demand forecasting. While the end-use method in conjunction with development plans was proving satisfactory for periods of five to seven years ahead, more reliable methods were needed for longer-term investment planning.

Japan. The situation in the Japanese electrical industry had been subject to unusual forces in recent years, as a result of economic recession followed by marked appreciation of the currency. The national economy was being stimulated and, because of the key role of the electrical industry, heavy investments were being made on additional installations to increase its reliability. Action was also being taken to reduce dependence on imported petroleum. Construction of nuclear power stations was continuing, and Japan was now the second largest operator of nuclear power plant. Nuclear generating capacity was 7.7 per cent of the total in March 1978, was expected to be 11.3 per cent of the total in March 1979, and continued growth of that percentage was expected. The plants designed solely for liquefied natural gas reached 29 units by September 1978, and seven more were under construction. Studies were being made of coal-oil mixtures, fluidized beds and coal gasification and liquefaction.

Malaysia had embarked on physical electrical interconnexions with its neighbours, Thailand and Singapore. Generation was based mainly on petroleum, and possibilities for fuel substitution to reduce use of oil were being studied. The industrial sector accounted for over half of the electricity consumed, and it was noted that the share taken by the mining sector had decreased to about 6 per cent. Substantial funds had been allotted to rural electrification, and a rural electrification department had been established. A training centre was being enlarged with support from UNDP and the French Government, and by 1980 should be fully operational and able to provide training at professional and technician levels in all skills required in an electricity organization.

Nepal. Investigation of hydroelectric resources was continuing expeditiously with a view to establishing the proportion of the total resources which could be developed economically. So far, projects totalling 12,200 MW had been identified, which was about 15 per cent of the total expected potential. Of that, 7,100 MW was in the Karnali basin in the western area (study supported by UNDP in 1964-1965). The hydroelectric potential of the country was much more than its internal requirements for some time to come. International and regional co-operation was essential for the development and utilization of those resources. It was projected that the current demand of 70 MW would increase to about 700 MW by the year 2000 in the country.

New Zealand. There was considerable potential for further hydroelectric development, particularly in the South Island, and planned installations would in due course require the duplication of the inter-island direct current link. Forecasts of load growth were now 3.5 per cent per annum compared with 7 per cent in the recent past.

About 45 per cent of electricity was used in the domestic sector, and since a large proportion of that was used for low-grade heating, a campaign was under way to substitute the use of gas and solar energy for electricity.

Pakistan. The construction of Tarbela dam and power station had had a very beneficial effect on the availability of electric power, and in most of the country the previous chronic shortage of reliable power supply had been greatly improved. This allowed more effort to be concentrated on the reduction of losses in the transmission and distribution systems, and significant advances were being made with the co-operation of China. The initial 500 kV transmission lines were being operated at 220 kV but, with planned expansion, uprating to 500 kV was under active consideration. Considerable effort was going into village electrification.

Republic of Korea. Installed generation capacity as at the end of 1977 was 5,790 MW, 88 per cent thermal and 12 per cent hydro. The capacity was expected to double by 1981, by which time nuclear power stations (the first of which was commissioned recently) were expected to constitute about 6 per cent of the total. The proportions of sectoral demand, currently 72 per cent mining and manufacturing, 15 per cent commercial and 13 per cent domestic, were not expected to change appreciably during that period. In planning the installation programme, reserve capacity had been about 11 per cent in 1977.

Sri Lanka. The growth rate of electricity sales had varied from period to period, and difficulties were experienced in making forecasts. A recent forecast postulated an increase of about 70 per cent by 1984, but that figure was heavily dependent on progress in the industrial sector. From studies of possible hydro sites on the main river systems, it would be possible to increase the present installed capacity by almost five times, but financial constraints remained. Major projects of the Mahaweli River scheme were scheduled to be completed in six years. Rural electrification posed a problem, as houses tended to be separated and away from roads, so that distribution costs would be very high. Moreover, the people concerned at present used fuelwood and vegetable waste for cooking, and kerosene for lighting, and it could be difficult to persuade them to change their habits. The Asian Development Bank had provided funds for a complete study of all aspects of rural electrification in Sri Lanka. In view of the widespread interest in the assessment of viability of rural electrification, the Committee requested the secretariat to arrange, if possible, for the results of that study to be made available.

Thailand. The national rate of growth of electricity consumption had averaged about 19 per cent for the past five years. The rate was expected to decline slowly, but would still require a massive installation programme of generation, transmission and distribution equipment. A power station fuelled by natural gas was included in the plant programme, a more rapid installation programme on lignite-fired power generation was planned, and a nuclear power plant was under consideration. The construction of mini and micro hydro plants in remote areas was to be accelerated in order to replace existing diesel generation and to increase the electricity supply to remote villages. Concern was felt about the rapid increase in subtransmission and distribution loads, and the possibility of adopting higher voltage levels was being studied.

Electricity tariffs had been increased in two large steps since 1973, and a further study was in progress on a marginal costs approach in order to refine the tariff structure to be more equitable.

In referring to the paper describing experience in the use of low-grade coals for electricity generation, the representative of the USSR drew attention to the variety of low-grade fuels available, brown coal, lignite, oil shale and peat, which could all be used satisfactorily with careful attention to equipment design. Designs for units from 50 to 500 MW were available, and units up to 800 MW were being designed. Technical assistance could be provided to countries of the region.

The Committee noted with interest that a study on the financing of rural electrification was being carried out by the Government of India on behalf of ESCAP, and that the first draft should be available early in 1979. It was agreed that the proposals contained in the draft should be examined by countries and, if possible, tested as a basis for financial planning, following which a working group meeting should be held, with participation by representatives of funding bodies.

In view of the widespread interest in small-scale hydroelectric development, it was agreed that the workshop on that topic, scheduled to be held in Nepal in 1979, should include the application of small-scale hydroelectricity. A publication on the current status of technology, including information on the plants currently available, costs and applications could be one of the outputs. A study on those matters should if possible be carried out in time for a draft to be submitted for consideration at the workshop.

The Committee noted that, having regard to the large potential for hydroelectric development in the region and the lack of balance between energy availability and demand among the countries concerned, international and regional co-operation was urgently needed for the speedy development of those resources.

The Committee was concerned at the difficulties commonly encountered in funding the capital necessary for electricity development. There were strong pressures for growth in electricity supply because of its versatility and attractiveness for various uses, and its contribution to industrial and rural development. It was noted that large incremental capital requirements were determined by high peaks in demand, and it was agreed that a study should be made of the problems involved in financial, economic, technical implications of system design with less than 100 per cent coverage of peaks, as a means of reducing capital requirements.

NON-CONVENTIONAL ENERGY RESOURCES

The Committee had before it documents on several aspects of non-conventional energy resources.

Document NR. 5/4 contained the proceedings of the meeting of the Expert Working Group on the Use of Solar and Wind Energy, held in March 1976 with the financial support of UNDP, and attended by experts from 13 countries. (The report had been distributed late in 1976.)

Document NR. 5/2 contained the report of the Workshop on Biogas and Other Rural Energy Resources. The Workshop, with the financial support of the Government of the Netherlands, had been held in Fiji from 20 June to 8 July 1977. It had been aimed primarily at countries in the Pacific area, and was attended by 14 participants from seven Pacific countries. (The report had been circulated in October 1977.)

Document E/ESCAP/NR. 5/2 contained the report of the Roving Seminar on Rural Energy Development. With the support of the Government of the Netherlands, the Roving Seminar had operated in four countries, Thailand, the Philippines, Iran and Indonesia, during the period July to October 1977. The recommendations resulting from the respective meetings covered the same general field, but differed in detail from country to country. The Committee noted that work was proceeding on the compilation of the material, and that one single volume of proceedings was planned to cover the Roving Seminar and the Fiji Workshop, which had covered much the same field.

Document E/ESCAP/NR. 5/1 contained the report of the Expert Group Meeting on Biogas Development. The Meeting, which had received financial support from the Governments of Australia and the Netherlands, had been held at Bangkok from 20 to 26 June 1978, attended by representatives from 11 member countries, the United Republic of Tanazania and interested United Nations bodies. The Expert Group had discussed technical and management aspects, and made a number of recommendations for further research and development. The Committee noted that one of the main outputs was an outline of a draft set of guidelines on biogas development, and that the secretariat had proceeded with the collection of the required material with a view to early dissemination of the guidelines.

The Committee expressed its appreciation to UNDP and supporting countries whose assistance had made possible the activities and publications referred to above.

The Committee noted that as a result of the meetings held, and other contacts made, the secretariat had been able to update its lists of organizations concerned with solar energy and wind energy, and prepare a new list of organizations concerned with biogas. It was recommended that the three lists be distributed to interested parties.

Information provided by participants showed widespread interest and activity in this general field, dealing with a variety of energy sources. Particular emphasis was placed on biogas, biomass, geothermal energy, mini-hydroelectricity, solar energy and wind energy.

Biogas

It was evident that there had been a great increase in activity in connexion with biogas in recent years. Most plants were based either on the Khadi and Village Industries Commission design in India, with movable steel gasholder, or the fixed dome design developed in China. However, a different type was being developed in Thailand which was suitable for smaller units and could be developed by stages. The Committee expressed interest in the proceedings of the second national conference on biogas which had recently been held in China, at which the latest information on experience in production and use of biogas in that country had been presented. This revealed that there were now nearly 7 million biogas plants in China, compared with less than half a million in 1975. Large plants for collective use had been developed, and the gas was used extensively as a fuel for prime movers in addition to use for domestic purposes.

It was agreed that more work was needed to provide a better understanding of the basic process, particularly with a view to improving gas production at relatively low temperatures and providing a basis for use of agricultural residues. Removal of these two constraints could greatly extend the applicability of biogas plants. Substantial cost reduction would also be needed before such plants could be economically attractive for individual families in most developing countries.

Biomass

Concern was expressed at the accelerating soil erosion in some countries associated with removal of vegetation for firewood. Reference was made to a programme which had been initiated in the Philippines for large-scale planting of the ipil-ipil **(Leucaena Leucocophala)** tree as an energy source. Nepal was also taking extensive preservation and afforestation measures, especially through village **panchayats** with due incentives. In some countries there were large wood residues associated with the timber industry and with plantations such as rubber, coconut and oil palm.

The Committee agreed that action should be taken by countries and international bodies to promote the development and management of plantations as a source of fuel and a means of land stabilization. In conjunction with that programme, there should also be action to promote the manufacture of improved kilns for charcoal production under conditions commonly encountered in the region, and of more efficient stoves for firewood.

Geothermal energy

A number of countries were engaged in vigorous programmes for investigation and development of geothermal energy, while others were at an early stage in evaluation of those resources. While geothermal energy had received publicity, particularly as a source for electricity generation, it was stressed that in most cases it was not a high-grade heat source, and that it could be used more efficiently for other purposes, where such needs existed.

Geothermal energy had been harnessed for some time in Japan and New Zealand, and major programmes were now under way in Indonesia and the Philippines. In Indonesia the first geothermal power plant (30 MW) was scheduled to be installed in 1980 on the Kamojang field near Bandung. For the total area of Indonesia the geothermal potential was assessed at 1,500 MW. Having regard to the number of government agencies involved in the exploration and development of geothermal energy, a consultative committee had been set up to co-ordinate activities. New Zealand was involved in provision of assistance to a number of other countries in geothermal programmes.

Geothermal energy was effectively a renewable energy form and, in spite of the need for care in disposal of liquid and gaseous effluents, was generally more attractive environmentally than other forms of thermal energy. The Committee therefore agreed that evaluation and, where appropriate, development of geothermal energy warranted serious attention in any country having prospective resources.

The Committee noted that, in addition to the training course which had been available for some years in Japan, a new annual post-graduate diploma course was to start at the University of Auckland in New Zealand in 1979. UNDP support was available for up to 17 places from developing countries, but all such places were already filled for 1979.

Mini-hydroelectricity

Many countries were interested in this form of energy, which could be particularly useful in rural development programmes where the cost of electricity supply from normal systems would be uneconomical. It was evident that a good deal of work had been done on the development and installation of equipment related to skills available in rural areas, and exchange of information on those development was desirable. The Committee noted that that process should be accelerated by the proposed workshop referred to earlier.

Solar energy

Many countries were involved in research and development on a wide range of aspects of solar energy development. In some cases special institutional arrangements had been made to provide for co-ordination of work in that field. While conversion of solar energy to electricity was likely to be increasingly important as costs declined, the Committee agreed that at present there should be special emphasis on the use of solar energy as a source of low-grade heat; on that basis emphasis might be placed on developments in relation to solar collectors, and the use of solar energy for drying of agricultural products, including timber, and for refrigeration, in order to help in reducing the high waste which commonly occurred in the storage and processing of agricultural products. There were also important applications in water pumping and desalination, particularly for drinking water and, even with current costs, photovoltaic conversion was being used for electricity supply for communication purposes in remote areas, and in some cases even for domestic purposes, using 12 V batteries and fluorescent lighting.

The importance of appropriate design and construction of buildings and the application of passive solar energy techniques as a means of improving comfort with low-energy inputs was stressed. In addition, solar energy was being used extensively in some countries not only to provide hot water, but also to heat domestic and commercial buildings. There was extensive experience on this aspect in the USSR.

Wind energy

A number of countries were using wind energy, particularly as a means of pumping water. Some attention was also being given to power generation, and in the Republic of Korea there was an extensive programme of installation of units of 2-3 kW capacity. Over 180 such units were being installed to provide power at communication stations in remote areas. Plans were being developed for a 10 kW unit with emphasis on simplicity in design and manufacture.

Tidal power

Although there was potential for tidal power generation in a number of countries, those resources were not economically attractive except in the Republic of Korea, where plans were being developed for a 400 MW installation in the late 1980s.

Having regard to the increasing concern regarding the availability of conventional energy sources in a number of countries, and the suitability, in appropriate circumstances, of non-conventional energy for rural areas, the Committee agreed that work on those energy forms should have an important place in the ESCAP programme. At the same time, it was stressed that such activities should be carefully co-ordinated with activities on rural development generally.

The representative of Japan said that his Government would consider providing assistance to the secretariat for activities in that field. In co-operation with the United Nations, an interregional symposium on solar energy for development was to be held at Tokyo from 5 to 10 February 1979. Topics for the symposium would be: (a) solar collector design and testing; (b) solar heating and cooling applications; (c) solar power: (i) small thermodynamic cycle engines, and (ii) photovoltaic solar cells; (d) wind energy; and (e) storage system design and applications for solar and wind energy. Under the Sunshine project, research and development was being accelerated on a number of non-conventional energy forms.

The representative of the United Kingdom informed the Committee of the interest of the Intermediate Technology Development Group in the development of non-conventional resources. At the same time, the importance of economic appraisal of proposals was stressed, in order to ensure appropriate allocation of resources, and to encourage the development of cheaper or more effective devices.

The representative of France advised on developments in his country with a number of forms of non-conventional energy, particularly biogas, geothermal, solar and wind energy, in relation to which technical assistance might be available.

The representative of AIT outlined recent work at the Institute, with particular reference to the development of a mathematical model for calculation of solar radiation data, and work on solar drying and refrigeration.

Having regard to the importance ascribed to non-conventional energy, the Committee was pleased to note that the Economic and Social Council had recommended to the General Assembly that a United Nations conference on new and renewable sources of energy should be held at the earliest possible time. The Committee was also pleased to note that ESCAP had advised that it would be feasible to hold a regional preparatory meeting in 1980, and recommended that countries give full support to such a meeting. Having regard to the interest expressed during the session, the Committee also recommended that the proposed conference should give special attention to biogas, biomass, geothermal energy, mini-hydroelectricity, solar and wind energy.

IMPROVEMENTS IN CONSERVATION AND EFFICIENCY IN THE PRODUCTION AND USE OF ENERGY

The Committee had before it document E/ESCAP/NR.5/14, in which it was noted, after a brief discussion of energy aspects related particularly to the region, that the subject-matter could be subdivided into three areas — efficiency in production, general principles of conservation and efficient use, and practical applications of efficiency in use in the various consuming sectors. The paper continued with a discussion of measures for energy conservation that could be applied by Governments, and concluded with some suggested guidelines for national action and international co-operation.

The Committee noted that, while the broad range of subject-matter dealt with made it impossible for the papper to deal with the subject in any depth, the method of treatment was in accordance with requests expressed at earlier meetings, and provided the Committee with an opportunity to select appropriate areas for more detailed treatment if desired. In that connexion it was noted that a working group meeting on efficiency and conservation in the production and use of energy was scheduled for 1979, and that consideration should be given to the way in which that meeting should be planned.

From the discussion it was evident that there was widespread recognition of the importance of the subject, and that many countries, developing and developed, were taking a variety of measures to improve over-all performance in the production and use of energy. In some cases, such as in France, Japan and the Republic of Korea, special institutional arrangements had been established to administer government policies and programmes in this sector.

In China and India, a variety of measures had been adopted to reduce specific fuel consumption in electricity generation. The measures included renovation and modernization of existing plants, improved designs and larger sizes for new plants, and beneficiation of fuel. In France, increasing emphasis on nuclear power generation would lead to a substantial reduction in oil imports. In the USSR, attention was also being given to extraction-condensing and back pressure turbines, which could substantially increase thermal efficiency.

In a number of countries, including China, India, the Republic of Korea and the USSR, efforts were being made to improve the over-all thermal efficiency of electric power generation by the use of residual heat for other purposes, and in the USSR co-generation (combined electricity and heat generation) had resulted in fuel savings of 27 per cent compared with separate heat generation.

The Committee urged that the developed countries and interested bodies assist the developing countries in increasing the efficiency of their existing and planned electric power plants. The possibilities for co-operation under technical co-operation among developing countries (TCDC) were also noted.

In a good many countries attention was also being given to reduction of transmission and distribution losses, particularly by the use of higher voltages and power factor control.

Various measures were being adopted to improve efficiency of fuel consumption in transport, ranging from dieselization and electrification of railways to limiting the speed and requiring engine performance checks on automobiles.

Pricing and other financial measures, as both incentives and disincentives, and mandatory requirements were being used in some countries to discourage waste and to promote the use of forms of energy which were considered to be in the national interest. In France, bonuses were given to stimulate reduced energy consumption, and soft loans were available for investment to improve energy efficiency. On the other hand, there were special taxes on the use of fuel oil above quotas based on desirable practice. There were also programmes to demonstrate desirable processes, materials and devices; public education was considered extremely important in promotion of economy and efficiency in the use of energy. In New Zealand, the relative prices of imported oil and indigenous natural gas and coal had been set at values designed to reduce dependence on imported oil and encourage conservation, which had proved successful. It was important to fix economic and social goals in designing and implementing measures of that nature, and to ensure the avoidance of undesirable secondary effects.

The Committee noted that energy used in buildings was becoming increasingly important in developing as well as developed countries, and in that connexion it was noted that measures adopted in France included penalties for the heating of rooms above a prescribed temperature. It was felt that in the hotter climates, substantial energy savings might be achieved by appropriate restraints on cooling of buildings.

The importance of appropriate design and materials in building construction as a means of providing acceptable comfort with low energy input was again stressed. This was an important item in the energy saving programme in the Republic of Korea, and was receiving increasing attention in other countries. The setting of required standards for insulation in buildings, as adopted in France, appeared to have wide application.

The representative of the Asian Productivity Organization referred to a symposium proposed to be held in Thailand in August 1979 on energy policies in south-east Asia, with particular reference to in-industrial use, corporate planning, policies and institutional mechanisms. Views expressed by the Committee would be helpful in planning the seminar, and contact would be maintained with the ESCAP secretariat.

The Committee agreed that the working group meeting proposed in the ESCAP programme for 1979 should concentrate on energy use, and should aim to make practical recommendations on matters of importance to countries of the region.

DEVELOPMENT AND MANAGEMENT OF ENERGY RESOURCES

The secretariat presented document E/ESCAP/NR. 5/13 (report of the Working Group Meeting on Energy Planning and Programming). The Working Group had met at Bangkok from 15 to 21 August 1978 with financial support from UNDP, and had been attended by representatives from 14 member countries and other interested parties.

Discussions by the Working Group had indicated that major issues for the 1980s in many countries were likely to be the establishment of appropriate institutional arrangements for co-ordinated energy programming; realistic forecasting of energy demand by forms of energy and consuming sectors; assessment and optimum production of indigenous energy resources; assurance of availability of imported supplies, where necessary; and efficient use and conservation of the various forms of energy.

The Committee noted that annex II to the report contained proposed regional energy activities and that the items listed had been taken into account by the secretariat in framing the draft programme of work and priorities for 1980-1981.

The Committee commended and generally endorsed the report of the Working Group and agreed that the proposed list of regional energy activities could be used as a basis for developing the ESCAP programme.

The Committee considered in particular paragraphs 23-26 of the report, expressing views on legal and institutional arrangements and guidelines for national energy policies. Having regard to their importance in setting a context for energy programmes in the 1980s, the Committee endorsed those paragraphs with the following minor modifications.

Institutional and legal arrangements

There was an urgent need for all countries, whether or not they currently had an adequate indigenous energy supply, to adopt institutional and legal arrangements which would ensure a co-ordinated approach to energy policy formulation and planning, and to implementation of programmes. Such arrangements should also include expansion of the public sector and state planning activities in energy development in co-ordination with other sectors of the economy. Planning and programming had to be flexible, and arrangements made must allow for appropriate reaction to changing circumstances. The type of institutional arrangements to be adopted could be expected to vary depending on circumstances in different countries, but in all cases they should be aimed at providing for the optimum use of resources on a short- and long-term basis, in harmony with national development objectives. In countries where there were several ministries with major interests in the exploration, production and use of energy resources, a committee or council at the highest government level was considered desirable, and should be established, where it did not already exist, as a mechanism for co-ordination at the highest level.

Particularly in the case of assignment of work to the private sector, there was a need for institutional and legal arrangements which ensured that, while terms and conditions were such as to attract the necessary capital and technology, national interests in the use and management of resources were safeguarded. In addition to matters relating to the use of resources as such, provision was needed to ensure satisfactory arrangements in relation to the supply of data, enhancement of social well-being, environmental protection, etc.

National energy policy

Countries should adopt a broad statement of policy as a framework for formulating and carrying out energy programmes. In spite of the extreme variations in the energy situation of countries in the region, it was expected that in many cases policies might be based on objectives along the following lines.

The over-all basic objective would be the timely provision of energy in appropriate forms and quantities, and at appropriate locations and prices, to enable development goals to be achieved, including goals for human well-being as well as for economic development. At the same time there was an objective to strive for self-sufficiency in energy supply. Within these broad objectives, the following subsidiary concerns might commonly apply:

(a) The exploration and development of indigenous energy resources with a view to building up reserves, reducing dependence on energy imports, particularly petroleum, and/or releasing premium fuels for export;

(b) The systematic collection, analysis and presentation of data on resources production, distribution and use of energy, including non-commercial forms of energy, as an essential base for energy planning and programming;

(c) The promotion of efficiency and economy in the production, distribution and use of energy, without inhibiting desirable economic growth and human well-being;

(d) The substitution of oil by other energy forms, particularly for the major stationary energy uses — electricity generation and industry — and for transportation, and the allocation of natural gas to premium uses, where feasible, taking into account, however, that the future supply of imported coal could also be difficult;

(e) The use of incentives, disincentives, pricing and mandatory requirements as tools to support the policies outlined above;

(f) The adoption of measures to ensure that energy programmes for the rural sector had a priority which matched the emphasis that countries might allocate to rural development, and were integrated with such rural development programmes;

(g) The adoption of practices for project and programme formulation and evaluation which gave due weight to the social and environmental implications of proposals;

(h) The education of the public in the importance of energy as a basic element in development, and in the need for care in its use and management, having regard to the increasing difficulty and cost of providing appropriate energy supplies;

(i) Participation wherever possible in co-operative international programmes of research and development, and information exchange, with a view to widening the energy base and encouraging more effective use and management of energy.

ACTIVITIES OF ESCAP IN THE APPRAISAL, DEVELOPMENT AND MANAGEMENT OF NATURAL RESOURCES

The Committee noted that item 9 of the agenda covered activities since its fourth session, held in 1977, plus a summary of the programme of work and priorities for 1978-1979, for each of four sections.

The representative of UNDP stated that no additional finance was currently envisaged for the UNDP-funded Southeast Asia Tin Research and Development Centre and Regional Mineral Resources Development Centre (RMRDC).

In connexion with UNDP support for projects, the Committee stressed the need for flexibility in interpretation of UNDP policy to phase out institutional support, and urged UNDP to continue such support as might be required to ensure the continued effective operation of the projects under reference — the Committee for Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP), the Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP/SOPAC), the Southeast Asia Tin Research and Development Centre, RMRDC, the Typhoon Committee and the WMO/ESCAP Panel on Tropical Cyclones. The Committee noted and endorsed the proposal by the first session of the Governing Council of RMRDC that UNDP support for the Co-ordinator should be extended for a further two years.

(a) Energy resources

The secretariat presented document E/ESCAP/NR. 5/5, noting that most of the completed and current activities of the Energy Resources Section had been mentioned under previous agenda items. Since the time element in programming was fairly flexible, and some activities listed in the programme for 1979 might well take place in 1980, discussion of the programme for 1979 was combined with discussion of the new programme proposed for 1980-1981 as a result of the energy planning meeting. Energy matters for 1978-1979 were therefore reported under agenda item 11(a).

(b) Mineral resources

The Committee noted with interest the progress in the activities of the secretariat in the field of geology and mineral resources development as described in document E/ESCAP/NR. 5/6.

It noted that the first triennial review and analysis of mineral development in the region, as agreed at the third session of the Committee, would be prepared and submitted to the sixth session for consideration and publication in 1980, and hence it would be necessary for member countries to provide the secretariat with data as at 31 December 1978, as early as possible in 1979.

The Committee was informed of a new activity in close co-operation with CCOP, involving the assessment of the needs of member countries in the field of quaternary geology and the possible early fielding of a fact-finding mission. The Committee also noted that a seminar/study tour on mineral prospecting planned to be held in the USSR in 1979 was to be postponed to 1980.

Concerning the CCOP/SOPAC project, "Investigations of mineral potential of the south Pacific", the Committee was pleased to note that the UNDP project document based on the recommendations made by the UNDP review mission fielded in mid-1978 had already been endorsed by six member countries and that a UNDP contribution of about $2.5 million over the three years 1979-1981 was expected. The representatives of Australia, France, New Zealand and the USSR advised that their Governments were willing to continue their support for that project.

The Committee was informed of the possibility of scientific vessels of the USSR being made available for use in CCOP and CCOP/SOPAC projects.

The Committee was also informed of the progress made in the project on stratigraphic correlation of sedimentary basins of the ESCAP region. A working group meeting on the project was to be held at Bangkok in November 1978. It noted with gratitude the provision of the services of a stratigrapher made available by the Government of Australia in 1977-1978 for that project and another 12 man-months of expert services in 1979 to continue the work of the project.

(c) Water resources

The Committee noted the information provided in document E/ESCAP/NR. 5/7 concerning the activities of the secretariat in the water resources sector. The following additional information was also reported to the Committee.

The Workshop on Efficient Use and Maintenance of Irrigation Systems at the Farm Level in China had been held successfully during the period 24 August to 8 September 1978 with two participants each from eight countries and three ESCAP staff members participating.

The eleventh session of the Typhoon Committee had been held in Bangkok from 3 to 9 October 1978 at which both long- and short-term plans of action had been adopted. In discussing support for the Typhoon Committee after 1979, it was decided that members would continue endeavours to meet requirements from their own resources. The Typhoon Committee had also requested the ESCAP secretariat to obtain additional support in the implementation of its programmes and had, in particular, referred to the possible value of a revolving fund through which countries could obtain urgently needed items of equipment. The representative of UNDP pointed out that its commitments to the Typhoon Committee and the WMO/ESCAP Panel on Tropical Cyclones already totalled over $1.4 million.

The issue of whether to hold an **ad hoc** intergovernmental meeting on water before the seventh session of the Committee in 1980 was still under review in consultation with the Advisory Committee of Permanent Representatives and Other Representatives Designated by Members of the Commission, and it was hoped that a decision would soon be reached. The need for additional definitive replies from countries was stressed. The Committee recommended that if an **ad hoc** meeting were not held, the views of Governments should be sought on the inclusion of that item in the next session of the Committee.

The first session of the Interagency Task Force on Water for Asia and the Pacific had been held at Bangkok on 29 September 1978, attended by representatives of ESCAP, UNEP, UNDP, FAO, UNESCO, ILO, WHO and the World Meteorological Organization (WMO). In addition to endorsing its draft terms of reference, the Task Force had discussed the respective activities of its members in the field of water resources development and identified those in which co-operation could be useful.

The Committee noted with appreciation that the USSR was making arrangements to host a seminar at Tashkent in 1979 on measures to improve irrigation efficiency at the farm level.

(d) **Remote sensing, surveying and mapping**

The Committee noted the information provided in document E/ESCAP/NR. 5/8.

It was also noted that, in consultation with AIT, arrangements had been made for a working group meeting to be held at Bangkok from 28 November to 2 December 1978, with support from UNDP, with a view to developing a regional programme on remote sensing, with emphasis on training and research and development on applications of remotely sensed data, particularly from satellites.

The Committee noted with appreciation that the Japan International Co-operation Agency had held a training course on remote sensing in Tokyo early in 1978, and that another course was to be held from 5 January to 23 February 1979. Invitations had been issued to ESCAP countries.

The Committee also noted that 12 countries had now indicated support for a working group meeting in 1979 to discuss programmes and needs in relation to thematic mapping and national and regional atlases. The proposal to hold that meeting was therefore endorsed, and the importance of giving due consideration to data requirements and map specifications was stressed. The meeting would assist in preparations for the United Nations Regional Cartographic Conference to be held in New Zealand in February 1980.

The Committee expressed its appreciation of the support provided during the year by Governments and international agencies in the natural resources sector.

ACTIVITIES OF OTHER INTERNATIONAL BODIES IN THE APPRAISAL, DEVELOPMENT AND MANAGEMENT OF ENERGY RESOURCES

The Committee had before it a number of documents from international organizations which were supplemented by oral statements made by representatives.

(a) **United Nations Development Programme**

The representative of UNDP outlined the interests of UNDP in the natural resources field in the region, and assured the Committee of UNDP's willingness to provide support in the energy sector, which was considered important. UNDP might organize a formulation mission to develop a proposal based on priorities established by the Committee.

(b) **United Nations Environment Programme**

Document NR. 5/CRP. 9 gave details of UNEP's strategy concerning the environmental impacts of all sources of energy. A study by a panel on the environmental impact of fossil fuels would be published shortly. The second panel on nuclear energy would be convened at Geneva in November 1978. The third panel on the development of renewable sources of energy would be convened at Bangkok in

March 1979. Two experimental centres were now being established by UNEP, using solar, wind and biogas energy sources, at Pattiyapola, Sri Lanka, and in Senegal, West Africa. The feasibility of a third experimental centre for Mexico was being examined.

(c) **Economic Commission for Europe**

Document NR.5/9 gave details of activities in many fields, including demand and supply issues, coal, natural gas, electric power, rural electrification, solar energy and other renewable energy sources and energy conservation. The Committee noted the regular interchange of relevant reports with ESCAP.

(d) **United Nations Conference on Trade and Development**

Document NR.5/10 described UNCATD's activities related to financing requirements in the energy sector, including analysis of gestation periods of investment, proportionate size of investment in the energy sector, and the impact of a shortage of energy on over-all development. A comprehensive report would be presented to the fifth session of the Conference in May 1979.

(e) **International Labour Organization**

As noted from document NR.5/6, ILO interest in the field of energy resources development lay particularly in the development and use of non-conventional energy for rural areas. Case studies had been and were being carried out, including studies on the more efficient use of animal power. Special attention was also being given to training. Guidance material was also available on techniques for project evaluation, including social and environmental factors.

(f) **Food and Agriculture Organization of the United Nations**

The main interests of FAO during 1978 to 1980 in the field of natural resources included biogas, water supply and remote sensing. Small-scale biogas production in China would be studied by a selected group. Four training courses would be held on different aspects of water, in addition to four meetings and a number of studies and surveys. A training course on the application of remote sensing to agrometeorology was also planned.

(g) **United Nations Educational, Scientific and Cultural Organization**

UNESCO had been promoting co-operative programmes for the development of research in energy problems with emphasis on different types of non-conventional and renewable energy resources. The main activity of UNESCO was providing international and regional conferences, meetings of experts, workshops, scientific and technical diploma and degree courses, fellowships, etc.

The UNESCO Regional Office for Science and Technology in South and Central Asia had assisted in the establishment of the Regional Centre for Energy Heat and Mass Transfer for Asia and Pacific in 1976, in India.

The Regional Centre had organized a regional workshop on heat and mass transfer in 1977, and a workshop on solar drying in 1978. The International Solar Energy Congress at Delhi in 1978 was followed by an Asian Expert Group Meeting on Solar Energy, the first result of which was a Working Group Meeting on Solar Drying held recently at Manila.

UNESCO provided assistance to the Indian Institute of Petroleum in different energy development projects.

(h) **World Meteorological Organization**

A described in document NR.5/13, WMO had a plan of action in the energy field, concerned particularly with hydropower resources, both large and small, solar energy source analysis and data, and the utilization of wind.

(i) **Asian Productivity Organization**

Document NR.5/8 mentioned particularly the survey on energy management in 1976 which had laid the foundation for a symposium in 1977. A further symposium on energy policies in developing countries would be held in 1979, and ESCAP was assisting in some of the preparatory work. A training programme in energy management was also scheduled for 1979. Three filmstrips on energy saving with a total duration of 110 minutes were available.

(j) **International Chamber of Commerce**

Document NR.5/5 stressed the critical need to strengthen the current energy policies of all countries. No energy policy could be successful which did not give equal importance to dealing realistically with two aspects of the energy problem: increasing and diversifying supply, on the one hand, and conserving the use of energy, on the other. It was considered essential that market forces be allowed to operate on prices.

(k) **International Energy Agency**

As described in document NR.5/CRP.10, one of the main activities of IEA was long-term planning because of the very long lead times involved in bringing new energy sources on stream. For example, renewable energy resources such as solar, tidal and wind power were often cited as one major solution for developing and developed economies alike. IEA studies suggested that non-conventional and renewable energy sources might account for perhaps 5 per cent of global energy needs by the year 2000.

Member country energy policies were reviewed annually by IEA, and a set of 12 general principles which should guide energy policy formulation in each member country had been adopted. The objectives of the IEA energy research, development and demonstration programme were to assure the development and application of those new and improved energy technologies which offered the potential of making a significant reduction in long-term dependence on oil.

IEA was endeavouring to develop a technically sound global energy data base. A workshop on energy data, with particular reference to the problems of collecting and using energy data in developing countries, to be held in co-operation with the United Nations, would provide a forum for energy experts from developing countries and international organizations to exchange views on technical problems relating to energy data compilation and usage. The results of that workshop would be published and would include detailed technical information of the energy balances for 25 developing countries.

(l) **Asian Institute of Technology**

Document NR.5/CRP.4 described activities in the field of solar energy since 1973, particularly the solar radiation climate of Thailand, water distillation, solar-powered refrigeration and a low-cost rice drier. Work on the latter two items was continuing. A Renewable Energy Resources Information Centre (RERIC) was established in 1978, and the first newsletter was distributed to the Committee. A new graduate programme in energy technology was being established, with the first intake of students in January 1980.

PROGRAMME OF WORK AND PRIORITIES IN THE APPRAISAL, DEVELOPMENT AND MANAGEMENT OF NATURAL RESOURCES, 1980-1981, IN THE CONTEXT OF THE MEDIUM-TERM PLAN, 1980-1983

The Committee noted that the draft programme had been formulated in consultation with the Advisory Committee of Permanent Representatives and Other Representatives Designated by Members of the Commission, which had also assisted in the development of the revised format for presentation of the programme.

(a) **Energy resources**

In the energy field the Committee considered the programme of work for 1979 as well as for 1980-1981, as set out in documents E/ESCAP/NR.5/5 and E/ESCAP/NR.5/9. The amendments suggested were as follows:

(i) In the programme of work for 1979, the expert group meeting on evaluation of geothermal energy should be replaced by the workshop on mini-hydro plant technology proposed to be held in Nepal, and the proposed survey of the use of liquefied natural gas should be deleted;

(ii) In the programme of work for 1980-1981, under programme component 02.02.04, "Development of energy resources", the meeting on international negotiation and contracts related to energy projects including equipment should be deferred, and the regional preparatory conference on new and renewable sources of energy and seminar on geothermal energy should be added.

With regard to the seminar on geothermal energy, the Committee agreed that the outline submitted in document NR.5/CRP.1 was a suitable framework for detailed planning.

The Committee recommended the adoption of the programme as amended.

(b) **Mineral resources**

The Committee recommended the adoption of the programme of work on mineral resources development for 1980-1981, as submitted in document E/ESCAP/NR.5/10.

(c) **Water resources**

The Committee examined the programme of work on water resources as contained in document E/ESCAP/NR.5/11 and was informed that the views and suggestions made at its fourth session had been taken into account in the preparation of the programme. At the same time, due consideration had been given to the state of development of the proposed activities and the appropriateness of including them in the programme of work.

Based on the requirements of the Typhoon Committee determined at its eleventh session, together with those of the WMO/ESCAP Panel on Tropical Cyclones, the 1980-1981 programme of work on water resources had been compiled to reflect the extrabudgetary resources needed for programme component 17.03, "Mitigation of damage from cyclones, floods and droughts", totalling 72 man-months. That figure represented the requirements for a hydrologist

(24 man-months) and a flood control expert (24 man-months) for the Typhoon Committee (17.03.01), and a hydrologist (24 man-months) for the WMO/ESCAP Panel on Tropical Cyclones (17.03.02). The Committee was pleased to note the statement by the representative of UNDP that the Typhoon Committee was regarded as a good example of the concept of TCDC, and that UNDP would consider sympathetically the provision of programme support to replace the institutional support under the present project.

It was suggested that consideration be given to adapting the *Water Resources Journal,* which was already effective in information exchange, in order to meet other requirements in that field.

The Committee endorsed the programme as amended.

(d) **Remote sensing, surveying and mapping**

The Committee endorsed the proposals contained in document E/ESCAP/NR.5/12, noting that details would depend on the outcome of meetings to be held later in 1978 and in 1979. The Committee was also pleased to note that UNDP would consider possible support for a regional programme in remote sensing, in the light of the recommendations of the working group meeting late in 1978.

Attention was drawn to the generally disappointing rate of development of hydropower in developing countries, a number of which had very large potential. Various possible factors could be identified, including shortage of capital, competing uses for water and land, and social and environmental factors. The Committee agreed that, if resources permitted, a study or working group meeting should be arranged by the energy and water resources sections to examine the matter.

Representatives of India, the Soviet Union and the United Kingdom, in expressing support for the programme in the natural resources field, indicated the readiness of their Governments to assist where possible in carrying it out. The Ministry of Overseas Development of the United Kingdom was particularly interested in the development of renewable forms of energy in rural areas. The USSR offered opportunities for seminars/study tours and for training on UNESCO scholarships. In particular, the following seminars/study tours were proposed:

(i) Modern methods of mineral prospecting in 1980;

(ii) Modern drilling methods in 1981;

(iii) Improvement of irrigation performance at the project level in 1980;

(iv) Policies with regard to comprehensive development of water resources and agriculture in land reclamation areas in 1981.

The Committee expressed appreciation for those offers of assistance.

CONSIDERATION OF THE AGENDA AND ARRANGEMENTS FOR SUBSEQUENT SESSIONS OF THE COMMITTEE

The Committee considered the provisional agenda for the sixth session proposed by the secretariat in document E/ESCAP/NR.5/3. It was agreed that a report of CCOP should also be presented to the sixth session under item 6.

The Committee was informed that the provisional agenda, with the above addition, would be submitted to member countries for further guidance as necessary before finalization.

It was noted that unless other proposals were put forward in the mean time, the next session would be held at Bangkok in about October 1979. The date would be finalized in consultation with the Advisory Committee of Permanent Representatives and Other Representatives Designated by Members of the Commission.

OTHER BUSINESS

No other matters were raised.

ADOPTION OF THE REPORT

The Committee adopted the report on its fifth session, for consideration by the Commission at its thirty-fifth session, on 6 November 1978.

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Throughout the session there was repeated reference to the need for countries to develop their indigenous energy resources and to conserve energy, and in doing so to take full advantage of experience available in developed countries and international bodies. The Committee also recorded its thanks to UNDP and other bodies and countries which had provided financial and other support for activities carried out during the year.

Specifically, the Committee:

(a) Requested that the secretariat document on progress in energy development be revised in the light of new information submitted by participants;

(b) Agreed that the forthcoming draft of the study on the financing of rural electrification should be examined by countries, if possible tested as a basis for financial planning, and that a working group meeting would be held;

(c) Agreed that the workshop on small-scale hydroelectric development, scheduled to be held in Nepal in 1979, should include applications of small-scale hydroelectricity, and should result in a publication on plants currently available, costs and applications;

(d) Noted that international and regional co-operation was urgently needed for the speedy development of hydroelectric resources;

(e) Agreed that a study should be made of problems in financing electricity development, with special reference to the effects of not fully meeting peak demands;

(f) Recommended that the respective lists of organizations concerned with solar energy, wind energy and biogas be distributed to interested parties;

(g) Agreed that more work was needed to provide a better understanding of the basic biogas process;

(h) Agreed that action should be taken by countries and international bodies to promote the development and management of fuel plantations, and improved kilns for producing charcoal and stoves for firewood;

(i) Agreed that evaluation and development of geothermal energy warranted serious attention:

(j) Agreed that there should be special emphasis on the use of solar energy as a source of low-grade heat, and identified specific areas of concern;

(k) Agreed that non-conventional energy forms for rural energy should have an important place in the ESCAP programme;

(l) Recommended that countries give full support to the proposed regional preparatory meeting for the United Nations conference on new and renewable sources of energy, and recommended topics for special attention;

(m) Recommended that developed countries and interested bodies assist the developing countries in increasing the efficiency of their existing and planned electric power plants;

(n) Agreed that the working group meeting proposed for 1979 should concentrate on energy use;

(o) Commended and generally endorsed the report of the Working Group Meeting on Energy Planning and Programming, including the list of regional energy activities given in annex II to the report of that meeting;

(p) Adopted the sections of the foregoing report dealing with legal and institutional arrangements, and guidelines for national energy policies, with minor modifications;

(q) Stressed the need for flexibility in interpretation of UNDP policy to phase out institutional support;

(r) Recommended that if an **ad hoc** intergovernmental meeting on water were not held, the views of Governments should be sought on the inclusion of that item in the agenda for the sixth session;

(s) Endorsed the proposal to hold a working group meeting in 1979 to discuss thematic mapping and national and regional atlases;

(t) Recommended the adoption of the ESCAP programme of work and priorities in energy resources for 1979 to 1981, with amendments;

(u) Recommended the adoption of the ESCAP programme of work and priorities in mineral resources for 1980-1981;

(v) Endorsed the ESCAP programme of work and priorities in water resources for 1980-1981, with amendments;

(w) Endorsed the secretariat proposals in respect of work and priorities in remote sensing, surveying and mapping;

(x) Agreed that, if resources permitted, a study or working group meeting should be arranged to examine the disappointing rate of development of hydropower in developing countries;

(y) Agreed that the proposed provisional agenda for the sixth session would be submitted to member countries.

II. WORKING PAPERS PRESENTED BY THE SECRETARIAT

PROGRESS IN ENERGY DEVELOPMENT

(Synopsis of E/ESCAP/NR.5/4)

This paper contained the report "Progress in energy development", prepared for the Expert Working Group on Energy Planning and Programming and included, as amended, in part one of these proceedings.

PROCEEDINGS OF THE SEMINAR AND STUDY TOUR ON ELECTRICITY DISTRIBUTION SYSTEMS IN URBAN AREAS AND THEIR INTEGRATION WITH TRANSMISSION SYSTEMS

(Synopsis of NR.5/15)

The proceedings of the Seminar and Study Tour on Electricity Distribution Systems in Urban Areas and Their Integration with Transmission Systems was published in 1978, as No. 18 in ESCAP's Energy Resources Development Series.[1]

The Seminar and Study Tour was held by ESCAP at Tokyo and other locations in Japan from 30 May to 14 June 1977, with the financial and technical assistance of the Government of Japan. The proceedings included the report of the meeting, technical documents presented at the Seminar by the secretariat, the host country and participants (including country reports and papers on specific topics), and brief notes on the Study Tour which followed the Seminar.

PEAK-LOAD COVERAGE WITH PARTICULAR REFERENCE TO GAS TURBINES AND HYDROELECTRIC PLANTS

(Synopsis of NR.5/1)

This document comprised a study in depth, prepared by a consultant for the secretariat with the financial assistance of the Government of Switzerland, and published by the United Nations in 1977 as No. 17 in ESCAP's Energy Resources Development Series.[2]

The electricity supply systems of many countries suffered from wide variations of simultaneous loading at different periods, both on a seasonal basis and, more particularly, on a daily basis. Generating facilities must be planned to supply the peak demands, bearing in mind that part of the plant needed for that purpose would be inadequately used during off-peak periods. It was clearly in the interests of the supply undertakings and their consumers that the capital investment in the power production facilities should be a minimum, and that consideration had led to the concept of peaking plant which might be specially designed for peaking duties, or base-load plant modified to be able to cover peaking requirements at minimal incremental cost.

The study, which had high technical content, first considered the characteristics of power systems in countries of the region, load management possibilities, and realistic approaches to system planning, with particular reference to factors affecting plant choice, and resulting plant mix. There followed a discussion of design, operation and economics of peaking plant: gas turbines, alternative thermal plants, pumped-storage and conventional hydro schemes, with reference also to related electrical equipment. The final section provided guidelines relevant to decisions to install peaking plants, and choice of plants.

ELECTRIC POWER IN ASIA AND THE PACIFIC, 1975 AND 1976

(Synopsis of NR.5/14)

The secretariat produced a biennial publication, *Electric Power in Asia and the Pacific.* The most recent in the series, covering statistics for the years 1975 and 1976, was published in 1978.[3]

The format included comments on the electric power situation in the region, and notes on developments in individual countries. Sixteen tables presented statistics on installed generating capacity and transmission systems (including recent additions and projects under construction), fuel consumption, energy generation, sales and tariffs, etc.

HIGH VOLTAGE DIRECT CURRENT LINKS

(Synopsis of NR. 5/7)

This paper contained an extract of information available on the 15 high voltage direct current links in service in the world, including average utilization and average availability. The material had been published by the International Conference on Large High Voltage Electric Systems (CIGRE), Paris, in its periodic publication *Electra,* No. 57, March 1978.

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[1] United Nations publication, Sales No. E.78.II.F.8.

[2] United Nations publication, Sales No. E.77.II.F.19.

[3] United Nations publication, Sales No. E.78.II.F.11.

PROCEEDINGS OF THE MEETING OF THE EXPERT WORKING GROUP ON THE USE OF SOLAR AND WIND ENERGY

(Synopsis of NR.5/4)

The proceedings of the meeting of the Expert Working Group on the Use of Solar and Wind Energy were published by ESCAP in 1976, as No. 16 in its Energy Resources Development Series.[4]

The meeting was held at Bangkok from 2 to 9 March 1976, with the financial assistance of the United Nations Development Programme. The proceedings included the report of the meeting, and technical documents presented by the secretariat and the experts, which were subdivided into sections on solar energy, wind energy and integrated systems (solar, wind and other energy sources).

REPORT OF THE WORKSHOP ON BIOGAS AND OTHER RURAL ENERGY RESOURCES

(Synopsis of NR.5/2

The Workshop on Biogas and Other Rural Energy Resources was held at Suva, Fiji, from 20 June to 8 July 1977 with the financial support of the Government of the Netherlands. The full report was included in *Proceedings of the Fiji (Suva) Workshop on Biogas and Other Rural Energy Resources and the Roving Siminar on Rural Energy Development,* Energy Resources Development Series, No. 19.[5]

REPORT OF THE ROVING SEMINAR ON RURAL ENERGY DEVELOPMENT

(Synopsis of E/ESCAP/NR.5/2)

The Roving Seminar on Rural Energy Development was organized with the financial support of the Government of the Netherlands. The Seminar was held at Bangkok from 18 July to 5 August 1977, Manila from 15 August to 2 September 1977, Teheran from 12 to 21 September 1977, and Jakarta from 10 to 21 October 1977. The full report was included in *Proceedings of the Fiji (Suva) Workshop on Biogas and other Rural Energy Resources and the Roving Siminar on Rural Energy Development,* Energy Resources Development Series, No. 19.[5]

REPORT OF THE EXPERT GROUP MEETING ON BIOGAS DEVELOPMENT

(Synopsis of E/ESCAP/NR.5/1)

The Expert Group Meeting on Biogas Development was held at Bangkok from 20 to 26 June 1978 with the financial support of the Governments of Australia and the Netherlands. Invited experts attended from 11 ESCAP member countries; in addition, there were participants from three United Nations bodies and from the United Republic of Tanzania.

The objectives of the Meeting were to identify existing technology, processes and devices in biogas for immediate application and suggest a suitable outline for compilation of a publication on guidelines on biogas development which could be used as a reference by those who wished to build a biogas plant and those concerned with biogas development.

The publication would be issued by ESCAP in the Energy Resources Development Series.

[4] United Nations publication, Sales No. E.76.II.F.13.

[5] United Nations publication, Sales No. E.79.II.F.10.

IMPROVEMENTS IN CONSERVATION AND EFFICIENCY IN THE PRODUCTION AND USE OF ENERGY*

(E/ESCAP/NR.5/14)

A. INTRODUCTION

General aspects as related to the region

The oil crisis had made it clear that the energy problem was closely related to the life-style, culture, economy, society, politics and environmental conditions of the people, and that the problem was not the problem of one particular country but one in which all the countries of the world had been involved so deeply that it could not be solved without international co-operation. Therefore, in each country of the world intensified efforts were being made to work out a more effective energy policy, and the Governments and the private sector were finding it necessary to work together.

It was accepted that within the foreseeable future oil production would reach its peak, and this might result in a shortage of energy supply. Among the developed countries, the International Energy Agency had been established to solve the urgent problem of conserving energy and expanding the energy supply. The problem was even more important for the developing countries, many of which were meeting serious financial difficulties because of the rise in oil prices.

The level of energy consumption of the developing countries, when compared with that of the industrialized countries, was very low, but owing to

* This paper was prepared by Mr. K. Matsui, consultant on energy production and use, at the request of the secretariat. The views expressed in it are those of the author and do not necessarily reflect those of the United Nations.

the rapid growth of the population, economic and industrial development, and an expected gradual change from non-commercial to commercial energy sources, an expansion of the demand for commercial energy was anticipated. In some of the advanced countries, how to attain further social and economic development without increasing *per capita* energy consumption was a subject for serious consideration, but that situation did not apply in the developing countries where national living standards were low. It was desirable for the developing countries to increase *per capita* energy consumption, implying a more rapid increase in the absolute quantity of energy consumption. In such a situation, they had to face a possible worsening of balances of international payments, further inflation, and the fear of a world-wide shortage of energy supply, and it had become a most important strategic task for the developing countries to attain their national goals with a somewhat slower growth rate of energy consumption than formerly seemed necessary.

Curbing the over-all energy demand growth rate by decree would not solve the problem, unless the curbing was related to policies to develop indigenous energy and promote efficient energy production and use.

The development of energy resources usually required a long lead time and a large amount of funds. However, there were many relatively low-cost and short-lead-time measures for energy saving and the efficient use of energy. That was the reason why, since the oil crisis, each country had made every effort to apply these measures as a high priority effort. There were various resulting implications, such as that scarce resources could be used as long as possible by spending energy wisely, considering its true value; international friction over the scramble for energy resources could be avoided and the undesirable impact on global environmental conditions could be reduced.

Considering the task of using energy in the most efficient way, thereby conserving energy, the actions which might be taken in regard to energy itself might be divided into the following three categories.

Firstly, from an over-all point of view it was necessary fo identify the forms and quantities of energy to be produced or imported under the given social, economic and natural and environmental conditions in a particular country or region.

Secondly, the problem of enhancing the efficiency of energy production must be tackled.

Thirdly, the conservation and efficient use of energy in the context of energy demand must be considered.

As noted previously, the energy problem was closely connected with the life-style, culture, society, economy, politics and environmental problems of the people, and it was impossible to frame an energy policy without paying due attention to problems which were peculiar to a certain region or country. In the case of the ESCAP region, member countries were mostly developing countries, and therefore energy problems must be considered in relation to factors peculiar to the developing countries, namely, the population problem, the disparity between urban and rural living conditions, the social structure, the industrial and economic srtucture, economic development, the balance of international payments, climate, and environmental conditions.

Characteristic features of countries in the region

Per capita commercial energy consumption in the ESCAP region in 1976 was, on the average, 651 kilograms of coal equivalent (kgce). However, there existed great differences between individual member countries. In that year, *per capita* energy demand was 6,249 kgce in Australia, while it was less than 200 kgce in countries such as Burma, Nepal and Sri Lanka. The degree of dependency upon energy imports also differed from country to country. For instance, the energy supply of such countries as Japan, the Philippines and Thailand depended largely upon imports, while there were energy-exporting countries such as Indonesia and Iran. Furthermore, member countries differed from each other in their industrial structure and stage of economic development. Thus, before proceeding to the main issues, it was desirable to group the countries. Following ESCAP practice, the grouping might be as follows:

(a) Developed countries: Australia, Japan, New Zealand;

(b) Energy-exporting developing countries: Afghanistan, Brunei, Indonesia, Iran, Malaysia;

(c) Energy-importing developing countries: other developing countries;

(d) China (a special case of large energy production and consumption).

The groups to be discussed were the last three. In those countries the emphasis on energy policy varied, because it depended on whether they had adequate resources or not. Needless to say, in countries where resources were adequate or in over-supply, the efficient use of the resources for economic development would be the most urgent task to deal with, while in those whose resources were meagre the main emphasis would be on how to reduce the degree of their dependency on energy imports. Furthermore, it was observed that the countries could also be divided into two categories, i.e. those with substantial economic development, which might adopt policies approaching those of developed countries, and those less advanced, which deserved special emphasis.

B. EFFICIENCY IN PRODUCTION

Improving efficiency in energy supply generally covered such problems as increasing efficiency in the production of conventional fossil fuels such as petroleum and coal, promoting the development of commercial energy resources which might have been somewhat neglected, and promulgating information on the utilization of renewable energy resources. There was also the problem of the efficient production of electric power which was important as a secondary energy source.

The production of nuclear fuels was a special case, since in mining, processing and utilization there were political and environmental problems as well as economic ones.

1. Solid fuels

Solid fuels were a basic source of conventional energy in the ESCAP region. They were produced in 15 countries of the region and their total production reached 705.9 million tons in 1976, which accounted for 44.4 per cent of the total regional production of commercial energy, although such figures were heavily influenced by production in China.

Currently, solid fuels were a major energy source in the region, and owing to the sharp rise in the price of oil their importance was expected to increase. In the United States and European countries, the mechanization of coal mining had made considerable progress, improving the output per miner. In those countries in the region which were already producing coal, rapid progress in increasing productivity might be expected through the introduction of advanced Western technology. In those countries which had reserves but were not yet in production, the main effort might need to be directed towards efficient exploration and assessment of the reserves, followed by adequate attention to the optimum mining techniques. Here again, advanced technology was available. In order to master such technology and machines, skilled manpower must be available. It therefore seemed urgent to train personnel in all aspects of either underground-mining or strip-mining coal exploration and production.

The use of coal was accompanied by the environmental problem of the production of nitrogen oxide, sulphur dioxide and ash particles. Techniques to deal with those pollutants were readily available. Low-grade coals or those with high ash content were likely to benefit from the current work on fluidized bed boilers, and liquefaction and gasification processes.

2. Liquid fuels

Liquid fuels were another important source of conventional energy in the region. Production was 745.4 million tons of coal equivalent (tce) in 1976, or 46.9 per cent of the total production of conventional energy in the region. Although a considerable amount of exploration appeared to have been carried out in the area, closer examination revealed that there were many areas that had not been throughly explored. Technical methods were well developed and readily available, and the main essential was to apply them, both on shore and off shore, either directly by Governments with the necessary equipment and manpower, or indirectly by inviting selected collaborators.

From the viewpoint of increasing efficiency of existing oil production, introducing secondary and tertiary recovery techniques would become more important. For new production, techniques for both on shore and off shore were readily available. As technical development in that field had not yet made much progress in the region, the developing countries would continue to depend largely on the technique of the developed countries. It seemed, however, necessary for developing countries to train experts in all aspects.

3. Natural gas

In 1976, natural gas was being produced in 12 countries of the region, amounting to 75.7 million tce, which accounted for 4.8 per cent of the total production of commercial energy of the region.

In many cases, natural gas was produced in association with oil production. Therefore, expanding the volume of its production depended largely on the progress of oil production and its techniques. However, even then, a large proportion of the gas was flared, and the main object was not to produce more, but to contain and use what was produced. This was a vital area for conservation of raw energy. Natural gas was not only useful as a fuel, but also had high value when used as material for the petrochemical industry.

4. Renewable sources of energy

With the oil crisis as a catalyst, renewable energy had attracted world-wide attention from the viewpoint that scarce fossil fuels should be conserved and the over-all impact on the natural environment should be lessened. The use of such forms of energy could be said to have a particular significance for developing countries. The reasons for this were that use would improve the balance of international payments, and it was often available in rural areas.

Hydropower. The resource volume of recoverable hydropower in the region was estimated to be 20 X 10^9 tce. Development of that hydropower had only been fully promoted in a few countries. Developing countries were now finding it necessary to accelerate the development of hydropower, paying particular attention not only to the construction of large scale hydropower stations but also to small ones for the electrification of rural areas and the securing of water for irrigation. Expertise was readily available, and funds could generally be obtained. Because of the political problems involved, it was not easy to carry out river development projects when rivers flowed through two or more countries. That was another vital case for use of available raw energy, and it was hoped that related countries would co-operate closely with each other.

Solar energy could be used to obtain hot water, and for crop drying, using comparatively low-skill techniques. Considerable information was available on the design of efficient devices. More advanced techniques such as solar power plants and solar batteries were now being developed.

It seemed to be a wise policy for the developing countries to develop their resources of solar energy first in the field where low-skill techniques could be utilized.

Biomass, biogas. Cultivating fast-growing plants (energy plantation, energy forest) or producing biogas from animal dung and vegetable waste was an important theme for development, and the volume of available information was increasing rapidly. In India, it was said that a cattle population of 222 million produced 1,200 million tons of wet dung and nearly 20 per cent of that was burnt directly at a conversion efficiency of 11 per cent. If the dung were processed through anaerobic fermentation plants, an energy output of about 167 X 10^{12} kcal per annum could be generated.

Geothermal. Some of the countries of the region were located in volcanic areas and were blessed with geothermal resources. It was hoped that those countries would utilize geothermal energy in various ways, for instance, to generate power using not only hot steam, but also hot water and hot rocks. The main problem, for which expertise is readily available in the region, was assessment of potential fields.

Vegetable waste and town waste were used in the developing countries to some extent as important energy sources. However, there was considerable scope for assessing supplies with respect to quantities and locations.

Firewood was also an important energy source. Observing the recent trend of deforestation, it was noted that to be truly renewable, attention must be paid to planned growing and harvesting.

Wind energy was available in many countries, and the main problem was to transfer the successful techniques for cheap, hand-made windmills for water pumping to more areas.

5. Nuclear energy

Developing nuclear energy has a vital significance, especially for those countries having scarce fossil energy sources. However, the main effort currently might well be directed towards exploration, with the new and advanced techniques which were readily available. Production of uranium oxide in a marketable form was not a difficult process.

6. Electricity

In addition to efficient production of primary energy, it was important to increase the production of secondary energy such as electricity, as use of electricity derived from a central power station was often a much more efficient procedure than using primary energy in small amounts.

The average thermal efficiency of steam power generation in Japan had improved from 20 to 38 per cent during the preceding 20 years, in line with enlargement of unit capacity. In the case of developing countries, the enlargement of unit capacity would have a certain limit because of the relationship between demand density and demand volume. Choosing a unit capacity which best fitted the conditions of each country or each region, and improving thermal efficiency, could lead to a considerable saving of primary energy.

Parallel with the increase in power generation efficiency, it was important to consolidate the network of power transmission and power distribution, thereby reducing the loss in transmitting and distributing electricity.

From the viewpoint of increasing efficiency, co-generation was also important in that waste heat could be used for providing hot water and heat for use in industrial processes. Due consideration should be given to this co-generation, not only in the case of public utilities but also of industrial power plants.

Development of techniques to store electricity in the form of heat, motive power, or chemical energy was an important research theme. If an efficient electricity storage technique were successfully developed, the over-all efficiency of power plants would increase considerably, which in turn could reduce the number of power plants to be constructed, and improve the conditions for introducing solar, wave- and tidal-based power generation.

C. PRINCIPLES OF CONSERVATION AND EFFICIENT USE

Energy conservation and efficient use meant, in a narrow sense, how to save energy and improve efficiency in its various uses. That, at the same time, was closely related to how to frame and attain a national target in consideration of the characteristic features of energy demand and supply in each country. Although various measures could be conceived to cope with the problems, the degree of priority which should be given and the points on which primary emphasis should be placed varied depending upon the respective countries' internal and external situation. Furthermore, such measures could not be effective unless combined with the national strategic policy. That was particularly so in the developing countries having difficulties such as meagre natural resources, lack of infrastructure, rapidly growing population, high level of unemployment and an unfavourable balance of international payments.

What should be examined first was the long-range prospect for social, economic and industrial development in the developing countries. It might be neither necessary nor desirable for the developing countries to follow the development patterns of industrialized countries, but, in order to enhance the living standard, to pursue economic and industrial development in line with the actual conditions in their countries. Such attempts would almost certainly be accompanied by an increase in energy demand. Therefore, to decide what kind of industries should be encouraged, and what forms of energy sources should be used were important tasks in each developing country. Owing to the sharp rise in energy cost and deteriorating environmental conditions, there was a tendency in industrialized countries to curb the growth of energy-intensive industries such as the production of pig iron, aluminium and chemical materials. This gave an opportunity for some well-endowed developing countries to take up those industries. At the same time, most developing countries were in a favourable position to take up labour-intensive industries. It was therefore an important task for developing countries to introduce and develop appropriate industries which fitted the conditions of their respective countries, avoiding environmental deterioration as far as possible.

To use goods for a long time, implying adequate care and maintenance, led to over-all energy saving and energy efficiency. Therefore, to produce goods having a long prospective life, and to use and repair them with care, should be regarded as one of the important items of the industrial and energy-saving policy.

Agriculture had a large share in GDP in the developing countries, and in the future its importance might not greatly change. Agriculture in the developed countries was energy-intensive owing to the use of a large quantity of chemical fertilizers and pesticides and the development of mechanization. That had increased productivity, but, on the other hand, it had caused a vicious circle in that the more chemical fertilizer was used, the less fertile the soil became, requiring even greater input of fertilizer.

In the developing countries, promoting mechanization to some extent might be necessary for increasing productivity but, considering the energy and employment problem, raising productivity up to the Western level was not necessarily either urgent or desirable. Animal dung and vegetable waste should be used for fertilizer as much as possible. The vital point in that regard was to clarify what kind of life could be called a comfortable life in the true sense of the word in farming villages and what type of farming should be carried out as the optimum form of agriculture, while at the same time making sure that all available land was in production.

Firewood, animal dung, and vegetable waste played important roles in many of the developing countries. The problem was that their thermal efficiency when burnt in a traditional manner was very low. However, these materials could be obtained at a cheaper price and would remain important energy sources in the future. Attention should therefore be directed towards improving the utilization efficiency of those energy sources.

An over-all energy strategy was needed which combined demand and supply management for commercial energy in forms suitable for end-uses with the introduction and expansion of all available renewable energy resources.

Energy was most often used to produce heat at a relatively low temperature, including hot water for kitchen use and for a portion of industrial heating. Therefore, using energy of a high grade to an unnecessary extent was a wasteful process. Furthermore, the possibility of substituting solar heat or biogas for fossil fuel used in the kitchen or for a portion of industrial heating should be studied. For providing mechanical power, there was still considerable scope for windmills, biogas plants and pedal power.

How to improve and develop living conditions was a problem directly associated with the energy problem. Those countries considered here had natural features quite different from those of Western countries. In tropical countries, houses were constructed to allow outer air to enter, and air-conditioners were not required. Rather, there was scope for improving the existing open and comfortable high-floor style house. Multistorey buildings in urban centres and houses in a densely built-up area might need air-conditioners, but if they utilized solar energy which was abundant in the region or used solar energy with a heat pump, commercial energy could be conserved.

As for transportation, the development and utilization of mass transport systems using railways and buses should be promoted. In the case of railways, besides the use of coal, it seemed necessary to give due consideration to dieselization and electrification. For freight transportation, the rationalization as well as expansion of marine transport and the building of pipelines not only for petroleum and natural gas but also for biogas and synthetic liquid gas should be duly considered.

D. EFFICIENCY IN USE: SECTORAL APPLICATIONS

1. Industrial sector

There was scope for saving and efficient use of energy in the industrial sector by improvement in operation and maintenance management, by partial remodelling and improvement of processes and integrated control with automatic systems, and by replacement of plants by large-scale, up-to-date and more efficient systems.

Improvement in efficiency in the use of energy in energy-intensive industries such as iron and steel, paper and pulp, cement and aluminium was a key point.

In the iron and steel industry, it was estimated that from 7 to 8 per cent of energy could be saved by reducing the blast furnace fuel consumption ratio by demoisturizing and ventilation, raising the recycle ratio of off-gas in revolving furnaces, reducing the fuel input per production unit through the application of computer control, raising the continuous casting ratio, using a blast furnace pressure circulation turbine, and employing the complete hot direct rolling method. A technique for mixing steaming coal with coking coal was being developed.

With regard to the paper and pulp industry, it was estimated that from 10 to 15 per cent of energy could be saved by using a continuous distilling cauldron and a new efficient paper manufacturing machine, raising the drain circulation ratio and the used paper recovery ratio, and reducing the weight of newspaper.

In the cement industry, it was estimated that a 15 to 20 per cent energy saving was possible by introducing a new suspension pre-heater method and utilizing the emitted heat of clinkers for drying raw materials.

In aluminium production, it was estimated that efficiency in the use of energy could be increased about 5 per cent through the application of a large electrolyzer, improvement of electrolyzing efficiency, standardization of rotary kilns, and improvement in the efficiency of heat exchangers. Furthermore, the introduction of the Alcoa method and the Toss method would help to increase energy efficiency. Although those techniques were mainly used in the developed countries, in the industrial sector the developing countries could also adopt such advanced production methods.

In the developing countries, light industry played a big role. Accordingly, energy saving and the efficient use of energy in that sector was very important. The drastic mechanization of light industry would not be easy, and was not necessarily desirable, since in that sector an intensive labour force was still needed and furthermore an employment problem existed. However, carefully thought-out measures would also make it possible to attain energy saving to a considerable extent in this area.

2. Residential and commercial sector

Energy demand in the residential and commercial sector in the developing countries was mainly for cooking (including the use of hot water) and the ratio of non-commercial to commercial energy was high. Thus, the first consideration was how to improve efficiency in the use of firewood, vegetable waste and animal dung. Slow-combustion stoves were readily available, and work was proceeding on larger units. These non-commercial energy sources were being replaced to some extent by kerosene and liquefied petroleum gas, especially in urban areas, and the development of more efficient kerosene stoves and LPG burning equipment was to be expected.

Also mainly in urban areas the use of advanced equipment, such as air-conditioners and refrigerators, had begun to spread. For those items, the achievements of technological development in the developed countries would be of use in the developing countries. In the developed countries the air-conditioning demand was very high, and the primary emphasis of the energy-saving policy was on installing insulation in houses, but in the developing countries such measures were not necessary except for buildings and some houses in densely built-up urban centres. In those cases, improved insulation, the use of the heat pump, and the introduction of air-conditioning utilizing solar heat should be considered.

Increasing the energy consumption level in the rural areas was seen as a vital requirement. Besides the proposed improvement in efficiency in the traditional use of non-commercial energy mentioned above, consideration should be given to the promotion of electrification by hydropower, to the development of solar heat and biogas units, to more widespread use of available low-grade coal, and measures based on the idea of an integrated energy supply system.

3. Transportation sector

In the developed countries, motor cars were an important means of transportation: in the most typical case, the United States, automobiles used more than 50 per cent of the energy consumption in the transportation sector. Automobiles were personal means of transportation and their energy efficiency per passenger mile was very low.

Contrary to that, in the developing countries much weight was attached to mass transportation means such as railways and buses, and considerable weight was also given to human power (bicycles) and animal power (horse-drawn carriages, ox carts). Even in the developing countries, curbing the popularization of motor cars unconditionally was not desirable, but basic priority should be given to the development of means of mass transportation and to increasing their over-all efficiency.

In that sense, for developing countries the building of efficient and rational railway systems, improving the energy efficiency of railways (dieselization and electrification of railways), and introducing buses and trucks would be more important than such measures to save energy as making the size of cars small and compact, and reducing fuel expenses by improving engines, which were the most important measures being taken in the developed countries.

As mentioned earlier, expanding marine and river transportation for freight traffic and raising its efficiency, building pipelines, and the rationalization of transportation by truck (rationalization of the distribution system), were also important tasks.

E. MEASURES FOR ENERGY CONSERVATION

1. Pricing policy

The setting of prices within a country through a free international market mechanism might work towards a reasonable allocation of resources, but might receive some over-all government adjustments for the realization of long-range policy targets. If the market were not free, monopolistic practices might distort the allocation, limiting the Government's freedom to apply adjustments. Viewed from past experience, energy prices had been too low, leading to wasteful use of energy and serious environmental destruction, and the energy crisis had pointed out the need for adequate study of the efficient use of precious resources and the protection of the environment, leading to stability in the international approach to commercial energy resource depletion.

From the aspect of energy conservation and the efficient use of energy within a country, such measures as direct price regulations and a demand-restrictive energy rate system might be considered.

The general adoption of direct price regulations should be limited to exceptional cases such as a very large deficit in the balance of external payments, necessitating a reduction in the amount of imported energy, when other measures proved to be ineffective. However, the adoption of selective direct price regulations might be advisable, to let the price to the user reflect the social cost or true cost of energy production and to check the wasteful use of energy.

The demand-restrictive energy rate system i.e. the penalization of unnecessarily large or luxury use, might be a practical pricing policy for energy conservation. In Japan that system was introduced for electricity tariffs in 1974, incremental consumption beyond a certain volume being subject to a higher rate.

In the transportation sector, a high rate of taxation on energy-intensive vehicles and/or a high rate of taxation on gasoline and/or a low fare policy for mass transport were also practical and effective. Part of the tax revenues collected might be used as funds or subsidies for the construction of mass transportation systems or to cover part or all of deficits caused through the adoption of low fares for mass transport systems, being careful to check that such subsidies did not themselves lead to inefficient application of other resources.

2. Legislative arrangements

Such direct regulations as the establishment of efficiency standards, the imposition of an obligation to indicate energy efficiency and to circulate and re-utilize waste heat were some of the examples to be studied.

In the United States, 10 specified energy-intensive industries had been set targets for improvement of energy efficiency by 20 per cent by 1980. This goal was also set for high energy-consuming equipment and a statement of energy consumption was required for specified equipment. In France, a minimum energy efficiency for boilers, re-utilization of waste heat, and a statement of energy consumption of domestic electric equipment, were obligatory. This approach had been introduced to a greater or lesser extent by most developed countries since the oil crisis.

In the residential and commercial sector, regulations concerning air-conditioning temperature, neon signs and night lighting might be applied. In France, heating a room to a temperature above 20°C could be punished with a fine. Regulations for the use of advertising illumination and street lighting were applied for a time after the oil crisis in many countries of the region.

3. Governmental support for the private sector

Governmental support for the private sector through financial incentives such as low interest rates, subsidies, and favourable tax and depreciation measures constituted one of the most important measures for energy conservation and efficient use of energy.

In the United States, tax deductions would be allowed for investment in energy conservation equipment and for investment for the improvement of energy efficiency in existing houses. A credit guarantee might also be provided by the Government for investment in energy conservation measures and for measures to utilize renewable energy sources. In the Federal Republic of Germany, subsidies were provided for construction of town waste power plants and other investments for energy conservation and efficient use of energy.

Such types of governmental support had been introduced in most of the developed countries. They were applied in many fields of energy conservation activity and took different forms in terms of amounts of subsidies, rates of interest and of tax reduction, reflecting the situation and policy of each country. Governmental support could play a big role also in countries of the region, for developing particular key industries and promoting the use of new energy sources, while the fuller use of indigenous energy resources became part of a policy of energy conservation and efficient use of energy in the wider sense.

4. Direct investment by the Government

Despite government support, there might be some energy-saving technologies the commercial use of which seemed difficult in the short term but promising in the longer term. As the private sector might not be anxious to develop such technologies, direct investment in such technologies might be made by the Government.

The government budget for energy conservation had been markedly increased in recent years in most of the developed countries. By far the biggest amount was noted in the United States, where it accounted for over $1,000 million in the 1977 budget allocation, two thirds of that amount being for the development of energy conservation technologies. The Government aimed at co-operating with the private sector to develop such technologies as heat recycling, an inexpensive but efficient fuel cell, improvement of electricity generation efficiency, energy storage systems, heat storage systems, a hybrid electric car, etc. The United States case was outstanding, but other developed countries also budgeted for the development of similar types of technology, and it seemed that the amount allocated would be increased rapidly in those countries.

5. Education, information and demonstration

It was also important to inform and educate the public on such issues as why the efficient use of energy was important, how energy could be saved and how far energy-conservation technology had been developed. Demonstration of energy-efficient houses, building and equipment would also help understanding, and stimulate the people to pursue the conservation of energy.

6. Institutional arrangements

In order to promote all those activities effectively, it was necessary to consolidate the related laws, enact an energy conservation law and establish administrative institutions for promoting energy conservation.

In the United States, the Energy Policy and Conservation Act was enacted in December 1975, and the Energy Conservation and Production Act in August 1976; other related legislation was under active debate. In France, an energy conservation law was enacted in October 1974 and the governmental agency for energy conservation (Agence pour les économies d'energie) was founded in November 1974. In the Federal Republic of Germany, a law for energy conservation in building (gesetz zur eensparung von energie in qebauden) was introduced in July 1976. Similar laws for energy conservation and efficient use of energy had been introduced also in many other countries.

A corollary to the enactment of legislation was the establishment of institutions for energy conservation to follow up and enforce the laws. These might be wholly governmental, or joint efforts between the Government, industry and other interested parties.

F. GUIDELINES FOR NATIONAL ACTION AND INTERNATIONAL CO-OPERATION

The problems concerning energy conservation and the efficient use and production of energy covered wide areas, but action which might be taken could be roughly divided into categories.

1. General aspects

Setting the goal. The first task for each country was to frame a long-range social and economic development goal. As part of the necessary investigation, each country must consider interrelations with other countries, and that should assist closer co-operation and co-ordination between countries.

Scope for industrial and agricultural development. In the over-all development goal, the roles of industrial development and agricultural development should be made especially clear. This would also require some measure of information exchange and close co-operation between the concerned policy-makers and those in other countries.

Demand management and supply strategy. The next step was to establish a comprehensive energy policy consistent with the over-all goal. In order to do this, it was necessary to make realistic demand forecasts and assessments of potential supplies of indigenous energy and imports of energy, leading to a practicable demand and supply policy, taking account of the proper forms and volumes of energy required to match the various end uses. In the case of developing countries, reduction of dependency on imported energy, environmental problems and problems in the rural areas should be given special attention.

Energy data centre. In order to form such an energy strategy it was a vital necessity to establish a data base giving reliable data on the demand and supply of energy, preferably in a format which allowed easy comparison with data from other countries. This could lead towards establishing a data centre for the region, which, in addition to such a function, could monitor work in other international organizations, including United Nations bodies, the International Energy Agency, the European Economic Community, and the Organization of Petroleum Exporting Countries, co-operating with them as appropriate.

Energy balance table. An especially urgent need seemed to be to produce an over-all energy balance table format which could be used by countries of the region, and an expert study to do that merited close consideration.

Energy model. An energy demand and supply forecasting model was desirable to develop a reliable and consistent approach, and it was suggested that information on that issue should be collected and studied with a view to demonstrating to the countries the type of model most suitable for developing countries, and assisting them to set up such models.

Financial and technical co-operation. There were serious bottle-necks in both financial and technical co-operation within the region, between countries in the region and outside countries and financial institutions. Even though procedures existed, in many cases they were slow and cumbersome, and it seemed that great efforts should be directed towards the fuller realization of the possible potential of such procedures.

2. Improvements of efficiency in energy production

The individual tasks or issues were noted in section B, and covered a very wide range of energy supply areas. In order to accomplish those tasks, country policy should include appropriate legislation and action on ownership of resources and rights to development taxes and depreciation allowances, pricing, government financial assistance and direct government investment.

It would be desirable that relevant features of policies adopted by countries both within and outside the region which had already developed particular energy resources should be studied with a view to setting down the range of approaches available, with indications of which régime of action, for each resource and over all, appeared to give the best results in developing countries. A consistent and understandable set of regulations would be expected to result in fewer problems in obtaining international finance for deserving projects.

Further work was also required in collecting and disseminating information on production technologies, and in setting up training centres or study tours to enable technical personnel to update their expertise.

3. Improvements in conservation and efficiency in the use of energy

Among the aspects peculiar to energy conservation and the efficient use of energy, several points seemed to stand out as priority requirements.

In each country, it was vital to investigate individually and in detail the possibilities and feasibilities for energy conservation and for the efficient use of energy by sectors, i.e. industrial, agricultural, residential and commercial, and transportation. Reference might be made to approaches introduced or discussed in developed countries.

Study was then needed of the effects of legislation on financing, taxes, pricing and the effects of institutional policies. Again, reference to the measures introduced or discussed in the developed countries might be instructive and could save a lot of trial-and-error attempts, but the special measures needed to cope with the special conditions in the developing countries also needed consideration.

In order to carry out those tasks, it was desirable that an energy conservation committee and study group and information centre be established in each country, and they should be provided with an appropriate forum and procedures for exchanging the necessary information between countries. A central regional secretariat could be appropriate, staffed by technical experts and economists.

REPORT OF THE WORKING GROUP MEETING ON ENERGY PLANNING AND PROGRAMMING

(Synopsis of E/ESCAP/NR.5/13)

The report of the Working Group Meeting on Energy Planning and Programming is contained in full in part one of these proceedings.

III. INFORMATION PAPERS SUBMITTED BY GOVERNMENTS AND OTHER INTERESTED PARTIES

AUSTRALIA'S ENERGY SITUATION

(NR.5/12)*

by

The Department of National Development (Australia)

This paper was the report "Australia's energy situation", prepared for the Working Group Meeting on Energy Planning and Programming and included in part one of these proceedings, with new material attached as an addendum. The new material is given below.

Crude oil pricing arrangements

Under the 1977 scheme, the oil producer received, for each "old" field, full import parity less a levy of $3.3 per barrel for the first 6 million barrels of oil per annum, or, alternatively, full import parity less levy for a gradually increasing percentage of production, the remainder being valued at the previous (much lower) price. All oil from a "new" field or a "small" field was eligible for full import parity.

A major modification made in August 1978 was to increase the price of indigenous crude oil to refineries to import parity levels. This recognized the critical need for conservation of liquid fuels and accepted the pricing mechanism as the best method of achieving a more efficient use of energy and allocation of scarce resources.

The proceeds of the increased price paid by refineries as a result of that decision would accrue in the first instance to the Government; the price to producers would continue to reflect the arrangements of the 1977 scheme.

The new arrangements involved the imposition of a production levy at the rate required to bring the price of "non-parity" oil up to import parity, with variable rebates being allowed to reflect, on the one hand, the maintenance of a net levy of about $3.3 a barrel on "import parity" oil and, on the other hand, the slight differences between Bass Strait and other oil-fields in both import parity prices and non-parity prices.

The decision had added 3 cents per litre to the price of petrol and was estimated to have a direct impact on the consumer price index of about 0.7 percentage points.

* Abridged.

ELECTRICITY GENERATION IN FRANCE*

by

M. F. Callot (France)

In France, since 1974, particular attention had been paid to saving of energy. One goal was to reduce the previously estimated consumption of energy in 1985 by 16 per cent. Consumption in 1977 was only 2 per cent higher than in 1973, this good result being mainly due to executive action on energy saving and the creation of a special agency.

In 1977, production of electricity was 54 per cent from thermal stations, 37.5 per cent from hydro stations and 8.5 per cent from nuclear stations. In order to keep down imports of oil, attention was being concentrated on nuclear power stations for the future, and a programme was under way by which 5,000 MW to 6,000 MW of nuclear stations would be added each year from 1979. According to projections, by 1985 about 80 per cent of electricity production would come from nuclear stations.

* Abridged from manuscript notes.

ENERGY SCENE IN INDIA

(NR.5/CRP.7)*

by

The Department of Power, Ministry of Energy (India)

This paper was an updated version of the report, "Country paper, India", prepared for the Working Group Meeting on Energy Planning and Programming and included in part one of these proceedings. Some figures for 1977/78 have been added to the tables in that paper where appropriate. The new material is given below.

Trends in the consumption of commercial energy

During the past two decades the over-all consumption of energy had increased at an average rate of 3.2 per cent in terms of heat content (4.5 per cent in terms of useful energy). The significant feature was the dominant role played by non-commercial forms of energy, though its share had declined from about 75 per cent in the early 1950s to about 59 per cent at present in terms of heat content (70 per cent to 40 per cent in terms of useful energy). The demand for commercial forms of energy had, however, shown a significant growth rate of 5.7 per cent per annum in terms of heat content (7 per cent in terms of useful energy).

* Abridged.

The non-commercial forms of energy were used as domestic fuel, predominantly in rural areas. The commercial forms of energy were mainly used in the industrial, transport and urban domestic sectors. They had been steadily entering the rural energy economy, mainly for agricultural use.

Part of the primary commercial forms of energy was converted to secondary forms, mainly electricity for use by the ultimate consumers. The trend in the use of commercial forms of energy by ultimate consumers is presented in table 1.

Table 1. Commercial energy consumption

Year	Coal[a] (million tons)	Oil[a] (million tons)	Electricity (million kWh)
1955/56	28.80	4.66	9,480
1960/61	40.40	6.76	10,900
1965/66	51.80	9.94	30,560
1970/71	51.35	14.95	48,650
1973/74	57.26	16.70	56,250
1974/75	64.87	16.80	58,980
1975/76	67.96	17.15	66,000
1976/77	67.00	18.65	73,100
1977/78	NA	19.75	75,500

[a] Excluding use for power generation.

An interesting feature of the trend in energy consumption up to the oil crisis in 1973 was a gradual decline of coal as a direct source of energy and growing preference for oil and electricity. During the period 1953/54 to 1973/74, the consumption of coal, oil and electricity by the ultimate consumers increased at rates of 3.5 per cent, 7.9 per cent and 10.8 per cent, respectively, per annum. The growth during the earlier half of that period was more impressive than the latter half. While the consumption of commercial forms of energy during 1973/74 to 1975/76 grew at a rate of about 6.3 per cent per annum in terms of heat content, direct energy consumption of coal registered a growth rate of 8.6 per cent per annum while the growth rate of oil consumption declined to 1 per cent per annum. Electricity consumption during the last few years, however, maintained the same *tempo* that obtained during the decade prior to the energy crisis. The spurt in coal consumption was mainly due to its increased production and improved availability. The fiscal and other measures taken to conserve oil, soon after oil prices increased, also accounted for the decline in oil consumption. Substitution of coal for oil, wherever possible, was also responsible for increased coal consumption. Coal consumption by sectors is indicated in table 2.

Consumption of oil by sectors in 1976 was: transport and agriculture, 49 per cent; mining and manufacturing, 20 per cent; domestic, 19 per cent; and others, 12 per cent.

The consumption of electricity by sectors in 1977/78 compared to that for 1976/77 showed an increase for industrial use from 62 per cent to 65 per cent, with a proportionate decline in other sectors.

Table 2. Coal supplied to sectors (millions of tons)

Sector	1974/75	1975/76	1976/77	1977/78
Steel	18.5	20.9	22.6	22.9
Power	20.0	23.5	28.9	28.1
Railways	13.3	14.3	13.1	13.3
Cement	3.6	4.5	4.9	5.1
Soft coke	0.7	3.6	4.3	3.9
Brick burning	1.7	3.3	6.1	3.5
Fertilizer	1.0	0.9	0.7	1.2
Other industries	22.5	20.5	16.5	20.9
Colliery consumption	2.3	2.5	3.4	3.3
Export	0.5	0.4	0.6	0.6
Total	84.1	94.4	101.1	102.8

INDONESIA ENERGY OUTLOOK

(Synopsis of NR.5/CRP.3)

by

Indonesia

This paper was the report, "Indonesia energy outlook", prepared for the Working Group Meeting on Energy Planning and Programming and included in part one of these proceedings.

CURRENT ASPECT OF ENERGY MANAGEMENT AND DEVELOPMENT IN JAPAN

(NR.5/CRP.8)*

by

Japan

A. TREND OF ENERGY CONSUMPTION AND SUPPLY

Energy consumption in Japan fell temporarily between 1973 and 1975, increased modestly from 1976, and was about 495 million tce in 1977. In order of importance, sectoral consumption was for mining/manufacturing, household/commercial, transportation, energy production and agriculture/forestry/fishery. The trend in each sector followed the general pattern, although household/commercial and transportation were less affected.

* Abridged.

The decrease of energy consumption in the mining/manufacturing sector was caused mostly by the economic recession, but also by energy conservation efforts (see table 1).

Table 1. Elasticity of energy consumption in major sectors

(per unit)

Sector	1960-1965	1965-1970	1970-1973	1970-1976
Mining/manufacturing	1.19	1.29	0.82	0.44
Household/commercial	1.32	1.14	1.38	1.37
Transportation	1.11	1.03	0.99	1.00
Energy	1.07	1.37	1.27	1.28
Agriculture/forestry/fishery	1.04	1.22	0.82	0.62

The increase of energy consumption in the household/commercial sector was caused by the spread of electric appliances, hot water supply, air-conditioning, etc., and by the development of large buildings, and the trend was expected to continue.

In June 1977 it was estimated that energy demand in Japan would be between 880 and 990 million tce in 1985, and between 1,060 and 1,230 million tce in 1990, depending on the success of energy conservation.

In 1975, Japan depended on imported oil for 73 per cent of its energy supply. Recently other types of energy resources, such as coal, nuclear power, LNG, geothermal, etc., were being utilized, and the percentage of dependence on oil was decreasing slowly. With maximum energy conservation, it could reach 57 per cent by 1990, allowing for nuclear power to have increased from 1.7 to 11.2 per cent of total energy.

B. ENCOURAGEMENT OF ENERGY CONSERVATION AND DEVELOPMENT OF ENERGY SCIENCE AND TECHNOLOGY

The Government established a special centre for energy saving in 1974, to promote resource and energy conservation in all sectors of industrial activity and in the household/commercial sector.

On the other hand, the Government recognized that it was very important to promote energy research and development, and established, in August 1978, a basic programme for energy research and development over the next decade. The research and development to be pursued by the nation as a whole, including both governmental and private sectors, was set out in some detail, and covered a broad range. As the prospects for success in individual research and development projects became clearer, it was expected that efforts would be concentrated more on subjects of outstanding potential.

C. TOPICS OF INTEREST

1. Wind energy utilization

Wind energy potential was abundant in the areas along the northern coast of the Japan Sea, in the areas along the southern coast of the Pacific, the Izu islands and the south-west islands, a total coastal length of 6,000 km, where general wind velocity was over 4.4 m/sec at heights of 100 m.

The Science and Technology Agency was carrying out research to find out the availability of wind energy utilization for intensive horticulture, fish cultivation, leisure facilities and so on, and was planning demonstrations with small-scale windmills at three locations. In addition, one windmill of the two-bladed propeller type had been installed at Ohshima, Tokyo, and another, of the two-bladed Darrieus type, had been installed at Sakata, Yamagata Prefecture.

2. Wave-power plant

The amount of wave energy surging to the coast of Japan was estimated at up to 1 million MW, as Japan was surrounded by sea and ocean, and had a long coastline.

Since 1975, the Marine Science and Technology Centre had developed a prototype wave-power plant, installed it off Tsuruoka, Yamagata Prefecture, and begun test operations. The prototype was a ship-shaped buoy 80 m in length, 12 m in width, 8 m and 5 m in height at the bow and the stern respectively, equipped with 3 (later 11) air turbine generators about 1.6 m in diameter with 125 kW generating capacity each.

A 250 MW wave-power plant was planned, depending on the results of the prototype up to 1980.

3. Pigpen air-conditioning by pig waste

Since about 1950, in rural areas, methane gas had been produced from cattle waste with simple facilities and used for domestic cooking and water heating. This method, however, disappeared gradually in favour of propane gas, because the volume of methane gas fluctuated according to the season.

However, recently a full-scale pigpen air-conditioning facility, operated by methane gas from pig waste, had been developed and operated. The facility consisted of two 30 m^3 fermenting tanks, a de-sulphurizer, a gas-holder and air-conditioning instruments. A total of 500 kg of pig waste was used each day, and the gas was stored in a gas-holder.

4. Power generation by blast furnace top gas

The iron industry was one of the main industries, and also one of the large energy-consuming industries, accounting for about 17 per cent of total energy consumption in 1976. The energy intensity (unit energy consumption index) of Japanese raw steel manufacturing was the lowest in the world, and energy conservation was very effective.

Many energy conservation techniques, such as coke dry quenching systems, continuous casting machines, direct rolling processes, etc., had been developed and used. Blast furnace top gas power generators had been developed and put into practical use during the last two years, the power being used in the works.

Five blast furnace top gas power generators with total capacity of 42.5 MW were already in operation in four companies, and 10 more generators were planned to be installed in five companies.

5. Utilization of exhaust heat from combustion of urban waste

There had been many examples of the utilization of exhaust heat from combustion of waste, but most of them were small-scale, such as hot water supply or small independent electric power plants. However, large-scale utilization, such as commercial electric power generation and/or district heating, was now proceeding.

The Katsushika Incinerator Plant at Tokyo had an electric power capacity of 12 MW and had been in operation since 1977; 5 MW was used in the plant and the rest was supplied to commercial electric lines.

The Atsubetsu Incinerator Plant at Sapporo had been in operation since August, 1974, and supplied steam for an independent electric power generation plant, district heating to about 6,000 houses, road heating, greenhouses, etc.

6. Fish breeding utilizing hot waste water

Power plants, ironworks and so on required large quantities of cooling water. Sea water was generally used, passing through heat exchangers; the water temperature generally rose 6°C to 9°C and was discharged back into the sea. Recently, efforts had been made to use the hot waste water positively for aquatic products breeding, intensive horticulture and so on.

The Hot Waste Water Research Centre at the Hamaoka Nuclear Power Station of the Chubu Electric Company bred up to 50,000 porgies, 2 million prawns, and 200,000 abalone a year. The breeding rate was high and the growth rate very fast.

The Chiba Ironworks had bred eels, carp, terapia and so on by making use of hot waste water. There were about 8,000 m^2 of ponds and 700,000 eels were bred in a year, the breeding rate being about 40 per cent above normal, and the growth rate also high.

7. Demonstration of solar energy utilization at a solar house

The Science and Technology Agency promoted demonstrative investigation of residential solar energy utilization at a solar house for improvement of the technologies. The fluctuation in energy consumption, the share of solar energy in total energy consumption, and electric energy consumption of the demonstration plant were measured continuously. In addition, energy movement in the systems and the house was measured for about 10 days in the room cooling season and in the room warming season, respectively. The efficiency of the heat collector was generally about 18 per cent in the room cooling season and 20 to 30 per cent in the room warming season. The design target was 30 per cent annual average. The utilization rate of the collected solar energy was about 50 per cent in the room cooling season and 50 to 60 per cent in the room warming season. The design targets were 77 per cent and 94 per cent respectively. Improvements were planned.

ENERGY PROGRAMMING AND PLANNING IN MALAYSIA

(NR.5/CRP.5)*

by

The Petroleum Development Unit,
Prime Minister's Department (Malaysia)

This paper was a revised version of the report, "Energy programming and planning in Malaysia", prepared for the Working Group Meeting on Energy Planning and Programming and included in part one of these proceedings. New material is given below.

A. AGRICULTURAL WASTE

Estimates had been made of the amounts of agricultural waste available in 1976 from various sources, as follows:

Rubber tree replanting	9,000,000 tons
Oil palm refuse	5,500,000 tons
Coconut plantations	659,000 tons
Rice-fields (excluding straw)	657,000 tons
Pineapple plantations	NA

B. BIOGAS

The livestock population in 1976 had been investigated, without classification as to stock size. Taking average figures, the gross potential biogas production from dung was calculated, as follows:

204,000 buffaloes	75,000 m^3
363,270 oxen	134,000 m^3
310,380 goats	26,000 m^3
42,980 sheep	4,000 m^3
789,990 swine	1,410,000 m^3
Total	1,649,000 m^3

* Abridged.

HYDROELECTRIC — NEPAL'S ENERGY RESOURCE

(NR.5/CRP.6)*

by

Nepal

A. ENERGY RESOURCES AND CONSUMPTION

The main commercial energy resource of Nepal was hydroelectric potential. Some exploration had taken place for other resources, and two areas were being studied more closely in the hope of finding oil and/or natural gas. No realistic indications had been found of the occurrence of coal.

The most important item among non-commercial energy resources was forest resources, which provided the basis for a considerable volume of fuelwood and charcoal. Some agricultural waste and cow-dung was also available.

A recent survey on consumption indicated that the *per capita* energy consumption was of the order of 580 kg of coal equivalent. The relevant percentages of use were: imported coal, 1 per cent; imported petroleum, 9 per cent; electricity, 1 per cent; fuelwood, 87 per cent; and vegetable waste, 2 per cent.

With the expected acceleration of economic development, the demand for commercial energy would grow at a much faster rate than in the past. The balance-of-payments situation was such that reliance on imported coal or oil would mean a slow rate of development. On the other hand, continued dependence on fuelwood was inadvisable. That left development of hydroelectric energy as the only realistic approach for large-scale usage.

B. DEVELOPMENT OF HYDROELECTRIC RESOURCES

The current installed generating capacity of the country was 64 MW, of which 37 MW was hydro. Of the total, 83 per cent, including all the hydro capacity, was owned and operated by the public sector. Most of the installations were in the central region. Under an arrangement with India, power was interchanged for border areas. The current electricity consumption *per capita* was 14 kWh per annum, but less than 3 per cent of households had access to electricity.

Developments under construction included projects of 15 MW due in 1978, 60 MW in 1981 and 14 MW in 1983, and feasibility studies were nearing completion on projects of 38 MW, 35 MW and 30 MW respectively. Further projects of moderate size were under preliminary study. Twelve micro hydro plants of sizes ranging from 100 kW to 500 kW were under construction, and 15 more such plants were planned, with emphasis on local participation.

* Abridged.

Total hydroelectric potential was of a much higher order: about 83,000 MW. Most of this potential was in three major river systems. A systematic study of the Karnali river basin carried out with the assistance of UNDP in 1964/65 indicated 10 power station sites ranging from 3,600 MW to 18 MW. A similar study was under way for the Gandak river basin, and one was planned for the Koshi river basin. The long-term strategy of development was related to the export of surplus power to neighbouring countries.

C. DEVELOPMENT OF OTHER INDIGENOUS RESOURCES

About 45 per cent of the land area was covered by forests, about two thirds being in the hills and mountains. About half the forest was classified as commercial forest, the remainder being unavailable for various reasons. About 60 per cent of the population lived in the hilly country, and the commercial forest area was gradually being encroached on. Approaches aimed at reducing the rate of denudation were under consideration.

About 350 biogas plants were in use, operating on cow-dung, and about 1,000 more plants would be in operation by 1980.

Large-scale studies were being undertaken on the possibilities of utilizing solar energy and wind energy, but application might be found to be relatively expensive in Nepal.

D. INSTITUTIONAL ARRANGEMENTS

Currently, responsibility for hydropower was apportioned between the Electricity Department, Ministry of Water and Power, the Nepal Electricity Corporation and the Eastern Electricity Corporation.

Forest resources were under the jurisdiction of the Forest Department and the Department of Soil and Water Conservation, both in the Ministry of Forests.

Exploration for petroleum was covered by the Department of Mines and Geological Survey, Ministry of Industries and Commerce, while marketing of imported supplies was in the hands of the Nepal Oil Corporation.

NEW ZEALAND'S ENERGY POLICY*

by

The Ministry of Energy (New Zealand)

A. INTRODUCTION

Two major institutional changes to the energy sector were made during 1978. On 1 April, 1978 the three principal departments with energy responsibilities,

* Abridged. Copies for participants were delayed, and were distributed subsequently.

the New Zealand Electricity Department, the Mines Department and the Ministry of Energy Resources, were merged into a single department — the Ministry of Energy, and certain energy responsibilities of other departments (e.g. geothermal, pricing) were transferred to that Ministry.

The second institutional change was the establishment of a new limited liability company, Petroleum Corporation of New Zealand Limited (Petrocorp), with three subsidiaries: the Offshore Mining Company Limited, the Natural Gas Corporation of New Zealand Limited, and Petroleum Corporation (Exploration) Limited. Petrocorp was a wholly government-owned holding company. The Natural Gas Corporation was a gas wholesaler and pipeline operator. The Offshore Mining Company Limited was the government company involved in the Maui natural gas venture. Petroleum Corporation of New Zealand (Exploration) Limited would undertake petroleum exploration, including the Government's own on-shore and off-shore programmes.

In May 1978 the Ministry published "Goals and guidelines — an energy strategy for New Zealand", for public discussion. The four energy policy goals set out in the document were: to ensure that energy supplies were adequate; to ensure that energy in its various forms was produced and used in the most economic, efficient and reliable manner; to reduce dependence on imported energy; and to ensure a balance between adverse environmental effects of energy developments and their benefits. The guidelines covered efficient production, distribution and consumption of energy, and the promotion of public understanding and acceptance of the need therefor.

B. ENERGY RESOURCES

To ensure the long-term adequacy and stability of energy supplies, New Zealand was attempting to diversify the development of its indigenous resources so that if a shortfall occurred in one resource another could be substituted.

Coal was the largest known fossil fuel resource. In 1976 an extensive programme launched to prove further reserves of coal achieved considerable success in two areas, including a new discovery of at least 2,000 million tons of lignite.

Exploration for oil, both on shore and off shore, had continued, although no commercial discoveries had as yet been made. Development of the substantial natural gas reserves was continuing.

There was great potential for further development of hydroelectricity, and, along with investigation into larger hydro schemes, the potential for small hydro stations was being studied.

The increasing cost of other energy resources, together with technological advances, was also making it economic to tap less readily available geothermal resources. Geothermal drilling was being increased and the associated scientific investigations and geophysical exploration stepped up.

In 1976 the possibility of a nuclear power station was considered, but a Royal Commission which conducted on enquiry into nuclear power generation concluded that there was no requirement for a few years.

Investigations to determine the viability of other energy sources such as solar, wind, biomass and energy from wastes were continuing. With its agriculture-based economy New Zealand was particularly well placed to develop the biomass option as a source of liquid fuels.

C. ECONOMIC AND EFFICIENT USE

The most significant step taken towards more efficient use of energy was the introduction in 1976 of an energy pricing policy, designed to encourage conservation of all forms of energy and, by setting a margin between imported oil and indigenous resources, to encourage the use of indigenous fuels in place of oil. Earlier pricing and tax measures included a graduated sales tax on cars, a depreciation limit for company cars, petrol price and tax increases, and the removal of certain petrol tax rebates.

1975/76 saw the introduction of a home insulation loan scheme, with interest-free loans for home insulation and a minimum thermal insulation requirement for new residential buildings, the launching of an extensive energy conservation publicity campaign, the establishment of a free energy advisory service for industry, the introduction of a tax incentive scheme for capital expenditure on plant using indigenous fuels other than electricity or oil, and interest-free loans for domestic gas-burning equipment. There were further increases in bulk electricity supply tariffs and the sales tax on petroleum products. The sales tax on air-conditioning units and domestic clothes driers was also increased.

In 1978 the industrial tax incentive scheme was widened to cover equipment for generating electricity from heat otherwise wasted during processes using indigenous fuels. A grant scheme to assist small firms with the investigation and design of energy conservation projects was also announced. Interest-free loans were made available for domestic solar water heaters.

D. REDUCING DEPENDENCE ON OIL

Many of the measures described above led to considerable savings in imported fuels, through both improved efficiency of energy use and the use of indigenous fuels in place of oil. A 240 MW oil-fired power station was currently under construction but no further exclusively oil-fuelled stations would be built.

The transport system was identified as a pressing problem. Earlier policy initiatives had been designed to reduce petroleum consumption through higher prices and by shifting consumer buying towards smaller, more efficient cars. More recent measures were aimed at encouraging the development and use of indigenous transport fuels. Investigations and feasibility studies were being carried out on a 15 per cent methanol/85 per cent petrol blend for cars, and the Government had decided to proceed with design work for a plant to produce methanol from natural gas. Other options included synthetic gasoline, the large-scale use of compressed natural gas (for which incentives had been announced recently), and in the longer term the use of wood or coal as feedstock for liquid fuel production.

E. ENVIRONMENTAL ASPECTS

While the planned development of any indigenous resource often created some kind of conflict as regards social, environmental and safety issues, in New Zealand problems were generally resolved through the appropriate Acts in force.

Before work began on any energy-related project, the department concerned consulted with the Commission for the Environment, and produced an environmental impact report. Members of the public were able to send in submissions at that stage.

In addition, development schemes must comply with statutory requirements of the Water and Soil Conservation Act and the Town and Country Planning Act. The Town and Country Planning Act had been revised in 1977 and considerable work was being done on the Water and Soil Act to achieve a closer integration of the procedures.

NATIONAL ENERGY DEVELOPMENT PLAN

(NR.5/CRP.12)*

by

Philippines

A. THE ENERGY PROBLEM, NATURE AND SOLUTION

Philippine development had evolved with an energy base characterized by rapid growth in energy consumption relative to national output and extreme dependence on imported energy in the form of oil. By 1972, the oil dependency ratio was 93 per cent compared to 87 per cent in 1960. The potential vulnerability of the economy arising from the situation did not receive attention until 1973 when, faced by an impending global oil crisis, national efforts were directed toward the solution of what had now become the national energy problem.

In 1973, a National Energy Plan outlined the initial work scheme and issues for resolution in response to the problem. The plan contained three basic strategies: the indication of the necessary institutional arrangements for national energy management; a short-term work programme calling for accelerated indigenous energy resource exploration, import supply assurance, stockpiling, fuel allocation, pricing mechanisms, and conservation; and long-term measures essentially involving the development of domestic alternative energy sources with emphasis on renewable forms. Substantial aspects of these strategies were implemented, but the power expansion programme experienced some lag relative to target incremental capacity.

B. THE NATIONAL ENERGY POLICY

The current energy programme represented an evolution in approach over the National Energy Plan of 1973, with an expanded scope. The basic goals and strategy were refined, but remained essentially the same.

The design and implementation of specific policies and programmes pursuant to the general objective would be effected within the following guidelines:

(a) Development goals required not only stability in the growth of energy supply but also equity in energy distribution within the country, aligned with areas identified as priority for social and economic reasons;

(b) The interactive nature of energy across all areas of economic activity highlighted the need to provide an energy dimension in all sectoral planning endeavours and to co-ordinate those endeavours through an effective institutional framework;

(c) Economic policies and other control mechanisms had to be implemented in a manner consonant with the output and productivity goals of the economy as well as with the general resource efficiency ideal;

(d) The role of the Government was primarily catalytic and pioneering in nature. With the exception of power utilities, private sector participation in the programme would be encouraged;

(e) The need for establishment of a strong domestic base of technical expertise was recognized and would be pursued through proper schemes in energy research and development;

(f) All the energy activities had to conform with the ecological and environmental goals set, within politically and scientifically acceptable limits.

C. THE STRATEGIC APPROACH

Supply adequacy, stability and security implied a substantial restructuring of the energy-source profile, both in terms of energy forms and geographic origins, and logically pointed to the development of the domestic energy base. There was also need for control of the growth rate of aggregate demand and restructuring of the demand components toward economically competitive forms and indigenously available energy sources.

* Abridged. Information given in the paper entitled "Ten-year energy development programme, 1978–1987", included in part one of these proceedings, is not reproduced here.

Economic policies and legislation, selective investment participation, and national energy planning and co-ordination would be the main thrusts of government involvement in the national energy programme. Direct controls and restrictions would be applied only when all other policy variables had been exhaustively applied.

The demand management of energy consisted of appropriate economic policies, the development of the market for domestically available non-oil energy sources and an extensive information campaign to lay down energy guidelines for planning activities and awareness of conservation needs and principles.

Until a significant development in both the market for, and the supply of, indigenously based energy sources was attained, the importance of a steady supply of oil would continue to be emphasized. In that respect, the diversification of foreign sources, the maintenance of a strategic reserve position, and participation in international emergency sharing agreements would be the main elements of short-term government oil supply policy.

Exploration and development of indigenous energy sources would be further accelerated through improvements in contractual schemes and provision of incentives in accordance with changing economic conditions. Direct government participation would be made only in selected areas. Import of non-oil energy forms would be made where a clear deficiency in supply was evident. Such import, while based on economic grounds, was not to prejudice domestic production.

The total investment requirement of the 10-year energy development programme was estimated to be $13,600 million (1978 prices), of which at least 63 per cent would be financed by foreign sources. Of the total investment, 73 per cent would be allocated to power development and electrification; the remaining 27 per cent would be channelled into field exploration and development, non-conventional energy research and downstream expansion programmes, an area where the private sector would be the principal participants.

D. POWER DEVELOPMENT PROGRAMME

Recorded aggregate installed generating capacity as at 1977 stood at 3,084 MW, providing support to industry, agriculture and commerce, and serving an estimated 35 per cent of total households. The low level of service coverage was even more critical when the quantity, quality and cost disparities among the three power regions of the country were considered.

The power sector consisted of over 800 public and private utilities, the majority of which either owned and operated generating units of less than 10 MW capacity or purchased and distributed power for base load requirements from the National Power Corporation. Following the transfer of the Manila Electric Company facilities and the recent completion of some major projects, the corporation currently operated 14 hydroelectric plants, 8 thermal plants and 7 diesel plants with a total installed capacity of 2,706 MW, accounting for 88 per cent of total capacity. The National Electrification Administration, whose main function was distribution and co-operative management, had an installed capacity of 133 MW. Small private utilities and municipal systems provided power in isolated areas not covered by the presently developed grid networks.

The principal aim of the power development programme was the total electrification of the country by 1990, and over the period 1978 to 1987 incremental generating capacity of 6,518 MW was programmed. Implied in the growth capacity was the extension of electric services to the rural sector to support small-scale industries and agricultural activities. Electricity coverage would extend to 85 per cent of households by 1987. Concomitant with the energy source diversification goal, the energy source mix of the sector would be transformed from an existing 20 per cent non-oil share to 63 per cent in 1987.

An appropriate policy scheme would be developed to encourage electricity use among the rural populace and promote regional dispersal of industries in priority areas. Medium and small-scale industrial operations in the rural areas would be matched with rural electrification. The pricing policy, however, assumed the minimum level to recover production costs.

Distribution systems would gradually be phased out from the private sector to a nation-wide system of electric co-operatives. Generation, however, lay in the domain of the Government, with private sector participation limited to areas where it did not prejudice integrated development through the grid system.

E. FIELD EXPLORATION AND DEVELOPMENT

The 10-year programme for oil exploration envisioned the drilling by private parties, with appropriate contractual arrangements, of at least 208 exploratory wells, of which 117 would be located off shore and 91 on shore. Related activities would include geological and geographical seismic surveys and basin studies specifically concentrated on frontier areas. The commencement of commercial petroleum production was expected in the early part of 1979.

Seven main coal areas were expected to supply domestic requirements over the 10-year period, and, by 1987, coal production was expected to reach 5.4 million tons.

There were currently 25 potential areas for geothermal development, of which 5 priority areas would be utilized for power generation. The programme required a minimum 10-year target of 400 exploratory and development wells (305 production and 95 reinjection wells) with average depths of 4,000 feet. Physical requirements included the installation of some 500 km of steam ducts and piping, and the commissioning of rigs, which would increase in number from 7 in 1978 to 10 in 1979.

Water resources development would consider the competing demands of power generation, irrigation, domestic, municipal, industrial, fisheries, and other purposes. In addition to the facilities under the development programme, small-scale generation stations were also expected to be developed.

Uranium exploration would be done on a nation-wide scale through borne radiometric and magnetic surveys, followed by supporting ground radiometric, geologic and geochemical surveys. Large-scale uranium recovery was programmed in the near future from the Larap mines in Camarines Norte, to supply a portion of the fuel requirement of Nuclear Power Plant I.

F. NON-CONVENTIONAL ENERGY PROGRAMME

Compared to the other components of the programmed development of domestic energy resources, the near-term contribution of the non-conventional energy programme might appear minimal, but had profound significance. Primarily, the programme provided a suitable area for the needs of localized energy, a problem arising from the geographically dispersed characteristic of the rural population. Furthermore, the rural areas possessed an abundance of biomass material in the form of agricultural crops and animal wastes, in addition to intense insolation and strong wind velocities.

The main thrust would be the adaptation and innovation of already available or relatively well-developed technologies. Of special interest were projects to use marsh gas, to obtain ethanol from sugar-cane, and to grow plantations of the fast-growing ipil-ipil tree.

ENERGY RESOURCES DEVELOPMENT AND MANAGEMENT IN THE REPUBLIC OF KOREA

(NR.5/CRP.2)*

by

The Republic of Korea

A. CURRENT ENERGY SITUATION

The GNP and consumption of energy had been growing rapidly during the last decade, and this was expected to continue, with an annual increase in energy consumption of about 10 per cent.

Since the second session of the Committee in 1975, the energy development policy had been oriented mainly toward the positive augmentation of nuclear power generation, the possibilities of increasing domestic coal production from lower levels, and other possible solutions, to decrease the dependence on imported crude oil.

* Abridged. Information given in the paper entitled "Energy programme in the Republic of Korea", included in part one of these proceedings, is not reproduced here.

A definite decision was made by the Government at the beginning of 1978 to develop and industrialize the technology of utilizing solar energy, particularly solar heating. The government had also been conducting prefeasibility studies of tidal power plant for several prospective locations.

Nevertheless, it was likely that the national dependence on imported oil would increase as the size of the economy expanded.

B. ELECTRICITY SUPPLY

The total provisional capacity of power generation (including 11.4 per cent reserve capacity) was 5,790 MW at the end of 1977. The component ratios were 12.3 per cent for hydropower and 87.7 per cent for thermal-power generation (of which 75.6 per cent was oil-fired).

In 1978, seven power plants had been completed, comprising the first nuclear power unit of 587 MW, 4 thermal power units, and 2 hydropower units. In 1979, completion of 7 thermal power plants and one hydropower plant was planned. New power plants would be added in 1980 and 1981, augmenting total capacity to 10,000 MW, and the component ratio would then be 12.0 per cent for hydropower (including pumped-storage), 82.2 per cent thermal power (71.3 per cent oil-fired), and 5.8 per cent nuclear power.

By 1991, total capacity was planned to reach 31,000 MW, comprising 15 per cent hydropower, 41 per cent thermal power and 44 per cent nuclear power.

Energy generation from the various components in 1977 was hydropower 5.2 per cent, oil-fired 79.5 per cent, coal-fired 15.0 per cent and nuclear 0.3 per cent. By 1981, the figures would become hydropower 5.2 per cent, oil-fired 75.8 per cent, coal-fired 11.3 per cent and nuclear 7.7 per cent. Consumption by categories in 1977 was mining and manufacturing 71.9 per cent, commercial 15.4 per cent, domestic 12.1 per cent and other 0.6 per cent. By 1981, mining and manufacturing usage was expected to increase to 73.9 per cent, and commercial usage to decline to 12.0 per cent.

The 354 kV transmission system was to be extended, replacing the 154 kV system, and the total length of 354 kV circuits was planned to increase from 821 km in 1977 to 4,851 km by 1987. It was also planned to increase the voltage for distribution from 110 V to 220 V.

C. NON-CONVENTIONAL ENERGY RESOURCES

In developing non-conventional energy resources, efforts had been and would be focused on the utilization of solar energy, tidal energy, mini hydropower and wind energy.

1. Solar energy

Under the guidance of the Solar Energy Research Institute, established early in 1978, long-range projects were under way as follows:

Period	*Projects*
1978–1981	Production of a home-made collector, establishment of a basic research team for standardization, and promotion of solar houses.
1982–1986	Popularization of solar heating systems, development of a solar battery, and development of new materials for collectors.
1987–1991	Development of a total system for solar-heat electricity generation.
1992–2000	Test operation of the solar-heat electricity generation system.

2. Tidal energy

Along the west coast the difference of tidal heights was unusually great, and the shore line was long and complicated. Pre-feasibility studies were carried out for tidal power schemes in three locations, the results indicating a possible capacity of several thousand megawatts. It was planned to construct a tidal power plant of 400 MW by 1986.

3. Mini hydropower generation

In March 1978, a model for mini hydropower generation was built in Kangwon Province, with a capacity of 450 KW. There were about 300 prospective sites, and development would be beneficial in many respects.

4. Wind energy

Following preliminary studies in 1974 and test of a prototype, 12 wind-power generators of 3.5 kW were installed to supply electric lighting, and 183 smaller units were in service for communication equipment. It was planned to develop a 10 kW wind-power generator.

D. IMPROVEMENTS IN CONSERVATION AND EFFICIENCY IN THE PRODUCTION AND USE OF ENERGY

The main points of the plans to increase efficiency in the use of energy are summarized below.

Summary plan for energy saving

Sector	*Plans*
Domestic	Improvement of the conventional hypocaust heating system.
	Popularization of the use of insulating materials.
	Development of fuel-saving structures for buildings.
Industrial	Positive heat control in large energy consuming industries.
	Development of energy-saving processes and/or facilities.
Transportation	Maximization of energy efficiency in use of automobiles.
	Public information and education for drivers.
Energy Supply	Gradual establishment of total energy systems.
	Utilization of industrial waste heat.

E. DEVELOPMENT AND MANAGEMENT OF ENERGY RESOURCES

In planning for the development of resources, nuclear power generation was the most likely replacement for thermal power generation. It was therefore necessary to develop the relevant technologies in the shortest possible time.

In view of the possibility that the world-wide demand for electricity supply from nuclear power would increase substantially, causing problems in uranium supply, it was suggested that a co-operative system was required at the international level to assist and control uranium supply for peaceful purposes.

ENERGY IN THAILAND

(NR.5/17)*

by

Thailand

A. ELECTRICITY SUPPLY

1. Organization

Thailand's electricity industry comprised three state enterprises classified according to their activities. The Electricity Generating Authority of Thailand (EGAT) was responsible for electricity generation and transmission. The Metropolitan Electricity Authority (MEA) was responsible for electricity distribution in the capital city of Bangkok and the surrounding metropolitan area which had a population of 5.4 million. The Provincial Electricity Authority (PEA) distributed electricity to the remainder of the country, serving a population of 37 million. Besides purchasing electricity from EGAT, in 1977 PEA owned and operated 308 small diesel plants which were used to serve areas not yet within reach of transmission grids. Apart from the three main authorities, there were still a few small privately-owned plants, which were in the process of being transferred to PEA.

EGAT's system was divided into four regions: the central, north-eastern, and northern parts, interconnected by 230 kV and 115 kV transmission lines, and the southern part which was isolated from the others but was expected to be connected to the central region by 1980 at 115 kV.

In addition to the enterprises mentioned above, the National Energy Administration (NEA), a government agency, was also involved in the power sector, working as the secretariat for the National Energy Board and the Electric Power Development Policy Committee, which served as an advisory council to the Prime Minister in the field of energy planning and policy-making.

* Abridged. Information given in the paper entitled "Energy planning and programming, Thailand", included in part one of these proceedings, is not reproduced here.

2. Installed capacity

In 1977, the total installed generating capacity of the EGAT system was approximately 2,437 MW, consisting of 7 hydro plants (909 MW), 5 thermal plants, oil-fired and lignite-fired (1,334 MW), 55 gas turbine plants (165 MW), and 4 diesel plants (29 MW).

The PEA had a total of 868 diesel power plants with an aggregate capacity of 87 MW.

The NEA was responsible for one hydroelectric plant at Mae Hong Son with a capacity of 1 MW.

The nominal frequency for all plants was 50 Hertz.

3. Transmission and distribution system

The EGAT transmission voltages were standardized at 230 kV and 115 kV. The total transmission line length was 8,439 circuit km, and there were about 89 transmission substations with aggregate installed transformer capacity of about 4,098 MVA.

Subtransmission voltages used by MEA for predominantly overhead multi-feed and interconnected radial supply from 5 terminal stations to 67 distribution substations were 115 kV and 69 kV. Primary distribution voltage for predominantly overhead supply from distribution substations comprised a 12 kV system in inner areas and a 24 kV system in outer areas.

The PEA normally used 22 kV and 33 kV overhead lines for its primary distribution system, but had some 11 kV distribution systems in provincial cities, and some 3.5 kV systems in isolated and remote areas. Total line length was about 14,000 circuit km.

4. Electricity generation and distribution

During the past 10 years, electricity generation in Thailand had increased fivefold with an annual rate of increase of about 19 per cent. In 1977, the peak demand was about 1,953 MW while the total internal generation was 11,173 million kWh. The hydro plants accounted for 29.2 per cent of generation, the thermal plants for 68.4 per cent, small diesel plants and gas turbine peaking units for 2.4 per cent. A further 171 million kWh came from the Lao People's Democratic Republic.

Of the total sales in 1977, 61.2 per cent was sold by MEA, corresponding to a consumption *per capita* of 1,041 kWh in the metropolitan area, compared with 102 kWh *per capita* in the remainder of the country.

5. Forecasting

The method to project the electricity demand on a macro level was to take the economic variables of population, GDP of the economic sector and average rate of growth of each category of service and find the relationships by linear regression. On that basis the maximum demand by 1987 would be 4,040 MW.

6. Future plan for electricity expansion

A large construction programme, involving generation, transmission, and distribution, had been planned for the next five years, including accelerated rural electrification.

Future fuel sources of power generation in Thailand included natural gas and nuclear fuel. A gas-fired thermal plant was planned to be in service in about three years. The project to construct a 600 MW nuclear power plant had not yet been approved owing to escalating investment costs and some degree of unpopularity.

7. Tariff policy

In 1974, the average tariff was abruptly increased by 20.8 per cent and the Government also provided subsidies to the utilities. In 1975, PEA residential tariffs were reduced in order to make them comparable with MEA residential rates, while industrial rates were increased by 16.8 per cent. In 1977, the Government allowed the electricity utilities to increase their tariffs by 30 per cent, and the government subsidies were eliminated.

B. NON-CONVENTIONAL ENERGY RESOURCES

There were three major non-conventional energy resources in Thailand, solar, wind, and biogas, which were worth further investigation and development.

The National Energy Administration proposed a five-year programme in 1976, which was approved, but the personnel and technical assistance requested for the effective development and implementation of the programme was not yet available. The main activities in the programme included the setting up of 26 solar radiation measuring stations, compilation of existing wind speed data, assessment of potential biogas energy, and a sampling field survey of a typical village to determine energy demand, existing sources of energy, its utilization, and relevant information needed in concocting a rural energy development plan.

Associated research and development proposed included priority listing of activities in each of the sectors. Other aspects to be covered were the setting up of regional centres to train local development and extension workers in known and proved technology and to educate and assist rural people in the application of new energy technology. Technical assistance would also be provided to potential manufacturers, entrepreneurs, and interested individuals.

In the meantime, traditional small-scale utilization continued, including wooden windmills with two or four blades, mat sails or cloth sails for low lift water pumping, multiblade steel windmills for deep well water pumping, solar water heaters for domestic and commercial uses, batch-type solar driers for agricultural products, and about 200 biogas plants. There were currently 56 solar energy projects, 10 wind energy projects, and 6 biogas energy projects being carried out by various universities, research institutions, government agencies, and the private sector.

C. IMPROVEMENTS IN CONSERVATION AND EFFICIENCY IN THE PRODUCTION AND USE OF ENERGY

The Government had established several committees and working groups to solve various energy problems in the country, and the Prime Minister had been given special power to impose emergency decrees relating to energy. Some activities, measures and plans for energy conservation and efficient use had been implemented, and there had also been some good efforts in the private sector.

1. Government action

Emergency decrees which had been imposed included cutting down oil and electric power consumption in governmental use by 10 per cent, limiting the size of new government automobile engines used for general purposes to 1,300 cc, closing all gasoline stations in the Greater Bangkok area during the night, turning off neon advertising signs after 2200 hours, and closing television stations at midnight.

Other active projects included the promotion of a campaign on energy conservation, and encouraging energy-saving programmes in industrial plants.

2. Transportation

Measures implemented included construction of flyovers at busy intersections, and pedestrian bridges, increase of tax on gasoline and increased registration charges for large cars, and those approved included reduction of speed limits for vehicles on highways and insistence on enforcement, and staggering of the opening time of government agencies and educational institutions. Improvements to the mass transit system and waterways, and reorganization of road haulage arrangements were being investigated.

3. Private sector

Two examples of efforts in the private sector follow.

The Ajinomoto Co. (Thailand) Ltd. had had its own energy control committee since 1973. The initial objective of the committee was to find ways and means which could easily and promptly be applicable to reduce energy use, mainly in the form of steam. By 1977 the steam consumption had been reduced by 20 per cent, mainly through savings in operation heat loss and machine heat loss. The goal was then raised to 35 per cent, and further investment was authorized in anticipation of recovering the investment costs within about two years.

The Firestone Co. (Thailand) won second place for the 1977 energy conservation contest among the international Firestone companies. Compared to 1972, their rubber and tire products for 1977 increased by 50 per cent while fuel oil consumption decreased by 12.5 per cent and electricity usage increased by 18.8 per cent.

THE EXPERIENCE IN USING LOW-GRADE FUELS FOR ELECTRIC POWER GENERATION IN THE USSR

(NR.5/11)*

by

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INTRODUCTION

From the very early days of the Soviet State great attention had been paid to the electric power industry. The first long-term plan was the State Plan for the Electrification of Russia (GOELRO) adopted in 1920, which included power stations using low-grade fuels: brown coal, anthracite slack and peat. The total installed capacity and electric energy production are illustrated in table 1.

In 1976 the share of the steam power stations using solid fuels was about 50 per cent of total production, and about 35 per cent of total production was generated making use of low-grade fuels: brown coals and some of the bituminous coals, anthracite slack, oil shale, and peat. Unit sizes ranged up to 500 MW, and station sizes ranged up to 2,500 MW on coal, 1,610 MW on oil shale and 600 MW on peat.

* Abridged.

Table 1. Electricity production 1921 to 1977

	1921	*1940*	*1950*	*1960*	*1970*	*1975*	*1977 (plan)*
Installed capacity (10^3 MW) . .	1.2	11.2	19.6	66.7 .	166.2	217.5	240
Electricity production (10^9 kWh) .	0.5	48.3	91.2	292.3	740.9	1,038.6	1,160

A. PROPERTIES OF LOW-GRADE FUELS

1. Moscow region brown coal

This was a dense, medium-rank brown coal. Average moisture content was 32 per cent, but could reach 45 per cent, depending on ash content, the moisture content decreasing as ash content increased. Ash content varied from 25 per cent to 45 per cent, and had a high fusing point. Heat value was 2,490 kcal/kg, and sulphur content from 2.0 per cent to 8.0 per cent.

2. Brown coals of the Kansk-Achinsk field

These coals fell into the category of meagre, humic, medium-rank coals. A high moisture content was typical, sometimes reaching 44 per cent, but ash and sulphur content was low. Heat value was above 3,000 kcal/kg.

3. Ural brown coals

These were medium-rank coals, with moderate moisture content, 16 per cent to 29 per cent, high ash content, up to 42 per cent, and heat value of 2,380 kcal/kg to 3,400 kcal/kg. The ash had relatively low softening and fusion temperatures.

4. Far East brown coals

The largest deposits were mainly dense, medium-carbonization coals. In the open these coals would readily loss moisture, crack and disintegrate to form smalls; stored in piles they were inclined to spontaneous ignition.

5. Central Asia brown coals

The coals were high in moisture, 34.5 per cent, and ash, 20 per cent; the heat value of the coals was 3,300 kcal/kg.

6. Ekibastuz high-ash bituminous coals

The field was unique in coal accumulation density and in the thickness of coal beds distinguished by a rather complex structure, coal seams chaotically alternating with carbon shales and rock. The coals were high in ash, with content ranging from 35 per cent to 55 per cent. The content of sulphur was low, 0.8 per cent, and heat value was on average of 4,000 kcal/kg. The high-fusing ash was very abrasive.

7. Coking coals concentration rejects

Basic properties varied within a wide range depending on the qualities of the original coals.

8. Anthracite slack

The fuel consisted of smalls obtained during production and concentration of anthracite, which was a high-rank fuel. Ash had a low fusing point.

9. Oil shales

The power industry made use of Kashpirsk oil shales with a low heat value, 1,390 kcal/kg, and Estonian oil shales with heat value averaging 2,230 kcal/kg.

10. Peat

For pulverized combustion, both moss and valley peats were used, their decomposition ranging from 20 per cent to more than 35 per cent.

B. FUEL PREPARATION FOR COMBUSTION

Four models of pulverizing mills were in use; ball-tube mills, hammer mills, roller mills and beater wheel mills.

All the models under consideration combined coal grinding with drying, for which purpose the milling space was ventilated by hot air (up to 400°C), or flue gas extracted from the furnace (800-900°C) or the boiler (300-500°C).

Ball-tube ventilated mills were used for hard and abrasive fuels, and processed about 48 per cent of fuel used in the power industry. Balls were mainly 40 mm diameter, of Brinell hardness 300 to 400. The tube had a cylindrical form, and was designed for vacuum operation only. Sizes ranged from 4 tons/hour to 50 tons/hour.

Hammer mills accounted for 50 per cent of fuel consumed by power installations, and were used for processing milled peat, lignite, brown and bituminous coals as well as oil shales. There were axial and tangential hammer mills, depending on the gas/air mixture supply techniques. The capacity of the tangential mills, which were preferably used, was 3 tons/hour to 100 tons/hour. Air was generally used for fuel drying.

Roller mills had found limited use as yet, being confined essentially to dry bituminous coals, and accounting for about 1.2 per cent of fuel. The commercially produced roller mills were of 4 tons/hour to 16 tons/hour capacity.

Beater wheel mills had not been used until recently, and had not yet gained wide acceptance, but in the coming years much more extensive use of these mills was anticipated, particularly for high moisture content brown coals, using furnace gas up to 900°C as a drying agent. Models of 3.6 tons/hour to 60 tons/hour capacities were being manufactured.

All the mill models were equipped with natural draft separators. In the ball-tube mills, 2 m to 5.5 m centrifugal separators were employed, depending on the mill capacity. Pulverization fineness was controlled by a separator adjustable flap. Roller mills used separators of similar design installed on the mill body. Hammer mills used gravitational, inertial or centrifugal separators, while beater mills used inertial separators.

The power stations, as a rule, employed individual direct-fired, closed pulverizing systems or pulverized coal storage systems, the waste drying agent being fed into the furnace of the boiler. Open pulverized systems, where the drying agent was discharged into the atmosphere or into the gas duct before the draft fan, were being tested. In all cases, the individual pulverizing systems were arranged near the boiler unit and were interconnected by air and gas ducts.

C. BOILER INSTALLATIONS

Industry had gained great experience in manufacturing boiler equipment of various outputs.

1. Boilers for Moscow region brown coal

These boilers had a rated output of 50 tons/hour to 950 tons/hour. With few exceptions, the pulverized systems were direct-fired air drying and hammer mill based systems. Use was made of dry-bottom furnaces only. Irrespective of high average ash initial melting temperatures, slagging of wall tubes might occur but could be successfully eliminated by steam blowing. The boiler units of small output employed simple slot-type burners, each connected to one mill, while the larger boiler installations were equipped with slot-type burners of two-tier front or oppositely displaced arrangement. Efficiency of the larger boilers was up to 91 per cent.

2. Boilers for Kansk-Achinsk brown coal

Output varied from 75 tons/hour to 1,650 tons/hour, for 150 MW to 500 MW power units. Hammer mills and wet-bottom furnaces were used. The brown coals were highly slagging and, when fired, stubborn deposits of fly ash were formed on the heating surfaces.

3. Boilers for Ural brown coal

The 640 tons/hour boilers were analogous to those adopted for firing Moscow region coals. The ash had a low fusing point. The pulverizing systems were mostly direct-fired with air drying and hammer mills which were generally arranged on the front side of the boilers, and were equipped with inertial separators. The coals were fired in dry-bottom furnaces, and the burners were mostly of front single-tier or double-tier arrangement. The low ash fusion temperature with one-side burner arrangement led to slagging of the opposite furnace walls which necessitated steam blowing.

4. Boilers for high-ash bituminous Ekibastuz coal

The output was 75 tons/hour to 1,650 tons/hour. The main feature of such coal was high ash content, up to 50 per cent, as well as high ash initial melting temperature. Ekibastuz coals were fired in dry-bottom furnaces only. The efficiency of the boilers was 92 per cent.

5. Boilers operated on wet concentration rejects of coking coals

Such fuel required special technical solutions in designing boiler units. Taking into account the varying properties of the concentration rejects supplied, the boiler units utilized reduced gas velocity in the gas ducts, pulverized coal-storage systems and ball-tube mills, with air or gas air mixture predrying of the coal, opposite swirl double-tier burners and dry-bottom furnaces. Maximum capacity was 640 tons/hour (200 MW units).

6. Anthracite slack boilers

The anthracite slack ash had a low fusion temperature and contained a large amount of alkalies which, after being sublimated in the flame, condensed on the heating surfaces and fly ash. To make firing more efficient, wet-bottom furnaces were used with a high flame temperature in the active zone. For this purpose use was also made of extended, lined stud wall tubes, swirl burners with extended surface for air ignition and with intense hot air suction and increased air preheating. The boilers used pulverized coal storage systems and ball-tube mills.

7. Boilers designed for firing Estonian shales

Firing of shales required a number of special technical solutions. This fuel, irrespective of moisture and ash content, had high reactivity, and firing as such presented no difficulties. However, the shale ash was unfavourable in that some components melted at lower temperatures than usual and were deposited on the heating surfaces in the furnace and in the convective gas ducts. Therefore, Estonian shales were fired in dry-bottom furnaces at moderate furnace section combustion rates. Preparation of shales for firing was carried out in individual direct-fired pulverized systems and hammer mills. Boiler output was 75 tons/hour to 320 tons/hour, and equipment included steam and water blowing and vibration cleaning of heating surfaces.

8. Milled peat boilers

The fuel was characterized by sharply varying moisture content and large inclusions of wood and grass, which required special measures. The milled peat was disintegrated in individual direct-fired pulverized systems, in hammer mills or beater wheel mills and dried with hot air or furnace gases. The main difficulties in firing milled peat were poor stability of combustion with increased moisture content and lower reliability of operation of firing equipment owing to slagging when dry fuels were used. To increase stability of combustion of wet fuel, provision was made for addition of fuel oil, whereas when dry milled peat was used it was wetted to prevent early ignition. The size of boilers ranged from 50 tons/hour to 320 tons/hour.

9. Boilers for other countries

Boiler units had been supplied to other countries to be operated on low-grade fuels.

Twelve 220 tons/hour boiler units were shipped to India designed for firing lignite with a moisture content of 47 per cent to 62 per cent, an ash content of up to 27 per cent, and heat value of 2,450 kcal/kg. The pulverized system was individual, direct-fired with gas air drying and four hammer mills with fan-shaped arrangement as viewed from the boiler's front side.

A total of 160 boiler units rated at 250 tons/hour had been developed for Bulgaria, designed for lignite with moisture content of 52.5 per cent, ash content of 40 per cent and heat value of 1,320 kcal/kg. The quality of lignite actually supplied to the power stations varied widely, with moisture content of 51 per cent to 62 per cent, ash content of 24 per cent to 45 per cent and heat value of 1,100 kcal/kg to 1,400 kcal/kg. The lignite was predried in drum gas driers. The lignite contained fibrous matter which was difficult to disintegrate. The pulverizing system was individual, direct-fired, using hammer and beater wheel mills. The furnaces were equipped with slot burners located on the front side (for hammer mills) or in the corners (for beater wheel mills). Heating surfaces required blowing.

Further boiler installations were being shipped to Bulgaria for firing low-grade brown coals.

STATUS AND PROSPECTS OF COAL PRODUCTION AND UTILIZATION IN DEVELOPED AND DEVELOPING COUNTRIES

(Synopsis of NR.5/16)

This report of the Secretary-General was issued as document E/C.7/67 to the Economic and Social Council's Committee on Natural Resources at its fifth session, held at Geneva from 9 to 20 May 1977. It provided a broad assessment of the scope and outlook for increased coal production and utilization, with a view to clarifying the potential role of coal in world energy supplies.

A NOTE ON THE ACTIVITIES OF THE UNCTAD SECRETARIAT WITH RESPECT TO FINANCING REQUIREMENTS IN THE ENERGY SECTOR OF DEVELOPING COUNTRIES

(Synopsis of NR.5/10)

This note by the UNCTAD secretariat stated that a preliminary report had been prepared, covering the analysis of the characteristics of the various kinds of capital required for the development of the energy sector in the developing countries, and a broad assessment of the order of volume of financing needed towards that end in non-OPEC developing countries over the next 25 years. Further work would include study of the relationship between investment requirements in the energy sector, and the level and pattern of development. An over-all report would be submitted to the fifth session of the Conference in 1979.

UNEP AND ENERGY RESOURCES DEVELOPMENT

(Synopsis of NR.5/CRP.9)

In this note, the UNEP Regional Office for Asia and the Pacific stated that UNEP strategy consisted of a study of the environmental impact of all sources of energy, and the relationship between different approaches of energy conservation and environment, and the increase of awareness of policy-makers in the field of energy with regard to the feasibility of utilizing renewable energy sources.

Three panels of international experts had been selected to consider environmental aspects of fossil fuels (April 1978), nuclear energy (November 1978) and renewable sources of energy (March 1979). Two studies had been undertaken on social responses to energy developments. Two experimental centres using solar, wind and biogas energy sources were being established in Sri Lanka and Senegal, and consideration was being given to a third centre in Mexico.

CURRENT AND FUTURE ACTIVITIES OF ECE

(Synopsis of NR.5/9)

This note by the ECE secretariat was an extract from volume II of the annual report of the Economic Commission for Europe to the Economic and Social Council for the period 1 May 1977 to April 1978. The paper listed current and future activities in regard to general energy questions, coal, electric power, gas, nuclear power and non-conventional forms of energy, grouped under headings corresponding to the agenda items of this meeting.

THE ILO AND ENERGY RESOURCES DEVELOPMENT

(Synopsis of NR.5/6)

In its note, the ILO secretariat stated that ILO was more concerned with the impact of technology than its technical details. Studies had been made on the effects of technological choice in Bangladesh, India, Pakistan and Sri Lanka, and reports would be published shortly. Being concerned with poverty in rural areas, ILO was particularly interested in non-conventional energy forms as sources of power for rural areas, and proposed to undertake case studies on the utilization of various sources of energy, including animal power, for those areas. Attention was also being paid to training, health and safety.

CURRENT AND FUTURE ACTIVITIES OF FAO IN THE NATURAL RESOURCES FIELD

(Synopsis of NR.5/CRP.11)

The activities in the field of land and water resources development and management described in this note by the FAO secretariat were grouped as follows:

1. Biogas

Work on small-scale biogas production to improve soil fertility through organic recycling included identification of problem areas and a study tour of selected technical personnel to China.

2. Joint use of land and water

Aspects considered included assessment and planning, water development and management, and conservation and reclamation of natural resources. Three training courses were held in 1978, on water management at the farm level, application of remote sensing to agrometeorology, and upland irrigation. Six meetings and/or training courses were planned for 1979, on supplementary irrigation, water lifting devices, relation of field sizes to irrigation and drainage, investment in reclamation projects, ground-water exploration and exploitation, and water management at the farm level. Further plans included study of legal questions.

WORLD METEOROLOGICAL ORGANIZATION ACTIVITIES IN THE FIELD OF RENEWABLE SOURCES OF ENERGY

(Synopsis of NR.5/13)

According to this note by WMO, a number of the priority activities in the WMO programme concerned the collection and processing of meteorological and hydrological data for the design and operation of water resource projects. A report on aspects related to hydrological data for hydropower resources was being prepared, and steps would shortly be taken to initiate activities to assist and offer guidance at the micro hydro level.

An expert meeting was planned for October 1978 to finalize a Technical Note on meteorological aspects of the utilization of solar radiation as an energy source. A meeting was planned for late 1979 to produce a similar Technical Note on utilization of wind.

As part of its normal functions, WMO was able to support limited training activities and provide technical advice.

MAJOR ACTIVITIES IN THE FIELD OF ENERGY

(Synopsis of NR.5/8)

This paper, presented by the Asian Productivity Organization, stated that APO had commenced a major involvement in energy matters in 1976, and since then had rendered over 360 days of consultancy services to five countries. Two seminars, a survey and a symposium had been held, and a further symposium, on energy policies in developing countries, would be held in Thailand in 1979, with ESCAP co-operation.

A four-week training course on energy management had been held in Japan in 1977, and a similar course was planned for November/December 1979.

Three 35 mm filmstrips had been produced. The main one, on energy saving at the plant level, had 142 frames lasting 50 minutes and was in colour with English script and narration.

IEA ENERGY POLICIES FOR THE 1980s

(Synopsis of NR.5/CRP.10)

As stated in this note by the International Energy Agency, the IEA perception of future global energy balances, based on an assumption that the oil consumption in countries without planned economies would rise at an annual average rate of 3.5 per cent, was that sometime during the 1980s the world would enter a period when the physical availability of petroleum supplies would fall short of potential demand levels. However, the level of demand would depend on future rates of economic growth and the success of energy conservation programmes. Advance planning was required because of long lead times for both new oil facilities and other conventional energy facilities, and technical and cost considerations of new energy technologies.

Considering the interdependence of global energy and economic developments, IEA member countries had strengthened the system of regular systematic reviews of each member's energy policy. In addition, principles were adopted on conservation and pricing of commercial energy, and development of non-oil energy sources, with a view to limiting the rate of increase in oil consumption. Oil-exporting developing countries would be encouraged to share in the development of new energy sources, while oil-importing developing countries would be encouraged to reduce their dependence on oil.

IEA had embarked on a programme of energy research and development, to be carried out by member countries, and the testing of demonstration projects in priority areas of high mutual interest, for example, a small geothermal well-head generator (in Mexico).

The Agency was also very concerned with developing a technically sound, global energy data bank. A workshop was planned for December 1978, one of the outputs of which was expected to be a detailed technical compilation of the energy balances for 25 developing countries.

CURRENT AND FUTURE ACTIVITIES OF THE ASIAN INSTITUTE OF TECHNOLOGY IN THE ENERGY FIELD

(Synopsis of NR.5/CRP.4)

by

R. H. B. Exell (Asian Institute of Technology)

AIT had been active in solar energy research since 1973, and outputs had included analysis and a computer model of the solar radiation climate of Thailand, and development of water distillation, solar powered refrigeration and solar drying units, including a low-cost rice drier for farm use in the wet season harvest.

In 1978, the Renewable Energy Resources Information Center was established, operated in liaison with ESCAP. In the first year solar energy would be covered, followed by attention to biofuels, wind and small-scale hydropower.

A new graduate programme in energy technology was being established, covering both practical engineering studies and economics. A laboratory devoted mainly to thermal science experiments and demonstrations would be set up in 1979, and the first enrolment of students would be in January 1980.

INTERNATIONAL ENERGY PROBLEMS

(Synopsis of NR.5/5)

This paper, by the Commission on Asian and Pacific Affairs of the International Chamber of Commerce, stated that ICC fully supported the group objectives and principles for energy policy adopted by the International Energy Agency, and agreed with the conclusion that the world would face a curtailment in the available supply of petroleum in the 1980s.

It stressed the critical need to strengthen the energy policies of all countries, particularly with regard to increasing energy supplies from sources other than oil. It was necessary that domestic energy prices be allowed to rise to a level which would encourage both conservation and development of alternative sources. ICC urged that new consideration be given to expanding and ensuring future international trade in coal and uranium.

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