ELECTRICITY PROBLEMS
Power Planning based on Economic Considerations

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1. Introduction

Sri Lanka is confronting an electricity shortage, evidently threatening the growth expectation of the economy. The country has been experiencing power shedding during several years in the recent past. There exits a vast diversity of views among professionals, business community, general public, and politicians on the causes behind this problem and the solution paths. Lack, inadequacies or deficiencies of planning are among the widely and frequently cited reasons. The power shortage and the resultant load shedding programme are said to reflect however, a complex mixture of political, managerial, and technical reasons which have been compounded by natural factors. It would be extremely important therefore to correctly identify the real causes behind the problem, because without identifying the real causes, realistic solutions cannot be attempted.

This paper accordingly has twofold objectives; to investigate whether the planning in the power sector has been deficient, erroneous or defective, and to depict the problem and remedies. In order to achieve these objectives, this paper attempts to -

- Examine the short term, medium term and long term scenario of the electricity supply and demand,
- Articulate the methodology used in the country for power sector planning,
- Evaluate the past plans and forecasts against real situations,
- Assess whether any divergence from plans have had any significant impacts on electricity supply,
- Identify causes for such divergence,
- Percieve future risks, and
- Propose remedies.

Table 1:
Approximate Capacity of the Power System in Sri Lanka in January 2002

	Nominal Installed capacity (MW)	Effective capacity (MW)
CEB Hydro	*1147*	*904*
CEB Thermal	*507*	*166*
Independent (private) Power Producers	137	123
Total	*1791*	*1193*

Source : Long-term Generation Expansion Plan 2002-2016 and other sources of CEB

2. Present state (January 2002) of Electricity Supply and Demand

Power demand in the country is growing rapidly, and is predicted by the Ceylon Electricity Board (CEB) taking GNP, population and other factors into account. Annual predicted demand increase works out to approximately 8% per year.

The grid connected power generating system of Sri Lanka in January 2002 had a gross installed capacity of 1791 MW, but the effective capacity is only about 1200 MW. The Ceylon Electricity Board (CEB) currently owns the majority of generating capacities of the country consisting of nominal hydro capacity of 1147 MW and a thermal capacity of 507 MW. **Table 1**: Approximate Capacity of the Power System in Sri Lanka shows the installed and effective capacities of the Sri Lanka power system including power generation capacity of the private producers.

3. Methodology used by the CEB for power sector planning

3.1 Planning Cycle
3.1.1 Demand

The annual power planning cycle begins with load (demand) forecasts. In power sector planning exercises, economic growth and development are explicitly recognized as fundamental prerequisites for achieving an increase in living standards and equity. Accordingly, assumptions about economic growth and development are considered as important determinants of electricity demand. It would be important to elaborate on two uses of the word 'demand' in its application to electricity, as the 'difficulty in meeting the electricity demand' is central to the issue addressed in this paper. They are (i) the peak power demand during day [Kilowatts (KW) or Megawatts (MW) and (ii) the time integration of such power demand (area under the curve) is termed energy (Kilowatt hours (kWh) or Mega Watt hours (MWh). ***Figure 1:** Daily Load Curve* illustrates the electricity consumption pattern in a typical day in 2000 in Sri Lanka with the sharp evening peak, and ***Figure 2:*** Electricity demand forecasted 1994 compared with realization in 2001 (Source: CEB) shows the peak demand (base case) forecast of the Ceylon Electricity Board (CEB) carried out in 1994, which predicted that the peak load would be 1428 MW in 2001 (the base case). In actual terms, the peak demand behaved around 1445 MW in 2001.

3.1.2 Supply : Plan for new generating plant additions

3.1.2.1 Cost to CEB vs Cost to Economy

CEB is mandated to provide an adequate supply of electricity in the most reliable manner at the cheapest cost to the economy. The CEB Act No.17 of 1969 states "It shall be the duty of the Board to develop and maintain an efficient coordinated and **economical** system of electricity supply for the whole of Ceylon (Sri Lanka) ......"

The Power System Expansion planning in Sri Lanka has been by the CEB based on the principle of delivering an anticipated need (forecast demand) for electrical energy at "least cost" to economy, **but not at the least financial cost to the CEB.**

Thousands of possible power plant installation sequences consisting of different thermal and hydro plants coming up in a time frame of over 15 years are analysed for this purpose. The least cost **sequence** of power plants is there after chosen.

This has made it necessary to use sophisticated capacity expansion optimization tools. The main planning tool in the development and analysis of optional generation plans is the Wien Automatic System Planning Package (WASP 111+) developed by the International Atomic Agency and extensively used in many developed and developing countries worldwide. The objective function of WASP is to minimize the present

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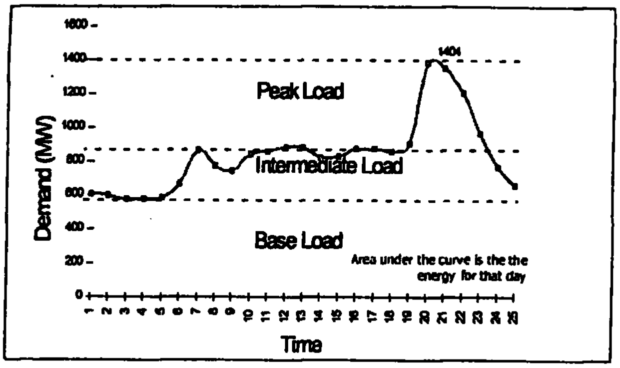
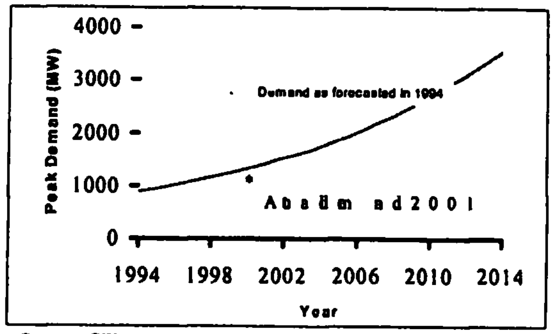
Figure 1: Daily Load Curve



Source : CEB

Figure 2: Electricity demand forecasted 1994 compared with realization in 2001



Source : CEB

value of power system expansion costs over some planning horizon subject some given levels of user defined constraints such as the system reliability. The optimum generation mix to meet the demand for power and energy in a particular study period is evaluated using programming techniques for comparing the costs of alternative system expansion policies. In simple terms, it attempts to minimise the cost of investment, operation and maintenance and the cost to the economy of power cuts (cost of energy unserved). The cost of energy unserved (power cuts) to the economy of the country is generally taken to be in the order of ten times the sale price of electricity. This heavy penalty on unserved energy reinforces in the model to plan for near zero power cuts.

In order to meet the forecast demand, the planners have to formulate the most economic sequence of plants (Diesel, steam, hydro etc.) to be commissioned serially in the future years. Each possible sequence of power units added to the system is evaluated in the planning exercise by an expected cost function comprising capital investment costs, salvage value of investment costs, fuel costs, non-fuel operation and maintenance costs, and cost of the energy not served. The plant sequence with the minimum cost is interpreted as the optimal expansion plan. It should be reemphasized here that what is minimized here is the expected cost, including those of the plants already running. Expectation comes mainly because one does not know the rainfall with certainty. Therefore, only an expected cost in probabilistic terms is possible, even though the demand is taken as determininstic.

Figure 3: Least Cost Planning

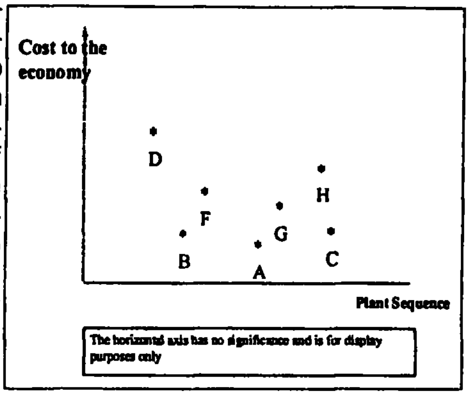


Figure 3 hypothetically represents the concept of least cost planning. Sequence A (which represents a whole sequence of power plant additions at different times) has the least cost and is recommended from a planning perspective. However, sequences B and C are also near optimal solutions and if preferred on social, political, or environmental grounds which have not been quantified, such a sequence may be chosen based on judgement. The present power sector planning methodology therefore, provides the policy makers with set of near optimal options, but not only one single optimum solution.

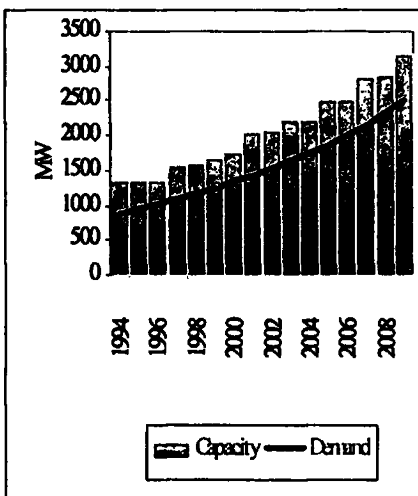
4. How good were the plans and their implementation?

For the purpose of this paper, the actual performance of the power sector in the recent past would be evaluated against the following categories of possible reasons which could be considered have been attributable to the present crisis.

The plant sequence drawn up in 1994 by the power sector planners is given in **Figure 4**: Generation Capacity Additions – Plan 1994. The demand projected here for 2002 was in fact realized by 2002 but the shortages occurred due to delayed or non implementation of the planned generating plants.

A peak demand of approximately 1500 MW is realized in year 2002. According to the CEB estimates in 1994, the country's electricity demand, the medium scenario, in the year 2002 was predicted to be 1525 MW which is very close to what is realized. However, plant commissioning was advocated to meet even the high scenario, *i.e.* 1759 MW by 2002. In order to meet this demand, plans had been drawn up to add 738 MW to the system increasing the total installed capacity upto 1862 MW (**Table 2 : Plan** Proposed in 1994 – for the Period 1995 – 2009). However, it was possible to add only 312 MW to the system during the period which increased the effective capacity to the level of 1436 MW, which reflects a much lower supply level than both forecast and actual demand. It is very clearly noticeable that non implementation of the proposed Upper Kotmale hydro power plant and the Coal fired thermal plant and the delayed implementation of the Kukule hydro power plant. Further, the 110 MW combined cycle plant was not fully operational at the beginning of 2002, which limited the actually realized capacity to 1326 MW, thereby resulting in an obvious and significant power system capacity

Figure 4: Generation Capacity Additions – Plan 1994



Year	Hydro additions	Thermal additions
1997		Gas turbine 66 MW
		Diesel 170 MW
1998		Gas turbine 22 MW
1999		Combined cycle 68 MW
2000	Kukule 70 MW	
2001	Upper Kotmale 150 MW	Coal (Trinco) 150 MW
2002		Gas turbine 22 MW
2003		Coal (Trinco) 150 MW
		Refurbished GT 60 MW
2004		Refurbished GT 60 MW
2005		Coal (Trinco) 300 MW
2007		Coal (Trinco) 300 MW
2008	Gin Ganga 49 MW	
2009		Coal (Trinco) 300 MW

Source: Long-term Generation Expansion Plan: 1994 – 2009, CEB

Table 2 : Plan Proposed in 1994 – for the Period 1995 – 2009

PLAN PROPOSED IN 1994 – FOR THE PERIOD 1995 - 2009

Plants to be installed by 2002 as per plan		*Actual 2002*
Gas Turbine	110 MW	0 (out of order)
Diesel	190 MW	Diesel: 212 MW
Combined cycle	68 MW	110 MW(JBIC GT Part)
Kukule Hydro	70 MW	0
Upper Kotmale hydro	150 MW	0
Coal	150 MW	0
	738 MW	312 MW
Effective capacity available in 1994 = 1000 MW		
Capacity if plan realised = 1000 MW + 738 MW =1738 MW		Capacity actually realised = 1000 MW+312 MW = 1312 MW

Low demand	= 1441 MW
Base case	*= 1525 MW*
High demand	= 1759 MW
Actual demand 2001	= 1445 MW
Shortage of Power 2001	= 133 MW
Expected Shortage of Power 2002	= 213 MW

shortage This plainly suggests that the power shortage has its origins in implementation issues but not in defective planning.

The Long Term Generation Plan is formulated in the form of a rolling plan, in order to off-set the impacts of the deviations from the planned path due to delays and inactivity etc on the power supply expectations, the plan is reformulated from annually. The implementational deviations and delays indicated in **Table 2** have lead to generation plant shortages and introduction of more expensive plants which could be commissioned quickly but at a cost..

Further, the power system was unable to (i) meet the demand in a dry year (ii) to allow for outage of the largest generator and, (iii) allow for typical forced (unexpected) outages of other generators, which have been provided for in the planning exercises.
Specifically, the supply capacity of the power system was severely limited mainly owing to the following reasons:

(i) Delay of commencement of construction of the two combined cycle power plants (165 MW + 163 MW) planned to be installed at Kelanitissa,
(ii) Delay of timely completion and commencement of Kukule hydro power project
(iii) Prolonged delay in implementing Upper Kotmale Hydro power project
(iv) Continued controversy on implementation of a coal power plant
(v) Below average rain fall due to four consecutive failures of north east monsoons
(vi) Due to the large number of un-metered electricity supplies (approx. 350,000), electricity losses appear to have increased.
(vii) Total estimated losses between generation and billed sales increased to an approximate level of 23% of gross generation, which is excessive.

These have acted as very significant and immediate contributory factors to the power problem which has been experienced by the country since year 2000. Consequently, the CEB was compelled to purchase emergency power, despite its inconformity with the least cost planning concept, and at a heavy cost to the CEB, environment and the economy.

5. Future challenges and issues

Forecasts carried out by the CEB indicate that the peak load demand rises at an approximate annual rate of 8% which amounts to an incremental generating capacity of about 120 MW to be annually added to the system presently. This additional requirements (some of which are not in the plan but introduced to avoid power cuts due to delays in implementation of the plan) are presently planned to be achieved as follows:

Mid 2002 : 165 MW - Combined cycle JBIC
2002 – 2003 : 280 MW temporary emergency power purchases
Mid 2003 : 20 MW diesel plant at Horana
June 2003 : 22 MW Sapugaskanda diesel plant,
Mid 2003 : 163 MW combined cycle AES
End 2003 : 70 MW kukule hydro power plant
Jan 2004 : 200 MW of Medium term power
End 2005 : 300 MW Combined Cycle Plant
End 2007 : 105 MW Gas turbine
150 MW Upper Kotmale Power Plant
End 2010 : 300 MW Coal Power Plant
End 2012 : 300 MW coal power plant
2013 : 300 MW Coal Power Plant
End 2015 : 300 MW Coal Power Plant

Overall, it is estimated that Sri Lanka will need to add approximately 1,500 megawatts (MW) of new generating capacity by 2010. By the year 2010, 8,000 GWh will have to come from thermal sources out of the total requirement of approximately13,000 GWh **(Figures 5, 6)**. This indicates a more than 100% increase in the annual energy contribution from the thermal systems which is presently amounting to about 3500 GWh.

There are two issues associated with this plan, which need special policy attention; the capital investment needs and the fuel costs.

Massive investments in the generation, transmission and distribution of energy will be needed to meet the growing demand. The bulk of these investments is needed to upgrade (i) the system capacities to meet the future demand and (ii) the quality of services of the electricity sector. The estimated financing needs for the seven years from 2001 to 2007 is of the order of US$ 3000 million – some US$ 430 million (around Rs 40 billion) per year on average. A large part of these investments is expected to come from the private sector and in the form of foreign assistance.

With increasing share of the thermal based generation indicated above, the fuel costs currently amounting to about Rs.12 billion per year for electricity will rise to about Rs.22 billion by the year 2010 (and to about Rs.40 billion by the year 2016), at the current parity rates. This will be a very steep increase which will result in a significantly heavy incremental foreign exchange

Figure 5 : Energy Balance Forecast

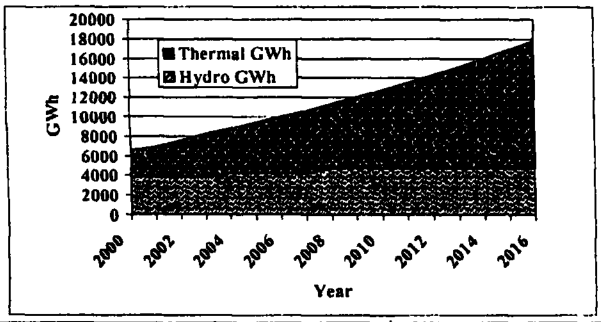
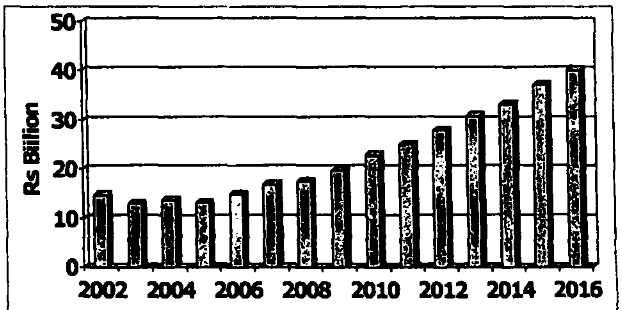


Figure 6 : Fuel Cost Forecast



drain out of the country associated with a tremendous burden on the balance of payments, **and a severe risk on the energy security of the country.** Energy security can be ensured through local adequacy which is inherently associated with varied forms of indigenous energy resources, energy conservation and efficiency of use. Therefore, we must actively look for alternate local resource based power generation which will reduce oil and coal imports and increase energy security of the country.

6. Conclusions

The power sector problems have their origins in non achievement of implementation targets. The power demand planning by CEB throughout 1990s has been proper. Sequences of new generation plants planned have been adequate and appropriate. Implementation of the Long Term Power Generation Plan has been poor and delayed perhaps due to dilution of ownership and responsibility as many players had entered the decision making and procurement process. The future additions to power generation capacity of the country will be mainly thermal based. This will necessitate significantly heavy incremental foreign exchange drain for importing oil or coal, resulting in serious problems of managing the balance of payment and the parity rate, while also threatening the energy security of the country. The economic value of energy generated by any alternative energy source in the future will therefore be very significant and accordingly, the country should actively look for developing domestically available alternative energy sources and thereby increasing the diversity of energy sources also. This should proceed in parallel with increasing traditional energy generating sources.

References:

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- The focus on policy management would require a drastic reduction of the number of Ministers at the Centre. The reduced number of Ministries should, in order to provide institutional continuity, be based on a medium to long-term division of sector policy areas in to portfolios.
- As a critical stage of the policy formulation process would be the reconciliation of inter-sector relationships, the establishment of an appropriately staffed and authoritatively mandated Cabinet Secretariat would be a key element of the reform agenda. The new Cabinet Secretariat should also assist the Cabinet of Ministers in the monitoring of the impact of policy decisions.
- The continuing regulatory responsibility at the Centre would also require the establishment of independent regulatory institutions. These, created under Statutes that cast on them accountability for their regulatory role, should, if they are to be truly independent, be accountable to the Parliament – and not to ministries with sector responsibility.
- Whilst a parliamentary institution is required for continuous policy discourse and approval as well as for the provision of the legislative underpinning that is necessary for policy management, it should, whilst being appropriately representative of all interests and spatial areas, be considerably smaller in size as compared with its current counterpart.

Several related changes are required concerning the roles and functions at the Centre. These include –

- The withdrawal of the State and its administrative organisations from the micro-management of economic activities;
- The shift of the role of the government in the social sectors of health and education from one of provision to one of empowering of access; and
- The abolition of the resultant administrative organisations.

The reform agenda would, naturally have implications for human resources in the administrative system and their management. The changes in human resources management should be such as to ensure that there is continuous matching of skills in inducting personnel to jobs. This would call for several changes to personnel systems in the public sector.

- The current dependence of the administrative organisations on life-time-employees would need to be abolished.
- Concurrently, the remuneration and compensation practices applied in the public sector should, unlike today, be geared to levels and conditions that would make public sector jobs more competitive in the job market.

Such a radical reform agenda, obviously, needs extensive and continuing public support. The creation of a support constituency for the reform agenda has to include organisations of the civil society as well as elements in the bureaucracy and in the polity who are ready to accept reforms. The creation of such a support constituency has to be based on the fullest awareness of the need for and content of the proposed reforms. If, therefore, a reform agenda is to be launched, a mandatory obligation is cast on the political leadership to be in the vanguard of a process of public education and of awareness creation.

The readiness of a support constituency to rally behind an agenda for the restructuring of governance would only be forthcoming if there is a perception that the leadership in the polity, both within and outside the government of the day, is serious about and is committed to implementing the agenda of restructuring.

NOTE

In the article published under the title "Consumer Rights in Comparison with other countries – UK, Australia and India" in our Jan/Feb. 2002 issue on Consumer Protection & Fair Trade the author's designation has been inadvertently printed as "President, Federation of Consumer Association of Sri Lanka (FOCAS)" by an oversight. While we regret this error give below the correct designation of the writer. We also regret the inconvenience caused in this connection to Mr Leel Gunasekera the present President of FOCAS.

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