

Report on additional inter-regional corridor between Southern Region & Western Region

Background:

1. Capacity addition programme of 66.5 GW ISTS connected RE generation on all-India basis inter-alia includes 2.5 GW each at Koppal and Gadag area in Karnataka. Studies have been carried out to check the adequacy of existing Inter Regional (IR) corridors between WR & SR to cater to evacuation of power from REZs in Southern Region under high RE generation scenario in Southern Region. The same was discussed in the 3rd WRPC(TP) meeting held on 14.06.2021 and after deliberations, the following was agreed:
 - Re-conductoring of Kolhapur (PG) – Kolhapur 400 kV D/c line with conductor of minimum capacity of 2100 MVA/Ckt at nominal voltage along with bay upgradation work at Kolhapur (MSETCL) – *Present status: Being implemented under RTM by POWERGRID* (Anticipated: March, 23)
 - The strengthening requirement beyond Kolhapur other than reconductoring of Kolhapur (PG) – Kolhapur 400 kV D/c line would be studied in a separate joint study meeting with CEA, CTU, WRPC & POSOCO.
2. Various alternatives were studied, out of which two following alternatives were found to be technically in order:
 - i) Narendra(New) – Pune (GIS) 765kV D/c line(Alternative-VII)
 - ii) Narendra(New) – Jejuri – Pune (GIS) 765kV D/c line wherein a new S/s at Jejuri (Alternative V)
3. The merits of the above two alternatives over other possible alternatives were observed as below:
 - Power flows generally in order
 - Fault level at Narendra(New) being well within its design limits
 - 4x1500 MVA, 765/400kV ICTs required at Narendra (New) S/s as against 5x1500MVA ICTs required in some of the other alternatives.
 - System losses are also low as this alternative results in direct feed of power from generation pockets in SR to load centres in WR
 - The alternative of LILO of Narendra(New) – Pune 765kV D/c line at Jejuri improves reliability of power supply as well as leads to improvement in voltage profile of Jejuri and adjoining areas.

4. As MSETCL was not in agreement of the requirement of the LILO at Jejuri S/s, the alternative “Narendra(New) – Pune (GIS) 765kV D/c line” was proposed in place of “Narendra(New) – Jejuri- Pune (GIS) 765kV D/c line”. The scheme was deliberated in various meetings and also put up in 41st WRPC meeting held on 21/23 February 2022 and 41st SRPC meeting held on 02.03.2022. The scheme was not agreed by the Southern Regions States. The scheme was also not agreed to by Maharashtra and some other Western Region States. However, POSOCO agreed for requirement of the proposed transmission system and has requested to take up the implementation of the “Narendra(New) – Pune (GIS) 765 kV D/c line” on urgent basis to address the constraints beyond Kolhapur during the high export scenario from Southern Region. The scheme would help in relieving transmission constraints in exporting surplus power from Southern Region during high RE generation and low electricity demand scenario in Southern Region.
5. The above proposal was discussed in the 8th meeting of National Committee on Transmission (NCT) held on 25.03.2022 and NCT directed CEA to examine the proposal and requirement of the proposed SR-WR link.

Load flow studies carried out by CEA:

6. Load flow Studies were carried out by CEA for different scenarios and observations are as follows:

(i) Following are the Stage-II connectivity granted /under grant at Koppal and Gadag.

Stage-II connectivity granted /under grant at Koppal PS:

Sl. No.	Generation project	Capacity (in MW)	Type
1.	ReNew Surya Ojas Private Limited	300	Wind
2.	Ayana Renewable Power Six Pvt Ltd	300	Wind
3.	Adani Renewable Energy Holding Fifteen Ltd	300	Wind
4.	Renew Solar Power Pvt Ltd	300	Wind
5.	Tunga Renewable Energy Pvt Ltd	350	Wind
6.	Project Ten Renewable Power Private Limited	150	Wind
7.	Project Eight Renewable Power Private Limited	300	Solar

Sl. No.	Generation project	Capacity (in MW)	Type
8.	Solar One Energy Private Limited	300	Solar
9.	Serentica Renewables India 1 Private Limited	210	Solar
10.	Kleio Solar Power Private Limited	154	Hybrid (W & S)
	Total (in MW)	2664	

Stage-II connectivity granted /under grant at Gadag PS:

S. No.	Generation project	Capacity (in MW)	Type
1.	Renew Solar Power Pvt Ltd	300	Wind
2.	Vena Energy Vidyuth Pvt Ltd	160	Hybrid (W & S)
3.	Azure Power India Pvt Ltd	170	Wind
4.	M/s Green Infra Wind Energy Ltd (180 MW) +Roha Renewable India Pvt Ltd (115 MW)	295	Wind
5.	ReNew Naveen Urja Private Limited	300	Wind
6.	Project Eight Renewable Power Private Limited	300	Solar
7.	Solar One Energy Private Limited	300	Solar
8.	Sterlite Power Technologies Private Limited	285	Solar
	Total (in MW)	2110	

(ii) CTU has simulated the worst case scenario i.e when there is full generations at both Koppal (2.5 GW) and Gadag Pooling Station (2.5 GW), full generations at Kudgi TPS (3x800 MW).

(iii) Normally, wind generations is maximum in the evening and night cases when there is no solar generation. Even, maximum wind generation is observed from July to October months.

(iv) Considering the above, following case studies were studied:

Sl. No.	Case Study	Description
a)	Case-1	June Solar Maximum Dispatch Case (as Simulated by CTU) with i. 90% generation at Kudgi TPP and Sholapur TPP ii. 100% generation at Koppal and Gadag

Sl. No.	Case Study	Description
b)	Case-2A	<p>June Solar Maximum Dispatch Case</p> <ul style="list-style-type: none"> i. 55% generation at Kudgi TPP and Sholapur TPP ii. generation at Koppal and Gadag as per St-II connectivity granted/under grant with 100% dispatch from solar and 55% dispatch from wind
c)	Case-2B	<p>June Solar Maximum Dispatch Case</p> <ul style="list-style-type: none"> i. 90% generation at Kudgi TPP and Sholapur TPP ii. generation at Koppal and Gadag as per St-II connectivity granted/under grant with 100% dispatch from solar and 55% dispatch from wind
d)	Case-3	<p>August Evening Peak load case</p> <ul style="list-style-type: none"> i. 90% generation at Kudgi TPP and Sholapur TPP ii. 100% generation at Koppal and Gadag
e)	Case-4	<p>August Evening Peak load case</p> <ul style="list-style-type: none"> i. 90% generation at Kudgi TPP and Sholapur TPP ii. generation at Koppal and Gadag as per St-II connectivity granted/under grant with zero dispatch from solar and 100% dispatch from wind

The details based on the above case studies are enclosed at **Annexure-I**.

Gist of the analysis of each case is as follows:

a) Case-1: (June Solar Maximum Dispatch Case: 90% generation at Kudgi, Karnataka & Sholapur, Maharashtra; RE at Koppal & Gadag 100%):

After reconductoring of Kolhapur(PG)- Kolhapur 400kV D/c line, its capacity would be 2x2100 MW. In this case study, the power flow on this line exceeds its capacity under ‘N-1’ condition. The Kolhapur –Karad 400 kV D/c line is also highly overloaded. The 400/220kV ICTs at Kudgi are critically loaded. This case study has been done without the proposed “Narendra-Pune 765kV D/c line”.

With the proposed “Narendra-Pune 765kV D/c line”, no such overloading is observed and also there is reduction of system losses.

- b) Case-2 A (June Solar Maximum Dispatch Case: 55 % generation at Kudgi TPP & Sholapur TPP; RE at Koppal –Gadag as per St-II connectivity- 100 % dispatch from solar, 55 % dispatch from Wind)**

This case study has been done considering that all the St-II connectivity granted/under grant at Koppal and Gadag gets converted to LTA, so the dispatch from RE generations has been considered as 100% from solar & 55% from Wind and thermal generation at Kudgi and Sholapur have been reduced to 55%.

Loadings on Kolhapur(PG)- Kolhapur 400kV D/c line and Narendra- Kolhapur 400kV D/c line is normal. The loading on Kolhapur –Karad 400 kV D/c line is ‘N-1’ non-compliant. With increase in generations from Kudgi (above 55 %), the line loading on Kolhapur –Karad 400 kV D/c line further increases.

- c) Case-2 B (June Solar Maximum Dispatch Case: 90% generation at Kudgi TPP & Sholapur TPP; RE at Koppal –Gadag as per St-II connectivity- 100 % dispatch from solar, 55 % dispatch from Wind):**

Kolhapur –Karad 400 kV D/c line becomes overloaded and is ‘N-1’ non-compliant.

- d) Case-3: (August Evening Peak Load Case: 90 % generation at Kudgi & Sholapur; RE at Koppal –Gadag 100%(as per CTU assumptions)).**

Under this case study, Kolhapur(PG)- Kolhapur 400kV D/c line, Kolhapur –Karad 400kV D/c line and 2x 500 MVA400/220kV ICTs at Kudgi becomes ‘N-1’ non – compliant, without the “Narendra-Pune 765kV D/C link”.

With the “Narendra-Pune 765kV D/C link”, no overloading is observed and also in this case, there is substantial reduction in system losses with implementation of the Narendra-Pune 765 kV D/c line.

- e) Case-4 (August Evening Peak Load Case: 90 % generation at Kudgi TPP & Sholapur TPP; RE at Koppal –Gadag as per St-II connectivity - 100 % dispatch from solar, 55 % dispatch from Wind)**

In this case study, Kolhapur(PG)- Kolhapur 400kV D/c line, Kolhapur –Karad 400kV D/c line and 2x 500 MVA,400/220kV ICTs at Kudgi becomes ‘N-1’ non – compliant, without the “Narendra-Pune 765kV D/C link”. However, with reduction of generation at Kudgi, (below 60%), the power flows on these line and power flow on ICTs at Kudgi are within limits.

With Narendra-Pune 765kV D/C link, no overloading is observed and also in this case study, there is substantial reduction in system losses with implementation of the Narendra-Pune 765 kV D/c line.

- (v) MNRE has indicated additional potential of 4GW (2GW-Solar, 2 GW- wind) each at Koppal and Gadag with evacuation requirement of 2.4 GW each at Koppal & Gadag. With integration of these additional generations and implementation of “Narendra-Pune 765kV D/C line”, no constraint is observed on Narendra-Kolhapur, Kolhapur- Karad 400kV D/c line.

Conclusions:

7. From the analysis of studies, following is concluded:
- (i) After reconductoring of Kolhapur(PG)- Kolhapur 400kV D/c line, the next constraint in export of power from SR to WR is Kolhapur –Karad 400 kV D/c line.
 - (ii) Due to typical location of Kudgi TPS, the power from Kudgi TPS flows towards Western Region, therefore, with increase in the generation from Kudgi TPS beyond 55%, Kolhapur –Karad 400kV D/c line becomes ‘n-1’ non- compliant.
 - (iii) With high RE generation at Koppal and Gadag, and dispatch beyond 60 % from Kudgi TPS, several lines are overloaded and become ‘n-1’ non-compliant. With the “Narendra-Pune 765 kV D/C line”, flow on these line is observed to be within limits. There is considerable reduction in the system losses with “Narendra-Pune 765 kV D/C line”.
 - (iv) Government of India has set a target of achieving 500 GW of non-fossil installed capacity by 2030. MNRE has identified potential RE zones totaling to 181.5 GW to be added till 2030. This includes additional 17 GW potential (solar-9 GW, wind-8 GW) in the state of Karnataka. The identified potential zones in Karnataka are Koppal (4 GW), Gadag (4 GW), Davangere/Chitradurga (4 GW), Bijapur (2 GW), Bellary (1.5 GW) and Tumkur (1.5 GW). These are in addition to the RE capacity totaling to 18.5 GW in Southern

Region being integrated to ISTS network. The “Narendra(New) – Pune (GIS) 765kV D/C line” would also help in evacuation of power from the additional identified RE zones, particularly Koppal & Gadag RE Zones.

Case Study Details

- a) **Case-1: (June Solar Peak Case: 90% generation at Kudgi, Karnataka & Sholapur, Maharashtra; RE at Koppal & Gadag 100%):**

The power flows on the various lines are as follows:

Transmission line	Without Narendra-Pune 765kV D/c line (MW)	With Narendra-Pune 765kV D/c line (MW)
Narendra- Kolhapur	2x1486	2x850
Kolhapur- Kolhapur	2x1563(2700 MW under n-1)	2x897
Kolhapur -Karad	2x806 (1128 MW under n-1)	2x497
Narendra-Pune 765kV D/c line	-	2x 2061

The flow on 2x 500 MVA, 400/220kV ICTs at Kudgi is 2x 458 MW and 220kV lines from Yalwar to Yalwar Switching station are also getting overloaded without proposed SR-WR link.

- b) **Case-2 A (June Solar Peak Case, 55 % generation at Kudgi TPP & Sholapur TPP; RE at Koppal –Gadag as per St-II connectivity- 100 % dispatch from solar, 55 % dispatch from Wind)**

This case study is done considering that all the St-II connectivity granted/under grant at Koppal and Gadag gets converted to LTA, so the dispatch from RE generations has been considered as (100% solar+55% Wind) and thermal generation at Kudgi and Sholapur has been reduced to 55%. The power flows on the various lines are as follows:

Transmission line	Power flow (MW)	Power flow (MW) under 'n-1' scenario
Narendra- Kolhapur	2x1375	1832
Kolhapur- Kolhapur	2x995	1608
Kolhapur -Karad	2x572	786

With increase in generations from Kudgi (above 55 %), the line loading on Kolhapur – Karad 400 kV D/c line further increases.

- c) **Case-2 B (June Solar Peak Case, 90% generation at Kudgi TPP & Sholapur TPP, RE at Koppal –Gadag as per St-II connectivity- 100 % dispatch from solar, 55 % dispatch from Wind)**

The power flows on the various lines are as follows:

Transmission line	Power flow (MW)	Power flow (MW) under 'n-1' scenario
Narendra- Kolhapur	2x1514	2000
Kolhapur- Kolhapur	2x1050	1694
Kolhapur -Karad	2x610	829

Kolhapur –Karad 400 kV D/c line becomes overloaded and ‘N-1’ non-compliant.

- d) **Case-3: (August Evening Peak Demand Case- 90 % generation at Kudgi & Sholapur; RE at Koppal –Gadag 100%(as per CTU assumptions)).**

The power flows on the various lines are as follows:

Transmission line	Power flow (MW)	Power flow (MW) under 'n-1' scenario
Narendra- Kolhapur	2x1378	1854
Kolhapur- Kolhapur	2x1458	2626
Kolhapur -Karad	2x616	861
2x 500 MVA400/220kV ICTs at Kudgi	2x493	690

The 220kV lines from Yalwar to Yalwar Switching station are also getting overloaded.

Studies were repeated with Narendra-Pune 765kV link and the flows are as given below:

Transmission line	Power flow (MW)	Power flow (MW) under 'n-1' scenario
Narendra- Kolhapur	2x715	937
Kolhapur- Kolhapur	2x739	1300
Kolhapur -Karad	2x266	370
2x 500 MVA400/220kV ICTs at Kudgi	2x75	
Narendra-Pune 765kV D/c line	2x2038	3060

It is observed that in this case study, there is a reduction of system losses by approximately 300 MW with implementation of inter-regional Narendra-Pune 765 kV D/c line.

- e) **Case-4 (August Evening Peak Case- 90 % generation at Kudgi TPP & Sholapur TPP; RE at Koppal –Gadag as per St-II connectivity - 100 % dispatch from solar, 55 % dispatch from Wind)**

The power flows with and without Narendra-Pune 765kV D/c line are as follows:

Transmission line	Without Narendra-Pune 765kV D/c line (MW)	With Narendra-Pune 765kV D/c line (MW)
Narendra- Kolhapur	2x1137	2x575
Kolhapur- Kolhapur	2x1213(2176 MW under n-1)	2x586
Kolhapur -Karad	2x503 (705 MW under n-1)	2x201
Narendra-Pune 765kV D/c line	-	2x 1681

The 220kV lines from Yalwar to Yalwar Switching station and 2x 500 MVA, 400/220kV ICTs at Kudgi are also getting overloaded without Narendra-Pune 765kV D/c line. Again in this case study also, there is a reduction of system losses by approximately 250 MW with implementation of inter-regional Narendra-Pune 765kV D/c line.

Further, with 60% generation at Kudgi TPS, power flow on Kolhapur –Karad 400kV D/c line (105 km) is 2x450 MW (630 MW under ‘n-1’ condition) and without Kudgi generation, the power flows on Kolhapur –Karad 400kV D/c line further reduces to 2x340 MW.