REPORT OF THE WORKING GROUP

ON

ENERGY POLICY

GOVERNMENT OF INDIA
PLANNING COMMISSION
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CONTENTS

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Energy Policy.

MINISTRY OF ENERGY
(Department of Power)
Shram-Shakti Bhavan,
New Delhi, November 5, 1979.

Dear Shri Rajadhyaksha,

I have pleasure in enclosing the Report of the Working Group on Energy Policy. For me personally, and for all the members of the Group who have participated in the preparation of the Report, it has been a stimulating assignment. The 'energy crunch' is real and it is easy to define the problem, but the answers are many and most of these are yet in the experimental stage and some only in conceptual stage. Energy in one form or another enters practically every single economic activity and its availability and cost would decide the economic future and well-being of the nation. Considerable work is being done on alternate sources of energy all over the world, but it is still uncertain as to the areas where the major breakthroughs will occur and in what period of time, but it is quite certain that in the next two or three decades, patterns of energy generation and consumption will change.

There has been a delay in the submission of the Report but many factors have been responsible for this, the most important of which is the fact that all the members had other full time responsibilities. This may have added to the usefulness of the Report in that the Members have been able to bring to the Group discussions their very different perceptions of the problem and the required solutions.

At your request, a brief note on some preliminary conclusions of the Group was submitted in February 1979. This note had given a demand forecast of energy for the next two decades and had analysed briefly the different energy sectors. Considerable work has been done by the Group since then, but the main conclusions remain valid. The Reference Level Forecast of energy consumption as given in the note have been modified in the case of oil due to a revaluation of the conversion factor for different fractions of oil in terms of coal replacement. During the period the Group was engaged on this Report, the Draft Sixth Plan has undergone some changes and there will be some discrepancies between the figures used by the Group for the year 1982-83 and those given in the revised Draft Sixth Plan. This is particularly so in the case of oil consumption, where the Group has used a lower figure. The Committee on Transport Policy has been reviewing the transport sector in considerable detail and it is understood that the projections of the Committee for the year 2000-01 are lower than assumed by the Group. The Group has not considered it necessary to revise the figures in the Report as it is difficult to be precise about the future forecasts and the main conclusions of the Report would remain valid in either case.

An important factor that emerges from the study is the relative intensity of energy consumption in the economy. The elasticity coefficient of energy to GDP over the period 1953 to 1979 shows a remarkable stability, varying only marginally, around 1.80. Data for other developing countries or for other countries during their development period is not readily available, but the Indian coefficient is substantially higher than the coefficient of most of the industrialised countries, which is less than one. This may be due to a fairly steep 'S' curve during the early phases of industrialisation. It could also be due to the fact that there is an element of substitution of non-commercial energy by commercial energy in the Indian economy.

Another factor that emerges from the study is the even greater elasticity coefficient of electricity to GDP in the Indian economy since 1953. For the period 1953 to 1979 the coefficient works out to 2.7 which is significantly higher than the elasticity coefficient of energy to GDP. This would indicate that the relative share of electricity in total commercial energy consumption has been increasing over time. This is clearly brought out in Table 2.4 of the Report where the share of electricity has gone up from 12.6 per cent to 28.7 per cent while oil has gone up from 39.6 to 47.9 and coal has declined from 47.8 to 23.4 per cent. It is believed that the coefficient might well have been higher but for the recurring power shortages that have been experienced since 1965/66 and more particularly since

1970/71 when the rate of growth of electricity consumption dropped to 6.4 per cent, compared to about 12 per cent for the period 1951—1966. Electricity has been the preferred form of energy consumption and has consistently registered a higher growth rate than even oil, which in other countries has grown at a faster rate. This is probably a reflection of the growth model we have chosen over the years. An aspect of electricity consumption that requires carefull consideration in the Indian context is its increasing use in the agricultural sector and the cushion it provides to agricultural production in the event of a bad monsoon as in the current year.

The areas of energy intensity in the economy may be generally identified. The primary inputs of commercial energy today are some 100 million tonnes of coal and 23.5 million tonnes of oil, both including the quantities used for power generation. To this must be added the electricity generated from hydel and nuclear sources. Out of the 100 million tonnes of coal, some 30 million tonnes (for 1978-79) has been used for power generation, some 24 million tonnes in the steel plants and some 13 million tonnes for transport, practically all of it in the railways. The other sectors of the economy including agriculture, industry other than steel and the domestic sectors have accounted for only 33 million tonnes of coal. In the case of oil, the transport sector accounts for bulk of the consumption amounting to 11 million tonnes and the power sector accounts for about 2 million tonnes. The other sectors of the economy, including industry, agriculture and household sectors account for about 10.5 million tonnes or about 45 per cent of the total consumption for energy uses. This would indicate that the primary fuel inputs into the economy excluding power, steel and transport sectors is around 33 million tonnes of coal and 10.5 million tonnes of oil or a modest 101 million tonnes of coal replacement. Any future energy policy has to take this consumption pattern into account in formulating strategies for conservation of energy, particularly in the steel and transport sectors. These aspects are reflected in the relevant chapters of the Report.

We have a substantial potential for hydro-electric generation in the country of which we have so far exploited only a small fraction. Out of an estimated energy potential of 396 TWH (equal to a power potential of about 100,000 MW at 40 per cent load factor) only some 10 per cent with an installed capacity of approximately 10,000 MW has been developed so far. The energy generation in the last year (1978-79) which has been a good year for hydel generation was a little over 47 TWH. If this amount of energy was to be obtained by thermal generation, it would require the burning of some 30 million tonnes of coal. There has been a severe drought in many parts of the country during the current year but hydel generation is expected to decline only marginally compared to last year and would still represent a saving in coal consumption of some 28 million tonnes. The hydel potential available for development would represent an annual coal 'bonus' of nearly 250 million tonnes. Being a renewable source, the hydel energy that is not utilised any year is lost for ever, whereas the coal that is not burnt is available for the next generation, and we must therefore develop our hydel resources with the greatest sense of urgency. This has an added significance when we realise that this energy is free of all pollution and causes least to environmental and ecological damage.

We have adequate reserves of coal and at present rates of consumption would last a few centuries but at anticipated rates of consumption may last only a few decades. We, therefore, have to plan the use of this valuable resource most optimally. At present, a large percentage goes for power generation, but given the hydel and nuclear resources, and our capabilities for exploiting these resources, we should plan for a lower percentage of thermal generation in the years to come. Another large part goes for transport—in the railway sector—over 13 million tonnes of relatively high quality coal. The same goods could have been hauled by oil at a lower cost even at current prices or at an even lower cost by electric traction and it may be desirable to phase out steam traction at a faster rate than indicated in the Report. Coal, in the years to come, will find its true value not as a fuel but as a reductant in metallurgical industry and as a feed stock for liquid fuels and a wide variety of synthetic products including fertilizers.

The Reference Level Forecast (RLF) for oil demand for the year 2000-01 is 92 million tonnes and the Optimal Level Forecast (OLF) puts it at 69 million tonnes. Indigenous production based on proven and probable reserves is estimated at 24 million tonnes, requiring an import of 68 million tonnes in the case of RLF and 45 million tonnes in the case of OLF. It may be prudent to plan that oil in these quantities is unlikely to be available for import and, even if available, would be at an unacceptable cost to the economy. The gas reserves presently established may sustain a daily production of over 30 million cubic meters of associated and free gas and this is equivalent in terms of oil to a little over 10 million tonnes per annum or about 45 per cent of anticipated oil production. It is likely that additional discoveries would be made and gas would emerge as a valuable resource but would still need to be conserved except for its use as a feed stock. Where associated gas cannot be gainfully utilised as a feed stock, as in some areas of Assam, it may be well worth considering reinjection of the gas into the fields instead of using it as a fuel. Given the limited availability of oil and the certainty that prices will continue to escalate, investment in injection facilities may be attractive. We have probably not funded our oil exploration programmes adequately in the past and given our prognostic reserves of oil and gas, current price trends and availability constraints, a much larger exploration programme is warranted. When oil sells for $ 30 to 40 per barrel, a discovery cost of even $ 5 per barrel can be justified. If only 20 million barrels (some 3 million tonnes) of recoverable reserves were to be established by incurring an expenditure of $ 100 million on exploration, it would be economically justified. Our present exploration expenditure would require only a few million tonnes of recoverable reserves to be established each year but the discovery rate has been significantly better than required on economic criterion with a discovery cost of less than $ 1 per barrel. A substantial step-up in our exploration programme would seem called for.

A peculiar aspect of the Indian energy scene is the substantial share of non-commercial energy. As discussed in the Report, this is likely to be a permanent feature of the economy and all efforts should be made to better manage or commercialise these so called 'non-commercial' and renewable sources of energy so that they can be used more efficiently. Unless the problem is adequately resolved, the energy problem of the rural sector, where it is most critical, is unlikely to be solved and alleviation of rural poverty nearly impossible. While there are many alternatives for meeting the lighting and mechanical energy requirements of the rural sector in the short-term from conventional sources and in the long-term from alternate sources, the energy requirements for cooking would need innovative solutions to be really cost effective.

As indicated in the Report, the power sector is fairly capital intensive and directly accounts for over 20 per cent of all Plan investment in the country. If investments in the fuel sector, including coal and oil and in the nuclear sector were added, the figure would be higher. Coal already accounts for about 30 per cent and oil some 13 per cent of all originating goods traffic in the railway sector. If investment in the transport sector to move these large quantities of fuels were added, the percentage for the entire energy sector including the concomitant investment in the transport sector, may be as high as 40. This may well be one of the reasons why capital output ratios have been going up for each successive plan periods. It is conceivable that a less energy intensive economy, requiring a smaller percentage of total investment in the energy sector may enable the country to achieve a higher economic growth rate.

An important aspect the study brings out is the totally inadequate investment on R&D in the energy sector, with the possible exceptions of oil and atomic energy. Research and development work is being carried out on a broad front in many countries of the world and alternate sources of energy will be the key to survival towards the end of this century. Unless we step up investment on R&D in the other areas of the energy sector, particularly power generation, transmission and distribution and the renewable sources of energy, including solar energy and biomass conversion, we may have to pay a heavy price not only for the technology that would require to be imported but also in terms of rate of growth of the economy as a whole.

These are some of the broad conclusions that emerge from the Report, but the most important conclusion is that energy planning and policy requires to be done on a full time basis, that energy audit should be a part of all investment decision-making and that a Report of this kind is not an 'once and for all time' exercise but needs to be done continually. The Group has, therefore, recommended an Energy Ministry dealing with all these matters and in the alternative that this is not feasible, an Energy Commission. The Group would like to convey a great sense of urgency required in dealing with these problems. Unless early decisions are taken on many of the issues posed in the Report, we may not be able to avoid a far more serious 'energy crunch' than the one we are passing through now when oil, coal and power are all in short supply.

Before concluding, I have to acknowledge the contribution of all the members of the Group to the preparation of the Report and particularly that of Shri T. L. Sankar, Member-Secretary of the Working Group, who has put the whole Report together.

With kind regards,

Yours sincerely,

N. B. PRASAD

Shri V. G. RAJADHYAKSHA
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Planning Commission,
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New Delhi.

CHAPTER I

THE APPROACH

1.1 The Government of India set up a Working Group on Energy Policy in December 1977 with the following terms of reference :

—to estimate the prospective energy demand in the different sectors of the economy and regions of the country by 1982-83 and a decade thereafter;

—to survey the present and prospective supplies of energy;

—to recommend measures for optimum use of available energy resources; and

—to outline the national energy policy for the next five years, fifteen years and the longer term conservation policy.

The composition of the Working Group is given in Annex I.

1.2 The Working Group commenced its work in May 1978, and held in all fourteen meetings. A smaller Sub-Committee of the Group met more frequently. In February, 1979 at the request of the Planning Commission an interim report was submitted to them to be kept in view in their formulation of the Sixth Five Year Plan. The interim report is at Annex II.

1.3 The Working Group considered whether it could limit its consideration to a review of the findings and recommendations of the Report of the Fuel Policy Committee, 1974 or whether a complete re-examination of the energy situation should be made. The Committee took note of the energy policy statement adopted by Government in 1976 after considering the report of the Fuel Policy Committee and the action taken thereon. The Group came to the conclusion that in view of the very steep escalation in oil prices that had taken place since then, and in view of the difficulties experienced in meeting the energy problems since the energy crisis of 1974, it would be useful to make a complete re-examination and reassessment of all the issues. It was also decided to do this with the data and the studies readily available and not to attempt a fresh data generation which would have led to further delays.

1.4 While there is a long tradition of data collection in the country on which the studies of the Working Group are based, the data in relation to consumption patterns and price elasticities are not available in a sufficiently disaggregated form. The procedures of data collection and their processing by the various compiling agencies are also not uniform and comparable. As a consequence, the Working Group had to put in significant effort in updating the comparable energy statistics from where it was left off by the Fuel Policy Committee.

1.5 The Group considered whether the time horizon of consideration should be kept at 15 years as per the terms of reference or a longer time horizon should be adopted. The Group felt that in view of the very long gestation periods of many projects in the energy sector and the fact that the policy decisions taken now would be reflected, at best from the mid-eighties, the horizon should be at least 25 years. For the sake of convenience, it was decided that the period which would be considered would be extended to 2000-01 A.D. Such a time horizon would also enable an overview to be taken on R & D programmes in alternative energy sources and the likely contribution from such sources in the foreseeable future.

1.6 In view of the uncertainties prevailing in respect of various factors which affect the energy sector, the Group has attempted to project a Reference Level Forecast (RLF) of energy demand which would represent the likely level of demand, if no deliberate measures are initiated to correct such growth and has given suggestions which might help in moderating the demand from that level to a more desirable level called the Optimal Level Forecast (OLF). The possible effect of the policy prescriptions have been quantified to some degree. The Group would urge that these numbers be taken as indicative for the sole purpose of policy formulation.

1.7 The Group is aware of the need for interfuel substitution to reduce the dependence of the economy on oil. The possibilities of substituting the use of oil with technologies, known and presently in use, have been taken into account specifically in the OLF projections. The group recognized the possibilities of using substitute fuels like alcohol and producer gas for internal combustion engines associated with transport vehicles and stationary applications. Similarly, the use or electricity to replace oil in the transport sector through more intensive electrification of railways, development of battery powered vehicles and introduction of electric trolley buses for intracity transportation were broadly considered. Considerable work is required to develop and adapt these technologies. As such, their impact on the future energy scene has not been quantified.

1.8 The exploration for oil and gas presently in progress does indicate the possibilities of finding substantially larger resources of gas and this has brought about an optimism in the prospects for utilising gas. Suggestions are being made that gas should be made available for power generation and use as fuel. The Working Group has not considered it necessary to change the present policy of confining the use of gas as feed-stock for fertilizer and petro-chemical industries on the basis of the presently known data.

1.9 The terms of reference of the Working Group required examination of the energy sector in the various regions of the country. The data regarding the use of various forms of energy except electricity in the various States/Regions of the country is not available. As such, a region-wise analysis of energy consumption trends was not immediately possible. While the differences in the pattern and levels of energy consumption in the different regions is recognised, the Group felt that they would not materially affect the overall policy implications. As such, a regional study has not been attempted.

1.10 The studies of the Working Group towards the formulation of a viable energy policy were influenced by two major factors. The studies had to be conducted in the context of rapidly changing conditions in the international oil market. The steep and frequent increases in oil prices and suddent supply interruptions have undermined the reliability of the findings of some of the studies on global energy and questioned some of the assumptions being made on economic growth proposals.

1.11 Reliable forecasts regarding international trade in goods in general and energy in particular were not available. The economic issues involving costs and prices of energy inputs were, therefore, confined to anticipated trends in the Indian context. Secondly, within the country, the perspective of economic development set out in the Fifth Five-Year Plan had not been revised and no co ordinated growth perspective upto the year 2000 was available which could be used as the basis for deriving the energy demand forecast. The Group, therefore, had to make certain assumptions regarding economic growth, population growth and pattern of development which are set out in Chapter III. An assessment of the progress in harnessing alternate sources of energy and the rate at which these newer techniques can be applied had also to be made. But the Group was aware of the limitations of these approaches and tried to visualise the future in consultation with various institutions and persons specialised in these areas. The rate and pattern of growth of the economy and other assumptions made in this report are not based on any projection by any Government agency. They have been adopted by the Group solely for the purpose of identifying the magnitude of the energy problem and the directions in which our energy policy ought to move. The Group feels that these assumptions regarding growth are reasonable for purposes of planning for the energy sector and the policy conclusions of this report would require no major revision even if the rate and pattern tend to be somewhat different.

1.12 The policy recommendations have been presented as broad suggestions, leaving the details to be worked out later. The Working Group feels that such details will have to be evolved by the implementing agencies in the framework of plans and programmes at any point of time.

CHAPTER II

TRENDS IN ENERGY CONSUMPTION

Sources of Energy

2.1 India, in common with many developing countries, consumes energy in a variety of forms ranging from electricity obtained from nuclear fuels to agricultural waste and animal dung. Besides the energy derived from fuels, a considerable amount of energy is also obtained from the use of manual labour and animal power. The most significant commercial energy sources are coal, oil and electricity. The details of production and consumption of these forms are regularly collected in fair detail and recorded by the concerned energy industries and they are reliable. The production and consumption data of the important non-commercial fuels viz. fuelwood, agricultural waste and animal dung, are scanty and they are derived from computations which are based on the quantity of energy that would be required in the households. The data regarding the extent of use of animal power is incomplete and unreliable. A discussion of the consumption of energy can be made in terms of primary fuels consumed viz. coal, oil and electricity obtained from non-fuel sources i.e. hydro and nuclear power or the total electricity consumed and the oil and coal which are consumed directly for energy uses i.e. excluding quantities used for the production of electricity. An analysis of the trends of energy consumption in terms of the forms of energy in which they are consumed would be more meaningful in understanding the causes and consequences of such consumption. The discussion in this Chapter, therefore, is in terms of energy forms in which they are consumed.

2.2 For purposes of understanding the level of production and consumption of total energy, the energy produced or consumed in different forms have to be aggregated. Several methodologies have been developed for aggregation of energy and each agency/country adopts a specific methodology depending on the data availability and the purpose for which aggregation is required. In India, in the earlier studies on energy related issues, the coal replacement measure was adopted as the common unit of measurement. International energy data is usually given in coal equivalent units. The differences between the conversion factors for the two methods of measurement are set out below :

Original Unit	Equivalent factor to convert to Million tonnes of coal replacement (MTCR)	Equivalent factor to convert to Million tonnes of coal equivalent (MTCE)
1 million tonne of coal	1.0	1.0
1 million tonne of oil	6.5	2.0
10^9 kWh (TWH)	1.0	0.123*
1 million tonne firewood (4750 kcal/kg)	0.95	0.95
1 million tonne of dry animal dung	0.40	0.48
1 million tonne of vegetable waste (4200 kcal/kg)	0.95	0.84

*It is conventional to use this factor only for electricity produced from hydro electric and nuclear sources. Coal and oil used for power generation are converted by using their specific coal equivalent co-efficients.

The adoption of the coal replacement measure overestimates the use of oil and electricity and under-estimates the use of animal dung as compared to the measurements made on the coal equivalent index. The Group decided that the balance of convenience lay in continuing the unit of measurement which has come to be used widely in studies on energy in India. The discussions set out in coal replacement terms should be considered very carefully when comparing the Indian data with international data which are normally set out in the coal equivalent units.

Commercial Energy Consumption

2.3 The analysis in this section covers the three principal forms of energy, viz. coal, oil and electricity. The quantum of natural gas used for energy purposes is very insignificant in the overall energy consumption and as such it is not included in the main analysis of commercial energy consumption but discussed separately.

2.4 The consumption of commercial energy in original units in selected years during the period 1953-54 to 1978-79 is shown in Table 2.1.

TABLE 2.1

Consumption of Commercial Energy

(in original units)

Year	Coal million tonnes	Oil million tonnes	Electricity TWH
1953-54	28.7	3.7	7.6
1960-61	40.4	6.7	16.9
1965-66	51.8	9.9	30.6
1970-71	51.4	15.0	48.7
1975-76	71.0	17.8	66.0
1978-79	68.8	21.7	84.4

Notes: (i) Coal consumption excludes coal used for power generation.

(ii) Oil consumption excludes oil used for non-energy purposes, for power generation and in refineries.

(iii) Electricity consumption includes supplies from both utilities and non-utilities and excludes consumption by power station auxiliaries and transmission and distribution losses.

The consumption of the commercial forms of energy in coal replacement measure as adopted in this report are given in Table 2.2.

TABLE 2.2

Consumption of Commercial Energy

(in million tonnes of coal replacement)

Year	Coal	Oil	Electricity	Total Commercial Energy
1953-54	28.7	24.1	7.6	60.4
1960-61	40.4	43.9	16.9	101.2
1965-66	51.8	64.6	30.6	147.0
1970-71	51.4	97.2	48.7	197.3
1975-76	71.0	115.7	66.0	252.7
1978-79	68.8	141.1	84.4	294.3

Note : Conversion factors given in paragraph 2.2 have been adopted to convert to coal replacement measure.

2.5 The rates of growth of consumption of different commercial energy forms and total energy are given in Table 2.3. It is significant that during the period upto 1970-71, the growth in the consumption of oil products and electricity was relatively more rapid than consumption of coal. In the period 1970-71 to 1975-76, there was a spurt in the coal consumption and a decline in the growth of oil and electricity consumption. There was a reversal of this trend after 1975-76 and the growth of oil and electricity consumption has again picked up. The above trends are reflected in the shares of different forms of energy in the total commercial energy consumption presented in Table 2.4.

TABLE 2.3

Rate of Growth of Commercial Energy Consumption 1953-54 to 1978-79

Period	Average annual compound rate of growth (%)			
	Coal	Oil	Electricity	Total Commercial Energy*
1953-54 to 1960-61	5.0	9.1	12.1	7.7
1960-61 to 1965-66	5.1	8.0	12.6	7.8
1965-66 to 1970-71	(—)0.2	8.3	9.7	6.1
1970-71 to 1975-76	6.3	3.5	6.3	5.1
1975-76 to 1978-79	(—)1.1	6.9	8.6	5.2
1953-54 to 1970-71	3.5	8.6	11.5	7.2
1953-54 to 1975-76	4.2	7.5	10.3	6.8
1960-61 to 1970-71	2.4	8.3	11.1	6.9
1960-61 to 1975-76	3.8	6.7	9.5	6.3
1960-61 to 1978-79	3.1	6.8	9.3	6.1

*In terms of coal replacement measure. The growth rates of total commercial energy in terms of coal equivalent measure will be lower as oil and hydel/nuclear electricity will be reflected in terms of their heat value.

TABLE 2.4

Trends in Share of Different Energy Forms in Total Commercial Energy Consumption

Year	Percentage share in total commercial energy consumption		
	Coal	Oil	Electricity
1953-54	47.8	39.6	12.6
1960-61	39.9	43.4	16.7
1965-66	53.2	44.0	20.8
1970-71	26.0	49.3	24.7
1975-76	28.1	45.8	26.1
1978-79	23.4	47.9	28.7

Note : Shares have been calculated using coal replacement measure for aggregation.

Consumption of Non-Commercial Energy

2.6 Firewood, agricultural waste and animal dung are commonly referred to as non-commercial forms of energy in India. In the absence of a more appropriate nomenclature, the same classification is adopted in this report though a small but an increasing proportion of the latter fuels are exchanged through the market system. It is well recognised that substantial quantities of non-commercial fuels are used in a few major industries such as sugar and in unregistered factories and household industries. It has not been possible to estimate on a reliable basis the total contribution of non-commercial fuels to energy consumption in the industries sector. The analysis of consumption of non-commercial fuels in this report relates entirely to their use in the house-hold sector. Even in respect of this sector, there is no record of production or usage of such fuels and it is necessary to estimate consumption from sample surveys. Various alternative methods of estimation of consumption of non-commercial fuels were considered and it was decided to adopt the methodology used in the Report of the Fuel Policy Committee 1974. Briefly, the estimation is based on the assumption that the annual per capita consumption of energy (of all forms) in the household sector is 0.38 tonnes of coal replacement (tcr) in rural areas and 0.40 tcr in the urban areas. Using the estimates of rural and urban population for each year, the total energy consumed in the household sector is worked out. From this total energy consumption, the consumption of commercial energy, viz. coal, oil products and electricity, in the household sector is deducted and the total non-commercial energy is derived. The consumption of firewood, agricultural waste and animal dung are calculated on the assumption that their shares in the total non-commercial energy consumption are 65 per cent, 15 per cent and 20 per cent respectively. The analysis has been confined to the period upto 1975-76 as the data for non-commercial energy beyond is less precise. The results of such computation for selected years are set out in Table 2.5 in original units and Table 2.6 in coal replacement measure.

TABLE 2.5

Consumption of Non-Commercial Energy 1953-54 to 1975-76

(in million tonnes)

Year	Firewood	Agricultural waste	Animal dung
1953-54	86.3	26.4	46.4
1960-61	99.61	30.6	54.6
1965-66	109.3	33.6	59.9
1970-71	117.9	36.3	64.6
1975-76	133.1	41.0	73.0

TABLE 2.6

Consumption of Non-Commercial Energy in Coal Replacement Measure—1953-54 to 1975-76

(in million tonnes of coal replacement)

Year	Firewood	Agricultural waste	Cow-dung	Total
1953-54	82.2	25.1	18.6	125.9
1960-61	94.6	29.1	21.8	145.5
1965-66	103.8	31.9	23.9	159.6
1970-71	112.0	34.4	25.8	172.2
1975-76	126.5	38.9	29.2	194.6

2.7 The serious shortcomings of the methodology adopted in deriving the estimates of non-commercial fuel consumption as set out in the above tables (which is dependent on the invariant level of per capita consumption and rate of increase of population and urbanisation) should make us cautious in using these data for any purpose other than policy prescriptions. However, they could be compared with the levels of commercial energy consumption to get a picture of the relative levels of consumption of various forms of energy over time. The quantities and the relative shares of commercial energy and non-commercial energy are given below :

TABLE 2.7

Consumption of Commercial Energy and Non-Commercial Energy—1953-54 to 1975-76

(in million tonnes of coal replacement)

Source	1953-54	1960-61	1965-66	1970-71	1975-76
(a) Total Commercial Energy	60.4	101.2	147.0	197.3	252.7
(b) Total Non-Commercial Energy	125.9	145.5	159.6	172.2	194.6
(c) Total	186.3	246.7	306.6	369.5	447.3

Note : The contribution from draught animals are not included.

TABLE 2.8

Relative Shares of Commercial and Non-Commercial Energy—1953-54 to 1975-76

(*in percentage*)

Source of Energy	1953-54	1960-61	1965-66	1970-71	1975-76
(a) Total Commercial Energy	32.4	41.0	47.9	53.4	56.5
(b) Total Non-Commercial Energy	67.6	59.0	52.1	46.6	43.5

Note : Relative shares are computed using coal replacement measure for aggregation. If coal equivalent measure is used for aggregation the share of non-commercial energy would be substantially higher.

It is significant that while the relative share of non-commercial energy in the total energy consumption has gradually diminished over the last two decades, there has been an increase in the absolute quantity of non-commercial energy consumed.

Animate Energy

2.8 Animate energy from bullocks, camels, etc. and muscle power of human labour are used in India as sources of mechanical energy. It is also traditional that the same source of animate energy is used for different purposes. For example, the bullock might be used for lifting water, tilling land, performing other agricultural operations and for transporting goods and passengers. Estimation of energy derived from such sources involves a number of conceptual assumptions and approximations which are not backed by scientific and reliable studies. In view of this, the Working Group felt that it would not be meaningful at this stage to make any detailed assessment of the extent of the contribution of animate sources of energy consumption in India. However, the relevant aspects of animate energy consumption and their implications to the long-term demand for commercial energy consumption are discussed in the Chapters dealing with energy consumption in the various sectors. It is important to note that the contribution of energy from animate sources is quite large in India and should not be lost sight of while considering certain specific energy issues like the use of energy in the agriculture sector or the transport sector.

2.9 The magnitude of energy derived from animate source could be seen from Table 2.9, which gives the number of bovine animals, work animals, animal drawn carts and plough shares in certain selected years. The work animals are also used for lifting water from wells which are not served by diesel or electric pump sets. Such wells are estimated to number about six millions.

TABLE 2.9

Animate Energy Sources

(*in millions*)

	1961	1966	1972
No. of bovine animals	226.8	229.0	235.8
No. of working animals	78.0	78.5	80.1
No. of animal drawn carts	12.0	12.6	13.0
No. of ploughshares	N.A.	43.4	44.6

The absolute number of working animals and the devices which are used to put the animals to work have been increasing over time, although at a very slow rate. As the total energy consumption has been increasing at a higher rate, the relative importance of the animate energy in the total energy consumption should be declining gradually. Assuming that each working animal to contribute the energy equivalent to one tonne of coal per annum, the share of total energy derived from the animate sources would be quite large even at present.

Sector-wise Consumption of Total Commercial Energy

2.10 The sectors of energy consumption may be divided into five for purposes of energy analysis :

(i) Household sector (which was named domestic sector in previous reports).

(ii) Agricultural sector.

(iii) Industries sector (which was referred to as mining and manufacturing sector in earlier reports).

(iv) Transport sector, and

(v) Other sectors (which will include Government, commercial, construction, etc. sectors).

2.11 The details of consumption of coal, oil products and electricity in selected years in different sectors of the economy are set out in Table 2.10.

TABLE 2.10

Total Consumption of Commercial Energy—Sector-wise—1953-54 to 1978-79

(in million tonnes of coal replacement)

Sector	1953-54	1960-61	1965-66	1970-71	1975-76	1978-79
Household	12.7	20.8	26.5	35.5	37.4	40.3
Agriculture	1.8	3.6	6.3	9.1	18.1	31.3
Industries	22.4	39.7	60.8	76.3	101.8	113.4
Transport	21.5	34.2	49.7	64.6	85.5	93.2
Others	1.7	2.9	3.7	11.8	9.9	16.1
Total Commercial Energy Consumption . .	60.1	101.2	147.0	197.2	252.7	294.3

The share of different sectors in the consumption of Commrcial energy are given in Table 2.11.

TABLE 2.11

Share of Different Sectors in the Consumption of Commercial Energy—1953-54 to 1978-79

(in percentage)

Sector	1953-54	1960-61	1965-66	1970-71	1975-76	1978-79
Household	21.3	20.6	18.0	18.0	14.8	13.7
Agriculture	3.0	3.6	4.3	4.6	7.2	10.6
Industries	37.3	39.2	41.4	38.7	40.3	38.5
Transport	35.8	33.8	33.8	32.7	33.8	31.7
Others	2.8	2.8	2.5	6.0	3.9	5.5

It would be observed that the largest share of Commercial energy is consumed in the industries sector. The transport sector is the second largest consumer of commercial energy and accounts for about 30% of the commercial energy consumed. Industries and transport together account for nearly three-fourths of the commercial energy consumption. This share has changed only marginally over time in the last two decades. Energy consumption in the agricultural sector has registered the sharpest rate of growth and its share has increased from 3 per cent in 1953-54 to about 11 per cent at present. A part of the increase is due to substitution of animate energy and manual power by commercial energy while a part of it may be due to intensification of energy use in agriculture. Besides, the increased level of activity in the sector would also get reflected in the level of consumption. While the increase in commercial energy use in all the sectors would be the result of the three determinants viz. substitution of non-commercial forms increase in intensity of use and increased level of activity, the fact that in the agriculture, transport and domestic sectors a large portion of the annual increase in consumption of commercial energy is due to the substitution of commercial energy for non-commercial energy should be kept in view in interpreting the data in the tables above.

Sector-wise Consumption of Different Forms of Commercial Energy

2.12 The relative shares of the different sectors in the consumption of coal, oil and electricity has changed gradually over time. Table 2.14 gives the percentage shares of consumption of coal in different sectors of the economy in different years.

TABLE 2.14

Sector-wise Share of Coal Consumption—1953-54 to 1978-79

(in percentage)

Sector	1953-54	1960-61	1965-66	1970-71	1975-76	1978-79 (Provisional)
Household	7.6	8.4	7.9	7.9	5.1	5.8
Agriculture	..	..	..	..	..	..
Industries	48.1	47.1	58.1	60.5	71.9	73.4
Transport	42.2	42.5	33.4	31.0	20.3	18.0
Others	2.1	2.0	0.6	0.6	2.7	2.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

Note : Use of coal for power generation is exclude

It is seen that the major use of coal is in the industries sector, the share of which has steadily increased in the last two decades. The sharp rise beyond 1970-71 is particularly note-worthy. The share of household sector in coal consumption has been steady till 1970 and in the years after 1970, it has unexpectedly gone down. The share of the transport sector has shown a steady decline.

2.13 Table 2.15 gives the percentage share of different sectors in the consumption of oil for selected years.

TABLE 2.15

Sector-wise Share of Oil Conusmption 1953-54 to 1978-79

(in percentage)

	1953-54	1960-61	1965-66	1970-71	1975-76	1978-79 (Provisional)
Household	41.1	37.7	30.9	28.4	33.7	20.3
Agriculture	6.8	6.2	6.8	4.6	8.0	13.7**
Industries	15.3	16.5	12.6	11.2	6.4	6.4
Transport	36.8	39.6	48.5	48.6	58.9	55.4**
Others	Neg	Neg	1.2	7.2	3.0	4.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

Neg—Negligible

**Please see foot note under Table 10.1 in Chapter X.

The transport sector has accounted for the largest share of oil consumption since 1960-61. Its share has increased steadily over time and it is now in the range of 55 to 60 per-cent. The share of industries has steadily declined and it is the smallest among the major economic sectors. The oil consumption in household sector has remained more or less stagnent in recent years and as a consequence, its share has come down to about a fifth of the total consumption at present.

2.14 Table 2.16 sets out the relative share of different sectors in electricity consumption.

TABLE 2.16

Sector-wise Share of Electricity Consumption 1953-54 to 1978-79

(in percentage)

Sector	1953-54	1960-61	1965-66	1970-71	1975-76	1978-79 (Provisional)
Household	9.2	8.9	7.7	7.9	8.8	9.1
Agriculture	2.6	4.7	6.2	9.3	13.2	14.2
Industries	65.8	68.7	74.0	70.7	65.6	63.8
Transport	7.9	4.7	3.8	2.9	2.9	3.1
Others	14.5	13.0	8.3	9.2	9.5	9.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

The share of household sector has been steady with small fluctuations over the last two decades. The share of agriculture has increased at a rapid pace and at present, nearly one and a half times the electricity consumed in households is consumed in the agriculture sector. The share of industries was about two-thirds in the sixties and increased to about three-fourths in mid sixties and has declined from then on. It still accounts for about two-thirds of the electricity consumption. The share of transport sector has declined.

Composition of fuel consumption in Different Sectors

2.15 Table 2.17 delineates the relative share of coal, oil and electricity in the total commercial energy consumption in certain selected years during the last two decades. A detailed examination of the trends noticed and the causes and consequences of such trends would be analysed in the chapters dealing with energy consumption in the various sectors.

TABLE 2.17

Relative Shares of Different Forms of Commercial Energy in the Various Sectors of the Economy

(*in percentage*)

Sector	Energy from	Years					
		1953-54	1960-61	1965-66	1970-71	1975-76	1978-79 (Provisional)
Household	Coal	17.3	13.5	15.5	11.5	9.7	10.0
	Oil	77.2	79.3	75.6	77.7	74.7	71.2
	Electricity	5.5	7.2	8.9	10.8	15.6	18.8
Agriculture	Coal	0.0	0.0	0.0	0.0	0.0	0.0
	Oil	89.0	77.4	70.0	49.8	51.8	61.8*
	Electricity	11.0	22.6	30.0	50.2	48.2	38.2
Industry	Coal	61.5	52.6	49.5	40.7	50.1	44.5
	Oil	16.2	18.2	13.3	14.3	7.4	7.9
	Electricity	22.3	29.2	37.2	45.0	42.5	47.6
Transport	Coal	56.4	46.8	34.8	24.6	16.8	13.3
	Oil	40.8	50.8	62.9	73.2	81.0	83.9
	Electricity	2.8	2.4	2.3	2.2	2.2	2.8
Others	Coal	35.3	24.1	8.2	2.6	16.5	11.9
	Oil	0.0	0.0	23.1	59.2	30.0	36.2
	Electricity	64.7	75.9	68.7	38.2	53.5	51.9

*Please see foot-note under Table 10.1 in Chapter X.

Consumption of Commercial Energy in 1970-71 to 1978-79

2.16 The analysis of the trends in enegry consumption for the period 1953-54 to 1970-71 into five year sub-periods from 1960-61 shows that there has been no dramatic change in the pattern of energy consumption. The period beyond 1970-75 however shows a significant change. This only confirms the expectation that the very large increase in the price of oil products should have affected the trends. In addition to the oil price increase which has affected the pattern of energy consumption in all countries, the nationalisation of the coal industry in late 1972 and early 1973 (in two stages) could be expected to have had an impact. As the period after these events is somewhat short, the analysis is attempted by a study of the year-wise consumption of coal, oil and electricity.

TABLE 2.18

Consumption of Commercial Energy 1970-71 to 1978-79

Year	Coal (million tonnes)	% change over consumption of previous year	Oil (million tonnes)	% change over consumption of previous year	Electricity (TWH)	% change over consumption of previous year
1970-71	51.35		14.95		48.65	
1971-72	54.14	5.4	15.92	6.5	51.25	5.3
1972-73	53.14	—1.5	17.05	7.1	54.15	5.7
1973-74	59.91	12.2	17.56	3.0	55.52	2.5
1974-75	67.10	12.0	17.30	—3.5	58.17	4.8
1975-76	70.96	5.8	17.79	2.8	65.97	13.4
1976-77	71.40	0.6	18.83	5.8	73.03	10.7
1977-78	75.86	6.2	20.06	6.5	76.0	4.0
1978-79	68.80	—9.3	21.70	8.2	84.2	11.1

Note : Consumption of coal excludes use of coal for power generation and consumption of oil excludes oil used for power generation and non-energy purposes and refinery losses. Consumption of electricity is at the consumer end. Data for 1978-79 are provisional.

2.17 The data in Table 2.18 show that in the last six years from 1972-73, the pattern of energy consumption has been undergoing a process of difficult adjustments in response to changes in the relative prices, scarcities and levels of activity in the consuming sectors. The annual changes show sharp changes. In the case of coal, the year in which the industry was nationalised was followed by the year of the oil crisis. These factors have given a sharp thrust upward to coal consumption for two years (1973-74 and 1974-75) followed by a lower rate of growth. The oil price increases led to adjustments in the local consumer prices of oil products in 1973-74 and a sharp rise in 1974-75. In line with the normal anticipation, the rate of increase of oil products sharply declined in 1973-74 and further in 1974-75. From then on, oil consumption has picked up and has reached the rates of increase of the earlier periods. A more detailed analysis of the sector-wise consumption changes of oil products and product-wise changes in these years is included in the chapter on 'Oil Policy'. Electricity consumption somewhat unexpectedly shows wide variations in the years 1973-74 to 1977-78. The uneven increase might be due to different degrees of electricity scarcity prevailing in these years.

Factors Affecting Energy Consumption

2.18 In spite of the vissicitudes that the economy had to undergo in the last twenty five years and the changes in the relative price of coal, oil and electricity, there is a long-term secular trend in the consumption of these energy forms. It is well brought out by the fact that correlation of total energy consumption as well as consumption of specific forms of commercial energy against time is seen to be statistically significant. Regression models indicate that the trend rates of growth of various forms of energy were as follows :

total commercial energy is . 6.02% per year
coal is . . . . . . 2.92% per year
oil products is . . . . 6.96% per year, and
electricity is . . . . . 8.79% per year.

2.19 The increase or decrease of total commercial energy consumption or the consumption of specific energy forms is the result of a complex set of factors like the level of activity in the energy consuming sectors, the availability of different fuels, their relative prices, technological changes in the sectors, changes in the composition and quality of output in the sector population, changing life-styles, etc. In addition to these factors which are common to all developed countries, in developing countries like India, the rate of substitution of non-commercial fuel by commercial energy also affects the quantity of commercial energy consumed. Though it is theoretically possible to build elaborate models which relate the level and pattern of consumption to the different factors which affect such consumption, the lack of reliable data regarding the explanatory variables would make it necessary to make several approximations and assumptions which would be subjective. Such implicit assumptions and approximations in estimating the quantities whose relationships such models specify would greatly constrain the usefulness of such models. While the Group recognises the need for building up more reliable data which would form the basis of energy models and the usefulness of such models based on reliable data, it felt that a meaningful analysis at this stage could only be limited to the examination of the broad trends of energy consumption to the levels of activity in the economy as a whole and the sectoral activity levels. In the absence of other reliable indices of overall activity levels in the different sectors, 'value added' in the different sectors is assumed to represent the sectoral activity levels.

2.20 Table 2.19 sets out the rates of growth of energy consumption and the rates of growth of sectoral activity levels in the different sub-periods from 1953-54 to 1978-79.

TABLE 2.19

Rates of Growth of Commercial Energy and Selected Economic Indicators 1953-54 to 1978-79

(Average annual compound %)

Period	Rates of growth of consumption of				Rates of growth* of			
	Total Commercial Energy	Coal	Oil Products	Electricity	GDP	Value added in Agri.	Value added in Industry	Value added in Transport
53-54 To 60-61	7.71	5.0	9.12	12.09	3.95	2.21	2.92	6.82
60-61 To 65-66	7.76	5.10	8.05	12.60	2.94	—1.00	7.30	6.22
65-66 To 70-71	6.05	—0.20	8.31	9.70	4.87	5.60	3.51	4.52
70-71 To 75-76	5.29	6.28	3.50	6.30	2.85	1.69	3.27	5.29
75-76 To 78-79	5.2	—1.10	6.90	8.60	**	**	**	**
53-54 To 70-71	7.23	3.48	8.62	11.51	3.92	2.28	4.36	5.96
53-54 To 75-76	6.78	4.20	7.50	10.33	3.68	2.14	4.12	5.81
60-61 To 70-71	6.89	2.43	8.28	11.10	3.90	2.33	5.39	5.37
60-61 To 75-76	6.35	3.83	6.61	9.51	3.55	2.11	4.68	5.34
60-61 To 78-79	6.10	3.10	6.80	9.30	**	**	**	**

Note : *The rates of growth of GDP and values added in the sectors have been calculated with reference to factor cost at constant 1960-61 prices.

**The growth rates could not be worked out as the GDP and value added data for 1978-79 were not available.

2.21 The rates of increase of total commercial energy over the long run follows the same trend as that of GDP. But during the sub-periods, such similarities in the trends are not noticed. This is true not only of rates of growth of GDP but of the value added from other productive sectors. In the different sub-periods, the total commercial energy consumption does not move with value added in industries sector.

2.22 *Energy*—GDP elasticity or elasticity of energy consumption to economic growth (defined as the ratio of the percentage per year increase of total commercial energy consumption over a period to the percentage per year increase in GDP over the same period) varies sharply in the different periods as would be seen from Table 2.20.

TABLE 2.20

Energy—GDP Elasticity co-efficients in India

Period	Energy/GDP elasticity coefficient
1953-54 to 1960-61	1.95
1960-61 to 1965-66	2.63
1965-66 to 1970-71	1.24
1970-71 to 1975-76	1.86
1953-54 to 1970-71	1.84
1953-54 to 1975-76	1.84
1960-61 to 1970-71	1.77
1960-61 to 1975-76	1.79

Note : The growth rates of total energy consumption have been computed using coal replacement measure for aggregation. If coal equivalent measure is used for aggregation, the Energy/GDP elasticities will be somewhat lower. This should be kept in view in international comparisons.

The long-term energy—GDP elasticity coefficients, however, show a remarkable stability varying marginally around 1.8 and a very low reduction over time is discernable. The energy—GDP clasticity Co-efficient in India is high compared to developed countries where it is lower than unity. (Table 2.21).

TABLE 2.21

Energy—GDP Elasticities in selected Countries

Country	Energy—GDP Elasticity Co-efficient 1953 to 1970
1. France	0.76
2. Germany (FRG)	0.73
3. U.K.	0.42
4. U.S.A.	0.81
5. U.S.S.R.	0.84

2.23 It is significant that in spite of the apparent intensification of energy use in almost all the sectors in the highly developed countries, the energy—GDP elasticity coefficient is less than one. The reasons appear to be that there is a gradual increase in fuel utilisation efficiency and that over a long period the energy sources with a low efficiency of utilisation like coal have been replaced by more 'efficient' energy forms like oil or electricity. There are grounds to believe that in India, while there has been a shift away from coal in most sectors, the efficiency of fuel utilisation has not significantly increased. Furthermore, a part of the apparent increase in energy consumption is due to the substitution of commercial energy for non-commercial fuels, whose utilisation is not taken into account in the computation of the energy—GDP elasticity coefficients. For example, if one million irrigation wells which were using animate power for lifting water get energised with electricity during a period (and if the productivity has not changed as a result of such electrification) the total commercial energy consmuption would have increased while GDP would have remained constant and the elasticity coefficient would show an apparent increase. With all the limitations, the very small decreasing trend in the elasticity coefficient is noteworthy.

2.24 Regression models correlating energy consumption with activity levels of the economy as a whole and on the sectoral levels were studied. It is found that linear and exponential models are statistically significant as would be observed from Table 2.22.

TABLE 2.22

Results of Regression Analysis of Energy Consumption and Economic Activity

S. No.	Dependent variable	Independent variable	Regression Model	r^2	t values
1	2	3	4	5	6
1.	Y1	X1	(i) log Y1 $= -16.133 + 1.775 \log X_1$	0.9641	20.101
			(ii) Y1 $= 121.124 + 0.00161 X_1$	0.9709	22.410
2.	Y1	X2	(i) log Y1 $= -9.665 + 1.4265 \log X_2$	0.9675	21.163
			(ii) Y1 $= -71.0835 + 0.007543 X_2$	0.9734	23.456

1	2	3	4		5	6
3.	Y_2	X_1	(i) $\log Y_2$	$= -14.86 + 1.518 \log X_1$	0.9193	13.111
			(ii) Y_2	$= 9.44 + 0.000243\, X_1$	0.8422	9.002
4.	Y_2	X_2	(i) $\log Y_2$	$= -9.202 + 1.227 \log X_2$	0.9124	12.538
			(ii) Y_2	$= 16.04 + 0.001171\, X_2$	0.8930	11.234
5.	Y_3	X_1	(i) $\log Y_3$	$= -20.29 + 2.0345 \log X_1$	0.9649	20.347
			(ii) Y_3	$= -76.67 + 0.000857\, X_1$	0.9668	20.937
6.	Y_3	X_2	(i) $\log Y_3$	$= -12.7233 + 1.6463 \log X_2$	0.9597	18.932
			(ii) Y_3	$= -49.71 + 0.004017\, X_2$	0.9656	20.548
7.	Y_4	X_1	(i) $\log Y_4$	$= -20.746 + 2.58 \log X_1$	0.9652	20.429
			(ii) Y_4	$= -53.94 + 0.000506\, X_1$	0.9831	29.592
8.	Y_4	X_2	(i) Y_4	$= -34.42 + 0.002353\, X_2$	0.9654	20.487

Y_1 = Consumption of total commercial energy in MTCR
Y_2 = Consumption of coal in MTCR
Y_3 = Consumption of oil in MTCR
Y_4 = Consumption of electricity in MTCR
X_1 = GDP at factor cost in 1960-61 prices in million rupees
X_2 = Value added in mining and manufacturing sector at factor cost in 1960-61 prices in million rupees.

Consumption of Natural Gas in India

2.25 The production and consumption of natural gas in India is still a very small fraction of the total commercial energy consumption. Of the consumption, a sizable portion is used for power generation and for non-energy uses and as such the quantity to be included in the final internal consumption as energy in India is less than one per cent even in 1975-76. Table 2.23 sets out the results for selected years.

TABLE 2.23

Consumption of Natural Gas in India in 1965-75

Year	Total Prodn.	Total consumption	Consumption* for energy use	Consumption for energy use MTCR
	in million cubic metres			
1965-66 . .	753	352	31	0.20
1970-71 . .	1445	698	180	1.17
1975-76 . .	2335	1318	576	3.74

2.26 As the level of use of natural gas would increase in the coming years, it is desirable to set up a good system for collection of data on the various end-uses of natural gas and integrate the details in future studies on the production and consumption of energy in India.

*Excluding the use for power generation.

Notes : 1. Consumption for financial years computed as 3/4th of the earlier & 1/4th of the later years.

2. Conversion factor : one billion cum of natural gas = 6.5 MTCR.

CHAPTER III

FORECAST OF DEMAND FOR ENERGY

3.1 Forecasting the future demand for energy has always been a hazardous task. The demand for energy in different forms is dependent on a number of factors like the rate and pattern of economic activities, the technologies adopted for production of different goods and services, the efficiencies of use of energy in the different sectors and the extent of substitution of animal power and non-commercial fuels by the commercial fuels, the behaviour of which is difficult to predict on a long term basis. The recent realisation of the severe constraints on the availability of finite fossil fuel resources and the producers' response to such realisation have made it almost impossible to make a realistic long term forecast of the energy demand. In spite of the uncertainties in regard to the factors that determine demand, there is need to make long term forecasts of energy demand, as the long gestation of energy supplying projects necessitate decisions to be taken far ahead of the demand for installing production facilities for different forms of energy. If we take into account the investments for the preliminary investigations and explorations necessary for setting up energy projects and the timing of the investments for the development of alternate energy resources, the optimal forecasting horizon recedes further.

3.2 The selection of an appropriate forecasting horizon is an important issue in attempting energy demand projection exercises. The gestation period of coal projects, from the time of the investment decision to its commissioning varies between 5 to 12 years*. The hydro-electric projects have similar periods of gestation. Even thermal power stations take 5 years to construct; nuclear power stations take longer. Decision on research and development in the energy sector would have to be made, with reference to meeting the demand which would arise after 20 years. Taking all these into consideration, the Group felt that, though the terms of reference had specified that the group should make a forecast for a period of 15 years from now, it would be appropriate to extend the forecast upto the year 2000 A.D.

3.3 The Group examined various forecasting methods and models that could be used for energy demand forecasting in the present context. In the past, time trend models, regression models that relate energy consumption to diverse explanatory variables like population, GNP, sectoral activity levels, prices etc. have been used. End use analysis was also attempted to provide a mean of moderating these results. In the present context, when the price of energy relative to other economic inputs and the relative price of different energy forms have undergone a sea-change and the basic direction of technological innovations are being re-examined, the Group felt that the data relating to the past might not provide a reliable guide to forecast the future demand. In a situation where the utility of the different conventional tools is severly limited for forecasting long term energy demand, the Group adopted the following methodology :

—first, using the conventional methodologies, a Reference Level Forecast (RLF) of energy demand was attempted. This was obtained by harmonising the forecasts obtained by different methodologies. It represents the best judgement of the Group as to the likely level of demand for energy if no deliberate measures are initiated to manage the energy supply and demand. This forecast, however, took note of the likely adjustments that would take place normally in response to increased price and uncertainties of supplies of certain fuel forms ;

—the second stage of the exercise was to set out the best level and composition of energy demand that could materialise if the policy prescriptions suggested by the Group are adopted and the assumptions made by the Group of the likely developments in the international energy system actually materialise, keeping in view the same rates of growth of GDP as in RLF. This is referred to hereafter as the Optimal Level Forecast (OLF).

These exercises showed that with the adoption of policy prescriptions of the type suggested, it might be possible to achieve the same rate of economic growth with a substantially lower level of energy inputs.

*It is possible to construct coal mines, especially shallow opencast mines, within 4 to 5 years.

3.4 These two levels of the forecasts namely RLF and OLF are not meant to provide the precise demand with reference to which the investment decisions could be made in the energy sector. Such decisions have to be made on the basis of the specific forecast for the particular fuel form projected at the time of the investment decision with reference to the best information available at that point of time. The forecasts made in this report are meant only to draw certain broad policy measures.

3.5 The estimates of RLF were drawn up adopting the methodology that was followed in the earlier studies. Briefly, the method consisted of deriving the demand for total commercial energy and energy in different forms by the extrapolation of the past trends of energy consumption; by using regression models which correlate past levels of energy consumption with the past levels of economic activity and by forecasting demand by analysis of end-use energy consumption (i.e. energy consumption norms of various categories of consumption were determined and the likely demand for each consumer category was computed with reference to the likely level of activity in the consuming sector). In projecting the level of activity in each sector, a sort of scenario approach was followed as set out in the Chapters V, VI, VII and VIII. The results obtained by the different methods were harmonised to arrive at a reasonable forecast.

3.6 The forecast of demand was made for the years 1982-83, 1987-88, 1992-93 and 2000-01. The results obtained were checked for their credibility with reference to the global and sectoral elasticity co-efficients of energy with economic growth.

3.7 The following basic assumptions were made regarding the determinants of energy demand :

(i) After a very detailed consideration of the alternative rates of growth of GDP which could be adopted the Group decided that it would be useful to project the demand and analyse the supply issues for a somewhat higher rate of growth than achieved so far in order to examine if energy would be a constraint to economic growth at such levels. The growth of GDP assumed is as follows :

Period	Average annual Compound Growth Rate
1977-78 to 1982-83	4.7%
1982-83 to 1987-88	5.5%
1987-88 to 1992-93	6.0%
1991-99 to 2000-01	6.0%

(ii) Rate of growth of the different sectors of the economy were assumed to be :

(average annual compound %)

Sector	Period		
	1982-87	1987-92	1992-2000
Agriculture	3.92	3.72	3.93
Industries	6.81	7.23	7.23
Transport	6.50	6.80	6.72
Others	6.27	7.23	6.74

Note : The decimal points are the result of arithmetical manipulations and are not intended to represent the accuracy of the rates of growth.

(iii) The population was assumed to be :

In 1982-83	697.2 million
In 1987-88	760.5 million
In 1992-93	823.3 million
In 2000-01	920.9 million

(iv) The relative prices of different fuels were assumed to be of the same order as in 1978.

(v) The rate of substitution of non-commercial fuels and animal energy by commercial fuels was assumed to follow the same trend in future as in the last 25 years.

Reference Level Forecast

3.8 As explained earlier, the RLF was based on the results of the demand forecast obtained from time-trend models, regression models, scenerio analysis, etc. A careful consideration of the results of the three methods indicates that in respect of oil, the three methods give values which are very close to each other. In respect of coal, the end-use method gave values which are higher than the GDP regression model. By harmonizing the results derived from the various methods and keeping in view the projection of demand made by the other agencies, the Reference Level Forecast (RLF) of energy demand was estimated by the Working Group as in Table 3.1.

TABLE 3.1

Reference Level Forecast of Energy Demand 1982-2000

(in million tonnes of Coal replacement)

Energy from	1982-83	1987-88	1992-93	2000-01
Coal*	96.8	131.5	186.6	308.0
Oil*	165.1	217.1	290.6	482.3
Electricity	128.3	191.2	282.0	471.0
Total Commercial Energy	390.2	539.8	759.2	1261.3

*Includes only quantities used directly for energy uses.

3.9 In terms of original units, the Reference Level Forecast of demand for consumption directly as coal, oil and electricity would be as in Table 3.2.

TABLE 3.2

Reference Level Forecast of Energy demand 1982-2000

(in original units)

Energy from	Unit	1982-83	1987-88	1992-93	2000-01
Coal . . .	Million Tons	96.8	131.5	186.6	308.0
Oil . . .	,,	25.4	33.4	44.7	74.2
Electricity* .	TWH	128.3	191.2	282.0	471.0

*the figures denote electricity used at the consumer end. The generation requirements will be higher.

3.10 The rates of growth of consumption of commercial energy for energy purposes directly in the form of coal, oil and electricity implied in the RLF of energy demand are as in Table 3.3.

TABLE 3.3

Rate of Growth of demand for commercial Energy 1975-2000 Reference Level Forecast

(average annual compound %)

Period	Rates of growth of			
	Coal	Oil	Electricity	Total Commercial Energy
1975-82 . .	4.5	5.1	10.0	6.3
1982-87 . .	6.3	5.6	8.3	6.7
1987-92 . .	7.4	6.0	8.1	7.1
1992-2000 . .	6.4	6.5	6.6	6.6

3.11 The energy—GDP elasticities implied in the forecast are as follows :

Period	Energy/GDP Elasticity Coefficient (RLF)
1975-82	1.34
1982-87	1.22
1987-92	1.18
1992-2000	1.08

The forecast (RLF) implies a gradual decline in the energy/GDP elasticity and a rapid increase in the per capita consumption of commercial energy. The per capita commercial energy measured in coal replacement tonnes (tcr) is projected to change

from	0.424 in 1975
to	0.559 in 1982
to	0.71 in 1987
to	0.919 in 1992 and
to	1.364 in 2000

It is noteworthy that as compared to 0.424 tcr of per capita energy consumption and a per capita GDP of Rs. 390 in 1975, in 2000 AD the per capita energy consumption would be 1.364 tcr and the per capita income would be Rs. 800 (GDP in 1960-61 prices).

3.12 Coal and oil are required to produce electricity. These fuels are also used increasingly for non-energy uses like in the production of chemicals, fertilizers, as solvents etc. If all the non-energy uses and uses for transformation in the energy sector are taken into account, the requirements to be met by production and|or import, of the fuel forms would be as set out in the Table 3.4. In this forecast, it has been assumed that upto 2000-01 the total naphtha available from the indigenous refineries would be used as feedstock for manufacture of fertilizers and petro-chemicals. The currently proved recoverable reserves of natural gas and the possibility of additional discoveries would provide the option of utilising gas as feedstock and exporting surplus oil products.

TABLE 3.4

Total requirements of Coal, Oil, Electricity 1982-2000 (Reference Level Forecast)

Energy from	Unit	1982-83	1987-88	1992-93	2000-01
Coal (total) .	Million tonnes	151	214	313	531
Oil (total) .	,,	35.5	44.7	57.3	92.7
Electricity generation .	TWH	154.9	228.7	333.7	551.6

Note : (a) For details of the methodology adopted in estimating the non-energy and transformation demand see Chapters IX, X and XI.

(b) The figures of coal and oil include the quantities used for power generation and as feedstock and other non-energy uses. The consumption of the three energy forms given in this table cannot therefore be added to arrive at the total commercial energy requirements.

3.13 Consumption of Non-Commercial Fuels :— As explained in Chapter II, the consumption of non-commercial fuels has been computed solely with reference to the demand for these fuels in the household sector. The consumption of non-commercial fuels in the industries sector which might be of the order of about a million tonnes of firewood in the organised industries, about 20 million tonnes in the unorganised industries including brick burning and household industries and about 30 million tonnes of bagasse in the sugar industry, are not taken into account.

The projections of future demand for non-commercial fuels have been made on the lines described in para 2.6 of Chapter II. The consumption of non-commercial fucls (i.e. firewood, vegetable waste and animal dung) consistent with the projection of demand for commercial fuels made in those exercises would be as in Table 3.5.

TABLE 3.5

Forecast of demand for Non-commercial Fuels Reference Level Forecast

(In MTCR)

Year	Total non-commercial fuels*
1982-83	204.1
1987-88	202.8
1992-93	195.8
2000-01	163 5

*This is exclusive of the use of non-commercial fuels in industries which might be about 20 MTCR of firewood/agricultural waste and about 30 MTCR of bagasse.

3.14 Non-commercial energy consumption which was about 194 MTCR in 1975-76 increases to a maximum of 204 in 1982-83 and from then on, the absolute level of non-commercial fuels used in the country diminishes slowly. In other words, inspite of the population increase, on the basis of the forecast for commercial energy needs, it can be expected that the absolute level of non-commercial energy use might start declining from the year 1982-83.

Optimal Level Forecast

3.15 The RLF which does take into consideration the increasing price of oil and some adjustments in the fuel usage pattern that would materialise in response to the changing prices, leads to demand levels which appear to be unmanageable. The increase in the demand for oil and electricity, in particular, would become difficult to meet in view of the increasing costs and scarcity. The Group, therefore, considered various ways in which the demand could be reduced without affecting the development plans underlying the energy growth in the RLF. These have been considered sector by sector of the economy in Chapters V to VIII. Briefly, the optimisation of the pattern of energy utilisation is proposed to be obtained by :

(i) adopting measures to increase the efficiency of fuel utilisation keeping in view the levels of efficiencies obtaining at present in different sectors and the possible technical developments in the future;

(ii) reducing the energy consumption as a whole by using more efficient technologies in terms of energy usage;

(iii) reducing the demand as a whole for transport services by more optimal planning of production and consumption locations ;

(iv) reducing energy intensity of the industries sector by adopting different strategies of industrial growth; and

(v) inter fuel substitution from commercial energy to a greater use of non-commercial energy and energy of the renewable type (hydro power etc.) for which special plans of production are suggested.

3.16 Based on these, the Group estimated the Optimal Level Forescast (OLF) of energy demand as given in Table 3.6.

TABLE 3.6

Optimal Level Forecast of energy demand 1982-2000

(in original units)

Energy from	Unit	1982-83	1987-88	1992-93	2000-01
Coal	Million tonnes	96.8	128.0	170.4	266.0
Oil	,,	25.2	30.4	37.0	54.8
Electricity	TWH	128.3	173.6	241.0	395.6

The same estimates in terms of coal replacement measure are given in Table 3.7.

TABLE 3.7

Optimal Level Forecast of Energy Demand 1982—2000

(In MTCR)

Energy from	1982-83	1987-88	1992-93	2000-01
Coal	96.8	128.0	170.0	265.0
Oil	163.8	197.6	240.5	356.2
Electricity	128.3	173.6	241.0	395.6
Total Commercial Energy	388.9	499.2	651.5	1017.8

3.17 The rate of growth of commercial energy implied in the OLF of energy demand are given in Table 3.8.

TABLE 3.8

Rates of Growth of Demand for Commercial Energy 1975—2000

(OPTIMAL LEVEL FORECAST)

(Average Annual Compound %)

Period	Rate of growth of			
	Coal	Oil	Electricity	Total
1975—82	4.4	5.0	10.0	6.3
1982—87	5.7	3.8	6.2	5.1
1987—92	5.8	4.0	6.8	5.5
1992—2000	5.8	5.0	6.4	5.7

3.18 The elasticity coefficients of energy consumption to GDP corresponding to OLF would be as below :

1975—82	1.34
1982—87	0.93
1987—92	0.90
1992—2000	0.95

3.19 It would be seen that by 1987-88 it is possible to bring down the energy—GDP elasticity to something less than unity and from then on maintain it. The rates of growth are not as smooth as in the Reference Level Forecast for specific fuels as well as the total commercial energy. The several measures that have been suggested to moderate the demand computed in the Reference Level have been assumed to result in a certain reduction or modify the pattern of fuel consumption, for which no exact quantification is possible. As the different measures would be implemented with different degrees of efficiency, the resultant configuration of demand would be somewhere in between RLF and OLF. As such the Group felt that there was no need to correct the trends implied in the OLF rates of growth of consumption of energy and to make less abrupt the changes in the rates of growth of specific energy consumption, as well as the elasticity of energy consumption to GDP.

3.20 The Group would like to point out that the OLF need not represent the limit to the optimisation of the energy consumption pattern. The results set out in the Report in quantitative terms are merely to emphasise broadly the extent of benefits that can be derived by following a comprehensive energy policy instead of allowing the energy situation to drift along the lines of the past and are not presented as accurate forecasts of the results of implementing the policy.

3.21 The total requirements of coal, oil and electricity which would be needed to support this energy demand and the other demands for non-energy use and use for transformation into electricity have been calculated for the Optimal Level Forecasts as set out in Table 3.9.

TABLE 3.9

Requirements of Coal, Oil, Electricity 1982—2000

OPTIMAL LEVEL FORECAST

Energy from	Unit	1982-83	1987-88	1992-93	2000-01
Coal (Total)	Million tonnes	150.4	203.3	273.5	427.2
Oil (Total)	Million tonnes	35.38	40.97	48.30	69.11
Electricity Generation	TWH	155.2	207.5	281.7	457.6

Note :—(1) For details of the methodology adopted in estimating the non-energy and transformation demand, see Chapters IX, X and XI.

(2) The figures of coal and oil given above include the quantities used for power generation and as feedstock and other non-energy uses. The consumption of the three energy forms given in this table cannot therefore be added to arrive at the total commercial energy requirements.

CHAPTER IV

ENERGY RESOURCES IN INDIA

Coal Resources

4.1 The most important source of commercial energy in India is Coal. The quantity of coal resources available in the country is assessed on a continuous basis regionally by the Geological Survey of India through regional mapping and exploratory drilling. Further proving is established by detailed drilling done by Mineral Exploration Corporation, Central Mine Planning & Design Institute at the instance of Coal Companies and by some State Governments and private agencies. In the past, in some cases, assessment of coal resources has been made for small blocks by the Coal companies like the former National Coal Development Corporation and the present Coal India Limited, and Singareni Collieries Ltd. Certain State Governments have also made assessment of some deposits. In 1972, all these assessments were compiled together on a comparable basis and a total estimate of coal resources of the country was made assuming two crucial parameters i.e. coal available up to a depth of 600 metres and in seams of thickness of more than 1.2 metres. A summary of the total gross reserves of different varieties of coal is given in Table 4.1.

TABLE 4.1

Coal Resources (1972)

(in million tonnes)

Coal Variety	Total Gross Reserves	Proved Reserves	Indicated Reserves	Inferred Reserves
1. Coking Coal				
Prime Coking Coal . .	5,650	3,650	1,540	460
Medium Coking Coal .	9,431	3,850	4,309	1,272
Semi & Weekly Coking Coal	5,073	1,559	2,600	214
Total Coking Coal . .	20,154	9,059	8,449	2,646
2. Non-Coking Coal				
Non-Coking Coal . .	59,968	12,306	22,310	26,180
Tertiary Coal . . .	288			
3. Lignite				
Lignite	2,025	1,795	202	28
Grand Total . . .	82,975	23,160	30,961	28,854

4.2 The estimate in Table 4.1 was incorporated in the Report of the Fuel Policy Committee (1974). The Working Group felt that this information should be updated. Accordingly, the Geological Survey of India has updated the reserves of coal occurring up to a depth of 600 metres and in seam thicknesses of 1.2 metres and above. The revised estimate based on information available up to 1978 place the total reserves of coal at 85,444 million tonnes comprising 17,911 million tonnes of the coking variety and 67,533 million tonnes of the non-coking variety. The break-down of the estimate by varieties of coal and categories of estimates is given in Table 4.2.

TABLE 4.2

Revised estimates of Coal Resources in India (1978) Coals occurring with seam thickness 1.2 Metres and above and at Depths up to 600 Metres

(in million tonnes)

Depth in Metres	Semi Coking Coal				Medium Coking Coal				Prime Coking Coal				Non-Coking Coal				Total
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	Coal
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0—300 . . .	1028	1081	300	2409	1972	2980	584	5536	832	—	..	832	13088	21253	14413	48754	57531
300—600 . .	170	729	307	1206	1151	2012	641	3804	3664	460	..	4124	2699	9070	7010	18779	27913
TOTAL . . .	1198	1810	607	3615	3123	4992	1225	9340	4496	460	..	4956	15787	30323	21423	67533	85444

A—Proved reserves
B—Indicated reserves
C—Inferred reserves
D Total

4.3 The Working Group felt that the coal reserves occurring at depths of greater than 600 metres and seam thickness smaller than 1.2 metres had relevance in the context of the recent developments in the World energy scene. The possibilities of mining at greater depths and from thinner seams are coming up for consideration. The coal exploited from thinner and deeper seams would no doubt be much costlier than coals from seams which have so far been assessed as available reserves. There are also technological problems of strata control and higher temperatures at greater depths. However, in view of the importance of coal to the country's energy economy, the Working Group felt the need for assessing the reserves located at greater depths and with smaller seam thickness.

4.4 Geological Survey of India has made a quick inventory of the coal reserves with the help of available information to cover deposits located up to a depth of 1200 metres and with seam thickness in the range of 0.5 to 1.2 metres. The results of the quick assessment are summarised in Table 4.3. It would be seen therefrom that the extension of limits of seam thickness and depth would add to the estimated reserves of different varieties of coal as follows :

Depth (Metres)	Seam thickness (Metres)	Additional reserves (million tonnes)		
		Coking Coal	Non-Coking Coal	Total
0–600	0.5 to 1.2	929	3168	4097
600–1200	1.2 and above	3547	17899	21446
600–1200	0.5 to 1.2	166	475	641
	Total	4642	21542	26184

TABLE 4.3

Estimates of additional Coal Resources in India (1978) Coal occurring at depth between 600—1200 Metres and seam thickness 0.5 Metre and above

(in million tonnes)

Depth in Metres	Semi Coking Coal				Medium Coking Coal				Prime Coking Coal				Non-coking Coal				Total
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	Coal
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
AA Seam thickness 0.5 to 1.2 metres																	
0—300 . . .	41	155	28	224	53	204	52	309	43	50	10	103	392	1519	615	2526	3162
300—600 . .	5	64	27	96	6	65	51	122	*	32	42	75	8	138	496	642	935
600—900 . .	2	41	27	70	*	6	49	56	..	..	..	..	*	16	328	345	471
900—1200 . .	*	14	*	15	..	*	25	25	..	..	..	..	*	3	127	130	170
TOTAL 'AA' . .	48	274	83	405	60	275	177	512	44	82	52	178	400	1676	1566	3643	4738
BB Seam thickness more than 1.2 metres																	
600—900 . .	20	242	130	392	23	574	847	1444	930	..	..	930	21	633	8916	9570	12336
900—1200 . .	9	55	18	82	..	9	690	699	..	..	..	..	11	945	7373	8329	9110
TOTAL 'BB' . .	29	297	148	474	23	583	1537	2143	930	..	..	930	32	1578	16289	17899	21446
GRAND TOTAL 'AA' + 'BB' .	77	571	231	879	83	858	1714	2655	974	82	52	1108	432	3254	17855	21542	26184

Note : *Indicates insignificant reserves but computed in the total

A—Proved reserves

B—Indicated reserves

C—Inferred reserves

D—Total

If these additional reserves are taken into account, the total coal reserves of the country add up to 111,628 million tonnes.

4.5 Among the 50 important coal fields in the country, coal is known to occur at depths below 600 metres in only a few fields like Raniganj, Jharia, East Bokaro, Karanpura and Godavari Valley coal fields. Deep drilling has been done in a few locations in Jharia, Raniganj and Bokaro coal fields to serve as pilot boreholes. Thus, the assessment of additional reserves in deeper coal seams has been done with very limited exploratory information and should, therefore, be considered at this stage as very tentative.

4.6 These estimates of coal reserves indicate that the addition to prime coking coal reserves by extending the limits of seam thickness and depth is very small. This aspect is important in formulating the conservation policy for coking coal.

4.7 The result of this brief exercise to reassess the coal reserves underline the need for a more careful periodical examination of our natural resources especially the energy resources by adopting parameters which are more in keeping with the technology and cost conditions that prevail at each point of time. Coal being the largest and the most important of the naturally occuring energy resources in India, it is important that a sustained effort should be made to constantly appraise the reserves and classify them by varieties of coal and categories of reserves. The Working Group recommends that the Standing Committee on Assessment of Coal Resources, which has been revived recently, may also assess the extent of extractable coal resources as also those blocked due to various constraints.

Oil and Gas Resources

4.8 The two principal oil exploring, drilling and producing organisations viz., the Oil and Natural Gas Commission (ONGC) and Oil India Limited (OIL) carry out assessment of oil and gas reserves annually. The assessments are based on the new information gathered during the previous year by way of drilling, production, workover, pressure-volume-temperature data and reservoir engineering studies and reported as per classifications which they have evolved and which they consider best suited for their techno-economic evaluations. The classification of the reserves is based on the degree of reliability attached.

4.9 Tables 4.4 and 4.5 set out the reserves of oil and gas according to the latest assessment. The categories employed in this assessment are :

TABLE 4.4

Oil Resources

(As on 1-1-1978)

(million tonnes)

Category of Reserve	Onshore	Offshore	Total
I. Definite			
(i) Initial Geological Reserves (Oil-in-place) . . .	508.56	327.37	835.93
(ii) Net Recoverable Reserves left after production as on 1-1-1978 . .	108.56	186.05	294.61
II. Probable			
(i) Initial Geological Reserves (Oil-in-place) . . .	204.63	600.34	804.97
(ii) Net Recoverable Reserves left after production as on 1-1-1978 . .	14.62	—	14.62
III Possible			
(i) Initial Geological Reserves (Oil in-place) . . .	26.42	72.56	98.98
(ii) Net Recoverable Reserves left after production as on 1-1-1978 . .	7.27	—	7.27

TABLE 4.5

Gas* Resources of India

(As on 1-1-1978)

(in million cublic metres)

Category of Reserve	Onshore	Offshore	Total
I. Definite			
(i) Initial Goelogical Reserves (gas-in-place) . . .	115316	38302	143618
(ii) Initial Recoverable Reserves (Gross ultimate recovery) .	66543	22981	89524
(iii) Net Recoverable Reserves left after production as on 1-1-1978 . .	50650	22792	73442
II. Probable			
(i) Initial Geological Reserves (gas-in-place) . . .	60808	255606	316414
(ii) Net Recoverable Reserves (Gross ultimate recovery) .	35484	134761	170245
III. Possible			
(i) Initial Geological Reserves (gas-in-place) . . .	1020	—	1020
(ii) Net Recoverable Reserves left after production as on 1-1-1978 . .	—	—	—

*Solution, Gas cap and Non-associated gas.

Definite (Proved) : Includes reserves which are considered proved to a high degree of certainty by actual well completion or successful testing. The lateral extent of these proved reserves is limited to those areas where geological control has been established by actual drilling. These reserves are considered to be producible by existing wells, by recompletion of existing wells or by additional development wells.

Probable (Indicated) : Includes those reserves which are defined by less direct well control but are based upon evidence of producible oil obtained from electrical logs or side-wall samples within inferred producing limits of the structure of reservoirs.

Note : The above categories also include reserves estimates credited to fluid injection operations where a positive reservoir response has been noticed.

Possible : Includes additional recovery that may be reasonably expected from the reservoirs where some pressure maintenance schemes have been planned/just initiated.

4.10 The long-term view must, however, take cognisance of the so-called prognosticated resources which are defined on the basis of the total geological analysis of the area. In a paper on "Problems of Oil and Gas Geology in India" presented at the IIIrd ECAFE symposium on the development of petroleum resources of Asia and the Far East in Tokyo (Nov. 1965), N.A. Kalinin described four methods of prognosticated reserve estimates :

— the method of average hydrocarbon reserves per square unit of oil/gas bearing area ;

— volumetric-genetic methods of calculating reserves for one cubic kilometre of oil source rock ;

— estimation method per average structure; and

— estimation on the basis of large scale analogies (platforms, foredeeps, etc.)

On the basis of the first two methods, Kalinin estimated the total (recoverable) reserves of oil at about 4000 million tonnes and gas at 2 trillion cubic metres. More recently, an Indo-Soviet team of experts headed by Prof. Markovich put the geological reserves of oil (or oil-in-place) figure at 12700 million tonnes, of which 8700 million tonnes (69%) offshore and 4000 million tonnes (31%) onshore. The recoverable reserves as estimated by the team is given below :

Area	Onland		Offshore	
	Oil	Gas	Oil	Gas
	MT	MTOE	MT	MTOE
(i) Cambay basin inculding Saurashtra, Kutch and Jaisalmer .	20	80	760	1790
(ii) Assam-Arakan including Tripura .	360	780	—	—
(iii) West Bengal . .	40	560	90	1080
(iv) Punjab & Ganga valley .	60	280	—	—
(v) Other areas e.g. Andaman, Cauvery, Palar, Mahanadi, Krishna, Godavari, etc. . .	20	100	150	330
	500	1800	1000	3200

MT—Million Tonnes

MTOE—Million Tonnes of Oil Equivalent

4.11 It must be emphasized that the prognosticated resources are based on a multiplicity of variables and imponderables/and are, as such, subject to wide fluctuations. They provide, nevertheless, a broad indication of the total theoretical oil and gas resources of the country.

Hydro-Electric Resources

4.12 The assessment of hydro-electric resources of a country is often being worked out as a theoretical potential which represents a theoretical upper limit of the hydro-electric potential that could be developed, were it possible to utilise all the run-off over all the heads, without taking into account the practicability of developing the potential. In a more practical context, assessment of hydro-electric potential is made corresponding to the technically feasible limit of the potential which incorporates the judgement in regard to the possible potential that would be feasible of development dependent on the existing technology. This assessment is thus subject to a degree of change with development of technology of utilisation. Finally there is an economically viable limit of the hydro-electric potential which besides technological factors is dependent on the cost conditions governing the construction of the hydro-electric power projects and the cost of the power generated with reference to other alternative sources of similar energy, which may extend the limit of feasible potential into the less economic schemes.

4.13 The first systematic survey of India's hydro-electric potential was undertaken in 1953—60 by the then Central Water and Power Commission. The scope of the survey covered a systematic assessment of the economically feasible hydro-electric potential of the country, based on the data of topography, development techniques, hydrology, etc. then at hand. It was felt that under Indian conditions, it would not be very meaningful to estimate the theoretical potential of the hydel resources. The flows in the Indian rivers vary very widely from thousands of cusecs in the monsoon season to a few cusecs in the dry season. The generation capacity and size of the grids in the initial stages made regulatory facilities essential to a much greater degree than today for the absorption of useable power from Indian river sources and the limits of regulations set by topography, etc. formed important constraints in technical and economic feasibility. Problems of submergence as well as water requirements for priority uses such as irrigation, industry and households also have an impact in the actual magnitude of utilisable power potential. In view of these, the estimation of hydro-electric potential resources was done by identifying specific schemes in each river basin with potential for hydro-power generation and having features, which would be technically feasible and economically viable. Potential sites were identified with reference to large scale topo-maps and the hydrological data were developed with rainfall data and the limited data on water run off, that were available at that time. Technical feasibility and economic viability were considered with reference to the quantity and nature of the physical works required and the physical proportion of the civil works in relation to the benefits. On this basis, 260 possible schemes were identified as those with economic viability and the total firm hydro-electric potential was estimated to be equivalent to an annual energy generation of 216 TWH*.

4.14 Even while drawing up these estimates it was indicated that in certain regions, especially in the Himalayas, some more viable potential might be identified later. As expected, this was borne out by studies and investigations done particularly in the upper reaches of some of the Himalayan rivers subsequent to the survey. The Central Electricity Authority has organised a technical group to make a systematic re-assessment by first evaluation of available information relating to investigations of specific hydro-electric schemes and then to take up further studies to re-assess the economically feasible hydro-electric resources of India and also to attempt an assessment of theoretical potential. The technical group commenced this work early in 1978.

4.15 The re-assessment will take into account the technological advances and experience in regard to assumption of possibilities of construction of more complex and advanced structural elements of project work. It will make use of better information regarding topography of the various parts of the country particularly the upper reaches of Himalayas and also greater information on the hydrological conditions that is now available based on investigations which have been carried out for a large number of projects by now. The hydro-electric survey will also attempt to locate some viable pumped storage sites. An attempt will also be made to make an assessment of theoretical potential although constraints in regard to its utilisation still remain. The work of re-assessment is presently in its initial phases. Even at the present stage of studies, however, some useful inputs can be provided to enable the consideration of a more optimal national policy for better utilisation of the hydro-electric resources.

4.16 The tentative results of the re-assessment exercise, which is still incomplete, indicate that the total hydro-electric potential is equivalent to 396.3 TWH of annual energy generation. A regionwise break up of the tentative estimate is given in Table 4.6 alongwith the earlier estimation of the potential.

TABLE 4.6

Hydro-Electric Potential

(As per 1960 survey and 1978 reassessment)

Region	Potential as per 1960 Survey — Annual Energy Potential TWH	Potential as per 1978 reassessment — Annual Energy Potential TWH	% change in Potential
Northern	56.4	147.3	+161.2
Eastern	19.1	37.6	+96.9
Western	37.7	37.7	—
Southern	42.5	68.2	+60.5
North-Eastern	65.5	105.5	+61.1
All India	221.2	396.3	+79.2

It is seen from the above that an increase of the total utilisable hydro-electric resources by about 83% is estimated. It will be noted that an increase is

*Assuming development at the prevailing annual load factors of 60% this would be equivalent to 41,155 MW.

estimated in almost all the regions but the magnitude is higher in the Northern and Eastern Regions where considerable power potential lies in the Himalayan range.

4.17 The potential which has already been developed till the end of 1978 is 39.4 TWH which is about 10% of the total available potential. The utilisation of the available potential, as expected, has not been even in the various regions, as shown in Table 4.7.

TABLE 4.7

Hydro-Electric Potential Status of Development

Region	Energy Potential as per 1978 re-assessment-TWH	Energy Potential developed March 1979-TWH	% of potential developed
Northern	147.3	13.4	9.1
Eastern	37.6	3.0	8.0
Western	37.7	6.6	17.5
Southern	68.2	16.1	23.6
North-Eastern . . .	105.5	0.4	0.4
All India	396.3	39.4	9.9

4.18 The lower degree of utilisation, for evident reasons, is in the North Eastern Region which constitutes a major reservoir of hydro-electric energy. The maximum utilisation has been achieved in the Southern Region.

4.19 It may be mentioned that the assessment of the average potential is based on water inflows which can be expected with 90% dependability, which means inflows which are likely to be available in 90 out of 100 years. It would be generally possible to achieve a greater average energy utilisation keeping in view the fact that in years of goods inflows additional energy generation would be possible at no cost to the utility.

4.20 The hydro potential in the above analysis has been expressed in term of energy. It is also customary to express the potential in MW at a specific load factor. A load factor of 60% is being adopted in the power potential studies to represent the potential in terms of capacity. This does not truly reflect the capacity value of the hydel potential, as this does not tally with the average load factor of hydel plants obtaining at present, which is about 42%. At this load factor, the total power potential in MW would be of order of 100,000 MW and the corresponding potential already developed would be about 10,830 MW which was the total installed hydro capacity in the country at the end of 1978-79. The Region-wise distribution of the installed capacity is given below :

Region	Installed Hydro Capacity in MW
Northern	3718
Eastern	895
Western	1770
Southern	4303
North-Eastern	146
All India	10832

4.21 The present re-assessment is not expected to cover micro/mini hydro-electric schemes due to problems in establishing norms of technical and economic feasibility because of several constraints. However, the general topography and other conditions in various part of the country, particularly in the sub-mountainous regions, are such as to permit development of a large number of such schemes. Some of these may not be considered economic under present conditions but apart from changing economic considerations necessitating maximum utilisation of hydro potential, the micro/mini hydel schemes serve a very useful purpose in making available, with least maintenance and operation problems, power supply in remote and isolated regions and thus meeting not only a social requirement but creating conditions for the overall development of these remote regions. Further, advances in the development of low head bulb type units and the increasing irrigation and canal works are adding to the potential for low head developments. Although an accurate assessment is difficult, it is considered that the mini, micro, canal drop and other probable low head developments in the country provide an additional hydro potential equivalent to an annual energy generation of about 25 TWH.

4.22 In view of the size of the resource, the potential for its perennial utilisation and possibilities of using it for peak power supply for which alternative modes of power generation would be very expensive, the hydro-electric resources of India represent a very valuable energy source. The costs of hydro-electric projects brought into use in the last five years indicate that the cost of construction varies from Rs. 3000 to Rs. 10,000 per kW at current prices. The average cost works out to Rs. 5000 per kW.

Nuclear Resources

Uranium

4.23 Extensive prospecting and exploration efforts of the Department of Atomic Energy have led to the discovery of occurrences of Uranium in a number of locations. The most important deposits of Uranium ore are located in the Singhbhum region in Bihar. New target areas have recently been identified in the crystallines of Madhya Pradesh and some significant Uranium deposits have been discovered. The exploration efforts have revealed Uraniferrous zones in the precambrian conglomerates in Rajasthan and struturally controlled Uranium deposits in parts of Central India. Uranium is also found as a by product from other mineral industries. Sizeable quantities have been established to be available as a byproduct of copper tailings from the Singhbhum part of Bihar and recovery operations have already commenced.

4.24 Uranium mined in India has, in the past, been more expensive than in many other countries since the Uranium concentration in the ore is relatively low. However, even though Uranium concentrate prices have increased very steeply in the international market, our prices allowing for reasonable returns have not and currently compare very favourably with international prices.

4.25 The reasonably assured Uranium resources in India are about 34,000 tonnes U_3O_8 of which about 15,000 tonnes are considered economically exploitable at current international prices. Estimates of likely additional resources are placed at 27,000 tonnes U_3O_8. The established Uranium sources are estimated to be capable of supporting a first stage nuclear power programme consisting of natural Uranium reactors of about 8000 MW installed capacity. It may be possible to support a larger programme of first stage reactors, if the present exploration programme yield other viable sources. With the eventual introduction of fast breader reactors in the subsequent stages, many times the capacity mentioned earlier can be supported by even the currently known reserves of Uranium.

Thorium

4.26 One of the largest reserves of Thorium contained in monazite deposits occur along the Indian sea board and in the inland places. The deposits are expected to yield 363,000 tonnes of Thorium Oxide (ThO_2). When Thorium fuelled reactors are constructed in the subsequent stages of the nuclear programme, this resource base can support a very large capacity indeed, for a long period of time.

Fuel-Wood Resources

4.27 Firewood is the most important source of non-commercial fuel in India. Firewood is obtained not only from forests but also from trees which exist outside the forests—in the privately owned plantations and woodlots, on the bunds in the cultivated lands, on roadsides, on the banks of rivers and canals and around private houses. The data collected in the 28th Round National Sample Survey indicates that about 22 per cent of the total consumption of firewood (or about 25 million tonnes) is obtained from private lands and gardens and from trees around houses. Though the quantity obtained from forest lands is not known, it is reasonable to assume that forest lands represent the most important potential source of fuelwood.

4.28 The area under forests in India is approximately 0.75 million sq. km. which is about 23 per cent of the total geographical area of the country. Though it is generally believed that the forests are getting denuded at a fast rate, the records of land-use do not indicate any shrinkage of the area under forests in the last twenty years. The distribution of forests and the per capita area under forests in different States shows that the area per person of population varies very widely as between the different States from a minimum of 0.01 hectare to a maximum of 0.91 hectare the average for the country as a whole being 0.13 hectare. Even if, in the long run, the fuel wood resources of forest areas are likely to be utilised by the rural population only, the forest area per rural person is found to be widely divergent in different States. As the transport costs form a large proportion of the final price of fuelwood to consumers, the availability of firewood, policies for its use and conservation have to be discussed with due regard to the Statewise variation in the resource position.

4.29 Not all the area under forests is in use. Of the total area under forests of 75 million hectares, 45.6 million hectares (60 per cent) are in use and another 14.8 million hectares (20 per cent) are potentially exploitable, and the rest unexploitable. Most of the unexploitable areas are in the Himalayan States, the North-Eastern region and the Andaman & Nicobar Islands.

4.30 As discussed earlier, the area under forests is no indicator of the quantity of wood available in the forests which could be indicated by the index called 'Growing Stock' and the annual increment in growth of the forests by the index called 'Mean Annual Increment'. These indices would depend on the nature of the forest, the varieties of trees in the forest etc. Adequate information is not available about the quantities of wood that each of these species have per tree or per hectare. Growing stock estimates made by different agencies on various occasions have yielded different results. See Table 4.8 below :

TABLE 4.8

Estimate of Growing Stock in Forests

Item	As per Forest Centenary publication 1961	As per Indian Forest Statistics 1969	As per the compilation for Commonwealth Conf. 1968	Tentative estimate of P.C. in 1972
In million cum (a)	1126	2510	2611	1727
In million tonnes (b)	901	2008	2089	1382

Notes: (a) Data have been compiled in the reports in terms of volume in cum.

(b) Converted to tonnes assuming 1 tonne=0.8 cum.

4.31 These are at best well informed guesstimates. The Pre-investment Survey, made by Govt. of India (in 1965) in collaboration with F.A.O., investigated the forest resources in three small selected areas of the country using modern appraisal techniques and gave results which indicated that the quantity of growing stock would be widely differing in the different areas.

TABLE 4.9

Results of Pre-Investment Survey of Forest Resources in 1965

Item	Unit	Central Zone	Northern Zone	Southern Zone
1. Area surveyed	Million hectares	2.02	0.412	0.506
2. Growing stock	Million cum	132.0	82.7	110.0
4. Growing stock per hectare	cum/ha.	65.7	200.7	217.4

4.32 It is seen that growing stock per hectare can be as high as 200 cum per hectare in good forests and can be as low as 65 cum/ha. also. The most optimistic forecast made for the country as a whole implies an average growing stock of about 35 cum/ha. only. Furthermore, all the estimates of growing stock appear to have been made with reference to timber production and so set out the growing stock in terms of volume under bark and exclude the wood from branches. As fuel needs could be met conveniently from branch wood and bark, the growing stock for purposes of assessing the fuel wood resources would be higher than the figures discussed above.

4.33 The Gross Annual Increment of forest represents the additional wood produced each year in the forests. If the extent of removal of wood from the forests is at about the same level as the annual increment and if such extraction is scientifically managed, the stock of wood in the forest should remain undiminished. The annual increment in Indian forests has not been estimated in a sufficiently detailed and reliable manner. While the official estimates place the Gross Annual Increment at about 33.3 million cum, some experts claim that the actual Gross Annual Increment is not less than 60 to 70 million cum in terms of timber wood. The rate of annual increment per hectare is only 0.36 tonnes as per official estimates. All these calculations are exclusive of bamboo growth and consumption.

4.34 These estimates appear to be very low, when compared to estimates of dry biomass yields for sub-tropical forests in USA, where studies indicate an annual increment (of total biomass) of about 24.5 tonnes/ha.* Other sources indicate that Mean Annual Increment of wood might be about 5 t/ha in the tropical zone, 4 tonnes/ha in temperate and 1 tonne/ha in dry tropical forests.** The under-estimation may be the result of the Indian surveys assessing only the wood under bark exclusive of branch wood while the U.S. studies include all biomass. It might also be due to the relatively poor stocking of trees in our forests compared to U.S. forests in similar geographic zones.

4.35 The wood from forests would have to meet the demand for industrial use besides meeting the fuel requirements. The needs of industrial wood is only a small fraction of the needs for fuel requirements. Consumption of Industrial wood was about 12.7 million tonnes in 1965 and is estimated to be about 32.6 million tonnes in 1990.***The consumption of wood (from all sources) as fuel was about 104 million tonnes in 1965 and about 126 million tonnes in 1975.

* See Energy for Rural Development : Renewable Resources and Alternative Technologies for Developing Countries. National Academy of Science USA. Washington, 1976. p. 169.

** See Dean E Eral, Forest & Eco. Development, Oxford University Press, 1975. p. 46.

*** Estimate given in "Indian Report on Production Forestry—Man Made Forests" National Commission on Agriculture. G. O. I., New Delhi, 1972.

4.36 The analysis shows that the available information about the existing fire-wood resources in the forests is woefully inadequate. We have neither information on the level of stock of fuelwood now available in the forests, nor the quantities added each year by growth of trees. If the published data is taken as the basis, one could conclude that the growing needs for industrial wood (which is an important charge on the wood resources in the forests) would increase over time and that by 1990, the forests could meet only the timber needs. But it is also possible to take the deficiencies of data into account and state that if the average biomass production in Indian forests is even one fifth of the biomass production reported in subtropical forests in USA and if one fifth of the biomass can be used as firewood, the annual yield of wood for fuel purposes can be 0.98 tonnes per hectare. The firewood obtainable from forest lands alone can be over 73 million tonnes. The Working Group considers the state of our knowledge about fuelwood resources in the forest areas is very inadequate and would like to recommend strongly that urgent measures should be initiated to assess the fuelwood resources of our forests on a systematic and scientific manner. As the methods normally followed appear to be based mostly on measurements and microstudies made with a view to assess the logwood and timber extractable from the forests, which are time consuming and cumbersome there may be need to design survey methods and norms specially for Indian conditions based on modern developments in resources assessment. The Group therefore recommends that the methodology for assessment of fuelwood resources should be examined by a Committee of technical experts including experts on rural energy and fuel technology.

4.37 There are trees outside the forest areas also. No attempt has been made to collect systematic data on the growing stock of wood in the areas outside the forests. In the most systematic survey done of forest resources in 1965, the growing stock in non-forest area was also estimated and roughly in the 0.97 million hectares of non-forest land covered by the survey, the growing stock was estimated to be about 9 million cum. Roughly a little over 9 cum. growing stock per hectare can be taken to be the results of this survey regarding non-forest lands. It is not clear whether this result could be used to estimate the growing stock of non-forest land. Even if the growing stock in the country on the whole in non-forest lands is about half of this estimate, the total growing stock in non-forest lands could be about 1150 million cum. If trees have a life cycle of 30 years, the annual increment can be taken to be on the average of about 38 million cum. or about 30 million tonnes of fuelwood. The Committee would recommend that in view of the importance of trees in non-forest lands as a source of fuel for domestic consumption a survey should be organised to estimate the total fuelwood available in the non-forest areas.

4.38 In the case of regenerative resources unlike in the fossil fuels, there is no finiteness about the resource availability. Forests can be grown in new areas and the extent of availibility would depend on the nature of the trees, the years they take to mature and the area which is taken up for afforestation. A number of quick growing fuelwood species which can yield upto 10 tonnes per hectare are known in India. Some of the news species not known in India but considered to be suitable for our climatic conditions like Ipil-Ipil are reported to yield upto 25 tonnes per hectares per year. The potential for growing forests in India has to be established with reference to the lands which could be allocated to afforestation and the extent of area in the reserve forests which can be restocked with quick growing fuelwood species. National Commission on Agriculture (1976) and fuel Policy Committee (1974) have strongly urged the widespread adoption of the scheme for Social Forestly developed by the National Commission on Agriculture. The potential that could be created as a result of this should be taken into account in assessing the long-term resource availability of fuelwood for use in the energy sector.

Agricultural Waste

4.39 The amount of agricultural waste arising in the country would depend on the extent of agricultural production. The quantity of waste material which arises with different crops varies with the crop. There are very few reliable studies on the quantity of vegetable material produced with each crop and such data, as are available from different sources are not consistent with each other. This is not surprising as the agricultural waste contains a great deal of moisture and the estimations of waste material, made with different objectives in view, have not been made under comparable conditions. However, on the basis of the best available information, an estimation of the agricultural waste that might have become available in the country in 1975-76 is given in Table 4.10 :

TABLE 4.10

Agricultural Waste Production (1975-76)

Description	Area (thousand hectare) A	Production (thousand tonnes) Y	Agri. waste (thousand tonnes) (estimated)
Rice	39475	48740	77984
Wheat	20454	28846	50480
Maize	6031	7256	8707
Cotton	7350	1012	3036
Jute	584	755	1510
Barley	2802	3192	4788
Other minor crops	67422	36157	28926
Sugarcane	2762	140604	28121
TOTAL			203552

4.40 Against the total agricultural waste which could be around 200 million tonnes, the actual consumption as fuel might be about 40 tonnes (see Chapter II). There are several competing uses for agricultural waste like use as fodder for household animals, as roofing material or as organic matter for compost making. The allocation of available agricultural waste to different uses would depend on the availability of alternative materials for these uses, the prices at which they are available the social conventions regarding the use of agricultural waste for different purposes, etc. It is however seen that wherever agricultural waste arises in a sizeable quantity at a place where there is a use for it as a process fuel, the waste is invariably used e.g., the use of bagasse in sugar khandsari and jaggery industries. Even the organised sugar industry finds it convenient and economical to use the bagasse, which is produced by crushing sugarcane, for providing the heat and steam required for manufacture of sugar. In the unorgainsed sector, the bagasse is used in the ovens for concentrating sugarcane juice. The paddy husk that comes as a waste product from the rice milling industry can also be used for supplying heat required for parboiling the rice for milling. But the use of paddy husk is not so widespread at the moment, but there are efforts to make greater use of paddy husk in the rice milling industry. The use of agricultural waste as a raw material for biogas production is also under experimentation and development. Microbial fermentation of agricultural waste can yield liquid fuels, but the technology has not been developed to the required level of economic efficiency. It is difficult on the basis of available information to estimate the share of the agricultural waste that would be normally used as fuel or the optimal level of the use of agricultural waste as fuel. But the steady increase in the agricultural production can be expected to steadily increase the total quantity of agricultural waste available and a substantial part of it can be used as a source of energy, if appropriate procedures for collection and technologies for efficient utilisation are developed.

CHAPTER V

ENERGY IN THE HOUSEHOLD SECTOR

5.1 The household sector is the largest consumer of energy accounting for about 50 per cent of total energy consumption. Most of the energy used in this sector is in the form of non-commercial energy. Energy is used in the households essentially for cooking and lighting. Some energy is also used for space heating|cooling and water heating but the quantities involved are very small compared to the quantities required for cooking and lighting. The pattern of fuel consumption varies between the urban and rural households and there are also variations within each class depending on the household incomes. The lighting needs are mostly met by kerosene and to some extent by electricity. There is evidence that a small portion of the population still use non-edible oils and vegetable waste as illuminants. The energy for cooking is derived mostly from firewood and agricultural waste and to some extent from kerosene. The use of LPG as a cooking fuel is still very small.

TABLE 5.1

Consumption of Commercial Energy in the Household Sector

(in million tonnes of Coal replacement)

Energy from	1953-54	1960-61	1965-66	1970-71	1975-76	1978-79*
Coal	2.2	2.8	4.1	4.1	3.7	4.0
Oil Products (including LPG) . .	9.8	16.5	20.0	27.6	27.9	28.76
Electricity . . .	0.7	1.5	2.4	3.8	5.8	7.7
Total . . .	12.7	20.8	26.5	35.5	37.4	40.3

*Provisional

Commercial Energy

5.2 The consumption of Commercial energy in the households is fairly reliably estimated. These data are examined first.

5.3 A comparision of the commercial energy forms used in the household sector in 1953-54 and 1975-76 shows that the share of coal has declined from 17.3 per cent to 10.0 per cent and that of oil from 77.2 per cent to 71.0 per cent while that of electricity has increased from 5.5 per cent to 19.0 per cent. Soft coke is used as a domestic fuel mostly in the States of Bihar, West Bengal, U.P. and Delhi. Kerosene is used as an illuminant in all the States and is the chief source of energy for cooking in the metropolitan cities. Most of the energy consumed as electricity serves to illuminate households. The rapid increase in the number of towns and villages electrified has given an impression that the number of unelectrified houses is fast diminishing. Facts prove that this is not the case. All the towns (over 10,000 population) numbering 2699 in India have been electrified. Of the total number of 570,000 villages, about 2,30,000 have been electrified. The number of households electrified has increased from 3.7 million in 1960-61 to 16 million in 1978-79. Inspite of electrifying all towns and about 44 per cent of villages, the percentage of households electrified remains at about 14.0 per cent only. Even with the acceleration in the pace of electrification in the seventies, the number of new electricity connections to houses has increased at the rate of about one million households a year, while the number of new households has been increasing at the rate of about 2.2 million per year. In otherwords, the number of non-electrified houses is steadily increasing inspite of the accelerated rural electrification programmes. Studies show that in any electrified village only 10 to 14 per cent of the houses obtain electricity for household purposes and the rest of the houses do not switch to electricity as the householders are not able to pay for the inital investment required to set up the switch board and for the wiring arrangements to receive electricity. Further, the construction materials used in the housing also set a limit to the extent of electrification. NSS Survey of Housing (1973) reveals that the percentage of pucca houses is about 65 per cent in the urban areas and hardly 19 per cent in the rural areas. The number of huses using electricity for lighting is only about 45 per cent of the houses in the urban areas and about 5 per cent in the rural areas.

5.4 Data relating to kerosene use for lighting is not available separately. It is therefore difficult to estimate the number of households which use kerosene either solely or partially for meeting the cooking needs. Based on the technical data* of the requirement of kerosene

*See foot note to Table 5.5

for lighting and cooking and assuming that houses which are not electrified use kerosene only for lighting, some rough estimates of the quantity of kerosene used for cooking were made. If it is assumed that the quantity of kerosene thus estimated is used by households as their only fuel for cooking, the number of such house holds would amount to 5 million only. But as a number of households use kerosene as a supplement to fuels like firewood etc., the number of houses which use kerosene will be substantially higher. The number of households using LPG is estimated to be over 1 million. The remaining households are dependent on other non-commercial fuels such as firewood, agricultural waste and animal dung cakes for meeting their cooking energy needs. Their number still continues to be over 90% of the total households in the country.

Non-Commercial Fuels

5.5 The important sources under this category are fuel-wood, cow-dung cakes and agricultural waste. The household surveys of NSS (18th round and 28th round) indicate that some other fuels like non-edible oils and animal fat are also used in certain areas in small quantities. The quantities involved are, however, too small to affect the analysis made in this report. The rural areas rely mainly on the available and usable firewood, animal dung and agricultural waste for cooking, as these are obtained at near zero private cost. It is not the poor alone who use non-commercial fuels, but also the rich in rural areas who seem to get their non-commercial fuels more from their own lands than by collecting from public lands and forests. Waste wood from trees in non-forest areas, trees cut for replantation, branchwood and wastewood from fences, etc. are used as fuel. The quantity of wood collected from registered forests for rural consumption as fuel is only a part of the total fuel use. The information from the latest Census of Energy Consumption in Households (28th round of NSS) gives some indication of the shares of different fuels used in households and the sources of their supply and is summarised in Table 5.2.

TABLE 5.2

Energy Consumption in Households Shares of Fuels and Sources of Supply

Energy	Rural per capita energy consumption				Urban per capita energy consumption			
	% share of energy forms	% share of source of supply of each form			% share of energy forms	%share of source of supply of each form		
		Purchased	Collected	Home grown		Purchased	Collected	Home grown
1	2	3	4	5	6	7	8	9
1. Electricity	0.6	100.0	0.0	0.0	5.9	97.0	3.0	0.0
2. Oil Products*	16.9	100.0	0.0	0.0	30.2	100.0	0.0	0.0
3. Coal Products	2.3	65.1	34.9	0.0	13.7	95.6	4.4	0.0
4. Firewood	68.5	12.7	64.2	23.1	45.5	73.7	14.8	11.5
5. Animal Dung	8.3	5.1	26.2	68.7	3.2	49.1	12.3	38.6
6. Others	3.4	8.9	61.0	30.1	1.5	71.2	28.8	0.0
7. Share of commercial fuels	20%				49%			
8. Share of non-commercial fuels	80%				51%			

*A very small part of the oil products included in the data may relate to motorgas used for private cars and two wheelers.

Note: Shares have been worked out by converting consumption of various forms of energy to coal replacement measure.

As seen from table 5.2 the share of non-commercial energy is over 80% in rural areas as compared to 51% in urban areas. It is note-worthy that even in 1973-74 the share of electricity in the total energy consumption in the household in rural areas is less than 1% and even in urban areas it is less than 6%. A little less than half of the energy consumed in households in urban areas is in the form of firewood. In rural areas, firewood contributes a little over two thirds. As could be anticipated, the share of purchased non-commercial fuels is very high in the urban areas; nearly half of animal dung and about two thirds of the firewood needs of urban households are obtained by purchases. The results of this survey compared with the results of NSS 18th round shows that non-commercial fuels are becoming commercial in urban areas and a similar trend though at slower pace, is observed in rural areas.

5.6 There is noticeable income elasticity of consumption of fuels in the household sector both in the urban and the rural areas. The data collected in the 28th Round Survey of NSS can be interpreted as in Table 5.3 :

TABLE 5.3

Index of Income-wise Energy Consumption in the Household Sector

Expenditure class Rs. per month per capita	Index of Total per capita energy consumption in	
	Rural	Urban
All expenditure class together	100	100
(i) 0–21	66	48
(ii) 21–28	80	61
(iii) 28–43	90	82
(iv) 43–75	101	96
(v) Above 75	138	125

5.7 The lowest income groups consume hardly half the energy consumed by the highest income group. The relatively less skewed distribution of household energy consumption in the rural areas as compared to the urban areas might be due to the easier and more abundant availability of zero private cost fuels in the rural areas.

5.8 A comparison of the nation-wide survey of household energy consumption in 1963-64 (18th round) and 1973-74 (28th round) by the NSS organisation, suggests that the average per capita consumption of energy has not changed significantly during this period. For the purpose of this study, it is assumed (as in the earlier reports) that the annual per capita consumption in households is :

0.38 tonnes of coal replacement in rural areas.

0.40 tonnes of coal replacement in urban areas.

Reference Level Forecast (RLF) of Demand for Energy in the Household Sector

5.9 After trying out several methods available for forecasting the long term energy demand in the household sector, the Working Group decided to adopt the 'scenario approach' in which the likely development in energy consumption in the household sector visualises using as pointers, the current level of consumption, trends of change in the past, the widely accepted goals towards total rural electrification and substitution of non-commercial energy by commercial energy to the extent possible. The various steps involved in the forecasting exercise were as follows :

(a) On the basis of the consumption of different fuels in the households sector in the past, the data of the National Sample Survey and the computed consumption of Commercial fuel for meeting the lighting and cooking needs of average household, the number of households using electricity and kerosene for lighting and LPG, kerosene, soft coke and non-commercial fuels for cooking in 1975-76 were estimated.

(b) The trend in the electrification of household sector and the rate of rural electrification at present were kept in view and the number of households electrified per year was assumed to increase in each plan period as follows :

2.14 million households in the period 1975-76 to 1982-83

3.6 million households in the period 1982-83 to 1987-88

4.0 million households in the period 1987-88 to 1992-93

5.0 million households in the period 1992-93 to 2000-01

It was assumed that electrification would lead only to use of electricity for lighting and recreational needs and not for cooking.

(c) The level of LPG use was projected keeping in view the availability of LPG in different periods from indigenous oil and gas production.

(d) Keeping in view the various efforts being made to increase the production of soft coke by traditional as well as by new technology, the level of soft coke production was assumed at 6.5 million tonnes in 1982-83, 9 million tonnes in 1987-88, 14 million tonnes in 1992-93 and 30 million tonnes in 2000-01. Roughly this would mean that the soft coke production would have to increase by 0.5 million tonnes/year in the period 1982-83 to 1987-88, another 1 million tonnes/year in the period 1987-88 to 1992-93 and a further 2 million tonnes/year after 1993.

(e) Kerosene consumption was projected at a rate which would enable the consumption of non-commercial fuels for cooking to be reduced to about 70% of households in the rural areas and about 10% in the urban areas.

5.10 The pattern of change in the consumption of fuels in households in urban and rural areas is given in Table 5.4.

TABLE 5.4

Change in the Pattern of Fuel/Energy use in Households 1975—2000

REFERENCE LEVEL FORECAST

(in percentage)

	Rural					Urban				
	1975-76	1982-83	1987-88	1992-93	2000-01	1975-76	1982-83	1987-88	1992-93	2000-01
					For Lighting					
Electricity .	4.4	12.9	19.3	27.6	45.2	42.1	53.0	62.3	73.8	89.0
Kerosene . . .	91.4	84.0	78.8	71.4	53.9	53.6	45.2	36.9	25.5	10.4
Others . . .	4.6	3.1	1.9	1.0	0.9	4.3	1.8	0.8	0.7	0.6
Total . . .	100	100	100	100	100	100	100	100	100	100
					For Coocking					
LPG . . .	0.0	0.8	1.2	1.6	2.7	5.0	8.4	12.7	16.4	24.8
Kerosene . . .	0.6	4.0	8.7	13.3	22.3	17.2	26.5	32.2	38.6	50.3
Soft coke . . .	0.4	0.7	1.1	2.2	5.0	4.6	7.0	8.1	9.0	14.1
Non-Commercial .	99.0	94.5	89.0	82.9	70.0	73.2	58.1	47.9	36.0	10.8
Total . . .	100	100	100	100	100	100	100	100	100	100
No of House hold in Million	90.1	100.9	108.6	116.1	128.3	26.1	32.1	36.9	42.0	51.7

5.11 Based on these projections, the demand for different energy forms derived as the Reference Level Projection would be as given in Table 5.5 :

TABLE 5.5

Demand for Energy in the Household Sector

REFERENCE LEVEL FORECAST

Energy from	Units	1982-83	1987-88	1992-93	2000-01
Electricity .	TWH	10.70	15.50	22.00	35.80
Kerosene (Total)	Million tonnes	4.76	6.57	8.57	12.95
LPG . .	Million tonnes	0.71	1.22	1.79	3.31
Soft Coke .	Million tonnes of Coal equivalent	5.20	7.20	11.20	24.0

Note : The demand for fuels was estimated on the assumptions that the per household annual consumption is as follows :

	For Lighting		For Cooking	
	Rurals	Urban	Rural	Urban
Kerosene	24 Litres	36 Litres	240 Litres	240 Litres
Electricity	300 kWh	400 kWh	—	—
Soft Coke	—	—	1.750 tonnes	1.750 tonnes

Share of commercial and non-commercial energy :

5.12 As already discussed, Commercial energy forms provide only a fraction of the energy needs of the households, while the major part of the requirements are met from non-commercial sources of energy. The quantity of non-commercial energy used is estimated by adopting the methodology described in para 2.6 of Chapter II earlier. The total energy need of the households and the likely share of commercial and non-commercial fuels are estimated as in Table 5.6 :

TABLE 5.6

Demand for Total Energy in Household Sector and Share of Commercial and Non-Commercial Fuels

REFERENCE LEVEL FORECAST

Year	Energy Demand			Percentage shares of	
	Total	Commercial	Non-commercial	Commercial Energy	Non-Commercial Energy
	(in million tonnes of coal replacement)				
1982-83 . .	255.7	51.6	204.1	20.2	79.8
1987-88 . .	276.1	73.3	202.8	26.5	73.5
1992-93 . .	296.4	100.6	195.8	33.9	66.1
2000-01 . .	329.0	165.5	163.5	50.3	49.7

In the RLF of household energy demand, it is estimated that by the end of the century, the non-commercial energy used would get reduced from the current level of about 80% to about 50%.

Share of non-commercial fuels

5.13 The shares of firewood, vegetable waste and animal dung in the total non-commercial energy used were estimated to be 65%, 20% and 15 per cent respectively on the basis of a survey in the early sixties. The NSS (18th and 28th rounds) data suggest that the share of animal dung has declined over the years. But the evidence is not conclusive and there is no estimate of the rate at which the shares of different non-commercial fuels have changed. The increasing agricultural production would suggest that the share of agricultural waste might have increased over time. In view of the uncertainties regarding the likely share of firewood, animal dung and vegetable waste. the Group has assumed for the purposes of RLF of household energy demand that the past ratios would continue. The consumption of non-commercial fuels as derived in these exercises is set out in Table 5.7 :

TABLE 5.7

Demand for Non-Commercial Fuels

REFERENCE LEVEL FORECAST

(In million tonnes of coal replacement)

Year	Total Non-commercial energy	Fire wood	Agrl. waste	Animal Dung
1982–83 . .	204.1	132.7	40.8	30.6
1987–88 . .	202.8	131.8	40.6	30.4
1992–93 . .	195.8	127.3	39.2	29.3
2000–01 . .	163.5	106.3	32.7	24.5

5.14 The forecast of dmand for non-commercial fuels in original units is given in Table 5.8 :

TABLE 5.8

Non-Commercial Fuel Consumption in Households

REFERENCE LEVEL FORECAST

(In million tonnes)

Year	Firewood	Agrl. waste	Animal Dung
1982–83	139.7	42.9	76.5
1987–88	133.7	42.7	76.0
1992–93	134.0	41.3	73.3
2000 01	111.9	34.4	61.3

Note : Computed from table 5.7.

Non-commercial energy consumption which was about 194 MTCR in 1975—78 increases to a maximum of 204 MTCR in 1982-83 and from then on diminishes slowly. In other words, inspite of the population increase, the absolute level of non-commercial energy use could start declining from the year 1982-83.

5.15 As agricultural waste and animal dung are products available at low private cost to most of the consumers, it may not be realistic to assume that their use in absolute quantities would decline, especially when the price of commercial fuels like kerosene is increasing and is likely to be very high beyond 1982-83. It might be more rational to assume that the absolute quantities of agricultural waste and animal dung might at least remain at the maximum levels reached in 1982-83. This would in effect mean that the quantity of firewood demand in the years after 1982-83 might be lower than in the RLF. These adjustments have been made in the OLF of demand for non-commercial fuels. It is also possible that in view of the increase in total agricultural production in the years beyond 1982, there would be an increase in the availability of agricultral waste and this might increase the quantity of such waste used in households. In the case of animal dung, only a part of the total available dung is used for fuel, as the rest of what is collected, is used for fertilising agricultural lands. With the popularisation of biogas plants, which would enable the use of dung for fuel purposes, without foregoing its use as a nutrient, there might be an increase in the quantity of animal dung used as fuel in the household sector. These possibilities are further examined in the chapter on Rural Energy Policy.

Optimal Level Forecast (OLF) of Energy Demand in the Household Sector

5.16 When the results of the Demands for fuels for all sectors as per the RLF were examined along with the results of the exercise on availability of fuels, the Working Group felt that it would be desirable and even absolutely necessary to modify the pattern of fuel consumption as projected in the RLF. It was also felt that the oil consumption should be reduced considerably and the emphasis should be on the increased use of renewable energy resources. In the household sector, the adoption of these guidelines towards optimisation of fuel consumption can lead to several policy prescriptions. The Group examined these and opted the following in deriving the OLF of demand for energy in the household sector :—

(a) The fuel efficiency of lighting in households and commercial enterprises is not very high and there is scope for improvement. The use of fluorescent lamps and vapour bulbs and more efficient lighting system designs are under development and many of them are likely to be available for widespread use in the coming years. It would, therefore, be reasonable to adopt certain targets of improvement in consumption efficiency of electricity in the household sector for different plan periods. The Group assumed that upto 1982-83, there would be no change in the efficiency but as a result of measures to be initiated from now on, there would be efficiency improvement in the household sector as follows :

1987–88	2.5%
1992–93	5%
2000–01	10%

(b) The data in Table 5.4 suggest that even by 2000 A.D., about 54 per cent of the rural households and 10 per cent of the urban households, numbering in total 74.7 million, would use kerosene for lighting and about 1.54 million tonnes of kerosene are likely to be used for lighting purposes. As it is anticipated that by 2000, all the villages are likely to be electrified, there is a possibility of electrifying all the houses also by that year. While this would save about Rs. 200 crores worth of kerosene per year at current prices, the electrification of these additional households would require nearly Rs. 2250 crores of private investment (at the rate of Rs. 300 per household) and over Rs. 5000 crores in public investment at current prices, over a 20 year period, or Rs. 300 crores per year. The Group felt that the additional investments could be reduced considerably if the normal specifications and rules regarding electrification of households were modified. The costs and benefits of electrifying the unelectrified houses in the villages already electrified would vary from village to village. The Group did not take note of the likely level of useful substitution on account of such intensive electrification of households, as there are a number of unresolved issues relating to this. The Group would, however, like to recommend that the possibility of complete electrification of all households in all the electrified villages be given serious consideration, as it would improve the quality of life in addition to economic and other benefits.

(c) The anxiety to replace the use of non-commercial fuels, especially firewood, by commercial fuels in the decade of the sixties and early seventies was due to a growing apprehension that our forest resources were being depleted. As discussed in Chapter IV on Fuel Wood Resources, the areas under forests in the country and the areas on which fuel wood can be grown like road sides, tank bunds, etc. are very large and the possibility of increasing productivity of forests by more scientific cultivation of high yielding fuel wood species deserves further consideration. It would appear that if adequate investment is made in fuel wood development, the availability of fuel wood can be increased to levels much beyond what has been forecast. In fact, the social forestry scheme under which fuel wood supply would be increased from new plots close to village sites appears to be the most cost effective way of supplying the fuel requirements of households in several areas of the country. It is possible, therefore, to reduce the growth in future in the consumption of kerosene as well as soft coke for cooking by making adequate investment in forest development. The RLF projection of soft coke demand is based on increasing the production of soft coke by conventional means as well as by setting up low temperature carbonisation plants. The production of increased quantities of soft coke by conventional means can be done only in the Jharia coal fields and soft coke produced there has to be transported by rail or road to all parts of the country and this calls for increase in the investment required on transportation. Production of domestic coke from non-coking coal can be done only by high cost low temperature carbonisation technology. It might be more economical to divert such investment to forest development. In the OLF it is assumed that the rate of increase of soft coke production would be limited to 6.7 per cent which is the projected growth rate during the period 1982-87. This would mean that by the year 2000 A.D. the soft coke consumption would increase to only 16.75 million tonnes as against 34 m.t. in RLF. Further the percentage of households dependent on kerosene for cooking in rural areas would be maintained as in the year 1987-88 i.e. at 8.7 per cent. The RLF implies that this would increase to 22.3 per cent in 2000 A.D. As a result of these changes the reduction of demand for kerosene and soft coke as against the RLF would be as follows :

	Unit	1987-88	1992-93	2000-01
Kerosene	Million Tonnes	Nil	—0.91	—2.99
Soft Coke	Million Tonnes of coal	Nil	—1.24	—7.25

In order to supply these 'savings' in kerosene and soft coke the level of firewood to be increased would be as follows:

1992-93 = 12.2 + 1.6 = 13.8 Million Tonnes

2000-01 = 40.1 + 9.5 = 49.6 Million Tonnes

(d) In the case of kerosene for cooking, it is possible to increase the fuel efficiency of the kerosene stoves used in rural as well as urban areas. The wide acceptance of the scientifically designed more efficient stoves introduced by Indian Oil Corporation and Indian Institute of Petroleum is an indication of the extent to which this recommendation can be successfully implemented. For the purpose of OLF demand, the Group has assumed that the saving of kerosene on account of such increase in efficiency of stoves would be at a moderate level as follows :

By 1982-83	1.0%
By 1987-88	2.5%
By 1992-93	5.0%
By 2000-01	5.0%

(e) Fuel utilisation appliances for cooking with firewood and agricultural waste have very low efficiency and in fact in many cases, the appliance comprise three stones placed in a triangular formation over which the cooking utensils are made to rest. It is possible to introduce more efficient appliances by taking up a vigorous scheme of extension and distribution of more efficient locally-made cooking ovens whose use might be encouraged if necessary by appropriate fiscal incentives. Even on conservative assumptions it is possible to increase the overall efficiency by a substantial measure at least from 1987-88 onwards. For the purposes of OLF, however, very moderate savings have been assumed of firewood and agricultural waste as follows :

Year	% of savings	Qty. of non-commercial fuel saved in MTCR
1987-88	2%	4.1
1992-93	5%	9.8
2000-01	10%	16.4

As indicated earlier, the RLF assumption that the net quantity of agricultural waste and animal dung used in the economy would get reduced in absolute quantities after 1982-83, may require some modification. This assmuption might hold good if the commercial fuels were available at a relatively cheap rate. However, in future when kerosene is likely to be very costly and probably scarce, the use of agricultural waste and animal dung in improved appliances should be maintained at least at the level which their use reaches by 1982-83. As the animal population is assumed to stay unchanged, it might be assumed that the quantity of animal dung used would not change. With the increase in agricultural production, the quantity of agricultural waste available would increase and it is possible that more of this could be used as a fuel even after 1982-83. However, for the OLF, we are assuming that the quantity of agricultural waste and animal dung would remain as in 1982-83 and only the residual needs in terms of non-commercial fuel would be used in the form of firewood. The effect of this assumption on the OLF demand for different fuel forms would be as follows :

(in million tonnes of coal replacement)

	1982-83	1987-88	1992-93	2000-01
Total non-commercial fuels .	204.1	202.8	195.8	163.5
Firewood . .	132.7	131.4	124.4	92.1
Agricultural waste	40.8	40.8	40.8	40.8
Animal dung .	30.6	30.6	30.6	30.6

Optimal Level Forecast

5.17 If the various suggestions which have been discussed above are implemented the level of fuels that would be required for consumption in the household sector in future would be as set out in Table 5.9.

TABLE 5.9

Energy demand in the household sector 1982—2000

OPTIMAL LEVEL FORECAST

Energy from	Units	1982-83	1987-88	1992-93	2000-01
Electricity	TWH	10.7	15.1	20.9	32.2
Kerosene	Million tonnes	4.73	6.48	7.34	9.39
LPG	Million tonnes	0.71	1.22	1.79	3.31
Soft Coke	Million tonnes of coal replacement	5.20	7.20	9.96	16.75
Non-commercial Fuels	Million tonnes of coal replacement	204.1	198.7	199.10	194.70

Policy Measures

5.18 In the household sector a variety of fuels are used with appliances which have remained unchanged over the centuries. The most important use in the household sector appears to be the fuel needs for cooking. The importance of this has not been fully realised on account of the decentralised production and collection of fuel wood mostly by methods and procedures which are to be decided and regulated by Government. But with the increasing scarcity of forest areas near village sites and the increasing costs of kerosene, the fuel wood problem of the rural areas has assumed great importance. So the most important aspect of energy policy for the household sector should concern itself with increasing the availability and increasing the efficiency of fuels used for cooking. Specific recommendations on these aspects are made in the Chapter on Rural Energy Policy.

5.19 The increase in fuel wood production is an issue which bristles with many legal, administrative, managerial and sociological problems. The efforts made in setting up some social forests are a good beginning. New ideas of introduction of fast growing species purely for fuel wood production are being widely discussed. This is a matter which must receive priority attention and suitable institutional structures would have to be designed as to who should be entrusted with the responsibility for increasing the productivity of existing forests and raising new forests in depleted forest areas and in non-forest areas. The Group would urge that the importance of fuel wood supplies should be recognised and suitable institutional arrangements should be made to monitor the demand and supply of fuel wood at Government level.

5.20 Increasing the efficiency of use of fuels in the household sector is another important area for policy action. The Working Group is conscious of the fact that increasing the efficiency of use of fuels in the household sector would not be easy. The number of households to be approached is very high. Setting up of standards of fuel efficiency for manufacture of lighting and cooking appliances and introduction of more efficient choolas at subsidised rates on a large scale are some of the measures called for. While the measures would have to be designed with reference to time specific and location specific conditions, the Group would urge that these normative goals of increasing efficiency upon the present levels should be accepted as a national policy and the work entrusted to a specified agency. If necessary, fiscal incentives to encourage the use of more efficient appliances should be given.

5.21 Alternative energy technologies for use in households have not been taken into account in assuming the energy supply available in the household sector even in the year 2000 A.D. The Group is of the view that the bio-gas plants is the most promising alternative energy technology in the household sector, but a greater level of its use has already been implied in the OLF estimates. There are a number of problems connected with the more rapid popularisation of bio-gas plants. The Group recommends that a centralised agency should be entrusted with the overall responsibility for increasing the number of bio-gas plants of the household as well as community types. The level of use of agricultural waste would depend on the relative costs of agricultural waste and other fuels and the kind of appliances which are locally available for the use of agricultural waste as fuel. With increasing agricultural production, the total quantity of agricultural waste is increasing. With the increase in the cost of chemical fertilizers and growing awareness for replenishing the organic content in the soil, agricultural waste would also be used in compost making in a larger measure. Even so, the amount of agricultural waste available for use as a fuel would increase over time. To the extent that use of agricultural waste is increased, the pressure on fuel wood would decrease. In view of the wide variety of agricultural waste, it is not possible to make any general recommendation regarding the kind of equipment that could be popularised. But the effort must be maximised for the use of agricultural waste as fuel either directly by burning or by conversion into liquid/gas fuels by microbial conversion. Bio-gas plants capable of using more of agricultural waste are to be developed.

5.22 A more detailed discussion of the issues on rural energy supplies are presented in Chapter XII on "Rural Energy Policy".

5.23 Among other new energy technologies solar energy is the next most promising for use in the household sector. While solar cookers which would replace other fuels might not be used in large numbers by the year 2000 there are possibilities of using solar energy devices for preheating of water before using it for cooking with conventional appliances. This is likely to lead to a great deal of saving in cooking fuels (see Chapter on Rural Energy Policy).

CHAPTER VI

ENERGY IN THE AGRICULTURE SECTOR

6.1 A wide variety of technologies ranging from the most primitive ones to the most modern sophisticated technologies based on a high degree of mechanisation, and fertiliser and water application are in use in the agricultural sector in India. The energy needs in the agricultural sector are for land preparation, lifting of water, harvesting and transporting the produce from the field to the village or the market. Almost all the energy need is in the form of mechanical work for which, in traditional technology, the sources of supply are human labour or animal power. In the modern technologies, mechanical work is supplied by oil based mobile and stationary equipment like tractors, power tillers, trucks and pumpsets or with electricity which can normally supply on the needs to be met through stationary equipment (e.g. water pumps, threshers). It appears necessary that for an understanding of the nature of energy use at present and in the future in this vital sector, the total use of energy including animal power, should be examined even though the data may not be adequate for a very reliable quantitative consideration of the relevant issues.

6.2 The commercial energy consumption in the agriculture sector in the last two decades is set out in Table 6.1.

TABLE 6.1

Consumption of commercial energy in agriculture sector—1953-54 to 1978-79

(in MTCR)

	1953-54	1960-61	1965-66	1970-71	1975-76	1978-79
Coal	..	..	..	..	..	..
Oil	1.6	2.8	4.4	4.5	9.4	19.37
Electricity	0.2	0.8	1.9	4.5	8.7	11.95
Total Commercial Energy	1.8	3.6	6.3	9.1	18.1	31.32

The total share of the agriculture sector in the consumption of commercial energy in all the sectors has increased steadily from 3 per cent to about 7.2 per cent by 1975-76 and about 10.6 per cent in 1978-79. As heat energy is not required for agricultural production, it is not surprising that no coal is used in agriculture*. Electricity is used in agriculture almost entirely for lifting water from irrigation wells and from canals, whereas oil is used in tractors for tillage and for transport and pumps for lifting water. Tractors are also used in rural areas for transportation of agricultural products to market places etc. As such a part of the oil used for tractors should rightly figure under the transport sector. The number of electrical and diesel pumps and tractors used in agriculture in the different years is set out in Table 6.2 below :

TABLE 6.2

The use of electrical and diesel pumps and tractors in agriculture—1953-54 to 1975-76

(in thousands)

	1953-54	1960-61	1965-66	1970-71	1975-76	1978-79
No. of Elect. Pump sets	39	196	509	1417	2792	3600
No. of Diesel pumps	107	230	471	1377	2178	2704
No. of Tractors	16	31	54	141	208	305

*Energy in the form of heat is required for drying of agricultural produce. This is obtained traditionally from the sun with the exception of tea and tobacco.

6.3 Working animals supply energy for tilling land as well as for the lifting water and for transport. Their number has grown very marginally in the last decade and is around 80 million, which operate about 13 million animal drawn carts and 44 million plough shares.

Reference Level Forecast of Energy Demand in the Agriculture Sector

6.4 The level of use of energy in the agricultural sector would depend on the gross area sown, the kind of crops, the extent of irrigation and the methods used for tilling of land and lifting of water and doing other agricultural operations. In the RLF exercises, the likely changes in the rate and pattern of energy consumption in two major operations viz. the energy needs for lifting water and the energy needs for tilling land, have only been considered. The energy needs for water lifting are projected with reference to the ultimate ground water potential, the rate at which new wells are dug and the rate at which diesel or electrical pumps are added in each sub-period. The energy needs for land preparation have been projected with reference to the area cropped, the rate of increase in the area served by irrigation facilities and the average level of energy needed for tilling a unit of land.

6.5 The number of dugwells and tubewells will keep steadily increasing till the ultimate potential for the exploitation of ground water is reached. The volume of water available from each of these wells would not be of the same level and the area that could benefit from the water from the wells and the incremental production that it could generate would also vary widely. The lifting device provided for a well could be powered by electricity, diesel or bullocks depending on these and other factors. Though the diesel pumps were expected to be gradually replaced by electrical pumps, their number have been steadily increasing at the rate of about 1.5 to 2.0 lakh pump sets a year. The addition to electrical or diesel pumpsets has to be limited by the number of wells which represents the ultimate potential and this is reported to be about 16 millions. Projecting from the past trend at which new wells have been constructed and the rate at which the electrification of wells has been achieved, the likely level of wells in use and the number of different kinds of devices used for lifting water from the wells would be as in Table 6.3 :

TABLE 6.3

Future trends of utilization of ground water potential

(*in thousands*)

Item	Ultimate Potential	1977-78	82-83	87-88	92-93	2000-01
Dugwells	12,000	7,700	8,700	9,700	10,700	12,000
Pvt. Tubewells	4,000	1,740	2,300	2,800	3,300	4,000
Public Tubewells	60	30	45	60	60	60
Total wells	16,060	9,470	11,045	12,560	14,060	16,060
Elect. Pumps		3,300	5,400	7,400	9100	11,000
Diesel Pumps		2,500	3,250	3,750	4,000	4,400
Animal powered lifting devices		3,670	2,395	1,410	660	660

6.6 The forecast is somewhat optimistic as it assumes that the entire ground water potential is fully exploited by close to the end of the current century. The increase in the diesel pumpsets is the result of several factors. There might be wells which can yield water only in such small quantities that only small diesel pumps or probably mobile diesel pumps might have to service them. Some wells may be too far away from the village or other wells and might have to use diesel. The average annual addition to the number of diesel pumpsets has been 1.6 lakhs in recent years and in the period 78—83 an annual addition of 2.0 lakh diesel pumps has been planned. As the addition of diesel pumps is not likely to be stopped abruptly, it has been assumed that it would continue at a reduced rate of 0.5 lakh diesel pumps per year from 1987-88 to 2000-01. By 2000, the number of diesel pumpsets is assumed to stabilise at about 27 per cent of the total number of wells. The wells dependent on animal power would, however, get reduced to hardly 4 per cent as compared to the present level of 40 per cent.

6.7 The electricity requirement for irrigation pumping varies widely within the country. It ranges from 6000 kwh/pump in Punjab where there are more tubewells to about 1500 kwh/pump in Karnataka, Madhya Pradesh and in other States. It is noteworthy that both the consumption per consumer and the kwh/kw of connected load in the agricultural sector steadily declined till 1973 ; from then on, there is a marginal increase probably due to a greater proportion of tubewells being electrified and due to extensive multicropping in a few States like Punjab, Haryana and parts of U.P. On the basis of the latest figures, the average consumption is taken to be about 3000 kwh per pumpset and this level is adopted for the entire forecast. For giving an equivalent energy, the amount of diesel consumed in a diesel pumpset would be 0.8 tonne of diesel per year.

6.8 The number of tractors that would be introduced for agricultural use in future is uncertain. We have therefore relied on the generally accepted level of demand for tractors and the factors that would determine such demand. Presently about 80 million working animals about 44 million plough shares and 0.25 million tractors are used in agricultural operations. Though the net sown area has increased from about 130 million hectares to the present 140 million hectares in the last 15 years, the stock of plough shares and working bullocks has remained almost unchanged. But the tractor population has increased from 30,000 to 250,000. The gross addition of tractors from indigenous production is about 35,000 per year in the last two years, and the net addition is around 25,000 per year. The capacity for indigenous production of tractors is of the order 150,000 tractors per year. The gross area cultivated (which includes multiple crops) is about 160 million hectares and the ultimate potential for gross average is considered to be about 200 million hectares. The irrigated area is considered as capable of being increased from the present level of 55 million hectares to about 107 million hectares. The increase possible in areas under cultivation and irrigation and in the intensity of cropping would definitely call for additional draft power in the agricultural sector which could be supplied either by animal power or by tractors. As yet there is no definite policy regarding the rate and pattern of modernisation in Indian agriculture. In view of the large differences in agro-climatic conditions, soil fertility, water availability, structure of land holding etc., the policy has to be different for different regions of the country. Choices would have to be made from among several alternative combinations available to provide the necessary energy inputs to agricultural activities. With the introduction of electrical and diesel pumpsets, more of the animal power available on the farms might be used for meeting the requirements of tillage and transport. Alternatively the animals might be phased out and tractors might be introduced or more tractors might be introduced while retaining the present level of population of working animals. An examination of the directions in which the agricultural technology transformation would take place is beyond the scope of this report.

6.9 The national policy towards mechanisation in the Draft Plan 1978—83 clearly emphasises the need for full utilisation of manual and bullock power in the context of small farmers economy and the restricted and selective introduction of tractors to cope with labour shortages during peak periods, etc. Keeping in view this policy and the past trends in the net addition to the stock, the net annual addition to the stock of tractors including power tillers and bulldozers can be taken to be

30,000 in the period 1978—83

50,000 in the period 1983—87

70,000 in the period 1987—2000.

The gross irrigated area had increased at the rate of 3.3 per cent per year in the period 1960-61 to 1977-78 and the increase in the period 1978—83 has been planned at 5.54 per cent per year. Assuming this to increase to 6 per cent per year for 1982-83 to 2000-01, the gross cropped area, the irrigated area and the draft power available can be projected as in Table 6.4 :

TABLE 6.4

Forecast of draft power requirements in agriculture

Item	Unit	1982-83	87-88	92-93	2000-01
1. Gross cropped area	Million hectares	180	187	195	200
2. Gross Irrigated area	Million hectares	63	84	112	120
3. Working animals	Million	80	80	80	80
4. Tractors	Thousands	450	700	1050	1610
5. Draft power in agriculture	(a) hp per gross cropped ha.	0.13	0.17	0.21	0.29
	(b) hp per gross irrigated ha.	0.37	0.37	0.37	0.48

Note: Only half of the available animal power is assumed as used for tillage and each working animal is assumed to be equivalent to 0.5 hp.

The exercise in the Table 6.4 suggests that the draft power (other than for water lifting) might increase steadily in terms of horsepower per gross cropped area, but in terms of horsepower per irrigated area it would remain unchanged till 1992—97.

6.10 Based on these assumptions, the commercial energy needs of the agriculture sector is likely to be as in Table 6.5 :

TABLE 6.5

Energy demand in agriculture 1982—2000

REFERENCE LEVEL FORECAST

Energy from	Unit	82-83	87-88	92-93	2000-01
Electricity	TWH	16.2	22.2	28.2	33.0
Diesel oil for pumps	Million tonnes	2.6	3.0	3.2	3.5
Diesel oil for tractors	do	1.1	1.6	2.5	3 6
Diesel oil total	do	3.7	4.6	5.6	7.1

Note: (i) Specific consumption : Electric Pumps =3000 kwh/Yr/pump*
Diesel Pumps =0.8 t/year/pump
Diesel =2.5 t/year/tractor
Tractors =(90% in use)

(ii) For the sake of simplification, tractors have been taken as one category and include power tillers and crawler tractors.

*The specific consumption for 1982-83 has been assumed to be slightly higher level in view of the large number of tubewells to be added in the 1978—83 period.

Optimal Level Forecast of Energy Demand in the Agriculture Sector :

6.11 In the light of the consideration of the total RLF of demand for energy and its availability, the Group considered policies and other measures which could reduce the overall demand for energy in the agriculture sector and in particular reduce the demand for oil products. A part of this reduction could be achieved by improving the efficiency of fuel utilisation of diesel and electric pumps and agricultural tractors. The other possible measure is to increase the number of working animals available for agriculture which would reduce the demand for commercial fuels.

6.12 It is well known that irrigation pumps, both diesel and electric, presently in use are inefficient due to poor design and the use of non-optimal size pumps. Experts estimate the efficiency in some of the electrical and diesel pumps in use to be as low as 30 per cent. There is a case for examining the proposal that all fuel using equipment should be standardised for each category and size of equipment, certain minimum standards should be prescribed, and the equipment should carry their fuel rating on the equipment itself. The implementation of such a proposal and some extension work to optimise the size of pumps used under different conditions would lead to conservation of electricity and diesel without any reduction in the benefits anticipated. While it is difficult to estimate the savings, it would be reasonable to set a normative goal for conservation. In the case of diesel tractors, about one third to one fourth the use of tractors is for transport purposes. As more buses and trucks are available for use in rural areas, the need to use tractors for transportation needs would become reduced. Here again some broad order of magnitude of the savings could be assumed. The Group considered the targets for improving full efficiency as set out in Table 6.6 to be reasonable :

TABLE 6.6

Savings of energy possible by adopting the conservation measures in Agriculture

(in percentage of total consumption)

Equipment	1982-83	1987-88	1992-93	2000-01
(a) Electric pumpsets .	1.0	5.0	10.0	15.0
(b) Diesel pumpsets .	1.0	5.0	10.0	15.0
(c) Diesel tractors . .	0.0	3.0	5.0	10.0

6.13 Given the demand and supply situation for different commercial fuels, interfuel substitution should be directed towards the reduction of the use of oil products even at the cost of increasing the level of demand for coal or electricity. In the agriculture sector, the addition of diesel pumpsets has been assumed to be reduced sharply to one fourth the level of additions in the current Plan period. It would be irrational to assume that diesel pumps could be replaced by electrical pumps as a means of optimising the fuel usage. The costs of extending power lines to remote pumps might not be less than the cost of energy saved. Social cost-benefits studies of application of diesel and electric pumps in agriculture indicate that already in many areas (where the capital costs of transmission and distribution are high) the use of electricity is not the rational choice. Probably in such cases, the realistic assumption would be the increased use of bullocks. The same trends are likely in the case of tractors, where the pace of introduction of tractors may be slower than anticipated, leading to the continued use of bullocks. This tendency would be strengthened if the efficiency of use of bullocks in agriculture is improved by design changes, etc.

6.14 It could be assumed that by improvements in the design of bullock-drawn lifts and ploughshares, the effective energy contributed by bullocks would increase even if the size of the stock remained unchanged. Furthermore, it is possible to increase the number of working animals, if a scientific and co-ordinated programme is undertaken. The targets for saving of diesel used for irrigation and tillage by introducing more efficient animal drawn implements could be.

5% by 1987-88

10% by 1992-93

15% by 2000-01

6.15 Summing up, as a result of conservation and interfuel substitution measures, the optimal level forecast of commercial energy in agricultural sector would be as in Table 6.7 :

TABLE 6.7

Optimal Level Forecast of Demand for Energy in the Agriculture Sector

Fuel from	Units	1982-83	1987-88	1992-93	2000-01
Electricity	TWH	16.0	21.1	25.4	28.0
Diesel	Million Tonnes	3.70	4.2	4.6	5.26

Policy Measures

6.16 (a) Agriculture is one sector where there is likely to be a substantial increase in the input of commercial energy with a view to increase agricultural production. The Group feels that while every effort should be made to increase the input of energy into the agricultural sector, the nature and quantum of the input should be consistent with resource availability. With the increasing areas under cultivation and the steeper increase of area under irrigation (see Table 6.4) there is likely to be a rapid increase in demand for tillage power. Whether this would be supplied in the form of mechanical equipment like tractors and power tillers or by human and animal power would have to be decided with reference to several factors like the total annual quantity of energy required for tillage, the agro-climatic conditions and the crop pattern, the level of energy inputs required at different points of time, the peak requirements of energy and the availability of energy from different resources. With reference to these and other relevant factors a policy towards mechanisation in agriculture has to be decided. The Group has only assumed that interms of the total needs for the country, the horsepower per unit of irrigated area would remain more or less unchanged upto 1992-93 and would slightly increase from then on. The appropriateness of this assumption would have to be carefully examined by experts in the agricultural sector and the source of supply of additional energy if required should be defined with reference to location specific and time specific factors.

(b) From the data analysed and studies undertaken it is evident that there is room for increase in the fuel efficiency of appliances and implements used in the agricutural sector. The efficiencies of electric and diesel pumps used in agriculture can be improved considerably with even small efforts made in this direction. Standards of fuel efficiency would have to be prescribed for electrical and diesel pumps and the manufacturers pursuaded to adopt a time bound programme of increasing the efficiency of pumps to the level suggested in the report. These are very modest levels and it is possible that the increase in efficiencies could be much more if a more vigorous policy of standardisation is followed.

(c) The efficiency of diesel tractors is likely to improve as a result of design changes aimed at improving the fuel efficiency. Here again, it is necessary that standards of fuel efficiency should be prescribed for tractors and their adherence monitored.

(d) As there are and would be a large number of small landholders in India and in view of the socio-cultural practices the Group feels that the use of bullocks in agriculture would continue long after the end of the century. It is, therefore, necessary to improve the design of animal drawn water lift and agricultural implements which would increase the useful energy delivered by animal driven appliances/implements. As these implements are manufactured in large, small scale and village industries all over the country, training and extension methods would have to be resorted to on a large scale and incentives might have to be given during the initial period for the adoption of more efficient implements. There is also need for a programme of upgrading the quality of work animals used in the rural areas. It is felt that while there has been significant effort to improve the quality of the milch animals, the extent of research and extension work for improving the quality of work animals has not been adequate. This might have to be taken up vigorously from now on.

(e) Even in the OLF, the Group has assumed that diesel pumps would be used to the extent of 4.4 million by 2000 AD. There is room to believe that with the electrification of all villages in the country and with the greater availability of electricity, it is possible to reduce the number of diesel pumps. The extent to which the diesel engines in operation could be reduced would depend on a number of location-specific factors. The OLF suggests that 3.5 million tonnes of diesel (valuable middle distillate oil products) would be used in diesel pumps. The substitution of diesel pumps by electrical pumps could lead to considerable savings of oil. It is therefore, suggested that a careful examination should be made of the ed, that a careful examination should be made of the national policy towards the use of diesel engines for water lifting and the extent of encouragement that should be given to their continued production. This has to be a region-specific policy. The use of bio-gas for tractors and pump-sets is another available option.

(f) The Group feels that there is need to explore even now various alternative energy technologies for supplying the energy requirements of agriculture sector. In the OLF, energy obtainable from alternative energy technologies has not been quantified, as there are several uncertainties still regarding the commercial viability of these technologies and any target for energy supplies would lead to under-estimation of the likely demand for conventional energy sources. Solar pumps, both of solar-electric and solar mechanical types, would require to be developed and tested in different parts of the country. As the use of wind mills for water lifting would depend very largely on the wind regimes cropping pattern and agro-climatic conditions more detailed studies of the possibility of using wind energy should be taken up alongwith the effort of development of wind mills of appropriate designs. Alcohol based engines and producer gas engines working with charcoal as the fuel should be tested in areas where there is likely to be long term availability of alcohol or charcoal.

The policy towards alternative energy technology is discussed in the Chapters on Rural Energy Policy and Research and Development in Energy Sector.

CHAPTER VII

ENERGY IN THE INDUSTRIES SECTOR

7.1 The industries sector is the single largest user of commercial energy in India. It consists of two distinct parts—one referred to as the registered sector consisting of factories registered under the Factories Act and the other the unregistered sector. The unregistered sector includes not only unregistered industrial establishments but also a very large number of household industries whose total number has been reported as 2.2 millions in the 1971 Census. The unregistered sector is a very important contributor to the total industrial production and contributes over one-third of the total value added in industries.

TABLE 7.1

Relative Share of value added from Registered and Unregistered Sectors in Industries

(in percentage)

Sub-sector	1950-51	1960-61	1965-66	1970-71	1975-76
Registered Industries . .	55	60	62	64	66
Unregistered .	45	40	38	36	34
TOTAL . .	100	100	100	100	100

7.2 Though a major portion of the commercial energy appears to be consumed in the registered units, the unregistered sector also consume significant quantities of commercial energy. The unregistered units also depend on large quantities of non-commercial fuels, animal power and human labour for performing task which in the registered sector might involve the use of commercial fuels. An attempt to quantify the extent of non-commercial energy use in the unorganised sector by the working Group has not been successful for want of data and the very large divergences in the information available from different sources. It is clear, however, that the published data regarding commercial energy consumption in the industries sector understates the total energy consumed in this sector while the production data appear to be a fair estimate of the total production in the sector. The intensity of energy consumption calculated from such data would therefore, give an underestimate of the actual intensity of energy used in industries in India.

Commercial Energy Consumption

7.3 Keeping in view these shortcomings, the pattern of commercial energy consumption in the industries sector could be examined. Table 7.2 sets out the consumption of commercial energy in industries.

TABLE 7.2

Consumption of Commercial Energy in Industries Sector 1953—79

(in MTCR)

Energy from	1953-54	1960-61	1965-66	1970-71	1975-76	1978-79
Coal	13.80	20.90	30.10	31.07	51.01	50.50
Oil	3.65	7.23	8.09	10.90	7.55	9.00
Electricity	5.00	11.60	22.62	34.35	43.35	53.90
Commercial Energy : Total	22.45	39.73	60.81	76.32	101.91	113.40

7.4 It would be seen from Table 7.3 that the total commercial energy consumption increased at the rate of about 7.1 per cent in the period 1953—75. During the last few years it has increased by about 6 to 6.5 per cent. Electricity consumption has shown a steadily decelerating rate in each sub-period. Though the average rate from 1953 to 1975 was about 10.3 per cent, the rate of growth in the period 1970—75 was only 4.8 per cent per year.

TABLE 7.3

Rates of growth of Consumption of Commercial Energy in Industries Sector

(Average annual compound %)

Period	Rate of Growth of value added in industries sector	Rate of Growth per year of consumption of			
		Commercial Energy Total	Coal	Oil	Electricity
1953—60	2.92	8.5	6.1	10.2	12.8
1960—65	7.30	8.9	7.6	2.3	14.3
1965—70	3.51	4.6	0.7	6.2	8.7
1970—75	3.27	6.0	10.4	(—8.0)	4.8
1953—70	4.36	7.5	4.9	6.6	12.0
1953—75	4.12	7.1	6.1	3.4	10.3
1960—70	5.39	6.7	4.0	4.2	11.5
1960—75	4.68	6.5	6.1	(—0.7)	9.2

7.5 The composition of fuel consumption in the industries sector in the years 1960-61 and 1970-71 is given in Table 7.4.

TABLE 7.4

Relative Shares of Different Forms of Energy Consumed in Industries Sector

(in percentage)

	1960-61	1970-71
Coal	52.6	50.1
Oil	18.2	7.4
Electricity	29.2	42.5
TOTAL	100.0	100.0

It is found that coal as continued supplying about half the energy needs of the industries sector. About 20—23 per cent of the coal consumed in the industries sector is accounted for by a single industry, viz. steel, while cement industry accounts for over 5 per cent.

Non-Commercial Energy Consumption

7.6 The facts about non-commercial energy consumption in industries sector are very scarce. The number of units in the unregistered sector has been reported as 2.2 millions in 1971 census whereas the National Sample Survey gives the result as over 7 millions. The quantity of fuels consumed in these industries has not been surveyed. Even in the organised industry, some quantity of charcoal and firewood is being consumed besides a very large quantity of bagasse which is consumed in the organised sugar industry. The Annual Survey of Industries (Census Sector) lists the quantity of firewood used in the census sector units as about 1.1 million tonnes in 1961 and about 0.9 million tonnes in 1969. The charcoal used is of the order of 65,000 tonnes only per year. Bagasse which is produced in the sugar industry is consumed entirely in the industry itself. As it is the consumption of a waste product from the industry, the consumption is not separately listed in the Annual Survey of Industries. The availability of bagasse from the cane crushed can be taken as the quantity consumed. On this basis the estimate of bagasse consumed in the organised sugar industry would have been about 12 million tonnes in 1975-76. Though the estimates of consumption of non-commercial energy attempted from National Sample Survey varying from 4 to 7 MTCR, there are reasons to believe that this is a gross under-statement. The khandsari and jaggary manufacturing units in the unregistered sector should be using a great deal of bagasse. The ratio of bagasse to cane crushed is estimated to vary between 25 per cent and 35 per cent. Taking the lower value, the quantity of bagasse used in the industries sector could be estimated as follows :

	Cane used for sugar, jaggery and khandsari manufacture	Bagasse used in industries
	(in million tonnes)	
1970-71	111.2	27.8
1975-76	125.7	31.4

It is clear that the total bagasse used would be of the order of 19 million tonnes in 1975-76 in unregistered units. The brick making industry uses a great deal of firewood and agricultural waste. Rough estimates on the basis of bricks manufactured in the early seventies suggest that the consumption of firewood or agricultural waste should be of the order of about 10 million tonnes. The total quantity of non-commercial fuels used in industry should therefore be of the order of over 50 million tonnes which would be about 47.5 million tonnes in terms of coal replacement. Of this over about 60 per cent is derived from bagasse, the use of which does not put any pressure on firewood demand.

Intensity of Energy Use

7.7 The intensity of energy use can be defined as the ratio of the quantity of total commercial energy used per unit of value added in the industries sector. The total commercial energy consumed in MTCR per Rs. 100 crores of value added (1960-61 prices)in the industries has been :

1960-61	1.86
1965-66	1.99
1970-71	2.11
1975-76	2.40

The intensity of energy use in industries has been steadily increasing over time.

7.8 An examination of the different fuels consumed indicates that the increase in electricity consumption is the main reason for the rise in the intensity of energy consumption.

The study of the electricity consumption from 1960-61 to 1975-76 shows the following :

TABLE 7.5

Intensity of Electricity Consumption in Industries

Item	1960-61	1965-66	1970-71	1975-76
Value added in industry in Rs. 100 crores (1960-61 prices)	21.38	30.41	36.14	42.46
Electricty consumed 10^9 kWh	11.60	22.62	31.35	43.35
Intensity of Elec. consumption (kWh/Rupee value added)	0.54	0.74	0.95	1.02
Increase per year of 3 over 3 in previous column		6.5%	5.1%	1.4%

7.9 The above table shows that the intensity of electricity consumption which has increased over each sub-period, but the rate of growth of intensity has been steadily declining. This is in line with international experience; in the initial stages of industrialisation the share of industries which produce or process primary commodities or minerals is high and these industries have a relatively higher electricity intensity. Further, in the initial stages of spread of electricity in a country, a larger number of industries using other energy forms switch to the use of electricity. In view of these factors, the intensity of electricity use in industries tends to be high in the initial stages of development and it slowly diminishes over time. Any major intra-sectoral change in industries would, of course, alter this trend. Attempts to make a comparative study of the intensity of electricity use in specific industries in India with similar industries abroad, were unfruitful due to deficiencies of data. It was, however, possible to learn that while the quantity of electricity for a unit of a specific product did not increase over time, in a general class of industry like paper or textiles, the electricity consumption per unit of production has increased due to the increase in the share of superior and special quality paper or textile within the general overall category of that industry.

Forecast of Electricity consumption in the Industries Sector

7.10 A forecast of electricity demand in the industries sector has to take into account the possible changes in the composition of industries, the possible shifts in technology and the rate of substitution of non-commercial energy and animal/human power by commercial energy. A detailed study of these factors is beyond the scope of the work of this Group. In order, however, to trace the possible implication of developments in the industries sector on the energy demand, some of the major thrusts in industrial development could be considered. An exercise to project the level of production of some of the large electricity consuming industries on the basis of the growth rates in the recent past yields results which appear too high and too unrealistic. It is reasonable to expect that these industries, such as steel, fertilizer and aluminum etc. would grow at a slower pace than in the past, while some of the technology intensive industries like electronics, sophisticated machine tools, etc. which involve a lower electricity input per unit of value added would increase at a relatively faster rate. Further, the Government have clearly enunciated a policy of encouraging decentralised industrial growth based on appropriate technology. Such technology is not always energy saving in terms of energy used for units of output. It is expected however, that the selection of appropriate technology would be done with due regard to energy consumption, so that there is at least a marginal decrease in the intensity of energy use. Furthermore, the accent on increasing the rate of employment generation in all sectors would naturally lead to a decrease in the energy intensity. The commonsense point of view that if the use of other inputs remains unchanged, commercial energy would substitute some form of work done by men or animals, is supported by the data of the Annual Survey of Industries. These data indicate that there is significant correlation between capital/output ratios and energy/output ratios and a similar correlation between capital|employment ratios and energy/employment ratios. The new policy of the Government should therefore result in a lowering of the energy intensity and, consequently electricity intensity in the industries sector. The new product or new technology developments within the country or outside would also tend to be relatively less energy intensive in view of the increased awareness of global energy problems. As against these, however, the unaviodability of the trend for substitution of non-commercial energy by commercial energy in india would result in a slow increase in the intensity of energy. Though the annual increase in the intensity of electricity used by industries has been 1.4 per cent per annum in the period 1970—75, the group recognising the fact that this was a period of scarcity in electricity, and keeping in view the annual rate of increase noticed in the earlier sub-periods, assumed the following declining rate of increase in the intensity of electricity use :

for the period 1975-76 to 1982-83	4 per cent per year
for the period 1982-83 to 1987-88	2 per cent per year
for the period 1987-88 to 1992-93	1.5 per cent per year
beyond 1992-93	0 per cent

7.11 The intensity of electricity consumption in the industries sector and the resultant demand for electricity as per RLF projection are given in Table 7.5(A).

TABLE 7.5(A)

Forecast of Electricity demand in the Industrial Sector 1982—2000

REFERENCE LEVEL FORECAST

	1975-76	1982-83	1987-88	1992-93	2000-01
1. Value added in industries in Rs. 100 crores (1960-61 prices) .	42.46	60.64	81.78	115.94	202.86
2. Itensity of Elec. Consumption kWh/Rupee value added . .	1.02	1.40	1.60	1.72	1.72
3. Electricity demand in TWH	43.35	85.0	131.0	199.7	350.0

7.12 Several industrialised countries have adopted as a goal the gradual reduction in the intensity of energy consumed per unit of national income. In our country also, it is necessary that at least in respect of electricity, which is a very high cost energy, there should be an attempt to reduce this intensity. This can be achieved by better utilisation of capacity, more efficient use of electricity in the industries sector and by following a strategy of industrialisation in which very large electricity consuming industries like aluminium, ferro silicon etc., form a diminishing part. The Working Group is of the view that it would be possible to adopt as a goal for optimal level energy consumption, the maintenance of intensity of electricity used as it would obtain in the year 1982-83, i.e., 1.4 Kwh per rupee of value added. The forecast of Electricity demand in industries sector based on the optimal assumption is given in Table 7.5 (B).

TABLE 7.5 (B)

Forecast of Electricity Demand in Industries (1982—2000)

OPTIMAL LEVEL FORECAST

	1982-83	1987-88	1992-93	2000-01
Intensity of Electricity consumption (OLF) kwh/ Rupee value added .	1.40	1.40	1.40	1.40
Possible Level of Electricity Consumption in TWH .	85.0	114.5	162.3	284.0

Forecast of Demand for Coal and Oil in Industries Sector

7.13 The use of coal in the industries sector is best examined in terms of coal for the steel industry and coal for all industries other than steel, as the consumption of coal per unit of value added contributed by steel industry is very high compared to the ratio for other industries. Furthermore, the steel industry requires metallurgical grade coal (coking coal) and cannot use (except in a small proportion) non-coking coal. Coal is used for providing heat and to raise steam in the industries sector and could be substituted by fuel oil of roughly half the weight of coal used. The intensity of coal and oil used in the industries sector is examined in Table 7.6.

TABLE 7.6

Intensity of Coal and Oil use in Industries Sector (1960-75)

	1960-61	1965-66	1970-71	1975-76
Value added in industries sector other than steel industry in Rs. 100 crores (1960-61 prices)	19.45	27.67	32.85	38.64
Quantity of coal used in million tonnes	13.02	13.90	21.99	29.16
Quantity of oil used in million tonnes of coal equivalent	7.23	8.09	10.90	7.55
Total Coal & Oil used in MTCE	20.25	21.99	32.89	37.71
Intensity of use of coal & Oil in kgce per rupee of value added	1.05	0.79	1.00	0.95

Note: Fuel used in steel industry is excluded in this table.

7.14 The intensity of coal and oil (combined) use industry shows a surprising stability except for the inexplicable dip in the year 1965-66. A very large number of small scale industries and certain large industries like sugar still use substantial quantities of non-commercial fuels. Except in the case of sugar, the other industries seem to be gradually switching to the use of commercial fuels. Such shifts would increase the intensity of coal and oil use. On the other hand, there is a gradual replacement of the old boilers of low efficiency by more energy efficient equipment and this would decrease the intensity of energy use. These two factors seem to have led to an apparent stability. In the coming years, the intensity would get reduced to some extent by the normal energy saving processes. But the industries might not get high grade coal of high calorific value which many of them get now. Taking these into account, for the Reference Level Forecast (RLF), the coal and oil intensity coefficient which was 0.95* in 1975-76, was assumed to go down to 0.90 and remain at that level till 2000 A.D. The share of oil in the industrial fuels has fluctuated depending on the relative price of furnace oil and coal and their availability. In the early seventies, the quantity of furnace oil used was over 5 million tonnes which in 1975-76, had been reduced to about 3.5 million tonnes. In view of widening gap between the price of coal and furnace oil and the administrative measures now being taken to restrict the use of furnace oil among new industries only to technical reasons and to encourage the shift from oil to coal in selected industries, the Group felt that the quantity of furnace oil used in the industries would be closely monitored, even under the existing procedures and would be maintained at the current level of 4.5 million tonnes upto 1982-83 and thereafter these might be marginally reduced to 4.4 million tonnes. By 1992, all the possible oil to coal conversions would be effected; from then on the absolute quantity of furnace oil used would increase, though the percentage share of oil would decrease. It was assumed that the share of oil in industrial fuels would be from the level of 21 per cent in 1975-76 to 7 per cent in 2000 A.D. On these assumptions the RLF demand for coal and oil is estimated as in Table 7.7(A).

TABLE 7.7(A)

Forecast of Coal and Oil demand in the Industries Sector 1982—2000

REFERENCE LEVEL FORECAST

	1982-83	1987-88	1992-93	2000-01
Value added in industries other than steel in Rs. 100 crores (1960-61 prices)	55.4	75.8	109.5	190.0
Intensity of coal and oil use in kgce per rupee of value added	0.90	0.90	0.90	0.90
Quantity of coal and oil required in MTCE	49.9	68.3	98.6	170.6
Quantity of oil required :				
(a) in MTCE	9.0	8.8	8.8	12.4
(b) in million tonnes of furnace oil	4.5	4.4	4.4	6.2
Quantity of coal required in million tonnes	40.9	59.5	89.8	158.2

Note: Requirements of Steel Industry excluded.

7.15 It is well recognised that the efficiency of fuel usage in industries is very low and can be improved by greater attention to energy thrifts in industries. By diligently pursuing fuel efficiency norms for each industry and by a more rational selection of industrial products and technology with reference to energy use, the Group feels that it should be possible to gradually

*Expressed in terms of kilograms of coal equivalent (kgce) per rupee of value added in the industrial sector.

reduce the coal and oil use intensity coefficient to about 0.70 from the Reference Level Forecast assumption of 0.90. The reduction is likely to be gradual and the rate at which the reduction is achieved would be faster after 1987-88 when the structure of industrial growth could be changed. The level of use of furnace oil could be regulated by controlling more strictly the requirements of new industries proposing to use furnace oil and expediting the oil to coal conversion in selected industries. It is also assumed that after 1992-93, due to technological advances in coal utilisation, the use of furnace oil for heat raising would be almost totally avoided in industries. As a consequence, it might be possible to reduce the absolute quantity of fuel oil used even in the nineties. The quantity of furnace oil used is assumed to be maintained at 4.5 million tonnes upto 1982-83, and reduced thereafter to 4.0 million tonnes in 1987-88, to 3.5 million tonnes in 1992-93 and to 3.24 millon tonnes in 2000 A.D. With these assumptions, the Optimal Level Forecast is estimated to be as in Table 7.7 (B).

TABLE 7.7 (B)

Forecast of coal and oil demand in the industries sector 1982—2000

OPTIMAL LEVEL FORECAST

	1982-83	1987-88	1992-93	2000-01
Assumed intensity of coal and oil use in kgce per rupee of value added	0.90	0.85	0.75	0.68
Quantity of coal and oil required in MTCE	49.9	64.0	81.8	129.5
Quantity of furnace oil required:				
(a) in MTCE . .	9.0	8.0	7.0	6.5
(b) in million tonnes of furnace oil .	4.5	4.0	3.5	3.24
Quantity of coal required in million tonnes	40.9	56.0	74.8	123.0

Note : Requirements of steel industry excluded.

Coal for Steel Industry

7.16 The requirement of coal in the steel industry is to be determined with reference to the production of steel and the technology adopted. Though various possibilities of reducing the coke rate in steel production has been under discussion, no noticeable improvement has been observed in the last few years. One can see the current norms of coking coal for a tonne of steel production as remaining unchanged over time and project the demand. The demand for and production of steel in the country has not been forecast for the period beyond 1987-88. The demand saleable mild steel was 6.5 million tonnes in 1977-78. This is expected to rise to 10.9 million tonnes by 1982-83 and 15.4 million tonnes by 1987-88. The production in the integrated steel plants is expected to go up from the present level of 7.7 million tonnes to 11.8 million tonnes in 1982-83. Production plans for the period beyond 1982-83 have not been projected. Exercises which made use of the current elasticity of demand for steel with respect to certain macro variables indicate a very high level of production requirement. For example, a production of 75 million tonnes of steel in 2000-01 has been suggested in some studies. Considering, however, the constraints on increasing steel production in our country and with a growth of about a little less than a million tonnes a year being planned for the period 1977-78 to 1982-83, one can reasonably assume that the level of additions to capacity would be of the order of about a million tonnes per year in the period 1982-83 to 1987-88 and about 1.5 million tonnes per year in the period 1987-88 to 1992-93 and about 2 million tonnes per year in the period 1992-93 to 2000-01. Based on these assumptions, a reasonable level of demand and production of steel and the consequential coking coal requirements for steel industry can be forecast as in Table 7.8 :

TABLE 7.8

Steel industry & coking coal requirement 1982 To 2000

	1982-83	1987-88	1992-93	2000-01
Steel demand (million tonnes) . . .	11.8	15.4	22.0	36.0
Steel production (million tonnes) . . .	11.8	17.0	25.0	40.0
Norm of coking coal to steel (tonnes of coal/tonne of steel) . . .	2.88	2.88	2.88	2.88
Coking Coal (million tonnes) . . .	34.0	48.98	72.03	115.25

7.17 Even the modest assumptions of steel demand made in this exercise result in levels of production of coking coal which appear high. However, the coking coal requirement of steel has to be dovetailed to the plans for the development of steel industry and as and when the Government take a decision regarding the steel industry development, the demand forecast made here would have to be suitably amended. As the demand projection here is in the nature of a conditional forecast and as the Group cannot examine the social costs-benefit of reducing the size of the steel plan, the Group did not attempt any variation in the OLF.

Policy Measures

7.18 (a) The most important element of energy policy in the industries sector should be the measures to improve the efficiency of energy utilisation in industries. It has been established by several studies, that within the same category of industries, the energy used per unit of production varies widely between the efficient and inefficient units. In the small scale industries, fuel efficiency has not been given adequate attention and in industries like foundries even simple improvements in equipment and procedures would yield significant savings in energy. The Group has recommended that the intensity of coal and oil should gradually diminish and also the intensity of electricity used should not increase over time. Standards of fuel efficiency for each sector of the industry could be fixed with gradual improvement over time and the achievement monitored.

(b) Among the fuels used in industries special attention should of course be paid for savings in the use of oil. The use of coal could substitute the use of fuel oil in most of the industries and the use of coal can be encouraged by the supply of appropriate quality of coal. Efforts have already been initiated in this direction by the Department of Technical Development and these should be intensified.

(c) With a view to reduce the intensity of use of energy in industries, there is need to re-examine some of our assumptions regarding the targets of production for high energy consuming industries like steel, aluminium, ferro silicon, etc. For obtaining technical and strategic self-reliance, a certain level of production of these commodities is essential. However, the desirability of increasing production to meet all the indigenous demand by using large quantities of fuels like coking coal or electricity deserves to be considered. For example, the increase of steel production from 22 million tonnes in 1992 to 36 million tonnes in 2000 A.D. would call for an incremental production of about 43 million tonnes of coking coal. As coal would also be required for other uses, the costs and benefits of importing the additional needs of steel and using the investment saved in steel and coking coal industries for producing exportable commodities with less energy intensive technology deserves serious consideration.

(d) A major factor that would improve the ratio of energy used to output is the improvement in the level of utilisation of rated capacity of most of the industries. Except in industries which use energy as a process input, the specific energy consumption is inversely proportional to the level of capacity utilisation. In the coming years, in most of the industries, the utilisation factor should be improved, with special reference to conservation of energy.

(e) Energy conservation could be achieved by several industries by adopting alternatives, less energy itnensive, technologies and also by substituting or supplementing conventional sources of energy by renewable sources. In existing industries, such possibilities should be explored and adopted wherever they are techno-economically justified. In the case of new industries, the energy implications of the technology to be used should be clearly studied to ensure that they represent the least energy intensive options, particularly with respect to the use of depletable sources of energy and electricity.

(f) Co-generation (combined heat and power production) holds prospect of large energy savings in the industrial sector, as it improves the overall thermal efficiency. Such possibilities in existing industries should be identified and pursued, if necesary by providing financial incentives. New industries with such potential should be encouraged to design their systems to include co-generation to the optimum extent.

CHAPTER VIII

ENERGY IN THE TRANSPORT SECTOR

8.1 The modes of transport used in India range from the age old animal drawn vehicles to the most modern trucks, railcars and jet planes. The traditional forms of transport depend mainly on the use of manual labour and animal power, though a very small contribution is also derived from wind-driven boats. Road and rail transport dominate the transport scene, contributing as much as 95 per cent of the fuel using transport (1975-76). The level of transport service derived from animals is still a matter of conjecture. No attempt has so far been made to measure the level of service derived from manual labour, which is used to move goods through short distances as headloads, hand carts or by pedalled vehicles.

8.2 The modes of transport used are determined by a number of factors, of which the important ones are the characteristics of the load to be carried, the quantities normally transported at a time, the value of the commodities, the costs of different modes of transport, their relative speed, reliability, etc. The rate of displacement of the traditional modes of transport by the more modern ones cannot be easily anticipated. Bullock carts are estimated to carry over 60 per cent of the marketed produce from the farms to the markets and an equal quantity of agricultural inputs from markets to the farms*. Bullock carts also help in carrying the produce to the farm houses and inputs to the farms. The total number of bullock carts has been counted as 12 million in 1961 and 12.7 in 1965 and now it should be over 13 millions.

Bicycles are used extensively for short distance transportation. There is no record of the number of bicycles in use in the country. The indigenous manufacturing industry has a capacity to produce 42 lakhs bicycles per year and the production during the period 1968—1978 was 264 lakhs. This is indicative of the rate of increase in bicycle stock in the country.

Road and Rail Tranport

8.3 The number of vehicles in use in road and rail transport gives a good indication of the level of service rendered. The stock of road and rail vehicles in operation in the country has steadily increased as seen from Table 8.1 :

TABLE 8.1

Stock of oil using road transport vehicles

(in thousand s)

S. No.	Type of Vehicle	1961	1970	1975	1977
1.	Cars	256	490	591	827
2.	Jeeps	32	78	93	
3.	2-Wheelers	88	472	936	1334
4.	3-Wheelers	6	31	75	
5.	Buses	57	92	100	117
6.	Trucks	168	322	334	367
7.	Tractors	31	133	202	N.A
8.	Other Vehicles	35	113	236	

8.4 It is significant to note that the stock of two and three-wheelers has registered a sharp increase in the period 1970—75. The manufacturing capacity for such vehicles has increased to nearly 4.85 lakhs per year and it is anticipated that the number of two and three wheelers in use will increase steeply in the future.

8.5 The type of traction used in the railway system show that the stock of steam locos has declined gradually, while the diesel and electrical locos have increased. (See Table 8.2)

TABLE 8.2

Stock of Railway Locomotives

	1960-61	1970-71	1975-76	1977-78
Steem locos	10312	9387	8496	8215
Diesel locos	181	1169	1803	2025
Electrical locos	131	602	796	901

The reduction in the number of the steam locos and the intensity of their use has resulted in the decline of consumption of coal by the railways. The diesel and

*Techno-economics of Bullock cart Transportation—A Pilot Study, I.I.M. Bangalore (1974).

electricity used by the railways, as anticipated, shows a steady increase.

8.6 A careful examination of the stock of vehicles used for road and rail transport reveals that the rail system has expanded at a relatively slower rate than the road system. This reflected in the increase of the share of the road transport in respect of both passenger and goods transport (See Table 8.3):

TABLE 8.3

Relative share of road and rail in Transport Sector

Year	Railways	Road
	Goods Transport (billion tonne kilometres)	
1960-61	88 (84)	17 (16)
1965-66	117 (77)	34 (23)
1973-74	122 (65)	67 (35)
1976-77	157 (67)	76 (33)
	Passenger Transport (billion passenger kilometes)	
1960-61	78 (58)	57 (42)
1965-66	96 (54)	82 (46)
1973-74	136 (39)	211 (61)
1976-77	164 (39)	261 (61)

Note: Figures in brackets indicate percentage share of each mode during the year.

Water Transport

8.7 The total length of navigable inland waterways is estimated to be 18000 km, of which 10,000 km are usable throughout the year. But the number of boats plying on these waterways is so small that the total volume of goods and passengers carried by inland waterways is negligible.

8.8 Coastal shipping employed about 104 ships with gross registered tonnage (GRT) of 3,60,000 tonnes in 1960 by 1975 this had changed to 70 vessels with a total GRT of 3,70,000 tonnes. Though successive plans have emphasised the advantages of encouraging the use of inland waterways and coastal shipping for transport, there has been no striking development in this sub-sector.

Air Transport

8.9 Air transport has registered a spectacular increase in the last 15 years with an annual growth of about 10-11 per cent per year.

TABLE 8.4

Development of AIR Transport

	Unit	1961	1971	1974
Kilometres flown	million	28	33	34
No. of passengers carried	thousand	745	2056	2458
Passenger—Kilometres	million	575	1578	1935
Freight in tonne kms.	million	18	14	15

Commercial Energy use in the Transport Sector

8.10 The railways use coal, diesel oil and electricity, while the roadways use only oil products in the form of motor-gas and diesel. ATF is used in airways along with very small quantities of Av gas ; coastal ships are run on fuel oil and diesel oil. The commercial energy consumption in the transport sector has been estimated as set out in the Table 8.5 :

TABLE 8.5

Commercial energy used in the transport sector 1953—1978

(in million tonnes coal replacement)

Year	Coal	Oil Products	Electricity	Total Commercial Energy
1953-54	12.10	8.76	0.60	21.46
1960-61	16.00	17.37	0.80	34.17
1965-66	17.30	31.26	1.16	49.72
1970-71	15.91	47.23	1.43	64.57
1975-76	14.37	69.29	1.89	85.55
1978-79	12.40	78.18	2.60	93.18

8.11 The share of the commercial energy consumed in the transport sector to the total commercial energy consumed in the economy has remained somewhat steady at about 33 per cent during the last fifteen years (See Chapter II). The railways, the only user of coal in the transport sector, have adopted a policy of phasing out the steam locos in their system and replacing them with diesel or electric locos. This explains the steady decline in the absolute level of use of coal in the transport sector since 1965-66. The consumption of oil in the transport sector increased by 10.2 per cent per year in the period 1953-60 and 10.5 per cent in 1960-70 but decreased to 8.0 per cent per year in the period 1970-75. Electricity is used only in one mode of transport viz., railways and the increase in the rate of growth is the result of specific sections of the railway network being electrified.

8.12 The composition of fuel consumption in the transport sector has changed as follows :

	1960-61	1975-76
Coal	47%	17%
Oil	51%	81%
Electricity	2%	2%

Note: The shares are based on consumption in coal replacement measure.

While the share of electricity in the energy consumption in transport sector has remained unchanged in the period 1960-61 to 1975-76, the share of oil has increased by 30 per cent, entirely at the cost of coal.

Forecast on Eenergy Demand in the Transport Sector

8.13 The diversity of the existing stock of transport vehicles, the complexity of the factors which would influence the rate and pattern of growth of traffic in future make the task of forecasting the future demand for transport services as a whole or the demand of specific modes of transport a very difficult task. The Group is aware of the fact that a high level committee on transport policy is examining the future transport needs and the various policy measures required to meet the transport requirements optimally. As the report of the National Transport Policy Committee is not yet finalised and as the developments in the transport sector have a large impact on energy demand, this Group had to make an independent forecast of the energy needs of the transport sector. The analysis that follows is attempted solely with a view to trace the energy implications of the developments in the transport sector and the conclusions should be amended as and when a more rigorous forecast of the transport needs are made by the National Committee.

REFERENCE LEVEL FORECAST

Railway Transport

8.14 The railways have been the major transporter of passengers and freight and the growth of the railway transport system is set out in Table 8.6 :

TABLE 8.6

Passengers and freight moved by Railway Transport 1950—78

Year	Passenger traffic (billion passenger kilometres)		Freight (billion tonne kilo-metres)
	Intra city	Inter city	
1950-51	6.6	59.9	44.1
1960-61	11.8	65.8	87.7
1965-66	17.2	79.1	116.9
1970-71	23.1	95.1	127.4
1972-73	26.6	106.9	136.5
1975-76	32.9	116.0	148.3
1976-77	37.0	126.7	156.8
1977-78	39.4	137.3	162.7

8.15 The possible increases in transport were forecast with reference to the trends of the past and the elasticity of transport services to GDP in respect of each category of transport. The level of demand derived from these exercises is set out in Table 8.7 :

TABLE 8.7

Forecast of Railway Transport Services (1982—2000) reference level forcest

	Passenger traffic (billion passenger kilometres)		Feright (billion tonne kilo-metres)
	Intra-city	Inter-city	
1982-83	44.0	160.0	200
1987-88	56.0	204.0	240
1992-93	71.0	268.0	300
2000-01	101.0	426.0	410

8.16 From the data regarding the passenger kilometres and the ton kilometres of freight carried, the total gross tonne kilometres to be carried by railway was computed and the results are set out in Table 8.8 :

TABLE 8.8

Share of different types of traction in Railway Transport

REFERENCE LEVEL FORECAST

(in million gross tonne kilometres)

Year	Total	Steam	Diesel	Electric
1982-83	620	155	298	167
1987-88	760	137	403	220
1992-93	967	97	570	300
2000-01	1388	42	861	485

8.17 Table 8.8 also sets out the relative share of the total gross ton kilometres carried by steam, diesel and electric traction. These relative shares were derived by making the following assumptions :

In 1977-78 the share of the different kinds of locos in the total railway transport were roughly as follows :

Steam	30%
Diesel	45%
Electric	25%

It is assumed that the share of steam locos would get reduced gradually to 3% by the year 2000-01 and the share of electric and diesel loco services would become roughly 1 : 2.

8.18 The fuel requirements of the railway sector in different years is estimated in Table 8.9:

TABLE 8.9

Forecast of energy demand in Railway Transport 1982—2000

REFERENCE LEVEL FORECAST

Year	Coal (million tonnes)	Diesel (million tonnes)	Electric (TWH)
1982-83	12.4	1.04	3.00
1987-88	11.0	1.41	3.96
1992-93	7.8	1.99	5.40
2000-01	3.4	3.01	8.73

Road Transport

8.19 Passenger and freight carried by road transport in the last 25 years is summarised in Table 8.10 :

TABLE 8.10

Trend of growth of road Transport

Year	Passenger traffic (billion passenger kilometre)	Freight (billion tonne kilometres)
1950-51	23	6
1960-61	57	35
1965-66	82	55
1968-69	153	64
1973-74	211	67
1976-77	261	76

8.20 Road transport data do not show any regular trend which could be taken as the basis for projection of future demand for road transport services. The steep increase in the road passenger traffic during the period 1965-66 to 1968-69 is not easily explainable. The average rate of growth in the last 15 years from 1960-61 to 1976-77 has been about 10 per cent per year in respect of passenger kms. and about 5 per cent per year in respect of freight tonne kms. A forecast was made keeping in view the trend rate as well as elasticity of road transport services to GDP.

TABLE 8.11

Forecast of demand for road transport reference level forecast)

Year	Passenger (billion passenger kilometres)	Freight (billion tonne kilometres)
1976-77	261	76
1982-83	370	114
1987-88	495	169
1992-93	698	260
2000-01	1243	518

8.21 The fuel requirements have been calculated assuming that the share of passenger traffic carried by cars, taxis, 2-wheelers and 3-wheelers, which is today 23 per cent of the total passenger traffic and showing a declining trend, would get reduced to 15 per cent by 2000 and the share of the bus and truck transport would increase to 85 per cent. The fuel requirements have been projected as in Table 8.12 :

TABLE 8.12

Fuel Requirements for Road Transport

REFERENCE LEVEL FORECAST

Year	Passenger tariff (billion passenger kilometres)			Freight (billion tonne kilometres)	Fuel requirements (million tonnes)		
	Total	By car/ Taxi/2-wheelers/ 3-wheelers	Bus		Mogas	Diesel (Bus)	Diesel (Freight)
1982-83	370	77.7 (21%)	293.3 (79%)	114	1.69	1.80	5.18
1987-88	495	99.0 (20%)	396.0 (80%)	169	2.15	2.44	7.68
1992-93	698	125.6	572.4	260	2.73	3.53	11.8
2000-01	1243	186.5 (15%)	1056.5 (85%)	518	4.05	6.52	23.5

8.22 The forecast of transport demand in the Reference Level Forecast as anticipated is mostly an extrapolation of the past trend as would be seen from Table 8.13:

TABLE 8.13

Future shares of Rail & Road in the transport of Passengers & freight reference level forecast

Year	Railways	Road Transport
	Goods Transport (*in billion tonne kilometres*)	
1976-77	157 (67)	76(33)
1982-83	200 (64)	114 (36)
1987-88	240 (58)	169 (42)
1992-93	300 (54)	260 (46)
2000-01	410 (44)	518 (56)
	Passenger Traffic (*in billion passenger kilometres*)	
1976-77	164 (39)	261 (61)
1982-83	204 (36)	356 (64)
1987-88	260 (35)	486 (65)
1992-93	339 (33)	618 (67)
2000-01	527 (30)	1243 (70)

Note: Figures in brackets indicate the percentage share of each mode during the year.

8.23 The increase in freight transport in the roadways, however, appears to be high, if the number of trucks required to be added each year in order to enable the transport of the projected level of goods is considered. The projected level of freight transport by road would require an annual average net addition of about 116,000 trucks to the stock in the period 1982-83 to 2000-01 as against a net addition of about 20,000 in the recent years. It may be repeated that a detailed examination of the growth in transport is being undertaken by the National Committee on Transport Policy and the above projections may need considerable modifications.

Air Transport

8.24 The passenger kilometres of service rendered by air transport increased at an average annual rate of 10.3 per cent in the period 1961-71 but slumped to 5.8 per cent in the period 1971-74. There is evidence that the rate of growth has picked up to about 7 per cent in the more recent past. For the purpose of estimating the demand for ATF, the principal fuel for air transport, it has been assumed that air transport would increase by 8 per cent per year in the coming years upto 2000-01. On this basis, the demand for ATF would be as in table 8.14 :

TABLE 8.14

Reference Level Forecast of Demand for ATF

Year	Demand in Million tonnes
1977-78	1.044 (actual)
1982-83	1.53
1987-88	2.25
1992-93	3.30
2000-01	6.11

Coastal Shipping

8.25 Coastal ships use both fuel oil and LDO as bunker oil. As coastal shipping has not registered any growth, it is not surprising that the total consumption of LDO and FO for coastal ships has remained surprisingly steady in the last 15 years as seen from Table 8.15 :

TABLE 8.15

Consumption of Oil for Coastal Shipping

(*in million tonnes*)

Year	Furnace Oil	Diesel Oil	Total
1969	0.242	0.023	0.265
1970	0.199	0.042	0.241
1975	0.190	0.051	0.221

8.26 As there was no long term plans for development of coastal shipping, the Group assumed the following levels as the likely demand for coastal shipping :

TABLE 8.16

Forecast of Demand for Coastal Shipping Reference Level Forecast

(*in million tonnes*)

Year	Furnace Oil	Diesel Oil	Total
1977-78	0.180	0.070	0.250
1982-83	0.200	0.090	0.290
1987-88	0.300	0.120	0.420
1992-93	0.350	0.170	0.520
2000-01	0.400	0.250	0.650

Energy Demand Projections of the Transport Sector 1982—2000

8.27 The total fuel requirements of the transport sector are derived by aggregating the demand for fuels in different sub-sectors of the transport sector. The results are set out in Table 8.17 :

TABLE 8.17

Forecast of Demand for Energy in the Transport Sector (1982—2000)

REFERFNCE LEVEL FORCAST

Year	Coal in million tonnes	Oil in million tonnes					Electricity (TWH)
		Mogas	Diesel	ATF	FO	Total	
1982-83	12.4	1.69	8.11	1.53	0.20	11.53	3.00
1987-88	11.0	2.15	11.65	2.25	0.30	16.35	3.96
1992-93	7.8	2.73	17.49	3.30	0.35	23.87	5.40
2000-01	3.4	4.05	33.28	6.11	0.40	43.84	8.73

Optimal Level Forecast

8.28 The RLF implies that the Oil demand in the transport sector would increase at the rate of about 7.7 per cent per year in the period 1982 to 2000. Even at this seemingly modest rate of growth, the consumption of oil products in the transport sector alone would reach 44 million tonnes by 1982-83. The Group felt that this level of demand will almost be impossible to service satisfactorily (see Chapter on Oil Policy). The Group considered various possible methods of reducing the likely demand for oil products in the transport sector without compromising the growth target for the economy. The measures to reduce demand for oil products deserve serious consideration on the lines elaborated later in this Chapter.

8.29 In setting certain targets for improvement over time of the average efficiency of the road transport vehicles, the Group adopted an increase in the rate of efficiency of 7.5 per cent in the case of motorgas driven vehicles and 10 per cent in the case of diesel driven vehicles by the year 2000-01. Several other countries are aiming at much higher levels of efficiency to be achieved in a shorter time frame and there is no reason why we should not also set higher targets for increased efficiencies. The savings in fuel on account of such increased efficiency has been estimated as in Table 8.18 :

TABLE 8.18

Fuel Likely to be Saved by Improved Efficiency in Transport Sector 1982-2000

(in million tonnes)

Year	Motorgas	Diesel
1982-83	0.02	0.07
1987-88	0.05	0.25
1992-93	0.14	0.77
2000-01	0.30	3.00

Optimisation of Modes of Transport

8.30 For long distance passenger and freight traffic the most efficient mode in terms of energy utilisation is Railways. The RLF assumed only a continuation of the trends of change in the sharing of passenger and other traffic between road transport and railways The railways have been pleading their inability to increase the level of service. However, the railways can and should increase their services at least in the long-run if energy saving in the transport sector is to be attempted. If the inter-city passenger traffic and freight traffic is increased over the RLF by 15 per cent in 1987-88, 20 per cent in 1992-93 and 25 per cent in 2000-01 in the railway Sector, the freight traffic carried by railways will reach 500 billion tonnes km. and that of inter-city passenger traffic would increase to 530 billion passenger km. by the year 2000. If the increased traffic by the railways is distributed equally between diesel and electricity, there would be an increase of about 0.44 million tons in demand of diesel and 2.28 billion kwh of electricity by the year 2000 in the railways sector. But as this traffic would have been diverted from road transport, the reduction in the requirement of road transport would amount to over 5.5 million tonnes of diesel and motorgas. The specific measures which would ensure the optimisation of the share of road transport and railways are likely to be detailed in the report of the National Transport Policy Committee. The net impact of the optimisation suggested for intermodal distributions of traffic as above would be as follows :

Year	Motor Gas (million tonnes)	Diesel (million tonnes)	Flecticity (TWH)
1982-83			
1987-88	—0.13	—1.64	+0.76
1992-93	—0.24	—2.74	+1.30
2000-01	—0.35	—4.79	+2.28

8.31 There is need to reduce the elasticity of demand for traffic to GDP. This could be done by a more rational location policy for all productive activities with a view to ensure that the production and consumption needs are met as much as possible from the nearest available sources and the need for transportation of inputs and outputs is minimised. A low average transport economy has to evolve over time if there is to be conservation of the energy resources. The Working Group is conscious that the problems of planning this would involve a very detailed study of various sectors of the economy and the cost benefits of locating production activities in different places. If we set as a target a total transport reduction of about 3 per cent by the year 1992-93 and about 6 per cent by 2000 AD the savings that can be achieved would amount to 0.7 million tonnes of oil and 0.16 TWH of electricity by 1992-93 and 2.5 million tonnes of oil and 0.53 TWH of electricity by 2000 A.D.

8.32 Taking all these suggestions into account the Optimal Level Forecast on demand for energy in the transport sector would be as in Table 8.19 :

TABLE 8.19

Forecast of Demand for Energy in the Transport Sector 1982—2000

OPTIMAL LEVEL FORECSAT

Year	Coal (million tonnes)	Oil (million tonnes)					Electricity (TWH)]
		Mogas	Diesel	AIF	FO	Total	
1982-83	12.4	1.67	8.04	1.53	0.20	11.44	3.00
1987-88	11.0	1.97	9.76	2.25	0.28	14.26	4.72
1992-93	7.8	2.27	13.46	3.20	0.32	19.25	6.54
2000-01	3.4	3.16	23.49	5.74	0.38	32.77	10.48

Bullock Carts

8.33 The number of bullock carts has very slowly increased from 12 millions to 13 millions during the sixties. The total number of work animals, which are used to motivate the carts, to draw water from wells and to plough lands up to 80 million and this number has remained almost unchanged for some years. In Chapter VI it was suggested that the number of bullock powered irrigated wells would steadily decline in absolute numbers from 1977-78 itself due to the rapid dieselisation and electrification of irrigation wells. Though the number of tractors was estimated to increase steadily, it was assumed that the number of plough shares drawn by bullocks might not decrease. Considering all these trends, it appears that if the number of work animals continues unchanged till the end of the century, there would be a steadily increasing amount of animal power available for use in the transport sector. As long as small holdings and poor farmers form a large part of our rural sector, there would be a steadily increasing need for carrying increasing amounts of marketable surplus to the market towns in small quantities and to bring from the market towns small quantities of farm inputs. The demand for bullock cart service might increase and this demand might be met by the bullock power released from agricultural use. While it is not possible at this stage to quantify the likely increase in the use of bullock power, the overall trends suggest that measures to encourage the use of bullock carts and to increase their efficiency should receive urgent consideration. It is also noteworthy that the bullock carts render service in a specific segment of the transport sector where it might not be cost effective to use other more modern modes of transport. The Group would, therefore, recommend that adequate attention be paid to the improvement in the efficiency of bullock power.

Policy Measure

8.34 The transport sector represents an area where there is maximum potential for energy optimisation. The transport needs could be serviced by a number of modes of transportation and each mode has different capital and energy cost per unit of service rendered. It is necessary to evolve a transport policy keeping in view the long term costs of energy and their availability. The discussion in this chapter indicates a number of uncertainties which characterise the demand forecast for transport service. The coordination of rail and road traffic and the extent to which other less energy intensive modes like inland waterways, costal shipping etc. should be encouraged would have to be decided based on a much deeper study of the transport demand from different categories of goods and passengers, the identification of origin and destination of traffic, etc. The Working Group would have liked to have inter-acted with the National Committee on Transport Policy but as the studies of the Committee are not yet available, their views could not be taken into consideration. The Group would emphasise the need for a careful consideration of the transport policy in a comprehensive manner keeping in view the long term changes in the relative prices and availability of fuels. One of the major issues in the transport sector is the steady increase in the share of road transport which is less efficient from the point of view of energy use and has resulted in a sizeable increase in the consumption of oil. The relative shares of rail and road transport should be reviewed critically keeping in view their relative efficiencies of energy use and pressure on scarce fuels.

8.35 Even though dieselisation and electrification in railways have considerable advantages in terms of energy efficiency, operating cost, etc. the present policy is to continue the use of existing stock of available steam locos till the end of their useful life. The coal used in the steam locos is of high grade and the present consumption of about 13 million tonnes could be replaced by about 0.6 million tonnes of oil or about 3 TWH of electricity, which can be generated using less than 2 million tonnes of low grade coal. In view of the need to conserve high grade coal which has a high opportunity cost, the feasibility of early replacement of steam traction by the other modes should be considered urgently. Electric traction is more advantageous than diesel traction from the points of view of both energy efficiency and conservation of oil. In this context, accelerated pace of electrification of the high density traffic trunk routes, specifically those connecting Bombay, Delhi, Calcutta and Madras deserves serious consideration.

8.36 In the case of intra-city traffic, i.e. urban and sub-urban, the Group did not examine in detail the extent to which electric trolley buses could be introduced as a means of reducing consumption of oil. A Working Group set up by the Planning Commission on the introduction of trolley buses has recently submitted its report which is under consideration. The Working Group feels that there is a case for introducing electric trolley buses in not only the metropolitan cities but also in other major cities.

8.37 Another measure which would lead to fuel efficiency in the transport sector is by increasing the efficiency of the road transport vehicles. There is an effort all over the world to improve the fuel efficiency of the automobile engines and it is possible, even with our limited resources, to set specific targets for improved fuel efficiency in the indigenously manufactured vehicles. The Group would recommend that such targets should be set at least to the levels that have been suggested in this Chapter.

8.38 As the transport sector is presently dependent on oil whose availability would be uncertain in the coming years, there is need to develop alternate fuels for use in the transport sector. The possibilities of introducing producer gas powered vehicles and the use of alcohol to substitute petrol|diesel should be studied from now on. Necessary efforts should be initiated in this direction at the earliest.

CHAPTER IX

POLICY FOR THE POWER SECTOR

9.1 Electricity is a secondary form of energy which is produced on a large scale commercially from coal, oil, gas, water, power and fissile material. For a variety of reasons, the rate of growth of electricity has been the highest as compared to all other sources of commercial energy. Electricity unlike other forms of energy, can neither be stored nor can be distributed using ordinary means of transport like rail or road. For distribution of electricity, transmission and distribution lines are required to be built connecting the sources of generation and the points of consumption. This is of particular relevance in analysing electricity consumption in India as benefits of electricity are not available in many parts of the country due to lack of transmission and distribution lines.

Trends in the use of Electricity

9.2 The trends in the use of electricity could best be analysed based on specific-end use, had sufficient data been available regarding its consumption for the various end-uses such as heating, lighting, electro-chemical process and motive power. In the absence of such data, the analysis in this report had to be carried out in terms of consumption by various consumer categories, viz., domestic, commercial, agricultural, industrial, transport, etc.

9.3 As mentioned earlier in Chapter V, "Energy in the Household Sector", while all the towns have been electrified, only 2.3 lakhs villages out of a total of 5.7 lakhs have been electrified so far. Even in the towns and the villages which have already been electrified, not all the households have been provided with electric connections. The number of households electrified so far constitute only about 14 per cent of the total number of households in the country. In the case of organised industries, however, there is hardly any which does not use electricity to meet its energy needs. The category-wise consumption of electricity during the past two decades is shown in Table 9.1 :

TABLE 9.1

Category-wise Consumption of Electricity

(in TWH)

Consumer Category	51-52	60-61	65-66	70-71	75-76	78-79 (provisional)
Household	595	1492	2355	3840	5821	7660
Commercial Sector	332	848	1650	2573	3507	4970
Industrial	4549	12563	22610	34290	43446	53939
Agriculture	203	833	1892	4470	8721	11950
Railways	330	454	1057	1397	1891	2610
Public Lighting	68	193	280	500	573	695
Public Water Works	211	436	625	1017	1327	1690
Miscellaneous	..	..	..	382	868	930
Total	6288	16819	30469	48478	66060	84435

Note : Electricity consumed from generation by non-utilities is included.

9.4 There have been shortages of electricity in various parts of the country during the seventies, the worst being the year 1974-75, when the shortages were widespread and were of comparatively large magnitudes. This has resulted in power cuts and restrictions of varying dimensions in a number of States. Although it is difficult to quantify the shortfall in consumption due to these power cuts and restrictions, some attempts have been made by the C.E.A. to estimate the level of consumption if power cuts and restrictions were not there, based on the information furnished by the various States. The results of these exercises are shown in Table 9.2 :

TABLE 9.2

National Unrestricted Demand for Electricity

(in TWH)

	70-71	71-72	72-73	73-74	74-75	75-76	76-77
Actual consumption	48478	51795	54239	55592	58253	66080	73023
National Consumption if power cuts/ restrictions were absent	49445	54266	59557	62602	67655	73888	77361
Gap	1.9%	4.5%	8.9%	11.2%	13.9%	10.6%	5.6%

Table 9.3 shows the rates of growth of electricity consumption by various categories of consumers :

TABLE 9.3

Rates of Growth of Electricity Consumption in the various Sectors

(average annual compound%)

Period	Total Electricity	Household	Commercial	Industrial	Agricultural	Transport	Others
1951-52 to 1960-61	11.6	10.9	11.1	11.9	17.0	3.5	9.5
1960-61 to 1965-66	12.6	9.5	14.2	12.5	17.9	18.2	7.5
1965-66 to 1970-71	9.7	10.3	9.3	8.7	18.8	5.7	15.9
1970-71 to 1975-76	6.4	8.7	6.4	4.8	14.3	6.2	8.0
1975-76 to 1978-79*	9.2	9.5	12.2	7.4	11.0	11.4	6.2

*Based on provisional figures for 1978-79.

In order to meet the increasing demand for power, the installed generating capacity in the country has been increased rapidly from a meagre 2300 MW in 1950 to about 29,000 MW by the end of 1978-79. There has also been considerable expansion in transmission and distribution facilities as well as rural electrification, with about 2.3 lakh of villages electrified and about 33 lakhs of pump sets energised. This large expansion in generation, transmission, distribution and rural electrification has been achieved through substantial investment in the electricity sector, as shown in Table 9.4 :

TABLE 9.4

Investment in the Power Sector

Plan Period	Invesment in the Electricity Sector (Rs. crores)	As a percentage of total plan expenditure
Ist Plan	320	16.3
IInd Plan	625	11.2
IIIrd Plan	1334	15.6
Three Annual Plans	1817	27.43
IV Plan	2523	16.0
V Plan	7294	18.6
VI Plan (Proposed)	15750	22.6

9.5 In spite of manifold increase in generating capacity, power shortages have been experienced in various parts of the country during the past several years. The basic reasons for these shortages have been the continuous slippages in the achievement of targets of additional generating capacity in each successive plan period as shown in Table 9.5 and the lack of strategy for management of power demands which is reflected in the very steep increase in electricity demands, irrespective of the supply constraints. Past experience in electricity development and management suggests the need to assess more reliably the likely additions to power supply and also to manage the building up of demand for power with due regard to the annual additions of supply that take place. In other words, demand management is as important as supply augmentation so that both demand and supply increase in step with each other.

TABLE 9.5

Targets and Achievements of Additions to Generating Capacity

Plan	Target (million kw)	Achievement (million kw)	Percentage shortfall
Ist Plan (1951-56) .	1.30	1.10	15.4
IInd Plan (1956-61) .	3.50	2.25	35.7
III Plan (1961-66) .	7.04	4.52	35.8
Three Annual Plans (1966-69) . .	5.43	4.12	24.1
IV Plan (1969-74)	9.26	4.58	50.5
Period 1974-79 . .	12.50	10.2	18.4

Forecast of Demands

9.6 The forecast of demands arrived at by using different methodologies such as end-use method, GDP linear models and time series models have been discussed in Chapter III. Experience all over the world has shown that there is always some decline in the rate of growth of consumption of electricity with time, depending upon the state of the economy. Keeping this in view, the Working Group has examined the various methodologies and has come to the conclusion that the End-Use Method would provide a reasonable forecast of demand in the short term. Considering, however, the various uncertainties involved and with a view to prevent recurring shortages, the Working Group also feels that in so far as long term power planning is concerned the results provided by the end-use method could be checked by GDP models.

9.7 Adopting various possible methods of forecasting and harmonising the results, the Group has suggested two different levels of electricity demand, viz. RLF which indicates the consumption that might materialise if no cogent energy policy is adopted and the OLF which indicates the level at which electricity demand could be contained without affecting the production and growth perspectives, if only the policy prescriptions made in the report are adopted. These levels have been discussed in Chapter III; for the sake of convenience they are reproduced in Table 9.6 :

TABLE 9.6 (A)

Forecast of Category-wise Demand for Electricity 1982—2000

REFERENCE LEVEL FORECAST

(*in TWH*)

Category	1982-83	1987-88	1992-93	2000-01
Household .	10.7	15.5	22.0	35.8
Commercial .	7.1	10.3	14.7	24.0
Agricultural .	16.8	22.2	28.2	33.0
Industrial . .	85.0	131.0	199.7	350.0
Transport .	3.0	4.0	5.4	8.7
Others . .	5.7	8.2	11.9	19.5
Total Consumption .	128.3	191.2	281.9	471.0
Generation required (*) (at the busbar) .	154.9	228.7	333.7	551.6

*Includes non-utilities. For details see table 9.14(A).

Note : The commercial energy demand is assumed to be about two thirds of the demand in the household sector.

TABLE 9.6 (B)

Forecast of Category-wise Demand for Electricity 1982—2000

OPTIMAL LEVEL FORECAST

(*in TWH*)

Category	1982-83	1987-88	1992-93	2000-01
Household .	10.7	15.1	20.9	32.2
Commercial .	7.1	10.6	14.6	21.4
Agricultural .	16.8	21.1	25.4	28.0
Industrial . .	85.0	114.5	162.3	284.0
Transport .	3.0	4.7	6.5	10.5
Others . .	5.7	8.2	11.9	19.5
Total Consumption .	128.3	173.6	241.0	395.6
Generation required (at the busbar)*	154.9	207.5	281.7	457.6

*Includes non-utilities. For details see table 9.14(B).

9.8 The Optimal Level Forecast (OLF) implies that savings in the consumption of electricity is possible especially in the industries sector. The household and commercial demands could also be trimmed. As the optimisation is assumed to start after 1982-83 and as it is assumed that efforts to realise the optimal demand configuration would be initiated from now on, there is a somewhat sharp decline in the rate of growth of electricity consumption in the period 1982—87 as per OLF. The rates of growth of electricity consumption implied in the two levels of forecast are set out in Table 9.7 :

TABLE 9.7

Rates of Growth of Electricity Consumption 1976—2000

(average annual Compound %)

	1982-83 / 1976-77	1987-88 / 1982-83	1992-93 / 1987-88	2000-01 / 1992-93
As per RLF .	9.8	8.3	8.1	6.6
As per OLF .	9.8	6.0	6.3	6.3

In the OLF, the rate of growth in the period 1982-83 to 1987-88 is lower than the rates of growth in the subsequent periods. This is because of the high rate of increase in the growth rate postulated in consumption for the period 1976-77 to 1982-83 keeping in view the past shortages which would get moderated during 1983—88 and thereafter there would be a more orderly decline in the electricity consumption growth rate over the different sub-periods.

Transmission and Distribution Losses

9.9 Transmission and distribution losses which represent the difference between the net energy generated and the energy sold, has been continuously rising from about 14.3 per cent in 1965-66 to about 19.7 per cent in 1976-77. A part of these losses is due to pilferage which cannot be accounted for. As compared to many developed countries, transmission and distribution losses in India are high for a variety of reasons, such as low power factor, low load density, inadequate investment in transmission and distribution as compared to generation, large scale electrification of rural areas and inefficient distribution systems in urban areas. Coupled with high transmission and distribution losses is also the problem of low operating voltage levels. Some steps have already been taken towards power system improvement by the various State Electricity Boards as well as the Rural Electric Corporation during the past several years. Inspite of this, the losses have been steadily increasing and the Working Group feels that much larger efforts would be necessary in this direction. The importance of reducing transmission and distribution losses may be judged from the fact that at the present level of generation, even 1 per cent reduction in loss would amount in additional revenue of the order of Rs. 20 crores per year. If the steps already initiated in the last two or three years towards reduction of transmission and distribution losses are more vigorously followed, it may be possible that the losses would show some declining trend and the levels of T&D losses may be of the order given in the column under RLF below. The Group however feels that with the steeply increasing costs of power generation it might become more remunerative to invest in system improvements that might reduce losses in T&D, than investing in additional capacity and if this is done, it may be possible to reduce losses still further, as given in Table 9.8 under OLF.

TABLE 9.8

Assumption Regarding Transmission & Distribution Losses

Year	Transmission & Distribution Losses as per	
	RLF	OLF
1982-83	18%	18%
1987-88	17%	17%
1992-93	16%	15%
2000-01	15%	14%

Annual Load Factor

9.10 In the case of electricity, the energy demands are not consistent throughout the year and there are large variations from month to month, day to day and hour to hour. Since electricity, unlike other sources of energy, cannot be stored, adequate capacity has to be installed to meet the peak demand occurring at any point of time of the year. Thus, in the case of electricity, besides making a reasonable forecast of energy requirements, it is also essential to make an assessment of the annual peak demand. This is arrived at by dividing the energy consumption figures by the annual load factor, which is defined as the ratio of the average demand to the actual peak demand during the year. Historically the annual load factors at station bus bars have varied between 61 per cent in 1961-62, 66.5 per cent in 1972-73 and 63.5 per cent in 1975-76. Some improvement in the load factor has been noticed in certain years which is due to peaking shortages and not due to any significant changes in the demand structure. The Working Group feels that with the lifting of the various cuts and restrictions, the load factor might show a downward trend, which would require larger installed capacities to meet the demands. In the RLF, the Group has assumed that the load factor would continue to be at the current level of 63 per cent upto 1992-93 and increase to 64 per cent in the year 2000-01. The Group, however, feels that there may be scope to improve the load factor marginally by introducing a system of demand management, so as to reduce the peak demand through regulatory measures and offering incentive tariffs to promote consumption during off-peak hours. On this basis, the Working Group recommends the figures of annual load factors for assessing future capacity required in optimal level forecast could be as indicated in Table 9.9 :

TABLE 9.9

Assumptions Regarding Load Factor 1982—2000

Year	Percentage Annual Load Factor	
	RLF	OLF
1982-83	63	63
1987-88	63	64
1992-93	63	65
2000-01	63	66

Generation from non-utilities

9.11 The term non-utilities refers to captive power plants set up by some industries to meet their own demands. In the initial stages of development, a large number of industries in India had set up their own captive power plants as either they were located in areas which were not served by a utility grid or availability of electricity was inadequate to meet their requirements. However, since captive power generation is invariably costlier both in terms of capital investment as well as operational costs, the share of generation in non-utilities in the total power generation in the country has been continuously decreasing, as shown in Table 9.10.

TABLE 9.10

Share of Non-utilities in Installed Capacity and Electricity Generation 1951—77

Year	Installed capacity (thousand MW)			Generation (TWH)		
	Utilities	Non-utilities	%share of non-utilities	Utilities	Non-utilities	%share of non-utilities
1951	1.71	0.59	25.6	5.86	1.66	22.0
1960-61	4.70	1.00	17.7	16.93	3.19	15.8
1970-71	14.70	1.50	9.6	53.80	5.40	8.8
1975-76	20.10	2.10	9.6	79.20	6.70	7.8
1977-78	23.70	2.35	9.0	91.14	7.50	7.6

This declining trend in captive power generation has been observed in all countries. There would, however be some additions to the captive power generation due to two reasons :

(i) As more sophisticated industries with continuous processing are set up, they would need to have standby facilities to keep on the essential processes without interruption in case of failure of the utilities system.

(ii) As large size fertilizer, paper, etc. plants get installed, the total energy balance of the industry would call for the setting up of a power facility to produce electricity and steam needs without significant increase in fuel consumption.

It is assumed that the generation from non-utilities would gradually get reduced to about 3 per cent of total power generation in 2000-2001.

Assessment of Supply Requirements

9.12 The increase in the demand for electrical energy would have to be met by a well thought out strategy of management of electricity sector with the major objective of optimising the investment and the system operation so as to meet the electricity needs most economically consistent with a desired degree of reliability. Adequate provision has to be made in terms of capacity as well as energy to meet the perspective power demands. In the case of hydro-electric power stations, the energy availability may vary considerably during the year depending upon river flow conditions, storage provided and constraints of irrigation requirements in the case of multi-purpose schemes. Hydro-electric stations are normally designed on the basis of 90 per cent dependability i.e. the potential which is available for 90 per cent of the time. In a mixed system, it has been found that hydro-power stations are suited to take the peak and thermal and nuclear power stations to meet the base load requirements. Table 9.11 shows actual average energy output in terms of kwh/kw in respect of nuclear, hydro and thermal power stations in the country.

TABLE 9.11

Trends in Utilisation of Power Generation Capacity

(in kWh per kW)

	1951	1960	1965-66	1968-69	1973-74	1975-76	1978-79
Hydro	4972	4089	3692	3508	4161	3935	4380
Thermal (Steam power plants)	2532	3584	3933	3975	4028	4042	3513
Nuclear	..	..	..	..	3744	4104	4350
Total	3192	3640	3655	3661	4002	3938	3895

The hydro energy output in terms of kWh per kW installed has shown a downward trend over the years, whereas thermal and nuclear power stations have shown a rising trend (with the exception of 1978-79 in the case of thermal stations). This is in line with the concept of utilising hydro power for peaking purposes and thermal and nuclear for base load operation and it is expected that this trend would continue in future.

9.13 It is a common experience that in the initial stages of operation thermal units are faced with a large number of teething problems and take quite some time before they reach their normal expected level of performance. For this reason, the kwh/kw in the case of new units is low as compared to matured units, and for purposes of this study the following norms have been adopted :

Year of operation	KWH/KW
1st year	2500
2nd year	4000
3rd year	5000
4th year onwards (matured)	5350

Based on the above and the anticipated thermal capacity additions in 1982-83, it has been found that during the period upto 1982-83 there may be a declining trend in the value of kwh/kw mainly due to higher rate of growth of thermal capacity additions as compared to hydro. However, the trend would again be reversed during the subsequent years, as it is expected that hydro contribution would improve in line with the strategy of according high priority to hydro power development in future planning. Based on these considerations, it may be assumed that kWh/kW contribution from hydro, thermal and nuclear plants would normally follow the pattern as given under RLF in Table 9.12. However the Committee feels that with proper load structuring and improvement of the supply system, the kWh/kW ratio could improve as given under OLF in the same time.

TABLE 9.12

Projected Plant Utilisation 1982—2000

(in kWh per kW)

	1982-83	1987-88	1992-93	2000-01
REFERENCE LEVEL FORECAST				
Nuclear	4185	4225	4300	4550
Hydro	3900	3290	3250	3200
Thermal	3633	4508	4550	4720
OPTIMAL LEVEL FORECAST				
Nuclear	4500	5000	5200	5400
Hydro	3900	3290	3250	3200
Thermal	4000	4500	4550	4720

9.14 In assessing the capacity requirements to meet a peak demand, margins have to be provided for scheduled outages covering overhauling and maintenance of equipment and also unforeseen forced and partial outages. Allowance has also to be made for larger outage rates on new units. To cover all these factors, capacity requirements are worked out by providing an appropriate gross margin over the expected peak demand. In this connection, the Working Group on Power Development which was constituted by the Planning Commission in September, 1977 had adopted 12.5 per cent for hydro sets (peak availability factor of 87.5 per cent). The gross margin in the case of matured thermal units had been taken as 36 per cent (peak availability factor of 64 per cent) for all regions except Eastern and North-Eastern Region where a higher margin of 41 per cent has been adopted. For new thermal units it had been assumed that for the first three months after commissioning they would not contribute anything towards peaking capacity, only 50 per cent capacity would be abailable during next 9 months and full output would be available after that. Based on these assumptions and the anticipated likely additions upto 1982-83, the peak availability factors work out as follows :

Nuclear	0.56
Hydel	0.79
Thermal	0.53

The peak availability factors of thermal plants in India are generally very low in comparison with most of the developed countries partly due to long maintenance periods and partly due to higher rates of forced and partial outages on thermal units. Most of the problems of thermal power stations in India have arisen on account of poor quality of coal of high ash content, often exceeding 40 per cent. The ash is highly abrasive and erodes the vital parts of the boilers and pulverising system. Coal beneficiation has been suggested as one of the solutions to improve the quality of coal for thermal stations which merits serious consideration. Besides, streamlining maintenance procedures, training of manpower in the operation and maintenance of large thermal units, adequate arrangements for supply of spares and updating boiler and equipment technology are some of the important areas of interest to improve performance of thermal stations. The Working Group feels that with a more vigorous follow up of these measures, the performance of thermal stations in India would considerably improve and there would be an upward trend in the peak availability factors with time. Table 9.13 shows the peak availability factors assumed in various years for assessment of capacity requirements :

TABLE 9.13

Peak Availability Factors*

REFERENCE LEVEL FORECAST

	1982-83	1987-88	1992-93	2000-01
Nuclear . .	0.56	0.60	0.66	0.70
Hydel . .	0.79	0.80	0.81	0.82
Thermal . .	0.53	0.56	0.62	0.70

OPTIMAL LEVEL FORECAST

Nuclear . .	0.56	0.64	0.70	0.75
Hydel . .	0.79	0.80	0.81	0.82
Thermal . .	0.55	0.58	0.64	0.70

*Capacity available to meet the peak demand at the time of annual peak.

9.15 Based on these considerations the installed capacity requirements are set out alongwith the implied assumptions in Table 9.14(A) :

TABLE 9.14(A)

Requirement of Installed Capacity 1982—2000

REFERENCE LEVEL FORECAST

Particulars	Unit	1982-83	1987-88	1992-93	2000-01
1	2	3	4	5	6
Total energy demand at the consumer end	TWH	128.3	191.2	281.9	471.0
Anticipated Capacity in Non-utility	MW	2500.00	3000.00	3600.0	4900.0
Energy supply from Non-utility	TWH	7.0	8.1	10.1	14.7
Energy required from utilities	TWH	121.30	183.1	271.8	456.3
T&D losses	%	18	17	16	15
Energy demand at the power station bus	TWH	147.9	220.6	323.6	536.9
Annual load factor	%	63	63	63	64
Peak Demand	MW	26854	39972	58636	95766
Peak Demand served by—					
Nuclear	MW	745	1220	1808	3500
Hydel	MW	11699	19600	27540	40180
Thermal	MW	14410	19152	29288	52086
Total	MW	26854	39972	58636	95766
Installed Capacity					
Nuclear	MW	1330	2035	2740	5000
Hydel	MW	14809	24500	34000	49000
Thermal	MW	26193	34200	47240	74409
Total	MW	42332	60735	83980	128409
Energy availability from :					
Nuclear	TWH	5.56	8.60	11.78	22.8
Hydel	TWH	57.70	80.70	110.50	156.8
Thermal	TWH	98.75	153.90	214.90	351.2
Total	TWH	162.01	243.2	337.18	530.8
Energy Deficit(—)/Surplus (+)		(+)13.81	(+)22.60	(+)13.58	(—)6.1
Additional thermal capacity to meet shortages in energy	MW	..	..	..	1291
Total Installed capacity in Utilities	MW	42332	60735	83980	129700

TABLE 9.14 (B)

Requirements of the Installed Capacity 1982—2000

OPTIMAL LEVEL FORECAST

Particulars	Units	1982-83	1987-88	1992-93	2000-01
1	2	3	4	5	6
Total energy consumption	TWH	128.3	173.6	241.0	395.6
Capacity in Non-utility	MW	2500.00	3000.00	3600.0	4900.0
Energy supply from non-utility	TWH	7.0	8.1	10.1	14.7
Energy consumption in utilities	TWH	121.3	165.5	230.9	380.9
T&D losses	%	18	17	15	14
Energy demand at the bus bar	TWH	147.9	199.4	271.6	442.9
Load factor	%	63	64	65	66
Peak demand	MW	26799	35565	47690	76605
Peak demand served by—					
Nuclear	MW	745	1302	1918	3750
Hydel	MW	11739	16800	25110	38540
Thermal	MW	14315	17463	20652	34315
Total	MW	26799	35565	47690	76605
Installed capacity					
Nuclear	MW	1330	2035	2740	5000
Hydel	MW	14809	21000	31000	47000
Thermal	MW	26027	30110	32284	49020
Total	MW	42166	53145	66024	101020
Energy available from					
Nuclear	TWH	5.98	10.18	14.25	27.00
Hydel	TWH	57.70	69.09	100.75	150.40
Thermal	TWH	104.11	135.50	146.89	231.37
Total	TWH	167.79	214.77	261.89	408.77
Deficit(—)/Surplus (+)		(+)19.89	(+)15.37	(—) 9.71	(—)34.13
Additonal thermal capacity required to meet shortages in energy—capacity	MW	..	..	2134	7231
Total Installed Capacity in Utilities	MW	42166	53145	68158	108251

9.16 Table 9.15 shows the total capacity additions in utilities to meet the projected demands and the average addition per year during each sub-period.

TABLE 9.15

Capacity Additions Required to Meet Perspective Demands

(in MW)

Period	Capacity Additions: Nuclear	Hydro	Thermal	Total	Average additions per year
REFERENCE LEVEL FORECAST					
1977/78—1982/83	690	4799	13143	18632	3726
1982/83—1987/88	705	9691	8007	18403	3680
1987/88—1992/93	705	9500	13040	23245	4649
1992/93—2000/01	2260	15000	28460	45720	5715
OPTIMUM LEVEL FORECAST					
1977/78—1982/83	690	4799	12977	18466	3694
1982/83—1987/88	705	6191	4083	10879	2176
1987/88—1992/93	705	10000	4308	15013	3003
1992/93—2000/01	2260	16000	21833	40093	5011

It may be observed from the above that capacity additions during the sub-period 1982-83—1987-88, is low as compared to any other sub-period. In this connection it may be mentioned that in the above exercises, capacity additions have been worked out purely on the basis of projected power demands. The Working Group feels that any exercise on long term planning for power should take into account design, manufacturing and construction capabilities in the country and make suitable adjustments to take those factors into account in capacity additions in various sub-periods without affecting the long term perspective. If this is done, the adjusted capacity additions requirements are given in Table 9.16 and the installed capacity is given in Table 9.17.

TABLE 9.16

Capacity Addition Requirements (Adjusted)

Period	Capacity addition				Average addition per year in MW
	Nuclear	Hydro	Thermal	Total	
REFERENCE LEVEL FORECAST					
1977/78—1982-83	690	4799	13143	18632	3726
1982/83—1987/88	705	9691	9274	19670	3934
1987/88—1992/93	705	9500	13215	23420	4684
1992/93—2000/01	2260	15000	25727	42987	5411
OPTIMAL LEVEL FORECAST					
1977/78—1982/83	690	4799	12977	18466	3694
1982/83—1987/88	705	6191	5800	12696	2540
1987/88—1992/93	705	10000	4600	15305	3061
1992/93—2000/01	2260	16000	20000	38260	4783

TABLE 9.17

Total Installed Capacity (Adjusted) in MW

	R.L.F.	O.L.F.
1982/83	42332	42166
1987/88	62002	54862
1992/93	85422	70167
2000/01	128409	108427

Note : The capacities above have been worked out on the assumption that full benefits will be derived from new generating units immediately after commissioning. This, however, is not the case and some flexibility in capacity planning would be required to allow for the initial stabilisation of the new units.

9.17 From Table 9.17 it would be seen that the optimal level forecast implies a saving of installed capacity of about 7300 MW (12 per cent) by 1987-88 and 15000 MW (18 per cent) by 1992-93 and 20000 MW (15 per cent) by 2000 A.D. The possible savings on account of the optimisation would be of the order of Rs. 2920 crores by 1987-88, Rs. 6000 crores by 1992-93 and Rs. 8000 crores by the turn of the century. Even if a significant part of this 'saving' has to be spent on system improvement to achieve the optimisation the effort would be worthwhile, as it would help in conserving the diminishing stock of fossil fuels.

CHOICE OF SOURCE OF GENERATION

9.18 Table 9.18 shows the percentage contribution from various sources in different regions in the country as on 31st March, 1978.

TABLE 9.18

Shares of Modes of Generation as on 31-3-78

(as % of installed Capacity)

Re ion	Hydro	Thermal	Nuclear	Total
Utilities :				
Northern .	48.75	47.94	3.31	100.00
Western . .	27.24	65.97	6.79	100.00
Southern .	67.47	32.53	..	100.00
Eastern . .	19.74	80.26	..	100.00
North-Eastern .	30.06	69.94	..	100.00
All India .	42.24	55.06	2.70	100.00

In the Northern Region both thermal and hydro have almost equal shares. Both Eastern and Western Regions are predominately thermal due to limited hydro resources and availability of large deposits of coal, whereas the Southern Region has been mostly dependent on hydro power. Generally, the choice of source of generation has followed the availability of resources in each State. From operational angle, however, this may not lead to optimal solutions due to widely different technical characteristics and cost structure of various types of plants. Though it has been recognised that reservoir type hydro-electric stations should function as peaking station, many of such stations have been designed to operate to meet both the peak as well as the base requirements of the State grid within which they function. As discussed in Chapter IV, as per the latest survey, the Central Electricity Authority have estimated the total hydro potential equivalent to about 400 TWH of annual energy generation. This potential can be more beneficially used if the storage type hydro plants are designed in future primarily as peaking stations. The nuclear generating stations should be able to fulfil their functions as base load Stations and provide about 6500 to 7000 kwh/kw. Power planning in future should be based on the concept of an optimal mix of thermal/nuclear and hydro stations in which the hydro stations should take the peak and the thermal stations provide the base load.

9.19 Hydro development should receive a very high priority, and in this connection, the Working Group feels that the following aspects should receive immediate attention :

(a) a time-bound programme for completing quickly the reassessment of hydel potential and the survey and investigation required to formulate hydel projects ;

(b) recognising the long gestation of hydro power stations and the limited resources of the States in each Plan period, evolving a well-conceived scheme of financial and technical assistance from the Central Government to the State Government to encourage State Government to take up hydel projects with long gestation periods ;

(c) speedy resolution of inter-State disputes and evolving procedures for taking up large river valley projects jointly by the States and the Centre ;

(d) prompt and pragmatic examination of their impact on environment ; and

(e) developing appropriate organisational structure to manage large hydel projects located in small States and remote areas.

9.20 Management of Transmission and Distribution Systems

Along with generation there has to be commensurate investment in transmission and distribution to evacuate power from the generating stations and deliver it to the point of consumption. It has been found that expenditure on transmission and distribution should normally be about 66 to 100 per cent of the expenditure on power generation. The national average of the investment in T&D in USA is about 70 per cent of the investment in generation. In India, however, the investment on transmission and distribution needs to be much higher, although it has been much less. Table 9.19 shows the investments in transmission, distribution and generation during the various Plan periods :

TABLE 9.19

Comparative Investment in Generation, Transmission and Distribution

Plan period	Investment in generation	Investment in T & D	3 as percentage of 2
1	2	3	4
	(Rs. crores)	(Rs. crores)	
II Plan	250	115	46
III Plan	774	301	39
Annual Plans 1965-68	676	290	43
IV Plan	1480	796	55
V Plan* . . . . (1974—78 four year)	3323	1499	45

*Figures of 1977-78 are provisional

This imbalance between investment in generation and transmission and distribution resulting from the emphasis laid by the States mostly on generation schemes in the past coupled with persistent shortages of essential materials like aluminium, steel and lack of a long-term power system plan are some of the main reasons for high transmission and distribution losses in India.

9.21 In general, the transmission and distribution losses increase with generation of power and the distance between the generating stations and the load centre and adoption of higher voltages, generally, reduces transmission and distribution losses. Planning of transmission and distribution systems has to be viewed from a long-term angle so as to ensure that adequate provision exists to meet the demands at least for next few years and changes which become necessary at a later date can be carried out in a convenient and economical manner. This explains the trend towards the adoption of progressively higher voltages all over the world. At present, the highest operating voltage in the country is 400 kV. Development of large hydro resources located in remote areas at long distances from the major centres of consumption, coupled with the need for providing inter-connecting facilities among the various States in each region, might require adoption of voltages higher than 400 kV. DC high voltage transmission may also be a viable alternative in some cases. It is essential that a long-term transmission plan is prepared for each region which could be executed in a phased and systematic manner.

Possible Cost Reduction in Power Sector

9.22 There has been a rising trend in the capital cost of power plants all over the world, partly, due to inflation in economy and partly due to the increase in the cost of various inputs. All possible efforts have, therefore, to be made to contain these rising prices to the extent possible. As already discussed, future planning for power should be based upon optimal mix of various sources of generation viz. hydro, thermal and nuclear which will ensure optimal development of these resources and minimise the total overall cost. The choice of the various sources of electricity should be based on detailed studies covering various possible patterns of development on the basis of a systems approach. The Working Group would like to strongly urge that investment decisions in the power sector should, hereafter, be based on systems considerations, as decisions based on old thumb rules and ad hoc reasons may lend to sub-optimal solutions which may prove to be very costly. Reduction in transmission and distribution losses is equally important as even 1 per cent reduction in loss at the present day price would mean an additional revenue of the order of Rs. Rs. 125 crores by 2000-01. Another important parameter which could have substantial impact on investment is the load factor which may be judged from the fact that by 2000-01 there can be saving of the order of Rs. 850 crores by improving the load factor by 1 per cent. Thus it may be seen that substantial savings in costs are possible through adoption of a system-approach in power planning, reducing transmission and distribution losses and improvement of load factor. It is important that detailed State-wise and region-wise power planning studies should be undertaken by different concerned agencies like State and Regional Electricity Boards and the Central Electricity Authority so that there could be some meaningful discussions on the possibility of meeting increase of electricity demands at minimum cost.

9.23 Provision has to be made to compensate for retirement and derating of old plants. The Group feels that the annual retirement/derating may be of the order as indicated below :

Period	Derating and retirement in MW per year
1982-83 to 1987-88 . .	200 MW
1987-88 to 1992-93 . .	350 MW
1992-93 to 2000-01 . .	500 MW

Alternatively, these old units after renovation can be retained for peak load duty. The economics of retiring the old units or retaining them to operate on peaking duty, should be carefully examined. Similarly, in the case of hydro-electric plants, secondary energy is quite often available in years of good monsoons. A more systematic study of the availability of secondary energy in the past in hydro-electric stations in operation would enable us to determine the required thermal capacity to firm up the secondary energy. If this is shown to be cost effective, special consideration should be given for investment in such back-up plants which could be used only in dry years when adequate energy from hydro plants is not available.

9.24 Table 9.20 shows the order of investment required for power development corresponding to RLF projection upto the year 2000-01.

TABLE 9.20

Investment Requirements in Power Sector Reference Level Forecast

(in Rs. crores)

	1978—83	1983—88	1988—93	1993—2001
Nuclear . .	487	494	494	1580
Hydel . .	3375	6780	6410	9750
Thermal . .	4888	3226	5236	11390
Total Generation	8750	10500	12140	22720
T&D . .	5300	6825	8500	17040
RE & Misc. . .	1700	2485	2150	4960
Total . .	15750	19810	22790	44720

Notes :

(i) The projections of investment are based on the present day costs and do not take into account any cost escalations in the future;

(ii) In the case of hydro projects, it has been assumed that the cost per kW would gradually decrease from the present figure of an average of about Rs. 7000 per kW to Rs. 6500 per kW by 2000-01 to take into account the possible reductions on account of planning of hydel for peaking purposes for a optimal mix of hydro and thermal plants. The investment figures for nuclear and thermal are based on a constant level of Rs. 7000 and Rs. 4000per kW of installed capacity respectively;

(iii) In the case of transmission, it has been assumed that the investment will gradually increase from about 60% in 1978-83 to 75% in 2000-01 of the investment on generation.

Rural Electrification

9.25 Rural electrification has always been accepted as a very important component of the overall rural Development strategy. Most of the State Governments have been spending considerable amounts of development funds on rural electrification in the hope that this would lead to betterment of the standard of living of people and their quality of life ; but the procedures adopted for rural electrification and the manner in which rural electrification schemes are operated have tended to belie this expectation. In each village that is electrified, hardly 10 to 12 per cent of the houses make use of the electricity and, literally, in thousands of villages which are classified as 'electrified' there is not even public lighting. Of the total number of wells in a village, hardly 25 per cent get energised with electricity. It is obvious that only the affluent sections of the village population avail themselves of the electricity facility. The electrification of households requires in most of the States the installation of main meters and other equipment and internal wiring which calls for an investment of not less than Rs. 500 to Rs. 800 per household. For those who could afford this initial investment, the recurring charges for electrical energy consumption are almost the same as that of oil, though the benefits derived from the electricity are much more than what is obtained from oil lamps. There are very few States where there are facilities of getting loans for electrifying the households. In the case of electrification of irrigation pump sets, a farmer using an electric pump set gets substantial subsidy, whereas no such subsidy is available to a person who operates a diesel pump or a pair of bullocks to lift water. The number of artisans or industrial undertakings which take advantage of rural electrification is quite small compared to the number of such units in the villages and here again the lack of procedures to help through advances/loans, the potential consumers who are too poor to pay for the investment is a big hinderance to the wider use of electricity in electrified villages.

9.26 The Working Group considers that it is possible to evolve procedures which would make the distribution of electricity more equitable and which would ensure better utilisation of the electric supply in rural areas. For example, the overall social cost benefits of pump sets with different productivities by means of electricity, diesel or bullocks should be examined and there should be more rational selection of pump-sets for electrification. All villages which are given electricity must be provided with public lighting so that some of the benefits of rural electrification percolate to all sections of the people. The Working Group would strongly recommend that further investment on rural electrification should be carefully restructured to make rural electrification a real instrument of rural progress. The continuation of the current procedures for selection of villages for electrification and the extension of electricity to only a few households and wells would only aggravate the rural inequalities. The need to have a coordinated approach to the supply of all energy needs of rural areas is discussed in the Chapter on 'Rural Energy Policy'.

9.27 The other areas that should receive attention are :

(i) Planning and operation of power systems on a regional basis.

(ii) The role of central organisations like N.T.P.C. & N.H.P.C. in power generation and bulk transmission.

(iii) Procedures for ensuring adequate and timely flow of funds for power projects, especially those constructed by the State Electricity Boards.

(iv) Organisational structure of the power supply industry.

A high Level Committee has been set up by the Deptt. of Power to examine the various technical and organisational aspects of the power supply industry. This Committee would, no doubt, examine all these areas and make specific recommendations.

Role of Nuclear Development

9.28 Development of nuclear energy is necessary to widen the energy resource base of the country. For the present and foreseeable future, nuclear energy is expected to supplement coal and hydro-power for generation of electricity. In the long run, however, application of nuclear energy for process heat is also a possibility. The corner stone of our nuclear energy development programme is the achievement of self-reliance in all respects, especially the sensitive technologies and inputs.

9.29 Keeping in view the rather limited Uranium reserves, a three stage programme has been envisaged. The first stage involves establishment of thermal reactors. These reactors can either be Light Water Reactors (like Tarapur Atomic Power Station) or Heavy Water Reactors (like the ones at Rana Pratap Sagar). Both these reactors produce fissile fuel as a by-product. All our other reactors under construction and proposed are planned to be natural uranium fuelled and heavy water moderated, similar to the one installed at the Rajasthan Atomi Power Plant at Kota. The second stage of our nuclear power programme is based on Fast Breeder Reactor (FBR) which would enable us to fully utilise the uranium resources, as well as exploit our vast thorium reserves. The Breeder Reactor System is a self sustaining system as it produces more fuel than it consumes. These reactors would use plutonium either with natural Uranium or with thorium to produce power and more plutonium or convert a part of thorium into fissile U233. The third stage would be based on reactors fuelled with U233 and thorium, sizeable reserves of which exist in the country.

9.30 The feasibility of using Heavy Water Reactors with Thorium is being examined. This could provide an alternative to Fast Breeder Reactor route in case the Breeder development gets delayed due to technological or political reasons. The advantage of this scheme is that no development work is required on the reactor system itself.

9.31 The present nuclear installed capacity is 640 MWe consisting of two Boiling Water Reactor Units at Tarapur and one pressurized heavy water reactor unit at Kota (RAPP). In addition, the second unit at Kota has nearly been completed and will be commissioned shortly. In addition, two more units of 235 MWe each are in advanced stage of construction at Kalpakkam and two units of 235 MWe each are under construction at Narora.

9.32 Following these it is planned to set up two new stations of two units of 235 MWe each. Plans are also in hand for increasing the unit size to 500 MWe. This will enable acceleration of growth of nuclear power.

9.33 The construction of a prototype fast breeder reactor is in progress. It is expected that it will be possible to commission fast breeder reactors as part of the power systems by mid-nineties. Beyond 2000, the fast breeder Reactors are expected to play a major role in the nuclear power generation.

9.34 The established Uranium resources can support a nuclear power programme of about 8000 MWe installed capacity of first stage thermal reactors. It may be possible to support even a larger programme if the present exploration programme yields other viable sources. The total capacity from Breeder reactors can grow to many thousands of MWe.

9.35 The importance of radiocative waste management to the growth of nuclear power production was recognised very early in India. Work on development of suitable treatment and safe disposal practices was initiated much ahead of the power programme. In our programme, the basic philosophy has been to concentrate and contain as much radioactivity as possible and discharge to the environment only effluents at 'as low a concentration as practicable'.

9.36 Growth of the installed nuclear capacity has been relatively slow at the beginning, especially since it was planned on the basis of self-reliance. The prevailing political atmosphere in the world restricting free trade in the nuclear components and materials has also affected the pace. Notwithstanding these restraints it is necessary to keep the nuclear option open as it is a major answer to fill the energy gap. It certainly requires a degree of sophistication in the fabrication and maintenance of its various components but this is well within our capacity.

9.37 An installed nuclear capacity of 5000 MWe has been visualised by the year 2000-01 considering the present constraints. However, given the limited options available for meeting the growing demands for electricity and the likely role that nuclear power may have to play beyond the year 2000, it is considered appropriate to undertake a larger nuclear power programme to develop and enlarge the technological design and manufacturing capabilities. In this context, it is necessary to review the present programme and constraints and evolve measures to accelerate the nuclear power development to achieve an installed capacity of 8000-10000 MWe by the turn of the century.

CHAPTER X

OIL POLICY

10.1 Oil is a versatile fuel which is used for a variety of purposes in all the sectors of the economy. Besides being an energy source, oil is also an important raw material for production of petro-chemicals and fertilizers. During the sixties when the real price of oil was declining while the other fuel prices were rising, there was a higher rate of growth of oil in most countries and oil came to be used even for uses which were traditionally the areas of use of coal. The major share of total consumption of oil products is accounted for in the Transport sector. In India, where electricity supply is yet to be extended to many rural areas and many houses are unelectrified even in villages which have been electrified, oil (kerosene) serves as the most important illuminant. The sector-wise consumption of oil products is given in Table 10.1.

TABLE 10.1

Sector-wise Consumption of Oil Products for Energy Uses

(in million tonnes of coal replacement)

Sector	1953-54	1960-61	1965-66	1970-71	1975-76	1978-79 (provisional)
Household	9.79 (41.1)	1652 (37.7)	20.00 (30.9)	27.58 (28.4)	27.89 (23.7)	28.73 (20.3)
Agriculture	1.61 (6.8)	2.74 (6.2)	4.41 (6.8)	4.51 (4.6)	9.37 (8.0)	19.37 (13.7)
Industries	3.65 (15.3)	7.23 (16.5)	8.09 (12.6)	10.90 (11.2)	7.55 (6.4)	9.0 (6.4)
Transport	8.76 (36.8)	17.37 (39.6)	31.26 (48.5)	47.23 (48.6)	69.29 (58.2)	78.18 (55.4)
Other	.. ..	.. ..	0.85 (1.2)	6.97 (7.2)	3.52 (3.9)	5.82 (4.2)
Total	23.81 (100)	43.86 (100)	64.61 (100)	97.19 (100)	117.62 (100)	141.10 (100)

Note : (1) Figures in brackets indicate the percentage of share of use in the sector. These shares relate only to energy use. Non-energy uses of oil are mostly in industries sector and adding all uses will alter the shares correspondingly.

(2) The consumption in Agriculture includes estimated consumption of H. S. D. O. by tractors based on I. I. P. estimates. The tractors are also used in rural areas for transportation and to that extent part of the consumption by tractors should logically figure under transtort sector. The sudden spurt in the consumption in the Agricultural sector and nominal increase in the consumption in the transport sector during the period 1978-79 may be due to differences in the methods adopted to a portion H. S. D. O. consumption between the transport and agricultural sector.

(3) In compiling this table, the conversion factors appropriate for the specific products used in the different sectors have been adopted, vide the Report of the Fuel Policy Committee, 1974 (page 5).

10.2 It is found that over 80 per cent of the total oil used in the energy sector is in two sectors, viz., Transport and Household Sectors. While the share of the use in household sector is declining, the share in the Transport sector is rapidly increasing. The increasing share of agriculture where oil is used to run tractors and irrigation pumps is a development which would continue in the future also.

10.3 Oil is used in power generation, both as a primary fuel and as an auxiliary fuel. In certain locations very close to the refineries established in the initial stage, some power plants were set up to make use of the residual fuel oil from the refineries. These oil burning stations are being converted gradually to coal burning and the installed capacity of the power stations using oil as a primary fuel is about a million kW (1977-78). But in all the coal based power stations, a certain amount of oil-use is necessary to serve as a starter and for flame stabilization during low load operations. This was about 0.6 m. tonnes in 1977-78. The oil use in power generation would slowly increase eventhough technically all the additions to thermal power capacity would be coal-based. Oil is also used for non-energy purposes such as feedstock for petro-chemicals and fertilizers, as solvents and lubricants, as bitumen in road making and as petroleum coke in metallurgical industries. The use of oil products directly for energy purposes, for power generation and for non-energy uses and the relative shares of oil used for different purposes are shown in Table 10.2.

TABLE 10.2

Oil Products Consumptions For Both Energy And Non-Energy uses

(in million tonnes)

Use	1960-61	1965-66	1970-71	1975-76	1978-79
Energy (Direct)	6.75 (84.5)	9.94 (83.4)	14.95 (83.5)	18.10 (80.6)	21.68 (77.5)
Power Generation	0.11 (1.4)	0.55 (4.6)	1.20 (6.7)	1.70 (7.6)	1.92 (6.8)
Non-Energy Uses	1.13 (14.1)	1.43 (12.0)	1.76 (9.8)	2.65 (11.8)	4.38 (15.7)
Total	7.99 (100)	11.92 (100)	17.91 (100)	22.45 (100)	27.98 (100)

Note: Figures in brackets represent % share of total consumption.

10.4 The share of oil products used directly for energy purposes is slowly declining while the use of oil for non-energy uses is increasing. With the increase in price of oil products, the use of oil for energy purposes might steadily decline, it alternative fuels are developed at lower prices.

Imports and Indigenous Production of Oil

10.5 Unlike coal and electricity, a major portion of the oil required in the country is being imported from outside either as crude oil (for refining within the country) or imported as directly usable oil-products. As a result of the far-sighted policies followed in the country in the face of tremendous odds in the last 15 years, both in terms of production of crude and indigenous refining capacity, there has been an appreciable progress. India was one of the earliest among the developing countries to realise the need and the feasibility of moving towards self-reliance in oil technology from the state of exploration to the stage of refining. The degree of self-reliance expressed as the amount of oil obtained from local resources to the total consumption of oil is set out in Table 10.3

TABLE 10.3

Crude Oil Products, Indigenous Production Imports and Index of Self-Reliance

(in million tonnes)

	1953-54	1960-61	1965-66	1970-71	1975-76	1978-79 (Provisional)
1. *Crude*						
Indigenous Production	0.26	0.45	3.47	6.82	8.45	12.47
2. *Imports*						
(a) As crude	—	5.71	6.84	11.68	13.93	14.50
(b) As products	3.62	2.22	2.54	1.08	2.15	3.94
(c) Crude equivalent of product*	3.85	2.36	2.70	1.15	2.29	4.19
(d) Index of self-reliance of oil %**	—	5.3	26.7	34.7	34.3	40.01

*Estimated on the assumption

1 tonne of oil product = 1.0638 tonnes of crude

As the refinery capacity is based on requirements of middle distillate, the gross requirements of Crude will be higher.

$$\text{**Estimated as } \frac{\text{Row (1)}}{\text{Row (1)} + \text{Row 2(a)} + \text{Row 2(c)}} \times 100$$

10.6 Table 10.3 indicates that the degree of self-reliance has increased rapidly in the sixties and since then the rate of increase has been slow but steady. Though the strategy adopted initially for setting up refineries included encouraging foreign oil companies to set up their own refineries and jointly owned refineries, all such refineries were nationalised in the last four years with the consent of the foreign oil companies, except a small refinery in Assam (Assam Oil Company).

10.7 The problems of oil demand and supply can be examined meaningfully only with reference to the pattern of consumption of products. Table 10.4 sets out the product-wise consumption of oil products for the different years.

TABLE 10.4

Product-wise Consumption of Oil for Energy and Non-Energy Uses

(*in thousand tonnes*)

	1953-54	1960-61	1965-66	1970-71	1975-76	1977-78	1978-79 Provisional
LPG	..	8	46	176	336	391	400
Motor-gas	807	859	1102	1453	1275	1388	1490
Naphtha	..	..	32	904	1836	2300	2502
Other LD Products	86	116	190	164	149	153	160
Total LD	893	983	1370	2694	3596	4232	4561
Kerosene	1198	2024	2455	3283	3104	3617	3946
ATF	16	202	428	689	897	1044	1149
Diesel Oils	734	1941	3183	4929	7473	8893	9835
Other MD	142	130	159	139	179	199	210
Total MD	2070	4297	6225	9040	11653	13753	15140
LSHS/HHS	..	324	349	1151	1501	1853	6393 (LSHS/HHS and F.O. combined)
F.O. for Industries & power	605	1066	2312	3108	3964	3654	
Bunker (Coastal)	NA	190	239	197	178	106	NA
Bunker (External)	239	343	324	208	137	162	NA
Bitumen	NA	434	576	777	690	933	938
Other HE Products	141	349	523	734	728	793	955
Total HE products	985	2706	4323	6175	7198	7501	8286
Total	3948	7986	11918	17909	22447	25486	27987

10.8 The product-wise demand analysis shows changes in the rate of growth of consumption of the different distillate products on account of the new uses for oil products and the prices of the products. In the period 1953-60, the gradual reduction in the population of buses and lorries using motor-gas seems to have affected the growth of motor-gas, while in the period 1960-65 the introduction of larger number of 2-wheelers and 3-wheelers which use motor-gas seems to have added to the demand for those products. A sudden increase in the light distillate demand during the period 1965-70 is the result of setting up of fertilizer projects with naphtha as feedstock. These factors have made the demand for light distillate products to increase steadily from 1970 onwards. The oil price increase in 1973-74 had led to the absolute quantity of motorgas consumed in 1977-78 being lower than the consumption in 1970-71 but inspite of this, the demand for light distillates as a whole, kept increasing during this period. In the case of middle distillates, except for ATF which is picking up at a fast rate in the last few years, the demand for other products has shown a long-term steady trend. The kerosene consumption in 1975-76 was lower than what it was in 1970-71 due to the increase in the price of kerosene in the year 1973-74. But since 1975, the demand for kerosene has picked up sharply. Among the heavy-end products, furnace oil consumption has to be examined along with the consumption of LSHS (Low Sulphur Heavy Stock) and HHS (Hot Heavy Stock). The latter products being relatively difficult to transport, are used very near the refineries where they are produced and are mostly used for power generation. The furnace oil for industrial use has grown at a fairly high rate from 1960 to 1973 and since then the consumption has declined gradually till recently, when coal shortage and transport problems have arrested the trend and revised it somewhat. Bitumen demand has been widely fluctuating. It is noteworthy that the total consumption of heavy end products has grown at about 9.8 per cent in the period 1960-65, 7.4 per cent in 1965-70 and 3.1 per cent in 1970-75 and has been a little over 2 per cent in the period after 1975.

The composition of oil product consumption distillate-wise is set out in Table 10.5 :—

TABLE 10.5

Distillate-wise Composition of Oil Product Consumption

(As a percentage of total oil consumption)

	1953-54	1960-61	1965-66	1970-71	1975-76	1977-78	1978-79
Light distillates	22.6	12.3	11.5	15.0	16.0	16.6	16.3
Middle distillates	52.4	53.8	52.2	50.5	51.9	54.0	54.1
Heavy ends	25.0	33.9	36.3	34.5	32.1	29.4	29.6
Total	100.0	100.00	100.0	100.0	100.0	100.0	100.0

Refining Capacity

10.9 The refining capacity in India as on 1-1-1979 is given in Table 10.6.

TABLE 10.6

Petroleum Refining Capacity in India

(in million tonnes per annum)

Refinery	Capacity on 1-1-1979
Refineries under operation	
Public Sector	
1. BRL Bombay	5.25
2. GRL Cochin	3.30
3. CORIL Vizag	1.55
4. HPCL, Bombay	3.50
5. I.O.C. Barauni	3.30
6. I.O.C Gauhati	0.80
7. I.O.C. Haldia	2.50
8. I.O.C. Koyali	7.30
9. MRL Madras	2.65
Private Sector	
10. AOC Digboi	0.50
Total Capacity	30.65
Refineries under construction	
1. Bongaigaon Refinery (Public Sector)	1.00
2. Mathura Refinery (Public Sector)	6.0

10.10 The total refinery capacity in operation by end of 1980 would be 37.65 million tonnes of throughput. All the refineries except for the very small unit of the Assam Oil Company are now in the public sector which enables the industry to take up coordinated action to optimise the crude and products at least cost to meet the market demand. In view of the middle distillate consumption forming the largest share of the total oil product consumption, there has been a continuous effort on the part of refinery industry to increase the share of the middle distillate in the product-mix from the refineries. In the sixties, only secondary processing facilities which led to mild cracking of heavy ends were used. On the basis of a detailed system study of the oil products demand including the demand for non-energy uses and the refinery investment choices, the Fuel Policy Committee made a strong recommendation that a larger investment should be made in secondary processing like hydro-crackers, catalytic crackers or delayed coking equipment which would convert the surplus heavy-end products to middle distillates. This recommendation has been accepted and increasing investment is planned in the secondary processing facilities at various refineries. The pattern of refinery production in the past is set out in Table 10.7.

TABLE 10.7

Pattern of Refinery Production in India

(as a percentage of total throughput)

	1960-61	1965-66	1970-71	1975-76	1976-77	1978-79
Light Distillate	17.2	17.0	16.4	16.4	17.0	16.5
Middle Distillate	42.4	42.2	46.2	48.2	48.6	48.0
Heavy-end Products	34.8	34.2	30.5	29.0	27.7	28.9
Refinery Losses	5.6	6.6	6.9	6.4	6.7	6.6
Total	100.0	100.0	100.0	100.0	100.0	100.0

10.11 The light distillate production in the sixties was in excess of the needs and this necessitated the export of naphtha from time to time. When naphtha based fertilizers and petro-chemical plants were established, the percentage share of light distillates in refinery production was brought in line with demand. The gradual increase in the percentage share of middle distillate production and the reduction of the share of heavy end products has been the result of deliberate attempts to balance the product-mix of the refineries to the pattern of market demand and this attempt is expected to continue in future also.

FORECAST OF DEMAND FOR OIL PRODUCTS :

Reference Level Forecast

10.12 In Chapter III, the demand for enegry products in future has been set out for the RLF and OLF of energy demand. The factors which determine their demands are discussed in Chapters V, VI, VII and VIII. In addition to the demand for energy uses, oil products required for power generation (both as primary fuel in certain power stations and as support fuel in other thermal stations) and the oil products required for non-energy uses should be estimated so as to compute the total demand for oil products.

10.13 Principally in all power stations using coal as fuel, furnace oil is used as a support fuel to start up the operations as well as to sustain low-load operations. Due to certain historical reasons a few power stations, viz. Dhuvaran, Trombay, Barauni and Chandrapur (Assam) have been based on fuel oil as the principal fuel and the requirements are of the order af about one million tonnes of oil. On the recommendations made by various committees including the Fuel Policy Committee, the use of oil is being replaced by coal and this has been taken into account in the estimates. It is assumed that the use of fuel oil as primary fuel in the power stations would cease by 1987-88. Based on past data and possible future improvements the requirements of oil as a support fuel have been calculated on the assumption that 0.01 litre of fuel oil would be required for one kwh of thermal power generation.

10.14 The important oil products used for non-energy purposes are—naphtha used as a feed-stock for petro-chemicals and fertilizers, bitumen for road making and some derivatives of heavy end products which are required in the production of lubricants and petroleum coke. The quantities of naphtha and bitumen consumed are the larger among such demands. In our RLF forecast, the demand for products for non-energy uses is assumed to increase on the lines observed in the past. Bitumen demand is dependent on the investments on black surfaced roads. The demand has fluctuated very widely in the past but in the period 1960-70 the demand increased steadily at 6 per cent per year increase. Considering that the price of bitumen has increased very steeply, it is reasonable to assume a slightly lower rate of growth in future. An average rate of 5 per cent per annum has been assumed as the possible rate of growth of bitumen up to the year 2000. A forecast of the likely demand of naphtha for use in petro-chemicals and fertilizers is possible only on the basis of a detailed study of the demand for petro-chemicals and fertilizers and the feed stock choices that would be most cost-effective considering the spatial distribution of fertilizers and chemical plants and the feed-stocks available of each location. Indications of large availability of natural gas in the off-shore structures in the west coast suggest that more fertilizer and petro-chemical plants based on natural gas might be set up. In the absence of a detailed study of these factors, the demand has been estimated on the assumption that the naphtha available from the local refineries would be used up in industries for fertilizer and petro-chemical production. LPG is used in commercial and other establishments besides its use in the household sector. The demand in the former is assumed to be about 25 per cent of the household consumption. The RLF demand estimates for various oil products based on the best judgment of the Working Group are set out in Table 10.8 A&B (For details see Chapters V to VIII).

TABLE 10.8(A)

Projection of Demand for Oil Products for Energy Uses 1982—2000

REFERENCE LEVEL FORECAST

(in million tonnes)

Consuming Sector	Oil Product	1982-83	1987	1992	2000
Household	Kerosene	4.76	6.57	8.57	12.95
	LPG	0.71	1.22	1.79	3.31
Agriculture	Diesel	3.70	4.60	5.60	7.10
Industry	F.O.	4.50	4.40	4.40	6.20
Transport	Motorgas	1.69	2.15	2.73	4.05
	Diesel	8.11	11.65	17.49	33.28
	ATF	1.53	2.25	3.30	6.11
	F.O.	0.21	0.28	0.33	0.40
Commercial & Others	LPG	0.15	0.28	0.51	0.79
TOTAL		25.36	33.40	44.72	74.2

TABLE 10.8(B)

Projections of Demand for Oil Products for Energy and Non Energy Uses 1982—2000

REFERENCE LEVEL FORECAST

(*In thousand tonnes*)

Oil Product	1982-83	1987-88	1992-93	2000-01
L.P.G.	6860	1500	2300	4100
Motor-Gas	1700	2200	2700	4100
Naphtha (For Fertilizer) .	2750	3000	3000	4000
Naphtha (For Petro-chemicals)	1350	1780	2000	4000
Other Light distillates .	200	220	245	300
Total—Light distillates .	6860	8700	10245	16500
Kerosene	4760	6570	8570	12950
ATF	1500	2300	3300	6100
Diesel	11800	16300	23100	40400
Other Middle distillates .	250	275	300	360
Total—Middle distillates .	18310	25445	35270	59810
Fuel Oil :				
(i) For-Coastal bunker .	200	300	350	400
(ii) For international bunkers . . .	200	220	245	300
(iii) For Industry . .	4500	4400	4400	6200
(iv) For Power Generation . . .	1850	1320	2000	3570
(v) As fertilizer feedstock	500	1800	1800	1800
Other Heavy End Products	850	940	1040	1200
itumen	1198	1530	1952	2884
Total—Heavy ends .	10298	10510	11737	16354
Total Demand . .	35468	44655	57252	92664

Note : Draft Plan 1978-83 indicates the likely demand in 1982-83 as 36.32 million tonnes. The kerosene and diesel demand projected is higher than the forecast of this group.

10.15 The forecast shows that the total oil product demand would increase to nearly 92 million tonnes in the year 2000 implying a growth rate of over 6 per cent per year. The demand for middle distillate is seen to be steadily increasing at 6.8 per cent per year from 1982-83 onwards. The light distillate demand shows a somewhat steep increase in the period upto 1982-83 because of the commissioning of a number of fertiliser and petro-chemical plants based on naphtha. Similar increase in the use of fuel oil as fertiliser feedstock increases the demand for fuel oil in the period upto 1982-83. The rates of growth of the important oil projects and the different distillates are set out in Table 10.9.

TABLE 10.9

Growth Rate of Demand for Products

REFERENCE LEVEL FORECAST

(*Average annual compound%*)

Oil Product	1972-82	1982-87	1987-92	1992-2000	1982-2000
Motorgas .	4.1	5.3	4.2	5.4	5.0
Kerosene . .	4.5	6.7	5.5	5.3	5.7
Diesel . .	5.8	6.7	7.2	7.2	7.1
Light Distillates . .	10.2	4.9	3.3	6.1	5.0
Middle Distillates	5.9	6.8	6.7	6.8	6.8
Heavy-ends .	6.5	0.4	2.2	4.2	2.6
Total—Oil Products	6.8	4.7	5.1	6.2	5.5

10.16 As a result of the relatively higher rate of growth of consumption of middle distillates as compared to other products the share of the different distillates in the total oil product consumption changes rapidly leading to the middle distillate share increasing to about two-thirds of the total oil product consumption. See Table 10.10.

TABLE 10.10

Shares of Distillates in Oil Products Demand (1977—2000)

REFERENCE LEVEL FORECAST

(*as a percentage of total production*)

Distillate	1977-78	1982-83	1987-88	1992-93	2000-01
Light Distillates	16.5	19.3	19.5	17.9	17.8
Middle Distillates	54.0	51.6	57.0	61.6	64.5
Heavy Ends .	29.5	29.1	23.5	20.5	17.7
Total Production	100.0	100.0	100.0	100.0	100.0

Optimal Level Forecast

10.17 The demand for oil products as forecast in the RLF indicates that the growth rate would average about 5.5 per cent per year between 1982-2000 and that in the 90s it would be about 6 per cent. The developments anticipated in the oil market are that the total world supply of oil might peak somewhere in the 80s and the total availability get reduced in the 90s. The Group therefore feels that efforts should be made to reduce the level of demand of oil as early as possible and a gradual reduction in the demand in each sub-period should be aimed at. This has been the basic thrust of the Optimal Forecast. A case by case study of the technical feasibility and the economic viability of substituting oil by coal or electricity indicates that at the relative price of oil at $ 18 per barrel and Coal at Rs. 100 per tonne, coal or electricity can be used in most of the cases. But keeping in view various other relevant factors such as the total investment costs for effecting such substitutions, the equipment manufacturing capacity already established, the administrative problems of achieving substitution of oil by other fuels etc., the Working Group has made estimates of some moderate levels of substitution for saving of oil energy use. The details are set out in Chapter V to Chapter VIII.

10.18 The OLF of demand for Oil products for energy use as given in the chapters dealing with sectoral demands are summarised in Table 10.11.

TABLE 10.11

Projections of Demand for Oil Products for Energy Uses 1982—2000

OPTIMAL LEVEL FORECAST

(in million tonnes)

Consuming Sector	Oil Product	1982-83	1987-88	1992-93	2000-01
Household	Kerosene	4.73	6.48	7.34	9.39
	LPG	0.71	1.22	1.79	3.31
Agriculture	Diesel	3.70	4.20	4.60	5.26
Industry	Furnance Oil	4.50	4.00	3.50	3.25
Transport	Motorgas	1.67	1.97	2.27	3.16
	Diesel	8.04	9.76	13.46	23.49
	ATF	1.53	2.25	3.20	5.74
	F.O.	0.20	0.28	0.32	0.38
Commercial and Others	LPG	0.15	0.28	0.51	0·79
	TOTAL	25.23	30.44	36.99	54.77

10.19 In addition to the possible optimisation in the energy sector, some modifications of forecast of oil for non-energy uses were also considered. In the case of naphtha as a feed stock, RLF estimates were based on the assumption of all the naphtha available from Indian Refineries being used for fertilizer and petrochemical production. As increasing quantities of natural gas are expected to be available as both associated gas along with oil and free gas, the OLF is based on the assumption that beyond 1992-93, the additional naphtha use as feed stock would be about 1 million tonnes less in each case. As the use of bitumen can be replaced by other binding material, it is assumed in the OLF that the rate of increase of bitumen would be 3 per cent per year from 1982-83 onwards. In respect of furnace oil for industrial use, the OLF is based on the assumption that the replacement of oil by coal would proceed vigorously till 2000 AD when the use of F.O. would be strictly in accordance with the OLF forecast in Chapter VII on Energy in Industries Sector.

10.20 Based on the revised assumptions for non-energy uses and the OLF estimates of oil products demand for energy uses in Chapters V to VIII, the optimal Level Forecast of Demand for Oil products would be as in Table 10.12.

TABLE 10.12

Projections of Demand for Oil Products for Energy and non-energy Uses 1982—2000

OPTIMAL LEVEL FORECAST

(in Thousand tonnes)

Oil Product	1982-83	1987-88	1992-93	2000-01
LPG	860	1500	2300	4100
Motorgas	1670	1970	2270	3160
Naphtha for Fert	2750	3000	3000	3000
Naphtha (for Petro-chemicals)	1350	1780	2000	3000
Other Light Distillates	200	220	245	300
Total Light Disillates	6830	8470	9815	13560
Kerosene	4730	6480	7340	9390
ATF	1530	2250	3200	5740
Diesel	11740	13960	18060	28750
Other middle distillates	250	275	300	360
Total Middle Distillates	18250	22965	28900	44240
Fuel Oil :				
(i) For Coastal Bunker	200	280	320	380
(ii) For international bunker	200	220	245	300
(iii) For industry	4500	4000	3500	3240
(iv) For Power	1850	1200	1370	2650
(v) As fertilizer feed stocks	1500	1500	1500	1500
Other heavy Ends products	850	940	1040	1200
Bitumen	1198	1390	1610	2040
Total Heavy Ends	10298	9530	95851	11310
Total Oil Demand	35378	40965	48300	69110

10.21 In Table 10.13, the rates of growth of selected oil products consumption and the growth rate of different distillates as per OLF are set out :

TABLE 10.13

Growth of Selected Oil Products (1978—2000)

OPTIMAL LEVEL FORECAST

(average annual compound %)

Oil Products	1977-82	1982-87	1987-92	1992-2000	1982-2000
Motor Gas .	3.8	3.4	2.9	4.2	3.6
Kerosene . .	4.4	6.5	2.6	3.1	5.5
Diesel . .	5.6	3.6	5.3	6.0	5.1
Light Distillates .	10.1	4.4	3.0	4.0	3.9
Middle Distillates	5.8	4.8	4.7	5.5	5.1
Heavy End .	6.5	(—)1.6	0.1	2.1	0.5
Total Oil Products	6.8	3.0	3.3	4.6	3.8

As the OLF results are derived from a number of measures towards optimisation and the quantitive results of implementing these measures were roughly assessed by fixing certain norms and targets, it is not surprising that the growth rates of specific fuel consumption which are implied by these forecasts are not even and show sharp fluctuations. The Group felt that as the different policy prescriptions would be implemented with different degrees of success, there is no need to revise the estimates. The significant conclusion of the OLF of Oil demand is by adopting the measures proposed in the report, the demand for total oil products could be reduced from a growth rate of 5.5 per cent per year in RLF to 4.0 per cent in OLF in the period 1982-2000 and that the middle distillate demand could be reduced during the period from a growth rate of 6.8 per cent per year to 5.1 per cent per year. As a result of such measures, the total demand for Oil products is reduced from about 92 million tonnes in 2000 AD to 69 million tonnes, a clear saving of 25 per cent of the likely total oil demand by the end of the century.

Refining Capacity

10.22 In the oil industry, refineries are located as near as possible to the area of demand for oil product, as the cost of transporting crude is relatively cheaper than the cost of transporting products. In India, as the middle distillate from the largest portion of the total oil consumption and as middle distillates are normally the costliest of the oil products in the international market, the refinery capacity is determined at a level which would serve the middle distillate demand to the maximum extent possible. The maximisation of the production of middle distillate from local refineries also maximises the profitability of the local refineries. With the steady decline in the share of heavy-end products, the recommendation of the Fuel Policy Committee (1974) to increase the level of secondary processing would deserve greater consideration in future also. The import of some quantity of middle distillate would reduce the refinery capacity required to meet the oil products demand and might also reduce the surplus light distillate and heavy ends available from local refineries. India has been importing about 1.5 million tonnes of middle distillates per year mostly as diesel and kerosene from other countries so as to keep the refinery requirements at a lower level. Exercises indicate that it would be advantageous to increase the middle distillate imports to gradually higher levels in future. It is to be noted that even if middle distillate import is increased to about 5 million tonnes by the year 2000 and if there is no secondary processing, the refinery capacity has to be about 100 million tonnes to meet the demand as per RLF and about 71 million tonnes to meet OLF Demand.

10.23 A firm decision on the levels of refinery capacity and secondary processing could only be taken on a detailed system study of the pattern of oil products demand at different regions, the possible refinery locations, the import costs of crude relative to products and other considerations. It is gratifying to note that the additional requirements of refinery and oil products import for the Sixth Plan period have been examined on the basis of a comprehensive system study. The Working Group would recommend that such studies should be the basis for refinery planning in future.

Availability of Crude

10.24 The investments made and investment proposals approved for oil exploration and oil extraction from on-shore and off-shore are capable of increasing the level of production from Indian Oil fields to about 24 million tonnes by the year 1984-85. The production capability in 1982-83 would be of the order of 22 million tonnes. The Draft Five Year Plan (1978-83) suggests limiting the off-shore production to about 9 million tonnes against a capacity of 12 million tonnes so as to conserve the resources i.e. the crude production would be 18 million tonnes in 1982-83. On the basis of our proven and probable reserves and the order of investment likely in oil exploration, it is reasonable to assume that a production of 24 million tonnes would be reached by 1987-88 and this level of production would be retained up to 2000-01. On this assumption, the index of self-reliance in oil requirements calculated on the same basis as in Table 10.3 would indicate that index of self reliance in oil would decline even if the demand conforms to OLF. It is worth noting at this stage that to maintain levels of production assumed above would require considerable additions to known reserves.

Foreign Trade Implications of Oil Import

10.25 The import of large quantities of oil will have serious implications to our national import bill as would be seen from Table 10.14. A discussion on whether the levels of import of crude implied in the forecast (both RLF and OLF) is possible or not depends on the foreign exchange constraints in the economy, and this could be examined only by a detailed study of the developments in our foreign trade which is beyond the scope of this Report. However to bring out the impact of increasing oil imports on our export trade earnings, an exercise was made projecting a growth rate of 8 per cent per year at 1976-77 prices on such earnings and the oil price assumed as $ 25 per barrel.

TABLE 10.14

Expenditure on Oil Imports as a Percentage of Export Trade Earnings (1970-2000)

(*Rs. crores*)

Item	1970-71	1973-74	1974-75	1976-77	1982-83	1987-88	1992-93	2000-01
	Actual				Projected			
1. Export Trade Earnings	1524	2478	3180	5143	7295	9762	13065	20823
2. Expenditure on Oil Import								
(a) RLF	145	417	955	1423	3180	4930	9120	21490
(b) OLF					3120	4100	6900	14440
3. As % of 1								
RLF	9.5	16.8	30.7	27.7	43.5	50.5	69.8	103.2
OLF					42.8	42.0	52.8	69.3

POLICY MEASURES

10.26 There are great uncertainties about the price of oil. In future there are also similar uncertainties regarding the possible export earnings of India. Inspite of all these uncertainties it is possible to get some broad judgement about the likely impact of increased oil prices on assumptions of costs which in the light of the recent developments may appear very conservative. It is found that if we do not curb the oil consumption as recommended in this report, the expenditure on oil import by the year 2000 may reach a level very near to 75 per cent of our total earnings by foreign trade. This would leave very little for our other imports like fertilizers, intermediate goods etc. The OLF route may bring it down to somewhere around 50 per cent. All indicators today suggest that the oil prices would steeply increase. It would be imprudent not to assume a high increase and plan for the consequences.

10.27 The Working Group feels that keeping in view the grave uncertainties regarding the price and availability of oil in future and the fact that India is not likely to maintain the level of self-sufficiency likely to be achieved by early eighties, it would be necessary to initiate from now on, vigorous measures to bring down the level of oil consumption. Given the facts available now, it would be unreasonable to presume that the price of oil would come down or the availability would be better in the next two decades. If anything, the prices might go up and the supplies might be subject to frequent disruptions. It would, therefore, be prudent to plan a pattern of growth of the economy which is less dependent on oil.

10.28 One of the possibilities, of course, is that of increasing the production of oil within the country. In the studies, it has been assumed that best efforts would be made towards the discovery of more reserves and more production. The experience of the last few years after the discovery of Bombay High Oil field indicates that the possibilities of major discoveries are somewhat remote. In any case, it would not be prudent to presume that such discoveries would occur in time to reduce the dependence on imported oil.

10.29 A long term policy for using gas from Bombay High/Bassein fields and in the North Eastern Region for different purposes is under consideration based on reports submitted by a Working Group constituted by the Department of Petroleum. There are indications that more gas reserves are likely to be established in other areas. In case substantially larger quantities of gas become available, the techno-economics of converting it into liquid fuels for use in the transport sector should be examined.

10.30 As seen from Table 10.13, the demand for oil even in the optimal level forecast would increase by about 21 million tonnes during the period 1992-2000. As discussed earlier, this is the period when the total world production/availability for sale of crude is likely to decline. It would not be easy to obtain the additional crude requirements even if the country is prepared to pay a very high price that may prevail. It is, therefore, important that all efforts should be made from now on to reduce the demand of oil to levels even below what is forecast in the OLF. This is possible only if demand management is accepted as the most important element of oil policy in the future. Special efforts should be made to reduce the demand for middle distillates. The Group is aware of the fact that both diesel which is supplying the energy needs of the transport sector and kerosene which is supplying the fuel needs of the household are sensitive products the use of which is likely to cause more hardship. But a properly designed system of demand management might enable a further reduction of the likely demand. It is also necessary to explore possibilities of production of liquid fuels from alternate sources and new technologies. These are discussed in the Chapter on Research and Development.

CHAPTER XI

COAL POLICY

11.1 Coal is the most abundantly available source of commercial energy and also the cheapest source of commercial energy in terms of its heat content. Coal is partly used directly as fuel and partly by transformation into electricity. Its use as feed stock for chemical industries is negligible so far in India. The share of coal used for power generation has increased in India, a trend seen also in other coal producing countries. Table 11.1 gives the share of coal used directly and indirectly in different years.

TABLE 11.1

Coal Consumption (Direct and Indirect Use) (1953-79)

Year	Coal used (million tonnes)		Coal used indirectly as % of total coal consumption
	Direct Use	Indirect use (for power generation)	
1953-54	28.7	5.1	15.1
1960-61	40.4	9.1	18.4
1965-66	51.8	10.5	16.9
1970-71	51.4	13.2	20.4
1975-76	71.0	20.5	22.5
1978-79	68.8	30.7	30.9

11.2 Two coal-based fertilizer units are presently under construction and when these go into production use of coal as feed stock will begin.

11.3 In terms of primary forms of commercial energy the share of coal in total energy consumption is found to be about 33 per cent even in 1978-79, though the share has been declining steadily.

TABLE 11.2

Consumption of Commercial Energy in Primary Forms in India and Share of Coal (1953-75)

(In million tonnes of coal replacement)

Year	Coal	Oil for energy uses	Hydel and nuclear power	Total commercial energy	Share of coal as % of total Commercial Energy
1953-54	33.8	23.1	3.0	59.9	56.4
1960-61	49.5	45.8	7.8	103.1	48.0
1965-66	62.3	69.7	15.2	147.2	42.3
1970-71	64.6	102.6	27.7	194.9	33.1
1975-76	91.5	126.7	35.9	254.1	36.0
1978-79	99.5	153.4	49.9	302.8	32.9

Note : Consumption of Coal/Oil includes Coal/Oil used for power generation.

11.4 The share of coal is still understated as in the coal replacement scale of measurement used in these calculations, the higher efficiency of oil as an energy source is given due weightage. If as in international energy statistics, (e.g. UN) the coal equivalent measure, which merely takes into account the relative inherent heat content of fuels, is used to determine the relative shares, the importance of coal in energy use is clearly brought out.

TABLE 11.3

Consumption of Commercial Energy as Primary Fuels in India in Coal Equivalent Measures

(in million tonnes of coal equivalent)

Year	Coal (Total)	Oil (Total)	Hydel & nuclear Energy	Total Commercial Energy	% share of Coal
1953-54	33.8	7.1	0.4	41.3	81.8
1960-61	49.5	14.1	1.0	64.6	76.6
1965-66	62.3	21.4	1.9	85.6	72.8
1970-71	64.6	31.6	3.4	99.6	64.9
1975-76	91.5	39.0	4.4	134.9	67.8
1978-79	99.5	47.2	6.1	152.8	65.1

Note : The equivalent measures used are :
MTCE—Million tonnes of coal equivalent at an average calorific value of 5000 kcal/kg.
1 million tonne of coal—1MTCE
1 million tonne of oil—2 MTCE
TWH of electricity—0.123 MTCE

2 PC/79—12

Table 11.3 shows that in terms of coal equivalent measures, coal contributes more than two-thirds of the commercial energy needs even at present, while oil, hydel and nuclear sources provide the remaining one-third.

TRENDS IN COAL CONSUMPTION

11.5 Coal is consumed essentially for providing heat and steam to industry and railways. Coal used in the steel industry is consumed partly as a reductant to convert oxide ores of iron to the basic metal but the entire consumption is treated as though it is used for energy purposes only. Four consumers, i.e. power-generation, railways, steel and cement, account for 70 per cent of the total coal consumed in all sectors. The quantities of coal used by different consumer categories and their relative shares in total consumption are given in Table 11.4 :

TABLE 11.4

Trends in the Consumption of Coal (1953-78)

(in million tonnes)

Consumer Category	1953-54	1960-61	1965-66	1970-71	1975-76	1977-78
1. Power.	5.1 (12.9)	9.1 (17.5)	10.5 (17.7)	13.2 (18.5)	20.5 (22.5)	29.8 (28.9)
2. Railways	13.0 (35.2)	15.5 (29.8)	16.8 (28.3)	15.6 (21.9)	14.3 (15.7)	13.2 (12.8)
3. Steel	3.9 (9.9)	9.1 (17.5)	11.7 (19.7)	13.5 (19.0)	20.9 (22.9)	24.0 (23.3)
4. Cement	1.1 (2.8)	2.3 (4.4)	2.8 (4.7)	3.5 (4.9)	4.4 (4.8)	5.1 (4.9)
5. Industries other than steel and cement*	11.5 (29.1)	10.8 (20.8)	11.1 (18.8)	18.5 (26.0)	24.8 (27.3)	23·7 (23.0)
6. Soft Coke	2.3 (5.8)	2.6 (5.0)	3.6 (6.1)	4.1 (5.8)	3.6 (4.0)	4.0 (3.9)
7. Colliery consumption	1.7 (4.3)	2.6 (5.0)	2.8 (4.7)	2.8 (3.9)	2.5 (2.8)	3.3 (3.2)
8. Total consumption	39.5 (100)	52.0 (100)	59.0 (100)	71.2 (100)	91.0 (100)	103.1 (100)
9. Export	2.1	1.2	0.8	0.5	0.4	0.8
10. Total demand	41.6	53.2	60.1	71.7	91.4	103.9

Note : Figures in brackets represent percentage of total consumption.

*Includes coal used for brick burning and the curing of tobacco.

11.6 The share of coal used for power generation which was almost stagnant in the period 1960-61 to 1970-71 has steeply risen thereafter. The share of coal consumed in railways is steadily declining due to the deliberate policy of the Railways to phase out the steam locos, which are relatively slower and less efficient than other locos.

11.7 Prior to the nationalisation of the coal industry in 1972-73, the demand for coal was assessed by the Planning Commission and the Coal Advisory Committee (which includes the representatives of the industry) separately and the official production target was determined by reconciling these two estimates. A very careful estimation of the demand is attempted in respect of steel and coke oven plants, railways, thermal power stations and cement, the so called major consumers of coal, who account for over 70 per cent of the total coal demand. In the case of each of these consumers, using a norm per unit of production in these industries, an estimate of coal demand used to be made consistent with the production plans of these consumer categories. As a very sharp increase in the rates of growth of steel production, power generation and cement production was anticipated in each plan period, the forecast of coal demand of these industries used to show a steep increase. The demand in respect of other industries (including for brick burning) was estimated as the difference between the perceived possible increase in coal production and the anticipated demand of the major consumers of coal. There was therefore an in-built tendency to under-estimate the demand for coal for other industries. The consumption of coal by these industries in actual practice tended to be close to, if not higher than, the level forecast, even in plan periods when the rate of growth of industries sector was less than anticipated. This can be seen from the forecast of demand and actual consumption of coal as between the major consumers and the other industries category.

	As per IV Plan Document		As per Draft V Plan Document (in 1977-78)	
	Fore-cast	Actuals	Fore-cast*	Actuals
1. Average annual compound growth rate of Industries sector . .	8%	5.6%		
2. Demand for coal from major consumer categories in million tonnes	67.9	53.9	86	66.2
3. Other industries Export & Colliery consumption million tonnes . .	19.2	19.4	27.7	32.5

*Computed as 1973-74 consumption plus 75% of the incremental demand forecast in the document for the Five Year Period upto 1978-79.

Forecast of total demand for Coal

11.8 The forecast of demand of coal as discussed in Chapter-III relates only to the demand of coal from sectors other than power generation. To this must be added coal required for power generation and coal for non-energy purposes to get total requirements of coal. The level of coal required for power generation depends on the total demand for power generation and the electrical energy contributions anticipated from hydro-electric sources and nuclear power stations. A detailed discussion of this is given in Chapter IX. Based on these discussions, the demand for coal in the power sector has been derived separately for RLF and OLF. The coal requirements of the steel industry is assumed to be the same in both RLF and OLF forecasts and have been estimated in terms of raw coal. About 90-95 per cent of the Indian coking coal has to be washed before feeding into blast furnaces and in the process of washing about 25 per cent of the coal fed into the washery would be drawn out as middlings (with about 30 per cent ash-content) if it is a three product washery. As by product from two product washeries has been found to be unusable in the power stations, it has been decided to have only three product washeries in the future. Both RLF and OLF of coal demand imply that the quantities of middlings that would be produced is roughly as follows :

1982-83	6.8 Mts.
1987-88	9.8 Mts.
1992-93	14.4 Mts.
2000-01	23.0 Mts.

Note : Assumption here is that the availability of middlings would be roughly 20% of the raw coal demand for steel production.

11.9 Though middlings have been considered as a good fuel for thermal power stations, adequate efforts have not been made to plan thermal power capacity based on middlings. In recent times efforts have been made to upgrade the middlings for use in the steel industry. In order to bring out the extent to which coal production target can be implemented by proper policies, it has been assumed in the RLF that no new power station is planned on the use of middling. In the OLF, it is assumed that all the middlings would be used for power generation (1.2 million tonnes of middlings is assumed to replace one tonne of coal in power sector).

11.10 Among the non-energy uses of coal, the most important from the point of view of quantities of coal required is the use as feed stock for petrochemical or fertilizer production. The Group has assumed that for the present, the use of coal as feed stock for fertilizer production may be 3.0 million tonnes.

11.11 As there are several uncertainties about export demand as the national advantage of exporting coal appears quite doubtful, no export demand has been assumed in these forecasts.

11.12 Based on the assumptions set out in the above para, the RLF and OLF of coal demand have been computed and the results are set out in Table 11.5 (A) and Table 11.5 (B) respectively.

TABLE 11.5 (A)

Forecast of Demands for Coal for Energy and Non-Energy Uses (1992—2000)

REFERENCE LEVEL FORECAST

(in million tonnes)

Consumer category	1982-83	1987-88	1992-93	2000-01
1. Railways	12.4	11.0	7.8	3.4
2. Steel	34.0	49.0	72.0	115.3
3. Household . .	5.2	7.2	11.2	24.0
4. Other Industries .	40.9	59.5	89.8	158.2
5. Colliery consumption and other uses . .	4.3	4.8	5.8	7.0
6. Total Direct use in Energy sector . .	96.8	131.5	186.6	307.9
7. Power Generation** .	50.9	79.8	122.9	220.2
8. Total Coal Demand for energy uses . .	147.7	211.3	309.5	528.1
9. Non-Energy Use .	3.0	3.0	3.0	3.0
10. Total requirement of coal .	150.7	214.3	312.5	531.5

TABLE 11.5 (B)

Forecast of Demand for Coal for Energy and Non-Energy Uses (1982—2000)

OPTIMAL LEVEL FORECAST

(*in million tonnes*)

Consumer Category	1982-83	1987-88	1992-93	2000-01
1. Railways	12.4	11.0	7.8	3.4
2. Steel	34.0	49.0	72.0	115.3
3. Household	5.2	7.2	10.0	16.8
4. Other Industries	40.9	56.0	74.8	123.0
5. Colliery consumption and other uses	4.3	4.8	5.8	7.0
6. Total Direct use in Energy sector	96.8	128.0	170.4	265.5
7. Power Generation**	50.6	72.3	100.1	158.7
8. Total coal demands for energy use	147.4	200.3	270.5	424.2
9. Non-energy use	3.0	3.0	30.	3.0
10. Total requirement of coal	150.4	203.3	273.5	427.2

**for power generation the use of middlings has been assumed to be as in the following tables:—

1982-83— 6.8 million tonnes
1987-88— 9.8 million tonnes
1992-93—14.4 million tonnes
2000-01—23.0 million tonnes

11.13 The forecasts RLF and OLF imply that the production of coal which was 104.6 MTs. in 1978-79 should increase at the rates indicated in the table below during the different sub-periods in future :

TABLE 11.6

Required Rate of Growth of Coal Production 1978-79 to 2000 RLF and OLF

(*in percentage per year*)

Period	Rate of growth of production	
	as per RLF	as per OLF
1978-79 to 1982-83	9.6	9.6
1982-83 to 1987-88	7.3	6.2
1987-88 to 1992-93	7.8	6.1
1992-93 to 2000-01	6.9	5.7

11.14 In physical terms, OLF implies that during the period 1982—87 the average annual increase should be about 10.6 million tonnes, 14 million tonnes per year in the period 1988-93 and 19 million tonnes per year in the period 1992-2000.

Monitoring the Coal demand in future

11.15 The demand for coal, for steel and power industries requires careful monitoring. In the case of steel sector a number of decisions are yet to be taken for setting up new steel plants. Unless such decisions are taken in the near future the demand for coal for steel industry would be lower than anticipated in this forecast, especially for the year 1987-88. The coal demand for steel industry would require periodical revisions with reference to the development plans for the steel industry including the plans for technology shifts. The Group has also suggested a re-examination of the steel target beyond 1992 (see chapter VII). In the case of power plants, the demand is derived from the number of kilowatt-hours of energy generation from coal-based thermal stations in the country as a whole. While projecting the demand in respect of each power station the power industry with some justification suggests requirement to be 0.3 million tonnes for 100 MW power plant implying that the particular power plant would function at about 60 per cent capacity factor. In actual practice in the power industry, the total thermal generation system as a whole, operates on an average capacity factor of about 50 per cent only. The average plant factor is the result of forced outages in different plants which would occur differently each year and the pattern of forced outages is not predictable by the power industry. The forcast of coal demand derived by the power industry as the summation of the demand projected for each power plant would be higher than the demand derived here from the total power generation requirements. In other words, the forecast is of the likely level of consumption and the production plans for supplying the coal needs of the power industry would involve some amount of redundancy which is unavoidable. The demand for thermal power generation will decline steeply in the years of good rainfall, as the contribution from hydel units would then be higher than the levels forecast and coal demand for power generation units would also decline. The requirements of soft-coke forecast in the table are essentially the result of certain normative assumptions about the use of the coal as soft coke in the household sector. Materialisation of this level of demand would depend entirely on the production either by conventional technologies or by low temperature carbonisation of non coking coal and transport plans for soft-coke which ought to be separately decided in each plan period. The demand for other industries which includes the demand for cement industry is about the minimum that one can anticipate if the structure of the industry changes only in the directions forecast in the Chapter VII. In view of the inadequate attention paid to the production and supply of coal to this class of consumers the substitution of oil by coal in the industries has not been rapid. The Working Group would like to emphasise that this demand should be taken seriously and attempts made to increase production of appropriate quantity of coal to the levels suggested.

Major Problems of the Coal Industry

11.16 The task of increasing coal production from the current level of 100 million tonnes per annum to over 400 million tonnes by 2000-01 will not be easy or smooth. The problems which bedevilled the coal industry in the past would continue to hinder development unless urgent and sustained action is taken on several important issues related to coal development. The problems of coal industry in future could be grouped under the following four broad groups :

— Adoption of a suitable long term production strategy, and coal transport policy.

— Demand management & Market development.

— Conservation of coal.

Production Strategy

11.17 The Working Group would recommend that in the case of the coal industry a long term production strategy should be evolved with reference to the resources of coal available in different coal fields and the extent to which the production could be increased in each of them. As it is clear now that coal is the most important indigenous fuel and its role would keep increasing steadily overtime, planning and construction of coal mines should proceed on a steady basis without linking specific mines to specific consumers. There would therefore be the need to revise the procedures for decision making on investment and coal production and also coal using facilities, like the power plants, so that the latter may be based on the quantity and quality of coal that would be available during earlier decisions.

11.18 The Group would also reiterate the need for a well defined policy towards mechanisation of coal mines taking into account the need to increase production very quickly and with due consideration for employment and training implications. In doing so the changes in the share of open cast and underground mines and the optimal technology that could be used in such mines would also deserve careful consideration. The Group would like to point out the need to synchronise investment in coal production and coal transportation by railways with adequate flexibility so that transport would not become a constraint to the use of coal.

Demand Management and Market Development

11.19 The coal industry has so far been preoccupied with serving the demands of all the major consumers who also happen to be in the public sector like the steel plants, railways and power plants. Some attention has also been paid in servicing the needs of the cement industry in view of the long standing relationship between the cement and the coal industry. A very large number of consumers like jute plants, paper mills etc. who come under the category of other industries have very little direct contact with the coal industry. These consumers were and still are dependent on middlemen and railways obtaining their supplies; the coal industry has not been monitoring their needs or explored the prospects of increasing sales to these industries. As such there is no long-term relationship between the coal producers and these categories of consumer in terms of understanding the needs of the industry by the coal industry. The availability of furnace oil as a substitute fuel which could be used whenever the coal was in short supply has also led to a lack of interest on the part of consuming industries to build up lasting linkages with the coal producers. As the general thrust of energy policy is to reduce the quantity of oil products consumed, there is need for coal industry to take up the responsibility to supply the fuel needs of a large number of industries. Abolishing of the coal control system under which the Coal Controller was assessing the needs, determining the quality of coal to be supplied and the quantity to be supplied, etc. had led to a vacuum which has not been filled by any agency. If the demand as forecast in this report is to materialise and the pattern of fuel usage suggested is to emerge as anticipated, it is important that the coal industry and the coal consuming industries come together and plan the needs and supplies. In respect of some of the smaller consumers like households industries and commercial undertakings like hotels and other eating places, there is a big market for coal which is yet to be trapped. Such consumers are today dependent on either non-commercial fuels, kerosene or LPG which are all in short supply. The procedure for a smaller consumer of coal to obtain his needs from a particular mine is so encumbersome that he has necessarily to depend on middlemen for his supplies. The interest of the middlemen do not always coincide with the interests of the consumers or the coal industry. The need to have retail outlets in the form of coal stock-yards in the larger towns and industrial areas has been felt for a long time and should be recognised now.

11.20. The market development work should also include a Fuel Efficiency Service on the lines in which the National Board in England operates and helps the consumers to determine the best equipment for the kind of service that is required in a particular industry, methods by which wastage could be reduced, pollution avoided etc. Whenever there is any temporary surplus coal, it should be possible to use this surplus to speed up the pace of substitution of non-commercial fuel like firewood by coal. The Working Group would therefore, strongly recommend that a detailed plan for demand management industry in consultation with the railways and consuming industries, especially industries other than steel, power and railways.

11.21 The question of beneficiating non-coking coal was examined. The run of the mine coal contains considerable extraneous matter, the extent of which depends on the mining technology adopted. Indian coals are also characterized by high ash content. Both the extraneous matter and the ash in coal lead to erosion and other operational problems when used in boilers. The Group felt that, to the extent feasible, simple mechanical techniques should be resorted to eliminate shale and other extraneous material in the coal. For removal of ash embodied in coal, washing of coal is necessary. While the reduction in ash content would benefit in the shape of savings in freight on transport and improved performance of boilers, the process of washing could not only be costly but lead to loss of 20 to 30 per cent of coal as midlings or sinks. The idea of washing non-coking coal should, therefore, be pursued cautiously and resorted to only where its techno-economic benefits are clearly established.

Conservation of Coal Resources

11.22 Relative to other fossil fuels, the availability of coal is much more. It has, however, to be recognised that the available resources would be adequate to last only for about 90 years *after the year 2000, assuming that the annual coal production would reach at a level of 400 million tonnes by then and continue at that level beyond 2000. Within the coal reserves, the critical shortages are in respect of certain specific grades of coal with special qualities. The fact that metallurgical coal is relatively scarce as compared to non-coking coal is well-recognised. But within the metallurgical coal, prime coking coal, which on the basis of the current available technology should at least be 50 per cent of the total coking coal used in steel industry, is the category in most critical short supply. If the steel production proceeds on the rates assumed in this report, the prime coking coal may get exhausted by about 2025 AD. It may be even earlier on account of various major problems in exploiting the last bits of our resources of prime coking coal which are concentrated in the Jharia Coal fields only. However, there are a number of new developments such as conversion of non-coking coal to coking coal and using other reductants in steel-making other than coking coal. A careful study of the various possibilities of meeting the requirements of reductants and fuel of the steel industry has to be made on the basis of detailed techno-economic studies of various options.

11.23 To the extent Steel Industry use indigenous coking coal there would be increasing availability of middling in the country. The planning of thermal power stations based on middlings should proceed in step with planning of coal washeries. There are also possibilities of using the rejects and middling as raw material for manufacturing domestic fuels similar to soft coke. A number of technologies have been developed but none of them have been scaled up for commercial adoption. This must be pursued so as to make use of valuable fuel resources which might otherwise be wasted.

11.24 In the context of utilisation of fuels at maximum efficiency, concepts like 'Total Energy Systems' and 'Integrated Energy Systems' are being pursued. As we are setting up large super thermal stations at a number of locations, the possibilities of using the waste heat from such power stations by setting up appropriate industries in the vicinity deserves serious consideration.

*This estimate is based on total coal reserves in seams of thickness 1.5 metre and above and upto a depth of 600 mtrs. The recovery rate has been assumed to be equal to 50% of the total reserves. If the additional reserves corresponding to coal occurring at depths between 600 and 1200 metres and seam thicknesses between 0.5 and 1.2 metres mentioned in Chapter 4 are taken into account the life of the coal reserves would be extended by another 35 years.

CHAPTER XII

RURAL ENERGY POLICY

Distinct Features of Rural Energy Problems

12.1 In India, as in other developing countries, the problems of rural energy demand and supply must be discussed separately, because the patterns of energy consumption and sources of supply in rural areas differ radically from those in towns and cities. Firstly, the intensity of energy consumption (either in terms of population or area) is comparatively lower in rural areas. Secondly, the relative share of the various consumption categories in the total energy consumption in urban areas is quite different from that in rural areas where household energy consumption dominates the situation. Thirdly, the share of non-commercial energy in villages is much higher than in towns and cities. Fourthly, a major portion of the energy supply for rural needs is secured by the private efforts of individuals at a very low or even zero private cost and an energy policy which depends on fiscal and administrative controls on energy distribution may not have any impact in most rural areas. Finally, a large fraction of the rural population is too poor to buy commercial energy even when the supply of these is made available, e.g., the number of electrified houses and wells is only a small fraction of their total number in electrified villages.

Basic Issues

12.2 The basic issues in formulating a Rural Energy Policy for India are :

— the estimation of the quantities of non-commercial and animal energy used in rural areas for various consumption and production purposes, and the identification of the determinants of shifts from non-commercial and animal energy to commercial energy ;

— the estimation of likely changes in the pattern of rural consumption of different fuels with the growth of agricultural production and with improvements in the economic condition of the rural population ;

— the encouragement or discouragement of the normal trends of replacement of non-commercial and animal energy by commercial energy and the promotion or restriction of the extent of utilisation of non-commercial energy in view of the growing shortages and increasing costs of commercial energy ;

— the identification of the instruments available to Government to influence the pattern of energy utilization in rural areas ;

— the feasibility of adequately meeting the energy needs of rural areas from centralized energy-supply systems, and the extent to which decentralized energy systems can be evolved to cater to these energy needs ;

— the possibility of adopting alternative energy technologies to supply more effectively current and future rural energy needs.

12.3 The identification of the above issues implies that the approach to rural energy should be based on :

— elucidation of current rural energy consumption patterns and anticipation of future ones;

— translation of these patterns into a set of end-uses (e.g., heating, lighting, mechanical work in stationary and mobile equipment) ;

— consideration of the feasible technologies which can satisfy these end-uses with the available resources ;

— selection of technologies for satisfying each category of end-use ;

— integration of the selected technologies into a system.

12.4 The possibility of integration of technologies into a system arises because the rural settlements are extremely small compared to urban ones and therefore attempts can be made to match energy sources to end-uses and to deploy an optimal mix of sources to meet the requirements of a set of end-uses without creating insuperable distribution problems.

Energy Consumption in Rural Areas

12.5 There are, however, very few studies on the consumption of the different energy sources used in villages. The resulting lack of quantitative data has led to several problems. Thus, in discussions, rural household energy consumption has been considered to represent total energy consumption. In some cases, rural electricity and rural energy have been viewed as synonymous. The problems of rural transport which are dependent on the extension of roads and the provision of buses to villages and the issue of mechanisation (e.g. in agriculture) have been treated as separate issues without considering them together as part of the total problem of arranging adequate supplies of mobile sources of energy to the rural sector.

12.6 The Working Group attempted to assemble all the information available regarding the consumption of commercial, non-commercial and animate energy in the household, agriculture, rural industry and rural transport sectors. It was found that, while adequate data are available regarding household energy consumption as a result of the periodic surveys undertaken by the National Sample Survey, the information base is woefully inadequate in respect of other sectors. Even the data on commercial energy is not amenable to disaggregation into rural and urban consumption. A survey of available information revealed the large gaps in our knowledge of rural energy needs ; hence, the Group would like to emphasise the need for comprehensive surveys of all the energy needs in a village community, the current flows of energy within the rural system, and the exchange of energy between rural and urban areas.

12.7 As discussed in Chapter V "Energy in the household sector", the available data indicate that the share of non-commercial fuels is 80 per cent in the rural areas, whereas it is only about 51 per cent in the urban areas. It is also found that there is significant income elasticity of energy demand in households and the upper expenditure class (over Rs. 75 per month in 1973-74) consumes about twice the average per capita energy consumption in households. Even in rural areas, firewood and animal dung,— the so-called non-commercial fuels—are purchased to a small extent. In 1973-74, the share of purchased firewood was about 13 per cent in rural areas and that of animal dung was about 8 per cent. The per capita kerosene consumption of the rural and urban poor seem to be quite close,. while that of the rich in urban areas is very high as compared to the same expenditure class in rural areas.

TABLE 12.1

Consumption of Kerosene in Urban and Rural Households

Sl. No.	Monthly expenditure class in Rs.	Per capita consumption of kerosene in Rural and Urban households (in kgs. of coal replacement)	
		Urban	Rural
1.	0—21	38.08	30.67
2.	21—28	27.36	34.24
3.	28—43	67.47	56.95
4.	43—75	82.90	57.60
5.	Above 75	140.46	87.96
6.	Average	94.02	59.11

This is probably due to the fact that the poor in all areas use kerosene primarily for lighting, while a larger percentage of the urban rich use kerosene for cooking. It is also noteworthy that in 1973-74, when over 30 per cent of the villages had been electrified, the contribution of electricity was only 0.6 per cent of the total non-commercial energy consumption in households.

12.8 For all practical purposes, the consumption of energy in the agricultural sector in rural areas can be taken to be the same as consumption in the agricultural sector in the country as a whole, which has been discussed in Chapter VI of the Report. Two broad trends emerge from the analysis (1) commercial energy consumption is increasing rapidly in the rural areas and, (2) of these various forms of commercial energy, the rate of growth of electricity is the highest. Electricity is used mostly for pumping water from irrigation wells, and there is a limit to the extent to which ground-water can be exploited and consequently to which electricity can be used. If the current trends towards rapid exploitation of groundwater resources and the electrification of irrigation wells persist, such limits would be reached by the year 2000 or even a few years earlier. The extent to which commercial energy is used for land preparation depends on the Government policies towards mechanisation. The stock of work animals in the country as a whole has remained almost unchanged in the last three decades. Whether the numbers in rural areas have decreased or increased is not known. The contribution of animal power to the rural transport and agriculture sectors has also not been estimated.

12.9 The Group tried to estimate the energy consumption in industrial establishments in rural India. The consumption of registered establishments in rural areas has been included in Chapter VII on "Energy in the Industries Sector". As indicated therein, the unregistered sector contributes over one third of the total industrial production. The details of energy consumption, by such industries are not available. The percentage distribution of household industries with reference to the fuels used is given in Table 12.2.

TABLE 12.2

Fuel Use Pattern in Household Industries 1970

(In percentage)

	Electricity	Liquid Fuels	Coal, Wood	Others	Total
Food products	9	16	38	37	100
Beverages & tobacco	3	1	94	2	100
Non-metallic mineral products	Neg.	1	99	Neg.	100
Metal products	1	Neg.	99	Neg.	100
Others	8	2	88	2	100
All industries	6	10	62	22	100

Note : 1. Source : Census (1970).

2. Non-metallic mineral products cover brick and glass manufacture pottery, etc.

12.10 Although coal, wood and bagasse are the predominant fuels used, manual power is the major source in terms of all sources of energy—animate and inanimate—in over 75 per cent of the establishments, vide Table 12.3.

TABLE 12.3

Percentage Distribution of Establishment According to the Major Source of Energy

	All fuels including Electricity	Manual
1. Food products	92%	8%
2. Beverages & tobacco	5%	95%
3. Non-metallic mineral products	19%	81%
4. Metal products	73%	27%
5. Others	4%	96%
6. All industries	24%	76%

The available data indicate that energy consumption data do not include completely the supply obtained from different sources by the private efforts of individuals. The fuel used in brick making, in small establishments like village eating houses sweet-meat stalls etc., have not been adequately estimated. An understanding of the energy consumption pattern of industries in rural areas, the sources of supply of such energy, and the factors which govern their supply, are crucial for the formulation of policies towards rural industrialisation and rural development. The Group would therefore urge that a special study be undertaken to quantify these factors at least in respect of a few selected areas.

12.11 Transportation in rural areas is mostly dependent on human labour and animal power. Transportation of goods by head-loads, by animal carts and through pedal power is widely noticed even now in rural areas. There is little data which would enable a proper understanding of the energy needs of rural transportation.

12.12 The above discussion shows that, while energy required in the form of heat is still mostly obtained from non-commercial fuels like firewood, agricultural waste and animal dung, which are being slowly replaced by coal and kerosene, the energy needed in the form of mechanical work is supplied mostly by human labour and animal power and is slowly being replaced by electricity and diesel in the case of mechanical work in stationery equipment and by diesel in mobile equipment.

End-use Analysis of Village Energy Needs

12.13 In the absence of reliable and comprehensive data regarding rural energy consumption patterns, the absolute and relative magnitudes of the various end-use of energy in villages cannot be derived. Under these circumstances, the best that can be achieved is to identify the different end-uses and perhaps rank them. Even this attempt is complicated by the fact that the end-use pattern would depend upon the agro-climatic conditions, the level of productive activities, the life-style and the availability and accessibility of technologies. In so far as these factors differ widely in different parts of the country, end-use patterns are bound to be location-specific and culture-specific.

12.14 In this context, it would be useful to develop, for purposes of analysis, a typology of Indian villages. Thus, based on factors such as water availability, and quality and quantity of agricultural land, Indian villages could be classified into a few types, for example :

- villages with fertile land with the means to use both surface water and ground water,
- villages with good surface water availability from large irrigation networks,
- villages with cultivable lands and good ground water potential

— villages with cultivable lands and adequate rainfall,

— villages in semi-arid and arid zones,

— villages in hilly areas,

— villages in forest areas.

The end-use pattern for each one of these types would be required for the formulation of a comprehensive rural energy policy. Since such information is yet to be obtained, use will be made of whatever studies exist.

12.15 For example, a detailed study of a Karnataka village about 110 kms. from Bangalore leads to the following end-use analysis :

End-use	Input mkcals/ yr	Energy As a % of total input energy	Utili- sation Effici- ency (esti- mates)	Useful mkcals/ yr	Energy as a % of total useful energy
1	2	3	4	5	6
95—250°C Heat (Cooking)	688.9	80	5	34.4	6
<95°C Heat (Hot water)	112.4	12	5	5.6	11
>25°C Heat (Pottery, bricks)	23.8	3	5	1.2	3
Light	20.1	2.5	2.5	0.5	1
Mobile mechanical work (ploughing)	12.4	1.5	25	3.1	6
Stationary mechanical work (water-lifting, milling)	7.0	1	80	5.6	11
TOTAL	865	100		50.4	100

For the purpose of the present discussion, the only significance that needs to be attached to the particular numbers in the table is that they identify the most significant end-uses of energy and illustrate the general orders of magnitude for this type of village. For villages of other types, i.e. in other regions the relative percentages are bound to be quite different.

12.16 For example, in areas where there is considerable mechanization of agriculture (e.g., tractors and pumpsets are extensively deployed), the share of mechanical work in stationary and mobile equipment is bound to be much larger. Thus, in a synthetic end-use analysis obtained by assembling well-known facts about rural life and some engineering data for a village which is dependent on ground water, the relative requirements of energy for the various end-uses may be as follows :

End-use	%
95 250°C Heat	45.7
Light	5.3
Mechanical work (in stationary equipment)	14.3
Mechanical work (in mobile equipment)	34.7
	100

12.17 It may be concluded therefore that the central task of a rural energy Policy is to address itself to fulfilling the requirements of the following end-uses :

(1) 95—250°C heat,

(2) mechanical work in stationary equipment,

(3) mechanical work in mobile equipment,

(4) light,

(5) < 95°C heat,

(6) > 250°C heat.

Energy sources and devices for rural end-uses

12.18 What is necessary therefore is a screening of the various sources and devices to fulfil the energy requirements of the above end-uses of energy in rural areas, and a selection of those sources and devices which are most appropriate.

12.19 In this process, several criteria must be emphasised :

— the availability of the chosen energy sources must be assured ;

— the selected source and device technologies must be economcally viable ;

— the selected source and device technologies must be implementable, either immediately, or sufficiently soon to make an impact within the time horizon of this report, viz., 2000 A.D.

12.20 Before arriving at conclusions regarding energy sources and devices, several issues merit consideration. The replacement of manual labour and animal power in the agricultural sector by mechanical equipment has to be considered (as the problem of mechanisation in agriculture) not only with reference to employment but also with reference to energy.

There have been a number of studies with somewhat conflicting conclusions regarding the impact of mechanisation on labour employed in agriculture. It is evident from most of the studies that mechanisation will become meaningful from the employment point of view only when, as a consequence the intensity of cropping can be increased and the yields improved. As the labour and energy requirements in agriculture are dependent on seasonal conditions and on crop patterns, it would be undesirable to have a uniform policy towards mechanisation applicable to all areas. With reference to agro-climatic conditions, agricultural patterns, the demand and supply of labour in different seasons, etc. would have to be studied, and region-specific policies would have to be evolved. In terms of energy consumption, mechanisation would lead (unless alternate liquid/solid fuels are widely adopted) to increases in the consumption of diesel oil which is a very valuable middle-distillate oil product. At the same time, there appears to be some limitations to the extent to which work animals can be increased in rural areas, because of the limited availability of grazing ground and fodder. Irrespective of the level of use of work animals, there is need to increase the efficiency of animal-drawn ploughs and water-lifts. While subsidies to the individual farmers who use electricity for lifting water or diesel for tractors are given in pricing policies, there is very little subsidy for the use of animal driven implements or for maintaining work animals. These issues would have to be examined very carefully and policies must be evolved to encourage the use of appropriate technology in agriculture depending on location and specific conditions. A decision on this would have a very large impact on the forecast of electricity and oil discussed in this Report.

12.21 In the rural areas, electricity is used for providing light and for lifting water and for operating a few small village industries, such as milling of grain and extraction of oil. The load requirement for irrigation pumps is about 10-15 times larger than the connected load for even middle-class households. In view of the seasonal variations in the demand for lifting water, and the fact that lighting loads operate for only 2-3 hours in the evening each day, the load factor of electricity in rural areas tends to be very low. On the other hand, the need to draw transmission and distribution lines over long distances from the central electric supply system makes the cost of supplying electricity to village very high. This cost is further aggravated because the characteristics of the load in rural areas is such that the losses in transmission and distribution are also high. If the rates charged for supplying of electricity to rural areas were to reflect the total costs of supplying electricity to these areas, the real electricity tariff would have to be increased several fold. The present tariff rates involve a very large subsidy to electricity users in rural areas. The cost of supplying electricity to villages could be reduced by adopting procedures by which agricultural pumps are not operated while the supply is made for household lighting. It is also possible to arrange electricity supply for water lifting in such a way that a major portion of the demand comes up during the late night hours when there is surplus capacity in the electricity system. The Group feels that the various possibilities of reducing the costs of supplying electricity to rural areas and reducing the level of subsidies require urgent attention.

12.22 In respect of household energy an important need is to supply cooking fuel needs. This can be done through the use of firewood, agricultural waste, animal dung, soft coke or kerosene. The level of use of agricultural waste has not been satisfactorily estimated so far. Except for the quantities which are used in compost-making, there is need to use as much as of the agricultural waste as possible as fuel. From time to time, some schemes for the use of animal waste and agricultural waste in certain urban areas have been mooted but no systematic effort for decentralised agricultural waste utilisation has been made seriously. Most of the agricultural waste produced may not be useful as fuel directly, but may be used as the feed for production of gas or liquid fuel in small size equipment like biogas converters and the liquid or gas fuels can be used in the energy sector. In the OLF we have assumed that the quantity of agricultural waste used in the economy would not go down in absolute quantities beyond 1982-83. It is possible that this can be increased much further by developing efficient equipment which can use such waste material as household fuel.

12.23 In the recent past, there is a growing realisation that rural energy needs can be met from decentralised supply systems based on alternative technologies. While discussing these alternative energy technologies it should be kept in view that energy from conventional sources like electricity or kerosene is not being used by a large number of rural folk because these fuels are either too costly for them or because they have alternative fuel within their reach at very little private cost i.e. firewood. Alternative energy technologies should therefore either be very cheap or their use must be made much more convenient than conventional fuels like firewood etc.

12.24 Among the alternative energy technologies which appear promising are :

(a) solar energy for supplying low-temperature heat for water heating and post-harvest operations ;

(b) biogas plants to supply heat, provide mechanical energy by its use in I.C. engines and meet lighting needs either with gas mantles or through electricity ;

(c) Producer gas plants based on charcoal to run mobile equipment ;

(d) microhydel stations to give electricity; and

(e) wind mills for water-lifting, milling, etc.

The group came to the conclusion that all these can be deployed immediately or in the very near future.

12.25 A popular hope is to use solar energy for cooking. A solar cooker, if it is to serve completely the energy requirements of villagers, should be capable of giving heat and should deliver the usable heat into the houses away from the sun, and should be functional during normal cooking hours, i.e. during the early morning and late evening hours when the sun is not shining. In other words, if conventional solar cookers are to become acceptable, they will have to include a heat transmission system and a heat storage system. Hence, such solar cookers which can really replace other fuels for cooking, become very costly and out of the reach of a majority of the rural population. Several inexpensive solar cooking devices have been designed by various agencies but all of them can only provide a means of cooking out-doors during hours when the sun is shining. The Group however felt that there is a case for using solar devices in new ways e.g. for pre-heating water for cooking purposes, or for unattended cooking and the equipment for this could be made very inexpensive.

12.26 Solar energy could be used to provide electricity either by direct conversion of solar energy into electricity through photovoltaic cells or by using solar thermal power generators. An analysis of the status of the technology now indicates that photovoltaic cells are preferable for small-scale installations. The prices of photovoltaic cells have been coming down during the last five years from $ 10000 per peak kw to about $ 2000 per peak kw. This is expected to be further brought down by USA to $500 per peak kw, i.e. Rs. 4,000 per peak kw. It is important to recognise that the costs of installation in village should also include storage facilities as electricity for lighting would be required when there is no sunshine. The cost of such storage systems is very high and the maintenance of the storage facility is much more cumbersome than the maintenance of photovoltaic cells. Further, the life of photovoltaic cells in rural surroundings has also to be established. In view of all this, the Group does not consider that there would be any sizeable contribution from solar energy for lighting in rural areas in the next two decades. In this context, it is relevant to note that the projections on rural electrification envisage that within the next two decades all villages in the country would have access to electricity. By the end of 1979 nearly 40 per cent of the villages numbering 2.3 lakhs would have been electrified. Presently, the programme is to electrify about 25,000 villages per year. If this rate is kept up, all villages would get electrified by the end of the century and electricity from the grid may become the primary source of energy for lighting. The Group notes that in certain States which have electrified all villages, the realisation that the current procedures for extending electricity to individual householders might not help many poor householders has led to the introduction of some innovative processes of supplying one bulb point to each low income family at subsidised rates.

12.27 Similarly solar energy can be used for water lifting either through mechanical pumps operating directly on solar energy or through electricity. These are also very costly and the present cost would be about Rs. 10,000 for a 1/2 H.P. pump. Much more development work to reduce the cost of solar energy pumping devices is necessary before this can become a meaningful energy source for rural application. In contrast, wind driven pumps have been and are being used for water lifting in India and abroad.

12.28 Bio-gas plants have been tested for quite some time and in a number of places where conventional fuels like firewood are costly, biogas plants can be introduced. A study of biogas plants of different capacity indicates that there are high economies of scale. Household-size plants with 60 cft. capacity which could supply the energy needs of one household by using dung from about 3-4 animals, cost over Rs. 3,000/- and if the costs of gas production in the plant are evaluated, the cost of heat energy from such gas is equivalent to purchasing firewood at the cost of Rs. 200/- per tonne. Families which do not pay this price would not use it for purposes of reducing the cost of fuel. Some work is being done for developing cheaper biogas plant without a steel gas holder. This might help in wider use of biogas plants. Community bio-gas plants are less expensive for the production of bio-gas. But the cost of distribution to the households and industries in the village is high. Besides, such systems are yet to be tested on location to find out the problems of collecting/purchasing dung, gas and sludge distribution, safety problems etc. Such plants have to be set up in number of areas and the problems and costs evaluated, before widespread construction of community size biogas plants could be recommended as a general proposition. However, the Group would like to emphasise the fact that biogas plants have several other non-fuel benefits and among the various technologies under consideration, bio-gas appears to be the most promising for Indian conditions. The Group recommends that a number of biogas installations of the community type and the utilisation of gas from such plants for households, pumping and industrial installations, should be carefully studied by an objective group to decide the further course of action.

12.29 Methanol is a good substitute for petrol (motorgas) but its production from wood distillation calls for increased firewood production and till such increased production is achieved, the use of methanol would only increase the pressure on forests. There are also problems of separating the by-products and impurities, which might not be possible at reasonable costs in small-scale installations. A similar set of reasons prevent the advocacy of alcohol for use as a liquid fuel. Alcohol production is possible from any starch material, but the need for increasing such material for the food requirements of the villages has to be weighed against the need for the fuel. This is also a technology where the concentration of the alcohol as well as purification in small-scale installations may prove to be costly. Nevertheless, methanol and alcohol energy sources must be explored.

12.30 Producer-gas plants based on charcoal have been used to run buses and even private cars during the World War II. The local skills appear to be adequate to maintain this equipment. This is an option which has not been given adequate thought in the recent discussion on rural energy needs. The Group would strongly recommend that this should be taken up for urgent consideration.

12.31 Micro-hydel stations can be constructed in rural areas if the irrigation canals are suitably built to provide the necessary head at appropriate locations as well as if mountain streams are harnessed. A survey undertaken by the CEA recently indicates that around 10,000 MW of capacity could be installed on the canal systems by setting up turbines. The Group would strongly urge that this study should be continued and pilot installations set up in large numbers as early as possible.

12.32 The Group also felt that there is need to take up a few villages for studying the total energy requirements and for setting up decentralised energy systems based on one or more primary sources of fuel like firewood in certain places, biogas in some places, solar energy in some places and so on. These primary energy sources would have to be supplemented by other energy forms of the conventional or alternative energy and the possibility of operating decentralised systems based on locally available renewable resources should be very carefully examined.

12.33 A summary of the promising sources and devices to fulfil the energy requirements of rural end-uses is given in Table 12.4.

TABLE 12.4

Energy Sources and Devices for Rural End-Uses

End-uses	Energy Sources: Primary	Energy Sources: Secondary	Energy Devices
1	2	3	4
95—250°C Heat Cooking	Animal/Agro wastes	Biogas	Gas burner
	Energy Forests	Wood/charcoal	Wood/charcoal Stove
Stationery Mechanical Work	Draught animals	Animal Energy	Animal powered Devices
(water-lifting, milling, industries etc.)	Human Labour	Human Energy	Pedal powered devices
	Wind	—	Windmills
	Animal/Agro-wastes	Biogas	Biogas Engine
	Energy Forests	Wood/charcoal	Produces gas Engine
	Grid/Microhydel/Genset	Electricity	Electric motor
	Wood	Methanol	IC engine
	Crops	Ethanol	IC engine

1	2	3	4
Mobile Mechanical Work	Draught animals	Animal Energy	Animal powered Devices
	Human Labour	Human Energy	Pedal powered devices
	Energy Forests	Wood/charcoal	Producer-gas Engine
(Ploughing, Transport etc.)	Wood	Methanol	Engine I C
	Crops	Ethanol	I C Engine
	Animal/Agro-wastes	Biogas	Biogas Engine
Light	Grid/Microhydel/ Genset	Electricity	Incandescent/ Flourescent Lamps
< 95°C Heat (water heating, drying, etc.)	Wood/charcoal		
	Stoves	Waste heat	Water heater
	Solar	—	Solar Dryer/Water Heater
> 250°C Heat (pottery, brick making, smithy)	Wood/charcoal	—	Furnace
	Animal/Agrowaste	Biogas	Furnace

CHAPTER XIII

COSTS AND PRICES IN THE ENERGY SECTOR

13.1 In the energy sector pricing policy can be an important instrument for achieving specific objectives. This is true for other sectors also except that the role of pricing policy in the energy sector is crucial for several reasons :

(i) The energy sector provides inputs for practically every other sector so that changes in energy prices have wide-spread ramifications.

(ii) The need for economy in energy use has been shown in earlier chapters to be of paramount importance. It may be easier to achieve this if we have a structure of prices that reflects cost and relative scarcities.

(iii) The energy policy outlined in the earlier chapters requires certain specific types of inter-fuel substitution. Though some of these can be achieved by fiat, the task of regulation would be facilitated if relative prices of energy reflect the required direction of change.

(iv) The energy sector accounts for a very substantial proportion of investment. Though this can in principle be financed by surpluses of other sectors the magnitude of investment is such that the energy sector itself will have to show a sufficiently substantial surplus.

13.2 The commercial energy sector (coal, oil and electricity) is practically entirely owned by the Government and the prices and investment decisions relating to this sector are largely administered by Government. The Government has sufficiently authority to implement effectively any policy on energy prices that it considers desirable. The purpose of this chapter is to identify the broad outlines of such a policy. In what follows we discuss first the trend in energy prices in the past, second the extent to which energy prices reflect real costs, third the extent to which different sectors would be affected by a charge in energy prices, fourth the trends in energy costs that are likely to prevail and finally, the required direction of change in pricing policies.

Trend in energy prices

13.3 The trend in energy prices since 1961 is presented in Table 13.1 :

TABLE 13.1

Index Numbers of wholesale prices in India

(Base : 1961-62=100)

Years	All commodities	Fuel Power & Lubricants	Manufactured Products	Coal	Kerosene	Petrol	Diesel oil	Electricity
1961	100.6	100	100	100	100	100	100	100
1962	104.1	102.1	102.4	104.2	98.9	100.6	99.8	105.8
1963	107.9	114.9	104.2	110.8	126.4	115.4	123.6	112.2
1964	119.1	119.7	107.5	114.8	135.2	120.4	128.9	119.2
1965	128.9	122.4	115.4	120.4	141.9	124.5	117.5	122.3
1966	144.3	132.5	125.5	126.9	154.4	131.3	115.4	135.4
1967	166.0	139.8	130.9	141.3	154.8	140.8	119.3	137.8
1968	165.3	147.2	132.7	159.9	156.3	147.5	120.8	140.7
1969	168.8	153.3	140.9	164.7	168.8	156.6	122.8	143.4
1970	179.2	160.4	151.7	167.9	176.0	172.6	121.6	148.3
1971	186.1	168.9	164.3	169.1	182.8	195.9	126.4	152.9
1972	200.7	178.2	174.3	173.6	199.4	211.6	130.5	157.7
1973	239.3	196.9	194.1	189.7	214.7	259.4	139.9	161.5
1974	303.0	300.3	247.7	230.8	317.8	464.5	286.7	196.7
1975	309.2	340.7	253.2	288.0	354.1	493.0	324.2	230.8
1976	301.0	369.6	260.4	333.4	405.7	498.8	341.9	254.1
1977	326.1	372.7	262.4	333.4	405.7	500.9	341.9	269.7
1978	325.4	388.5	260.2	354.0	411.3	515.1	345.3	304.6

The overall level of energy prices is reflected in the index for fuel, power and lubricants. Between 1961 and 1970 this index rose more than the overall index for manufactured goods but less than the overall index for all commodities. In the early seventies the index for energy and for manufactures rose by roughly the same amount though both rose less than the all commodities index. The sharp break comes in 1974 when the energy index rose by 50 per cent, mainly because of the oil price hike. Since then the increase in energy prices has been substantially higher than the rise in the index for manufactures or for all commodities. However it may be noted that the change in relative prices is not as large as is commonly supposed. Relative to the all-commodities-index the change between 1961 and 1978 is only 19 per cent though relative to prices of manufactured goods the change is 49 per cent. However, these are the trends in prices at the consumer end. Changes in prices at the producer end would be different because of the change over time in the incidence of indirect taxes.

13.4 The increase in energy prices arises to a large extent because POL prices have increased by nearly four-and-a-half time since 1961. However, it may be noted that coal prices have also increased about three-and-a-half times. Though less than the increase in POL prices, the coal prices increase is more than the increase in the manufactured goods or all-commodities index. Electricity prices also have increased by more than the increase in manufactured goods prices. However, the bulk of the increase in the relative prices of all three sources of commercial energy come in the seventies.

13.5 Certain changes in relative prices within the energy sector are also worth nothing. Within the POL sector the increase is sharpest for fuel oil and petrol. The increase in diesel oil prices is substantially less and is broadly in line with the increase in coal and electricity prices. Kerosene prices also moved up roughly at the same rate as coke prices. Thus the use of POL products for steam raising and private transport became relatively costlier but their use for public transport and pumping or for cooking did not.

Prices and the profitability of energy production

13.6 The profitability of energy producing sectors reflects their efficiency of operation and the adequacy of the prices that they are allowed to charge. At present the picture in the commercial energy sector is as in Table 13.2 :

TABLE 13.2

Profitability in the Commercial Energy Sector 1977-78

(*in Rs. Crores*)

	Electricity	Coal	Petroleum	Average for production enterprises in the Central public Sector
1. Fixed and working capital	7487	1077	1439	9867
2. Sales realisation	2138	712	5861	..
3. Working expenses	1493	705	5467	..
4. Gross profit	645	7	394	852
5. Gross rate of return (%)	8.6	0.6	27.4	8.6

Source : Annual Report on the Working of Industrial and Commercial Undertakings of the Central Govt., GOI Ministry of Finance, BPE.

It will be seen from this table that the petroleum sector has a rate of profit that is substantially higher than for the public sector as a whole, the electricity sector is slightly below the average and the coal sector is well below it.

13.7 Shortfalls in profitability could imply subsidisation of consumers. However, the price that the consumer pays includes, amongst other additions, indirect taxes which are not included in the sales figures reported in Table 13.2. If subsidies are defined as the difference between what the purchase value would be if the sector bore a burden of indirect tax on output and earned a rate of profit equal to some overall average and the actual purchase value the picture would be as in Table 13.3.

TABLE 13.3

Effective subsidies in the energy Sector

(*in Rs. Crores*)

	Electricity	Coal
	1	2
1. Sales	2,300	842
2. Indirect taxes	92	70
3. Total purchase value	2,392	912
4. Notional purchase value. Average indirect tax burden assumed to be 5.8% and average rate of return to be 8.6%. Excludes trade and transport margins	2,433	977
5. Effective subsidy	41	65
6. Rate of subsidy	1.7%	7.1%

13.8 The figures presented above must be interpreted with caution. They reflect not merely the adequacy or otherwise of statutorily controlled prices but also temporary aberrations in the efficiency of operation (permanent aberrations would of course quite regretfully have to be alowed for in pricing formulae). They also do not take into account distortions in input prices. Thus the electricity sector's profitability should to some extent be counter balanced by the losses of the coal companies. Subject to all the qualifications mentioned above it would appear that the implicit subsidy in the coal and electricity sector amounts to about Rs. 100 crores. These calculations would be substantially different if the subsidy is worked out on the basis of the average incidence of indirect taxes in the industrial sector (approx. 15 per cent) and a normative return of 12 per cent. With these assumptions the subsidy would be Rs. 506 crores in electricity and Rs. 178 crores in coal.

13.9 In the case of the petroleum sector, under our current pricing arrangements, there is no subsidy on the average and in fact there is a net contribution to revenues. However, this is not the case for each product individually. Moreover, the calculations are partly distorted by the fact that domestic crude is priced well below import cost. Petroleum products, unlike electricity and (for all practical purposes) coal, are tradeable and subsidies should be defined with respect to the opportunity cost, which is the international price.

13.10 The subsidy calculations presented above do not measure fully the required adjustment in prices. Firstly, marginal costs in all sectors are substantially greater than average costs. Secondly, rate of return calculations do not take into account the need for conservation. If these are taken into account, the required adjustment in energy prices would be somewhat larger than what is supported by the above calculations.

Impact of Energy Prices on other Sectors

13.11 Commercial energy is used directly for final consumption or as an intermediate input in other sectors. An increase in energy prices relative to other prices would (a) raise profits (reduce losses) in the energy sector, (b) reduce real incomes in the household sector and (c) raise prices and|or reduce profits in other energy using sectors. The magnitude of (b) and (c) would depend on the share of energy costs in total consumption|costs.

13.12 According to the National Accounts Statistics in 1976-77 household expenditure on fuel and power was Rs. 1902 crores out of a total consumption expenditure of Rs. 53,587 crores*. Inclusive of savings households incomes amounted to Rs. 64,437 crores**. Thus energy consumption amounted to 3.5 per cent of consumption expenditure and 3.0 per cent of income. Therefore a 20 per cent increase in energy prices would amount roughly to a 0.6 per cent reduction in real incomes of households. The incidence of this would vary with the level of income of the household. According to Planning Commission (PPD) estimates, the share of various income classes in the total consumption expenditure on each commercial fuel was as in Table 13.4 in 1977-78 :

TABLE 13.4

Share of Commercial fuels in Household Expenditure

(in percentage)

Expenditure Class	Electricity	Coal (@)	Petroleum(£)
(i) Below the poverty line .	14.58	23.92	38.27
(ii) Above the poverty line	85.42	76.08	61.73
Total . . .	100.00	100.00	100.00

(@) Includes coke also

(£) Only kerosene

These data suggest that the impact of fairly large increases in energy prices on household incomes would not be intolerable and possibly more acceptable than losses that would arise if energy supplies are disrupted.

13.13 Industry accounts for a substantial proportion of energy use. The incidence of energy costs in total costs varies greatly; generally industries involved in the manufacture of basic materials (like steel, aluminium, cement) as well as chemical process industries are fairly energy-intensive and others involved in the fabrication of materials into products (engineering, electronics) are less energy intensive. A distribution of industrial output according to the incidence of

*Statement on page 24, National Accounts Statistics, January, 1979, C.S.O.

**Household savings as reported in statement 10 and household consumption as reported in Statement 8 of National Accounts Statistics, January, 1979, C.S.O.

energy costs in the total value of production is presented in Table 13.5 :

TABLE 13.5

Incidence of Energy Costs in Industry 1975-76

Energy cost as a percentage of value of production	Percentage of industrial production in the category
More than 25%	1.7%
15.1—25%	7.4%
10.1—15%	12.8%
5.1—10%	14.2%
3.1—5.0%	18.8%
2.1—3.0%	20.9%
1.1—2.0%	17.5%
1.0% or less	6.7%

The average incidence of fuel cost in industry works out to 6.8 per cent. Hence a 20 per cent increase in energy prices would require an increase of about 1.4 per cent in industrial prices if profit margins are not be eroded. However, this average figure hides the fact that for nearly two-thirds of industrial production the required increase would be less than 1 per cent. Thus the burden of higher energy costs in the industrial sector should not lead either to an unacceptable erosion of profit margins or increases in prices.

13.14 The incidence of energy costs in the transport sector is somewhat greater. In the case of the railways, in 1977-78, expenditure on fuel was Rs. 299 crores and gross traffic receipts were Rs. 2123 crores*, so that energy costs as a percentage of output comes to 14 per cent. Thus a 20 per cent increase in energy prices would require an increase of about 2.6 per cent in freights and fares if railway profitability is to be maintained. In the case of road transport the incidence of fuel and lubricant costs in total costs (inclusive of fixed and standing charges) varies from 28 to 31 per cent**. Thus, a 20 per cent increase in energy prices may require an increase in freight rates of the order of 6 per cent.

13.15 Amongst energy sectors the power sector is itself a major user of energy. In a pithead thermal power station operating on base load the incidence of fuel costs as a proportion of total costs works out to about 35 per cent. Assuming that coal based thermal power accounts for about 60 per cent of generation a 20 per cent increase in fuel prices would require an increase in electricity price of about 4 per cent if the profitability of electricity supply undertakings is not be eroded.

13.16 The example of coal brings out one general factor that has not been accounted for in the estimates presented above. A producing factor is affected by the increase in energy prices not merely because it uses energy directly but also because of the impact of energy prices on other input supplying scctors. This cascading effect of energy price changes is not included in the estimates of the first order effects presented above. However, as first-order effects seem to be fairly small, the likely second-order effects can for purposes of rough analysis be ignored.

Trends in Energy Costs

13.17 Energy price cannot be based solely on the current level of costs. Investments in energy-using industries made now will 'lock' the economic system into a particular pattern of energy requirements. Hence pricing policies, in so far as they are meant to stimulate an appropriate pattern of energy use, must take account of likely changes in costs over a decade at least. In doing this what matters is not increases in costs because of general inflation but those which reflect a change in relative prices.

13.18 In the coal sector, costs can be expected to increase over time because of deteriorating geological conditions. As cummlative output increases, seams which are less accessible or more difficult to work have to be exploited. This will mean an inevitable increase in costs. Some exercises on the optimum utilisation of coking coal indicate cost increases of the order of 2.5 times over a period of 25 years if the output grows at 5 per cent per annum. With non-coking coal, where deposits are available over a much wider area, diminishing returns may not set in so soon. Nevertheless it would be prudent to assume that future costs would be higher than current costs despite possible gains from mechanisation, rationalisation, etc.

*Indian Railways Year Book, 1977-78 pages 106-107.

**Survey data from Preliminary Report of the Study on modal costs, traffic flows and transport network conducted by RITES for the Transport Policy Planning Project, Planning Commission.

13.19 In the case of petroleum products, the critical factor is the likely increase in the real price of crude oil. The factors that determine the level of crude prices are not readily amenable to quantitative analysis. However, most analysts appear to accept that (a) crude demand would start running substantially ahead of crude supply by the nineties and (b) crude prices would increase in real terms in the eighties and nineties. The exact quantum of increase cannot be forecast with certainty. However, taking into account the costs of alternative sources for planning purposes it may be assumed that crude prices at the end of this century will not be less than $ 35|barrel in real terms.

Policies on Energy Prices

13.20 The basic objective of energy pricing policy can be to ensure that they (a) generate sufficient surpluses to facilitate the financing of investments in the energy sector (b) induce economies in the use of energy in all sectors and (c) encourage the desired forms of inter-fuel substitution. The facts presented in the previous sections suggest that our present pricing policies do not subserve the first objective. The evidence on inefficiency of energy use suggests that the second objective is also not being fulfilled. The third objective seems to be fulfilled as far as the substitution of coal for fuel oil in industrial applications is concerned but not necessarily in others.

13.21 The first priority at this stage must be to raise energy prices so that they at least reflect long-run marginal costs and allow for a reasonable return. In addition, a further increase may be desirable to promote conservation of resources and economy in energy use. This could take the form of a conservation cess and may be graded to reflect the degree of urgency necessary for resource conservation so that it would vary from product to product and grade to grade. The quantum of such a cess would have to be determined on a trial and error basis since reliable estimates of price elasticity are not available.

13.22 Since energy prices are regulated by Government they can get out of line if there are delays in price revision. Since changes in energy prices affect practically every other sector it is inevitable that any proposal for revision meets with opposition and the process of reconciling diverse interests takes time. These delays lead to an accumulation of losses and should be avoided. One way would be to allow for an automatic escalation in energy prices if input costs go up. An example of such a mechanism is available in the fuel surcharge on electricity tariffs. The weights and indices for this purpose can be determined on the basis of the cost structure of each sector. Since we expect energy costs to change rather more rapidly than the general price level, such automaticity may be necessary to ensure financial viability in the energy sector. There is need for a suitable institutional framework for regulating, monitoring and adjusting energy prices in a mutually comparable manner.

13.23 In general, energy prices for users have not been equalised. Thus, the cost of coal to a consumer situated at a substantial distance from the pithead is higher than for a consumer who is nearer. Power tariffs vary from State to State. POL prices reflect to some extent differences in the cost of transportation. However, in coal and petroleum, the variations arise only on account of transport costs. The implicit ex-plant cost is the same for all users irrespective of actual costs in the source from which they are supplied. (The higher ex-py-head cost for users supplied from Singareni is one exception). This means that some users are paying less than the actual costs of supplying them and some are paying more. There are some cases where there is a more direct form of cross-subsidisation in the form of a lower price for one category of users as in the case of Naphtha. In so far as such hidden subsidisation encourages inefficient use it should be avoided. The price to any user must reflect the real costs of supplying him. Since a separate tariff for each user is not practicable, the system of pricing should be structured to at least approximate these real costs. In the case of the coal sector this may involve a system of zonal pricing. In the case of electricity sector it would at least require a tariff schedule that distinguishes between peak and off-peak on a diurnal and seasonal basis.

13.24 Non-commercial energy sources are priced largely according to market forces. Since the policies recommended in this report require a systematic programme for the use of non-commercial fuels, it will be necessary to introduce a system of price surveillance and regulation. Subsidies will be required in some cases. Hence to ensure some consistency in the use of such subsidies, which may be linked with various promotional programmes, systematic cost analysis will also be required. The agency or agencies entrusted with the overall responsibility for energy policy may be asked to look after this aspect also.

13.25 A structure of energy prices that encourages the required inter-fuel substitutions and a degree of economy in energy use would make it easier to implement the energy plan outlined in the earlier chapters.

CHAPTER XIV

RESEARCH AND DEVELOPMENT IN THE ENERGY SECTOR

14.1 Research and Development (R&D) in the energy sector would necessarily be related to and linked with the various policy prescriptions outlined in the earlier Chapters. It is not intended to catalogue all R&D programmes necessary to develop the energy sector; instead, R&D priorities and specific areas of thrust will be dealt with keeping in view the overall policy objectives. The Group is of the view that in order to tackle the complex technological problems of the energy sector, R&D efforts on a substantially increased scale would be essential. In the time frame considered in this report, it is clear that conventional sources of energy, together with non-commercial sources will be the mainstay of all major energy consuming sectors. The Group is cognizant of the imperative need for development of renewable sources of energy and their potential role in the future. The basic thrust of the R&D effort should be oriented towards:

— improvements and adaptation of existing technologies with emphasis on conservation;

— development of more efficient technologies for utilising our indigenous conventional sources of energy; and

— development or renewable energy technologies.

14.2 Coal will continue to be a major source of commercial energy in the foreseeable future and as such, programmes that enhance its production and promote its efficient utilisation in all the consuming sectors, should receive high priority. In the oil sector, R & D priorities should be oriented towards maximising recovery from the oil reservoirs and efficient utilisation in major sectors like transport, industry and household as well as towards interfuel substitution, wherever feasible. R & D programmes in the electricity sector will have to have a high priority inconsonance with the power programme. In the area of alternative energy sources, R&D efforts in the fields of solar energy and biomass should be accorded high priority in view of their vast potential and their relevance to rural energy programmes.

14.3 Over the years, attempts have been made in the country to build up an R&D base in the energy sector. However, the Group feels that this is not commensurate with the total needs of the energy sector, both current and the future.

14.4 The responsibility for R&D is distributed among several Ministries/Departments and agencies. In some of the sectors like coal and oil, R&D programmes are fairly well institutionalised. For example, in respect of coal, R&D efforts in the areas of coal surveys, mining, coal preparation, etc., are dealt with mainly by CFRI, CMRS and CMPDI. In respect of oil, Institute for Petroleum Exploration, Indian Institute of Petroleum, IOC R&D Centre, etc. deal with major programmes in this sector. In the case of nuclear power, R&D programmes are well institutionalised and are being carried out by the Department of Atomic Energy. In other sectors such arrangements do not exist in an adequate measure and as a consequence, the R&D activities have not received the needed attention. For example, R&D programmes in the power sector are inadequate and do not reflect the priorities needed to ensure optimal production and efficient use of electricity. In the area of alternative sources of energy also, there is no institutional set-up. It is, therefore, necessary to develop proper institutional arrangements to promote R&D in a coordinated manner keeping in view the priorities of the energy sector.

R&D in the Coal Sector

14.5 R&D requirements in the coal sector range from improving methods of production and introduction of new technologies of coal-mining to better and more efficient methods of utilisation.

14.6 R&D activities in the field of coal-mining technology are presently related mainly to conservation of coal. The schemes presently in progress mainly relate to improved mining practices designed to increase recovery of coal and protect resources from fire hazards and collapse of mines. The coal mining programme envisaged for the future is so large that it is necessary to develop large mines with requisite capabilities. This would require development of new mining technology and use of larger and more sophisticated equipment. It is necessary to have a detailed review of the present status carried out to identify what further inputs will be required in this area.

14.7 Considerable R&D work has been done in the field of coal beneficiation by CFRI and Regional Research Laboratory at Hyderabad. A few R&D schemes covering areas of spherical agglomeration of coal, better recovery of coal from washeries, utilisation of rejects from beneficiation plants are presently under progress. However, the efforts are diffuse and require more emphasis. The Group feels that a coordinated approach would be required with close involvement of the user industries not only to upscale certain technologies which have been developed at the laboratory level but also to explore other promising techniques such as froth flotation, oil agglomeration and chemical demineralization.

14.8 For production and supply of relatively inexpensive coal based smokeless domestic fuels, the low temperature Carbonization technique is considered a viable option. The CFRI and RRL, Hyderabad have considerable R&D experience in this field. Further work is required to develop less expensive technologies.

14.9 R&D efforts in the field of coal combustion, particularly in respect of technologies for efficient burning of low grade coals are extremely important and relevant for the energy economy. In this regard, fluidized bed combustion offers considerable promise. Already, work is underway at CFRI, CMERI, RRL, Jorhat and BHEL and there has been significant progress. A 10-ton per hour experimental fluidized bed boiler has been developed and tested by BHEL and efforts are being made to upscale this type of unit. The Group feels that the R&D efforts in this field should be reviewed and intensified so that the technology is adequately developed for use in both the industrial and the power sector.

14.10 Technologies for gassification and liquefaction of coal are being considered in countries with plentiful coal reserves in the context of finding a substitute for oil or gas and environmental considerations. The Group feels that the relevance of these technologies to India needs careful assessment. R&D work relating to coal gassification on a modest scale is being pursued by CFRI, RRL Hyderabad and BHEL. On the question of liquefaction, recently a detailed study of the processes available for conversion of coal to oil and their economics under Indian conditions has been made. The Working Group feels that the need for pursuing R&D activities in these areas under our conditions should first be clearly established after which a comprehensive programme should be drawn up keeping in view the extent of and the time frame in which the gas and oil produced from coal would be required to play a role in our energy economy.

R&D in Oil Sector

14.11 The main thrust of the R&D efforts in the oil sector will have to be on enhancing our exploration capability, maximization of yield from oil reservoirs and efficient utilisation in all the consuming sectors. In the area of exploration, the Institute of Petroleum Exploration has been set up at Dehradun to carry out basic and applied research to support the exploration programme and in understanding the environment of the reservoirs. The Institute has been carrying out studies relating to sedimentary processes and delta formation, oil generation, migration and accumulation, production and reservoir problems. It has also been working on indigenous development of equipment required for oil exploration and development of sophisticated techniques for resolving geological, geophysical and reservoir problems. The adequacy of the present efforts need to be reviewed and they have to be reinforced and strengthened where necessary so that the expanding exploration activities required to locate potential oil and gas reservoirs in the country are adequately supported.

14.12 Development of secondary and tertiary recovery technologies is vitally needed to maximise the yield from oil reservoirs. An Institute for Reservoir Studies has been set up in Ahmedabad mainly to provide the R&D inputs necessary to develop such methods.

14.13 In view of the fact that the demand for middle distillates is large in our country, process technologies to upgrade heavier fractions such as LSHS to distillate products is of considerable importance. A scheme of establishing secondary processing facilities is already in progress in a number of Refineries. The Group would like to emphasise the need for R&D which is directed towards optimising such process technologies.

14.14 The Group is of the view that R&D efforts in the sphere of efficient utilisation of petroleum have been very inadequate with the result that significant technology gaps have developed. The transport sector which is a major consumer of liquid fuels should aim at a much higher efficiency of utilisation. Automobile engine and vehicle designs need to be considerably improved. In advanced countries, the performance of internal combustion engines has shown marked improvement while in India very little progress seems to have been made in this direction. It is also possible to develop transportation systems which would be optimal from the point of view of energy consumption. Considerable R&D would be required in these areas. Institutional inadequacies would also need to be rectified.

14.15 Inter-fuel substitution in the transport sector is important from the point of view of reducing the reliance on oil products. The areas which should receive attention are the development of battery powered vehicles and the possibilities of using fuels like alcohol and producer-gas for transport vehicles. R&D work has been initiated in a small way for the development of battery powered vehicles. The adequacy of such efforts need to be examined with a view to identify the suitable technological option. A battery powered two wheeler is under development in an industrial undertaking in the State of Karnataka. Battery powered buses for city use and commercial vehicles for short range applications show economic potential with further development.

14.16 The use of alcohol-run internal combustion engines has been pursued in the past and the technical feasibility of running automobile engines with blended petrol is reasonably well established. An interministerial committee in the Ministry of Petroleum & Chemicals is currently examining the various issues connected with the use of alcohol in the transportation sector. The Working Group feels that despite the fact that there are many complex issues involved requiring detailed examination from the long-term point of view, extensive R&D efforts covering optimum blends for use in existing engines, design of new engines to run entirely on alcohol, use of ethenol and methanol in diesel engines should be undertaken. There are sufficient indications that many new bioconversion technologies being researched all over the world may render production and utilization of alcohol much more attractive than is apparent now.

14.17 The potential of hydrogen as a source of liquid fuel for the transportation sector should be kept in view, although it is very unlikely that its potentialities can be realised within the next two decades. R&D programmes should be supported at an appropriate level so that the necessary capabilities could be gradually built up to be utilised whenever the use of hydrogen becomes technically and economically viable.

R&D for Nuclear Power

14.18 The Research & Development activities for nuclear power are primarily carried out at the Bhabha Atomic Research Centre at Trombay and in respect of fast breeders at the Reactor Research Centre at Kalpakkam. A number of test facilities have been set up. A 100 MWe thermal research reactor is under construction at BARC. The Fast Breeder Test Reactor (FBTR), under construction at Kalpakkam will serve as a facility for developing improved fuels having high specific power and better breeding ratios and material development for fast breeders. Studies are in progress regarding the feasibility of using thorium of which large deposits exist in India in the existing heavy water reactors. This will also provide an alternative to the fast breeder reactor route in case the breeder development gets delayed for any reasons. Work related to U_{233} separation is also on hand. While the technology for fabrication of uranium fuel elements has been well established, developmental work for fabrication of thorium plus U_{233} fuel and plutonium fuel is also being carried out. If the technological feasibility of the fast breeder reactor system, particularly based on the thorium fuel cycle, is established and indigenous capabilities adequately developed, a much larger nuclear programme becomes possible, particularly for the period beyond the year 2000 AD.

R&D in Power Sector

14.19 The large programme for expansion of the power sector envisaged for the future requires the development of technological capabilities and R&D support on a very big scale.

R&D in the power sector falls into the following categories :

(i) R&D concerning equipment manufacturing industry and system engineering including development of new designs for equipment, development of new materials and technological practices and systems to ensure better performance and higher reliability.

(ii) R&D oriented towards solving various operational and maintenance problems faced by various State Electricity Boards and Corporations.

(iii) R&D related to power system planning and operation.

14.20 With the growth of capacity and the interconnection of systems first on a regional basis and later on an all India basis, new problems have to be faced which require considerable R&D in many aspects of power system engineering. Concomitant with these efforts, there is also need for the development of facilities for manpower training in the sophisticated areas of automation, load despatching, on-line computer control, system simulation and optimisation, system dynamics and system protection.

14.21 The investment on R&D in the power sector amounting to roughly 20 crores per year has hardly any bearing on the size of the investment in the power sector or on the burgeoning problems. What is more, much of the annual R&D outlay is actually spent on routine operations such as quality control and testing and with a few exceptions, not enough innovative projects have been attempted. The Group, therefore, recommends that necessary resources should be allocated for substantially enhanced R&D efforts in this important sector. A concerted effort is needed to build a proper infrastructure and institutional framework for R&D activities in this area.

14.22 The Group is of the view that significant R&D inputs are required in the following areas :

(a) improvement in the methodology of load estimation and forecasting, power system planning including site identification, construction and project management techniques ;

(b) improvement of the reliability of power systems ;

(c) improvements in power system protection techniques ;

(d) optimisation of system economics, measures for power transmission and distribution in the low load areas, particularly the villages ;

(e) software development for problems in power system operation, load flow, short circuits, overvoltages stability, etc.

(f) research in the problems of integrated operation of power systems ;

(g) research and training in on-line computer control of power systems ; and

(h) research on EHV transmission and HVDC techniques.

A coordinated research plan on power systems should be evolved involving the Central Power Research Institute, the Central Board of Irrigation and Power, BHEL, CEA and State Electricity Boards.

Energy Conservation

14.23 The scope for energy conservation in the industrial, agricultural and transport sectors is indeed very vast. R&D activities relating to energy conservation in industries would involve improving existing processes to make them less energy intensive or developing new less energy intensive processes. The approach to be adopted would depend on the specific industry. It is necessary to review each major industrial process and identify the R&D efforts required to reduce energy consumption. As part of this exercise, the possibilities of substitution of coal for oil in various industries and the R&D required for such substitution should also be identified.

14.24 In the agricultural sector, the efficiencies of agricultural pumps commonly being used are poor due to both design and manufacturing deficiencies and improper motor-pump combinations. There is scope for significant improvements and therefore attempts should be made to identify R&D inputs required to improve energy use in agriculture.

Alternative Sources of Energy

14.25 The Group took note of various alternative sources and their potential applications. Amongst the alternatives, solar energy (direct), wind energy and bio-mass appear to be areas of high priority and therefore the Group feels that the basic thrust of the R&D effort should be directed towards development of technologies that appropriately harness these sources of energy.

Solar Energy

14.26 R&D in the field of solar energy is being pursued by a number of acadamic institutions, National Laboratories and a few industries such as BHEL, CEL, Jyoti, etc. They cover a number of application areas such as water heating, grain drying, refrigeration, cooking, space heating, pumping, power generation, etc. Research efforts in most areas have been mainly at the laboratory level although some devices and systems have reached the stage of demonstration and field testing. Commercial activity is yet to develop on any significant scale.

14.27 Although a coordinated programme at the national level has emerged, certain inadequacies exist in respect of engineering and fabrication support to R&D projects, institutional arrangements and extension activity. With the groundwork already laid, it is now necessary to determine how best the existing capabilities could be mobilized and further strengthened. The Group recommends that extensive field testing and demonstration of technologies which are ready should be undertaken on a country-wide basis with a view to promote their use. Solar energy devices for post-harvest operations and photovaltaic systems are areas in which considerable R&D work has been done but further efforts are needed to make them cost-effective. Photovoltaics is an area where a break through might occur in the foreseeable future.

14.28 One of the major drawbacks of some of the renewable sources of energy is their cyclic availability. Development of energy storage systems is essential to use sources such as solar energy and wind energy according to needs. There is strong need to strengthen the R&D efforts in this area.

Wind Energy

14.29 The potential of wind energy on a country-wide basis is yet to be assessed accurately. The available data indicates that the promising regions with good wind energy potential are the coastal areas of Karnataka, Gujarat, Maharashtra, Rajasthan and some hilly areas. In the interior of the country the average wind velocity is generally low but there appear to be certain periods during the day or month and this would vary depending on the season, when the wind velocities are sufficiently high to make wind mill installation feasible. It is felt that more detailed wind data especially regarding daily wind frequency distribution, seasonal variations, etc should be collected and the wind energy potential should be reassessed.

14.30 In the past few years, considerable progress has been made in the technology of wind mills in many western countries. However, these design may not be suitable for Indian conditions without modification and adaptation. Some wind mill designs have been evolved for low wind speeds also, but the cost-effectiveness and reliability are not yet proven.

14.31 The National Aeronautical Laboratory which had developed the horizontal axis wind mill and field tested many units has been continuing its efforts to evolve a cost-effective design suitable for Indian conditions particularly for pumping applications. Sail-type wind mills that could be made locally in rural areas are being investigated. Work is also in progress on vertical axis wind mills for electricity generation as well as for pumping application. A field Testing Programme of wind mills at Ghazipur in U.P. has given encouraging results. All these indicate that with further R&D, wind energy could become cost effective in many parts of the country particularly if the pattern of agriculture could be adapted to suit the wind conditions.

Fuels from Bio-Mass

14.32 The studies of the Group underline the importance of continuance of fuel wood as a source of fuel and the need for reliance on bio-mass for meeting the energy need in the foreseeable future. Research efforts directed towards identification of fast growing species, methods of increasing photo-synthetic efficiency and development of cost-effective processes utilising bio-degradable materials for producing fuels—gaseous as well as liquid deserve high priority.

14.33 Many bio-conversion routes are being researched. The choice of bio-conversion route is dictated by the physical nature of the material, its techno-economic viability and environmental benefits. The biological conversion of organic wastes by anaerabic digestion process is an area where considerable R&D is already in progress. Although the bio-gas programme based mainly on cow dung is being pursued with considerable emphasis, new techniques are required to utilise other types of solid materials like vegetable wastes and agricultural residues.

14.34 The technology of bio-gas production from animal dung is fairly well developed and a programme to popularise bio-gas plants based on the known technology is in progress. The present strategy is to encourage mainly individual effort with the result that the programme has benefitted individual families of a certain category in rural areas. While the present programme has served the need of bringing the technology to the rural areas, it is not adequate to harness the sizeable bio-gas potential and achieve the objective of the benefits reaching a larger section of the rural community. There are a number of scientific, technological and socio administrative problems to be resolved to harness the bio-gas potential and make it an effective component in the rural energy economy. A national level co-ordinated R&D programme is presently in progress to find solutions to some of the basic problems. The main objectives of the programme are to improve the gas yield, reduce costs, increase reliability, develop larger plants for community level applications, develop cheaper bio-gas stoves and other appliances, study the socio-economic impact and administrative arrangements for community level plants, etc. The pace of this programme has to be accelerated and it has also to be given a thrust so that the efforts can be concentrated in some of the more important areas.

14.35 The conversion of bio-mass into fuels by pyrolysis is a process of destructive distillation carried out in a closed vessel in an atmosphere devoid of oxygen. The gases produced are usually a mixture of hydrogen, methane, carbon monoxide, carbon-dioxide and lower hydrocarbons. The liquids are oil-like and the solids are similar to charcoal. Several versatile processes have been developed capable of using diverse feed-stocks such as coal, tree bark, waste timber, rice husk, urban waste with yields of as much as a barrel of oil for each ton of wet bio-mass. There are also other possibilities of using urban waste to generate electricity by direct combustion. In fact some western countries are already using such techniques on a commercial scale. Producer gas units based on wood/charcoal needs to be revived; R&D inputs necessary to develop cost effective units for rural application should be identified. Liquid and gaseous fuels can also be produced from bio-mass through the fermentation process. All these areas need intensive study to establish their niche in the Indian energy scene.

Decentralised Integrated Energy Systems

14.36 The possibility of decentralised energy production and distribution as against the centralised method deserves serious consideration particularly for meeting energy needs of the dispersed rural population. Such energy systems would be based on a system approach to energy problems taking into account all available energy resources in a given location with particular emphasis on new and renewable energy technologies. Most research on alternative energy sources has concentrated on single sources like solar or bio-gas or wind or geo-thermal and often a single application of that source. The intermittent nature of some of the sources like solar, wind etc. is one of the major problems in their effective utilisation. However, combining several sources might help to alleviate this problem and improve system reliability. R&D to establish the feasibility of integrated systems based on solar, wind, bio-gas and mini-hydro wherever available, will have to be undertaken expeditiously. The scope for such integrated systems seems to be most high in village situations, but it must be recognised that such technologies should as far as possible be simple and maintenance requirements low. It is necessary to take up a few pilot scale studies on integrated autonomous energy systems in village situations, including studies on socio-administrative problems and institutional requirements.

Application of R&D Results

14.37 The success of the R&D programme would ultimately be dependent on the application of their results for regular use in the energy economy. While the application of the results of the R&D programmes would provide considerable socio-economic benefits to the economy, only a few programmes will lead to direct monetary savings and profits in the near term. In the absence of sufficient direct motivation, difficulties would be faced in popularising the application of the results from R&D programmes for actual use. In this context, it would be necessary to consider monetary incentives and other motivating and regulatory measures to extent the results of the R&D activities to the field.

14.38 The measures to be taken to solve some of the problems being faced in providing assured energy supplies in rural areas have been dealt with in the earlier chapters. Considerable R&D inputs are required to make the present pattern of utilisation more effective and evolve new systems for application in the longer term. What is crucial in developing rural energy systems is the follow up action required to propagate and popularise them for application. Such follow up action through appropriate extension programmes should form part of the overall R&D programme to ensure that the benefits of R&D activities ultimately reach the sections of population for which they are intended.

CHAPTER XV

AN OVER-VIEW

15.1 The Working Group commenced its work in early 1978. The events in the international energy system during the past year and half (while studies and discussions were being carried on by the Group) have had a strong impact on the approach and the recommendations made by the Group in this Report. In the first half of 1978, it was widely recognised that the energy supplies, especially the oil supplies, would gradually run short of demand and that the previous trend of steadily increasing oil demand and matched supplies would yield place to a new situation of declining total oil production in the world, irrespective of demand. It was expected that the transition from the past trends to the new situation would be managed in an orderly fashion through a combination of market forces and positive intervention by the Governments through public policies to regulate the consumption of oil products. But the events in the last few months—the disruption of oil supplies from Iran and the steep increase in oil prices twice within one year—have forcefully brought home the realisation that any energy policy formulation will have to start with the assumption that there can be no guarantee of steady oil supplies to any importing country in future.

15.2 The experiences within the country and out side have shown that there are severe limitations to the pace at which supply could be increased from conventional energy sources like coal, nuclear power and hydro-electric resources. The growing realisation of the dwindling supply of conventional energy resources and the resulting rise in the real price of energy are expected to bring about some economies in the use of fuels in general and of oil in particular. The estimates of Reference Level Forecast drawn up by the Group reflect the Group's view that even if no deliberate measures are adopted to restrain and regulate energy consumption, the rates of growth of demand for energy in the coming years would be somewhat moderate as compared to those observed in the past.

15.3 The demand for coal and oil arises not only for direct use as sources of energy but also for conversion into electricity and for non-energy uses. Taking all the requirements into account, the Group has estimated that by the year 2000 AD the coal requirement would increase to 530 million tonnes, oil to 92 million tonnes and electricity generation to 550 TWb under the RLF*. It is to be noted that the consumption of coal for power generation by the year 2000 AD as per this forecast would be around 220 million tonnes and the non-energy uses of oil and oil used for power generation would amount to 18.5 million tonnes. The overall rate of growth of requirement of coal increases as per this projection at the rate of 7.7 per cent per year and of oil 5.6 per cent per year and electricity at 8 per cent per year from 1978-79.

15.4 The Working Group felt that it would not be desirable and might not even be feasible to step up the supply of energy to these levels and that ways and means should be explored to bring about an overall reduction in the energy demand, of which the reduction in the demand for oil products should be the highest. The exercises to seek reduction in the energy demand, however, should assume that the growth of the economy in terms of GNP should not be reduced from the levels adopted for the Reference Level Forecast. The results of these exercises are set out as the Optimal Level Forecast in the Report (see Chapter-III).

15.5 The Group has examined a large number of propositions and has recommended a number of measures to optimise the level and the pattern of use of energy. The major thrust of the policy prescriptions are towards :

— the curbing of consumption of oil to the minimum possible level ;

— conserving the use of energy by increasing the efficiency of its utilisation ;

— reducing the overall energy demand by lowering the intensity of energy consumption in the economy, particularly in the industries sector ;

— an increased reliance on renewable energy resources ; and

*These figures have been rounded off to the nearest convenient digits from Table 3.4 . The requirement of coal and oil include quantities used for power generation and non-energy uses.

— a reappraisal of our economic development strategies, especially those elements of the strategy which have a direct link to energy consumption like technology choice, location policies, urban growth, mechanisation in agriculture etc. with reference to the new awareness of the energy supply and demand in future.

15.6 Theoretically, options for substitution of oil by any other fuel should be examined case by case on techno-economic considerations. But under the current anticipation of rapidly increasing oil prices and possible discontinuities in the supply from time to time, the Group felt that it would be more pragmatic to examine all possible ways by which the consumption of oil could be restricted only to uses where it cannot be substituted.

15.7 In deriving the Optimal Level Forecast, the Group has suggested certain targets for the improvement in the efficiency of energy use which could be achieved at different points of time upto the end of the century. As the improvement in efficiency will require the replacement of capital stock which is currently in use by equipment which would be more efficient in the utilisation of energy, the targets for efficiency improvement have been assumed to be very small in the next five years but higher in each succeeding sub-period.

15.8 The Group feels that the targets for energy conservation suggested for different sectors in the report are moderate and could be improved upon if adequate institutional arrangements are made for each sector. It is necessary to examine the technological processes and the achievable levels of efficiency for each industry or equipment, and to prescribe the standards of efficiency to be achieved by energy users or equipment manufacturers. The systematic monitoring and the acceptance of all these norms may result in much higher levels of conservation than what has been assumed in the report. It is relevant to note that in countries where the efficiency of energy utilisation was higher compared to our country, it has been possible in the last few years to achieve substantial savings in energy consumption without affecting the rate and pattern of growth of the economy. The consumption of energy in industry in the United States is reported to have declined at the rate of 1.2 per cent per year on the average between 1973 and 1978, though a GNP increase of 2.3 per cent was registered during this period, and that the reduction was accomplished by conservation, recycling and burning of waste products. Given the relatively lower levels of efficiency of energy utilisation in many of our industries, it should be possible to achieve larger savings in energy consumption by adopting appropriate conservation measures.

15.9 The pattern of growth especially in the industries sector which has been evolved in the last three decades on the assumption of continuously available and relatively cheap energy supplies, requires to be restructured now. The Group felt that within the overall industrial production there is too large a share of some of the very high electricity consuming industries like aluminium, ferro silicon, etc. and this results in the overall energy intensity of the industries sector being very high. In the transition towards the optimal level of energy consumption, measures to restructure the industrial strategy with low energy intensity industries deserve serious consideration.

15.10 The Group has also emphasised the scope for greater reliance on renewable energy resources. Among the renewable resources, hydro-power is the most important one as the technology for its greater utilisation is readily available. The share of hydro-power generation in the total electricity/energy supply has to increase in the coming decades. In consultation with Central Electricity Authority which is currently making a reappraisal of the hydro electric resources, the Group has suggested a level of utilisation of hydro electricity which is much larger than what has been contemplated in the past and which has become possible due to the upward revision of the estimation of hydro-electric resources. The Group has also indicated that there is scope for setting up micro-hydel power stations in the hilly areas and that the possibilities of developing low head hydel resources along canals should be pursued.

15.11 The Group has suggested that the use of agricultural waste and fuel wood should be encouraged in future. While the increasing agricultural production would give rise to increased agricultural waste, the increase in the level of its utilisation would depend on the development of appliances and technologies which would make it convenient to use this kind of fuel. The fuel-wood resources could be increased by taking up forest plantations at the village level which would enable their use as a household fuel without any change in technology and without increasing the costs of transportation and transformation. In general the Group has placed great reliance on renewable resources to supply the increasing needs of rural areas.

15.12 Though the Group has given anxious consideration to the utilisation of new energy sources like solar energy, wind power, tidal power, etc. it was felt that in the absence of reliable data regarding the investment requirements as most of them are yet to be commercially tested and the cost benefits of these technologies are still uncertain, it would be hazardous to assume any supplies from such sources upto the year 2000 AD. The Group has, however, recommended R&D efforts on new energy resources as they might have to play a big role in the years beyond 2000 AD.

15.13 The strategy of economic growth adopted in our country has no doubt taken into consideration the endowment of resources and the major constraints to growth. The overall direction of growth, however, has been influenced by the internationally available technologies and the energy perspective of the world market in which abundant and inexpensive supply of oil and other relatively inexpensive forms of energy were the major elements. This has resulted in the ratio of energy consumption to GDP being high in our country. While it is generally maintained that there is a direct correlation between GDP and energy consumption, we do not have a full understanding as to why the intensity of energy consumption varies widely as between countries which are almost at the same level of economic well-being. A number of countries in the centrally planned economies seem to have high GDP even with low energy inputs. In our country a substantial portion of the energy supply is obtained in the form of non-commercial energy, animal power and human labour. One would expect that as a consequence of this, the consumption of commercial energy per unit of GDP in India would be low, but the facts indicate the opposite position. To some extent, this is due to the problem of computing GDP on a comparable basis for different countries at different levels of economic development. It is also due to varying levels of efficiency in energy utilisation. Even though more studies are required to understand the causes for the seemingly high energy intensity of the Indian economy, the Group is convinced that it is not only possible but necessary to reorient our strategies of economic growth in such a manner that the input of energy required to produce a given level of goods and services is reduced gradually over time. This would require a deatiled study of the specific operations which should be mechanised in agriculture and industries, the type of technology that should be chosen to produce a given set of goods, location of different production activities in the country so as to reduce the requirements of transport of the inputs and outputs of production activities, the extent of urbanisation and various other factors. In other words, the economic growth strategies would have to be realigned so as to be consistent with the current expectations of increasing scarcity and price of all energy products in general and of oil in particular. The Group has made some broad recommendations in this regard but these are not based on any detailed consideration of factors other than energy which might also have a decisive influence on these issues.

15.14 The Group has felt that the decentralised energy systems also would have a place in future especially if production activities are likely to be decentralised. The extent to which this could be achieved is not predictable at this stage.

15.15 The Optimal Level Forecast has been drawn up based on the above assumptions. The implementation of measures proposed in the Report would bring down the requirements of energy to 427 million tonnes of coal, 69 million tonnes of oil and 457 Twh of electricity. The OLF reduces the demand for oil by 25 per cent as compared to RLF. Consultations with experts connected with coal, oil and electricity production suggest that the stepping up of the production to these levels in the next 20 years might not be very difficult in the case of coal and electricity. In the case of oil, however, there are serious misgivings about the possibility of obtaining the oil supplies to the level of 69 MTs by the year 2000.

15.16 The Group has assumed that in view of the limited resources of oil identified so far and the somewhat sluggish rate at which additions to oil reserves are being made, the production of indigeneous crude in the year 2000 would be about 24 million tonnes. This would mean that over 45 million tonnes of crude would have to be imported then. Though this would represent a very small fraction of the overall oil trade in the world, it would be unrealistic to assume that we could get increasing supplies of oil when the world production is likely to decline in absolute terms. On the basis of the current knowledge of resources and market conditions the general anticipation is that world oil production might peak some time during the eighties. Some time between 1980 and 1990 the maximum level of production would be reached and then the level of world production might decline. At that stage, all importing countries would compete to obtain a fair share in the available supplies. Whether the problem is resolved by market-forces or by physical quota allocations, it would be unreasonable to expect that India would be able to obtain steadily increasing quantities of oil during the nineties.

15.17. It therefore, appears imperative to prepare ourselves for the contingency of not being able to import oil needed to the levels implied in this Report. The options to be considered in response to such a situation are either to increase further the production of crude from indigenous wells or to develop some liquid fuel which could substitute oil and which could be produced from renewable sources like agricultural products, either primary or waste products. Unless very large new oil discoveries are made, which are not anticipated in this Report, the increase of oil production would only shorten the life of our known resources. Theoretically, liquid fuels could be obtained from coal also. However, as the coal production for the other needs themselves add up to a substantial quantity by the year 2000, this proposition can be pursued only to a limited extent. Another option is the production of liquid fuels from renewable agricultural resources and bio mass.

15.18 The production of liquid fuels to a level of twenty million tonnes might not be possible by merely utilising available agricultural waste, as the quantities of waste required to produce about 20 million tonnes of liquid fuel cannot be obtained by collecting agricultural waste. The production of large quantities of liquid fuels from bio mass would therefore require cultivation of an appropriate agricultural product like sugarcane or cassava on lands which are allocated exclusively for energy plantations. The Group was not able to examine in detail the viability and feasibility of diverting lands in use now for cereal production for energy plantations, as the decision has to be based on a study of all factors that determine optimal land utilisation. India with its large population and a meagre land-man ratio, might have serious limitations of the extent to which this option could solve the problem of liquid fuel shortages. The Group would, however, like to recommend that this option should be pursued to the extent possible.

15.19 The sombre fact that emerges from this study is that international action is inevitable to ensure the supply of even the minimal levels of oil consumption required essentially to support our economic growth. The fact that India would be requiring in per-capita terms very meagre quantities of oil and that shortfalls in obtaining even this quantity might affect the growth of the economy, the Group hopes, would be recognised in any system of oil supply to be devised in future in the international energy system to ensure equitable distribution of a scarce resource essential for the well being of the world. In the absence of such a support, the basic objectives of economic development of improving the economic level and quality of life of our people would be difficult to achieve.

15.20 While on the one hand the international community should become sensitive to the needs of India securing a certain minimum level of oil supply to achieve her economic and social goals and should evolve a system that could allocate the minimum needs at reasonable prices, on the other hand, all efforts should be made within the country to secure a low energy growth and to optimise the fuel utilisation pattern. These domestic efforts cannot be successful, if the action of energy issues are not pursued in a sustained and comprehensive manner under a central direction. The Working Group is of the view that energy policy making could no longer be an exercise to be undertaken at periodic intervals, but should be a continuous one. Various policy measures suggested in this Report are only the broad outlines of policy for which the details would have to be worked out, implementing agencies identified and efforts for increasing production of energy supported with investment decisions. The efforts made in one sub-sector of the energy economy would have to be consistent with efforts made in other sub-sectors. The Group feels that such a coordination cannot be obtained under the present institutional arrangements. There should be a nodal agency which should take the responsibility for evolving the future energy policy options on a continuous basis, operationalising the policies into specific programmes, identifying agencies which must implement the programmes etc.

15.21 The Group discussed a number of alternative administrative structures which could achieve these ends. It felt that the best arrangements could be to have in the Energy Ministry the energy supply departments, viz. Coal, Petroleum, Electricity and Nuclear Power. In addition, there could be a Wing within the Ministry to deal with energy policy formulation and coordination. The task of evolving suitable policies towards non-commercial energy resources and new energy resources could be specifically entrusted to this Wing. Though such an arrangement would involve the creation of a very large Ministry, which by itself might give rise to certain problems, the Group felt that on balance, this would be the most practical, effective and least expensive of the various alternative arrangements.

15.22 If, for any reason, it is found not feasible to re-organise the Departments of the Government dealing with different forms of energy under a single Ministry of Energy, the alternative arrangement could be the creation of an Energy Commission. Such a Commission should work directly under the Prime Minister and should report on issues of energy policy and its implementation so that the Prime Minister could coordinate effectively the activities of the relevant Departments.

15.23 The broad conclusion that emerges from the studies of the Group is that India can no longer afford to take a fragmented and short term view of energy policy issues. The growth rates that have been assumed for the economy are believed by experts as the minimum required to achieve the economic and social objectives of improving the quality of life of the people and alleviating poverty. If the present strategies of growth are continued without change to attain the projected levels of growth, the quantities and the pattern of energy requirements would reach levels which cannot be met. It is therefore, necessary that measures towards optimisation of energy use are initiated from now on and implemented efficiently, so that supply of adequate energy would not set a constraint to growth of the economy. The Group would like to urge that all sections of the economy have to realise that the 'energy crunch' is not likely to be a transitional problem but a continuing one of increasing acuteness in the foreseeable future. Comparison of the levels of the energy consumption in India with those of developing countries with comparable population like USA, USSR and China, would not be very rational as the *per capita* energy resources available in India are far below what is available in these countries. In this context, the Group feels that while all attempts are made to conserve our resources of conventional fossil fuels by more efficient production and utilisation measures, the need to rely increasingly on renewable resources of the traditional types like firewood, agricultural and animal waste and on new energy resources like solar energy and energy plantations, cannot be over emphasized. If the importance of energy to support our plans of economic and social development is not fully recognised and action is not initiated in the right directions as indicated in this Report from now on and pursued vigorously, the Group feels that energy will become the major constraint to the growth of the economy. The Working Group herewith submits this unanimous report on the Energy Policy for the future.

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ANNEX I

CONSTITUTION OF THE WORKING GROUP ON ENERGY POLICY

The Working Group on Energy Policy was constituted by an order of the Planning Commission on 6th December, 1977, with a view to "carry out a comprehensive review of the present energy situation in the light of recent developments both within the country and outside, to develop a perspective for the next five to fifteen years and to recommend appropriate policy measures for optimal utilisation of available energy resources including non-conventional sources of energy".

2. The terms of reference of the Working Group were set out as follows :

"(a) to estimate the perspective energy demand in the different sectors of the economy and regions of the country by 1982-83 and a decade thereafter ;

(b) to survey the present and perspective supplies of energy ;

(c) to recommend measures for optimum use of available energy resources ; and

(d) to outline the national energy policy for the next five years, fifteen years and the longer term conservation policy."

3. Membership of the Working Group changed due to several reasons during the term of the Group. The names of members with periods served on the Group are listed below :

(i)	Shri R.V. Subrahmanian, Secretary, Department of power, Govt. of India.	Chairman till 31-7-1978
	Shri N.B. Prasad, Secretary, Department of Power, Govt. of India.	Chairman since 4-10-1978
(ii)	Professor M. Datta Chaudhury, Head of Department of Economics, University of Delhi.	Member
(iii)	Shri S.N. Roy, Chairman, Central Electricity Authority.	Member
(iv)	Dr. M.G. Krishna, Director, Central Fuel Research Institute, Dhanbad.	Member till 19-6-1978
	Shri N.C. Sinha, Scientist, Central Fuel Research Institute, Dhanbad.	Member since 19-6-1978
(v)	Dr. I.B. Gulati, Director, Indian Institute of Petroleum, Dehradun.	Member
(vi)	Professor A.K.N. Reddy, Convenor, ASTRA, Indian Institute of Science, Bangalore.	Member
(vii)	Shri C.R. Vaidyanathan, Joint Secretary, Ministry of Petroleum	Member, till 1-9-1978
	Shri R.K. Bhargava, Joint Secretary, Ministry of Petroleum.	Member since 2-9-1978
(viii)	Shri J.C. Shah, Chairman, Atomic Power Authority, Bombay.	Member, till 15-10-1978
	Dr. M.R. Srinivasan, Director, Department of Atomic Energy Atomic Energy Commission, Bombay.	Member since 16-10-1978
(ix)	Shri S. Chattopadhya, O.S.D., Department of Coal.	Member till 1-7-1978
	Shri S.K. Bose, Joint Secretary, Department of Coal.	Member since 1-7-1978
(x)	Shri M.G. Nair, Director (Railway Planning), Railway Board.	Member till 15-7-1979
	Shri B.K. Agarwal, Joint Director (Corporate Planning), Railway Board.	Member since 16-7-1979
(xi)	Smt. Otima Bordia, Joint Secretary (Energy), Department of Power.	Member
(xii)	Dr. Y.K. Alagh, Adviser (Perspective Planning), Planning Commission.	Member till 1-1-1979
	Dr. K.C. Majumdar, Jt. Adviser (Perspective Planning), Planning Commission.	Member since 1-1-1979

(xiii) Shri T.R. Satish Chandran, Adviser (Energy), Planning Commission. — Member

(xiv) Shri Nitin Desai Adviser, (Project Appraisal) Planning Commission. — Member

(xv) Dr. R.K. Pachauri, Administrative Staff College, Hyderabad. — Member since 26-4-1978

(xvi) Dr. J. Gururaja, Director, Department of Science & Technology. — Member since 26-4-1978

(xvii) Shri T.L. Sankar, Secretary, Industry and Commerce Department, Government of Andhra Pradesh, Hyderabad. — Member—Secretary

Dr. Jyoti Parikh, Consultant, (Energy-Division) of Planning Commission, Shri T. S. Nayar of the Department of Petroleum, Shri R. S. Verma of the Department of Atomic Energy and Shri Mukul Pandey of the Railway Board also participated in the discussions.

The staff of the Working Group consisted of :

Shri T.L. Sankar,	Member—Secretary.
Shri S.K. Prabhakar Miss R. K. Bhati	Personal Assistants.

Besides, the Working Group availed itself of the part-time services of the following officers working in the Planning Commission :

1. Shri J. N. Maggo
2. Shri Ashwini Kumar Sehgal
3. Shri Arun Chaitanya
4. Shri A. K. Singh

The Working Group was assisted in the later stages of its work by Shri M. K. Sambamurti, Director, Department of Power and Shri L. C. Jain, Chief Engineer (Planning), Central Electricity Authority. Shri S. N. Chibber, Desk Officer, Department of Power provided valuable assistance in the reproduction of the report in its present form.

The Working Group received unstinted co-operation from the various Wings of the Planning Commission and Ministries and Departments concerned with the development of the energy sector. The following organisations rendered valuable and prompt assistance in updating the statistical data, providing basic information and also in some of the analysis contained in the report :

Oil and Natural Gas Commission
Central Fuel Research Institute
Geologoical Survey of India
Central Electricity Authority
Indian Institute of Petroleum
ASTRA (Application of Science & Technology to Rural Areas) Cell of Indian Institute of Science.

The Working Group would like to place on record its sincere and grateful appreciation to all the individuals and organisations for their help.

ANNEX—II

INTERIM REPORT

WORKING GROUP ON ENERGY POLICY

The Working Group on Energy Policy was set up to review the developments in the energy sector within the country and outside and the conclusions and recommendations of the report of the Fuel Policy Committee. It was intended to consider very quickly the broad contours of the issues in energy policy and the report was to be submitted within a period of one year.

1.1 The Working Group reviewed the status of data available, the studies which had been taken up in pursuance of the recommendations of the report of the Fuel Policy Committee and the developments in the energy sector. The Group felt that it would not be possible to undertake fresh surveys and studies to enlarge the data base or to take up in-depth studies of some of the important issues which have surfaced during the last three to four years. The Working Group therefore decided that keeping in view the time and resources at the disposal of the Group, it would be appropriate to examine the broad issues and to complete the Report within the time allowed; while some of the recommendations are conclusive, other recommendations would require further studies to be undertaken.

1.2 The preliminary findings are submitted herewith, to enable the major recommendations to be considered before finalisation of the Draft Plan 1978—83. The full Report is under completion and will be submitted shortly.

2.0 *The Planning Horizon for Energy Policy.* The terms of the reference of the Working Group suggest that the forecast of energy demand and examination of energy supply issues should be made for a period extending to 15 years from now. As the gestation period of energy supply projects may extend to 12 years and beyond and as the long term energy options would involve an examination of 'demand and supply' over a 20 to 25 year time frame, the Group has attempted a forecast up to the year 2000.

2.1 Within this long term forecast, energy demand forecasts for sub-periods have been attemped for the years 1982-83, 1987-88, 1992-93 and 2000-01. The forecast of energy for 1982-83 will not be of any consequence in taking investment decisions regarding the energy industry as most of the energy projects for this period have already been identified. The decision taken during the period upto 1982 would result in additions to energy supplies in the period 1982—87 and beyond. As the investments to be made now should be with reference to the forecast of enrgy demand for 1987-88, carc has been taken to estimate the demand for 1987-88 as reliably and realistically as possible. In making the forecast, the Group was greatly handicapped by the fact that there is no official document setting out the possible rate and pattern of growth of the economy for the period beyond 1982-83. Some broad outlines are set out for the year 1987-88 in the Chapter on 'Perspective of Economic Growth' in the "Draft Five-Year Plan—1978—83". The Group had, therefore, to make certain assumptions regarding the rate of growth of GDP upto 2000 AD.

2.2 After a very detailed consideration of the alternative rates of growth which could be assumed, the Group decided that it would be useful to project the demand and analyse the supply issues for a somewhat higher rate of growth than achieved so far in order to examine if energy would be a constraint to growth at such levels. The growth of GDP assumed is as follows :

In the period :

1977-78 to 1982-83	4.7% per year
1982-83 to 1987-88	5.5% per year
1987-88 to 1992-93	6.0% per year
1992-93 to 2000-01	6.0% per year

The population assumed and the GDP at constant 1970-71 prices, as per rates assumed above, are set out below :

	Population (in million)	DGP* (Rs. in crores)
1982-83	697	58190
1987-88	760	76050
1992-93	823	101770
2000-01	921	162210

*Based on 1977-78 CSO data

3.0 *Trends in Energy Consumption in the past.* For purposes of understanding the level of production and consumption of total energy, the energy produced or consumed in different forms have to be aggregated. For this purpose, the Group has adopted the same units of measurement and conversion factors as adopted by the Fuel Policy Committee.

3.1 The consumption of commercial energy in the past in original units and in common units viz., coal replacement tonnes are set out in the Table below :

TABLE 1

Consumption of Commercial Energy in India

Year	Coal in million metric tonnes	Oil in million metric tonnes	Electricity 109 kWh
1953-54	28.7	3.7	7.6
1960-61	40.4	6.7	16.9
1965-66	51.8	9.9	30.6
1970-71	51.4	15.0	48.7
1975-76	71.0	17.8	66.0

TABLE 2

Consumption of Commercial Energy in India in Coal Replacement Tonnes

(In million tonnes of Coal replacement)

Year	Coal	Oil	Electricity	Total Commercial Energy
1953-54	28.7	24.1	7.6	60.4
1960-61	40.4	43.9	16.9	101.2
1965-66	51.8	64.6	30.6	147.0
1970-71	51.4	97.2	48.7	197.3
1975-76	71.0	115.7	66.0	252.7

(a) Conversion factors adopted :

1 m.t of coal	1 m.t.c.r.
1 m.t. of oil	6.5 m.t.c.r.
10^9 kWh	1 m.t.c.r.

Of the commercial energy forms, the rate of growth of consumption of electricity has been the highest, i.e. 10.3 per cent over the period 1953-75 while that of oil was 7.5 per cent and coal only 4.2 per cent.

3.2 An examination of the consumption of energy in different sectors also suggests that the relative share of industries in total energy consumption continues to be the highest, while the rate of increase of consumption of commercial energy in agriculture is fairly high. The rate of growth of total commercial energy and specific energy forms and the rate of growth of GDP and value added in different sectors are set out in the Table below :

TABLE 3

Rates of Growth of Commercial Energy and Selected Economic Indicators 1953-54 to 1975-76

(in percentage per year)

Period	Rates of growth of consumption of				Rates of growth* of			
	Total CE	Coal	Oil products	Electricity	GDP	Value added in Agri.	Value added in Industry	Value added in Transport
1953-54 to 70-71	7.23	3.48	8.62	11.51	3.92	2.28	4.36	5.96
1953-54 to 75-76	6.78	4.20	7.40	10.33	3.68	2.14	4.12	5.81
1960-61 to 70-71	6.89	2.43	8.28	11.10	3.90	2.33	5.39	5.37
1960-61 to 75-76	6.35	3.83	6.61	9.51	3.55	2.11	4.68	5.34

Note : *The rates of growth of GDP and values added in the sectors have been calculated with reference to factor costs and constant 1960-61 prices.

3.3 While the energy consumption per capita in India is low compared to other countries, the energy consumption per unit of output is fairly high in comparison to other countries and this ratio is increasing from Plan to Plan. The Group tried to examine the intensity of energy consumption (defined as the quantity of energy consumed per unit of GDP) for the economy as a whole and for the different sectors of the economy. The elasticity of energy consumption (defined as the ratio of rate of growth of energy consumption in a period of time to the rate of growth of GDP or value added during the same period) was also examined. A major cause for the intensification of energy consumption is a rapid increase in the levels of electricity consumption in the different sectors. These studies also indicate that the intensity of electrical energy consumption is very high in industries sector and that this intensity is deepening very rapidly over time. The electricity consumption and value added relationship for the year 1960-61 and for the year 1975-76 are given in the Table below :

	1960-61					
	Value added (Rs. billion at 1960-61 prices)	Electricity consumption (GWh)	Electricity per unit of value added GWh/Rs. billion	Value added (Rs. billion at 1960-61 prices)	Electricity consumption (GWh)	Electricity per unit of value added GWh/Rs. billion
Agriculture	68.3	833	12.2	90.1	8721	96.8
Industry	26.8	12696	473.7	52.7	44225	839.2
Other	38.2	3424	89.6	77.4	13957	180.3
Total	133.3	16953	127.1	220.2	66903	303.8

Source : Draft Report of the World Bank on certain economic issues in the power sector.

The increase in consumption of electricity per unit of value added in agriculture is due to the lower level of electricity use in agriculture for 1960-61. On the other hand, the increase in consumption of electricity per unit of value added in industries can only be explained by a shift in the structure of industry.

3.4 The electricity consumption per unit of GDP and the crude elasticities of electricity to GDP growth in selected countries are given in the Table below. The comparison indicates that both the absolute level of electricity use per unit output and the rate of growth of electricity consumption per 1 per cent growth of GDP is high in India compared to the developed countries as well as developing countries.

Electricity Intensity and Elasticity in Selected countries

Country	Electricity production per unit on GNP (1975) kWh/US$	Elasticity of Electricity consumption to GNP 1970-75
India	1.060	2.7
Brazil	0.709	1.3
Indonesia	0.138	2.0
Pakistan	0.894	1.4
France	0.590	1.3
Germany	0.732	2.1
Japan	0.959	1.2
U.K.	1.285	0.8
U.S.A.	1.318	1.7

Source : Draft Report of the World Bank on Certain economic issues in the power sector.

3.5 The intensity of electricity production is already high and if the elasticity of electricity consumption to GDP continues at the present rate in the future also, the total electricity requirements would become very high. Such a development would create severe problems in arranging for energy supplies, specially in view of the anticipated increase in the energy prices. In other words energy might become a real constraint to growth of GDP if the energy/GDP imbalance is not corrected over the coming years. The Working Group attempted to keep this in view in making the forecast of the future demand of energy.

4.0 *Forecast of Energy Consumption.*—All attempts to project the future demand for energy have tried to base the forecast on the past trends of energy consumption. The reliability of such exercises is somewhat doubtful in the context of a sea-change in the relative prices of fuels brought about by the steep fourfold increase in the price of oil during the years 1973 and 1974 and still higher in subsequent years. The production and consumption adjustments in response to the changing relative prices are still being made and the data of the last 3 to 4 years do not provide reliable clues regarding the future pattern of consumption. The Group therefore felt that the results of forecasting exercises which are based on past consumption data, should be checked with the results of the exercises based on end-use method forecasts.

4.1 In the end-use method, the Group has tried to visualise the developments in the household sector energy consumption by way of the shifts from non-commercial resources of energy to commercial resources, in the agriculture sector by way of modernizing the technology of tilling land and of lifting water and in the transport and industry sectors upto the year 2000. The Working Group is conscious of the fact that these exercises which are based on energy considerations alone, would require re-examination by undertaking a much more detailed study of the possible sectoral developments taking into account not only the energy implications but also the other relevant factors.

4.2 The Group has attempted first to make a forecast of the reference level projection of energy demand during the period upto 2000 AD. This would represent the possible level of energy demand consistent with the anticipated rate and pattern of growth of economy if there are no major policy changes in the energy sector. In other words, if no recommendations of the Working Group are implemented but the normal measures which have been initiated following the energy crisis are continued, the demand would likely to be of the order presented in the Reference Level Forecast (RLF). The results of the Reference Level Forecast are set out in Table below :

TABLE 4

Reference Level Forecast of Energy Demand

(In million tonnes of coal replacement)

Energy Form	1977-78	1982-83	1987-88	1992-93	2000-01
Coal*	74.0	96.8	131.5	186.6	309.9
Oil	165.7	226.4	291.4	369.7	596.8
Electricity	73.0	128.5	181.6	256.7	423.5
Commercial Energy Total	312.7	451.7	604.5	813.0	1330.2

*This is exclusive of coal for thermal power generation.

4.3 The Working Group recognizes that the energy demand forecast set out above is somewhat lower than the rates of growth which are assumed by the different sectoral agencies ; but a careful consideration of the overall energy consumption and anticipated growth of GDP suggest that the forecast now set out is more in line with current international thinking, that in the case of developing countries, the elasticity of energy consumption to GDP which is much over 1.0 should get reduced to close to 1.0 in the near future.

5.0 *Non-Commercial Energy Consumption.*—It is well known that considerable quantities of non-commercial fuels are used, mostly in the household sector for cooking. The studies of the Working Group indicated that besides this, considerable quantities of non-commercial fuels are used in the household industries, some village industries like brick-burning and pottery making besides the large quantities of bagasse used in sugar and khandsari industry. The available source of data do not enable a reliable quantification of total energy supplies derived from non-commercial fuels, nor the share of specific fuels like firewood, agricultural waste and animal dung in the non-commercial fuels. The Group suggests that a detailed study of this should be undertaken.

5.1 The total non-commercial fuels used in 1975-76 is estimated to be nearly 195 millions of coal replacement tonnes. Based on a field study conducted in the late fifties, it is normally assumed that 65 per cent of the non-commercial energy consumption in the household sector is in the form of firewood. This would mean that about 133 million tonnes of firewood are being used in the household sector alone, besides 41 million tonnes of animal dung. This is exclusive of about 30 million tonnes of bagasse and probably 10 to 20 million tonnes of firewood and agricultural waste used in the industry sector including village and household industry. As a major portion of the non-commercial fuels are obtained by households without payment by collecting fuel from their own farms or animals or from public sources, it is difficult to foresee the replacement of these fuels on a large-scale in the near future. As long as people in villages do not have a more gainful occupation which will provide them an income to buy fuels from the market, they would continue to collect fuels. The Group has, therefore, assumed that the replacement of non-commercial fuels by commercial fuels would not be total even by the year 2000 and that about 70 per cent of the households in the rural areas and about 10 per cent of the households in urban areas would continue to use non-commercial fuels for cooking. It is estimated that at present nearly 99 per cent of rural and 75 per cent of urban households use non-commercial fuels. Based on these assumptions, the total non-commercial energy consumption in the households is anticipated to get reduced to about 160 million coal replacement tonnes by the year 2000-01. The absolute quantity of non-commercial fuels use, though reduced, would continue to be very high. The Group, therefore, recommends that among the non-commercial fuels, measures should be taken to ensure that the fuels which cost the least to the nation like agricultural waste and animal dung as bio-gas should be increased.

5.2 The Group notes that the availability of agricultural waste would increase corresponding to anticipated increase in agricultural production. As a consequence, the share of firewood in the non-commercial fuels may get reduced to about 90 million tonnes.

Even this quantity is not likely to be available from our forests unless the productivity of fuel-wood in forest areas is increased and additional production of firewood from non-forest areas is stimulated by large-scale investments in social forestry and man-made forests. The area under forests in India is about 75 million hectares. Though the official records do not bear out the deterioration in the quality of forests, it has been estimated that about 4 million hectares have been reduced by way of conversion to other uses ; while the quality of forests has deteriorated very badly in some of the other areas. Investments to plant forests with quick yielding firewood species and designing procedures and institutional arrangements to improve the maintenance and exploitation of forests cannot be delayed any further. Simultaneously, measures should be taken to encourage the use of larger quantities of agricultural waste and animal dung by improving the conversion and efficiency of these as fuels.

6.0 *Agricultural Sector.*—In the agricultural sector, the energy is used mostly for lifting water and for land preparation. The number of wells in use in India is about 9.5 millions in 1987-88, of which 3.3 millions use electricity and 2.5 millions use diesel and about 3.7 millions use animal power to lift water. The Working Group projects that by 2000, the ultimate potential of 16 million wells would be realised, of which 11 millions would be using electricity, 4.4 million diesel pumps and the rest which is 0.6 million would use animal power. In other words, the Working Group visualises that the use of animal power for lifting water would be gradually phased out even with the gradual increase in the total number of wells. In a number of areas due to the fact that wells may be too unproductive to sustain a separate electrical pump or they are too remote to obtain electricity, the number of diesel driven pumps would not come down ; but would increase at a somewhat lower rate. It is useful to recall here that the Group has assumed only 100,000 diesel pumps to be added each year in the period 1982—87, and 50,000 pump sets per year in the period beyond 1987-88.

6.1 The present net sown area of 140 million hectares is cultivated with the help of 80 million working animals using about 44 million plough shares and 0.25 million tractors. The Working Group has assumed that the ultimate gross potential of 200 million hectares of cultivation would be realised by the year 2000 and that animal power would continue to be used at current levels upto the year 2000. The intensification of agricultural operations would be realised by addition of tractors at the rate of net addition of 30,000 tractors per year in the period upto 1983 and 50,000 tractors in the period upto 1980—97 and 70,000 tractors in the period 1987—2000. These calculations show that draft power available increases from 0.1 HP to about 0.3 HP per hectare in the year 2000-01. As the gross irrigated area increases from 60 million hectares to 120 million hectares during this period, the net increase in draft power is not substantial. Compared to the HP per hectare available on farms in other countries, the position in India would continue to be very low even by 2000-01. The Group notes that in view of the anticipation that more of electricity and oil would be used for lifting water, the animal power available for tillage could increase if the total working animal population on the farms does not decrease over time. With the emphasis on small farms, these animals would continue to play an important role in agriculture. If the efficiency of bullock power ploughing equipment is improved, the total availability of farm power would increase especially on the small farms, which are dependent on animal power. The Working Group feels that a policy towards the optimisation of the use of different forms to tillage power in the agricultural sector should be drawn up as early as possible.

7.0 *Industries Sector.*—The studies of the Working Group reveal that intensity of energy used in industry defined as the ration of the quantity of total commercial energy used per unit of value added in the industry sector has been rapidly increasing in India in the last 15 years. Most of the increase is due to the intensity of electricity used in industry sector. The intensity of electricity consumption defined as kWh of electricity use per rupee of value added in industries has increased from 0.34 kWh in 1960-61 to 0.65 kWh in 1975-76 at 1970-71 prices. These intensities appear very high as compared to the intensity observed in other countries.

Electricity Consumption in Industries per Unit Value added (at constant prices) by the Industry Sector (1970 Constant prices)

(*kWh*/$)

Country	1968	1971
France	1.129	1.679
Italy	2.4	2.68
Hungary	0.763	0.797
U.S.S.R.	1.66	2.915
U.K.	1.946	1.69
U.S.	1.929	2.199
India	2.45	5.03*

Note : *The exchange rate change has led to the steep increase. At 1961 exchange rate the result is 3.18 kWh/$.

7.1 Even when the consumption per unit of output like per tonne of paper or per tonne of steel is examined, energy consumed in India is higher as compared to that in other countries. It has not been possible to do a very detailed analysis of the factors which have led to this situation. The Working Group however feels that the broad reasons for high intensity of energy use in the industry sector in India as compared to other developed countries may be one or more of the following :

(1) The proportion of heavy industry to light industry is different in India as compared to other countries.

(2) The share of primary metal industries like steel and aluminium in the total industrial mix is high in India.

(3) In the production of specific commodities like paper, fertilizers and cement, though the new units are of a size now being adopted in the world, there are many small and old units which are relatively inefficient users of electricity.

(4) Capacity utilization of industry in India is low and energy use in industries does not get reduced with lower levels of utilisation of capacity.

(5) The normal correctives to these factors were not available as energy, particularly in the form of coal, and electricity have been by and large underpriced.

7.2 The Working Group is of the view that such a situation should not continue indefinitely, more so in view of the likely large increases in the price of all forms of energy in future.

7.3 The Group would suggest that in view of the need to correct the imbalance, and improving the efficiency of energy use, an indepth study should be undertaken of the future strategy for the development of industry. The intensity of electricity consumption would increase from 1.02 kWh per rupee (0.839 kWh per rupee inclusive of electricity industry) at 1960-61 prices of value added in 1975-76 to 1.38 kWh in 1980—83 based on draft Sixth Plan. For the purpose of the report, the Working Group has assumed that the intensity of electricity use in industry would only marginally increase to 1.48 beyond this period and would continue unchanged from then on. The intensity of coal and oil use would grow by only 12.5% in the next 25 years.

8.0 *Transport Sector.*—Though the modes of transport in India range from animal driven vehicles to most modern jet planes and the Working Group has tried to examine the likely rates of growth of all modes of transport, the important discussions in the Working Group centred round the relative growth of roads and rail for carrying goods and passengers. The Group is of the view that the present trend may not change in the next 20 years, unless specific policy measures are adopted. The trend observed in the last 25 years, of the share of road slowly increasing at the cost of railways, is expected to continue in future also, though the rate of change in future is expected to be lower than in the past. This is discussed in more detail in subsequent paras.

9.0 *Oil Policy*—The essential determinants of oil consumption are the extent to which oil is used in the transport sector and in the agricultural sector for tractors and irrigation pumps. Though the assumptions made by the Group are considered to be conservative, the total requirements of oil on this basis adds upto nearly 92 million tonnes by 2000. This level of demand implies that the import of crude and oil products would be of the order of about 60 to 70 million tonnes after taking into account any increase in domestic oil production likely to be achieved in future.

9.1 As there are clear signs that oil prices in real terms would increase steeply in the coming years, the burden of paying for such a level of oil imports would be almost intolerable. Assuming that the price of oil increases by 25% in real terms by 1982-83 and 50% by 1987-88 and that export earnings increase by 6% per year from now to 2000 AD, the share of expenditure on oil imports as a percentage of export earnings would be nearly 60% by the end of the century. The assumptions here are somewhat optimistic as the probability of the price of oil being higher than what has been assumed cannot be ruled out. The Committee is therefore, of the view that the level of oil consumption should be severely restricted from now on and it may be possible to effect the restrictions without adversely effecting the anticipated growth of the country.

9.2 A more appropriate policy in the transport sector whereby the quantity of goods moved by oil driven vehicles would be reduced or the efficiency of oil utilisation in the transport sector would be improved should be considered. There is also a case for examining very carefully the needs of using kerosene for cooking in rural areas where alternative fuels like properly processed agricultural waste or biogas could be used. The policy regarding the use of diesel driven irrigation pumps should be reviewed. The requirements of oil for power generation purely as auxiliary fuel in the thermal plants is anticipated to increase very sharply if no efforts are made to reduce low load operations of the power stations. The Working Group is still examining the extent to which savings in oil could be affected and the specific measures that could be taken in this regard. These would be incorporated in the final report of the Working Group.

9.3 The studies of the Working Group indicate that the share of the middle distillates in the total oil product consumption would increase from the present level of 54% to nearly 65% (as per the Reference Level Forecast). The extent to which refinery capacity should be increased and middle distillate imports should be allowed to secure overall economy in the expenditure for meeting oil requirements has to be carefully examined by detailed studies.

10.0 *Coal*—The studies of the Group indicate that the demand for coal other than for power generation would increase to nearly 310 million tonnes by 2000-01. The demand for power generation would increase to about 150 million tonnes, depending on the projected thermal/hydel mix.

10.1 The present assessment of coal resources in India is based on two parameters, namely, 600 metres depth and 1.2 metres seam thickness. The Group feel that these parameters would require relaxation in the light of new developments in technology and price conditions emerging in the energy sector. Coal available upto a depth of 1200 metres and in seams of 0.5 metres thickness could be considered as available resource. The Group has obtained a re-assessment from the Director General of Geological Survey and the reserves are now revised from 83000 million tonnes to about 111,000 million tonnes (an increase of about 38%).

10.2 The step up from the present level of about 110 million tonnes of production to about 460 million tonnes by 2000-01 (which represents about 6.5% growth) will not be easy to achieve unless very effective measures are taken to evolve a long-term production strategy which would ensure the proper planning of mines, investments in opening coal-fields sufficiently ahead of need for additional coal production and adequate investment in coal transport. The Group is examining certain broad strategies which could be placed for the consideration of the Government. The Group would like to draw attention to the fact that even with the additional coal reserves now identified, at the level of demand for the year 2000 the coal reserves would last for about one hundred years only. There is need, therefore, to take measures to conserve the use of coal and increase the recovery of coal in coal mining from now on. A long-term production strategy should be formulated for coal.

11.0 *Electricity*—The forecast of demand electricity categorywise as made by the Working Group is given below (Table 5):

TABLE 5

Forecast of Category-wise Demand for Electricity (1992—2000)

(*In TWh*)

Consumer Category	1976-77	1982-83	1987-88	1992-93	2000-01
Household	6.34	11.4	15.5	22.0	35.8
Commercial	4.14	8.1	10.3	14.7	23.9
Agriculture	6.62	16.8	22.2	29.2	33.0
Industries	47.98	83.8	121.4	173.5	302.6
Transport	2.21	3.2	4.0	5.4	8.7
'Others'	2.73	5.2	8.2	11.9	19.5
Total	73.02	128.5	181.6	256.7	423.5

The electricity consumption increases by about 10 per cent in the period upto 1982; but this is to make up the low rate of growth in the 1970—76 period which has resulted in widespread shortage of electricity. From 1982 onwards, the projected rate of growth is about 7.8 per cent upto 1992 and 6.5 per cent beyond that period.

11.1 The electricity industry is highly capital intensive and the cost of incremental production of electricity would be very high from now on. There is, therefore, need for improvement in all areas of the electricity sector. The Group is of the view that it should be possible to reduce the losses in transmission and distribution to about 12 per cent by the year 2000-01 from the current level of 20 per cent. The kWh per kW performance of the nuclear and thermal power stations should also be increased, while in the case of hydel plants, it should be deliberately reduced with a view to providing peak power requirements at low cost. The plant availability factor for all the stations needs to be increased. The detailed recommendations in this regard would be set out in the final report.

11.2 The tentative estimates of the installed generation capacity and possible mix of power station is given in Annex A. The capacity requirement to meet the projected load demand would be about 108,000 MW by the year 2000-01. The Working Group is of the view that the most important aspect of the electricity sector in future would be one of demand management. The relative share of the different consumer categories and the characteristics of power and energy demand of the different consumers would have to be structured with a view to have optimal utilization of the generation capacities. The proposed installed capacity for the year 2000 would include 39,000 MW of hydel capacity at an average load factor of less than 60 per cent.

11.3 It would be appropriate to mention here that the hydro electric potential of the country was projected as 41,000 MW at 60 per cent load factor in all previous studies. The C.E.A. has reassessed the power potential of the country at 76,000 MW at 60 per cent load factor.

12.0 *Summary*—The studies of the Working Group have brought out the need for a reorientation of our approach to the issues in the energy sector. So far, there has been an overwhelming concern with the problem of supplying energy to a level specified by demand from various sectors of the economy. The studies indicate that such an approach may not be desirable or even feasible in the long term. The energy policy issues have to be examined with reference to the management of demand as much as to meet a given demand. The energy consumption in the different sectors of the economy also indicate that there is considerable scope for conservation without restraining our economic growth and that, in fact, the economic growth rate might well be higher if the outlays on the energy sector were more prudently managed.

One of the inescapable conclusions of the study is that resources availability of conventional fuels is likely to be a constraint for long-term economic growth and that alternative sources of energy would need to be explored. A coordinated R&D programme has to be drawn up with clearcut priorities. The studies of the Working Group cannot be conclusive and would require to be periodically reviewed and updated. As this is likely to be a continuing exercise, there is need to have appropriate institutional arrangements for undertaking such studies.

ANNEX A

Requirements of Installed Capacity 1982—2000

Item	Unit	1975-76	77-78	82-83	87-88	92-93	2000-01
Energy demand	10^9kWh	66.172	78.3	128.5	181.6	256.7	423.5
Supply from non utilities	As % of	9.1	9.6	7.0	6.0	5.0	4.0
Energy demand on non utilities	10^9 kWh	6.0	7.5	9.0	10.9	12.8	16.9
Capacity in non-utilities	'000 MW	2.13	2.50	3.0	3.63	4.26	5.63
Energy demand on utilities	10^9 kWh	60.2	70.8	119.5	170.7	243.9	406.6
T & D losses	% total availability at bus bar	19.4	19.0	18.0	17.0	15.0	12.0
Energy demand at bus bar	10^9 kWh	74.7	87.4	145.73	205.76	286.94	462.05
Energy supply from :							
Nuclear	10^9 kWh	2.4	2.1	7.26	12.07	16.21	29.58
Hydel	10^9 kWh	33.2	37.5	54.64	75.08	94.04	135.84
Thermal	10^9 kWh	39.7	47.8	70.00	97.91	139.46	234.42
Total energy availability	10^9 kWh	74.7	87.4	131.90	185.06	249.71	399.84
Energy deficit	10^9kWh			—13.83	—20.60	—37.23	—62.21
Capacity required to meet deficit	'000MW			3.75	5.06	8.18	13.52
Assumption regarding kWhkW *per year*							
Nuclear		3765	3281	5460	5915	5915	5915
Hydel		3917	3742	3730	3730	3483	3483
Thermal		3553	3646	3690	4073	4550	4600
Energy demand at bus bar	10^9 kWh	74.675	87.4	145.73	205.66	286.94	462.05
Load factor	%	N.A.		63.0	64.0	66.0	68.0
Peak demand	'000 MW	N.A.		26.41	36.68	49.62	77.57
Peak demand served by :							
Nuclear	'000 MW	N.A.	N.A.	1.06	1.73	2.33	4.25
Hydel	'000 MW	N.A.	N.A.	12.45	18.12	24.30	35.10
Thermal	'000 MW	N.A.	N.A.	12.90	16.83	22.99	38.22
Total	'000 MW	N.A.	N.A.	26.41	36.68	49.62	77.57
Peak availability factor :							
Nuclear		N.A.	N.A.	0.80	0.85	0.85	0.85
Hydel		N.A.	N.A.	0.85	0.90	0.90	0.90
Thermal		N.A.	N.A.	0.69	0.70	0.75	0.75
Installed capacity :							
Nuclear	'000 MW	0.64	0.64	1.33	2.04	2.74	5.00
Hydel	'000 MW	8.64	10.02	14.65	20.13	27.00	30.00
Thermal	'000 MW	11.01	13.11	18.97	24.04	30.65	50.96
Total to meet peak demand	'000 MW	20.11	23.77	34.95	46.21	60.39	94.96
Additions to supply energy need :	'000 MW			3.75	5.06	8.18	13.52
Total required installed capacity :	'000 MW		30	38.70	51.27	68.57	101.48
	System load factor		42.37	42.9	45.8	47.8	48.6

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