

RAILWAY ELECTRIFICATION: LET US START, AT LEAST NOW

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Electrification of railways, of both Colombo suburban and long-distance, has been proposed by many in the past. The Ministry of Transport has so far not taken any meaningful steps to launch a project. Engineer DJ Wimalasurendra provided the first inspiration, who on his paper titled 'Economics of Power Utilisation in Ceylon' mentioned the importance and advantages of electrifying our railways, way back 1918. Now we are 92 years behind, and there is not even a debate on the subject at the Ministry of Transport. Initiatives of others come up and go away, once in a few years.

The latest effort is by the Institution of Engineers, Sri Lanka (IESL). In August 2008, IESL as a responsible body of professionals, presented a new proposal to electrify a segment of the railway network. The Institution of Engineers, India, gracefully accepted the request from IESL and provided the honorary services of an experienced railway electrification engineer. Through a series of deliberations and field visits facilitated by the Sri Lanka Railways (SLR), the study concluded the following: (a) the most widely used sector of the existing railway network, from Veyangoda to Panadura, should be the first to be electrified (b) Investments on electrification can be recovered fully with cost savings in energy and maintenance alone (meaning other benefits would be a bonus). (c) The estimated investment is about Rs 6 billion. We will examine the above recommendations and more, in a moment.

The Sector to be Electrified First

Forty four percent (42%) of the passengers using the present rail network today get-in and get-off in the Panadura-Veyangoda sector. This sector is 64 km long, which is a manageable length (and a manageable investment) for the first step to establish an electrified rail network. Of course, there are other sectors such as Kalutara South-Polgahawela, which can cover more than 50% of current passengers, but the length would be

more, making the initial capital outlay higher. So, the sector to be selected to launch electrification depends on further study, to provide the optimum benefit to commuters for the given investment. Whichever sector is selected, it would only be the first step, and eventually the entire railway network should be electrified, based on an economic justification.

The Approach

Greater Colombo suburban areas are congested, and clearing rights-of-way for a new electrified railway network would be a challenge. Numerous investors have examined the option of developing a light rail network or mono-rails, with tracks suspended on pillars. All these proposals have fallen by the way side, owing to poor economic viability caused by many factors including the lower population density in Colombo and the suburbs, compared with other major capitals in the region where new light-rail or underground rail networks have been recently built. Thus the more logical option is to make maximum use of the available tracks and rights of way. The way forward therefore, is to upgrade and electrify the existing railway network. The benefits are visible, can be calculated and fully justified, on energy and maintenance cost savings alone.

Why Electrify?

If one considers the passengers presently served, it may even be argued that the absence of electrification is not the cause for the problems of SLR. The infrastructure is poor and needs investment. Signalling and communication systems need to be further modernised. Shortage of locomotives and rolling stock is a major limitation that causes train services to be cancelled frequently. SLR has been making operating losses owing to a variety of reasons, beginning with underpricing of passenger fares.

Table 1 - Summary of Passenger Origin and Destinations for the Sectors Considered

Sector Starts	Sector Ends	Sector length (km)	Passengers served in the month of September 2007				
			Origin within sector	Destination with sector	Origin+ destination within sector	% of all SLR Passengers	Passengers per route km
Panadura	Veyangoda	63.4	5,180,960	5,230,930	3,620,631	42%	57,108
Kalutara S	Veyangoda	79.0	5,448,826	5,499,307	4,083,869	48%	51,695
Panadura	Ragama	41.7	3,896,168	3,942,688	1,755,510	21%	42,099
Fort	Ragama	15.5	2,782,911	2,783,840	746,657	9%	48,171
Fort	Gampaha	27.5	3,651,503	3,649,043	1,741,201	20%	63,316
Fort	Polgahawela	73.8	4,725,297	4,716,276	3,264,792	38%	44,238
Maradana	Panadura	28.1	3,114,081	3,149,971	927,217	11%	32,997
Maradana	Kalutara S	43.7	3,381,947	3,418,348	1,374,672	16%	31,457
Fort	Negombo	38.9	3,126,349	3,125,079	1,107,873	13%	28,480

Source: Origin and destination data of Sri Lanka Railways.

Yet we say that electrification should be a priority, because the investment can be fully justified on the basis of energy efficiency and maintenance cost savings alone. If SLR, the Government or even the multilateral lending agencies bring out a hundred reasons why electrification is not a priority, energy efficiency and sustainability would be an adequate reason to make that decision, and electrify the network. Another reason is the future: if one may ask how shall we move about in 100 years from today, the answer lies in electric vehicles, both trains and cars. Where would the electricity come from, when oil supplies decline? That will be from renewable sources (hydro, wind, biomass, solar, ocean energy sources), nuclear power and some remaining coal-fired power plants.

Energy Efficiency

All trains have an on-board electricity generator on the locomotive (or the power car), using diesel fuel. This generator produces electricity which drives the motors connected to the wheels. The generator is idling most of the time (when decelerating, during stops, waiting time, etc) and used for only a small amount of power when running at steady speed. In a suburban drive of 30 minutes (say Colombo to Moratuwa), it uses the full power only for one minute, in total.

If the same train is powered with mains electricity, there will be no wastage of fuel during the balance 29 minutes. And what is more? When the train decelerates or applies brakes, the motors will immediately transform themselves into generators, produce electricity

and send it back to the mains wires. Thus, the heat now generating in brakes will no longer be there, but converted back to electricity and "saved" in the grid for later use. Brakes will be applied only after the train is about to stop, and in an emergency.

And what is more? If electricity is taken from the mains, it will not be electricity produced from diesel. It will be a mix of hydropower and fuel-oil, and from next year, it will be hydropower and coal, which are the cheapest forms to produce electricity.

Savings in Energy Costs

A diesel multiple unit, more popularly known as a "power set" on a suburban service in flat terrain with 1000 passengers on board uses about 2.5 litres of diesel per km, when all losses are averaged out. At present prices, this will cost Rs 175. However, for a suburban electrified service, the electricity consumption from the grid is only 4.3 units of electricity per km. If this electricity comes from hydropower, the production cost is zero, but if it comes from the most expensive diesel power plant, the production cost will be Rs 120. In reality, the average production cost of electricity is presently about Rs 10 per unit, which will decline in real terms when the coal-fired power plants become operational from next year. Thus, even with the presently-high grid electricity costs, the economic cost of electricity is likely to be about Rs 45 per km, against Rs 175 for diesel. If network losses and other expenses are added, the financial cost of energy is likely to be a maximum of about Rs 85 per km. Therefore, energy costs would be

halved when trains are electrified. But there is another benefit: remember that when the train brakes, about 30% of this energy goes back to the grid.

Benefits to Passengers

The maintenance costs too will be significantly lower. The Indian experience is that the total maintenance costs of locomotives per train would drop from Rs 300 to 100 per km, and that is where the real savings are. Each diesel power set or a diesel locomotive is a self-contained power plant. The train carries its own power plant and roams the countryside. A central power plant would certainly be cheaper to maintain, than to maintain a fleet of roaming power plants, which too operate in the idling mode most of the time.

Savings that are not accounted for in this analysis are the passenger comfort, time savings owing to higher acceleration and speeds, and the overall benefits of a quiet, smooth operation, free from noise and pollution. What is more: as power is available on board the train, any comfort or service can be provided with ease: good lighting, air conditioning, music, cooking to serve warm meals. More passengers can be attracted to travel by train, if electrification is accompanied by a determined effort to improve the customer service and the image of SLR.

The Project

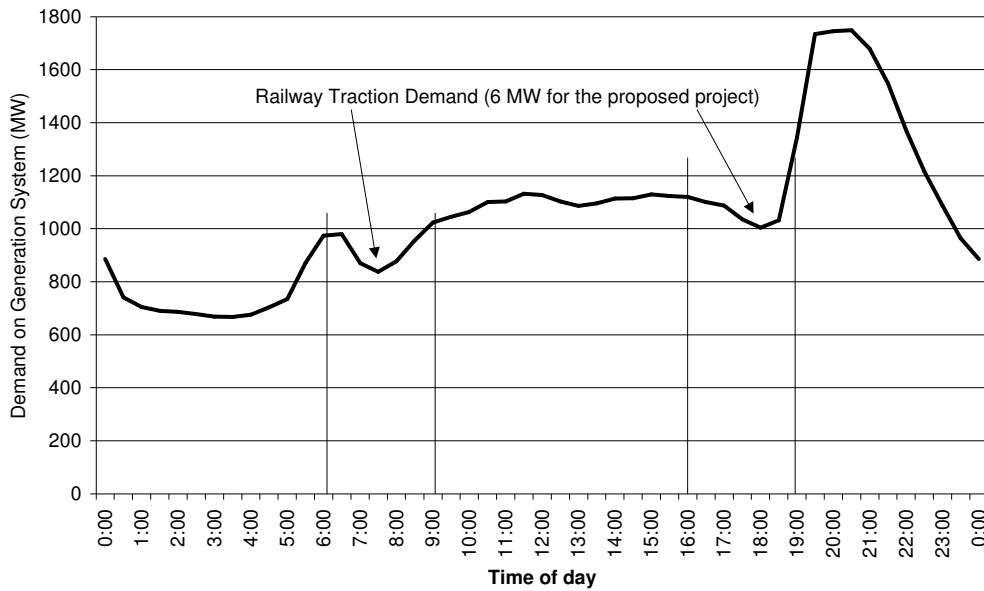
Electric lines would be drawn above the railway lines and loops. The operating voltage will be 25 kilovolt, which is now the standard in India and most other countries. Current will come from the overhead wire and return along one of the rails. The rails will be at zero voltage; so crossing them or stepping on them will not be dangerous. However, extreme caution is required at level crossings, to ensure vehicles taller than the stipulated height do not cross. Of course, high voltage lines cross our roads at thousands of locations, and this should not be a problem. Some existing station roofs and passenger bridges would have to be modified or re-built. The proposal of IESL, reviewed by the Indian Railways expert, was to begin with the Veyangoda-Panadura sector, with five electric multiple units, or let us call

them “electric power sets”. Thereafter, five electric power sets will be added once in two years, to provide an efficient suburban service. Thereafter, new power sets regularly purchased by SLR will be all electric, and the diesel power sets presently serving the Colombo suburbs will be gradually shifted to serve the peripheral areas or for suburban services around provincial towns such as Kandy, Galle, Trincomalee and later Jaffna. The long distance trains and the diesel power sets will continue to run in the electrified sector, too, with no hindrance.

What happens during a power failure? One precaution will be to build adequate spare electricity lines, which can immediately takeover if one line fails. Well, Sri Lanka does have total grid failures as well, typically once a year, when all lines will have no power. On October 9th last year, Sri Lanka had probably the longest grid failure in the history. Grid failures occur in developed countries too, but possibly once in 10-30 years, and when that happens, as in the great north American blackout in August 2003, rail passengers had to sleep on the streets overnight. It took two days for them to fully restore power. Sri Lanka’s electrified railway system will have backup generation, adequate to move a few trains in an emergency. Certainly all trains will be moved to the closest station using the backup power, until power supply is restored.

The economic benefits are high. If the costs of new electric power sets are excluded (as new power sets have to be purchased anyway for replacements), the economic rate of return will be over 14%. Even if all the costs are included, yet the minimum rate of return will be 5%. And that is only with energy and maintenance cost savings. All other benefits such as speed and comfort will be extra. The fact that SLR is running at a loss, is irrelevant to this analysis. This proposal is to cut down costs, and provide a faster, more comfortable passenger service. If the Government wants to convert the railways into a profitable entity, that has to be resolved through proper pricing and business management. That has to be done anyway, with or without electrification.

Figure 1 - Impacts on the National Grid Demand Profile



The figure shows the demand profile of Sri Lanka, with clear “valleys” at 6:30 am and 5:30 am. This exactly is the time when electrified railways will operate at their maximum frequency. The estimated maximum demand of five electric multiple units accelerating all at once is 6 MW, which is very small compared with the total demand. Thus, railways electrification is not expected to cause any need for additional generating capacity in the national grid. In contrast, electrified railways will be using electricity during off-peak periods, and should thus enjoy a preferential tariff. This study used the average tariff as the price of electricity.

So Why Wait?

This is the question asked by all. It is nearly one and a half years since the IESL proposal was presented. No specific actions have been taken to proceed to the next step, in spite of significant support by all in the energy sector and a wide cross section of the engineering community. The project is viable, will not burden the electricity supply system, and will

bring enormous benefits to rail passengers as well as to those who presently travel in crowded buses. Swift action by the Ministry of Transport is awaited. After all, it is the responsibility of the Ministry of Transport, and the energy community can only assist.

(The full proposal of IESL is available on www.iesl.lk)