Energy: Outlook for India by 2000 AD

Kotur S. Narasimhan

Energy management for any country is an important aspect of national development. Such energy management has three aspects of optimal utilization of indigenous resources, economic situation backed-up by global situation and environment-friendliness. These aspects pose peculiar angularity depending upon the socio-economic conditions that prevail. An attempt has been made in this article to analyse the problem of the energy management unique to India, taking into consideration the present situation, the projected demand in the country in the years to come and the choice of contemporary technologies available and the need to suitably adopt them to meet the challenges.

Ever since fire was created from flint stones, there has been a constant increase in the energy needs over and above the calories required to sustain life and therefore the quest for its sources. Beginning with a low profile consumption based on sunshine and forests and biomass, dependence has been steadily shifting towards commercial sources of energy. Discovery of fossil fuel sources, advent of steam power and electricity and the utility of nuclear energy, made such a shift predominant leading to industrialization and economic prosperity. As a result developed countries totally depend on commercial energy sources whereas developing countries are striving more towards that direction. Technological developments have also given rise to innumerable possibilities of refining, conversion and interconversion to convenient secondary energy sources of non-renewable fossil fuels like coal, petroleum and natural gas. Compared to the period of human civilization on the planet, there has been a quantum leap in the per-capita rate of the energy consumption in a very brief period of time following the turn of this century. The quantum of increase has been so enormous that during the past few decades, it has made an impact of threat to the very life on the planet. Thus, we have completed one circle and are thinking in terms of a shift back towards an increased dependence on the sunshine and other renewable forms of energy sources to abate the danger to our eco system.

At the same time, with more and more political systems shifting towards free economy, with trade barriers vanishing giving rise to more competition as against protection to economic activities and with compulsions of protecting the environment exerting a balancing force on the energy systems, not only the share of energy cost of gross domestic product (GDP) has become a key index to watch and control but also it has become essential to see that production and consumption of energy does not affect the environment. Towards such an energy management, barring the cost element, all aspects of environmental issues can be taken care of except containing the carbon dioxide for which no tangible practical solution exists today.

Figure 1 indicates the specific rate of carbon dioxide release per unit heat released from different energy sources and Figure 2 represents the specific rate of carbon dioxide release per unit of electricity generated through different modes. From these it can be seen that specific CO_2 rate is lowest when sources are used in the form in which they are available and the desirable source for hydrogen in order of preference is methane (natural gas), petroleum residue and coal. Gasification of coal is tenable only for power generation using combined cycle.

As no source of free hydrogen—the dream fuel—exists today and until harnessing fusion energy is commercially possible and/or large scale utilization of solar and aeolian energies are feasible, the known fossil resources need to be managed keeping the economics and the environment in view.

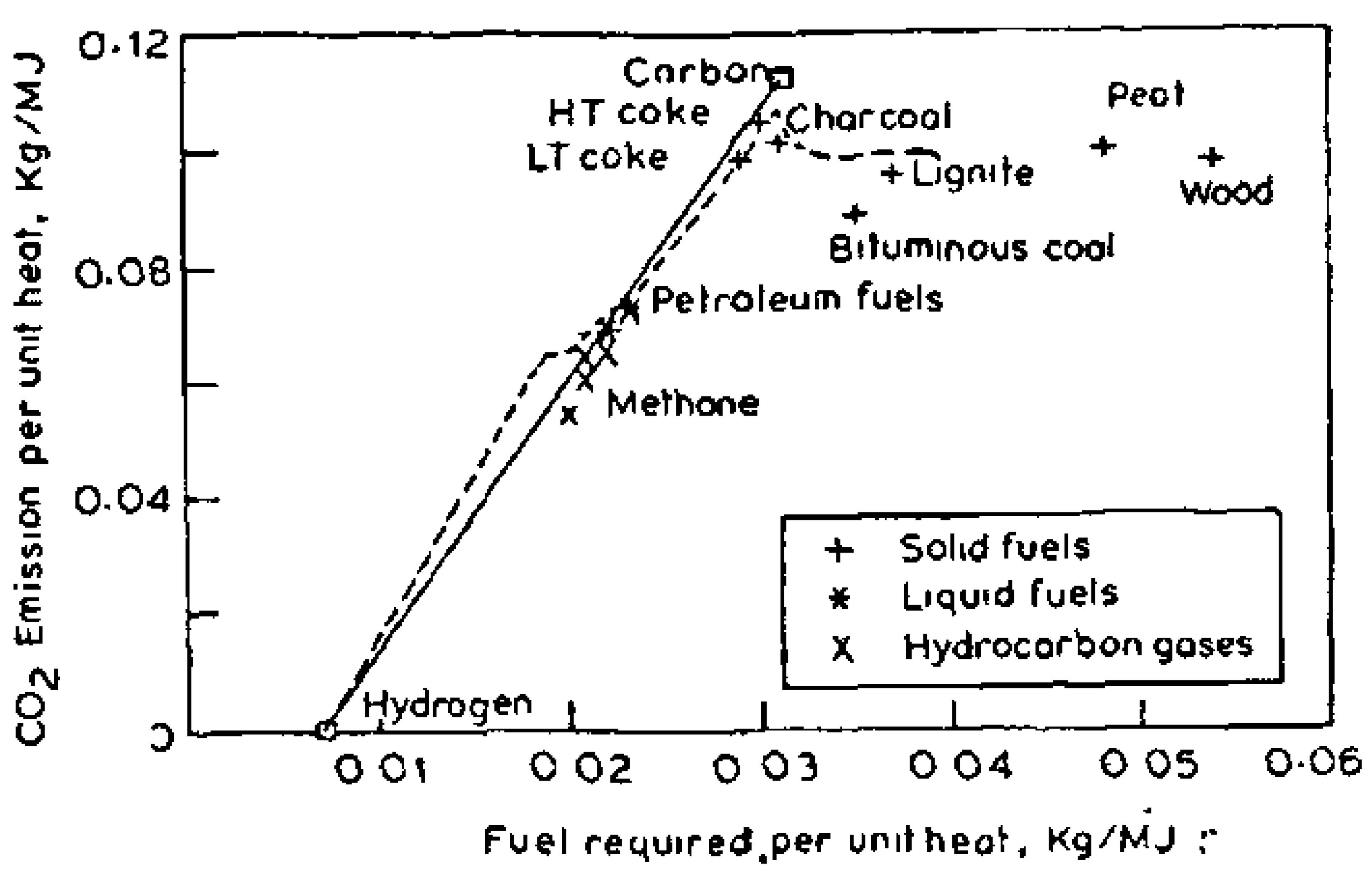

Figure 1. CO_2 emission from fossil fuels

Kotur S. Narasimhan is in the Central Fuel Research Institute, Dhanbad 828 108, India.

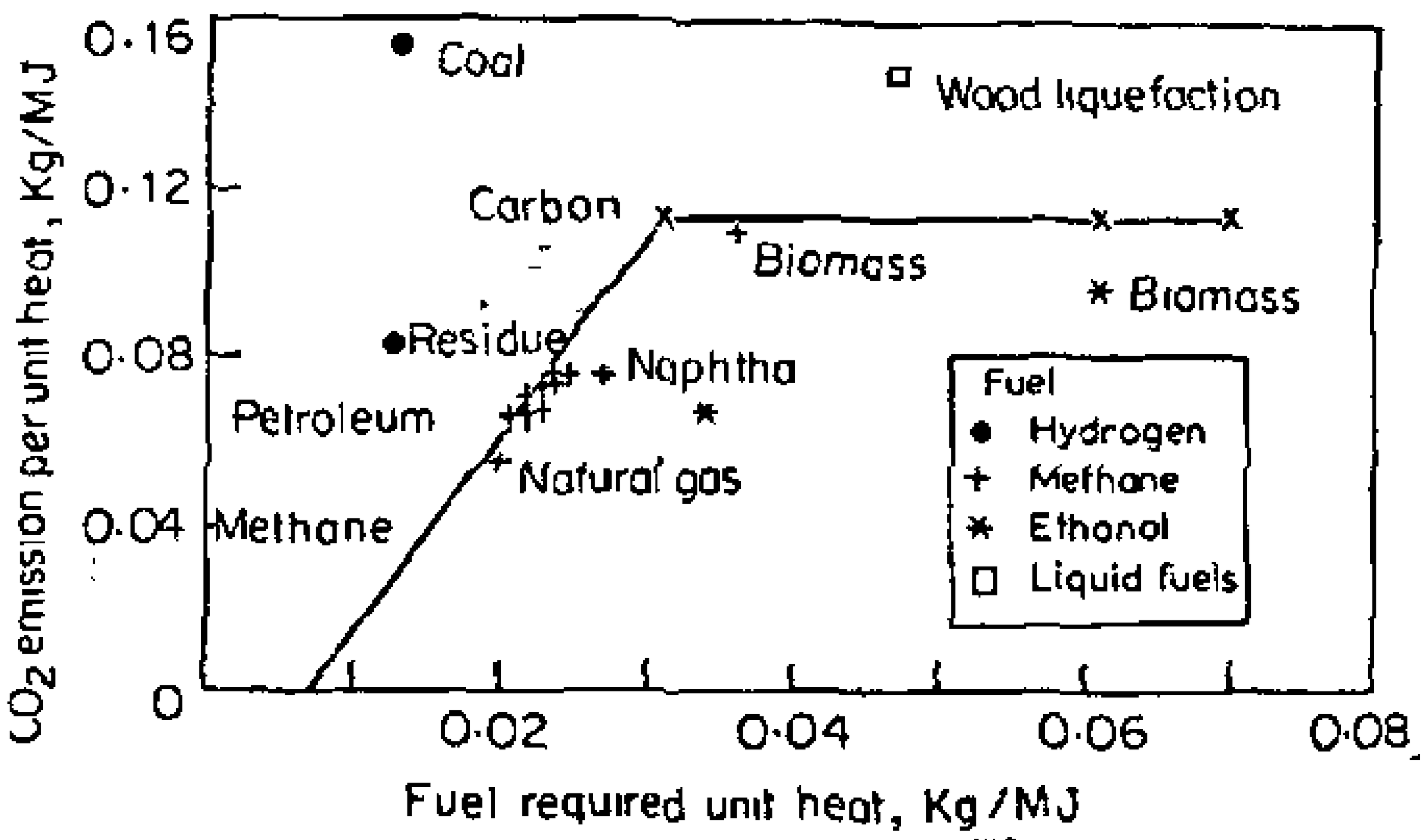

Figure 2. Net carbon dioxide emission through converted fuels

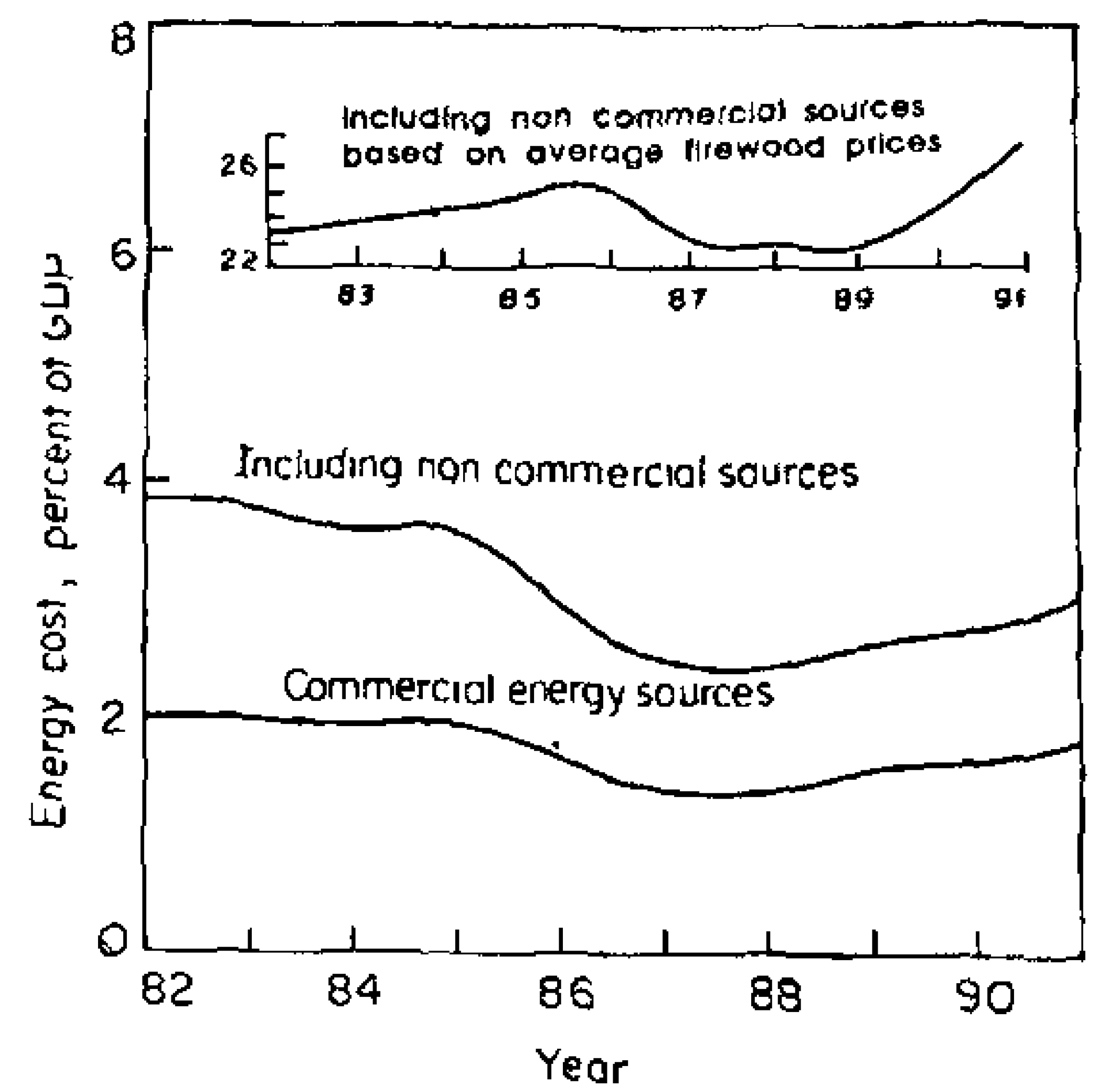

Figure 3. Energy cost related to GDP.

Energy scenario in India

India at the time of independence had more coal reserves and less oil and 350 million population depended on non-commercial sources (mostly firewood) for more than 60% of their energy needs. Even at that time without any significant steel production capacity, much of the prime coking coal is believed to have been indiscreetly consumed. During the past four and a half decades, by intense efforts of the Government through many agencies, additional sources of fossil fuels were discovered and as a result today we have an established 581 million tonnes of oil reserves to last 19 years, 841 billion cubic meter of natural gas to last 55 years and 160 billion tonnes of coal to last 300 years. However, the stock of the prime coking coal is feared to get exhausted during the next 30 years. Besides, sufficient nuclear fuel exists for exploitation depending upon the capital availability and safety acceptability.

Due to the implementation of the successive five year plans and progressive industrialization and growth in trade and commerce and agricultural production, there has been significant increase in the commercial sources of energy from 82.7 million tonne oil equivalent (mtoe) in 1951 to 291 mtoe in 1991. As a result the share of the non-commercial sources has reduced from 59% in 1951 to 41% in 1990. But, the absolute increase of consumption of non-commercial energy sources almost doubling from 61.2 mtoe to 119.31 mtoe is significant enough to be alarming as much of this is the cause for the dwindling of the forests.

With a significant proportion of energy coming from unorganized sector of non-commercial sources (mostly firewood), it is very difficult to assess how energy efficient the country is. Yet, an attempt has been made to evaluate the share of energy cost in GDP and its change with time. Figure 3 represents the variation of percent energy cost with GDP based on commercial sources only and also including all the sources. While the picture is comforting when commercial sources only are considered, the situation is not so to include non-commercial energy sources. The scenario is worst if the average prevailing prices of fire wood is taken to assess the cost (inset in figure 3). It is extremely difficult to really ascribe the cost of non-commercial energy the nation is paying for as it has to take care of the price of eroding forests. But the sum and substance is that the situation is worse enough to deserve serious consideration.

Figure 4 represents the energy pattern showing the consumption of commercial energy sources and their sector wise distribution. The dependence on imported crude and petroleum products is depicted in Figures 5 and 6. The petroleum products mainly include middle

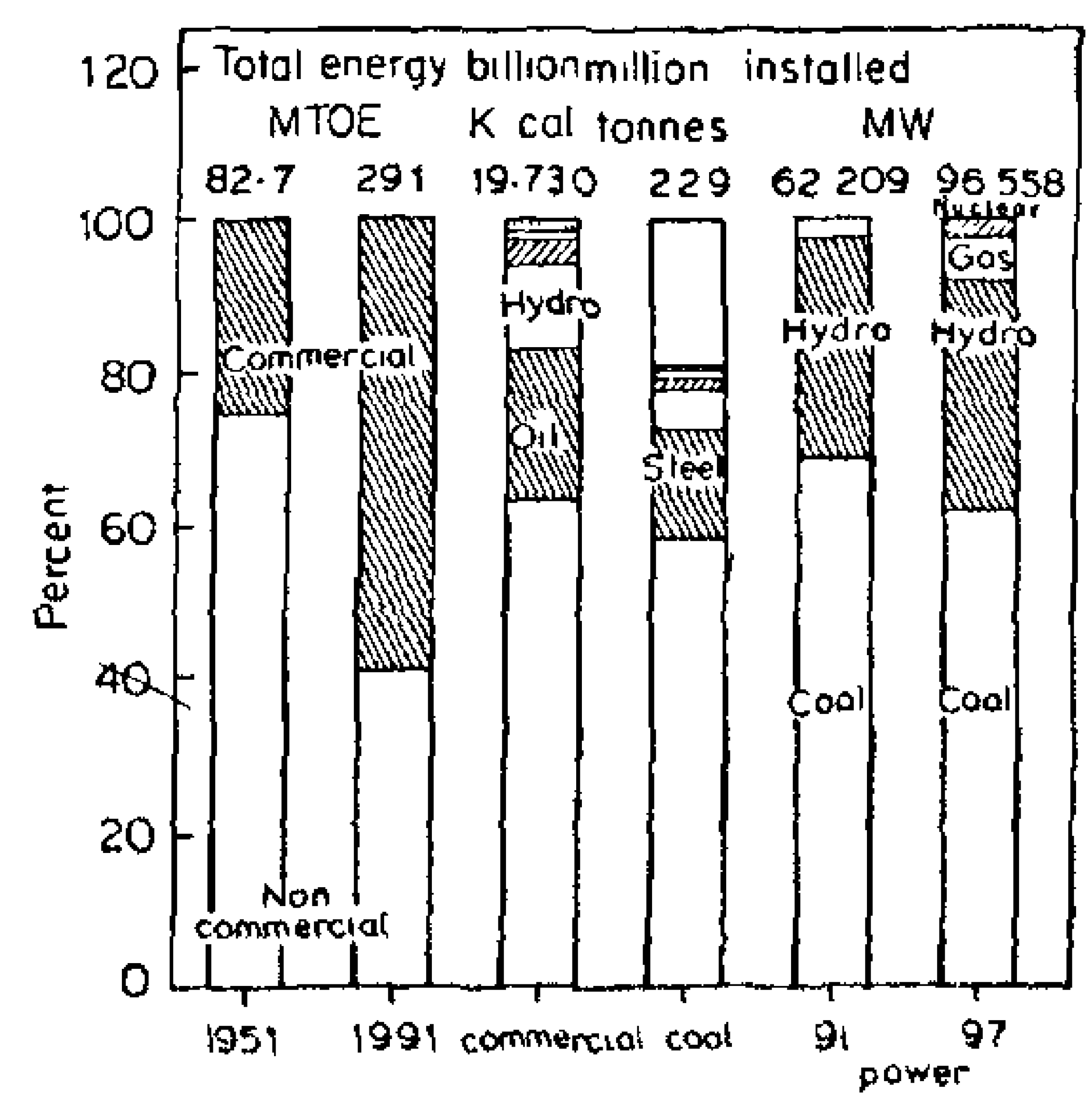

Figure 4. National energy pattern

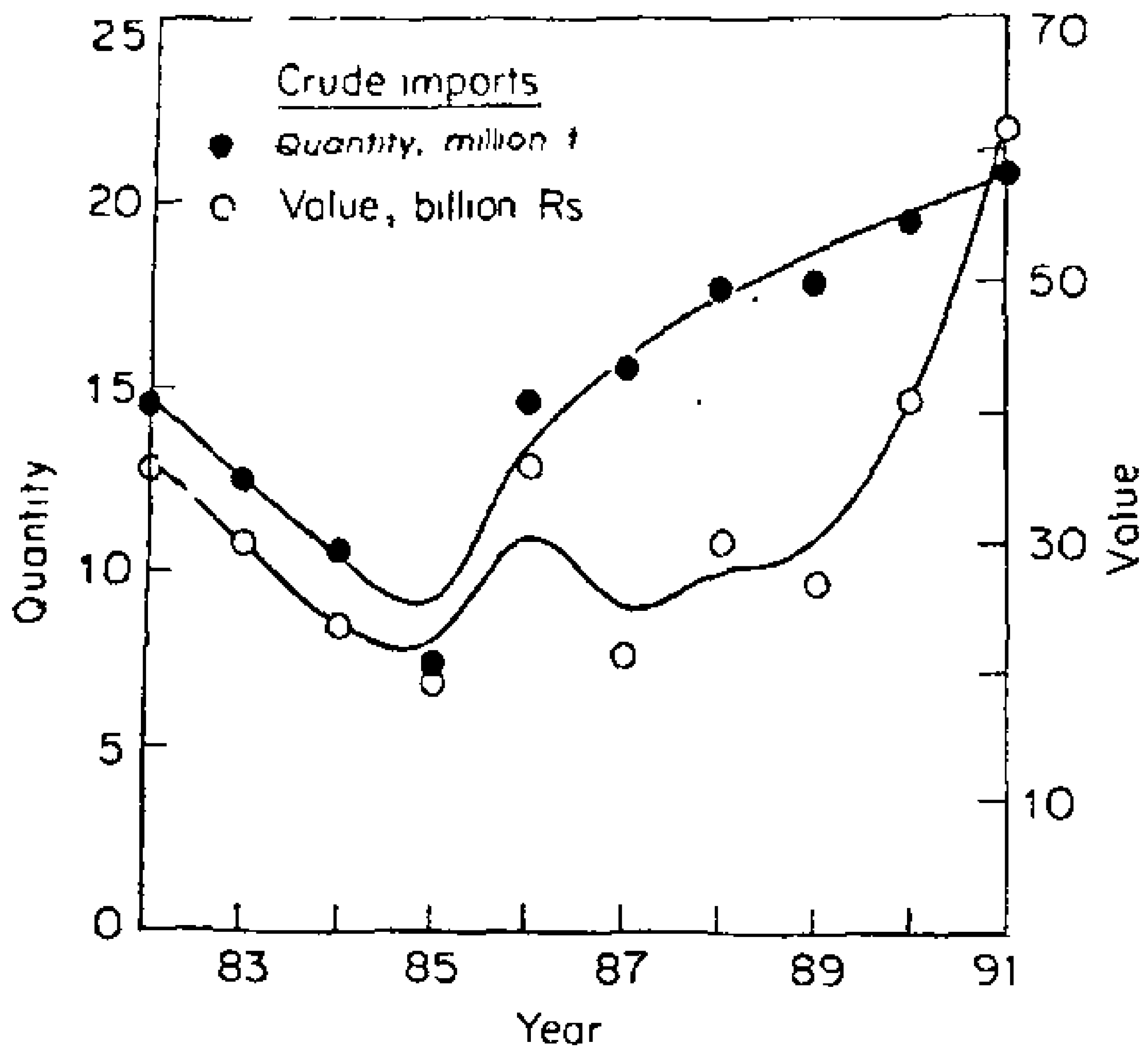

Figure 5. Import of petroleum products.

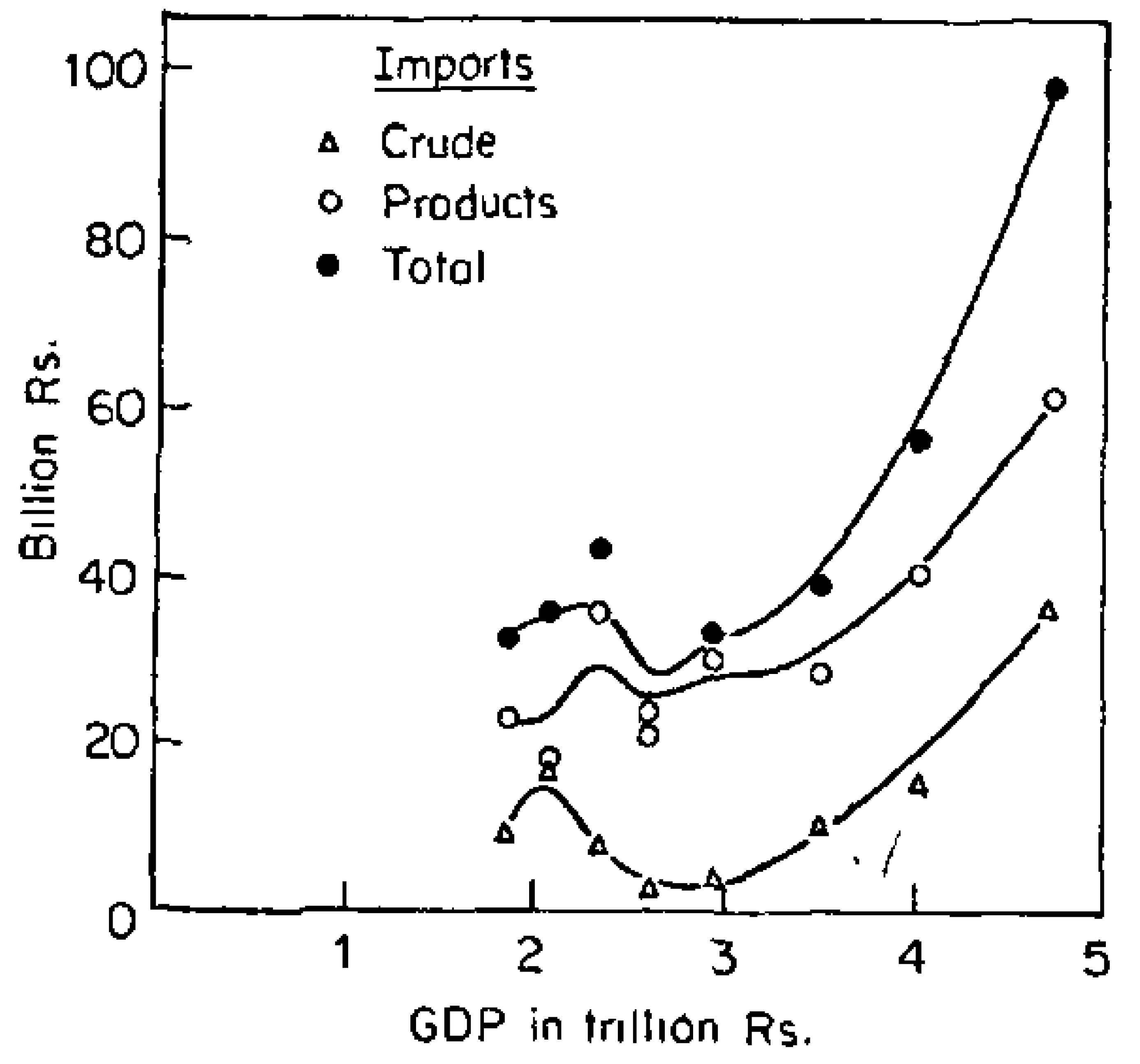

Figure 6. Value of oil imports.

distillates and some heavy ends. Besides the non-commercial sources, the cost of the petroleum and its products is the major contributor towards the expenditure. In fact, the trend and fluctuations of the energy costs are guided by the price of the petroleum products.

At present, the share of commercial sources of energy is 58% coal, 31% oil, 7% natural gas and 3% hydro power. Taken all sources together, the figures are 40% coal, 21% oil, 5% gas, 2% hydropower and the balance 30% is non-commercial sources.

The major share of coal is for thermal power generation accounting 58% of the total production. While the installed capacity for generation in the country is 44,000 MW, on the average only 50% of the potential is realized. Cost of the generated power by international standards is high as could be judged by the share of power costs to produce any commodity. The reasons are many. High ash in coal, cost of transportation, down time, low thermal efficiency and losses both technical and non-technical. These are reflected in Figures 7 and 8. Transport alone involves 8 trillion tonnes km of coal annually which contains 40% ash. Wastage in energy cost on account of this and grinding 65 million tonnes of ash every year would be phenomenal. Paradoxically, the grinding machines aim at grinding ash finer than coal.

The second largest share of coal is for steel-making. When integrated steel plants were planned in the country, 17.5% ash in coal for coke making was struck as a compromise. But over the years, supply of quality coal to steel plants has not been easy and low productivity and high cost of steel are among other things attributable to high ash in coal. Figure 9 (after MECON) presents the state of steel production with respect to the coke rate. At the same time, steel industry in order to be competitive internationally would move towards use of quality coal or coke even if it means import. Figure 10 gives the administered price of different forms of primary and secondary energy sources as well as the

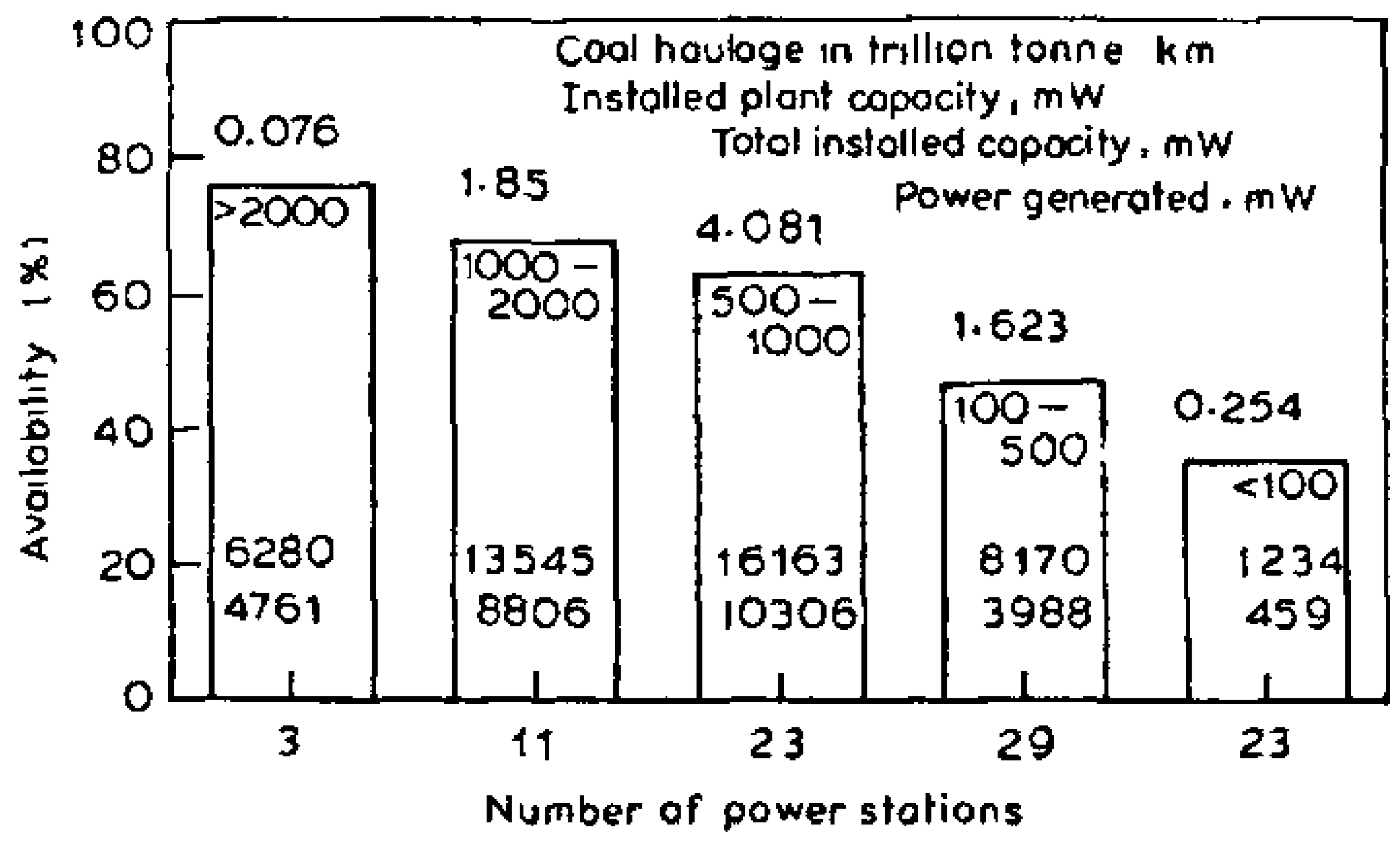

Figure 7. Availability of thermal power stations

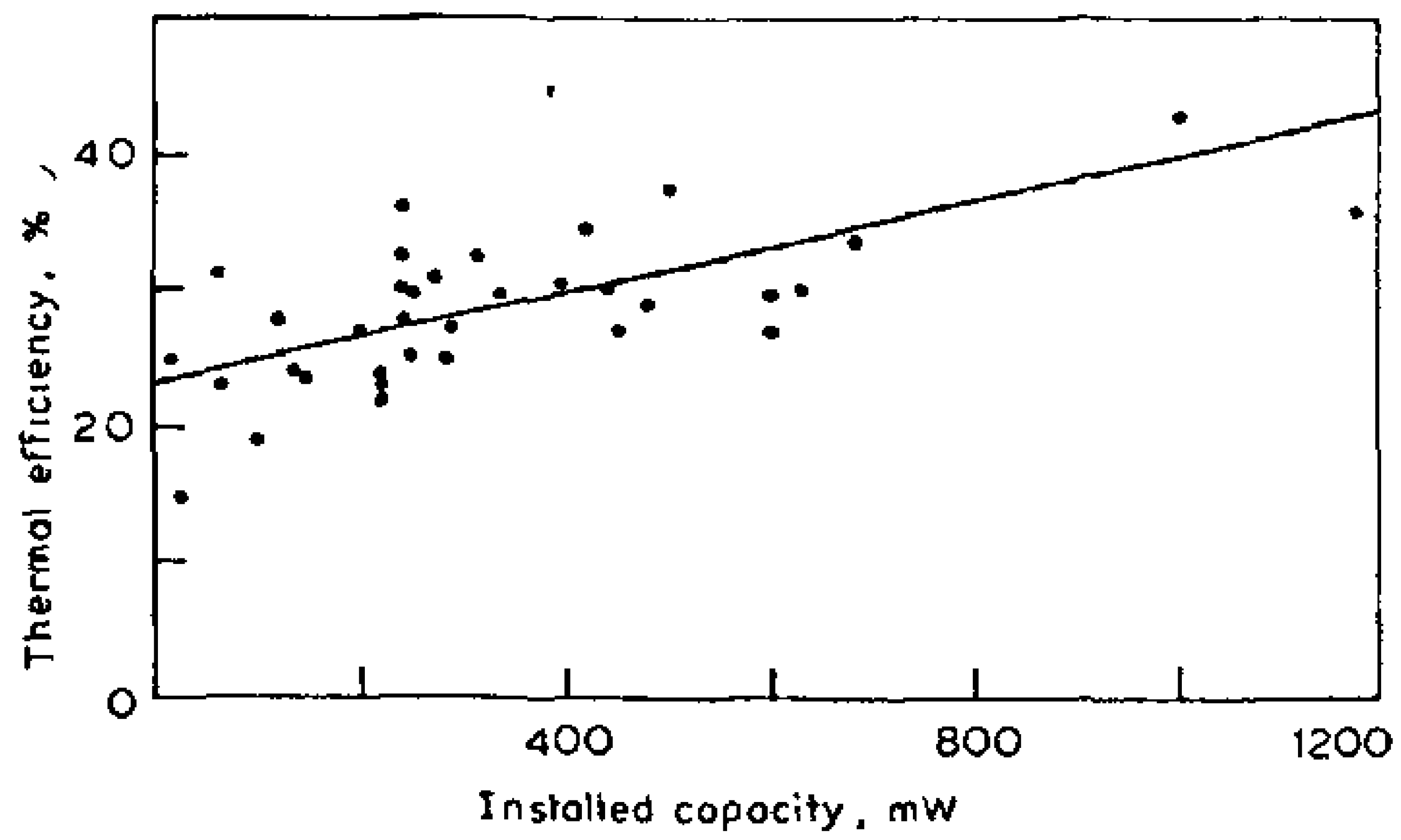

Figure 8. Thermal efficiency of power plants

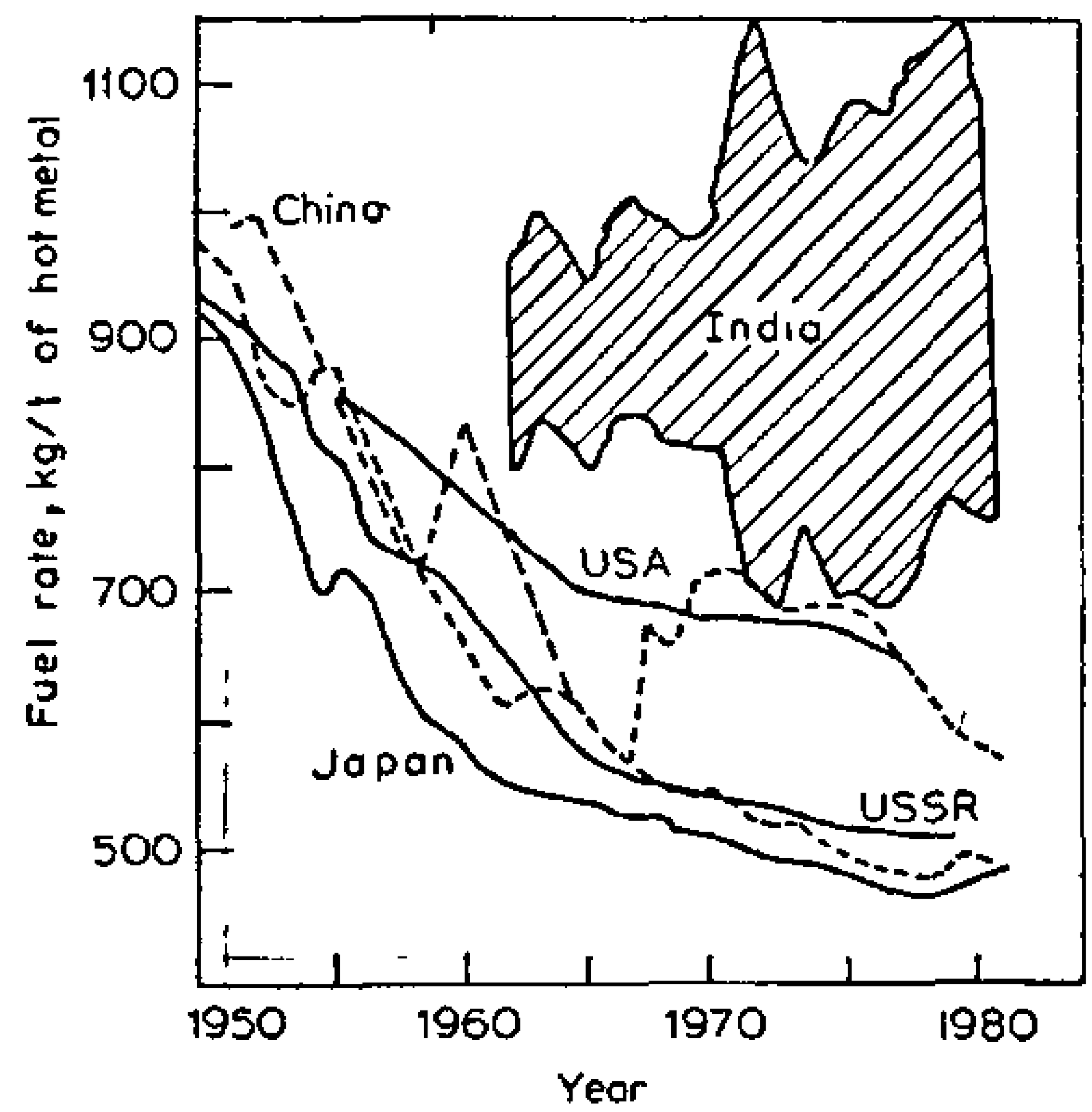

Figure 9. Fuel rate of blast furnances in India and other countries

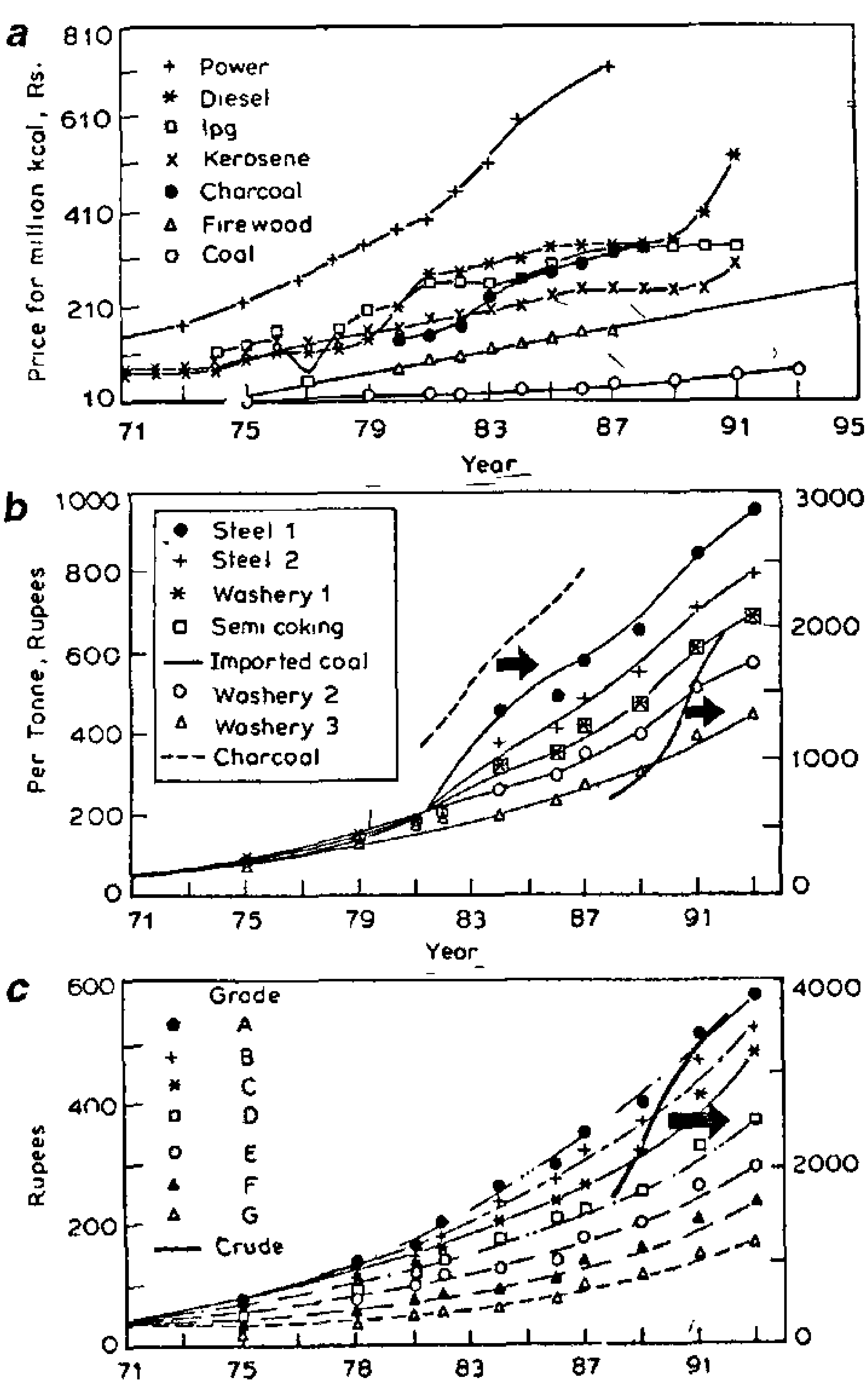

Figure 10. Administered price of power coal.

cost of imported crude and coal. In terms of unit heat, coal is still the cheapest of all the sources, electricity being the most expensive. Nearly 50% of the petroleum refined is to keep the transport sector moving, with greater share of the rest taken by kerosene and diesel.

Energy outlook for the future

From the point of view of the global energy management, it is imperative to keep the environment free from pollution, particularly of carbon dioxide besides oxides of sulphur and nitrogen. For this, it is necessary to be aware that:

- specific release of carbon dioxide per unit heat is least when fuels are used directly without any conversion;
- desirable source in order of priority for hydrogen generation is methane (natural gas), petroleum residue and coal,
- for power generation combined cycle integrated with gasification on the slurry-based technologies or pressurized fluid bed combustion to be preferred as also increasing the use of renewable forms of energy.

As far as the energy scenario in India is concerned priorities to reduce the share of energy costs as part of GDP (need not necessarily be in that order) are:

- drastic changeover from non-commercial energy sources—particularly firewood (cause for deforestation) to commercial energy sources for domestic consumption in rural areas;
- reduce dependence on petroleum products through the use of indigenous sources;
- improve the efficiency of power generation to realize much of the installed capacity and have a recourse to more efficient power generation cycles for the new plants;
- augment a better reductant for steel and other metallurgical purposes, and
- promote co-generation systems and improve the end use efficiency of energy, particularly electricity.

Some of these aspects have been dealt in Plan documents of the nation but specific programmes are wanting. Assuming that the present level of per capita consumption of 0.37 tonne oil equivalent (perhaps one of the lowest in the world) is the least to be provided for the estimated one billion population by 2000, and that the share of non-commercial energy use continues to decrease at the same rate as did in the past, the demand for commercial and non-commercial sources of energy would be around 250 mtoe and 120 mtoe respectively.

This would mean a generation and use of 300 million tonnes of coal, 80 million tonnes of crude oil, 40 million cu.m of natural gas at the least (Figure 11). If the standards, judged by the per capita consumption is to

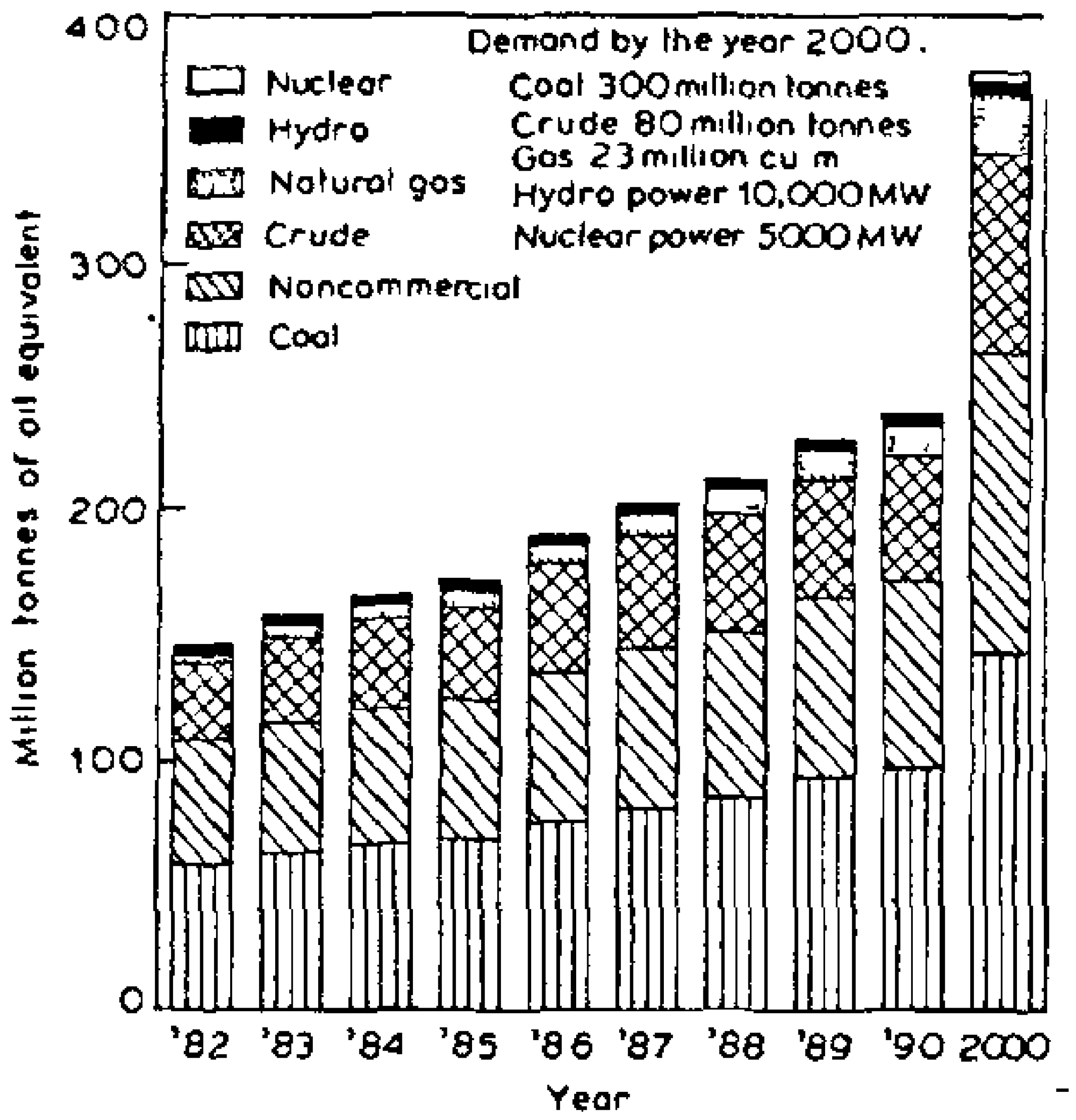

Figure 11. Energy demand by 2000.

improve, these projection would be higher. The Planning Commission, for the Eighth Plan, has projected a 311 million tonnes of coal requirement and 81 million tonnes of petroleum products by 1996–97. Presently, there is an outlay to increase the installed thermal power by 27,000 MW. Eighty per cent realization of such a capacity would require 160 million tonnes of coal which means for power sector alone (at the present performance of 50% of the existing installed capacity) at least 300 million tonnes of coal is required and taking the total coal requirement to near 500 million tonnes which is more than twice the current rate of production. Thus, there would be a tremendous pressure on coal production and utilization.

What possible strategies could be adopted to meet the challenges that the nation would face to:

- replace non-commercial fuel,
- reduce the dependence on the import of crude and petroleum products,
- improve the efficiency of power generation,
- augment better reductant for metallurgical use, and
- improve the end use efficiencies?

Replacement of non-commercial energy

This is perhaps the most difficult of all the tasks to see that a commercial energy source for domestic use reaches every nook and corner of the country. There have been many attempts ever since independence but the outcome is very nominal. Of the projects attempted to supply solid fuels and town gas, success has been limited to the supply of solid fuels resulting in projects at Neyveli, Singareni and Dankuni all together to process 0.3 million tonne per year coal. Its impact to meet the real rural needs perhaps is even less. To provide 120 mtoe in terms of domestic fuel, nearly 800 Neyveli Lignite projects would be necessary—placing a requirement of 60 to 80 million tonnes of solid fuel. Besides, adequate distribution system involving transport would again demand petroleum products and the price would accordingly go up.

Of equally nominal success is the popularization of biogas plants resulting in installation of 1.4 million family size plants, commercial viability of which remains to be established as the subsidies continue. The net result in spite of all these efforts has increased the dependence on kerosene and firewood by rural mass and LPG in urban areas. Kerosene substitute in rural areas could perhaps be one of the most satisfying solutions. Processing of heavy petroleum residue to increase the production of kerosene is a way out. Besides, the use of agricultural biomass needs to be given attention. Saving bagasse, which is already used for power generation in sugar mills, 150 million tonnes biomass is estimated to be available. Availability of agricultural biomass (Table 1) which would increase with time as the food production increases could be a potential source. Can the known technologies be improvized to get a kerosene substitute?

Substitute for petroleum products

Technically, conversion of coal to liquid fuels has been possible since the time of the Second World War and commercially is being produced in South Africa from coals, very similar to that found in India. But the option is being dispensed since at any given time it will not be economical considering the huge capital required. It should be a well thought-out policy decision that the Government should take either to import the technology as an investment for the future or go for an all-out effort to develop indigenously the required technology. Otherwise, the sub-critial half-hearted efforts that has gone practically for the past four decades is of no

Table 1. Availability of agriculture based biomass

Material	Million tonnes
Rice husk	37
Wheat straw	66
Maize cob	3
Bajra straw	11
Ragi straw	13
Millet straw	3
Bagasse	73
Groundnut shell	3
Cotton stalks	9
Jute sticks	2

practical impact.

Besides, there are other possibilities to marginally reduce dependence on some of the petroleum products like fuel oil/furnace oil through the use of some of the coals amenable to easy beneficiation and perhaps most of the lignites. Substantial portion of the 10 million tonnes of fuel oil being consumed can thus be conserved. One million tonne fuel oil thus conserved can save Rs 50 crores. Assam and Meghalaya coals and lignites of South and West can be gainfully utilized to serve the respective regions. To the extent demand on fuel oil can be eased, production of other petroleum products (particularly kerosene and diesel) can be to some extent increased without increasing the quantum of crude processing. Similarly, biogas that can be generated by urban waste particularly sewerage can be converted into diesel to meet some of the demand. Figure 12 represents such a possibility.

Improvements in the economics of thermal power generation

Coal accounts for 60% total commercial energy sources and 58% of which is used for power generation. To realize 50% of the installed 44,000 MW power, it requires 160 million tonnes of 40% ash containing coal involving transportation of over 8 trillion tonne km and grinding to fine sizes. Energy consumed in unnecessary grinding of the ash is nearly a billion kwh a year. Besides, the ash has many ill-effects both on the life of the plant and on the environment.

Paradoxically, by design implication, ash is ground finer than coal. Successive removal of ash by selective crushing and dry separation and/or subsequent grinding and beneficiation to burn the coal in slurry form should substantially improve the economics of the power generation. China has gone a long way towards such a proposition. Figure 13 represents the proposed change over. Such slurry-based technology can further be coupled with more efficient means of power generation through combined cycle involving gasification or pressurized fluid bed combustion.

Augment better reductant for metallurgical purposes

In the 1950s steel plants in the country were designed to use coal of 17.5% ash for coke-making as a compromise considering the quality of Indian coals. Progressively, it has become difficult to even maintain this level from 21 washeries of 37 million tonnes capacity processing 22 million tonnes of coal and in the recent years steel plants were forced to use partly imported coal. Gradually, imports of coal have increased to the present level of 6 million tonnes involving Rs 1200 crore worth foreign exchange annually. The Steel Authority of India (SAIL) has an ambitious programme of improving their performance of the steel plants by the year 2000 through the use of coal with 15% ash. Weighted average of ash in raw coking coal is 28% and practically a 30% yield is expected to obtain 15% ash product in the existing washery set-up. While there is a technical possibility to increase the yields by modifying the circuit to treat finer sizes, due to want of technology for efficient dewatering and also constrained by the problems of transportation of finer product, it would not be an easy proposition. Besides, SAIL is also not contemplating in terms of technologies like stamp-charging to accept finer sizes because of high

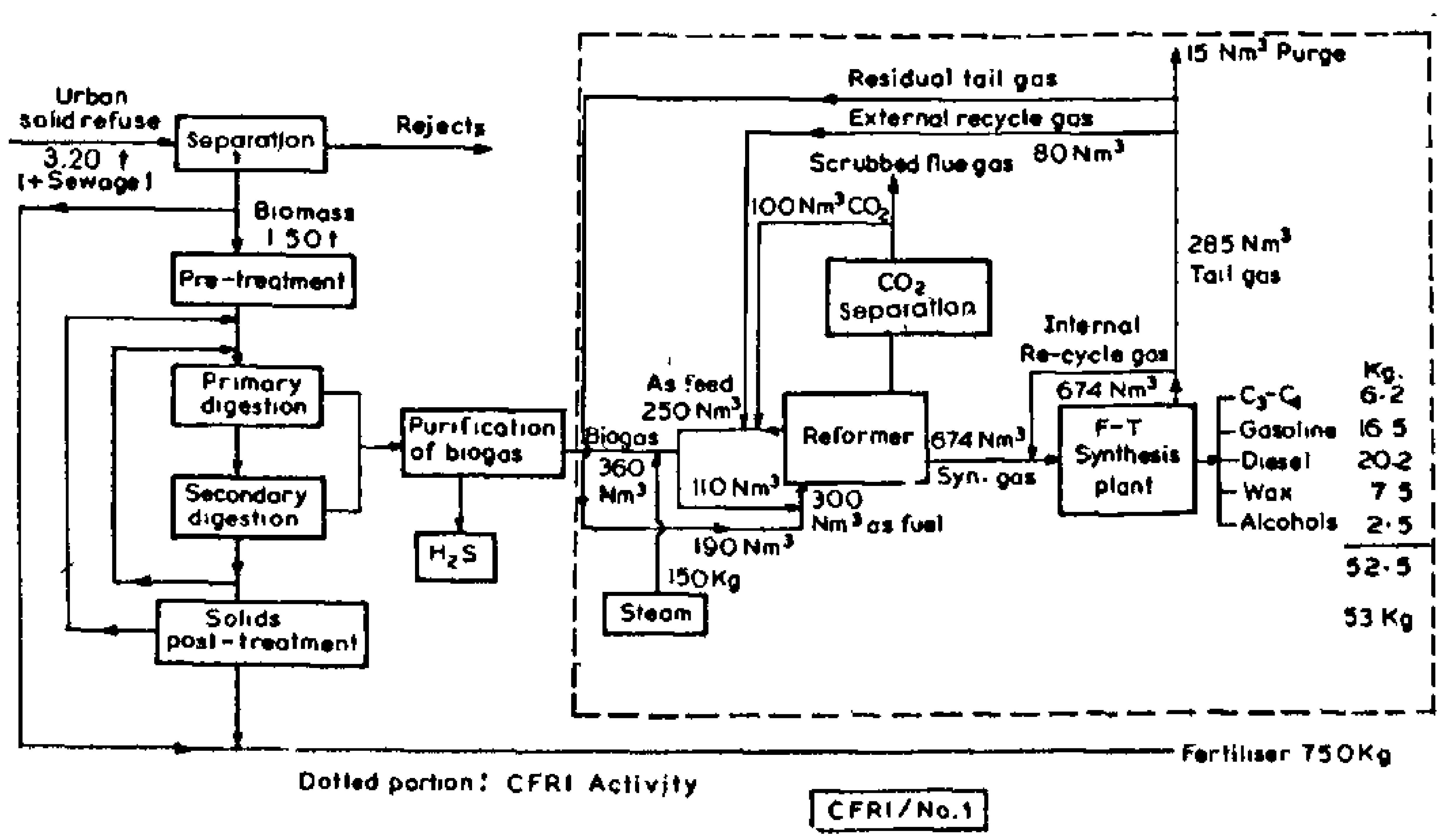

Figure 12. Block diagram for conversion urban solid refuse (USR) to city grade liquid fuels and chemicals. All units/day

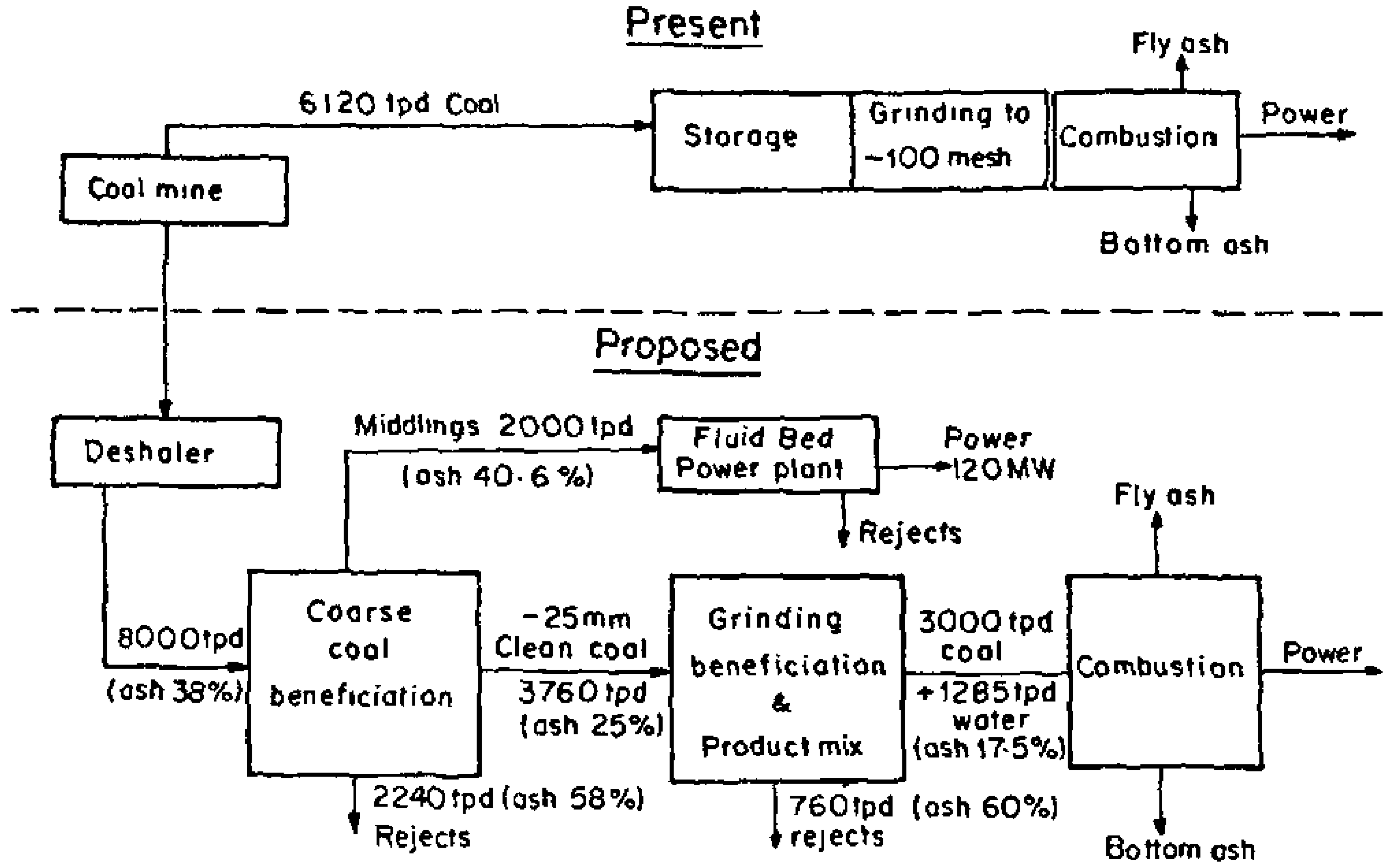

Figure 13. Impact of the proposed concept on A 470 MW plant.

capital needed for change over.

It would, therefore, be worthwhile to consider possibilities of operating multi-product washery to cater to:

– integrated steel plants,
– different grades for foundry, pig iron and ferro coke-making, and
– for fluid bed power generation captive to the unit towards optimal utilization of known reserves and available infrastructure and maximize overall economy.

There is another long-term need to step up or supplement the limited coking coal reserves and in this direction the significant contribution made by the Central Fuel Research Institute (CFRI), Dhanbad in proving the suitability of beneficiated LVMC coals being as good as imported coals is noteworthy. Commercial exploitation of this aspect depends on setting up of multiproduct washery for judicious utilization.

By such a concept, utilizing the full installed capacity of the existing washeries, it would still be possible to provide the committed quantum of coals to steel plant but of better quality.

Conclusion

To sum up, with the changed economic scenario, there would be an increased pressure on the nation to manage its energy resources efficiently. With the capital hard to comeby and demand, particularly for the petroleum products increasing against the dwindling domestic production, it becomes extremely important to realize the full potential of past investment and improve the end use efficiency through modern systems cogeneration etc. Abundant coal reserves, even though inferior (still cheapest per unit heat) and therefore less efficient, need to be extensively used. In specific, particular attention is needed for domestic energy needs specially in rural areas through conversion of bio-mass and agricultural wastes to substitute popularly required kerosene and urban waste to gas and liquid fuels.

Received 4 January 1994; accepted 11 January 1994