are additional and agreed for implementation of the proposed scheme. The scheme will be taken up in next NCT meeting for approval & finalisation of mode of implementation.

Scope of work along with tentative Cost and Implementation time-frame:

Sl. No.	Scope of the Transmission Scheme	Implementation time-frame	Total Estimated Cost (Rs. Cr)
1.	➢ Augmentation with 1x500MVA, 400/220kV transformer (3rd) at 400/220kV Bahadurgarh (PG) S/s	Jul'24.	Rs 117 Cr
	➢ 2 nos of 220 kV line bays at 400/220 kV Bahadurgarh (PG) S/s(for 220 kV D/c line from Kharkhoda pocket B)	Jul'24	
	➢ 2 nos of 220 kV line bays at 400/220 kV Bahadurgarh (PG) S/s (for 220kV METL – Bahadurgarh (PG) D/c line)	Mar'24	
	➢ Augmentation with 1x500MVA, 400/220kV transformer (3rd) at 400/220kV Jind (PG) S/s	Dec'23	
	➢ 2 nos of 220 kV line bays at 400/220 kV Sonepat (PG) S/s (for 220 kV D/c line from Kharkhoda pocket A)	Jul'24	

D)Rajasthan

I. Augmentation of Transformation capacity at Bhinmal S/s

In the 4th NRPC(TP) meeting held on 05.10.21 & 12.10.21, POSOCO highlighted the issue of 'N-1' non-compliance of loading of ICTs at Bhinmal (PG) S/s. POSOCO informed that currently with 2 no. of 315 MVA ICTs, loading of ICTs was more than 'N-1' compliance limit (>420 MW) for most of the time in Jan'21, Feb'21 and first week of March'21. POSOCO recommended that new ICTs may be planned or capacity enhancement of existing ICTs may be explored. POWERGRID confirmed the space availability for 3rd ICT at Bhinmal.

In the above meeting, replacement of one no. of 315 MVA, 400/220 kV ICT at Ludhiana (PG) S/s with a 500 MVA, 400/220 kV ICT was discussed and agreed. It was also decided that the 315 MVA ICT spared from Ludhiana may be shifted to Bhinmal based on the residual life assessment or refurbishment (if required).

Sl. No.	Scope of the Transmission Scheme	Implementation time-frame	Total Estimated Cost (Rs. Cr)
1	Shifting and installation of 400/220 kV, 315 MVA ICT at Bhinmal (PG) S/s spared from Ludhiana (PG)	12 months i.e. Mar'23	Rs 18 Cr

POWERGRID informed that the condition of said ICT was evaluated departmentally based on condition monitoring test on ICT and condition of ICT was found healthy. Subsequently, POWERGRID vide mail dated 21.02.22 also confirmed receipt of CPRI report on condition assessment dated 15/02/22 declaring healthiness of the transformer.

Accordingly, it is agreed in the meeting to shift the spared 315 MVA ICT from Ludhiana (PG) to Bhinmal S/s and installation of the same along with implementation of associated ICT bays at 400/220 kV Bhinmal (PG) S/s.

Scope of work along with tentative Cost and Implementation time-frame:

Sl. No.	Scope of the Transmission Scheme	Implementation time-frame	Total Estimated Cost (Rs. Cr)
1	Shifting and installation of 400/220 kV, 315 MVA ICT at Bhinmal (PG) S/s spared from Ludhiana (PG)	12 months i.e. Mar'23	Rs 20 Cr
2	Implementation of associated ICT bays (1 no. of 400 kV and 1 no. of 220 kV) at Bhinmal (PG) S/s		

The schematic of above Transmission system is under

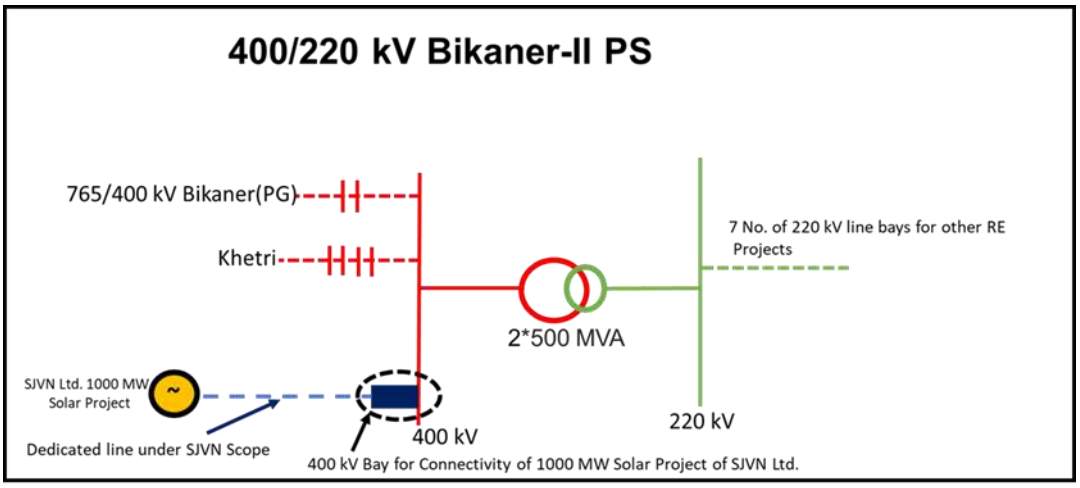

Figure 4-7: Schematic of Augmentation of Transformation capacity at Bhinmal S/s

4.5 Perspective transmission schemes under planning

A) Transmission system for evacuation of power from Zangla/Padum UMREPP in Kargil (2.5GW)

Study & analysis has been carried out for evacuation of power from Kargil UMREPP of 2.5GW capacity in Ladakh through 400kV High Capacity D/c corridor via Kashmir. The EHVAC corridor has been considered from Zangla/Padum-Alusteng via Drass. The total length of corridor is about - about 340kms (incl. U/G cable- about 25km). In Drass and Alusteng, anchoring with 220kV existing substation shall facilitate feeding the local demand.

In this scenario due to very low short circuit strength of proposed new substations viz Zangla/Padum, Drass(New) & Alusteng (New), reactive power management/voltage stability both for peak solar and no solar scenario would be addressed through STACOMs along with MSR/MSC of suitable capacity at Zangla/Padum & Drass (New) to address voltage stability

For power transfer beyond Alusteng, 400kV Alusteng – Amargarh and 400kV Alusteng – New Wanpoh is proposed. The scheme is under various stages of finalization

B) Issue of high voltage and requirement of reactive compensation at the various substations

In 4th NRPC meeting, issue of high voltage and requirement of reactive compensation at the various substations was deliberated. In the meeting CTUIL informed that due to prevailing high voltage in NR grid, it is observed that some of the 400kV ISTS lines having more than 200 km line length and without any line compensation experience difficulty in line charging.

CTUIL had further mentioned that Powergrid had analysed the past one-year data of voltage profiles of terminal substations of above ISTS lines and based on their detailed analysis and keeping in the view the availability of space at the substation, Powergrid has proposed the following

(i) Installation of 50 MVAR switchable line reactor at Mainpuri end and fixed 50 MVAR line reactor at Ballabgarh end on 400 kV Mainpuri- Ballabgarh D/c line.
(ii) (ii) Installation of 50 MVAR switchable line reactor at Allahabad end on 400 kV Kanpur- Allahabad line.
(iii) Installation of 50 MVAR line reactor at Bhiwadi end for uncompensated circuit of 400 kV Agra- Bhiwadi D/c line.

CTUIL has also carried the studies on the issue of high voltages in the grid and CEA vide its email dated 1.10.2021 has circulated the observations furnished by CTUIL to the constituents. Based on the analysis done by CTUIL, following additional reactive compensation (bus and line reactors) is proposed under Inter State transmission system strengthening scheme:

(i) 1x240MVAr switchable Line reactor at Moga end of 765kV Bhiwani-Moga line
(ii) 1x330MVAr,765kV Bus reactor at Fatehpur S/s

(iii) 1x80MVAr switchable Line reactor at Neemrana end of 400kV Sikar-Neemrana line (It will also improve voltage profile of Neemrana S/s which carry RE power through Sikar-2-Neemrana D/c line)
(iv) 1x80MVAr switchable Line reactor at Amritsar end of 400kV Banala-Amritsar line

In addition, CTUIL has also proposed the following:

(i) STUs may also explore bus reactive compensation at 400kV STU nodes (which doesn't have bus reactive compensation):
- HPPTCL -Wangtoo, Lahal, Gumma etc.
- HVPN -Daultabad, Deepalpur, Kabulpur, Dhanonda, Kirori, Nawada & Nuhiawali
- UPPTCL- Ataur, Badaun, Gonda, Harduaganj, Indirapuram
- RVPN- 765kV Anta, 400kV Ajmer
- PSTCL- Rajpura

(ii) STU/DISCOM should also ensure that shunt capacitors at sub transmission/distribution level may be switched off during off peak condition to avoid MVAr injection into the Grid. POSOCO also analysed the issue of high voltages in Northern region and made presentation highlighting the various nodes NR which are experiencing high voltages.

The matter was deliberated at a length and following was agreed:

i.) STUs would provide inputs regarding the reactors planned at various intra-state substations in the respective states along with their implementation timelines.
ii.) STUs would explore the possibility of installation of reactors at the node mentioned and accordingly intimate to CEA and CTUIL
iii.) Based on the inputs from STUs, CTUIL would carry out the studies to assess the requirement of reactive compensation at various nodes in Northern Region to overcome the issue of high voltages

Further data from most of states is received and comprehensive studies for high voltage and requirement of reactive compensation at the various substations is under process.

C) Transmission system for evacuation of RE power from Rajasthan Ph-IV (48GW)

MNRE vide letter 15.02.22 informed that SECI has identified REZs of aggregate capacity of 181.5GW in eight states for achieving 500GW capacity from Non Fossile fuel (incl. RE) by 2030. in the Meeting held on 02.02.2022 for identification of Renewable Energy Zones for achieving 500 GW capacity from non-fossil fuels (including RE) by the year 2030, SECI informed that at present, the installed capacity from Renewable Energy (RE) is150 GW (including large hydro). In addition, planning has already been done for around 132.48GW of capacity and further, there is margin in existing ISTS due to which RE capacity of around 33.87 GW may be set up in different states. This brings the total to around 316.35 GW. view of above, planning is to be done for around 183.65 GW. These RE capacities include the Solar –Wind hybrid projects along with energy storage systems. In the meeting, it was decided that based on the above identified REZs, CEA & CTU will prepare the transmission plan.

Out of total capacity, planning is to be done for 75GW RE (60GW-Solar, 15GW-Wind) installed capacity in Rajasthan with evacuation requirement of 48GW from GIB (Jaisalmer, Jodhpur, Barmer) and Non GIB Zones Sanchore, Sirohi, Jalor, Pali, Ajmer, Bikaner, Nagaur).

D) North-West Inter regional system strengthening scheme to relieve high loading of 400 kV Bhinmal- Zerda Inter-regional line

In the 3rd meeting of NRPC (TP) held on 19.02.21, it was discussed that more RE power is rushing towards Bhinmal and causing overloading beyond Barmer/Bhinmal especially high loading on 400 kV Bhinmal - Zerda line. This is also due to incremental intra state RE generation in western Rajasthan.

400 kV Bhinmal-Zerda line being an inter-regional corridor between NR & WR, this line may impact the inter-regional transmission capacity which may lead to operational constraints. Moreover, in low wind season (mainly Jan-Feb), due to less wind generation in Kutch area of Gujarat (Bhuj, Bhuj-II, Jam Khambhaliya, Khavda etc.), the loading in 400 kV Bhinmal-Zerda corridor further increases in peak Solar generation period (10 AM-2 PM).

NLDC(POSOCO) vide letter dated 7th Feb, 2021 requested to take actions to relieve the transmission constraints due to high loadings on 400kV inter regional transmission lines between Gujarat (WR) & Rajasthan (NR).

In the letter, it was informed that the direction of flow on 400 kV Bhinmal-Zerda & 400 kV Kankroli -Zerda lines is mostly from NR to WR and the loading on 400 kV Bhinmal-Zerda is above 500 MW for 5% of time which lies mostly during March & April month. The loading is N-1 insecure particularly when the generation within Gujarat is low and demand in Gujarat is high. Similar aggravates when the above coincides with high RE in Rajasthan (Solar Max scenario) and low demand in Northern Region. The non-availability of reverse power flow on HVDC Mundra-Mahendragarh Bipole further compounded the problem in operational horizon. In the coming months, the new RE capacity addition in Jaisalmer, Barmer and Ramgarh area of Rajasthan is expected. The incremental RE injection may aggravate the situation causing further increase in line loadings.

It was also informed the high loadings on these lines are limiting constraint in ATC/TTC calculation between western region and northern region and are likely to be in future also.

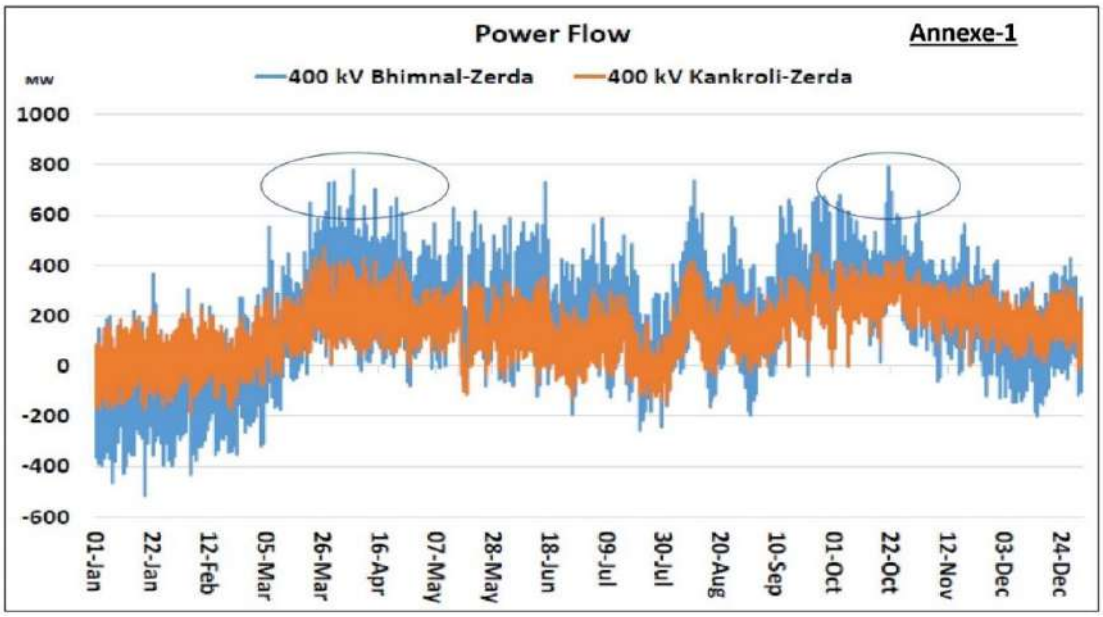

Figure 4-8: Loading of Bhinmal-Zerda & Kankroli-Zerda line for the past year (Source :POSOCO)

Considering the severity of overloading of 400kV Bhinmal - Zerda line, it was proposed that additional strengthening scheme need to be planned.

POSOCO have further informed about the power flow pattern in WR-NR corridors under the prevailing scenario of high RE(Solar) generation in Rajasthan, low demand in Northern region, high demand in Western & Southern region coupled with low generation from imported coal based conventional generations in Gujarat (mainly CGPL & Mundra UMPP) due to various issues and non-availability of HVDC Mundra-Mahendargarh bipole in reverse direction (NR to WR).

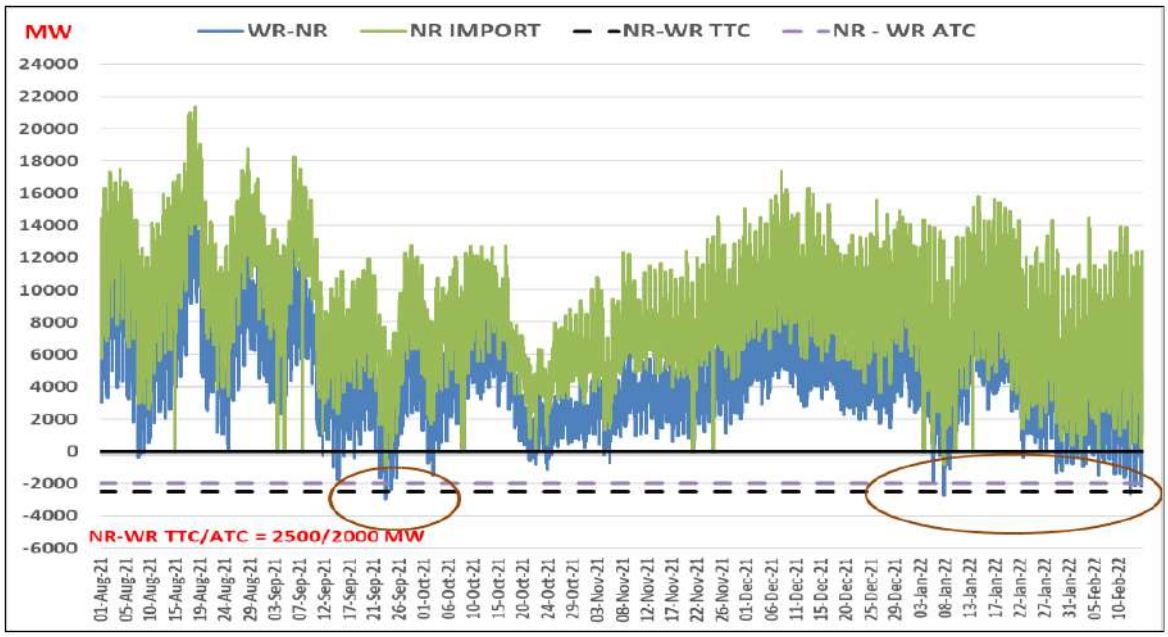

Figure 4-9: WR-NR & NR Import Flows (Source:POSOCO)

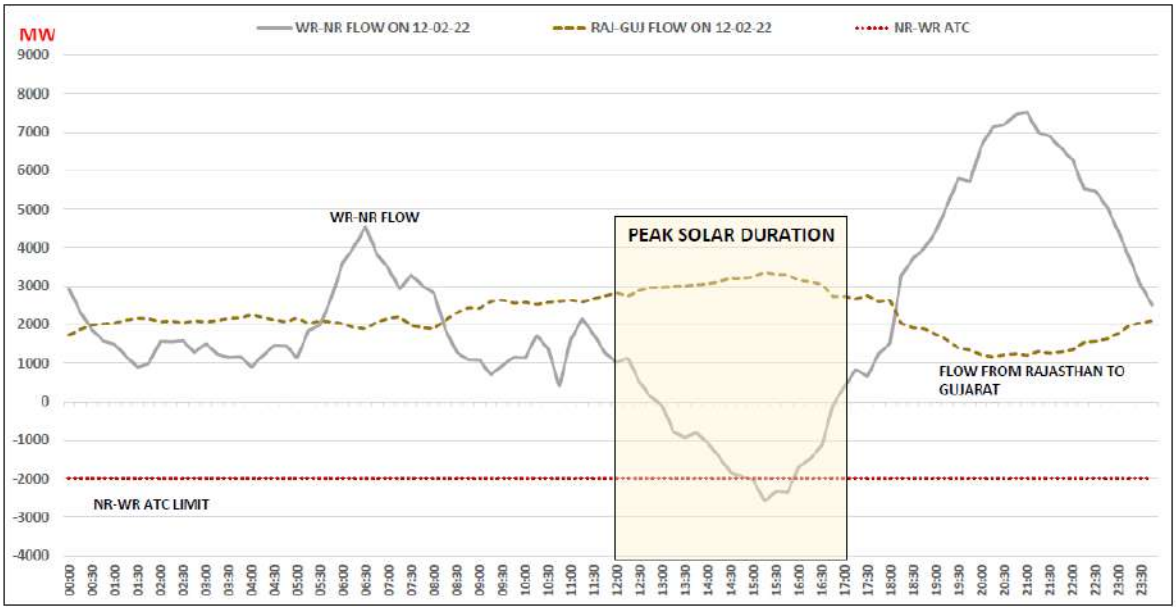

Figure 4-10: Pattern of WR-NR & Raj – Guj (Sec Axis) Flow for a Typical Day (12.02.2022) (Source: POSOCO)

From the prevailing scenario, it was observed that this pattern of NR-WR flow is mainly observed in winter season when the wind generation in WR is very low and dispatch of conventional plants in WR remain low. Under this emerging scenario, the power from Rajasthan rushes towards Gujarat during solar max condition due to high solar generation in Rajasthan and high demand and low generation in Gujarat.

In order to relieve above transmission constraint in emerging scenario, an additional high capacity Inter regional (IR) corridor between NR-WR is required. Further, Rajasthan is witnessing more RE generation in ISTS with allocation to WR & SR on firm basis from manufacturing linked plants (2024-25) which necessitates additional WR-NR corridor for power dispersal.

Considering all above aspects, studies are undergoing for winter solar max scenario for 2024-25 timeframe with low dispatch of Mundra-APL & CGPL.

4.6 System study analysis and results

4.6.1 Voltage Analysis

Voltages of all 765 kV and 400 kV buses were observed in all the nine scenarios. Maximum and minimum voltage of each bus were identified from the bus voltages in the nine number of scenarios. From the simulation results, no issue of undervoltage it was observed in Northern Region.

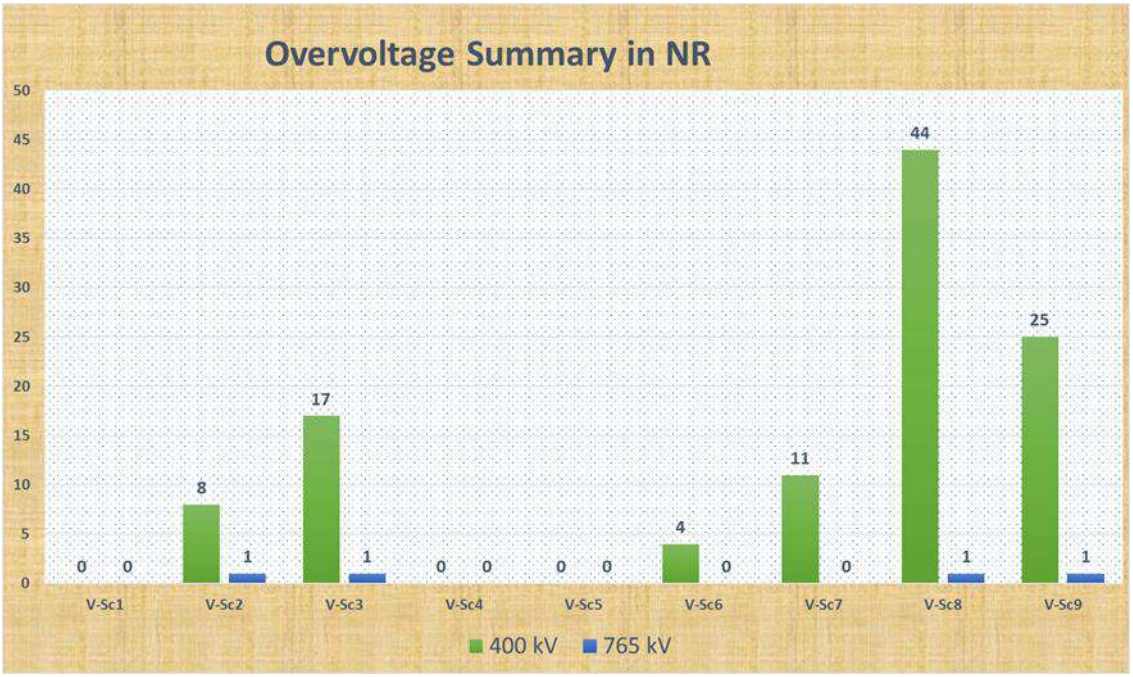

Figure 4-11: No. of S/s having Overvoltage in NR in various scenarios

However, 765kV & 400kV buses were observed to be having voltage more than 1.05 pu (in minimum two scenarios) is depicted in Table 4-6:

Table 4-6: Substations having high voltage in NR (>1.05pu in minimum 2 scenarios) (2026-27)

Sl. No.	Bus Name	Voltage Level(kV)	Owner	Max(pu)	Scenario
1	Jodhpur Kankani	765.00	STU	1.06	2,3,7,8
2	Chamera-1	400.00	ISTS	1.06	8,9
3	Hamirpur	400.00	ISTS	1.07	8,9
4	Ropar	400.00	STU	1.07	8,9
5	Dhanasanu	400.00	STU	1.08	7,8,9
6	Behmnjsingh (Malkana)	400.00	STU	1.09	3,7,8,9
7	Talwandi Saboo	400.00	STU	1.08	7,8,9
8	Dhuri	400.00	STU	1.08	7,8,9
9	Makhu	400.00	STU	1.1	3,6,7,8,9
10	Mukatasar	400.00	STU	1.1	3,6,7,8,9
11	Nakodar	400.00	STU	1.08	3,7,8,9
12	Rajpura	400.00	STU	1.07	8,9
13	Amritsar	400.00	ISTS	1.09	3,6,7,8,9
14	Moga (split section)	400.00	ISTS	1.06	8,9
15	Patiala	400.00	ISTS	1.06	8,9
16	Patran	400.00	ISTS	1.06	8,9
17	Ludhiana	400.00	ISTS	1.06	8,9
18	Jallandar	400.00	ISTS	1.08	7,8,9
19	Malerkotla	400.00	ISTS	1.06	8,9
20	Barmer	400.00	STU	1.06	3,8
21	Bhinmal	400.00	ISTS	1.05	3,8
22	Raj West	400.00	STU	1.05	3,8

Sl. No.	Bus Name	Voltage Level(kV)	Owner	Max(pu)	Scenario
23	Deedwana	400.00	STU	1.06	2,3,9
24	Ajmer	400.00	STU	1.05	2,3
25	Pachpadra	400.00	STU	1.07	2,3,8,9
26	Jodhpur (Surpura)	400.00	STU	1.06	2,3,8,9
27	Jodhpur (Kankani)	400.00	STU	1.06	2,3,8,9
28	Hanumangarh	400.00	STU	1.07	2,3,8,9

From the voltage analysis, it is emerged that some of substations i.e. Jodhpur Kankani, Moga, Barmer, Bhinmal utilized for evacuation of Solar/RE power in Rajasthan.. Due to no solar generation in evening/night time, there is minimal power flow on these 765kV long lines impacting high voltages. However adequate bus reactive compensation is also provided in this regard. Some of substations i.e. Talwandi Saboo, Makhu, Mukatasar, Nakodar, Dhuri, Dhanasanu, Amritsar, Patiala, Ludhiana, Jallandar, Malerkotla, Jodhpur (Surpura), Jodhpur (Kankani), Hanumangarh, Patran having high voltage in off peak scenarios and in winter season due to low demand in NR.

In the 4th NRPC meeting, issue of high voltage and requirement of reactive compensation at various substations was deliberated. In the meeting CTUIL informed that due to prevailing high voltage in NR grid. CTUIL has also carried the studies on the issue of high voltages in the grid and CEA vide its email dated 1.10.2021 has circulated the observations furnished by CTUIL to the constituents . In the meeting it was deliberated that

- STUs would provide inputs regarding the reactors planned at various intra-state substations in the respective states along with their implementation timelines.
- STUs would explore the possibility of installation of reactors at the node mentioned and accordingly intimate to CEA and CTUIL
- Based on the inputs from STUs, CTUIL would carry out the studies to assess the requirement of reactive compensation at various nodes in Northern Region to overcome the issue of high voltages

Comprehensive studies for high voltage and requirement of reactive compensation at the various substations in NR is undergoing and taken up in next rolling plan.

4.6.2 Contingency Analysis

a) Transmission Lines

In the base case file prepared for 2026-27 timeframe, in NR, 11 nos. of 400 kV lines are observed to be having critical loading in base case as well as Contingency scenario. Details of such lines are as under (Table 4-7):

Table 4-7: Major transmission lines having critical loading in NR (Base case/Contingency) (2026-27)

Sl. No.	Name of the Line	Scenario No.	Case	Owner	Max Loading	Rating	Remark
1	Baglihar – New Wanpoh 400kV line	1,4, 5,7	Base case (SC-4), Contingency (Sc 1,5,7)	ISTS	911 (1215 under n-1)	857 (Twin Moose)	The line loading will be higher in solar maximized scenario. Loading will be relieved with upcoming UMREPP in Kargil area
2	400kV Rajpura thermal-Rajpura D/c line	2,6	Contingency	STU	902 (under n-1)	857 (Twin Moose)	The line loading is marginally higher as per dispatch of Rajpura TPS.
3	400kV Jaisamer-2 -Barmer D/c line	1,4,7	Contingency	STU	1070 (under n-1)	857 (Twin Moose)	The line loading is higher in Solar maximized scenario. With proposed upgradation of Jaisalmer-2 S/s, loading may relieved
4	400kV Merta - Jodhpur(Kankani) line	1,4	Contingency	STU	884(under n-1)	857 (Twin Moose)	The line loading is marginally higher in Solar maximized scenario. With proposed RVPN schemes loading may relieved.
5	400kV Barmer - Bhinmal line	1,4,7	Contingency	ISTS	1328(under n-1)	857 (Twin Moose)	The line loadings are higher in Solar maximized scenario and further aggravated with low wind and high demand of Gujarat in winter. Strengthening scheme is under planning to relieve above loadings
6	400kV Kankroli - Jodhpur(Surpura) line	7	Contingency	ISTS	1328(under n-1)	943(Twin Moose)	
7	400kV Meja-Allahabad D/c line	2,3,5, 6.7.8	Contingency	ISTS	1078 (under n-1)	857 (Twin Moose)	The line loading is higher in evening peak and night off peak scenario. Action may required
8	400kV Agra-Agra(UP) line	2,3,5,6	Base	ISTS	1160 (under n-1:1452 MW)	857 (Twin Moose)	The line loading is higher in evening peak and night off peak scenario. Action may required.

9	400kV Agra-Agra(Fatehbad) line	2,3,5	Contingency	ISTS	1036 (under n-1)	857 (Twin Moose)	The line loading is higher in evening peak and night off peak scenario. Action may required.
10	400kV Dadri-Muradnagar line	3	Contingency	ISTS	924 (under n-1)	857 (Twin Moose)	The line loading is marginally higher in off peak scenario. Monitoring required
11	400kV Roorkee-Rishikesh line	1,4	Contingency	ISTS	924 (under n-1)	857 (Twin Moose)	The line loading is marginally higher in noon scenario. Monitoring required

b) Transformers

In the base case file prepared for 2026-27 timeframe, transformers at 2 nos. of 765/400 kV substations and 6 nos. of 400/220kV substations are having critical loading. Details of transformers is as under (Table 4-8)

Table 4-8: Major transformers having critical loading in NR (Base case/Contingency)

Sl. No.	Name of the Element	Scenario No.	Owner	Case	Maximum Loading/ICT	Remark
1	765/400kV, 2x1000 +1x1500 MVA Bhiwani ICTs	1,4	ISTS	N-1 Contingency	1192 (on 1000MVA ICT)	High loading observed in Solar maximized scenario. Augmentation/Replacement of ICT may be required
2	765/400kV, 2x1000 MVA Orai ICTs	5, 7	ISTS	N-1 Contingency	1145 (on 1000 MVA ICT)	loading is higher in future due to load growth of UP. Augmentation/Replacement of ICT may be required
3	400/220kV, 3X315 MVA Kishenpur ICTs	1,2,4,5,7	ISTS	Base Case	426	High Loading observed with upcoming HEPs integrated at Kishtiwar/Kishenpur. Augmentation of ICT shall be required
4	400/220kV, 2X500 MVA Sohna Road ICTs	1,2,3,4,5,6	ISTS	N-1 Contingency	668	High loading observed in Summer Season due to high load of Delhi/NCR. Augmentation of ICT may be required beyond 2024-25 frame

5	400/220kV, 2X315 MVA Hindaun ICTs	1,2,3.5,6	STU	N-1 Contingency	415	High loading observed in most of scenarios. Load diversion/Augmentation of ICT shall be required
6	400/220kV, 2X315+1x240 MVA Obra ICTs	2,3,5	STU	N-1 Contingency	348 (on 315MVA ICT)	loading is marginally higher at low/no generation of Obra thermal plant. Augmentation/Replacement of ICT may be required
7	400/220kV, 3X315 MVA Allahabad ICTs	3,5	ISTS	N-1 Contingency	330	loading is marginally higher at few instances. Augmentation/Replacement of ICT may be required
8	400/220kV, 2X315 MVA Agra ICTs	3,5,6	ISTS	N-1 Contingency	373	loading is higher in future due to load growth of UP. Augmentation/Replacement of ICT may be required

4.6.3 Short Circuit Analysis

Short circuit level was calculated for all 765kv and 400 kV buses of Northern Region and buses having fault level more than the design rating under any scenario were identified. From analysis it is emerged that there are 48 nos. of substations (765kV-1 no., 400kV- 47 nos)in NR having fault level more than designed capacity

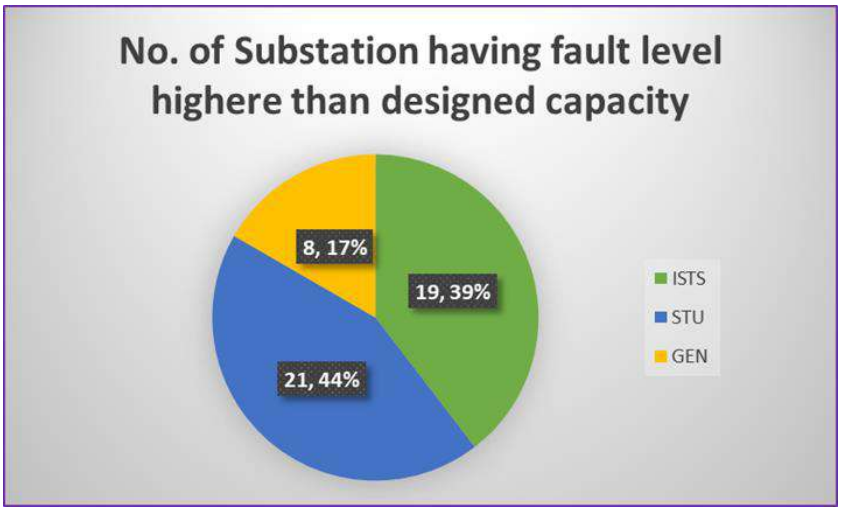

Figure 4-12: NR Substations exceeding fault level

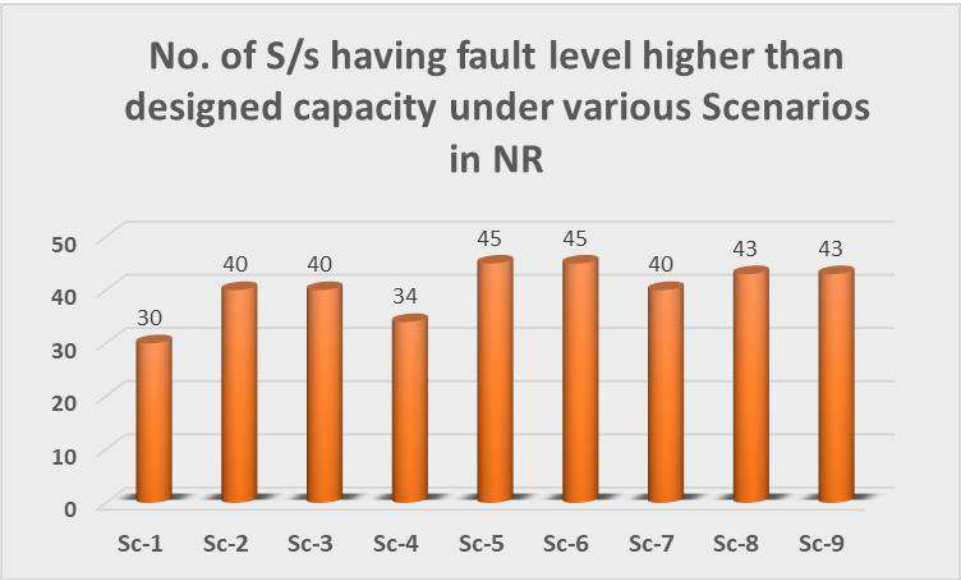

Figure 4-13: NR Substations exceeding fault level under various Scenarios (Nos.)

Out of above,5 nos. of ISTS substations and 10 nos. of STU/Generator substations exceeding fault level more than 20% design fault level for which immediate action shall be required. Details of the substations under any scenario are tabulated below in Table 4-9 and 4-10 :

ISTS Substations

Table 4-9: ISTS Buses Exceeding Designed Fault Level in Northern Region

Sl. No.	Substation Name	Scenario No.	Highest Fault level (kA)	Design Rating (kA)
1	400kV Abdullapur	All	49	40
2	400kV Neemrana	All	49	40
3	400kV Meerut	All	63	40
4	400kV Agra	All	51	40
5	400kV Allahabad	All	50	40

STU/Generation Substations

Table 4-10: STU Buses Exceeding Designed Fault Level in Northern Region

Sl. No.	Substation Name	Owner State	Scenario No.	Highest Fault level (kA)	Design Rating(kA)
1	400kV Dhanonda	Haryana	All	50	40
2	400kV Bawana Gas	Delhi	All	51	40
3	400kV Bawana	Delhi	All	51	40
4	400kV Jaipur (Phagi)	Rajasthan	All	50	40
5	400kV Meja	UP	All	49	40

Sl. No.	Substation Name	Owner State	Scenario No.	Highest Fault level (kA)	Design Rating(kA)
6	400kV Greater Noida (2 S/s)	UP	All	54	40
7	400kV Dadri	Gen (NTPC)	All	53	40
8	400kV Anpara	Gen (IPP)	All	52	40
9	400kV Anpara C	Gen (IPP)	All	51	40
10	400kV Dadri (HVDC)	Gen (NTPC)	All	52	40

Studies to limit high short circuit on ISTS S/s will be carried out and taken up in next rolling plan. STUs/Gen developer are also required to take necessary actions such as bus splitting, bypassing of lines, fault limiting reactors etc to resolve the issue of high fault level at their buses.

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Chapter 5: Western Region

Due to geographical location, Western Region is connected to Northern, Southern and Eastern Regions through 765kV/400kV high capacity corridors along with Back to Back HVDCs and Bi-Pole HVDC links. The thermal generating stations of Western Regions are predominantly concentrated in the coal rich states of Chhattisgarh, Eastern part of Maharashtra and Madhya Pradesh. Further, Gujarat, Maharashtra and Madhya Pradesh are RE rich states comprising of Solar & Wind capacity. Western part of Maharashtra, southern Gujarat and DD & DNH have high demand and less internal generation. Accordingly, power flows from Chhattisgarh/ Eastern Maharashtra through high capacity corridors to Western part of Maharashtra, Southern Gujarat, DD & DNH. Based on the generation availability and demand, Western Region imports power from other regions during high RE scenarios whereas it exports power to other regions during evening peak and night off peak load.

5.1 Present Power Supply Scenario

As on Jan'2022, total Installed Capacity (IC) of Western Region was about 128 GW and the peak demand was about 64 GW. At present, there is no shortage of power supply in meeting these demands. State-wise breakup is summarised at Table 5-1.

Table 5-1:All India Installed Capacity and Demand met as on Jan'22

(All Fig in GW)

State / UTs	Generation						Peak Demand Met
	Thermal	Nuclear	Renewable			Grand Total	
			Hydro	RES	Total		
Gujarat	24.3	0.6	0.8	15.5	16.3	41.1	19.5
MP	16.4	0.3	3.2	5.4	8.7	25.4	15.9
Maharashtra	28.8	0.7	3.3	10.6	14.0	43.4	25.7
Chhattisgarh	12.1	0.0	0.2	0.9	1.1	13.2	4.9
DD	0.2	0.0	0.0	0.0	0.0	0.3	0.4
DNH	0.5	0.0	0.0	0.0	0.0	0.5	0.9
Goa	0.6	0.0	0.0	0.0	0.0	0.6	0.6
Central unallocated	3.0	0.2	0.0	0.0	0.0	3.2	0.0
Total	**85.8**	**1.8**	**7.6**	**32.5**	**40.1**	**127.7**	**63.9**

Source: CEA Installed capacity Monthly Report

5.2 Region and State Wise envisaged Power Supply Scenario

As per the 19th EPS, Western Region demand for 2026-27 timeframe is expected to increase to about 95 GW. The Installed capacity of Western Region is expected to be about 180GW. The state wise bifurcation of the same is given at Table 5-2.

Table 5-2 Western Region Installed Capacity and Peak Demand (2026-27)

(All Fig in MW)

State	Thermal	Hydro	Nuclear	Solar	Wind	Gas	Total	Peak Demand
Gujarat	7912	568	0	7585	8285	2840	27190	28387
MP	5320	3066	0	1538	2392	0	12316	19682
Maharashtra	20415	2945	0	3680	5297	1240	33577	39828
Chhattisgarh	2303	139	0	223	0	0	2665	8518
DD	0	0	0	0	0	0	0	553
DNH	0	0	0	0	0	0	0	1798
Goa	0	0	0	0	0	0	0	1096
Central	19000	1450	3240	21590	15347	3281	63908	-
IPP	36850	0	0	0	0	2778	39628	-
Rooftop				4500			4500	
Total	**91800**	**8168**	**3240**	**39116**	**31321**	**10139**	**183784**	**94825**

There is growth of around 48% in the peak demand of Western Region from present timeframe to 2026-27. The state wise growth in demand for 2026-27 from present time-frame is tabulated below at Table 5-3:

Table 5-3: State-wise Demand Growth in Western Region

(All Fig in MW)

Peak Demand				
State	**Present**	**19th EPS**	***Diff***	***% Increase***
	2021-22	***2026-27***		
Gujarat	19451	28387	8936	46%
MP	15917	19682	3765	24%
Maharashtra	25653	39828	14175	55%
Chhattisgarh	4878	8518	3640	75%
DD	371	553	182	49%
DNH	871	1798	927	106%
Goa	646	1096	450	70%
Total	**63873**	**94825**	**30952**	**48%**

From the above data it is observed that the increase in peak demand is maximum for DNH (106%) and minimum for MP (24%).

5.3 Load Generation Balance

Load generation balance has been prepared considering the following despatch factors for the 9 scenarios and the same is given at Table 5-4

Table 5-4: Western Region Installed Capacity and Peak Demand (2026-27)

Scenario No & Name	Generation Dispatch Factors						Demand Factors
	Hydro	Nuclear	Solar	Rooftop	Wind	Gas	
1-Aug Solar Max	40%	80%	80%	50%	55%	0%	76%
2-Aug Peak Load	70%	80%	0%	0%	75%	85%	80%
3-Aug Night Off Peak	40%	80%	0%	0%	65%	65%	70%
4-Jun Solar Max	40%	80%	85%	60%	55%	0%	89%
5-Jun Peak Load	70%	80%	0%	0%	75%	85%	90%
6-Jun Night Off Peak	40%	80%	0%	0%	65%	60%	83%
7-Feb Solar Max	20%	80%	90%	60%	10%	0%	99%
8-Feb Peak Load	40%	80%	0%	0%	20%	85%	86%
9-Feb Night Off Peak	20%	80%	0%	0%	20%	30%	70%

The despatch from thermal generations have been done considering merit order despatch. Western Region LGBs for all 9 nos. of scenarios are summarized in Figure 5-1, Figure 5-2 and Figure 5-3.

Based on LGB, state wise surplus/deficit in these scenarios is summarised in Table 5-5. Further, both maximum and minimum import of each state from ISTS grid is highlighted in table below.

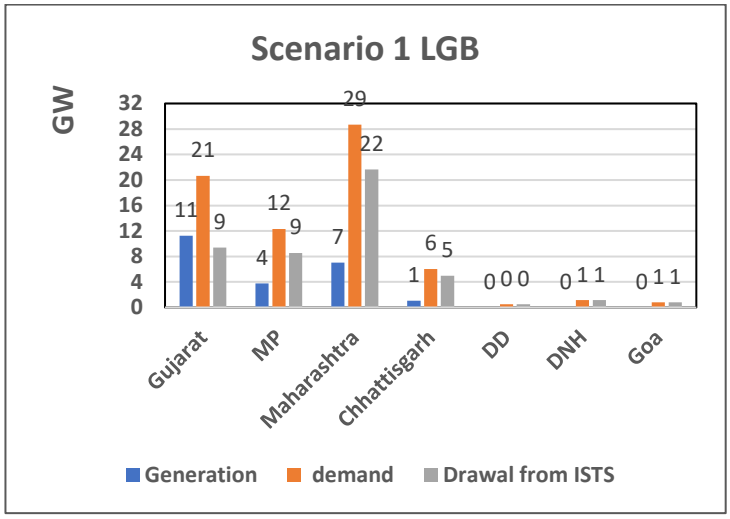
Table 5-5: Drawl of various states from ISTS grid

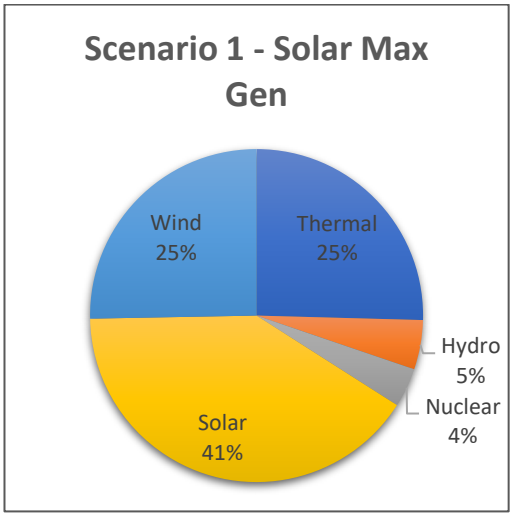
(All Fig in MW)

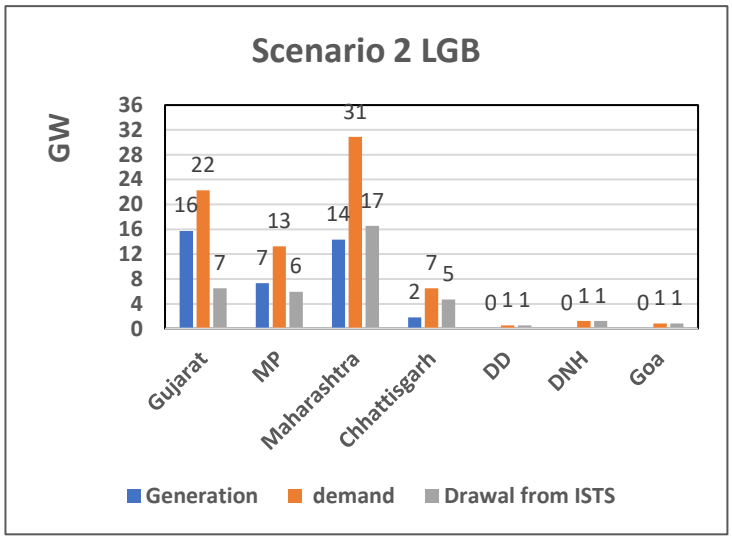
Drawal from ISTS	Aug'26			Jun'26			Feb'27		
Scenario / State	1	2	3	4	5	6	7	8	9
	Solar Max	Peak Load	Off Peak	Solar Max	Peak Load	Off Peak	Solar Max	Peak Load	Off Peak
Gujarat	9401	6500	3875	14824	11615	10841	15439	10948	10728
MP	8558	5936	6047	9528	6438	7558	16550	13415	7701
Maharashtra	21630	16533	17797	23323	18333	18490	25548	19506	15973
Chhattisgarh	4990	4715	4762	4420	4163	4260	4545	3593	2862
DD	495	533	430	503	520	392	488	440	298
DNH	1151	1239	998	1184	1224	922	1178	1061	718
Goa	794	855	689	894	924	696	876	789	534
Central	-34847	-29602	-26976	-37532	-30962	-28172	-32296	-24058	-20080
IPP	-10120	-23790	-23234	-13866	-33684	-32593	-20268	-33684	-27332
Total	2053	-17079	-15612	3278	-21428	-17606	12060	-7989	-8598

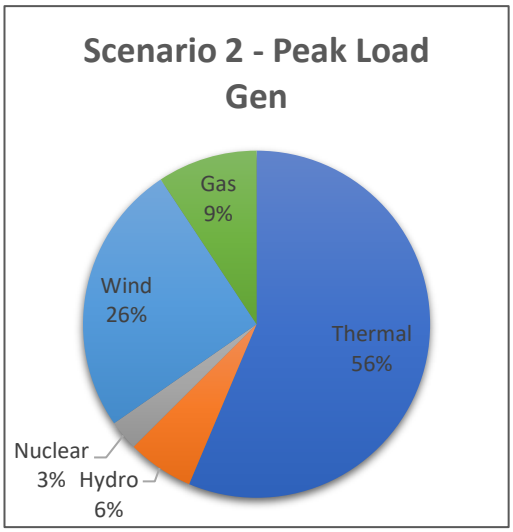
5.3.1 Monsoon Aug'26

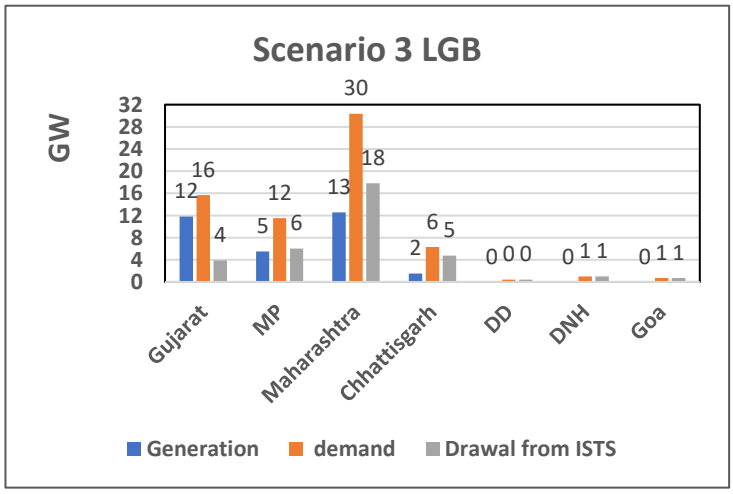
Figure 5-1: LGB for Monsoon Aug'26

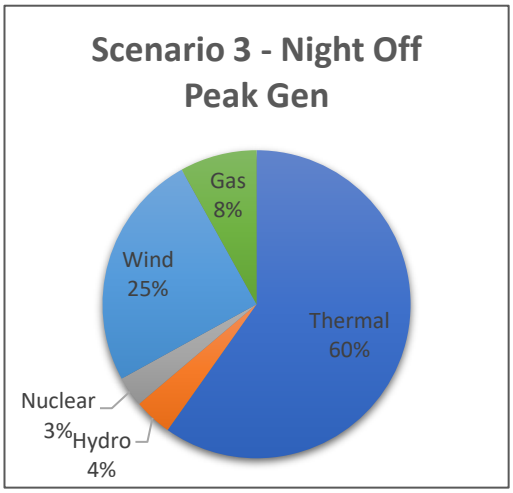






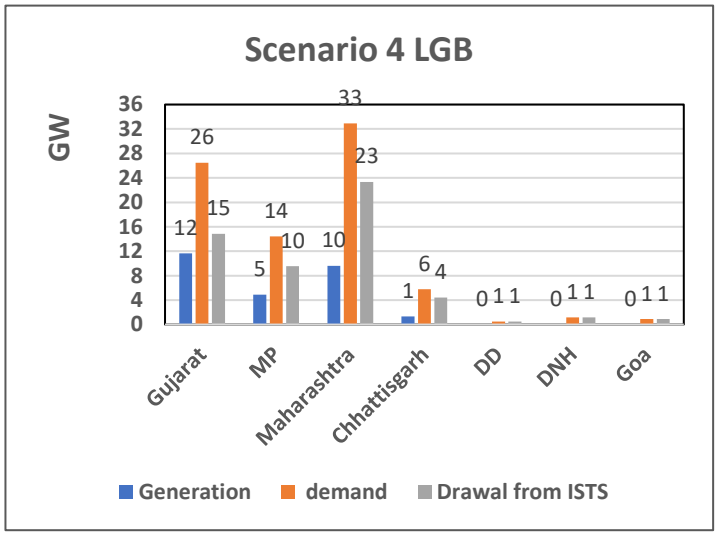


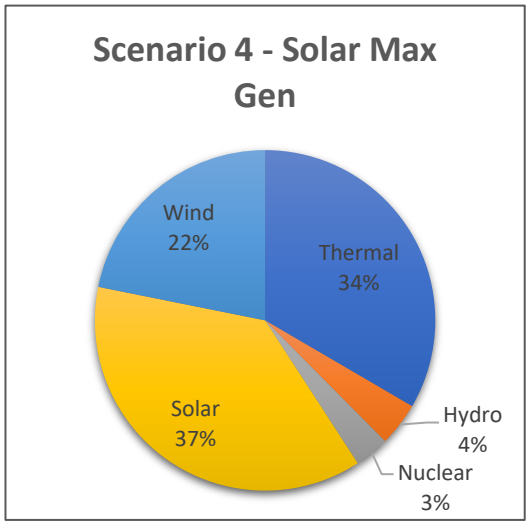


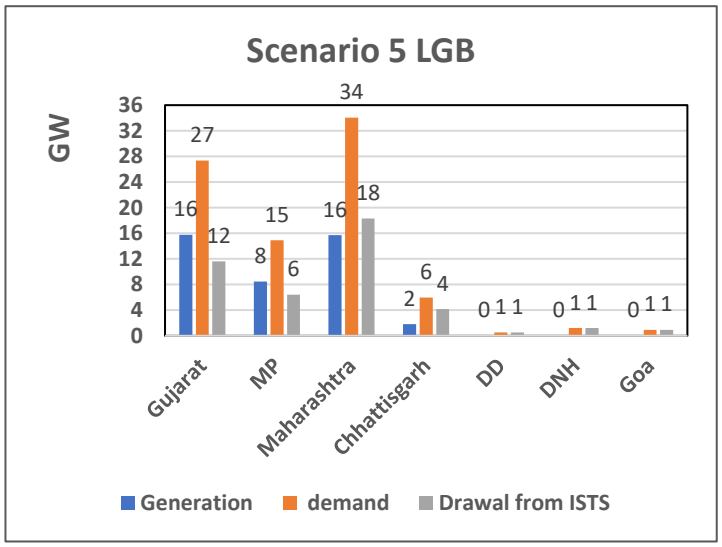


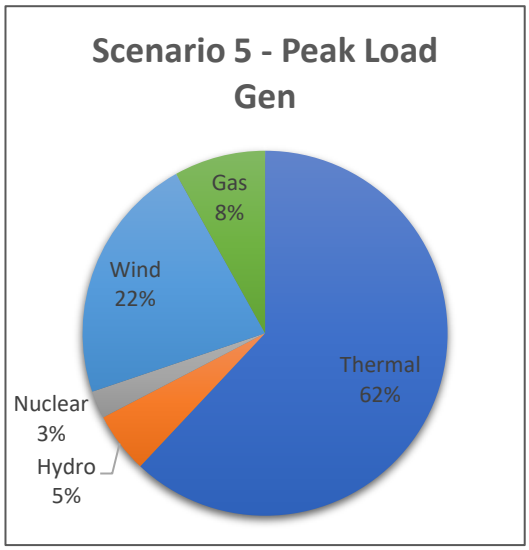
5.3.2 Summer Jun ’26

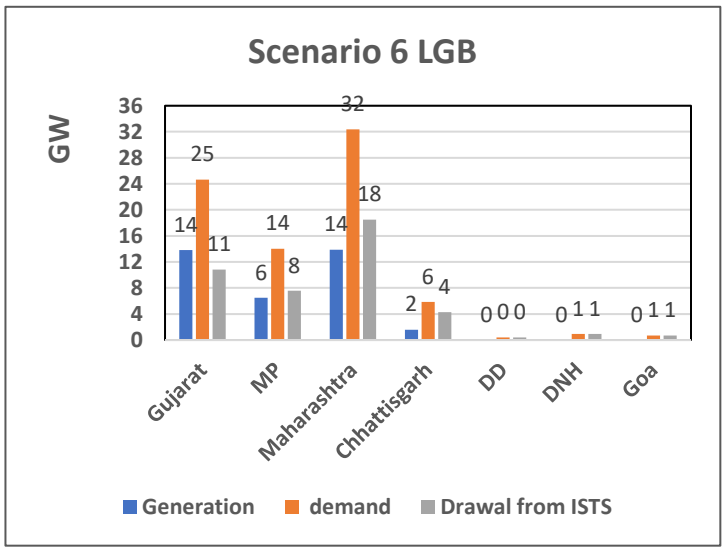
Figure 5-2: LGB for Summer Jun'26

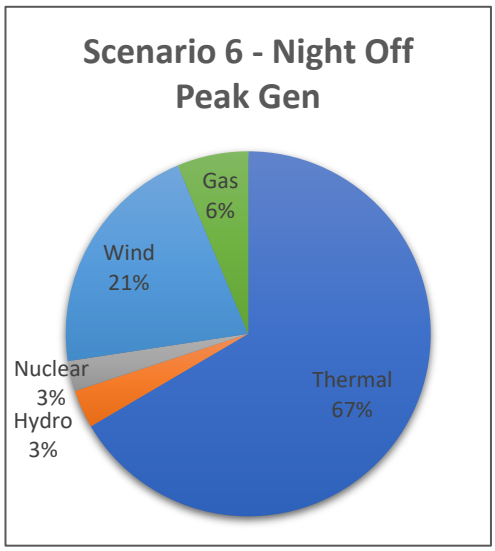






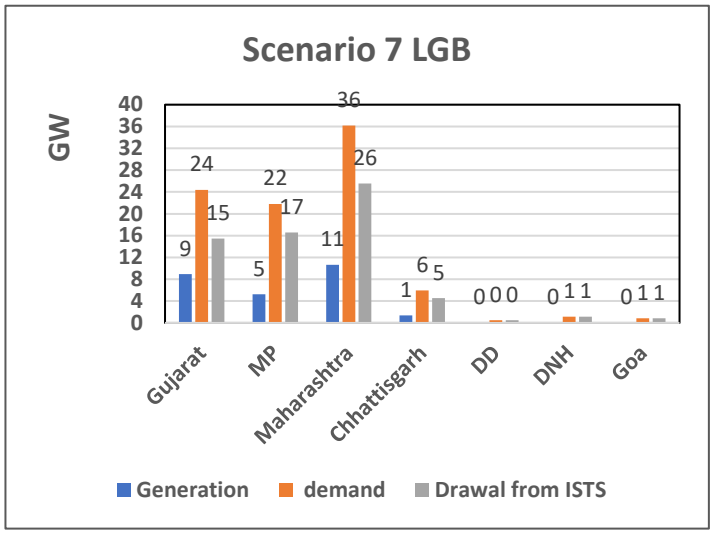


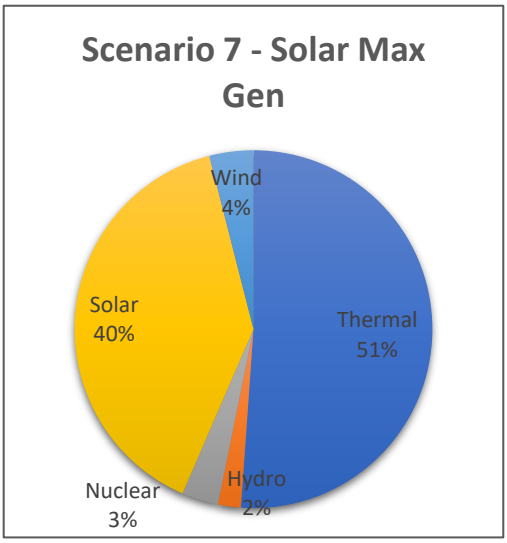


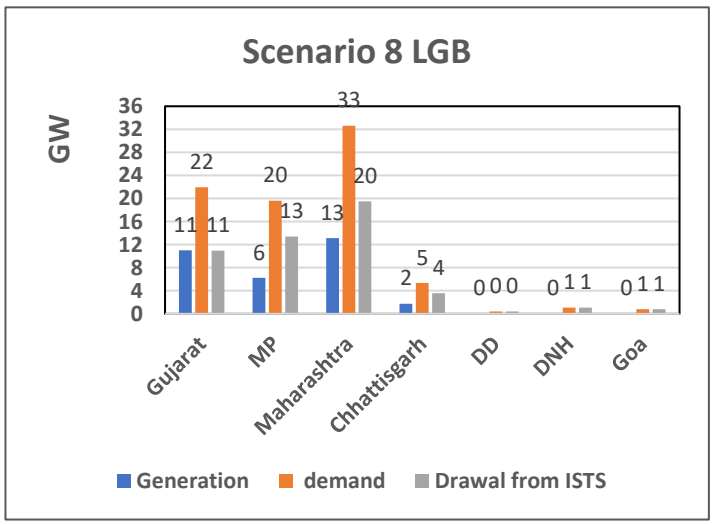


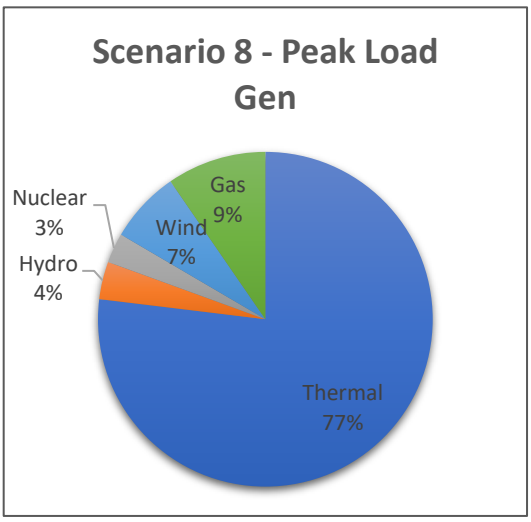
5.3.3 Winter Feb ’27

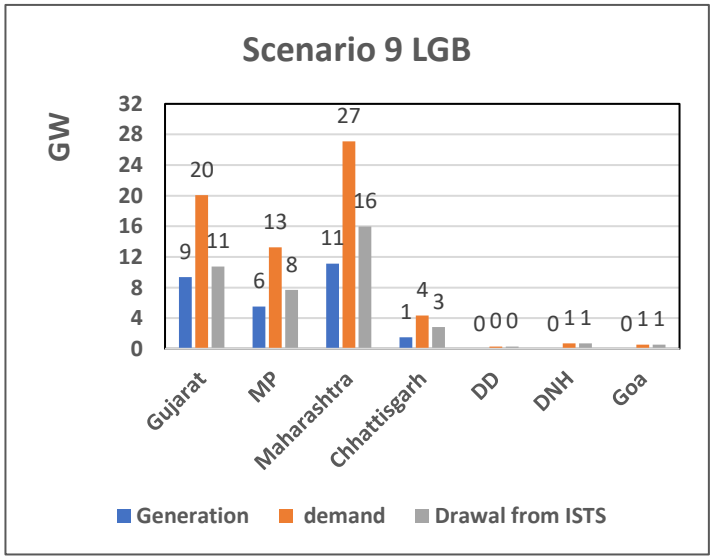
Figure 5-3: LGB for Winter Feb'26

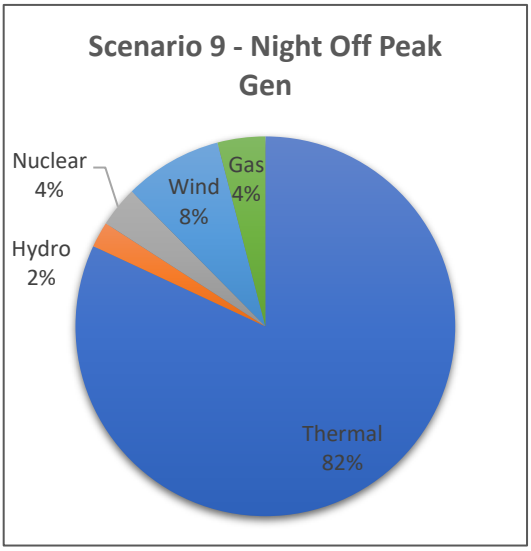












Out of these nine scenarios, Scenario-5 and Scenario-7 corresponds to two extreme cases with respect to import/export i.e. highest import (12GW) and highest export (21GW) scenarios respectively. In all other scenarios, import /export from Western Region to other regions is varying between these two extremes.

Detailed system studies have been carried out on the finalized load flow cases. The study results are discussed in subsequent chapters.

5.4 ISTS Network

Various transmission systems have been evolved for implementation in the Consultative Meeting for Evolution of Transmission System of WR (CMETS-WR) from Nov 2021 to Feb 2022. These schemes have either been approved or under various stages of approval. The details of the schemes including other important issues in regard to ISTS in the Western Region which were discussed during this timeframe has also been summarized below:

5.4.1 Gujarat:

GETCO vide letter dated 26.10.2021 had highlighted certain issues being faced in Gujarat which require ISTS system strengthening to increase ATC such as constraints observed on Vadodara 765/400kV ICTs, Kala – Kudus 400kV D/c line and Banaskantha – Veloda (Sankhari) 400kV D/c line. Hence, GETCO requested that system strengthening scheme in Gujarat needs to be evolved in such a manner that it is able to cater to RE evacuation from Khavda area as well as to enhance Gujarat system ATC for drawl of power from ISTS under peak load scenario (low RE). Accordingly, system studies were conducted in the 1st Joint study meeting on Transmission Planning for Western Region held on 05.11.2021 amongst CEA, CTU, POSOCO and GETCO and the transmission schemes in Gujarat under ISTS system were evolved:

- To meet the ATC requirement of ~16000MW of Gujarat in 2024-25 time-frame: Transmission Network Expansion scheme in Gujarat (Parts-A, B & C below)
- To cater to system strengthening requirements associated with integration of RE projects from Khavda potential RE zone

The details of finalized schemes under ISTS are given below:

a) <u>Transmission Network Expansion in Gujarat to increase its ATC from ISTS (Part-A)</u>

Scheme involves augmentation of transformation capacity at Vadodara (GIS) S/s by 1x 1500 MVA, 765/4000kV ICT to enhance ATC requirement of Gujarat and to mitigate network congestion under low local generation in Gujarat. In the Joint study meeting held on 05.11.2021 amongst CEA, CTU, POSOCO and GETCO to discuss various issues w.r.t. Gujarat, 3rd 765/400kV ICT at Vadodara (GIS) S/s was agreed to enhance ATC requirement of Gujarat and to mitigate network congestion under low local generation in Gujarat. The scheme was noted in the 1st WRTP (now CMETS-WR) meeting held on 29.11.2021.

Scope of work along with tentative Cost and Implementation time-frame is mentioned below in Table 5-6:

Table 5-6: Transmission Network Expansion in Gujarat to increase its ATC from ISTS (Part-A)

Sl. No.	Scope of the Transmission Scheme	Capacity /km	Implementation timeframe
1.	Augmentation of transformation capacity at Vadodara 765/400/220kV S/s by 1x1500MVA, 765/400kV ICT (3rd) along with associated 765kV ICT bay*	765/4000 kV, 1500 MVA ICT- 1 no. 765 kV ICT bays- 1 nos.	Apr'22
	Total Estimated Cost (Rs. Crore)	**70 Cr. (approx.)**	

**Out of the 2 nos. 400kV line bays already constructed by POWERGRID for DGEN – Vadodara line, 1no. line bay to be utilized for 765/400kV ICT (3rd) at Vadodara*

Implementation time frame of Apr'22 was agreed as a special case, as discussed in the meeting convened on 02.11.2021 with respect to resource adequacy for Gujarat. The scheme was allotted to POWERGRID vide CTU OM dated 16.11.2021.

b) <u>Transmission Network Expansion in Gujarat to increase ATC from ISTS: Part B</u>

Scheme involves setting up of 765/400/220kV Navsari (New) S/s and its associated interconnections along with Augmentation of transformation capacity at Padghe (GIS) 765/400 kV substation by 1x1500 MVA ICT to enhance ATC requirement of Gujarat and to mitigate network congestion under low local generation in Gujarat. The scheme was agreed in the Joint study meeting held on 05.11.2021 amongst CEA, CTU, POSOCO and GETCO to discuss various issues w.r.t. Gujarat and in the 7th NCT meeting held on 03.12.2021. The scheme was noted in the 1st WRTP (now CMETS-WR) meeting held on 29.11.2021.

Scope of work along with tentative Cost and Implementation time-frame is mentioned below in Table 5-7:

Table 5-7: Transmission Network Expansion in Gujarat to increase ATC from ISTS: Part B

Sl. No.	Scope of the Transmission Scheme	Capacity /km	Implementation timeframe
1.	Establishment of 765/400/220 kV Navsari (new) (South Gujarat) S/s (GIS) Space provisions for Future Scope 765/400 kV ICT: 4 nos. 400/220 kV ICT: 4 nos. 765 kV line bays along with space for switchable line reactor: 8 nos. 400 kV line bays along with space for switchable line reactor: 6 nos.	765/400 kV, 1500 MVA- 2 nos. (7 X 500 MVA inc 1 spare unit) 400/220 kV, 500 MVA- 3 nos. 765 kV ICT bays- 2 nos. 765 kV GIS line bays -2 (for Phadge line) 400 kV ICT bays- 5 nos.	Jun'23

Sl. No.	Scope of the Transmission Scheme	Capacity /km	Implementation timeframe
	220 kV line bays: 16 nos.	400 kV line bays – 4 nos. (for Kala and Magarwada lines) 220 kV ICT bays- 3 nos. 765 kV, 330 MVAr BR – 2 nos. (7 X 110 MVAr inc. 1 switchable spare unit) 1X 80 MVAr single phase switchable spare unit (for Ahmedabad – Navsari (New) (South Gujarat) 765 kV D/c line) 765 kV Bus Reactor bays – 2 nos. 400 kV, 125 MVAr Bus Reactor- 1 400 kV Bus Reactor bay- 1 no.	
2.	Navsari (new) (South Gujarat) (GIS)-Kala (GIS) 400 kV D/c line (conductor with minimum capacity of 2100 MVA/Ckt at nominal voltage) with 63MVAr switchable line reactor on each ckt at Navsari (new) (GIS) end.	110 km 400 kV GIS line bays- 2 nos. (at Kala) 63 MVAr, 400 kV SLR along with switching eqpts.- 2 nos.	
3.	Navsari(New) (South Gujarat) (GIS) – Magarwada (GIS) 400 kV D/c line (conductor with minimum capacity of 2100 MVA/Ckt at nominal voltage)	80 km 400 kV GIS line bays- 2 nos. (at Magarwada)	
4.	Navsari (New) (South Gujarat) (GIS) – Padghe (GIS) 765 kV D/c line with 330 MVAr, 765 kV Switchable line reactor on each ckt at Navsari(New) (South Gujarat) end.	200 km 765 kV GIS line bays -2 (at Padghe) 765 kV, 330 MVAr SLR – 2 nos (6 X 110 MVAr)	
5.	Augmentation of transformation capacity at Padghe (GIS) 765/400 kV substation by 1x1500 MVA ICT.	765/400 kV, 1500 MVA- 1 no	

Sl. No.	Scope of the Transmission Scheme	Capacity /km	Implementation timeframe
	The available spare equipped bays (765kV bay: existing & 400kV bay: under construction under WRSS XIX scheme) at Padghe(GIS) S/s shall be utilised for the subject ICT		
	Total Estimated Cost (Rs. Crore)	**2077 Cr. (approx.)**	

Note:

(i) Navsari (New) (South Gujarat) S/s shall be establishment as GIS substation to reduce the land requirement as there may be issues in getting contiguous land in this area which is industrial in nature as well as densely populated.

(ii) Augmentation of transformation capacity at Navsari(new) (GIS) 765/400 kV substation by 1x1500 MVA ICT (3rd) along with its associated bays to be implemented in matching time frame of Khavda Phase-II A (Ph-II) (5GW) scheme as a part of the scheme "Transmission Network Expansion in Gujarat associated with integration of RE projects from Khavda potential RE zone".

(iii) As Kala and Magarwada are located close to each other, majority of common stretch of Kosamba – Kala and Kosamba – Magarwada 400 kV D/c line may be constructed using Multi-circuit towers in order to save RoW.

(iv) ***Implementation Time-frame:*** *June 2023*

(v) GETCO shall implement the following downstream system in matching time-frame of Navsari(New) (South Gujarat) S/s:

220kV Interconnections Navsari(New) (South Gujarat) S/s) [Under Intra-state]

a) LILO of both circuits of 220 KV D/C Navsari – Chikhli line at Navsari(New) (South Gujarat) (GIS) substation along with associated line bays

b) LILO of both circuits of 220 KV D/C Navsari – Nasik line at Navsari(New) (South Gujarat) (GIS) substation along with associated line bays

The scheme was allotted to POWERGRID vide MoP OM dated 13.01.2022.

c) <u>Transmission Network Expansion in Gujarat to increase ATC from ISTS: Part C</u>

Scheme involves augmentation of transformation capacity at Banaskantha 765/400 kV S/s by 1x1500 MVA ICT and Banaskantha – Sankhari 400 kV 2nd D/c line to enhance ATC requirement of Gujarat and to mitigate network congestion under low local generation in Gujarat. The scheme was agreed in the Joint study meeting held on 05.11.2021 amongst CEA, CTU, POSOCO and GETCO to discuss various issues w.r.t. Gujarat and in the 7th NCT meeting held on 03.12.2021. The scheme was noted in the 1st WRTP (now CMETS-WR) meeting held on 29.11.2021.

Scope of work along with tentative Cost and Implementation time-frame is mentioned below in Table 5-8:

Table 5-8: Transmission Network Expansion in Gujarat to increase ATC from ISTS: Part C

Sl. No.	Scope of the Transmission Scheme	Capacity /km	Implementation timeframe
1.	Augmentation of transformation capacity at Banaskantha 765/400 kV S/s by 1x1500 MVA ICT	765/400 kV, 1500 MVA ICT: 1 no. 765 kV ICT bay – 1no 400 kV ICT bay– 1 no	Matching with establishment of Prantij 400/220 kV and Sankhari-Prantij 400 kV D/C line by GETCO (presently expected by Mar'25).
2.	Banaskantha – Sankhari 400 kV 2nd D/c line	26 km 400 kV line bays- 4 nos. (2 nos. at Banaskantha and 2 nos. at Sankhari)	
	Total Estimated Cost (Rs. Crore)	**148 Cr. (approx.)**	

The scheme was allotted to POWERGRID vide NCT letter dated 22.12.2021.

d) <u>Transmission Network Expansion in Gujarat associated with integration of RE projects from Khavda potential RE zone</u>

The project involves Banaskantha – Ahmedabad 765 kV D/c line so as to facilitate integration of RE Projects under Khavda Phase-A (Ph-II) (5GW). The scheme was agreed in the Joint study meeting held on 05.11.2021 amongst CEA, CTU, POSOCO and GETCO to discuss various issues w.r.t. Gujarat and in the 7th NCT meeting held on 03.12.2021. The scheme was noted in the 1st WRTP (now CMETS-WR) meeting held on 29.11.2021.

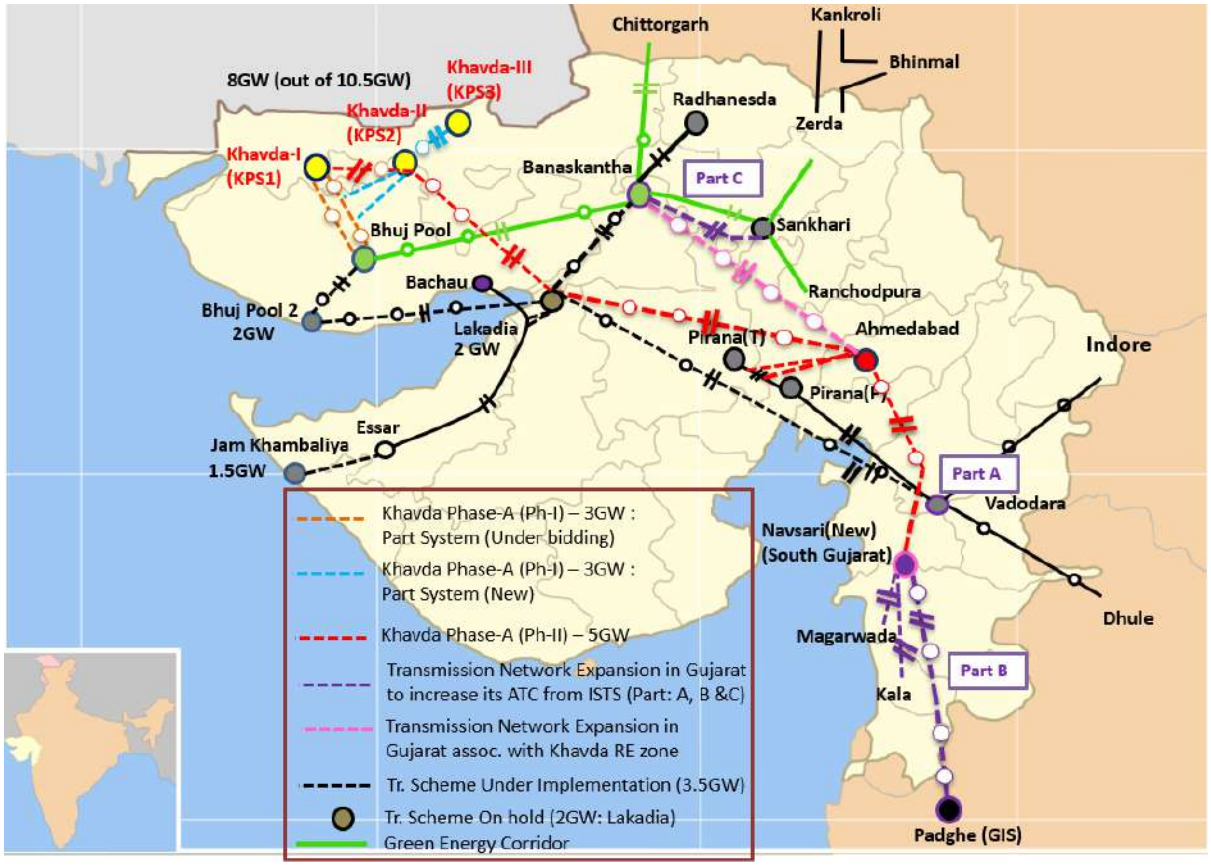
Scope of work along with tentative Cost and Implementation time-frame is mentioned below in Table 5-9:

Table 5-9: Transmission Network Expansion in Gujarat associated with integration of RE projects from Khavda potential RE zone

Sl. No.	Scope of the Transmission Scheme	Capacity /km	Implementation timeframe
1	Banaskantha – Ahmedabad 765 kV D/c line with 330MVAr, 765 kV Switchable line reactor on each ckt at Ahmedabad S/s end	200 km 765 kV, 330 MVAr SLR along with switching eqpts. – 2 nos (6 X 110 MVAr) 765 kV line bays- 4(2 nos. at Banaskantha and 2 nos. at Ahmedabad)	Matching with Khavda Phase-A (Ph-II) (5GW) scheme. NCT has recommended a time-line of 24 months from SPV Transfer for Khavda Phase-A (Ph-II) (5GW) scheme
	Total Estimated Cost (Rs. Crore)	**953 Cr. (approx.)**	

The scheme is currently under tendering process as per MoP Gazette dated 17.01.2022 with RECPDCL as the Bid Process Coordinator.

Figure 5-4:Schematic for Transmission Network Expansion in Gujarat to increase ATC from ISTS: Parts A, B & C and integration of RE projects from Khavda potential RE zone



Other Schemes:

e) <u>Scheme for fault level control at Dehgam (PG) & Ranchodpura (GETCO) S/s</u>

The project involves bypassing of Rachhodpura(GETCO) – Dehgam(PG) 400kV D/c line at Dehgam(PG) S/s and connecting it with Dehgam(PG) – Pirana 400kV D/c line (one circuit via Nicol) to form Ranchhodpura(GETCO) – Pirana(PG) 400kV D/c line (one circuit via Nicol). The scheme has been evolved for fault level control at Dehgam (PG) & Ranchhodpura (GETCO) S/s after deliberations in the 2nd CMETS-WR meeting held on 28.12.2021. Studies were carried out for the 2024-25 time-frame and the fault level at Dehgam S/s (PG) & Ranchhodpura S/s (GETCO) was observed to reach about 47kA & 41kA respectively as against its design rating of 40kA. At Dehgam S/s, there is more than 20kA contribution from Ranchhodpura (Vadavi) and Pirana/Nicol(Torrent) 400kV lines. In order to control the fault levels at Dehgam (PG) & Ranchhodpura (GETCO) S/s, the proposed bypassing scheme has been evolved. After the implementation above scheme, the fault level at 400kV buses at Dehgam S/s (PG) & Ranchhodpura S/s (GETCO) is observed to reach about 31kA & 38kA respectively (within limits).

Scope of work along with tentative Cost and Implementation time-frame is mentioned below in Table 5-10:

Table 5-10: Scheme for fault level control at Dehgam (PG) & Ranchodpura (GETCO) S/s

Sl. No.	Scope of the Transmission Scheme	Capacity/km	Implementation timeframe
1	Bypassing of Rachhodpura (GETCO) – Dehgam (PG) 400kV D/c line at Dehgam (PG) S/s and connecting it with Dehgam(PG) – Pirana 400kV D/c line (one circuit via Nicol) so as to form Ranchhodpura(GETCO) – Pirana(PG) 400kV D/c line (one circuit via Nicol). **Note:** 400 kV D/c Dehgam-Ranchodpura line is crossing with 400kV D/c Dehgam–Pirana line near the boundary wall of substation premises (tower 2 & 3 of Ranchorpura line and tower 3 & 4 of Pirana line from Dehgam SS end). It is possible to disconnect both the lines towards the Dehgam end and join with each other so that the 400kV D/c Ranchhodpura – Pirana line shall be established.	-	6 months from the issue of OM by CTUIL
		Total Estimated Cost:	**Less than INR 1 Crore[@]**

[@]*since no extra Tower is required as per communication received from POWERGRID*

The scheme was allotted to POWERGRID vide CTU OM dated 03.02.2022.