CHAPTER 8

POWER SUPPLY, SYSTEM OF TRACTION AND POWER TARIFF

8.0 POWER SUPPLY, SYSTEM OF TRACTION AND POWER TARIFF DETAILS

8.1 Power Supply arrangements

Electricity is the only source of energy for operation of Metro system. The electric power supply is required by Metro system for the following purposes:-

- For running trains
- For station services e.g. lighting, ventilation and air-conditioning (only in underground stations), lifts, escalators, signalling & telecom, fire fighting and pumping etc.
- For workshops, depots and other maintenance infrastructure within premises of metro system.

The major component of power supply is traction requirements for elevated section and auxiliary requirements for underground section.

8.1.1 Power Demand Estimation

The power requirement of a metro system is determined by peak-hour demands of power for traction and auxiliary applications. Broad estimation of auxiliary and traction power demand is made based on the following requirements:-

(i) Specific energy consumption of rolling stock – 70KWh/1000 GTKM
(ii) Regeneration by rolling stock – 20%
(iii) Elevated/at –grade station load – initially 250KW, which will increase to 300 KW in the year 2021
(iv) Underground station load – initially 1250KW, which will increase to 1750 KW in the year 2021
(v) Depot auxiliary load - initially 2000KW, which will increase to 2500 KW in the year 2021.

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements have been worked out for the year 2007, 2011 and 2021 which is briefly summarized in **Table 8.1** below:-

Table 8.1:- Power Demand Estimation (MVA)

Corridor		Year		
		2007	2011	2021
E-W corridor	Traction	5	11	14
	Auxiliary	13	15	17
	Total	18	26	31
N-S corridor	Traction	4	4	9
	Auxiliary	11	12	13
	Total	15	16	22

The detailed calculations of power demand estimation are attached at **annexure 8.1 and 8.2**.

8.1.2 Need for High Reliability of Power Supply

The proposed Bangalore metro system is being designed to handle 40,000 passengers per direction during peak hours when trains are expected to run at about 3- minutes intervals. The tolerance level of any power interruption during this period is extremely low, as such incidences, apart from affecting train running, will cause congestion at stations. In underground stations, the ventilation and air-conditioning as well as lighting will also be affected. Interruption of power at night or at any time in underground stations is likely to cause alarm and increased risk to traveling public. Lack of illumination at stations, non-visibility of appropriate signages, disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level are low on account of stress. Effect on signalling and communication may affect train operation and passenger safety as well.

Accordingly, Metro system requires a very high level of reliable and quality of power supply. To ensure reliability of power supply, it is essential that both the sources of Supply and connected transmission & distribution networks are reliable and have adequate redundancies built in. Therefore, it is desirable to obtain power supply at high grid voltage of 220kV or 66kV from stable grid sub-stations and further transmission & distribution is done by the Metro Authority itself.

8.1.3 Selection of Inputs Supply Voltage and the Locations of Receiving Sub-Stations (RSS)

The high voltage power supply network of Bangalore city was studied in brief. The city has got 220kV, 66kV and 11kV network to cater to the various types of demand. 220kV sub-stations are generally located at outskirts of the city. 66kV sub-stations are located near to the alignment of E-W and N-S corridor. Keeping in view of the reliability requirements, 2 input sources of 66kV voltage level have been considered for each corridor and accordingly, 2 receiving sub-stations (66/33kV) are proposed to be set up each for E-W and N-S corridor. Based on the discussions with Bangalore Power Supply Authorities, it is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations at 66kV voltage levels through double /single circuit cable feeders: -

S. N.	Corridor	Grid sub-station (Input source)	Location of RSS of Metro Authority	Approx. length of 66kV cables
1.	E-W corridor	NGEF sub-station (66kV)	Baiyappanahalli depot	1km. (Double circuit)
2.		REMCO sub-station (66kV)	Mysore Road Terminal	1km. (Double circuit)
3.	N-S Corridor	SRS Peenya sub-station (220/66kV)	Yeshwantapur Depot	4km. (Double circuit)
4.		SARAKKI sub-station (66kV)	R.V. Road Terminal	4km. (Single circuit)

The summary of expected power demand at various receiving sub-stations is given in **Table 8.2**.

Table 8.2 – Power Demand at various RSS

Corridor	RSS	Peak demand – Normal (MVA)		Peak demand* – Emergency (MVA)	
		Initial Year (2007)	Year (2021)	Initial Year (2007)	Year (2021)
E-W corridor	Baiyappanahalli	10	17	18	31
	Mysore Road Terminal	8	14	18	31
Total of E-W corridor		18	31	18	31
N-S corridor	Yeshwantapur	9	13	15	22
	R.V. Road Terminal	6	9	15	22
Total of N-S corridor		15	22	15	22

* Incase of failure of other RSS of same line

The 66kV power supply will be stepped down to 33kV level at the above RSSs of metro authority. The 33kV power supply drawn from the two RSS of each corridor will be distributed along the alignment through 33kV Ring main cable network for feeding to traction as well as auxiliary loads (Refer power supply schematic **drawings no. BM/PS/GA/001/R1 and 002/R1**). These cables will be laid in dedicated ducts along the viaduct & tunnel. Interconnection of 33kV power supply between the two corridors has been planned at interchange station as shown in the schematic drawings, which can be used for transfer of power from one corridor to other in emergency situation. If one RSS of each line trips on fault or input supply failure, services can be maintained from the other RSS. But if one more RSS fails, only curtailed services can be catered to. However, in case of total grid failure, trains will come to stop but station lighting, ventilation & other essential services can be catered to by stand-by DG sets. Therefore, the proposed scheme is expected to ensure adequate reliability and cater to emergency situations as well.

The 66kV cables will be single core XLPE insulated with 500sq.mm Al conductor. The cables shall be laid through public pathways to RSSs of Metro Authority. One RSS of each corridor shall be provided with 2nos. (1 as standby) 66/33kV 3 phase main receiving transformers for feeding to traction as well as auxiliary loads. The other RSS of each corridor will be provided with only single 66/33kV transformer with a provision of adding 66kV bay and transformer in future when traffic builds up. The two RSS of each corridor are proposed to be located at the ends and therefore, these will be able to cater the additional power supply requirements in case of likely extensions of the corridors on either ends.

Conventional outdoor type 66kV switchgear is proposed for each RSS to be located in approx. 60m x 60m (3600 sqm) land plot. Gas Insulated Switchgear (GIS), though requires less space (approximately half) & less maintenance, is not proposed because of high capital cost. Further 66kV GIS is not available indigenously and requires to be imported. The typical RSS layout is given in **Drawing 8.1**. The 66 & 33kV power supply arrangement is shown in **Drawing 8.2**.

8.2 Selection of Traction System

There are 3 standard and proven systems of traction for use in suburban and metro lines. These are 750V dc third rail, 1500V dc overhead catenary and 25kV ac overhead catenary system. All these three systems are already in use in India.

750V dc third rail system has been extensively used in metros and more than 60% of existing metro systems in the world utilize 600-750V dc third rail system. The system does not affect the aesthetics of the city as it is laid alongside the track and also require smaller tunnel diameter compared to other systems. With the standard gauge (SG) and proposed coach profile, 750V dc third rail system can be accommodated in tunnel diameter of 5.2m. The system has a technical limitation beyond a traffic level of 60,000 PHPDT on account of requirement of large number of traction sub-stations and difficulty in differentiation between over-current and short-circuit currents. Stray current corrosion is often encountered in dc electrified railways and therefore, suitable measures are required for protection against corrosion of metallic structures, reinforcement and utility pipes caused by dc stray current.

1500V dc catenary system has been adopted by few metros to overcome the limitation imposed by 750V dc system for catering to traffic level of 60,000-80,000 PHPDT. This system requires use of catenary masts on elevated viaducts thereby affecting aesthetics of the city and also larger tunnel diameter compared to 750V dc system. Tunnel diameter for 1500V dc system has been assessed as 5.4m.

25kV ac traction has the advantages of minimal number of traction sub-stations, potential to carry large traffic (60,000-100,000) PHPDT and possibility of linking to mainline railways, if required. But the system requires a bigger tunnel diameter of 5.7m and use of catenary masts thereby affecting aesthetics. Suitable measures are required for mitigation of electro-magnetic interference (EMI) caused by single-phase 25kV ac traction currents. In addition, 25kV ac train will require the heavy transformers to be carried in the motor coach. The proposed alignment of East-West and North-South corridors is passing through the congested roads and built-up area of the city and therefore, 25kV ac traction system is not considered a safe option.

The traffic requirements of the Bangalore Metro have been projected to be about 40,000 PHPDT in horizon year 2021 and the corridors will be mainly elevated with small underground sections. Keeping in view of ultimate traffic requirements, difficulty in constructing large diameter tunnels in the city, aesthetics and other techno-economic considerations, 750V dc type traction system is considered to be the best alternative and hence proposed. Since the route is entirely grade separated there is no danger of safety hazard to passengers from third rail.

750V dc third rail bottom current collection is envisaged from reliability and safety considerations with the use of composite Aluminum steel third rail on main lines. Low carbon steel third rail, which is available indigenously, is proposed for depot because of reduced current requirements. The third rail will be provided with suitable shrouds for safety of passengers as well as maintenance personnel. The cross-section of third rail will be about 5000 mm^2. The longitudinal resistance of composite and steel third rail is about 7 and 20 milli-ohm/km respectively. The life of composite and steel third rail is expected to be 25-30 years.

8.2.1 Design Criteria for Power Supply and Traction System:

Train operation plan envisages running of trains as summarized below in **Table 8.3**:

Table 8.3 Train Operation Plan

Corridor	Year		
	2007	2011	2021
E-W Corridor Train composition Headway	3 car 4 minutes	6 car 4 minutes	6 car 3 minutes
N-S Corridor Train composition Headway	3 car 4 minutes	3 car 4 minutes	6 car 4 minutes

In train bunching situation, headway may get reduced to 150 seconds for short durations. Accordingly, traction power supply system has been planned to cater for 6-car train operation at 150 seconds headway in year 2021 under bunching conditions in part of the corridor. However, initially equipment will be installed to cater the expected power requirements during initial years of operations. As and when the traffic builds up in year 2011 & 2021, the power supply system will need slight augmentation by way of adding main power transformers & traction transformer-rectifier sets.

8.2.2 Traction Sub-stations (33kV/750V dc)

Traction sub-stations (33kV/750V dc) are required to be set up for feeding 750V dc power supply to the third rail. In order to cater to traction load as per design criteria, it is envisaged to provide traction sub-stations (TSS) at alternate stations. The requirement comes to 9 TSS for E-W line and 7 TSS for N-S line as shown in the power supply schematic drawings. The TSS alongwith Auxiliary Sub-Stations (ASS) will be located at station building itself at mezzanine or platform level inside a room. An additional traction sub-station will be located in each maintenance depot. Thus the total requirement of TSS works out to be 10 and 8 for the E-W and N-S corridor respectively. The typical layouts for ASS & TSS for underground and elevated section are given in **Drawing 8.3 to 8.6**.

Self-cooled, cast resin dry type rectifier-transformer is proposed, which is suitable for indoor application. Initially, 1x2.5MW transformer-rectifier set shall be provided in each TSS with space provisions for an additional set to be accommodated in future as and when trains composition is increased to 6 coach at 3 minutes headway. From the traction sub-stations, 750V dc cables will be laid upto third rail and return current cables will be connected to running rails.

8.3 Rating of major equipment

Based on emergency demand expected at each RSS, 2 nos. 66/33kV main receiving transformers of 16/20 MVA capacity shall be provided, at Baiyappanahalli and Yeshwantapur RSS, one to be in service and second one to serve as standby. The RSS to be located at Mysore Road and R.V. Road terminal will be provided with only one 66/33KV power transformer of 16/20MVA. The 66kV cable shall be 3-phase single core XLPE insulated with $500mm^2$ Al conductor to meet the normal & emergency loading requirements and fault level of the 66kV supply.

Traction transformer-rectifier set (33kV/750V dc) shall be of 2.5MW rated capacity with overload requirement of 150% for 2 hours with four intermittent equally spaced overloads of 300% for 1 minute, and with one 450% full load peak of 15 seconds duration at the end of 2 hour period. The traction transformer - rectifier set shall produce 750V dc nominal output voltage with 12-pulse rectification so as to minimize the ripple content in the output dc voltage. The IEC 850 international standard envisages the minimum and maximum voltages of 500V and 900V respectively for 750V dc traction system and therefore, the dc equipment shall be capable of giving desired performance in this voltage range.

33kV cable network shall be adequately rated to transfer requisite power during normal as well as emergency situations and to meet the fault current requirement of the system. Accordingly, proposed 33kV cables sizes are as under:-

- 3 core x 400 mm^2 copper from RSS to 33kV cable network
- 3 core x 300 mm^2 copper for 33kV ring main cable network.

Entire 33kV cables shall be 3 phase, XLPE insulated with copper conductors. Cables to be located inside the tunnel shall be with Fire Retardant Low Smoke Zero Halogen (FRLSOH) properties, while those on outdoor may be with ordinary PVC sheath.

Adequate no. of cables are required for transfer of power from TSS to third rail. Single phase XLPE insulated cables with $400mm^2$ copper conductor are proposed for 750V dc as well as return current circuit. Based on current requirements, 3 cables are required for each of the four circuit to feed power to third rail.

The above capacities of transformers, cables etc. have been worked out based on the conceptual design and therefore, these capacities may be required to be fine tuned during design stage of project implementation.

8.4 AUXILIARY SUPPLY ARRANGEMENTS FOR STATIONS & DEPOT

Auxiliary sub-stations (ASS) are envisaged to be provided at each station. A separate ASS is required at each depot. The ASS will be located at mezzanine or platform level inside a room. Wherever TSS is required, ASS & TSS will be housed together inside a room. The auxiliary load requirements have been assessed to be about 300 kW for elevated/at-grade stations & 1750 kW for underground stations and accordingly two dry type cast resin transformers (33/0.415kV) of 315 kVA & 2000 kVA capacity are proposed to be installed at elevated/at-grade & underground stations respectively (one transformer as standby). Both the Depot ASSs will also be provided with 2 x 2000 kVA auxiliary transformers.

8.5 STANDBY DIESEL GENERATOR (DG) SETS

In the unlikely event of simultaneous tripping of all the four RSSs or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide standby DG set of 100 KVA capacity at elevated/at-grade stations and 750 KVA at underground stations to cater the following essential services:

(i) Lift operation
(ii) Essential lighting
(iii) Ventilation requirements of U/G stations
(iv) Signaling & telecommunications
(v) Fire fighting system

Silent type of DG sets are proposed which have low noise levels and do not require separate room for installation.

8.6 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

The entire system of power supply (receiving, traction & auxiliary supply) shall be monitored and controlled from a centralized Operation Control Centre (OCC) through SCADA system. Modern SCADA system with intelligent remote terminal units (RTUs) shall be provided. Optical fibre provided for telecommunications will be used as communication carrier for SCADA system.

Digital Protection Control System (DPCS) is proposed for providing data acquisition, data processing, overall protection control, interlocking, inter-tripping and monitoring of the entire power supply system consisting of 66/33kV ac switchgear, transformers, 750V dc switchgear and associated electrical equipment. DPCS will utilize microprocessor-based fast-acting numerical relays & Programmable Logic Controllers (PLCs) with suitable interface with SCADA system.

8.7 EMERGENCY TRIP SYSTEM (ETS)

In underground portion of each corridor, Emergency Trip System (ETS) shall be provided at platform ends and cross-passages in accordance with the requirements of NFPA-130. ETS can be operated by passengers and metro staff in case of emergency situations to stop the train(s). Operation of ETS push button will result in tripping of relevant section of third rail in order to stop the trains in that section. ETS cable shall be fire rated for one hour at 500^0 C.

8.8 STRAY CURRENT CORROSION PROTECTION MEASURES

8.8.1 Concept of dc Stray Current Corrosion

In dc traction systems, bulk of return current finds its path back to the traction sub-station via the return circuit i.e. running rails. The running rails are normally insulated to minimize leakage of currents to the trackbed. However, due to leaky conditions, some current leakage takes place, which is known as 'stray current'. The current follows the path of least resistance. Return current deviates from its intended path if the resistance of the unintended path is lower than that of intended path. The stray current may flow through the unintended path of metallic reinforcements of the structure back to the sub-station. It is also possible that part of the stray current may also flow into soil, where it may be picked up by metallic utilities and discharged back to soil and then to near the sub-station.

The dc stray currents cause metal detraction in watery electrolytes as per the following chemical reactions:-

- Stray current enters in the metal
  $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ (development of Hydrogen gas)
- Stray current exits from metal
  $Fe \rightarrow Fe^{2+} + 2e^-$ (Fe^{2+} ions migrate away from the metal)

That is how, dc stray currents cause corrosion of metallic structure where it leaves the metal. This is shown in schematic **Drawing 8.7**. Pitting and general form of corrosion are most often encountered on dc electrified railways.

8.8.2 Effect of Corrosion

Detraction rate of metals can be calculated by Faraday's First Law:

$$m = c.i.t$$

Where m = mass (kg)
c = Coefficient of detraction (kg/Amp.year)
i = Current (Amp)
t = time (year)
c = 2.90 for Aluminium
= 33.80 for Lead
= 9.13 for Iron
= 10.4 for Copper

That means dc stray current of 1 – ampere flowing continuously can eat away approx. 9 kg of steel in a year. If 5000 amperes of current flows for one year to power the trains on a transit system, and that 2 percent of this current (100 amperes) leaks as stray current, the amount of steel metal loss is 0.9 ton per year. Therefore, the safety implications are considerable for structural reinforcements. In addition, corrosion may also affect neighboring infrastructure components such as buried pipelines and cables.

8.8.3 Measures for Protection against Stray Current Corrosion

Earthing & bonding and protection against stray current corrosion are inter-related and conflicting issues. Therefore, suitable measures are required to suppress the stray currents as well as the presence of high touch potentials. Safety of personnel is given preference even at a cost of slightly increased stray currents.

Following measures are required to restrict the stay current:-

(i) Decreasing the resistance of rail-return circuit
(ii) Increasing the resistance of rail to ground insulation

Whenever buried pipes and cables are in the vicinity of dc systems, efforts shall be made to ensure that metal parts are kept away as far as practicable to restrict stray current. A minimum distance of 1 meter has been found to be adequate for this purpose.

Generally, 3 types of earthing arrangements (viz. Earthed System, Floating System & Hybrid Earthing System) are prevalent on metros Worldover for protection against stray current corrosion. Traditionally, Earthed system was used by old metros. Hybrid earthing system is being tried on experimental basis on few new metros. Floating system has been extensively used by recent metros. As per the trends Worldover, floating system (i.e. traction system with floating negative) is proposed which reduces the dc stray current to considerable level. The arrangement shall comply with following latest CENELEC standards:-

- EN 50122-1:- Railway Applications (fixed installations) protective provisions relating to electrical safety & earthing
- EN 50122-2:- Railway Applications (fixed installations) protective provisions against the effects of stray currents caused by dc traction system

The conceptual scheme of proposed floating system is described below :-

i) The running rails shall be adequately insulated as per EN50122-2. The recommended conductance per unit length for single track sections are as under:-

   Elevated section :- 0.5 Siemens/Km
   Tunnel section :- 0.1 Siemens/Km.

ii) Stray Current Collector Cables {commonly known as structural earth (SE) cable} (2x200 mm^2 copper) shall be provided along the viaduct/tunnel and all the metallic parts of equipment, cable sheath, tunnel/viaduct reinforcement, signal post etc. shall be connected to SE cable.

iii) The continuity of the reinforcement bars of the viaduct/tunnels as well as track slabs has to be ensured alongwith a tapping point for connection with SE cable in order to drain back the stray current. The typical arrangement of connecting the reinforcements of viaduct and tunnels is shown in **Drawings 8.8 and 8.9**.

iv) A provision shall be made to earth the running rail (i.e. negative bus) in case of rail potential being higher than limits prescribed (120V) in relevant standard (EN 50122-1) in order to ensure safety of personnel. This will be achieved by providing track earthing panel (TEP) at stations close to platform and at traction sub-stations.

v) In addition, provisions shall be made for connection of SE cable to negative return path through diode only for the purpose of periodical monitoring of stray currents. Under normal operations, switch provided for this connection will be in normally open (NO) position and switch will be closed for monitoring of stray current once or twice in a year as required.
The proposed scheme is shown in schematic **Drawing 8.10**.

8.8.4 Special Arrangements in Depot

A separate traction sub-station (TSS) shall be provided for each depot so as to facilitate isolation of depot traction supply from mainlines in order to prevent the leakage of return currents to depot area. Tracks of Depot area shall also be isolated from mainline through insulated rail joints (IRJ). Remote operated sectionalizing switches shall be provided to feed power from depot to mainline and vice-versa in case of failure of TSS.

The prescribed limit of highest touch potential in depot is 60V as per EN50122-1 and therefore Track Earthing Panels (TEP) shall be provided at suitable locations to earth the rail in case the rail potential exceeds this limit. In areas, where leaky conditions exist (e.g. washing lines, pit wheel lathe etc.), insulated rail joints (IRJ) shall be provided with power diodes to bridge the IRJ to facilitate passage of return current.
A detailed scheme shall be developed during the design stage.

8.9 ELECTROMAGNETIC INTERFERENCE (EMI) AND ELECTROMAGNETIC COMPATIBILITY (EMC)

AC traction currents produce alternating magnetic fields that cause voltages to be induced in any conductor running along the track. However, dc traction currents do not cause electromagnetic induction effect resulting induced voltages and magnetic fields.

The rectifier-transformer used in dc traction system produces harmonic voltages, which may cause interference to telecommunications and train control/protection systems. The rectifier-transformer shall be designed with the recommended limits of harmonic voltages, particularly the third and fifth harmonics. The proposed 12-pulse rectifier-transformer reduces the harmonics level considerably. Detailed specification of equipment e.g. power cables, rectifiers, transformer, E&M equipment etc shall be framed to reduce conducted or radiated emissions as per appropriate international standards. The Metro system as a whole (trains, signaling & telecomm, traction power supply, E&M system etc) shall comply with the EMC requirements of international standards viz. EN50121, EN50123, IEC61000 series etc. A detailed EMC plan will require to be developed during project implementation stage.

8.10 ENERGY SAVING MEASURES

Energy charges of any metro system constitute a substantial portion of operation & maintenance (O & M) costs. Therefore, it becomes imperative to incorporate energy saving measures in the system design itself. The auxiliary power consumption of metros is generally more than the traction energy consumed by train movement. The proposed system of Bangalore Metro includes the following energy saving features:

(i) Modern rolling stock with 3-phase VVVF drive and light-weight stainless steel coaches has been proposed, which has the benefits of low specific energy consumption and almost unity power factor.

(ii) Rolling stock has regeneration features and it is expected that 20% of total traction energy will be regenerated and fed back to 750V dc third rail to be consumed by nearby trains.

(iii) Effective utilization of natural light is proposed. In addition, the lighting system of the stations will be provided with different circuits (33%, 66% & 100%) and the relevant circuits can be switched on based on the requirements (day or night, operation or maintenance hours etc).

(iv) Machine-roomless type lifts with gearless drive have been proposed with 3-phase VVVF drive. These lifts are highly energy efficient.

(v) The proposed heavy-duty public service escalators will be provided with 3-phase VVVF drive which gives energy efficiency & improved power factor. Further, the escalators will be provided with infra-red sensors to automatically reduce the speed (to idling speed) when not being used by passengers.

(vi) The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc) have been incorporated in the system design.

(vii) Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control.

8.11 ELECTRIC POWER TARIFF

The electricity is the only source of energy for operation of the Metro system. The cost of electricity is a significant part of Operation & Maintenance (O&M) charges of a metro system and it is expected to constitute about 25-35% of total annual working cost. Therefore, it is the key element for the financial viability of the Project. The annual energy consumption is assessed to be about 90 million units in initial years (2007), which will double by horizon year 2021. In addition to keep the energy consumption to optimum, it is also necessary that the electric power tariff be kept at minimum in order to contain the O& M costs. Therefore, the power tariff for Bangalore Metro should be at effective rate of purchase price (at 66kV voltage level) plus nominal administrative charges i.e. no profit no loss basis. This is expected to be in the range of Rs. 2.50-2.75 per unit. It is proposed that Government of Karnataka take necessary steps to fix power tariff for Bangalore Metro at “No Profit No Loss” basis. Financial analysis has been carried out based on this tariff for the purpose of finalizing the DPR. Similar approach is being pursued for Delhi Metro.

Managing Director, DMRC has already requested Managing Director, BMRTL to take up the matter with Government of Karnataka and electricity bulk distribution authorities vide letter no. DMRC/Elec/16/Bang-M/02/06 dated 16 January 2003.

Annexure 8.1

POWER REQUIREMENTS	E-W Corridor of Bangalore Metro					
	Year 2007		Year 2011		Year 2021	
Motor coach-tare weight	36	T	36	T	36	T
Motor coach-passenger carrying capacity	322		322		322	
Trailer coach-tare weight	32	T	32	T	32	T
Trailer coach-passenger carrying capacity	356		356		356	
No of cars	3	(2M+1T)	6	(4M+2T)	6	(4M+2T)
passenger weight	60	T	120	T	120	T
Total Train weight	164	T	328	T	328	T
Section length	17.38	KM	17.38	KM	17.38	KM
Headway	4	mts	4	mts	3	mts
Specific Energy consumption	70	KWhr/1000GTKM	70	KWhr/1000GTKM	70	KWhr/1000GTKM
No. of trains/hr in both directions	30		30		40	
Peak traction power requirement	6.0	MW	12.0	MW	16.0	MW
Less Regeneration @20%	1.2	MW	2.4	MW	3.2	MW
Net traction power requirement	4.8	MW	9.6	MW	12.8	MW
Station aux power requirement						
Elevated/at-grade station	0.25	MW	0.30	MW	0.30	MW
U/G station	1.25	MW	1.50	MW	1.75	MW
no. of elevated/at-grade stations	14		14		14	
no. of U/G stations	4		4		4	
Total Station Aux Power requirement	8.5	MW	10.2	MW	11.2	MW
Depot Aux power requirement	2.0	MW	2.25	MW	2.50	MW
Total traction & aux power requirement (MW)	15	MW	22	MW	26	MW
Total power requirement (MVA) assuming 5% energy losses and .95 & .85 pf for traction & aux loads respectively	18	MVA	26	MVA	31	MVA

POWER REQUIREMENTS	N-S Corridor of Bangalore Metro					
	Year 2007		Year 2011		Year 2021	
Motor coach-tare weight	36	T	36	T	36	T
Motor coach-passenger carrying capacity	322		322		322	
Trailer coach-tare weight	32	T	32	T	32	T
Trailer coach-passenger carrying capacity	356		356		356	
No of cars	3	(2M+1T)	3	(2M+1T)	6	(4M+2T)
passenger weight	60	T	60	T	120	T
Total average weight	164	T	164	T	328	T
Section length	14.5	KM	14.5	KM	14.5	KM
Headway	4	mts	4	mts	4	mts
Specific Energy consumption	70	KWhr/1000GTKM	70	KWhr/1000GTKM	70	KWhr/1000GTKM
No. of trains/hr in both directions	30		30		30	
Peak traction power requirement	5.0	MW	5.0	MW	10.0	MW
Less Regeneration @20%	1.0	MW	1.0	MW	2.0	MW
Net traction power requirement	4.0	MW	4.0	MW	8.0	MW
Station aux power requirement						
Elevated/at-grade station	0.25	MW	0.25	MW	0.30	MW
U/G station	1.25	MW	1.50	MW	1.75	MW
no. of elevated/at-grade stations	11		11		11	
no. of U/G stations	3		3		3	
Total Station Aux Power requirement	6.5	MW	7.3	MW	8.55	MW
Depot Aux power requirement	2.0	MW	2.25	MW	2.5	MW
Total traction & aux power requirement (MW)	12	MW	13	MW	19	MW
Total power requirement (MVA) assuming 5% energy losses and .95 & .85 pf for traction & aux loads respectively	15	MVA	16	MVA	22	MVA