point of view

1000 MW Base Load Power Plant for Sri Lanka

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1. Introduction

1.1 Sri Lanka's electrical energy will be met mostly by her hydropower resources till about the year 1990. From here onwards due to the limited potential of this resource an alternative source of energy will have to be added to the power system. The paper discusses the multi-disciplinary civil engineering and water resources aspects of a thermal power plant fuelled with imported coal to produce the base load energy. The peak load requirements have been presented in Technical Paper 4 'The Peaking Power Requirements in the CEB's power system till the year 2000', Hydro Development Branch, CEB, June 1978.

2. Load Growth

2.1 In the context of the accelerated Mahaweli Programme, the Free Trade Zone and the increased industrial activity in the island, and also in view of diminishing oil supplies and the resulting high costs together with the changing over of oil operated machinery, transport and urban cooking to electricity, if the CEB's demand curve grows at 10.6% p.a. the total energy demand will be about 14000 Gwh units in 2000. Assuming hydropower development is in the range of 5000 Gwh by that time, the alternative energy requirement is (14000-5000) =9000 Gwh units.

2.2 However Preece Cardew & Rider, Electrical Consultants to the Victoria Project in their Feasibility Study on this project have assumed a probable initial rate of growth in 1980 at 10% pa falling to 7% p a by 2000, creating a total energy demand of 9000 Gwh units. In this case the alternative energy demand will be (9000-5000) = 4000 Gwh units.

2.3 The corresponding power plant installations, say working at 60% plant factor to produce 9000 and 4000 Gwh units by 2000 are 1700 MW and 760 MW respectively. For certainty it is not possible to forecast what the actual electricity demand will be 20 years hence. But the basic fact remains that an alternative source of power in the region of 1000 MW will have to be added to the system in 2000-2005.

2.4 Taiwan is a small island, half the size of Sri Lanka but with the same population. Despite the high national income and prosperity she enjoys, she had, for every one car in Sri Lanka 1/15 of a car in 1953 1/2 in 1968. This pattern of energy planning has contributed to a very high growth in electricity generation, resulting in an exceptionally high growth in overall national development.

2.5 From these statistics it is evident that Sri Lanka has a capacity for a high growth rate in electricity generation. So while planning for a 1000 MW power plant, it is advisable to leave provision for an extension of a further 1000 MW, to accomodate the same harbour facilities as will be pointed out later.

3. Coal or Nuclear

3.1 At the present level of power development in the international field and taking the oil crisis as well into account, to produce base load energy of the magnitude required in Sri Lanka in the 1990s, coal and nuclear are the only likely sources available. Advanced countries which hold a monopoly over nuclear technology have raised the cost of nuclear power from small power plants to be on a par with oil. Thus at today's costs the economical nuclear power plant is in the order of 1000 MW.

3.2 The shortage of an alternative source of energy starts in the late 1980s at say zero and will develop to 4000-9000 Gwh units in 2000-2005. This means the installation of a 1000 MW nuclear power plant is not feasible at the start. The development has to take place in stages in the order of say 250 MW at each stage. For such a development coal fired thermal is the only solution.

Another advantage of coal fired power over nuclear, is that peaking power requirements from another source is more in the case of the latter than in the former. The cost of the extra generating capacity for peaking power has to be added to nuclear when evaluating comparative costs.

4. Project Lead Time

4.1 Sri Lanka has no coal and thus a thermal power plant fuelled with imported coal has to be planned. Though a 1000 MW installation is required in the year 2000 or so, the first stage 250 MW will have to be commissioned in the late 1980s. Even in advanced countries for a power plant of 1000 MW fuelled with local coal, the lead time necessary for planning, design and construction activities is about 10 years. So in the case of Sri Lanka, a developing country where coal has to be imported, it is already rather late as the required lead time which will apply to her—possibly about 15 year has already been cut into, with no steps in this respect taken at all so far.

5. Project Siting and Arrangement

5.1 There are a number of factors which affect project siting and arrangement the more significant being fuel, fuel transport, cooling water and power transmission. Other factors of importance include land, sub-surface conditions affecting foundations and excavations, community infrastructure and transport of heavy leads. Then there are environmental aspects which have to be considered. Though these factors are intimately related, some of the planning aspects, have been touched on.

6. Coal—Source and Type

6.1 The design of the power plant has a very strong bearing on the type of coal. So the power station has to be tied upwith a particular coal mine. To change over from one type of coal to another, the power station has to go through major changes involving about 30% of the cost of the power plant.

6.2 In this respect, as Sri Lanka has no coal and it has to be imported, in the first instance she has to negotiate with countries like India, Australia, China with large coal reserves and sign an agreement for the supply of coal from a particular mine to the power plant in view, for a period of about 30 years, the life of the plant. This is an international agreement and it will take a fairly long time to weigh the pros and cons before a settlement can be reached.

6.3 In some instances a new mine has to be surveyed and planned. Opening a new mine to produce 10,000—30,000 tons of coal a day is in itself a vast problem. If they are open cut projects as found in Australia for brown coal, it occupies some thousands of acres.

7. Coal Transport

7.1 Next the transport facilities from the mine to the harbour in that country and from there to Sri Lanka have to be looked into. Coal required for a 1000 MW power plant is in the order of about 10,000 tons of coal per day of superior quality, enough to fill a freight train more than a mile long. In the case of brown coal found in certain parts of Australia, this requirement is about 30,000 tons per day. As the coal will be transported in ships, the best location for the power plant is by a harbour. The power plant can be located by an existing harbour or by a harbour which has to be constructed for this purpose. This will eliminate costly land transport and double handling.

8. Water Requirements

8.1 Water requirements can be segregated into low and high quality water. The major water requirements will be for low quality water and include make-up water in the condenser cooling system. A relatively small quantity of high quality water will be needed for boiler make-up and domestic uses in the project area.

8.2 Apart from eliminating the costly land transport of coal by incorporating the harbour and the power plant together, its vicinity to the sea solves the large cooling water requirements of thermal power generation. All large electricity generating stations, whether conventional (coal, oil, gas) or nuclear increase their efficiency by using large amounts of cooling water in the turbine steam condenser thus lowering the temperature of low grade heat rejection. The lower the temperature the higher the efficiency.

8.3 In many situations, this water is taken from a natural source such as the sea or a large river and simply returned after use. Where there is no natural source of water large enough to enable adoption of this once-through system, the water must be cooled and recycled. This is done by a cooling pond or by cooling towers.

8.4 So in Sri Lanka's case where coal has to be imported, siting the power station by the sea with harbour facilities will serve a dual purpose—eliminate costly land transport and also eliminate complicated problems involving cooling water requirements.

8.5 In addition to the above desired requirements for siting the power station, a perennial river or an underground water supply in the vicinity is also necessary for the supply of the required high quality water. Compared with the large requirement of low quality water, the high quality water requirement is small—about ½ a million gallons per day for a 1000 MW station.

9. Transmission

9.1 In the planning of a new power project it is necessary to consider its means of connection to the integrated transmission system, having regard to such factors as transmission voltage, length of transmission lines to convey power to the load centre, need for new easements, line losses, system stability and possible future development beyond the approved installation.

9.2 In the case of large bulk-energy transfer by adopting 400/500 KV transmission over distances of 100 miles range, considerable reduction in line losses and economic advantage can be achieved.

10. Land

10.1 While fuel, fuel transport, cooling water and transmission are generally the dominant factors affecting the siting of power projects, in selecting a particular location within a broadly defined area it is necessary to have regard to topography, ownership, existing development of the area and zoning of the land likely to be affected by the project.

10.2 In the case of a 1000 MW power complex fuelled by imported coal the area of affected land may be some thousand acres. Large areas are necessary for coal storage reserves to meet a few months supply in case of a break down in supply lines due to strikes, war and the like. Added to these, disposal grounds to receive wastes have to be provided.

11. Subsurface Conditions

11.1 Generally speaking, subsurface conditions have little influence on the siting of a power project bearing in mind that low-lying land with poor foundations does not generally meet technical requirements for good access and drainage.

11.2 A notable exception to this statement is hydro projects which entail civil engineering structures—dams, tunnels, underground or surface power stations,—the design and costs of which are greatly influenced by the geotechnical features of the site. Nuclear power plants also require good ground conditions to facilitate the construction of buried pressure vessels.

11.3 For many power projects the cost of the foundation represents only a few percent of the total project cost and the practice is to design the foundation systems to meet the plant requirements although wherever possible some re-arrangement may be recommended to make the best use of the available foundation conditions.

11.4 A great variety of foundation systems have been developed ranging from large reinforced concrete rafts or spread footings which are capable of supporting column loads of several thousand tons in the case of the huge coal boilers, to nests of piles designed to resist the uplift forces on transmission towers in the very poorest of ground conditions.

12. Community Infrastructure

12.1 The construction and operation of power projects requires a considerable workforce with a large element of highly skilled personnel. The labour force must be supported by adequate services—roads, railways, houses, shops, schools, technical schools, hospitals, libraries and the like—with appropriate opportunities for training and development if the workers are to be attracted and retained in the area.

13. Transport of Heavy Loads

13.1 The heaviest items of plant, namely transformers, generator stators and boiler drums for coal plants often weigh in the order of 200 to 300 tons. Road and/or rail systems have to cope with loads of this magnitude together with the tare of the transporters.

13.2 In arranging plant it is therefore necessary to balance the economic benefits deriving from say adopting heavier three —phase transformers rather than several lighter single-phase units against the cost of transporting the heavy loads to site, bearing in mind the necessity to upgrade facilities.

14. Plant Orientation for Thermal Plants

14.1 The general arrangement of a common turbine hall with boilers located along one side and transmission on the other is the usual layout. The physical sizes of large coal boilers as discussed in this paper requires that large areas be allocated for mills, bunkers, precipitators, heat exchange surfaces, fans and the necessary interconnecting ducts.

15. Environment

15.1 Environmental changes associated with power projects are not due to waste discharges arising from the operation of generating plants alone. For example in the case of power plants fuelled by coal from open cuts, large areas of land are affected by the open cuts, overburden dumps, power stations and ancillary works. Properties have to be purchased, people have to be moved, roads and other community service have to be altered, and new townships have to be developed in the vicinity of the works.

16. Discharges to Air

16.1 In order to protect the atmosphere, modern thermal power stations incorporate provisions such as electrostatic precipitator designed to trap most of the dust in the flue gases, and tall chimneys to ensure that flue gases rise high into the atmosphere and are diluted to harmless concentrations before returning to ground level.

16.2 In order to focus on specific areas of interest, it is convenient to list the steps in the process of evaluating the air quality effects of a proposed development. These are:

- (*a*) characterise the existing air quality and meteorology at the site;
- (*b*) calculate the contribution from the project;
- (*c*) superimpose the thus calculated contribution on to the background;
- (*d*) Compare air quality standards (and modify design if necessary);
- (*e*) Subsequently monitor to validate the above procedure.

In practice, carrying out each of the above steps throws up formidable difficulties.

16.3 First, sufficient data have not generally been accumulated to characterise the existing air quality and meteorology on a fully satisfactory basis.

16.4 In regard to the question of calculation of the concentration from a given project, the approach open to Sri Lanka is to use the methods pioneered and brought to an advanced stage of development by a highly experienced organisation in this field like the Central Electricity Generating Board in the United Kingdom, taking into due regard the meteorological situations, prevailing here and in the U.K.

17. Liquid Wastes

17.1 The predominant types of pollutants contained in liquid wastes from power projects are:

(*a*) dissolved solids, particularly in ash affluent;

(*b*) heat loading contained in discharges from cooling water systems in either marine or in land situations;

(*c*) suspended solids contained in, for example, run-off from open cuts, coal handling areas and overburden dumps.

17.2 Ash effluents are generally unacceptable for disposal to local streams and special provisions need to be made.

17.3 In order to minimise the heat loading in cooling water discharges from inland power stations, the practice has been adopted of installing cooling ponds or natural draught cooling towers. For the marine situation once through cooling water systems are generally used.

17.4 The control of suspended solid concentrations in liquid wastes is achieved by the provision of on-site settling ponds. Where considered appropriate, chemical treatment is utilised in addition to mechanical removal of these wastes.

17.5 Oil wastes are trapped in separation pits that are dimensioned according to the desired performance. The accumulated oil is removed by tankers off the site.

17.6 In the case of new developments the absence of a protection policy can lead to expensive and wasteful decisions. With the very long lead times required for development of designs for new power stations, it is necessary to make decisions on such matters as water usage, waste water treatment and disposal, years before the station becomes operational.

17.7 There are significant gaps in present knowledge of the effects that changes in the quality of water will produce, particularly with regard to modifications of the biota of streams and estuarine wasters.

18. Noise Emissions

18.1 The main sources of noise in an operating power station are all the items of rotating machinery and the items of plant where steam or air is allowed to be reduced in pressure suddenly. These include the turbo-generator, pumps, fans, blow down vessels, and circuit breakers. The noise emanating from this equipment can be continuous or intermitant and adequate precautious must be taken to attenuate the noise to an acceptable level.

19. Suitable Sites for the Power Plant

19.1 Following the main guide lines regarding installing a large power plant fuelled by imported coal as pointed out above, a suitable site for such a plant is in the vicinity of the harbour at Trincomalee. Here a large natural harbour lies idle. Vast unbuilt-up areas of laterite soils suitable to receive heavy loadings between 20—60 ft. contour are available.

19.2 Trincomalee is some distance away from the load centre—Colombo area. But here new harbour facilities will have to be built and suitable unbuilt-up areas are not available. Pollution in the metropolitan area will be an added problem. In this case power transmission has to be weighed against the provision of new harbour facilities and the acquisition of vast areas of built up land required for the project.

19.3 Trincomalee is suitable for further power plant extensions say for another 1000 MW as the need arises.

19.4 There could also be suitable sites for this power plant on the Western and Southern Coasts of the island which are closer to the load centres.

20. New Load Centres

20.1 With the implementation of the Mahaweli Project there will be a shift of population towards the north central and eastern parts of the country. Along with this trend rural development will take place in these areas. If properly planned, large industrial loads as well can be introduced in these areas.

20.2 The economy of the country mostly depends on the agricultural rural population. It is nothing but right that these people are granted some of the benefits of electricity. In the present set up the urban population which contributes relatively little to the real economy of the country enjoys most of the benefits of energy—inessential air conditioning flood lighting and the like.

21. Energy for Cooking

21.1 By the year 2000 the population is expected to be about 20 million. This large population in this a small island will need energy to cook their meals. Already our forest reserves are being depleted on a large scale to grow food and if our forests continue to be cut down to meet the firewood requirements of the increase in population, the forest cover is bound to reach a dangerously low level so as to make the country barren. If energy is not provided to meet at least some fraction of the cooking requirements of the population, trees will continue to be felled at an undesirable rate.

21.2 Diminishing supplies of oil and the resulting high price of kerosene will aggrevate this situation. Already the subsidy on oil has reached Rs. 700 million.

21.3 During recent times there were two, tree planting campaigns and though these were sponsored at the highest level they have to all practical purposes been complete failures.

21.4 Now Sri Lanka is importing timber for building purposes as our timber supplies are inadequate.

21.5 Already the accelerated depletion of woodlands throughout Africa Asia and Latin America is undermining the productivity of the land itself. Soil erosion, increasingly severe flooding, expanding deserts and declining soil fertility are all too common.

As an Indian official has put it "Even if we somehow grow enough food for our people in the year 2000, how in the world will they cook it."

21.6 Moreover in urban living in restricted apartments and the like, firewood cooking in the absence of kerosene, cannot be tolerated.

22. International Trends

It may be argued that the problems involved in this project are too cumbersome and will be too costly. Undoubtedly energy in the future will be by no means cheap. Nuclear the other source of power which can be thought of, has its own multiple problems. Many countries have evaluated the economics of nuclear and coal fired power plants and have found the latter to be more economical and preferred even where coal has to be imported.

—In Japan Matsushime power plant—1000 MW now under construction has been planned to be fuelled with imported coal.

—In the long range power development programme of the Taiwan Power Company no nuclear power plant will be added to its power system after 1984 while there is a vast coal fired thermal power development in the programme.

—An advanced country like Australia has this to say:

"A nuclear project would involve techniques new to Australia however well established overseas, and in the short term at least, its would mean that Victoria base load energy supplies would be dependant on overseas services.

From the above analysis the introduction of a nuclear power project in Victoria at this time has been rejected. (Loy Yang Project Report 1976, State Electricity Commission of Victoria)

—China is seeking Western expertise to expand her coal mining on a large scale.

—President Carter's National Energy Plan is to boost coal output to 1.2 billion tons a year by 1985—an unprecedent increase of almost 75% over the 685 million tons mined last year. By 1985 nuclear is planned to be only 20% of the coal energy (Time April 17, 1978)

23. Conclusion

23.1 The problems involved in siting and planning a 1000 MW power plant are very complex indeed. It is not a matter for one or two individuals to deal with. It is only a firm of consultants well experienced in this specialised field which could prepare a worthwhile feasibility report on this project taking into account all multi disciplinary and long term aspects into account.

23.2 While planning for a 1000 MW power plant it will be prudent to leave provision for an extension of a further 1000 MW in order to make use of the same harbour facilities. Trincomalee is suitable for such an extension of the power plant.

23.3 If a 1000 MW plant works at about 80% capacity factor the total coal requirement during a period of 30 years will range from about 100 million to 250 million tonnes depending on the grade of coal. In a case like this a new mine has to be explored, developed and kept reserved for this plant for a period or 30 years or more.

23.4 The power station has to be sited simultaneously with harbour facilities and transmission factors taken into account. The first set will have to be commissioned by about 1988-1990.

23.5 The development of the mine, the construction of the harbour, railways if necessary, and that of the power plant will take a minimum 5 years. That means the construction will have to start in 1983-85. Thus we are left with only 4 - 5 years to negotiate long term international agreements, plan, design, seek finance, prepare contract documents, call for bids and start construction.

23.6 To delay a project implementation after advanced planning does not do any harm. On the other hand attempts to accelerate project implementation with no proper plans will lead to much waste both in construction and in long term economics.

23.7 In this case we are already, badly running short of time to get this scheme ready in 1988 - 1990. If Sri Lanka is to avoid severe energy shortages which are certain to upset her economic development and her plans to overcome poverty and growing unemployment, immediate action in this matter should be taken.

23.8 It is not permissible for a power industry responsible for the economy of a nation to wait for a breakthrough of an alternative source of energy to obtain less expensive power. Planning for future power growth has to be made with whatever technology is available at present.