भारत सरकार
Government of India
विद्युत मंत्रालय
Ministry of Power
केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority
विद्युत प्रणाली योजना एवं मूल्यांकन-I प्रभाग
Power System Planning & Appraisal-I Division

To

-As per list enclosed-

विषय: पश्चिमी क्षेत्र विद्युत समिति (पारेषण योजना) [WRPC(TP)] की होने वाली तीसरी बैठक की मिटिंग नोटिस & अतिरिक्त कार्यसूची

Subject: Meeting Notice and Additional Agenda note of the 3rd meeting of Western Regional Power Committee (Transmission Planning) [WRPC(TP)]

Sir/ Madam,

3rd meeting of Western Regional Power Committee (Transmission Planning) [WRPC(TP)] scheduled to be held at 11:00 AM on 16.04.2021 had been postponed. The meeting is now scheduled to be held on **Monday, 14th June 2021 at 11:00 AM** through VC (Microsoft Teams).

Agenda for the meeting had already been circulated vide CEA letter dated 08.04.2021. Additional agenda for the meeting is attached herewith and same is also available on CEA 's website (www.cea.nic.in) at the link: https://cea.nic.in/pspc-region/western-region/?lang=en.

The link to join the meeting would be intimated in due course.

Yours faithfully,

(Ishan Sharan)
Chief Engineer (PSP&A-I)

List of Addressees:

1.	Member (Power System), Central Electricity Authority, Sewa Bhawan, RK Puram, Sec-1, New Delhi – 110066	2.	Member Secretary, WRPC, F-3, MIDC Area, Andheri (East), Mumbai – 400093 Fax – 022-28370193	3.	COO (CTU) POWERGRID, Saudamini, Plot no. 2, Sector -29, Gurgaon-122 001 Fax-0124-2571809
4.	Director (System Operation), POSOCO B-9, Qutub Institutional Area, Katwaria Sarai New Delhi – 110010	5.	Chief Electrical Engineer, Vidyut Bhavan, 3rd Floor, Panaji, Goa - 403001	6.	Managing Director, GETCO, Sardar Patel Vidyut Bhawan, Race Course, Vadodara-390007
7.	Managing Director, MPPTCL, Block no -2, Shakti Bhawan, Rampur, Jabalpur – 482008 (M.P)	8.	Chairman & Managing Director, MSETCL, Prakashganga, Plot No.C-19, E-Block, Bandra-Kurla Complex, Bandra (E), Mumbai - 400051	9.	Secretary (Power), Administration of Daman & Diu (U.T.), Fort Area, Moti Daman-396220
10.	Secretary (Power), UT of Dadra & Nagar Haveli, Secretariat, Amli, Silvassa - 396230	11.	Managing Director, CSPTCL, Dangania, Raipur (CG)-492013	12.	Chairman & Managing Director (NTPC), NTPC Bhawan, SCOPE Complex, Institutional Area, Lodhi Road, New Delhi - 110003
13.	Chairman & Managing Director (NHPC), N.H.P.C Office Complex, Sector-33, Faridabad - 121003 (Haryana)	14.	Managing Director (SECI), 1st Floor, D-3, A Wing, Prius Platinum Building District Centre, Saket, New Delhi - 110017		

Additional Agenda note for the 3rd Meeting of Western Region Power Committee (Transmission Planning) scheduled to be held on 14.06.2021

1. Transmission system for evacuation of power from Neemuch SEZ (1000 MW):

In continuation to the agenda no. 6, a meeting was held on 21.05.2021 to discuss the Transmission system for evacuation of power from Neemuch SEZ. The minutes of the meeting are attached as Annexure-XIII. The following was decided in the meeting:

After further deliberations, and considering the requirement of NRED, Govt. of MP for ISTS connectivity, the following transmission system was agreed for evacuation of power from Neemuch SEZ:

i. Phase-I: Neemuch PS – Chhittprgarh (PG) S/s 400 kV D/c line – for evacuation of 500 MW of power from Neemuch SEZ, to be implemented at present.
ii. Phase-II: Neemuch PS – Mandsaur s/s 400 kV (quad) D/c line – to be implemented after the receipt of LTA application for additionl 500 MW capacity at Neemuch SEZ.

The requirement of Neemuch PS – Mandsaur S/s 400 kV (quad) line could be taken up separately as a gid strength scheme.

Members may deliberate.

2. Transmission System for Khavda REZ and System Strengthening requirement in Gujarat

In continuation to para 9.5 of 3rd WRPC(TP) agenda circulated earlier (w.r.t. Transmission System for addl. 7 GW Khavda REZ) and in supersession of agenda item 8 of 3rd WRPC(TP) agenda (w.r.t. System Strengthening in Gujarat), system studies for 15 GW Khavda REZ & system strengthening in Gujarat were revised considering the modified Load Generation Balance for 9 scenarios as finalised in the meeting held on 11.03.2021 amongst CEA, CTU & POSOCO and joint study meeting amongst CEA, CTU, POSOCO, GETCO & MSETCL held on 13.04.2021.

In the joint studies carried out on 13.04.2021, GETCO and MSETCL had given certain observations on the study files mainly:

- Revised 400kV/220 kV lines from proposed Bharuch S/s (400 kV interconnection with Vav S/s & 220 kV lines to be shifted from GPEC 220 kV bus to Bharuch 220 kV bus)
- Bypassing of SSP - Asoj & Asoj-Chorania 400 kV lines at Asoj to control high fault level at Asoj S/s
- Kudus - Aray 1000 MW HVDC link along with 400/220 kV Velgaon S/s to be considered in 2024-25 time-frame as issue of high loading on downstream system of Kudus (Kudus - Kolshet 220kV line) was observed without above system modeled in files.

Subsequent to making above changes in the study file, GETCO vide e-mail dated 26.04.2021 observed that the STU generation (Thermal & RE) considered in the file is very less. Further, the Gujarat demand may be enhanced from 18000 MW to EPS demand for 2024-25 *(~25000 MW)* for simulating the worst case.

The study files were reviewed accordingly and following changes were made:

- Various state RE generations as provided by GETCO (~15GW) were incorporated in the file and were despatched as per the factors for each scenario (refer Annexure-XIV).
- Gujarat demand was enhanced to 19th EPS demand and was considered as per the factors for each scenario (refer Annexure-XIV).
- Various coal based projects located in Saurashtra & Kutch region viz. Adani Mundra (4620 MW), EPGL Vadinar (1200 MW), GSECL Sikka (500 MW), GSECL BECL (500 MW), GSECL KLTPS (290 MW), GMDC Akrimota (250 MW), etc. have been dispatched in evening peak scenarios. However, as the cost of these plants is higher as compared to other generating units in Western region, so in the solar max scenarios, these plants were considered out of merit order and other cheaper plants were kept running at the technical minimum of 55%.

Other assumptions w.r.t. Khavda study under para 9.5 of agenda for the 3rd WRPC(TP) meeting circulated earlier remains the same. The revised LGB considered and the study exhibits for the 9 scenarios are attached at Annexure-XIV and Annexure-XV respectively.

As per the revised studies, high loadings as well as fault level issues were observed in the Gujarat Transmission System in the base case (without any strengthening) as listed below (Most critical loadings are highlighted in yellow):

OUTPUT FOR ZONE 35 [GUJARAT] SUBSYSTEM LOADING CHECK (INCLUDED: LINES; BREAKERS AND SWITCHES; TRANSFORMERS) (EXCLUDED: NONE) **LOADINGS ABOVE 75.0 % OF RATING SET B** (MVA FOR TRANSFORMERS, CURRENT FOR NON-TRANSFORMER BRANCHES):

X--------- FROM BUS ----------X				X---------- TO BUS ----------X						
BUS#	X-- NAME	--X BASKV	AREA	BUS#	X-- NAME	--X BASKV	AREA	CKT	LOADING	RATING	PERCENT
3	ASOJ	400.00*	3	354029	KOSAMBA	400.00	3	1	823.0	850.0	96.8
164405	BHINMAL	400.00	1	354019	ZERDA	400.00*	3	1	1166.0	850.0	137.2
352012	SUGEN	220.00*	3	354012	SUGEN	400.00	3	1	269.1	315.0	85.4
352012	SUGEN	220.00*	3	354012	SUGEN	400.00	3	2	269.1	315.0	85.4
352012	SUGEN	220.00*	3	354012	SUGEN	400.00	3	3	269.1	315.0	85.4
352022	HAZIRA2	220.00	3	354022	HAZIRA4	400.00*	3	1	382.3	500.0	76.5
352022	HAZIRA2	220.00	3	354022	HAZIRA4	400.00*	3	2	382.3	500.0	76.5
352210	VADODARAPG	220.00	3	354035	VADODARA	400.00*	3	1	511.8	500.0	102.4
352210	VADODARAPG	220.00	3	354035	VADODARA	400.00*	3	2	511.8	500.0	102.4
354002	GANCS4	400.00	3	354003	DEHGM4	400.00*	3	1	750.1	850.0	88.2
354002	GANCS4	400.00	3	354003	DEHGM4	400.00*	3	2	750.1	850.0	88.2
354002	GANCS4	400.00*	3	354009	GPEC4	400.00	3	1	908.1	850.0	106.8
354009	GPEC4	400.00*	3	354021	KASOR4	400.00	3	1	908.0	850.0	106.8
354010	VAPI4	400.00	3	354012	SUGEN	400.00*	3	1	665.0	850.0	78.2
354014	PIRANA_P	400.00*	3	354101	NICOL TORREN	400.00	3	2	741.3	850.0	87.2
354029	KOSAMBA	400.00*	3	354047	VAV4	400.00	3	1	858.9	850.0	101.0
354044	AHMDABAD PG	400.00	3	358044	AHMDABAD PG	765.00*	3	1	1662.7	1500.0	110.8
354044	AHMDABAD PG	400.00	3	358044	AHMDABAD PG	765.00*	3	2	1662.7	1500.0	110.8
354136	BANASKANTHA	400.00*	3	354137	SANKHARI	400.00	3	2	1031.1	850.0	121.3
354136	BANASKANTHA	400.00	3	354137	SANKHARI	400.00*	3	4	1092.4	850.0	128.5
354136	BANASKANTHA	400.00*	3	358136	BANASKANTHA	765.00	3	2	1294.6	1500.0	86.3
354136	BANASKANTHA	400.00*	3	358136	BANASKANTHA	765.00	3	3	1294.6	1500.0	86.3

Further, fault level at Dehgam S/s (PG) & Ranchhodpura S/s (GETCO) is observed to reach about 47kA & 41kA respectively as against its design rating of 40kA. At Dehgam S/s, there is more than 20 kA contribution from Ranchhodpura (Vadavi) and Pirana/Nicol(Torrent) 400 kV lines. Fault level at Asoj (GETCO) S/s is observed to be 41 kA.

To overcome the above loadings / fault level issue as well as to facilitate the additional RE integration in Khavda region, the following System strengthening schemes are proposed:

Under Intra-state:

System Strengthening:

- Bypassing of LILO of one circuit of Gandhar – Navsari(PG) 400kV D/c line at Vav S/s and restoring it to original configuration i.e. Gandhar – Navsari(PG) 400 kV D/c line
- Utilisation of the 2 nos. 400 kV bays vacated at Vav S/s (above) along with portion of LILO line (as required) for LILO of 2nd 400 kV circuit of Kosamba(GETCO)– Ukai 400 kV line at Vav (GETCO) S/s

Scheme to control high fault level at Asoj (GETCO) S/s:

- Bypassing of SSP - Asoj 400kV line (twin) (83km.) & Asoj-Chorania 400kV line (twin) (~170km.) at Asoj S/s so as to form SSP – Chorania 400kV line (~250km.)

Since, no line reactors are present on the above lines being bypassed at Asoj S/s, GETCO may provide adequate reactive compensation on the line. **GETCO may update regarding the requirement of reactive compensation / PIR w.r.t. long SSP – Chorania 400kV line (~250km.).**

Under ISTS:

1. **Scheme for fault level control at Dehgam (PG) & Ranchhodpura (GETCO) S/s**

- 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:

a) As per information received from POWERGRID vide e-mail dated 03.09.2020, 400 KV D/c Dehgam-Ranchorpura line is crossing with 400 KV D/ c Dehgam-Pirana line near boundary wall of sub station 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 Dehgam end and join with each other so that 400 KV D/c Ranchhodpura-Pirana line shall be established.

b) With above bypassing, 4 nos. bays at Dehgam S/s shall become vacant.

c) After the implementation above scheme as well as considering proposed system strengthening scheme in Gujarat (below), the fault level at 400 kV buses at Dehgam S/s (PG) & Ranchhodpura S/s (GETCO) is observed to reach about 31kA & 38kA respectively (within limits).

d) Ranchhodpura - Dehgam 400 kV D/c line (twin) is 62km long while Dehgam – Pirana and Dehgam – Nicol 400kV lines are 56km. & 26km. respectively.

- **System strengthening in Gujarat**

In the joint studies carried out on 13.04.2021, GETCO had suggested connecting proposed Bharuch S/s with Vav 400/220kV S/s. However, based on revised study files with higher Gujarat demand and STU RE generation, loading on Vadodara & Sugen 400/220kV ICTs and Bharuch 765/400kV ICTs was found to again violate N-1 contingency even after considering all system strengthening schemes proposed in the agenda of the 3rd WRPC(TP) meeting as well as revised 400kV interconnections at Bharuch S/s as suggested by GETCO. In this scenario, establishment of 765/400kV Vapi-III S/s was found inevitable to reduce the above overloadings. However, to optimize the system without the requirement of establishment of additional S/s near Vapi, the scheme was reviewed and it was found prudent to shift Bharuch S/s further south to Kosamba and interconnect it with Kala and Magarwada substations for direct feed of power towards Kudus / Boisar (major load centres). Interconnection with Vav S/s was found to overload the 400/220kV ICTs at Vav S/s and hence the same was dropped. Further, to facilitate bidirectional power transfer from WR to NR and vice versa in various scenarios, Indore – Chittorgarh 765kV D/c line has been planned instead of Ahmedabad – Indore 765kV D/c line (planned under Transmission scheme for evacuation of 4.5 GW RE injection at Khavda P.S. under Phase-II – Part E) which was not found to be of significant help in any of the 9 scenarios studied. In view of the foregoing, the revised system strengthening scheme in Gujarat under ISTS is as under:

i) Banaskantha – Ahmedabad 765kV D/c line (~200km.) with 330MVAr, 765kV Switchable line reactor on each ckt at Ahmedabad S/s end
ii) Indore – Chittorgarh 765kV D/c line (~310km.) with 330MVAr, 765kV Switchable line reactor on each ckt at both ends
iii) Establishment of 2x1500MVA, 765/400kV & 2x500MVA, 400/220kV Kosamba S/s with **2x330MVAr** 765kV and 1x125MVAr 400kV Bus reactor. (with 110MVAr 765kV switchable single phase reactor (spare unit for bus/line reactor and 1x500MVA, 765/400kV single phase spare transformer)
iv) Kosamba - Kala (GIS) 400kV D/c line (conductor with minimum capacity of 2100MVA at nominal voltage) (~180km.) with 50 MVAr switchable line reactors on each ckt at Kosamba end and 63MVAr switchable line reactors on each ckt at Kala end

Kosamba – Magarwada (GIS) 400kV D/c line (conductor with minimum capacity of 2100MVA at nominal voltage) (~140km.) with 80 MVAr switchable line reactors on each ckt at Magarwada end

It may be noted that since Kala and Magarwada are located close to each other, majority of common stretch of Kosamba – Kala and Kosamba – Magarwada 400kV D/c line may be constructed using Multi-circuit towers in order to save RoW and hence both the 400kV lines may be kept part of the same package.

v) Kosamba – Padghe (GIS) 765kV D/c line (~270-280km.) with 330MVAr, 765kV Switchable line reactor on each ckt at Kosamba S/s end and

240MVAr, 765kV Switchable line reactor on each ckt at Padghe (GIS) S/s end

vi) Augmentation of Transformation capacity at Bhachau S/s by 1x500MVA, 400/220kV
vii) Augmentation of Transformation capacity at Magarwada (GIS) S/s by 1x500MVA, 400/220kV
viii) Augmentation of Transformation capacity at Padghe (GIS) 765/400kV substations by 1x1500MVA ICT
ix) Augmentation of Transformation capacity at Banaskantha S/s by 1x1500MVA, 765/400kV
x) Augmentation of Transformation capacity at Ahmedabad 765/400kV substations by 1x1500MVA ICT
xi) LILO of Sankhari – Zerda 400kV line at Banaskantha (LILO length ~30km.)*
xii) LILO of Sankhari – Ranchhodpura 400kV line at Banaskantha (LILO length ~30km.)*

*Other alternatives as mentioned in agenda for the 3rd WRPC(TP) meeting did not provide the required relief to Banaskantha – Sankhari 400kV D/c line and Banaskantha – Zerda 400kV line including reconductoring of Banaskantha – Sankhari 400kV D/c line with high capacity conductor. Alternatively, Banaskantha – Sankhari 400kV 2nd D/c line would be required subject to availability of space at Sankhari (GETCO) S/s. **GETCO may confirm regarding space at Sankhari S/s.**

220kV System interconnections considered at Kosamba (to be developed under Intra-state):

- Kosamba – Haldarwa 220kV D/c line (shifted from GPEC 220kV bus) (~25-30km. shifting)
- Kosamba – Karamsad 220kV D/c line (shifted from GPEC 220kV bus) (~25-30km. shifting)

GETCO may confirm regarding 220kV interconnection proposed above.

Note:
In order to control loading issues on Bhinmal – Zerda 400kV line, the following system was proposed earlier:

- LILO of Zerda – Kankroli 400kV S/c line at Bhinmal S/s (other circuit is already LILOed at Bhinmal S/s) along with reconductoring of Bhinmal – Zerda 400kV D/c lines with conductor having minimum capacity of 2100MVA at nominal voltage.

However, it was observed that the overloading is being observed on account of RE generation in Jaisalmer (Rajasthan) which is causing the entire Jaisalmer – Barmer – Bhinmal – Zerda 400kV line section to get overloaded [especially under high export scenarios in NR (*Scenario-7*)]. Hence, the same needs to be further examined in coordination with NR and system strengthening, as required, shall be taken up in subsequent meeting.

The estimated cost of above system strengthening schemes in Gujarat works out to **Rs. 5500 Crore.**

- **Transmission System for Additional 7GW (Total 15GW) injection in Khavda area**

Transmission System for Khavda REZ 27.7GW capacity is being planned in three phases based on deliberations in the 1st WRPC(TP) meeting held on 11.01.2020, 3rd NCT meeting held on 26.05.2020 & 28.05.2020 and in the 2nd WRPC(TP) meeting held on 04.09.2020:

- **Phase-A (8GW) expected by 2023**
  - Part-I: 3GW
  - Part-II: 4.5GW
  - Injection at Bhuj PS: 0.5GW
- **Phase-B (7GW) expected by 2024-25**
- **Phase-C (12.7GW) expected by 2026-27**

It is observed that it would be difficult for generation developers which have been allocated large chunks of land in Khavda area to separately inject 500MW at Bhuj PS when 3 nos. 765/400kV Pooling Stations are being envisaged in Khavda area. In view of the same, it is proposed to incorporate this potential as part of Phase-A (Part-II).

Accordingly, the revised phasing of Khavda REZ 27.7GW capacity and its current status is as given below:

Sl.	Phasing	Status
1	**Phase-A (8GW) expected by 2023** o Part-I: 3GW o Part-II: 5GW (including 0.5GW capacity shifted from Bhuj PS)	o Part-I (3GW): Scheme already notified as "Transmission scheme for evacuation of 3 GW RE injection at Khavda P.S. under Phase-I". o Part-II: ▪ 4.5GW: Scheme already notified as "Transmission scheme for evacuation of 4.5 GW RE injection at Khavda P.S. under Phase-II" (in 5 parts) ▪ 0.5GW capacity shifted from Bhuj PS to Khavda and to be made part of Part-II.
2	**Phase-B (7GW) expected by 2024-25**	o To be finalized in this meeting
3	**Phase-C (12.7GW) expected by 2026-27**	o To be planned

To cater to total 27.7GW injection in Khavda area, three pooling stations are being planned as per details at para 9.2 of 3rd WRPC(TP) agenda. The broad scope of works w.r.t. these pooling stations is given below:

Establishment of pooling stations (KPS2 and KPS3) in Khavda RE park

S. No.	Pooling station	Ultimate Capacity	Initial implementation by Dec 2024	Remarks
1	Khavda pooling station (KPS1) alongwith KPS1-Bhuj 765 kV D/C line.	8x1500 MVA, 765/400 kV	3x1500, 765/400 kV. Space for addl. 5x1500, 765/400 kV ICTs. Only one 400 & 765kV bus section to be implemented for injection upto 3GW.	Phase-A (Part-I: 3GW) Scheme already notified as "Transmission scheme for evacuation of 3 GW RE injection at Khavda P.S. under Phase-I".
2	Khavda pooling station (KPS2*) alongwith KPS1-KPS2 765 kV D/C line Or LILO of one ckt KPS1-Bhuj 765 kV D/C line at KPS2	9x1500 MVA, 765/400 kV	4x1500, 765/400 kV. Space for addl. 5x1500, 765/400 kV ICTs. Both bus sections to be implemented	Under finalization as a part of Khavda Phase-B (7GW)
3	Khavda pooling station (KPS3*) alongwith KPS3-KPS2 765 kV D/C line	8x1500 MVA, 765/400 kV	3x1500, 765/400 kV. Space for addl. 5x1500, 765/400 kV ICTs. Only one bus section to be implemented.	Under finalization as a part of Khavda Phase-B (7GW)

*KPS2 and KPS3 pooling stations shall be established in two sections (with bus sectionalizer at 765kV & 400kV level). Bus sectionalizer at 765kV level shall normally be closed and bus sectionalizer at 400kV level shall normally be open.

Khavda pooling station (KPS2) scope of works:

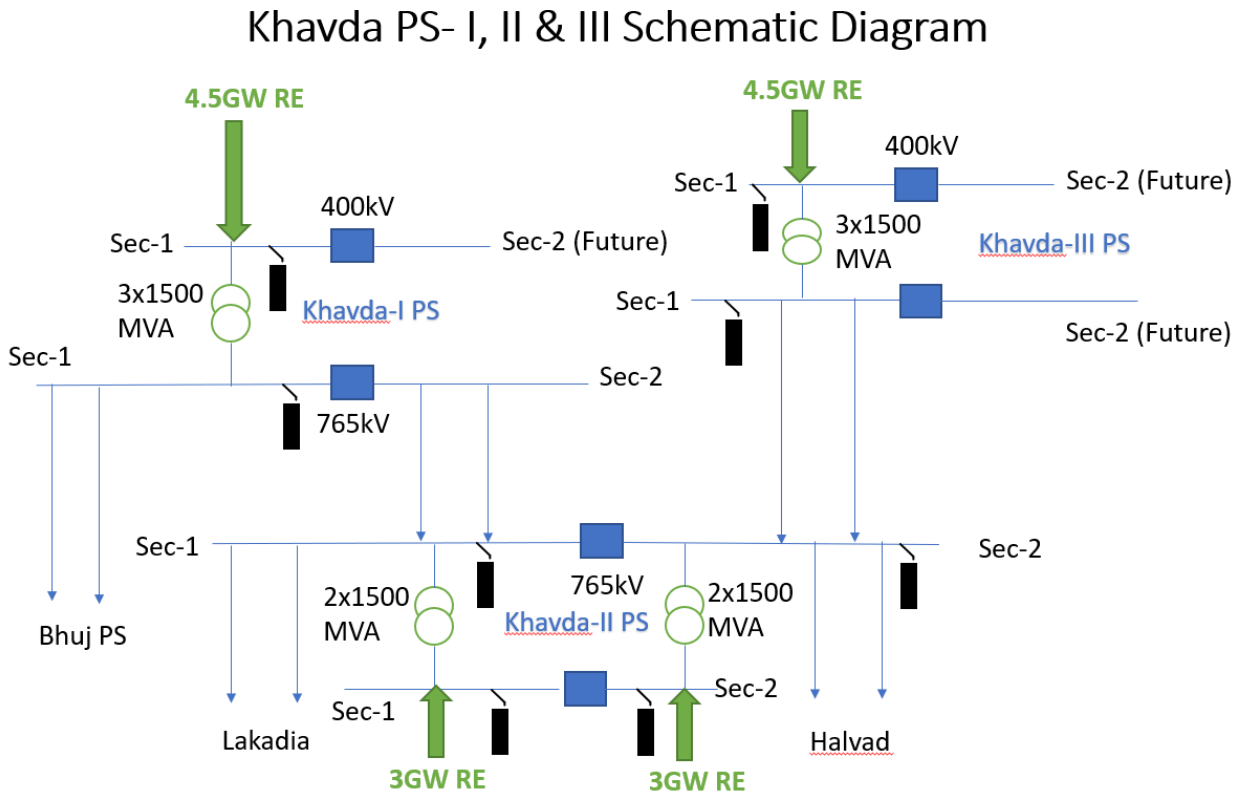
- Establishment of 765/400 kV, 4x1500MVA, KPS2 (GIS) with 2X330 MVAR 765 kV bus reactor and 2X125 MVAR 400 kV bus reactor. It will have space provisions for future expansion of 765/400 kV, 5x1500MVA.
- The pooling station shall be established in two sections (with bus sectionalizer at 765kV & 400kV level). On each bus section, there shall be 2x1500MVA 765/400kV ICTs, 1x330MVAr, 765 kV & 1x125MVAr 420kV bus reactor. First section will have space for future expansion of 3x1500, 765/400 kV ICTs and second section will have space for future expansion of 2x1500, 765/400 kV ICTs. Bus sectionalizer at 765kV level shall normally be closed and bus sectionalizer at 400kV level shall normally be open.
- 1x500MVA, 765/400kV (single phase) spare transformer at KPS2
- 110MVAr 765kV switchable single phase reactor (spare unit for bus/line reactor) at KPS2.

- KPS1-KPS2 765 kV D/C line (along with establishment of second 765kV bus section at KPS1 where above line shall be terminated) OR LILO of one ckt of KPS1-Bhuj 765 kV D/C line at KPS2

Khavda pooling station (KPS3) scope of works:

- Establishment of 765/400 kV, 3x1500MVA, KPS3 (GIS) with 1X330 MVAR 765 kV bus reactor and 1X125 MVAR 400 kV bus reactor. The pooling station would have space provision for future expansion of 5x1500 MVA, 765/400 kV ICT.
- The pooling station shall be created with bus section I with 765/400, 3x1500MVA ICTs and 1X330 MVAR 765 kV & 1X125 MVAR 400 kV bus reactors alongwith future space provision for expansion of 1x1500, 765/400 kV ICT. Bus section II (future) shall be created with 765/400, 4x1500MVA ICTs and 1X330 MVAR 765 kV & 1X125 MVAR 400 kV bus reactors alongwith future space provision for expansion of 1500, 765/400 kV ICT. Bus sectionalizer at 765kV level shall normally be closed and bus sectionalizer at 400kV level shall normally be open
- 1x500MVA, 765/400kV (single phase) spare transformer at KPS3
- 110MVAr 765kV switchable single phase reactor (spare unit for bus reactor) at KPS3.
- KPS3- KPS2 765 kV D/C line.

Final Configuration of Khavda PS-I, II & III (for 15GW injection by 2024-25) is given below:



Onward transmission system requirement from Khavda RE park:

Under Phase-A (8GW), Khavda PS- Lakadia- Ahmedabad-Indore/Vadodara 765 kV D/C line has already been agreed for evacuation of about 8 GW of power. Additional evacuation of 7 GW power from Khavda RE park would require an additional 765 kV corridor towards load centres. Various alternatives were studied on 9 scenarios and after several discussions in joint study meetings, the following transmission system is

proposed. To control overvoltages at proposed substations under evening peak, night off-peak scenarios and maintain voltages in 770-780kV range, 2x330MVAr 765kV bus reactors have been planned at Kosamba S/s (under system strengthening scheme above) as well as at Vataman & Halvad 765 kV S/s below. Further, additional 330MVAr bus reactors are proposed at Lakadia 765 kV & Vadodara 765 kV S/s.

Changes to earlier agreed schemes for 8 GW Khavda REZ (elaborated in detail package-wise later):

a) Termination of Ahmedabad – Vadodara 765kV D/c line (~112km.) (being implemented under Khavda Phase-II Part C scheme) to Kosamba S/s so as to form Ahmedabad – Kosamba 765kV D/c line (~220km.) with 240 MVAr switchable line reactor at both ends.
b) **Ahmedabad – Indore 765kV D/c line is no longer required** as a maximum flow of 1000MW per ckt is observed on the line in only one of the scenarios while in other scenarios, the flows were further less. Hence, the scope of work under Transmission scheme for evacuation of 4.5 GW RE injection at Khavda P.S. under Phase-II – Part E would not be required to be implemented.

New Transmission System proposed:

c) Establishment of 765kV switching station at Halvad with 765kV, 2x330MVAr bus reactors (with 110MVAr & 80MVAr 765kV switchable single phase reactor (spare unit for bus/line reactors at Morbi)
d) KPS2- Halvad 765kV D/c line (~220 km.) with 240 MVAr switchable line reactor at both ends.
e) LILO of Lakadia – Ahmedabad 765kV D/c line at Halvad (LILO length ~50km.)
f) 240MVAr 765kV switchable line reactor on each ckt at Halvad end of Halvad – Ahmedabad 765kV D/c line (~220km.)
g) Halvad – Vataman 765kV D/c line (~170km.) with 1x330MVAr switchable line reactor at Vatman end on each ckt.
h) Establishment of 765 kV switching station near Vataman with 2X330 MVAr, 765 kV bus reactor. 110MVAr & 80MVAr 765kV switchable single phase reactor (spare unit for bus/line reactor)
i) LILO of Lakadia – Vadodara 765kV D/c line at Vataman 765 switching station (~10km. LILO length)*
j) Vataman switching station – Kosamba 765kV D/c line (~200km.) with 330MVAr switchable line reactors on each ckt at Kosamba end
k) Conversion of 240MVAr 765kV switchable line reactor on each ckt at Lakadia end of Lakadia – Ahmedabad 765kV D/c line (being LILOed at Halvad) into bus reactors with NGR bypassing arrangement.

(considering requirement of additional reactive compensation at Lakadia S/s and also Lakadia – Halvad 765kV D/c line (~100km.) shall have ~100% compensation after LILO of Lakadia – Ahmedabad at Halvad)

l) Reactive Compensation at Vadodara S/s to control high voltages

One of the following is proposed:

- Conversion of 330MVAr 765kV switchable line reactor on each ckt at Vadodara end of Lakadia – Vadodara 765kV D/c line (being LILOed at Vataman) into bus reactors with NGR bypassing arrangement.

(considering requirement of additional reactive compensation at Vadodara S/s and also Vadodara – Vataman 765kV D/c line (~120km.) shall have ~100% compensation after LILO of Lakadia – Vadodara at Vataman)

- **Alternatively**, the Vataman substation may be shifted about 25km. south towards Pipali so that the substation is merely 15-20km. from Dholera. In this way, the requirement of additional substation at Dholera for injection of power from Dholera UMSP may not arise as Dholera UMSP may directly inject at 400kV level of proposed Pipali S/s. Also, the percentage compensation on Pipali – Vadodara 765kV D/c line (~150km.) is observed around 82.5%. In such case, conversion of line reactors to bus reactors will not be required and 330MVAr bus reactor (2nd) at Vadodara S/s would then be required for voltage control.

Locations of respective locations are given below:

The estimated cost of above schemes for evacuation of power from 7GW additional REZ in Khavda area works out to **Rs. 5830 Crore.**

Changes to earlier agreed schemes for 8GW Khavda REZ:

With the above proposed transmission system, following modification is required in the already agreed schemes for Khavda REZ Phase-A (Part II: 4.5GW):

I. Transmission scheme for evacuation of 4.5 GW RE injection at Khavda P.S. under Phase-II: Part A

S.No	Agreed scope of works	Modified scope of works
1	Augmentation of Khavda PS (GIS) by 4X1500 MVA, 765/400 kV ICTs with 1X330 MVAR 765 kV bus reactor and 1X125 MVAR 420 kV bus reactor on 2nd 765 kV and 400 kV bus respectively	Augmentation of **Khavda PS1** (GIS) by 4X1500 MVA, 765/400 kV ICTs with 1X330 MVAR 765 kV bus reactor and 1X125 MVAR 420 kV bus reactor on 2nd 765 kV and 400 kV bus respectively **Implementation beyond LTA of 4.5 GW at KPS1.**
2	Augmentation of 400/220 kV, 2X500 MVA transformation capacity at Khavda (GIS) P.S. (implementation to be taken as per connectivity/LTA granted at 220 kV level)	May be deleted for KPS-1 as connectivity granted at 400 kV level. Khavda PS(GIS) may be read as Khavda pooling station 2(GIS) – KPS2 Implementation with LTA requirement more than 3 GW from Khavda RE park
3	Khavda PS (GIS) – Lakadia PS 765kV D/c line with 330 MVAR line reactors at Khavda end.	Khavda PS2 (GIS) – Lakadia PS 765kV D/c line with 330 MVAR line reactors at Khavda end.
4	2 nos. of 765 kV line bays each at Lakadia PS for Khavda PS (GIS) – Lakadia PS 765kV D/c line	2 nos. of 765 kV line bays each at Lakadia PS for Khavda PS2 (GIS) – Lakadia PS 765kV D/c line
5	1x330 MVAr Switchable line reactor for each circuit of Khavda PS (GIS) – Lakadia PS 765kV D/c line at Khavda End	1x330 MVAr Switchable line reactor for each circuit of Khavda PS2 (GIS) – Lakadia PS 765kV D/ c line at Khavda end
6		In case KPS1-KPS2 765 kV D/C line is not planned with KPS2, the D/C interconnection to be established through: • Bypassing of LILO of one ckt. of KPS1-Bhuj at KPS2 • Utilisation of LILO section to establish KPS1-KPS2 765 kV D/C line along with establishment of second 765kV bus section at KPS1 where above line shall be terminated *Implementation in case of LTA exceeding 3 GW from Khavda RE Park.*

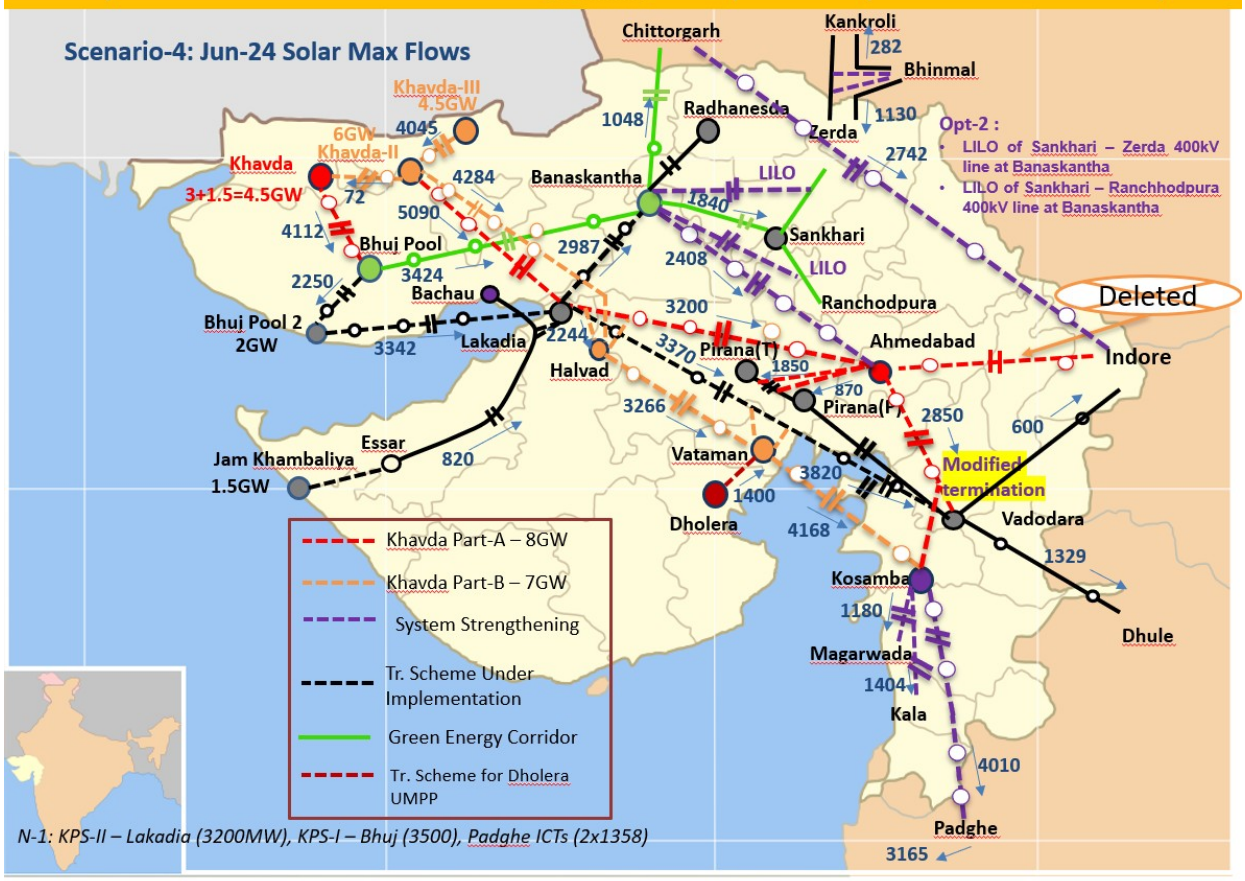
II. Transmission scheme for evacuation of 4.5 GW RE injection at Khavda P.S. under Phase-II – Part C

Sl. No.	Agreed Scope of the Works	Modified Scope of works
1.	Establishment of 2X1500 MVA, 765/400 kV, Ahmedabad S/s with 1X330 MVAR 765 kV bus reactor and 1X125 MVAR 420 kV bus reactor.	No change
2.	Ahmedabad – Vadodara 765kV D/c line	Ahmedabad – Kosamba 765kV D/c line
3.	2 nos. of 765 kV line bays at Vadodara for Ahmedabad – Vadodara 765kV D/c line	2 nos. of 765 kV line bays at Kosamba for Ahmedabad – Kosamba 765kV D/c line
4	-	240 MVAr, 765 kV switchable line reactor for each circuit at each end of Ahmedabad – Kosamba 765kV D/c line

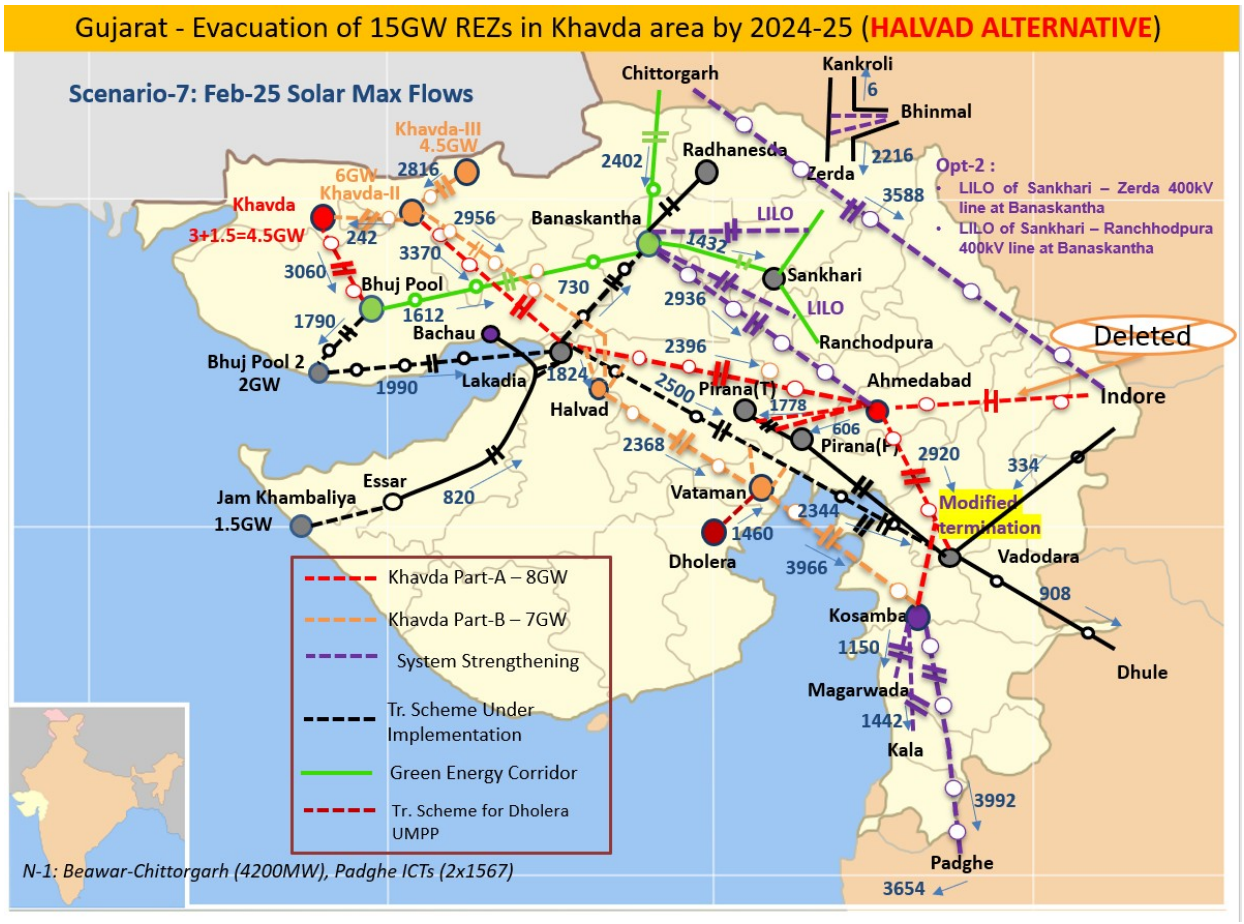
III. Further, the scope of work under Transmission scheme for evacuation of 4.5 GW RE injection at Khavda P.S. under Phase-II – Part E would not be required.

The load flow result for Scenario 4 (Solar Max – Jun'24) and Scenario 7 (Solar Max – Feb'25) is given below for better understanding of the flow patterns for high RE scenarios. Scenario 7 is an extreme case where NR is the exporting region and all other regions are importing. In this scenario, the new proposed Indore – Chittorgarh 765kV D/c line is of significant help. Load flow SLDs for each of the 9 scenarios are available at Annexure-XV.

Gujarat - Evacuation of 15GW REZs in Khavda area by 2024-25 (HALVAD ALTERNATIVE)



Gujarat - Evacuation of 15GW REZs in Khavda area by 2024-25 (HALVAD ALTERNATIVE)



Analysis for efficacy of Battery Energy Storage System (BESS) in respect of partial replacement of transmission system for 15 GW RE power evacuation corridor from Khavda area

An analysis has been carried out in respect of the value proposition of Transmission system investment deferral in favour of Storage(BESS), by partial replacement of 15GW RE power evacuation corridor from Khavda area by Battery Energy Storage systems(BESS). The analysis thus depicts the cost benefit analysis considering storage as an option for Transmission System deferral.

Transmission system for 8GW REZ in Khavda is already under approval stage (without storage). Hence, it was felt prudent to analyze the usage of storage for the balance 7GW RE capacity in lieu of transmission system for evacuation of the RE capacity and the same has been depicted hereunder.

The balance 7GW REZ evacuation corridor from Khavda area which can be replaced with storage system comprises of the following:

i. Establishment of 765/400 kV, 4x1500MVA, KPS2 (GIS) with 2X330 MVAR 765 kV bus reactor and 2X125 MVAR 400 kV bus reactor.
ii. Establishment of 765/400 kV, 3x1500MVA, KPS3 (GIS) with 1X330 MVAR 765 kV bus reactor and 1X125 MVAR 400 kV bus reactor.
iii. KPS3- KPS2 765 kV D/C line
iv. KPS1 - KPS2 765kV D/c line

v. Establishment of 765kV switching station at Halvad with 765kV, 1x330MVAr bus reactor (with 110MVAr & 80MVAr 765kV switchable single phase reactor (spare unit for bus/line reactors at Morbi)
vi. KPS2- Halvad 765kV D/c line (~220 km.) with 1x240 MVAr switchable line reactor at both end.
vii. LILO of Lakadia – Ahmedabad 765kV D/c line at Halvad (LILO length ~50km.)
viii. 240MVAr 765kV switchable line reactor on each ckt at Halvad end of Halvad – Ahmedabad 765kV D/c line
ix. Halvad – Vataman 765kV D/c line (~150km.) with 1x330MVAr switchable line reactor at Vatman end.
x. Establishment of 765 kV switching station near Vataman with 1X330 MVAr, 765 kV bus reactor. 110MVAr 765kV switchable single phase reactor (spare unit for bus/line reactor)
xi. LILO of Lakadia – Vadodara 765kV D/c line at Vataman 765kV switching station (~10km. LILO length)
xii. Vataman switching station – Kosamba 765kV D/c line (~200km.)
xiii. 1x330MVAr switchable line reactor at Kosamba end of Vataman-Kosamba 765kV D/c line

Cost of above corridor would be about **Rs.5800 Crore** and the same has been considered for analysis vis-a-vis Storage Costs.

Complete cost of BESS for 2024-25 time frame has been assumed as: Rs. 1.50 Cr/MWh(approx.)

The following cases have been considered:

i. 100% replacement of the above corridor by a BE Storage System to ensure zero curtailment of any RE generation:

4 hours storage capability duration as per details below:

RE capacity corresponding to 15GW Khavda injection: 9GW Solar (60%) 6 GW Wind (40%)
Peak RE Injection corresponding to 15GW Khavda REZ: 13.5 GW (assuming 100% Solar dispatch & 75% wind dispatch).

As per studies, around 8GW capacity gets evacuated through existing / planned HVAC lines (without the need for above corridor). Hence, assuming that peak **5.5GW RE capacity would need to be stored for 4 hour duration,** Capacity of Storage required would be = 22,000MWh [5.5 x 4 x 1]

The corresponding cost for Storage(BESS) would be Rs.33,000 Cr (CAPEX @ ₹ 1.5 Cr/MWh)which would still be around 5.7 times the cost of the above corridor. The above would take care of peak RE absorption for 4 hours only and there may be some curtailment in the other hours (during the RE ramp up / ramp down hours adjoining the peak 4 hour duration).

ii. BESS for 4 Hours peak RE shaving requirement and without above corridor:

Another case has been considered with 6 hours storage capability duration as per details below:

RE capacity corresponding to 15GW Khavda injection: 9GW Solar (60%), 6 GW Wind (40%)
Peak RE injection corresponding to 15GW Khavda REZ:13.5 GW (assuming 100% Solar dispatch & 75% wind dispatch).

As per studies, around 8GW capacity gets evacuated through existing / planned HVAC lines (without the need for above corridor). Hence, assuming that peak **5.5GW RE capacity would need to be stored for a 6 hour duration,** capacity of Storage required would be = 33,000MWh [5.5 x 6 x 1]

The corresponding cost would be: Rs.49,500 Cr. (CAPEX @ Rs.1.5Cr/MWhr)which would still be around 8.53 times the cost of the above corridor. The above would take care of peak RE absorption for 6 hours only and there may be some curtailment in the other hours (during the RE ramp up / ramp down hours adjoining the peak 6 hour duration).

iii. 100% replacement of the above corridor by a BE Storage System to ensure zero curtailment of any RE generation:

As per the studies carried out, the planned corridor will be able to evacuate 8000 MW RE power with reliability, especially during peak RE dispatch (Afternoon). For analysis of a 100% Transmission deferral application, deferral/replacement of Transmission system for the balance 7 GW RE by BESS is required to be done. However, considering that RE plants would not generate full capacity at all times, a

CUF of 30% has been considered for optimal sizing of the energy storage requirement of an equivalent BESS. The BESS is thus being sized considering capability to store the full RE energy quantum generated and would be charging/discharging considering availability of Solar generation and transfer capability of the transmission system to enable full utilization of theTransmission system (limited to the number of charging/discharging cycles as may be decided).
The storage requirement in this case is thus calculated @30% CUF over the 24Hours period:

Total RE energy per day = 50400 MWh (7000 x 24 x 0.30) or 50.4GWh

The corresponding cost would be: Rs.75,600 Cr. (CAPEX @ ₹ 1.5 Cr. per MWhr)

Considering the costs of the AC transmission system as Rs. 5800 Cr., we can conclude that 100% replacement of the line with battery would be associated with nearly a 13 fold cost increase which may not be a techno- economically feasible option.

It may be noted that with the present forecasted prices and technology, the Battery Energy Storage System (BESS) may not be a viable proposition in respect of transmission system deferral. However, storage systems offers several additional benefits as below:

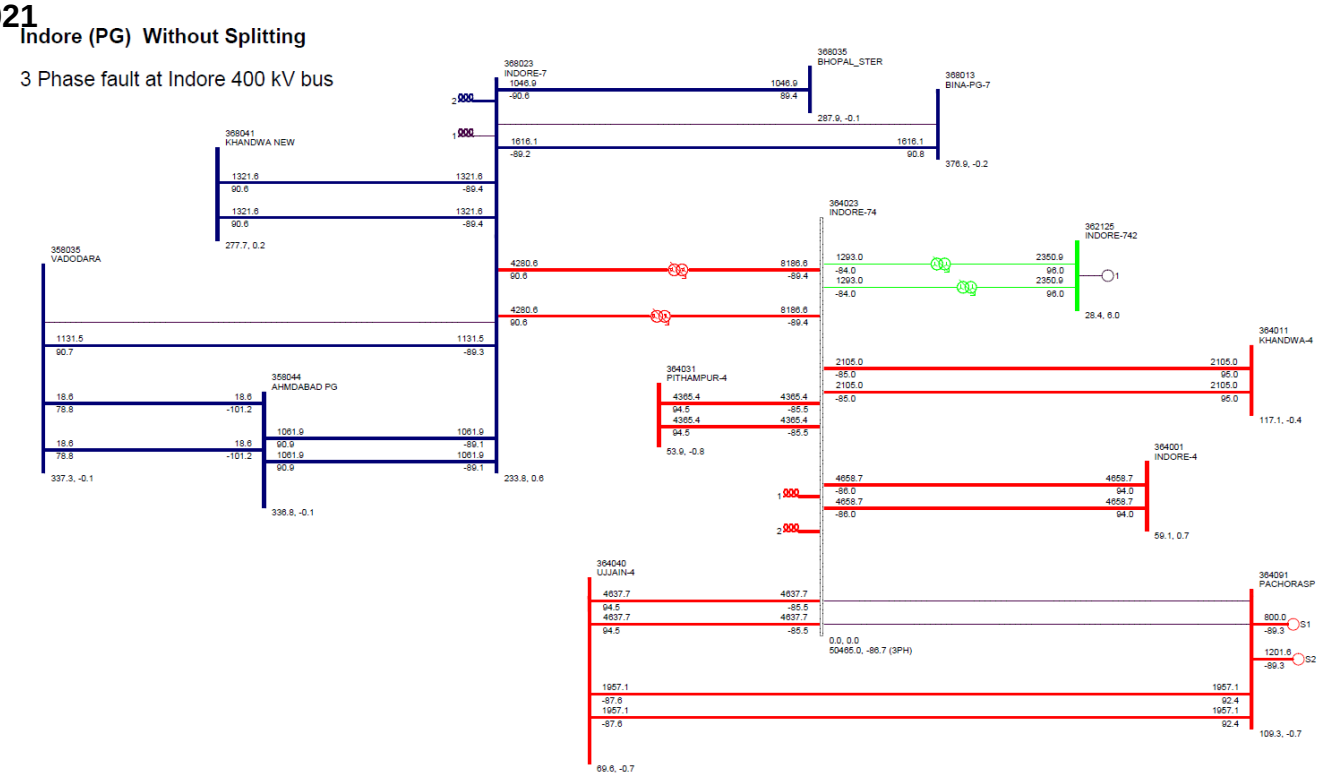
- BESS may not be a option for direct replacement of a transmission system and we need to stack the additional value streams created in form of reactive support, peak shifting and other enhanced reliability aspects, ancillary services applications, etc. and consider value proposition of the BESS only in due considerations of the above.

- Co-locating BESS with RE projects is also a promising prospect to convert variable RE as a Flexible Energy Generation Asset with capability to supply both base load and peaking power based on requirement.

3. Scheme to control fault level at Indore S/s

Indore 765/400/220 kV S/s in MP acts as a node for transfer of power from generation projects in MP and Gujarat to load centres in MP through high capacity 400 kV and 765 kV networks. A large number of RE generation projects are coming up in Gujarat whose power is getting dispersed through various substations (at 765kV level) including Indore (PG) for onward transfer of power to other parts of the grid resulting in high short circuit levels of interconnected grid. **Short circuit level at Indore (PG) 400kV substation in 2022-2023 time-frame crosses 50 kA which is designed at 40 kA. Even in the current time-frame, the fault level is about 42 kA.**

Contributions from various 400 kV lines can be seen from the diagram below (for high RE scenario):



Accordingly, system study was carried out for 2022-23 time frame for High RE and Low RE peak scenarios to control the high fault level at Indore(PG) S/s keeping in view the fact that **765/400 kV ICTs, Indore (MP), Ujjain (MP) and Pithampur (MP)** feeders are the major SC Fault contributors at Indore 400 kV (PG) S/s. Study results for various configurations are enclosed at **Annexure-XVI**.

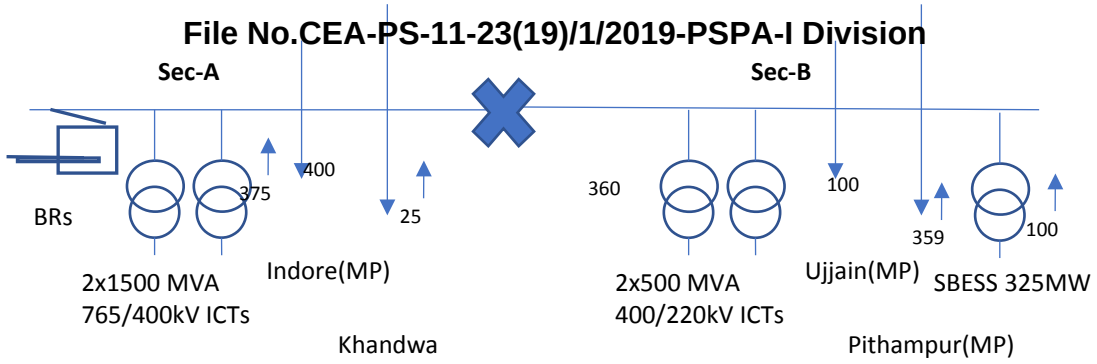
Insertion of series reactor instead of bus splitting offers improved system reliability in view of no requirement of bus segregation as the bus sections remain coupled through the series reactor. However, as per information received from Powergrid S/s, only 400kV bus splitting can be done using GIS/hybrid bays. Installation of 400kV Series reactor for Bus splitting and 400kV lines is not feasible as per site/layout constraints. Considering the same, the options studied for series bus/line reactors are not feasible to implement. Hence, it is observed that the fault level is within limits for alternatives 1, 4 & 6 (re-iterated below) along with peak short circuit values and load flows for evening peak scenario.

- **Alternative-1**: Bus Splitting without disturbing the existing lines/ICTs at Indore(PG) S/s
    - Section-A: 36kA & Section-B: 26kA

Diagram along with flows for peak load case is given below. Flow on sectionaliser when closed is **127MW**:

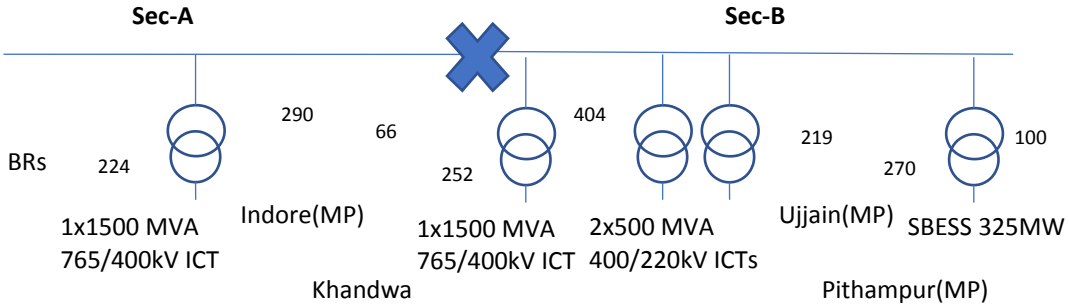
- **Alternative-4:** Bus Splitting along with shifting of 765/400 kV, 1X1500MVA ICT to Section B (through jumpering arrangement)
    - Section-A: 30kA & Section-B: 36kA

Diagram along with flows for peak load case is given below. Flow on sectionaliser when closed is **only 15MW**:


Sec-A
Sec-B
BRs
375
400
25
360
100
359
100
2x1500 MVA
765/400kV ICTs
Indore(MP)
Khandwa
2x500 MVA
400/220kV ICTs
Ujjain(MP)
Pithampur(MP)
SBESS 325MW

- **Alternative-6:** Bus Splitting along with swapping of Indore (PG)-Pithampur 400 kV D/c line (to Section A) and Indore (PG)- Indore(MP) 400 kV D/c line (to Section B)
    - Section-A: 34kA & Section-B: 27kA

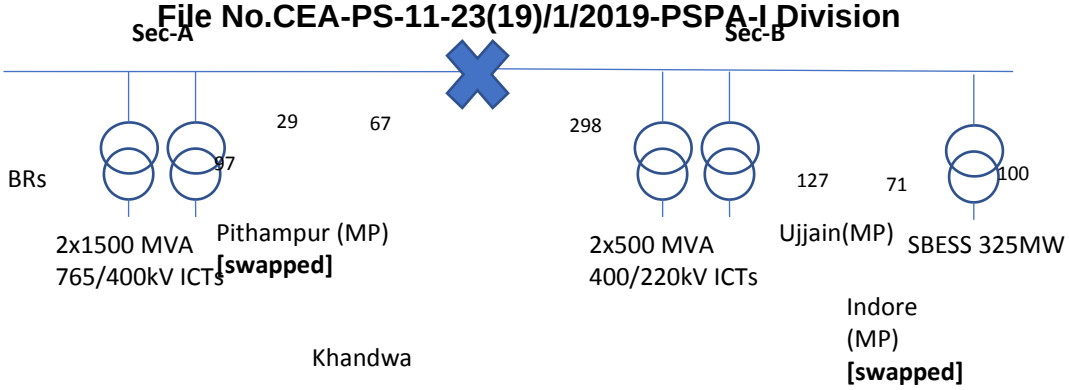
Diagram along with flows for peak load case is given below. Flow on sectionaliser when closed is 395MW:


Sec-A
Sec-B
BRs
224
290
66
252
404
219
270
100
1x1500 MVA
765/400kV ICT
Indore(MP)
1x1500 MVA
765/400kV ICT
Khandwa
2x500 MVA
400/220kV ICTs
Ujjain(MP)
SBESS 325MW
Pithampur(MP)

Among the three alternatives, power flow is balanced in both the sections in **Alternative-4** i.e. closing bus sectionaliser does not lead to significant flow from one section to another and **hence the overall flow pattern is not disturbed before and after splitting.** Further, 1X1500 MVA 765/400 kV ICT can be installed in Section-A in future for the above case. In case of outage of existing 1X1500 MVA 765/400 kV ICT on any of the sections both the sections may be interconnected as per the requirement through the bus sectionaliser.

Power flow is not well balanced in both Alternatives 1 and 6. Further, **Alternative-6** requires line shifting which would be difficult to implement due to layout constraints. **In each of the above cases, 1x125MVr bus reactor would be required in section B.**

The splitting arrangement has also been studied for **Alternative-4** in **2024-25 High RE scenario (Afternoon Peak)** and SC level / flows are obtained as follows:


Sec-A
Sec-B
29
67
298
BRs
97
127
71
100
2x1500 MVA
765/400kV ICTs
Pithampur (MP)
[swapped]
2x500 MVA
400/220kV ICTs
Ujjain(MP)
SBESS 325MW
Khandwa
Indore
(MP)
[swapped]

No issues are observed under N-1 of 765/400kV ICT on either section.

In view of the above, it is proposed to split 400kV bus of Indore S/s into two sections along with shifting of 765/400 kV, 1X1500MVA ICT to Section B (through jumpering arrangement) along with provision of 1x125MVr bus reactor would in section B.

Members may deliberate.

4. <u>Transmission system strengthening beyond Kolhapur for export of power from Solar & Wind Energy Zones in Southern Region</u>

The following transmission system was agreed in the 2nd SR Standing Committee on Transmission held on 10.06.2019 for evacuation of power from Phase-II Solar Energy Zone in Gadag, Karnataka:

Gadag SEZ (2500 MW)

i. Establishment of 400/220 kV, 5x500 MVA Gadag Pooling Station.
ii. Gadag PS-Koppal PS 400 kV (high capacity equivalent to quad moose) D/C Line.
iii. Gadag PS-Narendra (New) PS 400 kV (high capacity equivalent to quad moose) D/C Line.
iv. 220 kV line bays for interconnection of solar projects (8 nos.)
v. 1x125 MVAr (400 kV) bus reactor at Gadag PS.
vi. Upgradation of Narendra (New) to its rated voltage of 765 kV level alongwith 2x1500 MVA transformer and 1x330 MVAr Bus Reactor.
vii. Upgradation of Kolhapur (PG) to its rated voltage of 765 kV level alongwith 2x1500 MVA transformer and 1x330 MVAr Bus Reactor.
viii. Upgradation/charging of Narendra new - Kolhapur (PG) 765 kV D/c line (initially charged at 400 kV) to its rated voltage of 765 kV along with 1x330 MVAr switchable Line Reactor on Kolhapur (PG) end of each circuit.

It was also noted that the proposed system strengthening in the inter-regional corridors and system strengthening beyond Kolhapur in Western region shall require all-India study.

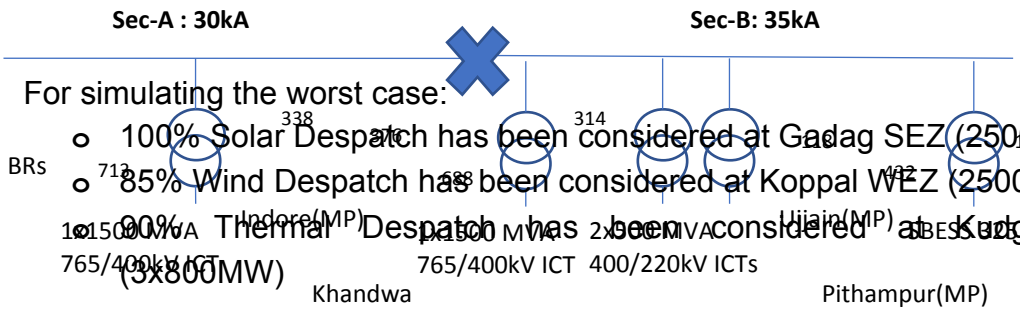
The present study has been carried out to check the adequacy of existing IR corridors beween WR & SR to cater to export of power from REZs in Southern Region to Western Region after considering Narendra(New) - Kolhapur charged at 765 kV level as agreed in above meeting.

A. Important Considerations for the study:

- Scenario: Solar Max (Jun'24 Afternoon Peak) with high generations in Narendra complex (Kudgi, Raichur, Bellary, Gadag SEZ & Koppal WEZ)

- All India Demand of 235 GW considered (against EPS demand of 266 GW)

- Demand for WR & SR is 73GW & 56GW respectively (against EPS demand of 85GW & 75GW respectively)



- For simulating the worst case:
  - 100% Solar Despatch has been considered at Gadag SEZ (2500MW)
  - 85% Wind Despatch has been considered at Koppal WEZ (2500MW)
  - 90% Thermal Despatch has been considered at Kudgi TPS (3x800MW)

With this, the Net SR Surplus in Solar Max scenario works out to 7800MW with SR to WR inter-regional flow to the tune of 9300MW. LGB shown at Annexure-XVII.

- Narendra New existing 765/400kV 2x1500MVA ICTs are seen to be heavily loaded in all study cases. Hence, Addl. 3x1500MVA, 765/400kV ICTs have been considered at Narendra New S/s. System strengthening, if any, in Southern Region is out of the scope of the present study.

- LILO of both circuits of Warora Pool – Parli (PG) D/c line at Parli (M) (Implementation by MSETCL) has been considered in studies as agreed in the 2nd WRPCTP meeting held on 04.09.2021 and needs to be expedited by MSETCL.

B. Alternatives studied:

Alternatives studied are given below:

Case ID	Transmission strengthening	Length (km.)	Solapur - Pune	Raichur - Solapur	Loading on Proposed Line	Loading on Kolhapur 765/400kV ICTs	Loading on Kolhapur (PG) - Kolhapur(MSETCL) 400kV Interconnection lines	Loading on Kolhapur(MSETCL) - Karad(MSETCL) 400kV D/c line	Remarks
0	Base Case				-	2x1423 N-1 violation	2x1531 N-0 violation	2x819 [N-1 non compliant (1142)]	Severe overloadings observed
1	Kolhapur (PG) (GIS) - Kolhapur (MH) reconductoring with conductor with min capacity of 2100MVA at nominal voltage & with Kolhapur 765/400kV 3rd 1500MVA ICT	-			-	3x1010	2X1589 [N-1 non compliant (2627)]	2x761 [N-1 non compliant (1172)]	Not technically feasible solution
2	Kolhapur (PG) (GIS) - Kolhapur (MH) 2nd D/c line with conductor with min capacity of 2100MVA at nominal voltage & with Kolhapur 765/400kV 3rd 1500MVA ICT	60	998	2x1590	2x987 (on New D/c line)	3x1106 [N-1 non compliance (2x1553)]	2x987 (New D/c) + 2x807 (Existing D/c) [N-1 non compliant (1308 + 2x1070)]	2x834 [N-1 non compliant (1284)]	Not technically feasible solution

Case ID	Transmission strengthening	Length (km.)	Solapur - Pune	Raichur - Solapur	Loading on Proposed Line	Loading on Kolhapur 765/400kV ICTs	Loading on Kolhapur (PG) - Kolhapur(MSETCL) 400kV Interconnection lines	Loading on Kolhapur(MSETCL) - Karad(MSETCL) 400kV D/c line	Remarks
3	Kolhapur (PG) (GIS) - Pune (PG) (GIS) 765kV D/c line along with Kolhapur (PG) (GIS) - Kolhapur (MH) reconductoring with conductor with min capacity of 2100MVA at nominal voltage*	270	455	2x1389	2x1459	2x713	2x830 [N-1 Compliant after reconductoring: 1462]	2x548 [N-1 Compliant (756)]	Technically feasible. Total losses: 9273MW Loading on Padghe 3x1500ICTs: 3x1235 (2x1582 under N-1 i.e. Critically loaded)
4	Kolhapur (PG) (GIS) - Solapur (PG) 765kV D/c line along with Kolhapur (PG) (GIS) - Kolhapur (MH) reconductoring with conductor with min capacity of 2100MVA at nominal voltage*	250	1233	2x1199	2x1456	2x748	2x952 [N-1 Compliant after reconductoring: 1509]	2x607 [N-1 Compliant (838)]	Technically feasible Total losses: 9321MW (48MW higher w.r.t. Case 3 above) Loading on Padghe 3x1500ICTs: 3x1094 (2x1406 under N-1 i.e. within limits)
5	LILO of Solapur – Pune 765 kV S/c line Kolhapur PG along with Kolhapur (PG) (GIS) - Kolhapur (MH) reconductoring with conductor with min capacity of 2100MVA at nominal voltage*	180	-	2x1236 (N-1: 1816)	Kolhapur – Pune: 1811 Kolhapur – Solapur: 1141	2x746	2x949 N-1: 1515	2X592 N-1: 818	Total losses: 9326 MW (53MW higher w.r.t. Case 3 above) Loading on Padghe 3x1500ICTs: 3x1129 (2x1451 under N-1 i.e. within limits)
6	Narendra New - Solapur 765kV D/	150	1342	2x857	2x2250	-	2x835	2X564	Technically feasible

Case ID	Transmission strengthening	Length (km.)	Solapur - Pune	Raichur - Solapur	Loading on Proposed Line	Loading on Kolhapur 765/400kV ICTs	Loading on Kolhapur (PG) - Kolhapur(MSETCL) 400kV Interconnection lines	Loading on Kolhapur(MSETCL) - Karad(MSETCL) 400kV D/c line	Remarks
	c line along with Kolhapur (PG) (GIS) - Kolhapur (MH) reconductoring with conductor with min capacity of 2100MVA at nominal voltage* with Narendra-Madhugiri-Salem- Tuticorin charged at 400 kV* Narendra New-Kolhapur 765 kV D/c line charged at 400 kV & Narendra New-Madhugiri-Salem-Tuticorin charged at 400 kV						N-1: 1386	N-1: 788	Total losses: 9223MW (98MW lesser w.r.t. Case 4 above) Loading on Padghe 3x1500ICTs: 3x1105 (2x1421 under N-1 i.e. within limits)

**Efficacy of the proposed transmission system was also seen in Evening Peak (Aug'24 case) which also has high SR export (~8000MW) and loadings were found to be generally in order.*

Study Results are given at **Annexure-XVIII**.

HVDC Sensitivity Studies:

- NEW – SR HVDC despatches considered are: Chandrapur – Bhadrawati (100MW), Gazuwaka (650MW), Talcher – Kolar (2000MW) & Raigarh – Pugalur (2000MW).
- Sensitivity of power flow on Kolhapur (PG) (GIS) – Kolhapur (MH) 400kV D/c line and Kolhapur - Karad 400kV D/c line was seen w.r.t. variation in flows on major WR – SR HVDCs viz. Talcher – Kolar (2000MW despatch) and Raigarh – Pugalur (2000MW despatch).
- Change in Talcher – Kolar HVDC from 2000MW to 0 leads to power flow change on Kolhapur (PG) (GIS) – Kolhapur (MH) 400kV D/c line to tune of 200MW (only ~10% sensitivity). Sensitivity to Raigarh – Pugalur HVDC link is of same order (~10%). Further, Sensitivity of power flow on Kolhapur - Karad 400kV D/c line is even lesser (~5%).

Hence, it would be difficult to control overloadings observed on the subject lines based on HVDC modulations alone.

C. Observations

Alternatives 3, 4, 5 and 6 are feasible solutions but Alternative-6 seems better than other alternatives. Alt-3 (Kolhapur to Pune) leads to marginally higher loading on Padghe 765/400kV ICTs. However, Alternative-6 provides comparatively higher relief to loadings on Kolhapur (PG) - Kolhapur(MSETCL) & Kolhapur(MSETCL) - Karad(MSETCL) 400kV D/c lines. The losses in Alternative-6 are minimum. **Members may deliberate on the preferred alternative.**

5. Augmentation of Transformation capacity at various Substations in Western Region

Requirement of transformation capacity augmentation in Western Region was assessed both in Solar Max (Scenario-4) as well as Evening peak (Scenario-5) cases in 2024-25 time-frame considering various planned / under implementation schemes and the following was observed:

Sl. / TRANSFORMER			EXISTING /PLANNED TRANSFORMERS (MVA)	CURRENT TIME FRAME	2024-25 TIME FRAME (Higher of Scenario -4 / 5)	
				PEAK LOADING (MW)	PEAK LOADING (MW)	N-1 Outage loading (MW)
1	Raigarh	400/220kV	2x315	2x263 (N-1 non compliant for 29% time)	2x223 (Scenario-5)	1x354
2	Satna	765/400/220kV	2x315+1x500	2x276+1x435 (N-1 non compliant for 20% time)	2x229+1x364 (Scenario-4)	2x315 (500MVA ICT out)
3	Sugen	400/220kV	3x315	3x270 (N-1 non compliant for 11% time in Mar)	3x268 (Scenario-4)	2x334 (315MVA ICT out)

Overloading at Satna ICTs is observed even after considering the planned Rewa(PG) – Rewa (MP) 220kV D/c interconnection. In last WRPC(TP) meeting, MPPTCL had stated that this line shall relieve loading on Satna ICTs. While it helps to relieve the loadings to some extent, the ICTs are still observed to be marginally N-1 non compliant in 2024-25 Solar Max scenario 4.

Bhatapara ICTs are getting critically loaded in the current time-frame, however, after considering Dhardehi S/s planned by CSPTCL as well as measures to control overloading on NSPCL ICTs, the loading on Bhatapara ICTs in found to be in order in future time-frame.

Current flow pattern on above ICTs as per the operational feedback of POSOCO for quarter ending Mar'21 is given below:

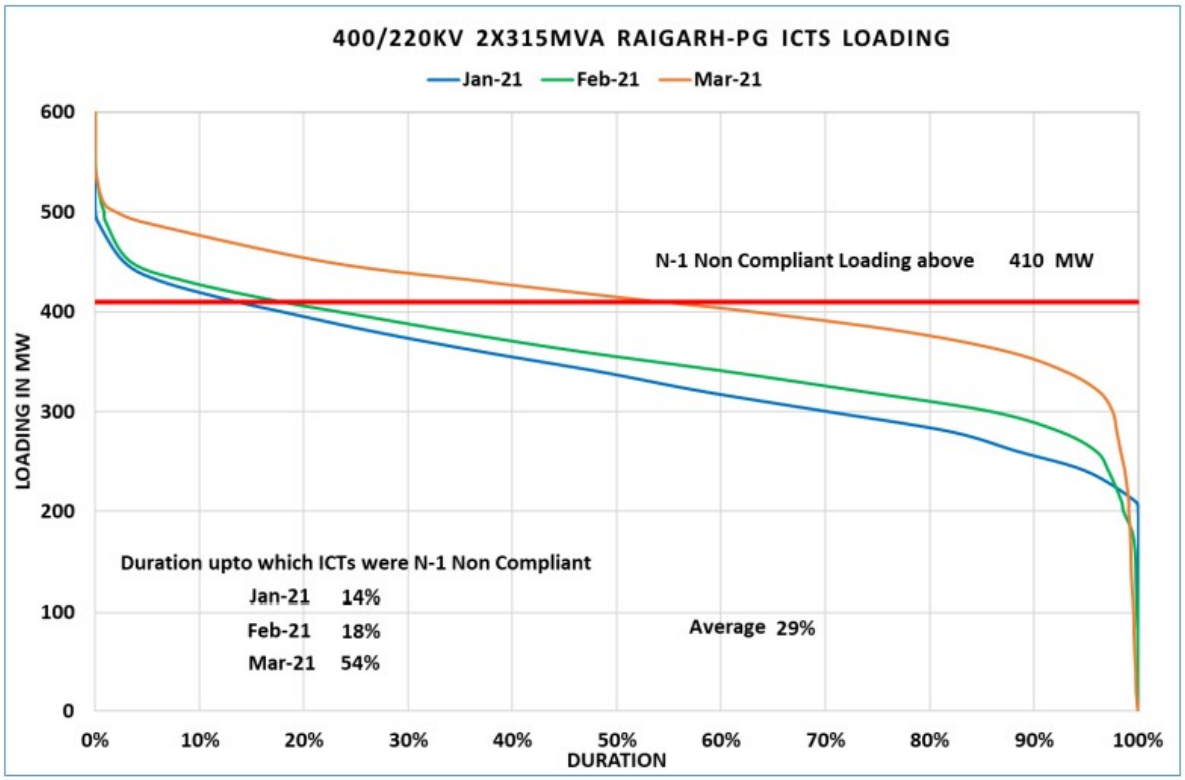


Figure-B22 400/220kV Raigarh(PG) ICT-1,2 Loading

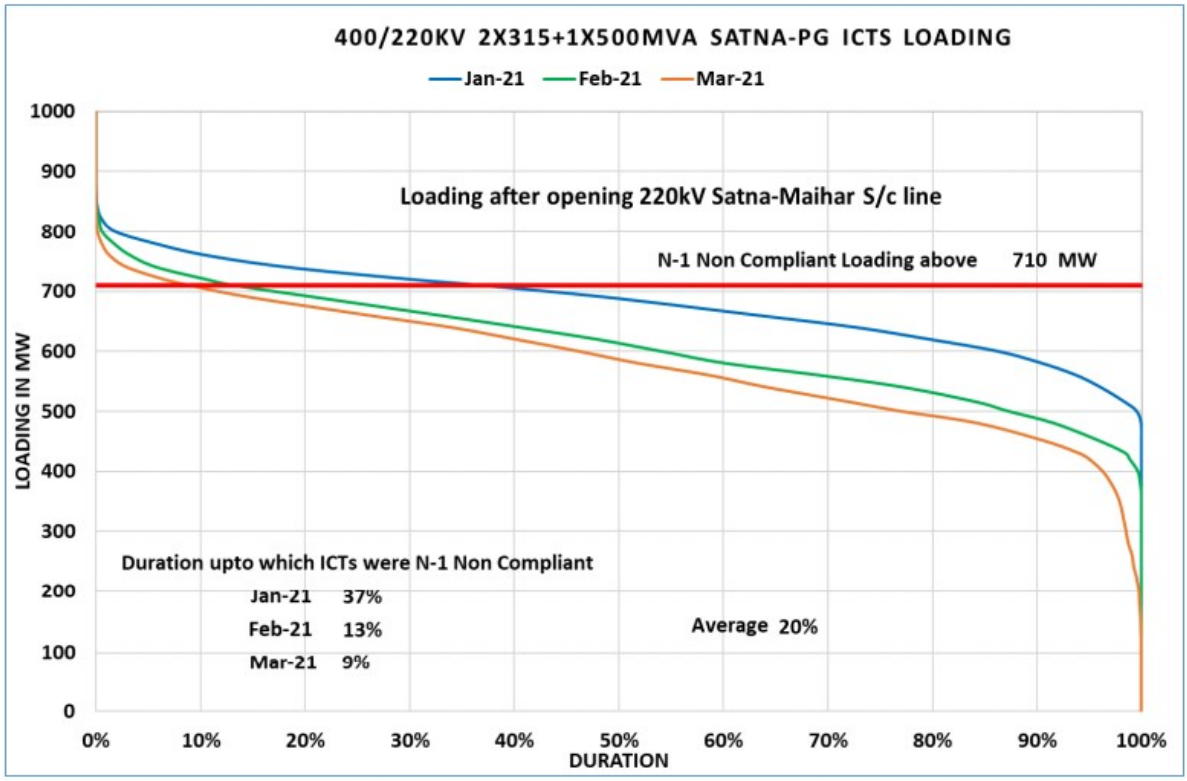


Figure-B16 400/220kV Satna PG ICT-1,2,3 Loading

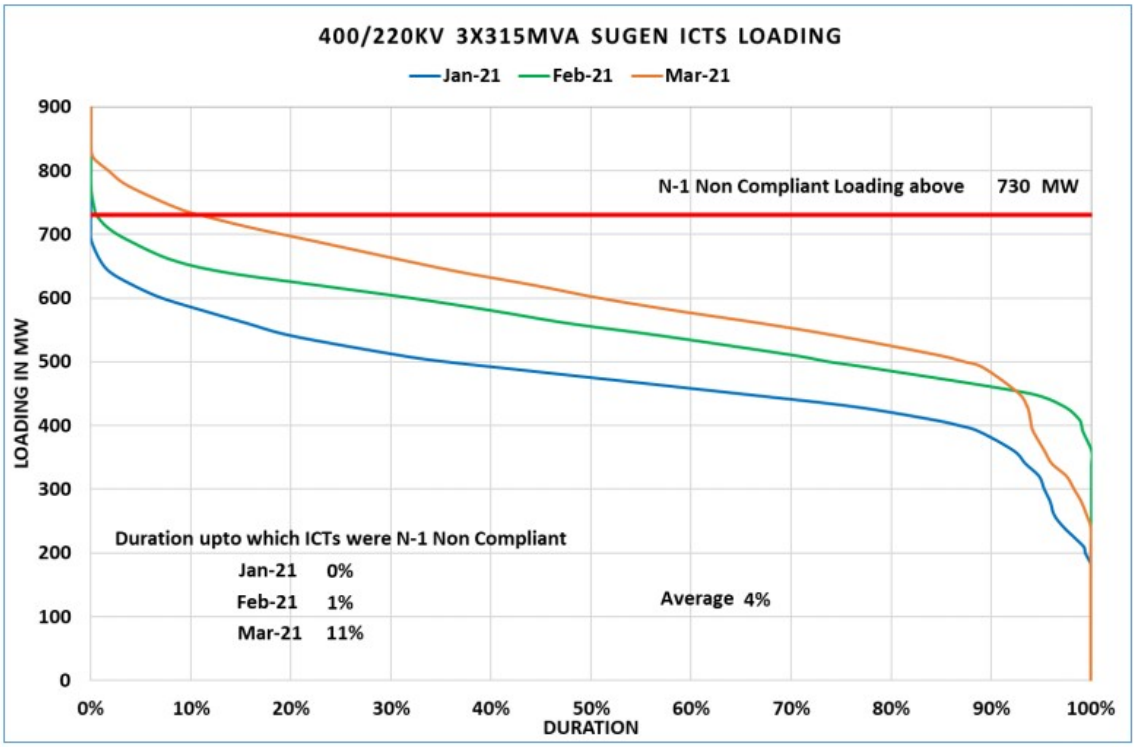


Figure-B25 400/220kV Sugen ICT-1,2,3 Loading

Members may deliberate.

6. Review of line reactors on transmission lines with high degree of compensation (70%)

Extra high voltage transmission lines with higher degree of compensation (more than 70%) may excite probable resonance modes and over voltage in dead time after initiation of Auto reclosure and the same has been observed under fault conditions. Occurrence of such high voltage can result in un-successful auto reclosure in case of single-phase faults and adversely affect the reliability of power system. In order to avoid occurrence of LC oscillations, tripping of shunt reactor at either end of the line along with main line breaker is achieved with the implementation of inter-tripping scheme. Accordingly, inter-tripping scheme needs to be implemented in transmission Lines with high degree of compensation (more than 70%). In view of the above, transmission lines with higher degree of compensation (>70%) have been broadly categorised in two cases:

Case-1: Shunt reactors are fixed in nature and inter-tripping scheme has not been implemented. It is proposed that fixed shunt reactor installed at either one end of the transmission lines as mentioned in table-1 may be converted into switchable alongwith implementation of inter trip scheme for avoiding probable Dynamic Over voltages. For utilizing the proposed switchable line shunt reactors as bus reactors, NGR bypass scheme with CSD in associated CBs should also be implemented.

Case 2: Shunt reactors are switchable in nature however inter-tripping scheme has not been implemented. It is proposed to implement inter-trip scheme for transmission lines at one end where line reactors are switchable as indicated in table-2 for avoiding over-voltage due to LC oscillations under fault conditions.

Table-1 : Shunt reactors are fixed in nature and inter-tripping scheme has not been implemented.

Tr. Line (ISTS)	Name of Line	Line Length (kM)	Voltage Level	Configuration	From L/R MVAR	Switchable(S) / Fixed(F)	To L/R MVAR	Switchable or not	Total Compensation MVAR	MVAR/ KM Generation	Total MVAR Generation	% Compensation	Existing / Under Construction
1.	Mansar-Limbdi	94	400	ACSR Triple Snowbird			63	F	63	0.67	63.48	99.25	E
2.	Boisar – Padghe	101	400	ACSR Twin Moose			50	F	50	0.56	56.06	89.20	E
3.	Korba - Birsinghpur II	227	400	ACSR Twin Moose	50	F	50	F	100	0.60	136.44	73.29	E
4.	Korba- Birsinghpur I	227	400	ACSR Twin Moose	50	F	50	F	100	0.60	136.65	73.18	E
5.	Bhilai – Bhadrawati	322	400	ACSR Twin Moose	80	F	50	F	130	0.56	178.71	72.74	E
6.	Jabalpur - Itarsi-I	232	400	ACSR Twin Moose	50	F	50	F	100	0.60	139.66	71.60	E
7.	Jabalpur - Itarsi-II	232	400	ACSR Twin Moose	50	F	50	F	100	0.60	139.66	71.60	E
8.	Jabalpur - Itarsi-III	234	400	ACSR Twin Moose	50	F	50	F	100	0.60	140.87	70.99	E
9.	Jabalpur - Itarsi-IV	234	400	ACSR Twin Moose	50	F	50	F	100	0.60	140.87	70.99	E
10	Bhadrawati – Dhariwal*	15	400	ACSR Twin Moose	63	F			63	0.56	8.33	756.76	E
11	Gandhar - Sugen (Upto LILO point)*	57	400	ACSR Twin Moose	50	F			50	0.56	31.64	158.05	E

** For elements at Sl. No. 10 and 11, fixed LR needs to be converted to switchable only as they are having a very high degree of compensation.*

Table-2: Shunt reactors are switchable in nature however inter-tripping scheme has not been implemented

Tr. Line (ISTS)	Name of Trans. Line	Line Length(km)	Voltage Level	Conductor Configuration	Sub-Conductor	From L/R MVAR	Switchable(S) or not /Fixed(F)	INTER TRIP	TOL/R MVAR	Switchable(S)/ Fixed(F)	INTER TRIP	TOTAL MVAR	MVAR / KM	Total MVAR Generation	% COMPENSATION	Existing / Under Construction
1	Aurangabad - Pune	158	765	Hexa Zebra	Hexa	240	S	No	240	S	No	480	2.66	420.3	114.2	E
2	Vindhyachal PS - Satna I	237	765	Bersmis	Quad	240	S	No	240	F		480	2.35	557.0	86.2	E
3	Vindhyachal PS - Satna II	237	765	Bersmis	Quad	240	S	No	240	F		480	2.35	557.0	86.2	E
4	Bhuj Pool-Banaskantha - I	289	765	Zebra	Hexa	330	S	No	330	S	No	660	2.66	768.7	85.9	E
5	Bhuj Pool-Banaskantha - II	289	765	Zebra	Hexa	330	S	No	330	S	No	660	2.66	768.7	85.9	E
6	Satna - Sasan II	242	765	Bersmis	Quad	240	F	No	240	S		480	2.35	569.2	84.3	E
7	Satna - Sasan I	246	765	Bersmis	Quad	240	F	No	240	S		480	2.35	577.4	83.1	E
8	Banaskantha-Chittorgarh - I	302	765	Zebra	Hexa	330	S	No	330			660	2.66	803.3	82.2	E
9	Banaskantha-Chittorgarh - II	302	765	Zebra	Hexa	330	S	No	330			660	2.66	803.3	82.2	E
10	Rajnandgaon – Pooling station near warora-I	267	765	Zebra	Hexa	330	S	No	240	F	No	570	2.66	710.2	80.3	E
11	Rajnandgaon – Pooling station near warora-II	267	765	Zebra	Hexa	330	S	No	240	F	No	570	2.66	710.2	80.3	E
12	Gadarwara STPS-PS Near Warora-I	314	765	Zebra	Hexa	330	S	No	330	F	No	660	2.66	835.2	79.0	E
13	Gadarwara STPS-PS Near Warora-II	314	765	Zebra	Hexa	330	S	No	330	F	No	660	2.66	835.2	79.0	E
14	Seoni - Wardha II	260.76	765	Bersimis	Quad	240	S	No	240	F		480	2.35	612.8	78.3	E

Tr. Line (ISTS)	Name of Trans. Line	Line Length(km)	Voltage Level	Conductor Configuration	Sub-Conductor	From L/R MVAR	Switchable(S) or not /Fixed(F)	INTER TRIP	TOL/R MVAR	Switchable(S)/ Fixed(F)	INTER TRIP	TOTAL MVAR	MVAR / KM	Total MVAR Generation	% COMPENSATION	Existing / Under Construction
15	Seoni - Wardha I	261	765	Bersimis	Quad	240	S	No	240	F		480	2.35	613.4	78.3	E
16	Pune - Solapur	270	765	Bersimis	Quad	240	S	No	240	S		480	2.35	634.1	75.7	E
17	Orai - Gwalior I	135	765	Bersmis	Quad				240	S	No	240	2.35	317.3	75.7	E
18	Satna - Orai	272	765	Bersmis	Quad	240	S	No	240	F	No	480	2.35	639.0	75.1	E
19	Satna - Bina I	274	765	Bersmis	Quad	240	S	No	240	F	No	480	2.35	644.3	74.5	E
20	Satna - Bina II	276	765	Bersmis	Quad	240	S	No	240	F	No	480	2.35	647.7	74.1	E
21	Warora(PS)-Parli(New)-I	348	765	Zebra	Hexa	330	S	No	330	F	No	660	2.66	925.7	71.3	E
22	Warora(PS)-Parli(New)-II	348	765	Zebra	Hexa	330	S	No	330	F	No	660	2.66	925.7	71.3	E
23	Seoni - Bina	292	765	Bersmis	Quad	240	S	No	240	F	No	480	2.35	686.3	69.9	E
24	Pune (GIS) - Pune I (AIS)	64	400	ACSR Moose	Twin	50	S	No				50	0.602	38.5	129.8	E
25	Pune (GIS) - Pune II (AIS)	64	400	ACSR Moose	Twin	50	S	No				50	0.602	38.5	129.8	E
26	Pune (GIS) - Pune III (AIS)	65	400	ACSR Moose	Twin	50	S	No				50	0.602	39.1	127.8	E
27	Pune (GIS) - Pune IV (AIS)	65	400	ACSR Moose	Twin	50	S	No				50	0.602	39.1	127.8	E
28	Betul - Khandwa I	169	400	ACSR Moose	Quad	50	S	No	50	F		100	0.732	123.7	80.8	E
29	Betul - Khandwa II	169	400	ACSR Moose	Quad	50	S	No	50	F		100	0.732	123.7	80.8	E
30	Itarsi - Indore ckt-I	207	400	ACSR Moose	Twin	50	F	No	50	S	No	100	0.60	124.6	80.2	E
31	Khandwa - Indore I	169	400	ACSR Moose	Twin				80	S	No	80	0.60	101.6	78.7	E
32	Khandwa - Indore II	169	400	ACSR Moose	Twin				80	S	No	80	0.60	101.6	78.7	E
33	Itarsi - Indore ckt-II	214	400	ACSR Moose	Twin	50	F	No	50	S	No	100	0.602	128.8	77.6	E
34	Mundra - Bhachau III	122	400	ACSR	Triple	63	S	No				63	0.67	82.2	76.6	E

Tr. Line (ISTS)	Name of Trans. Line	Line Length(km)	Voltage Level	Conductor Configuration	Sub-Conductor	From L/R MVAR	Switchable(S) or not /Fixed(F)	INTER TRIP	TOL/R MVAR	Switchable(S)/ Fixed(F)	INTER TRIP	TOTAL MVAR	MVAR / KM	Total MVAR Generation	% COMPENSATION	Existing / Under Construction
				Snowbird												
35	Mundra - Bhachau IV	122	400	ACSR Snowbird	Triple	63	S	No				63	0.67	82.2	76.6	E

Annexure-XVI : Alternatives to control high fault current at Indore S/s (2022-23 Time-frame)

Case	Transmission elements		High RE Scenario		Low RE peak scenario		Remarks
	Section-A	Section-B	Section -A	Sectio n-B	Sectio n-A	Sectio n-B	
Base Case	1. Indore (PG)- Indore(MP) 400 kV D/c line 2. Indore (PG)-Pithampur 400 kV D/c line 3. Indore (PG)-Khandwa 400 kV D/c line 4. Indore (PG)-Ujjain 400 kV D/c line 5. 765/400 kV, 2X1500MVA ICT 6. 400/220 kV, 2X500MVA ICT 7. 1X125 MVAr and 1X63 MVAr Br 8. SBESS (324.4 MW) [at 400kV]		50051.7		51763		Design Fault Level of the S/s : 40kA
Case-1 (Bus Splitting)	1. Indore (PG)- Indore(MP) 400 kV D/c line 2. Indore (PG)-Khandwa 400 kV D/c line 3. 765/400 kV, 2X1500MVA ICT 4. 1X125 MVAr and 1X63 MVAr Br	1. Indore (PG)-Pithampur 400 kV D/c line 2. Indore (PG)-Ujjain 400 kV D/c line 3. 400/220 kV, 2X500MVA ICT 4. SBESS (324.4 MW)	35704.8	25487.4	36192.5	26219.6	In future, 765/400 KV, 1500 MVA ICT can be installed in section-B
Case-2: Case1+ with 14Ω series LR at Indore(PG) end of Indore(MP) line and 14Ω series BR			38444.9	32893.8	39204.7	33891.6	
Case-3: Case1+ with 14Ω series LR at Indore(PG) end of Indore(MP) line and Ujjain (MP) Line and 14Ω series BR			38093.5	30327.6	38910.5	31409.4	In future, 765/400 KV, 1500 MVA ICT can be installed in section-B
Case-3A: Case1+ with 18Ω series BR			-	-	41158.7	32671	
Case-3B: Case1+ with 24Ω series BR			-	-	40238.7	31383.2	

Case	Transmission elements		High RE Scenario		Low RE peak scenario		Remarks
	Section-A	Section-B	Section -A	Sectio n-B	Sectio n-A	Sectio n-B	
Case-4: Bus Splitting with shifting of 765/400 kV, 1X1500MV A ICT to Section B	1. Indore (PG)-Indore(MP) 400 kV D/c line 2. Indore (PG)-Khandwa 400 kV D/c line 3. 765/400 kV, 1X1500MVA ICT 4. 1X125 MVAr and 1X63 MVAr Br	1. 765/400 kV, 1X1500MVA ICT 2. Indore (PG)-Pithampur 400 kV D/c line 3. Indore (PG)-Ujjain 400 kV D/c line 4. 400/220 kV, 2X500MVA ICT 5. SBESS (324.4 MW)	29666.8	34816. 9	30202. 9	35663. 8	By jumpering765/4 00kV ICT can be shifted. In case-4, 765/400 KV, 1500 MVA ICT can be installed in future in section-A.
Case-5: Case4+ with 14Ω series LR at Indore(PG) end of Indore-Indore line and Indore-Ujjain line alongwith 14Ω series BR			32647.9	37381. 5	33401. 7	38572. 4	
Case-5A: Case4+ with 12 Ω series LR at Indore(PG) end of Indore-Ujjain line and Indore-Pitampur line alongwith 14Ω series BR	1. Indore (PG)-Indore(MP) 400 kV D/c line 2. Indore (PG)-Khandwa 400 kV D/c line 3. 765/400 kV, 1X1500MVA ICT 4. 1X125 MVAr and 1X63 MVAr Br	1. 765/400 kV, 1X1500MVA ICT 2. Indore (PG)-Pithampur 400 kV D/c line 3. Indore (PG)-Ujjain 400 kV D/c line 4. 400/220 kV, 2X500MVA ICT 5. SBESS (324.4 MW)	-	-	36305. 1	37245	If Series LR on Pitampura line is removed, Section B fault level becomes 38.6kA (low RE)
Case-5B: Case4+ 18Ω series BR			-	-	35584. 3	40201. 6	
Case-5C: Case4+ 24Ω series BR			-	-	34506. 9	39324. 6	
Case-6: Bus splitting &Swapping of Indore (PG)-Pithampur 400 kV D/c	1. Indore (PG)-Pithampur 400 kV D/c line 2. Indore (PG)-Khandwa 400 kV D/c line 3. 765/400 kV,	1. Indore (PG)-Indore(MP) 400 kV D/c line 2. Indore (PG)-Ujjain 400 kV D/c line	32740.5	27136. 6	33920	26858	

Case	Transmission elements		High RE Scenario		Low RE peak scenario		Remarks
	Section-A	Section-B	Section -A	Section-B	Section-A	Section-B	
line and Indore (PG)-Indore(MP) 400 kV D/c line	2X1500MVA ICT 4. 1X125 MVAr and 1X63 MVAr Br	3. 400/220 kV, 2X500MVA ICT 4. SBESS (324.4 MW)					
Case-7: Case6+ with 14Ω series LR at Indore(PG) end of Indore-Pithampura line alongwith 14Ω series BR			37453.3	34614.6	38395.8	34632.4	
Case-8: Case6+ with 14Ω series LR at Indore(PG) end of Indore-Pithampura line and Indore(PG)-Indore(MP) line alongwith 14Ω series BR			37161.4	32118.7	38075.9	32075.6	In future, 765/400 KV, 1500 MVA ICT can be installed in section-B

Annexure-XVII– Load Generation Balance for High South export case (2024-25) (Solar Max Scenario-4)