CHAPTER 6

Power supply is the lifeline of Metro System

POWER SUPPLY ARRANGEMENTS

6.1 Power Requirements

Electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, signalling & telecom, fire fighting etc) and workshops, depots & other maintenance infrastructure within premises of metro system. The power requirements of a metro system are 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 – 30%
(iii) Elevated/at –grade station load – initially 250KW, which will increase to 350 KW in the year 2035
(iv) Depot auxiliary load - initially 2000KW, which will increase to 2500 KW in the year 2035.

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2010, 2025 and 2035 are summarized in table 6.1 below: -

Table 6.1 Power Demand Estimation (MVA)

Corridor		Year		
		2010	**2025**	**2035**
APMC/Vasna - Akshardham	Traction	10	18	36
	Auxiliary	14	15	15
	Sub-total	**26**	**33**	**51**
Ahmedabad – Thaltej	Traction	4	4	8
	Auxiliary	7	7	7
	Sub-total	**11**	**11**	**15**
	Total	**37**	**44**	**66**

The detailed calculations of power demand estimation for the two corrdiors are attached at annexure 6 (A) & (B).

6.2 Need for High Reliability of Power Supply

The proposed Ahmedabad metro system is being designed to handle about 50,000 passengers per direction during peak hours when trains are expected to run at 3 - 4 minutes intervals. Incidences of any power interruption, apart from affecting train running, will cause congestion at stations. Interruption of power at night 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 is generally low on account of stress. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, uninterrupted power supply is mandatory for efficient metro operations.

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 132 or 66kV from stable grid sub-stations and further transmission & distribution is done by the Metro Authority itself.

6.3 Sources of Power Supply

The high voltage power supply network of Ahmedabad city was studied in brief. The city has 220, 132, 66, 33 and 11kV network to cater to various types of demand in vicinity of the proposed corridor. Series of meetings were held with M/s Torrent Power AEC Limited (Licensee of the area) and various sub-stations sites were inspected to finalize the Input Power Supply sources & Supply Voltage.

Keeping in view the reliability requirements, three Receiving Sub-stations (two for N-S line and one for E-W line) are proposed to be set up. This is an economical solution without compromising reliability. Based on the discussions with M/s Torrent Power AEC Ltd., it is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations at 132 or 66kV voltage through cable feeders: -

Table 6.2 Sources of Power Supply

S. N.	Corridor	Grid sub-station of Torrent Power AEC Ltd. (Input voltage)	Location of RSS of Metro Authority	Approx. length of 132 or 66kV cables
1.	**APMC/vasna-Akshardham**	Sabarmati Receiving sub-station (132kV)	Sabarmati	1km. (Double circuit)
2.		Vasna Receiving sub-station (66kV)	Vishala/APMC	3km. (Double circuit)
3.	**Ahmedabad - Thaltej**	Thaltej Receiving sub-station (132kV)	Thaltej Depot	1km. (Double circuit)

The summary of expected power demand at various sources is given in table 6.3. M/s Torrent Power AEC Ltd have been requested to confirm availability of requisite power and 2 bays at their above sub-stations.

Table 6.3 – Power Demand projections for various sources

Corridor	Input Source	Peak demand – Normal (MVA)		Peak demand* – Emergency (MVA)	
		Initial Year (2010)	Year (2035)	Initial Year (2010)	Year (2035)
Vishala - Akshardham	**Sabarmati RSS**				
	Traction	6	18	12	36
	Auxiliary	7	8	14	15
	Sub-total (A)	13	26	26	51
	Vasna RSS				
	Traction	6	18	6	18
	Auxiliary	7	7	7	7
	Sub-total (B)	13	25	13	25
Ahmedabad - Thaltej	**Thaltej RSS**				
	Traction	4	8	10	26
	Auxiliary	7	7	14	15
	Sub-total (C)	11	15	24	41
	Grand Total	37	66	63	117

* Incase of failure of other source of power

The 132 or 66kV power supply will be stepped down to 25kV single phase for traction purpose at the three RSSs of metro authority and the 25kV traction supply will be fed to the OHE at viaduct through cable feeders. Similarly 132 or 66 kV supply will be stepped to 33kV voltage level and distributed along the alignment through 33kV Ring main cable network for feeding auxiliary loads (Refer power supply schematic drawings no. AM/PS/GA/001/R0). These cables will be laid in dedicated ducts along the viaduct. If one RSS trips on fault or input supply failure, train services can be maintained from other RSS. A 25kV power supply link is proposed between the Metro and Western Railway near Sabarmati station from the nearbys Rly's Traction Sub-station. This link will be used to pull trains to various stations when all the three RSSs fail. However, in case of total grid failure, all trains may come to a halt but station lighting & other essential services can be catered to by stand-by DG sets. Therefore, while the proposed scheme is expected to ensure adequate reliability, it would cater to emergency situations as well.

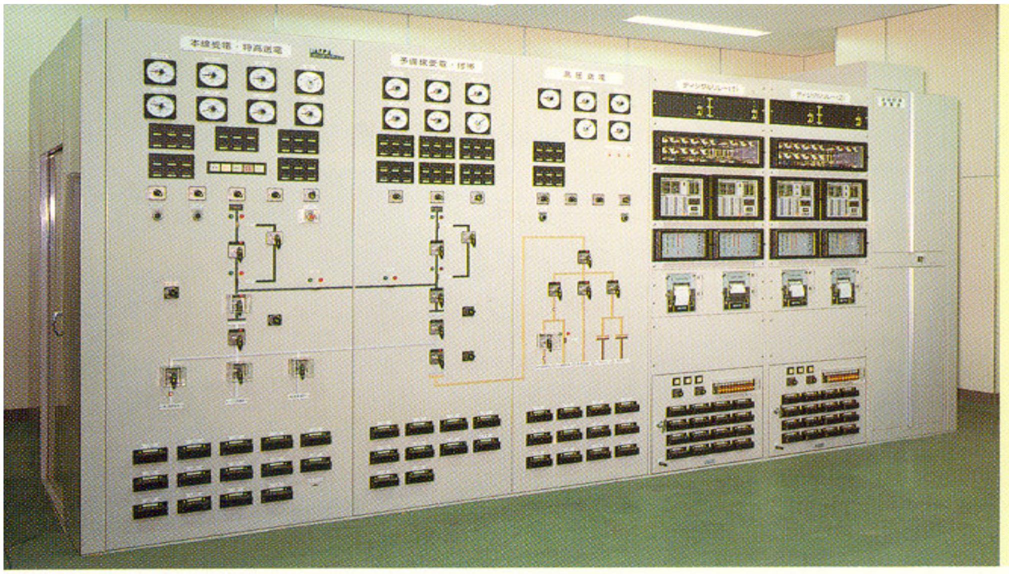
Typical High Voltage Receiving Sub-station

The 132 or 66kV cables will be laid through public pathways from Torent AEC Sub-stations to RSSs of Metro Authority. Each RSS shall be provided with 2nos. (one as standby) 132 or 66/25kV, 30 MVA single phase traction transformers for feeding to traction loads, being the standard design. This arrangement would also ensure that the system caters to additional power supply requirements in case of likely extensions of the corridors at either end. Sabarmati RSS can also be used for feeding 25kV traction supply to the proposed Regional Railway System.

Indoor type 33kV switchgear and outdoor type 25kV switchgear is proposed for each RSS to be located in approx. 50m x 50m (2500 sqm) land plot. Gas Insulated Switchgear (GIS) of 132 or 66 kV is proposed on account of reduced land requirement, maintenance and reliability considerations.

6.4 Auxiliary Supply Arrangements for Stations & Depot

Auxiliary sub-stations (ASS) are envisaged to be provided at each station. A separate ASS is required at depot. The ASS will be located at mezzanine or platform level inside a room. The auxiliary load requirements have been assessed at 350 kW for elevated/at-grade stations. Accordingly, two dry type cast resin transformers (33/0.415kV) of 400 kVA capacity are proposed to be installed at the stations (one transformer as standby). Depot ASS will also be provided with 2x2000 kVA auxiliary transformers.



Typical Indoor Auxiliary Sub-station

6.5 Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC)

25kV ac traction currents produce alternating magnetic fields that cause voltages to be induced in any conductor running along the track. Booster Transformer and Return Conductor (BT/RC) System is proposed for EMI mitigation. Concrete structures of elevated viaducts are not good electrical earths and therefore, Earthing and Bonding of the traction system shall be in accordance with the latest standards EN50122-1, IEEE80 and other relevant standards. Two earth conductors –Overhead Protection Cable (OPC) and Buried Earth Conductor (BEC) are proposed to be laid along with elevated via duct and all the metallic structures, structural reinforcement, running rails etc will be connected to these conductors to form an equiv-potential surface & a least resistance path to the fault currents. The overhead protection cable will also provide protection against lightning to the 25kV OHE and the elevated viaduct. Similar arrangements have been adopted on Delhi Metro as well.

Detailed specification of equipment e.g. power cables, transformer, switchgear, 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 EMI/EMC plan will be required to be developed during project implementation stage.

6.6 Rating of Major Equipment

25kV ac Overhead Equipment (OHE) shall comprise 150sqmm HD-copper contact wire and 65 sqmm Cd-copper catenary wire. Return conductor

(RC) shall be All Aluminum Conductor (AAC) of 233sqmm cross section. From safety considerations, Hydraulic type Anti-Tensioning Device (ATDs) are proposed on mainlines which does not require use of balance weight for tensioning of OHE conductors.

Based on emergency demand expected at each RSS as shown in Table 6.3, 2 nos. 132 or 66/25kV traction transformers of 30 MVA capacity shall be provided at each RSS, being standard design (one to be in service and second one to serve as standby). Each RSS will be provided with 2nos 132 or 66kV Auxiliary Main transformer of 20 MVA capacity. The 132 or 66kV incoming 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 system.

33kV and 25kV switchgear shall be rated for 1250 A being standard design. 33kV cable ring network shall be adequately rated to transfer requisite auxiliary power during normal as well as emergency situations and accordingly 3 core x 200 mm^2 copper conductor XLPE insulated 33kV cable is proposed for ring main network.

Adequate no. of cables are required for transfer of traction power from Metro’s RSS to 25kV OHE. Single-phase XLPE insulated cables with 240mm^2 copper conductor are proposed for traction power. Based on current requirements, 2 cables are required for each of the four circuits to feed power to OHE.

The above capacities of transformers, switchgear, cables etc. have been worked out based on the conceptual design. Therefore, these may be required to be revised for better accuracy during design stage of project implementation.

6.7 Standby Diesel Generator (DG) Sets

In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide a standby DG set of 100 KVA capacity at the stations to cater to the following essential services:

(i) Essential lighting
(ii) Signaling & telecommunications
(iii) Fire fighting system
(iv) Lift operation
(v) Fare collection system

Silent type DG sets with low noise levels are proposed, which do not require a separate room for installation.

6.8 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 33kV ac switchgear, transformers, 25kV ac switchgear and associated electrical equipment. DPCS will utilize microprocessor-based fast-acting numerical relays & Programmable Logic Controllers (PLCs) with suitable interface with SCADA system.

6.9 Energy Saving Measures

Energy charges of any metro system constitute a substantial portion of its operation & maintenance (O & M) costs. Therefore, it is 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 during initial years of operation. Subsequently, traction power consumption increases with increase in train frequency/composition in order to cater more traffic. The proposed system of Ahmedabad Metro includes the following energy saving features:

(i) Modern rolling stock with 3-phase VVVF drive and lightweight 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 30% of total traction energy will be regenerated and fed back to 25kV ac OHE 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-room less 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 services escalators will be provided with 3-phase VVVF drive, which is energy efficient & improves the power factor. Further, the escalators will be provided with infrared 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.

6.10 Electric Power Tariff

The cost of electricity is a significant part of Operation & Maintenance (O&M) charges of the Metro System, which constitutes 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 60 million units in initial years (2010), which will double by horizon year 2035. In addition to ensuring optimum energy consumption, it is also necessary that the electric power tariff be kept at a minimum in order to contain the O& M costs. Therefore, the power tariff for Ahmedabad Metro should be at effective rate of purchase price (at 33kV voltage level) plus nominal administrative charges i.e. on a no profit no loss basis. This is expected to be in the range of Rs. 2.75-3.25 per unit. It is proposed that Government of Gujarat takes necessary steps to fix power tariff for Ahmedabad Metro at “No Profit No Loss” basis. Similar approach has been adopted for Delhi Metro.

Annexure 6 (A)

POWER REQUIREMENTS		APMC/VASNA - AKSHARDHAM CORRIDOR				
	Year 2010		Year 2025		Year 2035	
Traction power requirements						
No of cars	3	(2M+T)	3	(2M+T)	6	(4M+2T)
Train Tare Weght	117	T	117	T	234	T
Passenger weight	47	T	47	T	98	T
Total Train weight	164	T	164	T	332	T
Section length	32	KM	32	KM	32	KM
Headway	5	mts	3	mts	3	Mts
Specific Energy consumption	70	KWhr/1000GTKM	70	KWhr/1000GTKM	70	KWhr/1000GTKM
No. of trains/hr in both directions	24		40		40	
Peak traction power requirement	8.8	MW	14.7	MW	29.7	MW
Depot power requirements	2.0	MW	2.0	MW	3.0	MW
Total traction power requirement	10.8	MW	16.7	MW	32.7	MW
Total traction power requirement (MVA) assuming 5% energy losses and .95 pf	**12**	**MVA**	**18**	**MVA**	**36**	**MVA**
Station aux power requirements						
Elevated/at-grade station--power consumption	0.30	MW	0.30	MW	0.30	MW
No. of elevated/at-grade stations	31		31		31	
Total Station Aux Power requirement	9.3	MW	9.3	MW	9.3	MW
Depot Aux power requirement	2.0	MW	2.25	MW	2.5	MW
Total Aux Power requirement	11.3	MW	11.55	MW	11.8	MW
Total aux power requirement (MVA) assuming 5% energy losses and .85 pf	**14**	**MVA**	**15**	**MVA**	**15**	**MVA**
Total traction & aux power requirement (MVA)	**26**	**MVA**	**33**	**MVA**	**51**	**MVA**

Annexure 6 (B)

POWER REQUIREMENTS		AHMEDABAD - THALTEJ CORRIDOR				
	Year 2010		Year 2025		Year 2035	
Traction power requirements						
No of cars	3	(2M+T)	3	(2M+T)	6	(4M+2T)
Train Tare Weght	117	T	117	T	234	T
Passenger weight	47	T	47	T	98	T
Total Train weight	164	T	164	T	332	T
Section length	10	KM	10	KM	10	KM
Headway	5	mts	4	mts	5	mts
Specific Energy consumption	70	KWhr/1000GTKM	70	KWhr/1000GTKM	70	KWhr/1000GTKM
No. of trains/hr in both directions	24		30		24	
Peak traction power requirement	2.8	MW	3.4	MW	5.6	MW
Depot power requirements	1.00	MW	1.0	MW	2.0	MW
Total traction power requirement	3.8	MW	4.4	MW	7.6	MW
Total traction power requirement (MVA) assuming 5% energy losses and .95 pf	**4**	**MVA**	**4**	**MVA**	**8**	**MVA**
Station aux power requirements						
Elevated/at-grade station--power consumption	0.30	MW	0.30	MW	0.30	MW
No. of elevated/at-grade stations	11		11		11	
Total Station Aux Power requirement	3.3	MW	3.3	MW	3.3	MW
Depot Aux power requirement	2.0	MW	2.0	MW	2.0	MW
Total Aux Power requirement	5.3	MW	5.3	MW	5.3	MW
Total aux power requirement (MVA) assuming 5% energy losses and .85 pf	**7**	**MVA**	**7**	**MVA**	**7**	**MVA**
Total traction & aux power requirement (MVA)	**11**	**MVA**	**11**	**MVA**	**15**	**MVA**