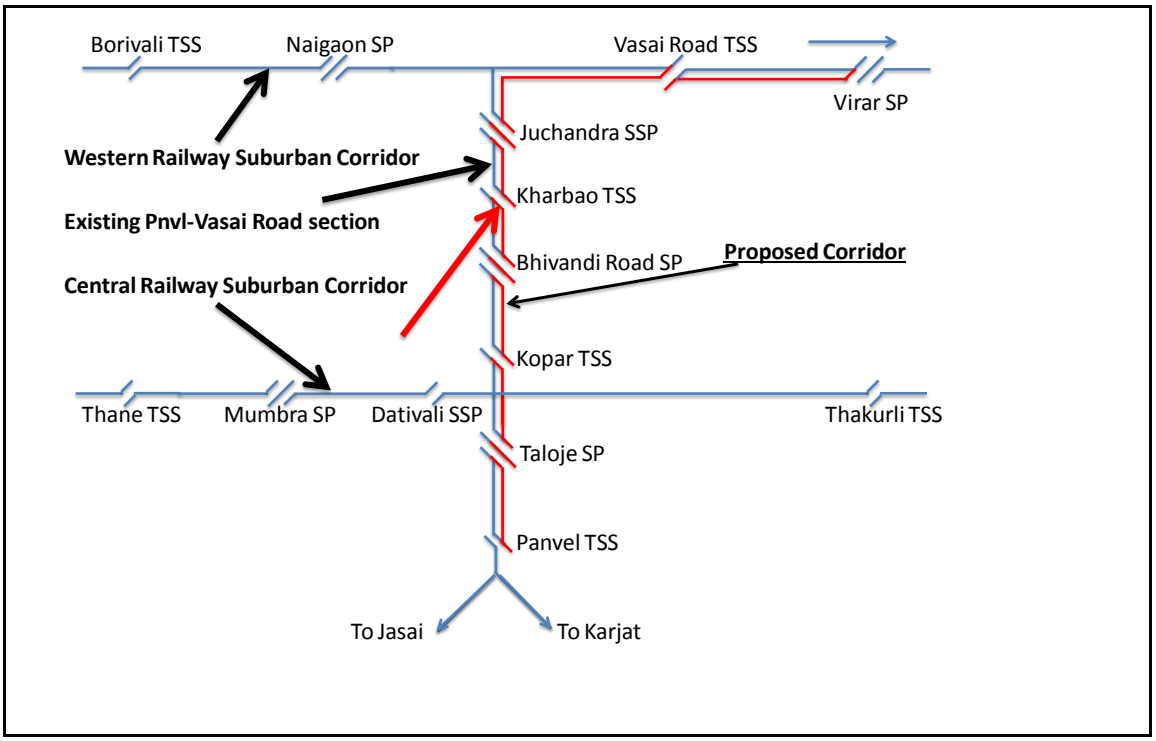
8. POWER SUPPLY SYSTEM

8.1 EXISTING POWER SUPPLY ARRANGEMENT

Existing Panvel-Diwa-Vasai section is operational on 25 kv AC traction, therefore it is logical to adopt same system for proposed suburban corridor also. This section broadly covers the power supply system to meet the power requirement for various horizon years, designed loads, sources of supply, broad description about distribution network and major equipment etc.

It is also prudent that power supply arrangements of the proposed corridor are integrated with existing arrangements so as to get ease of maintenance, economy of operation and keeping initial cost also bare minimum. At present, traction power requirement of existing section is met by three traction substations at Panvel, Kharbao, and Vasai Road and these traction substations are equipped with two transformers of 21.6 MVA rating and their present loading is around 10 MVA each. Therefore possibility has been explored to utilize existing TSS to feed power for proposed corridor also. Panvel TSS has a total feeding zone of 37 km (towards Nilje SP = 21 km and 16 km upto vasai yard and light loading due to Panvel-Karjat section), Kharbao TSS has a total feeding zone of 32km (towards Nilje SP = 17km and 15km upto Juchandra SP) andVasai TSS has a total feeding zone of 19 km (5 km towards Juchandra SP and 4 km towards Naigaon SP (Borivali end) and 10 km upto Virar SP). The schematic diagram power supply arrangement of existing sections and proposed corridor is given below:



8.2 ESTIMATION OF POWER DEMAND

The proposed corridor will be a predominantly a suburban corridor but it will also be available for goods operation and long distance mail express trains during margins available in the time table and also to meet any emergency situations. Suburban trains require more energy as compared to mail express or goods train. Therefore capacity of the power supply system shall be designed by assuming entire line capacity is utilized for suburban services ie 12 car services with headway of 3.0 minutes. Specific energy consumption data for suburban trains for different types of services ie fast-local, slow-locals or semi-fast-locals are available based on trial done on Central Railway suburban system with Siemens rakes. Specific energy consumption is the energy consumed for hauling 1000 tonnes of goods for a distance of one km, this DATA is used to work out the number of traction substation to be installed and the capacity of transformer to be used. Existing corridor has average 5.37 km inter station distance with 13 station and it is proposed to have additional 11 stations therefore 69.8 km long corridor will have 2.8 km inter station distance. Specific energy consumption is dependent on inter-station distance ie for shorter distance it is high and vice versa. Details of the result of trials conducted on AC/DC rakes of Siemens make on Central Railway suburban system, summarized as under;

Table 8.1

Inter-station Distance (km)	**Specific Energy Consumption(SEC)** kWh/1000 GTkm	
	Empty rake	With dense crush load
1.0	62.9	50.8
1.5	47.6	39.8
2.5	33.1	29.3
4.0	25.8	22.3

MVA demand for proposed corridor has been calculated based on above results with the help of following formulae,
Demand in MVA =km*(SEC/1000)*Train wt.*(Trains/hr.)*2*1.05/p.f

Factor of 1.05 has been taken into account to consider requirement for station auxiliaries and S & T demand @ 3% and other losses in system @ 2%, similarly, power factor of 0.9 has been considered to convert energy (KWH) into demand (KVA).

8.3 POWER REQUIREMENT FOR DIFFERENT LEVEL OF SERVICES

As per pink book of year 2012-13, work of automatic block signalling (ABS) in the existing corridor of Panvel –Vasai Road section will be taken up. Today, Cummulative demand of both TSS is 20 MVA, & assuming demand will double after introduction of ABS and section is reaching its saturation limit in the inception year itself. This means enhanced demand of TSS's namely Panvel and Kharbao will become 40 MVA. Similarly demand of Vasai TSS is likely to go from present level 4.67 MVA to 9.33 MVA.

Table 8.2

TSS	Present Demand	Likely demand after 2021
Panvel and Kharbao TSS	20 MVA	40 MVA
Vasai Road TSS	4.67 MVA *	9.33* MVA
Total	24.67 MVA	49.33 MVA
* Due to Diwa-Vasai section traffic and this does not include Demand due to Traffic of Borivli-Virar section		

Due to traffic in proposed suburban corridor, MVA demand is likely to grow to 13.87, 26.1 and 41.81 MVA in year 2011, 2031 and 2041 respectively. To meet gwouth of proposed and existing corridor, it is proposed to provide one additional TSS in the middle of the corridor namely at Kopar. Projected demand of new corridor and existing corridor in various horizon years is summarized as under:

Table 8.3

Demand Due to	Year	Demand in MVA				
		PNVL	Kopar	KHRB	BSR	Total
12-Car-15 min	2021	3.59	4.12	3.91	2.25	13.87
12-Car-8 min	2031	6.75	7.77	7.34	4.24	26.1
12-Car- 5 min	2041	10.83	12.42	11.78	6.78	41.81
12-Car-3 min	Designed	18.09	20.75	19.65	11.32	69.81
Existing corridor in 2031		15.87	10.34	13.79	9.33	49.33
Both corridor in 2031		19.46	14.46	17.7	10.80	63.2
Total requirement with 3 min service in new Corridor		45.7	26.94	33.58	17.60	123.05

Table 8.4: Feeding Zone proposed for of TSS

TSS	PANVEL	Kopar	KHARBAO	VASAI ROAD
Feeding Zone	Panvel-Dhansar Jasai-Panvel	Dhansar-Bhivandi Rd	Bhivandi Rd-Juchandra	Juchandra-Virar Naigaon-Virar
KM	12.7+16=28.7	18.7	24.94	5+14=19

8.4 POWER SUPPLY ARRANGEMENT PROPOSED

Panvel and Vasai Road TSS's have other duties, apart from serving for PNVl-Vasai-Virar section. Vasai TSS is important for suburban train operation in Borivli-Virar section of western railway and Panvel TSS is serving for PNVL-KJT and PNVL-Jasai sections also. Therefore while deciding number of TSS and capacity of transformers,

future growth of existing corridor being served by these TSS is also to be considered. To meet the additional load of new corridor, it is proposed to replace both 21.6 MVA transformer at all three TSS by 30/42 MVA transformers and provision of third transformer at Panvel, Kharbao and Vasai Road TSS, 12 car services with 2.5 minutes frequency will be feasible.

Kharbao TSS is adjoining with Vasai Road TSS, and it is not advisable to take service of Vasai TSS to feed power in Central Railway boundaries in the event of failure of Kharbao TSS as emergency feed. This means Kharbao and Panvel TSS's are to serve for each other in case of any emergency and this arrangement will not be healthy when new corridor is commissioned and power requirement is higher from present level. Therefore it is proposed to provide one additional TSS at Kopar station by drawing TATA power at 110 kv from Thakurli receiving station by laying 110 kv cable. This TSS shall be equipped with three units of 30/42 MVA. With addition of one new TSS, in case of shut down of one complete traction substation due to grid failure or due to any other reason, emergency feeding arrangement will be as under;

Table 8.5

Year	Normal Demand			Demand during Outage of one TSS		
	Kharbao	Kopar	Panvel	Kharbao	Kopar	Panvel
2021	17.75	13.31	20.42	-----	31.06	20.42
	17.75	13.31	20.42	31.06	-----	20.42
	17.75	13.31	20.42	17.75	33.73	-----
2031	21.18	15.88	24.37	-----	37.07	24.38
	21.18	15.88	24.37	37.07	-----	24.38
	21.18	15.88	24.37	21.18	40.26	-----
2041	25.59	19.19	29.45	-----	44.78	29.45
	25.59	19.19	29.45	44.78	-----	29.45
	25.59	19.19	29.45	25.59	48.64	-----
Designed Capacity	34.55	25.91	39.76	-----	60.47	39.76
				60.47	-----	39.76
				34.55	65.68	-----

From above it clear that in the inception year, during the outage of Panvel and Kharbao TSS , Kopar TSS is likely to be loaded upto 33.73 and 31.06 MVA respectively; and it is well within upgraded rating of 42 MVA by providing forced air cooling (ONAF). But by year 2031, maximum demand at Kopar TSS will touch 48.64 and 44.78 MVA during the outage of Panvel and Kharbao TSS respectively. Therefore around year 2031, Kopar TSS will require provision of third transformer of 30 MVA rating. During outage of either Panvel or Kharbao TSS, parallel operation of two transformer of 30 MVA capacity will be required. Similarly, by year 2041, Kharbao

TSS will also need provision of third transformer to meet the reqirement of emegency feed. To support design capacity also ie 3 minute service, Kharbao and Kopar TSS will need third transformer. This arrangement will have provision for availablity of Panvel TSS to support future provision for traffic ie doubling of PLVL-KJT line or electrification of Panvel-Pen-Roha section. PNVL TSS will not beused to meet emergency feed requirement in Panve-Vasai Rd section. Schamatic diagram of the propsed arrangement is shown below.

Table 8.6

TSS	MVA Capacity at TSS			
	2012	2021	**2031**	2041
Vasai Road	2*21.6	2*30	2*30	2*30
Kharbao	2*21.6	2*30	2*30	3*30
Panvel	2*21.6	2*30	2*30	2*30
New TSS at Kopar	--------	2*30	3*30	3*30
Total	64.8+64.8	120+120	150+120	180+120
Grand Total	**129.6**	**240**	**270**	**300**

With the proposed corridor, Panvel-Vasai Raod section will become 4-line section similar to the present 4-line Borivli-Virar section. For Mumbai Suburban area, protection scheme as per RDSO specification no TI/SPC/PSI/PROTECT/4050 will have to be adopted, therefore all feeding post, sectioning post (SP) and sub-sectioning post (SSP) will be equipped with circuit breakers in place of interrupters used at present.

For Kopar TSS, premises of exIsting DC TSS has been selected and size of this premises is not enough to have TSS with conventional air insulated switchgears, therefore is proposed to use latest state of switchgears ie gas insulated switchgears for this TSS. Supply will be taken from Thakurli receiving station which is connected to the network of M/s Tata Power Company. Other two substation are connected on MSETCL network therefore this will an added advantage ie in case of failure of grid of MSETCL, Tata feed can be used for maintaining train operations. GIS switchgears are widely used by SEB's and these are being used by various metros in our county to achieve their advantages such as almost maintenance free, less requirement of space, quick erection and commissioning etc. Cost of GIS equipment's are declining with their use increasing day by day therefore its advantages will offset its initial higher cost in time to come.

8.5 AUXILIARY SUPPLY ARRANGEMENT FOR STATIONS & DEPOT

New corridor is proposed to be opened with 25 stations ie additional of new 12 stations over and above existing 13 existing stations. Tapping HT supply from the nearest point of local supply undertaking will ensure reliable power supply for passenger amenity items and general power supply arrangement. Substation design shall be done in such a way that it meets not only the requirement of all passenger amenity items which will be introduced in the inception year and it shall also be

upgradable to meet the requirement of items likely to be introduced later. Typical design of a substation is as under;

Table 8.7: Summary of Loads (KW) for Typical Elevated/At Grade Station

S. No	Type of load	Elevated Stn.		
		Connected load	Diversity	Substation Load
1	Lighting load	40	1	40
2	Fan & other Misc small power load, power plugs etc.	50	0.5	25
3	Escalators (2Nos) @25Kw	50	1	50
4	Lifts (2Nos) @15Kw	30	1	30
5	Pumps	20	0.5	10
6	Signaling & Telecom	5	1	5
	Total Load (KW)			**160**

8.6 ELECTROMAGNETIC INTERFERENCE (EMI)

25kV ac traction currents produce alternating magnetic fields that cause induced voltages to be in any conductor running along the track. Booster Transformer and Return Conductor (BT/RC) system is proposed for EMI mitigation for elevated section.
Concrete structures are not good electrical earths and therefore, Earthing & Bonding of the power supply & traction system shall be designed in accordance with the latest standards EN50122-1, IEEE80, IS3043 etc.

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 and Earthing & Bonding plan is required to be developed during detailed design stage.

8.7 25 KV FLEXIBLE OVERHEAD EQUIPMENT SYSTEM

25 kV ac regulated Flexible Overhead equipment system shall comprise of HD-copper contact wire (150 sq mm in WRly territory and 193 sq mm in CRly territory) and 65sqmm Cd-copper centenary wire. Return conductor (RC) shall be All Aluminium Conductor (AAC) of 233 sq mm cross section.

8.8 MODIFICATION OF POWER LINE CROSSINGS

Modification of power line crossing listed at para 3.2.9 in chapter 3, will be required to be modified to get adequate clearances stipulated in ACTM and Schedule of Dimension for Broad Gauge.

8.9 SPECIFICATION OF EQUIPMENT

With addition of proposed new corridor, existing corridor will become four line corridors; therefore, protection scheme for PSI equipment suitable for Mumbai suburban system issued by RDSO is proposed to be implemented. Similarly for other items such as SCADA, PSI equipment, OHE items etc of latest RDSO specifications will be used. Rating of traction transformers, switchgear, cables, auxiliary transformer etc. have been worked out based on the conceptual design, however, these may be required to be revised and fine-tuned during detailed design stage of project implementation.

8.10 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 standby DG set of 200 kVA capacities at elevated/at grade stations to cater to the following essential services:

- Essential lighting
- Signalling & telecommunications
- Fire fighting system
- Lift/Escalators operation
- Fare collection system

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

8.11 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

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

8.12 ENERGY SAVING MEASURES

Energy charges will 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 for High Speed Metro corridor 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 Overhead equipment system to be consumed by nearby trains to the grid.

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 (operation or maintenance hours etc) through SCADA.

iv. Machine-room less type lifts with gearless drive has 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) has 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.

8.13 ELECTRIC POWER TARIFF

The cost of electricity is about 25-35% of total Operation & Maintenance (O&M) Cost. Therefore, it is the key element for the financial viability of the Project. The annual energy consumption is assessed to be about 100 million units in initial years (2019), which will increase to about 300 million Units by horizon year 2041. 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 this corridor should be at effective rate of purchase price (at 100kV/220kV 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. 4.00 - 4.50 per unit. It is proposed that Government of Maharashtra takes necessary steps to fix power tariff for this Suburban Corridor at “No Profit No Loss” basis.

Annual energy consumption for proposed corridor is calculated as under:

AEC=365*Length of section (km)*(Nos. Of train per day in both direction)*weight of 12 car*(SEC/1000)

8.14 ALTERNATE TRACTION SYSTEM PROPOSED

With conventional traction system, three TSS namely Panvel TSS (2*30 MVA), Kopar TSS (3*30 MVA) and Kharbao TSS (2*30 MVA) are required to meet the designed capacity in central railway territory and Vasai Road TSS in western railway territory. Alternatively, if 2x25 KV AT system is adopted in Panvel-Vasai Road section ie in central railway territory, only one TSS at Kopar, the mid point of the section, can achieve the designed capacity. This system will consist of one TSS with two numbers of three phase Scott connected transformers of 54 MVA rating, and SP/SSP at every 12-15 KM with autotransformer.

This system is operational in Bina-Katni-Annupur-Chirmiri Section of WCR and SECR railways since 1995. This system is considered energy efficient as compared to conventional system. Dedicated freight corridor has also adopted this system.