

भारत सरकार
Government of India
विद्युत मंत्रालय
Ministry of Power
केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority
वित्तीय एवं वाणिज्यिक मूल्यांकन प्रभाग
Financial & Commercial Appraisal Division

Sewa Bhawan, New Delhi
09th Jan 2024

विषय : राजस्थान (छबड़ा, कालीसिंध), गुजरात (उकाई) और हरियाणा (यमुनानगर) में प्रस्तावित नए ताप विद्युत संयंत्रों के लिए गैर पिट-हेड की तुलना में पिट-हेड पर संशोधित नोट [Revised Note on pit-head vis-a-vis non pit-head for proposed new thermal power plants in Rajasthan (Chhabra, Kalisindh), Gujarat (Ukai) and Haryana (Yamunanagar)]

The undersigned is directed to refer to the discussion in the meeting taken by Secretary (Power) on 02.12.2023, wherein GRID-India made a presentation highlighting technical advantages of having non-pit head thermal power stations. In the meeting, GRID-India was requested to revise their input regarding operational advantages of having non-pit head plants, particularly stability support may be shared with CEA and CEA shall submit a revised consolidated note on non-pit head vis-à-vis for pit head plants in respect of proposed new thermal plants in Rajasthan, Gujarat and Haryana.

2. Grid-India has sent the revised note on technical advantages of non-pit head plants (Copy enclosed).
3. Based on inputs of Grid-India, a revised note on pit-head vis-a-vis non pit-head for proposed new thermal power plants is enclosed.

Encl.: As above.

S. Prallek 09/01/24
(प्रवीण कुमार साहूकारी)
उप निदेशक (एफ एंड सीए)

Joint Secretary (Thermal), Ministry of Power, New Delhi

Copy to: Deputy Secretary (Shri Anup Singh Bisht), Ministry of Power, New Delhi

Note on choice of pit-head vis-a-vis non pit-head plants for future coal based power projects

1. Background

At Pit head thermal generating station, coal is available from the nearby mines, but the power generated by the Plant will be transmitted to the load center, and thus leads to applicability of Inter State Transmission System (ISTS) transmission charges and losses. Whereas, any non-pit head thermal plant will serve the nearest load center within the state, implying no ISTS transmission charges and losses. However, it has to get the coal from the mines and thus, will incur railway freight for transportation of coal. Any decision purely based on economic considerations as to whether a coal based thermal generating station should be located at pit head or non-pit head, would largely depend on comparison of railway freight vis-à-vis ISTS charges & losses. In addition to the above, the technical advantage of pit-head and non-pit head plants, which may not be quantifiable may also be worth considering.

2. Comparison of cost of generation from Pit head and Non-pit head plants based on economic consideration

An exercise has been undertaken in CEA to compare the railway freight vis-à-vis ISTS charges for four proposed Plants i.e. 660 MW Chabra TPS (Rajasthan), 800 MW Kalisindh TPS (Rajasthan), 800 MW Ukai TPS (Gujarat) and 800 MW Yamunagar TPS (Haryana) based on prices in July 2023. The details of the study are enclosed at Annex-I. Based on present level of coal transportation charges and inter-state transmission charges, the study reveals that for these states, the threshold distance from the mines above which it is economical to have pit-head plants varies from 1050 km to 1420 km. All the proposed power stations considered in the study were brown field in nature. In case of green field projects, this distance will be somewhat lower as brown field projects offer increased economic benefits in terms of lower capital cost. However, states can be offered power from expansion of existing pit-head stations also, which will also offer benefit in terms of lower capital cost.

3. Comparison of cost of generation from Pit head and Non-pit head plants based on Technical considerations

3.1 Stability support: Small perturbations (like tripping of generating units, tripping of transmission lines etc) are common occurrences in the grid. If the grid has inherent capability to curb the effects of these perturbations, it continues to operate smoothly. One of the factors providing support for stabilization of the grid is inertia in the form of large rotating mass of conventional generating units. Further, location of inertia is also important, and in case of RE rich states, which are away from coal mines, conventional

coal based generation will be of great help in providing stability support to the grid. A brief note on this issue is attached as Annex-II.

3.2 Voltage and reactive power support: Presence of conventional generation which has inherent capability to maintain voltage profile by generation or absorption of reactive power helps in steady state and dynamic voltage support. A brief explanatory note on this issue is attached at Annex-III.

3.3 Restoration in exigencies: Though grid disturbances are rare events, early restoration of power supply becomes critical, if such event does takes place. Presence of power stations near load centers helps in formulating islanding schemes, which allow sensing of imminent disturbance and isolating load pockets and the load centre generation from the rest of the affected grid. Such islands not only help in continuation of supply within the island but also helps in restoration of supply by extending start up power to other power stations.

4. Recommendations

It may be seen that the economic analysis in para 2 of this note is based on present level of transmission charges and railway freight charges for coal. However, the useful life to coal based stations is 25-35 years and the transmission charges and coal freight charges, and their relative impacts will undergo several changes during the useful life of the project. Therefore, it is for consideration that the decision for establishing thermal plants at pit head or load center may be taken by the project proponent on case-to-case basis, considering the cost-benefit analysis and operational benefits of non-pit head plants. This may lead to judicious mix of future coal-based generation capacity at pit head and at load centers. This is expected to take care of technical concerns also mentioned in para 3.

Analysis of the proposals of Gujarat, Rajasthan and Haryana to have non pit-head coal based stations in the state

1. Assumptions

a) Railway Freight for transportation of coal

i) While carrying out the estimation of railway freight for non-pithead stations, coal mines and their distance from the beneficiary States have been taken as under:

Plant Name	Capacity (MW)	Distance from Mine (km)
Chhabra TPS, Raj	660	830 (PEKB)
Kalisindh TPS, Rajasthan	800	1080 (PEKB)
Ukai TPS, Gujarat	800	1150 (SECL) (Scenario 1)
		700 (WCL) (Scenario 2)
Yamuna Nagar TPS, Haryana	800	1300 (CCL) (Scenario 1)
		1050 (NCL) (Scenario 2)

It may be seen that in case of Ukai TPS, two scenarios are envisaged - if coal is made available from SECL or from CCL. Similarly, in case of Yamuna Nagar TPS, two scenarios are envisaged - if coal is made available from CCL or from NCL.

In case of pithead stations, for the purpose of estimation of the railway freight, a distance of 100 km from the mine has been assumed.

ii) Station Heat Rate is taken as 2250 kcal/kwh, GCV of coal as 3850 kcal/kg, price of coal as Rs 1709/tonne (G12 grade of coal).

iii) Transportation cost of coal (railway freight) varies with distance and existing railway freight chart has been used. Transportation loss taken as 0.8% (as per CERC Norm).

b) ISTS Charges and Losses to be paid by beneficiary State for drawing power from Pit head Plant

i) Grid Controller of India vide notification dated 25.06.2023 issued "Notified transmission charges payable by Designated Inter State Transmission Customers for the billing month of July 2023". LTA charges (Rs/MW/month) of the concerned beneficiary States have been derived by dividing the total transmission charges payable by the State with total LTA of the States.

ii) ISTS charges payable by the concerned State for drawing power from pit head plant has been arrived at by multiplying installed capacity of the Plant with LTA charges of the

State (Rs/MW/month) and then per kWh transmission charges have been computed by dividing the ISTS charges with the energy generated by the Plant at 65% PLF.

iii) ISTS losses have been assumed at 4% and cost of power lost due to ISTS losses have been derived by average generation cost of Rs. 3.63 per kWh.

2. Consultation with States

Based on above, comparison of railway freight vis-à-vis ISTS charges for the above four thermal Plants were worked out and shared with States i.e. Rajasthan, Gujarat and Haryana. States have broadly pointed out following addition cost implication for pit head plants:

i. Greenfield project at Pit head vis-à-vis Brown field project at Non-Pit head:

All the three states mentioned that they are planning to set up brownfield projects in their State (Non-pithead). They claimed that setting up brownfield project is cheaper than green field projects (Pit head), because of availability of land, water, power evacuation system and various other common facilities and absence of any R&R issues for the new plant.

It is estimated that the capital cost for brownfield project would be about 10% less and would lead to the difference in fixed cost/kWh of around 22 paisa/kWh by considering CERC norms for tariff and PLF of 65%. Considering that all State DISCOMs have raised this issue, the savings in setting up of brown field not pit head power plant, compared to setting up of green field power plant has been considered for comparison purpose.

ii. Supply of certain percentage of energy generated to the Host States at ECR

RVUNL has stated that Chattisgarh is pressing for 5% to 7.5% power at ECR (without any fixed cost payment). Opportunity cost of non-availing that much power from pit head plant has been considered in fixed cost which comes out to be 0.13 Rs /kWh.

HPGCL has also mentioned about additional financial implication on account of the notifications of States having coal mines viz Odisha & Chattisgarh which require generating companies setting up plants in these states to provide 5% power at ECR.

Even though legal status of such provision has to be ascertained, the financial implication of loss of fixed charge (for 5% generation) based on CERC norms works out around 13 paisa/unit (Capital cost – 8.79 Cr/MW, 65% PLF).

As there appears to be no rationale for host States pressing of certain amount of power at ECR without paying any fixed cost, the same has not been considered for comparison purpose.

iii. Other Points

The above States have pleaded that following additional cost of Pit head plant should be considered for comparing electricity generation cost from pit head and non-pit head plants:

SI No	Items	Remarks
A	Additional cost due to transportation of fly ash at Pit head Plants (RRVUNL) – 5 paise/unit	Ash disposal at pit head plant may involve higher costs as the demand for ash is less at pit head. Whereas for load centre plants the demand of ash being high there may be lower cost of ash disposal. However, in the absence of any details, additional cost for transportation of fuel has not been considered for comparison purposes.
B	Additional cost at pit head due to electricity duty on APC at Chattisgarh @14% of average cost of supply (RRUVNL)- 3 paise/unit	This cost is equally applicable to pit head and non-pit head plants. However, rate of electricity duty may vary from State to State. In the absence of any details, additional cost for transportation of fuel has not been considered for comparison purposes.
C	In case Plant is located in the Haryana, then the Plant will be eligible for lower RoE @ 10% compared to CERC norm of 15.5%. Similarly, CERC has capped initial spares @4%, whereas HERC permits the same @2%. Considering the above, saving per unit in case of non-pit head plant would be Rs. 0.20 per unit (HPGCL)	In case Haryana wants to set up a dedicated plant in Chattisgarh, then norms of HERC will be applicable. Therefore, the saving as projected by HPGCL for non-pit head plant is not correct and the same has not been considered for comparison purposes.

3. Comparative additional cost for Non-pit head and Pit head Plants

3.1 All above 3 States have stated that they would like to install non-pit head brown-field thermal power plants.

3.2 Based on submission of States, additional cost for pit head and non-pit head plants in the present day context have been worked out as under:-

(all figures are in Rs/unit)

Plant Name	Capacity (MW)	Distance from Mine (km)	Additional cost for Non pit head			Additional cost for Pit head
			Additional cost for Railway Freight	Saving due to brownfield @65% PLF	Net	Additional cost for ISTS charges and losses @65 % PLF
(1)	(2)	(3)	(4)	(5)	(6)=(4)-(5)	(7)
Chhabra TPS, Raj	660	830 (PEKB)	0.89	0.22	0.67	1.01
Kalisindh TPS, Rajasthan	800	1080 (PEKB)	1.13	0.22	0.91	1.01
Ukai TPS, Gujarat	800	1150 (SECL)	1.21	0.22	0.99	0.88
	800	700 (WCL)	0.74	0.22	0.52	0.88
Yamuna Nagar TPS, Haryana	800	1300 (CCL)	1.36	0.22	1.14	1.25
	800	1050 (NCL)	1.10	0.22	0.88	1.25

3.3 Electricity from pit head power plants would be cheaper compared to that of non-pit head plants located, when in distance of the State/load centre from coal mine exceeds

certain distance (break-even distance). Based on above assumption including brown-field non-pit head plants, break-even distances have been estimated for these States as under:

States	Break-even distance (km)
Rajasthan	1161-1180
Haryanana	1401-1420
Gujarat	1051-1060

3.4 From table given at para 2.3 above, it may be observed that cost of electricity generation from expansion of Chabra TPS (Rajasthan), Kalisindh TPS (Rajasthan) and Yamunanagar TPS (Haryanana) would be lower (Non-Pit head) compared to cost of electricity generation from new greenfield pit head plants near mines. Therefore, non-pit head plants can be recommended for these power plants.

In case of Ukai TPS (Gujarat), electricity from non-pit head thermal stations would be cheaper in case coal is sourced from WCL mine (distance of 700 km from State); however, if coal is sourced from SECL mine (distance 1150 km), then electricity from pit-head plant appears to be cheaper. In case of coal sourced from WCL, then cost of electricity from non-pit head plant is cheaper by about 36 paise/unit; whereas if coal is sourced from SECL, cost of electricity from non-pit head plant would be costlier by about 11 paise/unit. Considering the number of assumptions used for comparison purposes, it appears that non-pit head plant for Ukai TPS would be beneficial to State.

Stability support by Coal based Generating units near load centers

The synchronous generators have an inherent capability to provide inertial response due to large rotating masses during steady state (i.e. when grid parameters are steady and health) as well as transient conditions (when grid parameters are undergoing changes due to some perturbation in the grid). Inertial response from huge rotating masses of synchronous machines is delivered instantaneously (without any manual intervention or activation) prior to the primary & secondary frequency ancillary services and help in providing the inertial response which is required for arresting the frequency dip immediately after loss of generation. The primary response gets activated 30-40 seconds after the event followed by secondary response through Automatic Generation Control which is activated in 3-5 minutes. The inertial, primary, secondary, and tertiary frequency response is illustrated in Figure 1.

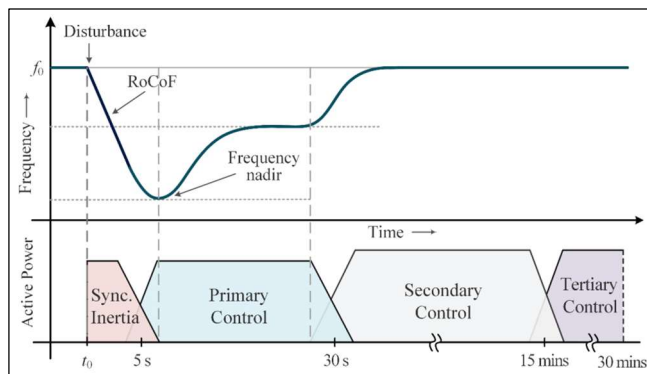


Figure 1: Stages of power system frequency response after a disturbance

Inertia limits the rate of change of frequency (RoCoF) in the first few seconds from the onset of a sudden power imbalance. RoCoF values experienced by the system for a given contingency varies across the system depending on the location of the contingency and availability of synchronous machines in the vicinity. Synchronous machines provide synchronizing torque and prevent high RoCoF. Absence of non-pit head power plants (synchronous machines) would make load centres and RE pockets vulnerable to very high rate of change of frequency post generation loss. In such cases the localized RoCoF may trigger Rate of Change of Frequency (RoCoF) based load shedding which is set to act below 49.9 Hz and at 0.1 Hz per second decline in frequency.

Voltage support by Coal based generation near Load Centers

The flow of reactive power over transmission system causes voltage to drop. Most of the SERCs have already put in place regulations to charge the consumers for drawl of reactive power. The objective is to ensure that consumers meet their reactive power demand locally by installing capacitors etc. However, in spite of these regulations, it is not uncommon for load centers to draw reactive power from the grid. Thermal power plants can also absorb and inject reactive power into the grid thereby helping in efficient voltage control and dynamic reactive power support. The Excitation system and Automatic Voltage Regulator (AVR) in the case of synchronous machines help maintain the bus voltage at a desired level and contribute to local voltage control. This can be helpful in addressing the low voltage-related issues in the load centres experienced during peak demand periods. The table below captures improvement in voltage at various places when additional units are turned on:

Bus Name	Base Voltage (kV)	Change in Bus Voltage by turning on the 660 MW Unit at Chhabra & 800 MW Unit at Kalisindh (kV)	Bus Name	Base Voltage (kV)	Change in Bus Voltage by turning on the 660 MW Unit at Chhabra & 800 MW Unit at Kalisindh (kV)
ANTA	765	5.4	KOTA	400	1.8
PHAGI	765	2.9	KAWAI	400	1.7
AJMER_765	765	2.6	CHITTORGARH	400	1.5
CHITTOR_765	765	2.3	AJMER	400	1.5
BHADLA II-PG	765	1.9	MERTA	400	1.4
FATEHGARH-II	765	1.8	AJMER_PG	400	1.4
BHADLA-PG	765	1.7	PHAGI_400	400	1.4
BIKANER-PG	765	1.4	CHITTOR_PG	400	1.4
HINDAU-4	400	2.9	HERAPU-4	400	1.4
CHABRA-4	400	2.8	KANKANI	400	1.3
ANTA-4	400	2.4	JODHPU-4	400	1.3
ALWAR_GSS	400	2.3	KOTA	400	1.8
BHILWA-4	400	1.9	RAMGARH_GSS	400	1.2

Further, an analysis through PSS/E simulation platform also indicate that the unavailability of thermal generators (synchronous machines) in the Chhabra – Kalisindh – Kawai complex in Rajasthan deteriorates the transient stability of the system. The results are shown in figure 2 below:

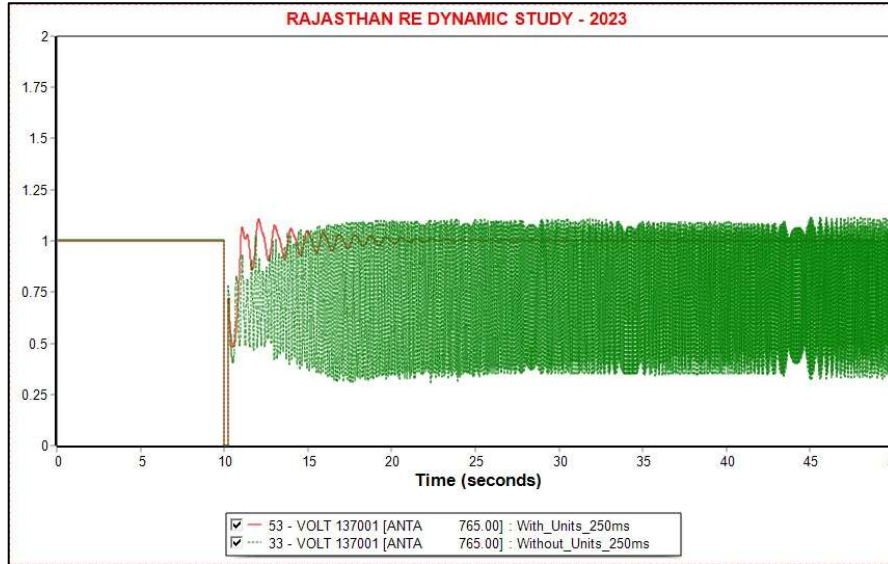


Figure2: Bus Voltage of 765 kV Anta (in pu) for a Three Phase Fault of 250 ms duration at 765 kV Anta Bus (Red: with 4340 MW in Chhabra – Kalisindh – Kawai complex , Green: with 2640 MW in this complex)

It may be seen that for a delayed fault clearance case (250 millisecond), the voltage perturbation dies down when more generating units are operating (4340 MW) in Chhabra – Kalisindh – Kawai complex (red colour), whereas the voltage perturbation continues unabated when less number of generating units are operating in this complex (2640 MW) (green colour).

Thus, it may be concluded that availability of conventional generation units in load centers helps in steady state and dynamic voltage support.

Grid Controller of India Limited
(A Govt. of India Enterprise)
(Formerly Power System Operation Corporation Limited)

26th Dec 2023

Sub: Comparison of Railway Freight Charges vis-à-vis Inter State Transmission System (ISTS) Charges for Deciding on the Location of Thermal Generating Stations (Pit head or Non-Pit head).

Ref: FU-2021/23-FSC dated 25th Sep 2023 from Ministry of Power forwarding a CEA study on the above.

- 1.0 Grid-India had been requested vide the above communication to evaluate the operational considerations for pit head vs load centre from the view point of voltage control, stability, island formation, black start etc. The detailed report on the issues was submitted by Grid-India on 2nd Nov 2023.
- 2.0 Subsequently, a meeting was held under the chairmanship of JS (Thermal), MOP on 10th Nov 2023 wherein Grid-India was directed to submit the summary of the results in tabular form. The same was shared with MOP vide email dated 10th November 2023.
- 3.0 On 2nd December 2023, another meeting was held under the chairmanship of Secretary, Ministry of Power where Grid-India presented the results of the report which evaluated the merits of pit head and non-pit head plants from technical point of view. During the discussion, the importance of inertia and stability in the future power system with decreasing share of synchronous machines and increasing penetration of renewable energy (asynchronous) was also highlighted. Grid-India was directed to submit a note analysing the challenges in terms of power system inertia with large scale integration of wind and PV solar generators in renewable complexes like Rajasthan.
- 4.0 **The note is provided as Annexe – 1.**

Note on the Impact of High Renewable Penetration & Displacement of Thermal Generators on Power System Stability in Rajasthan

1. India has set an ambitious target of reaching an installed capacity of 500 GW of non-fossil fuel-based generation by the year 2030. There has been a significant addition of renewable energy sources at both intra-state and inter-state levels in the past few years in several high RE potential states like Rajasthan. Currently, around 14.5 GW of ground mounted PV solar-based generators and more than 5 GW of wind-based generators are installed at the intra-state and inter-state transmission levels in the state of Rajasthan [Source: MNRE Installed Capacity Report]. Further, by 2030, an additional 75 GW of renewable energy capacity consisting of 60 GW of PV Solar and 15 MW wind-based generators is expected to be integrated in Rajasthan. [Source: CEA Report on Transmission System for Integration of over 500 GW RE Capacity by 2030].
2. The synchronous generators have an inherent capability to provide inertial response (due to large rotating masses) and dynamic reactive support during steady state as well as transient conditions. Inertial response from synchronous machines is delivered instantaneously (without any manual intervention or activation) prior to the primary & secondary frequency ancillary services. The kinetic energy stored in the huge rotating masses of the synchronous generators help in providing the inertial response which is required for arresting the frequency dip immediately after loss of generation. The primary response gets activated 30-40 seconds after the event followed by secondary response through Automatic Generation Control which is activated in 3-5 minutes. The inertial, primary, secondary, and tertiary frequency response is illustrated in Figure 1.

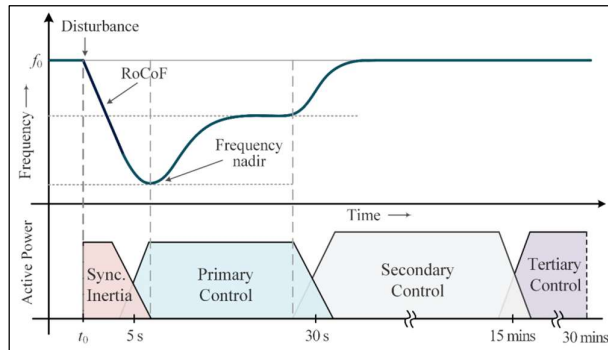


Figure 1: Stages of power system frequency response after a disturbance

3. The solar and wind generation sources coupled to the grid through inverters are asynchronous in nature unlike the thermal, hydro, nuclear and gas-based generation sources. They have negligible contribution to system inertia.
4. Inertia limits the rate of change of frequency (RoCoF) in the first few seconds from the onset of a sudden power imbalance. RoCoF values experienced by the system for a given contingency varies across the system depending on the location of the contingency and availability of synchronous machines in the vicinity. Inadequate inertial response could result in very high rate of decline in frequency post generation loss and the frequency may dip to a level where automatic load shedding (last line of defence) gets triggered. Rate of Change of Frequency (RoCoF) based load shedding is triggered below 49.9 Hz and at 0.1 Hz per second decline in frequency. The first stage of automatic Under Frequency Relay based load shedding (AUFLS) is set at 49.4 Hz.

5. The trend of system inertia assessed during grid events between the period Oct 2013 to Oct 2023 is illustrated in figure – 2 (left side). The trend of inertia vis-à-vis renewable energy penetration in the grid is also illustrated in figure – 2 (right side). Thus, it may be inferred from fig-2 that the available system inertia is declining with increase on renewable penetration.

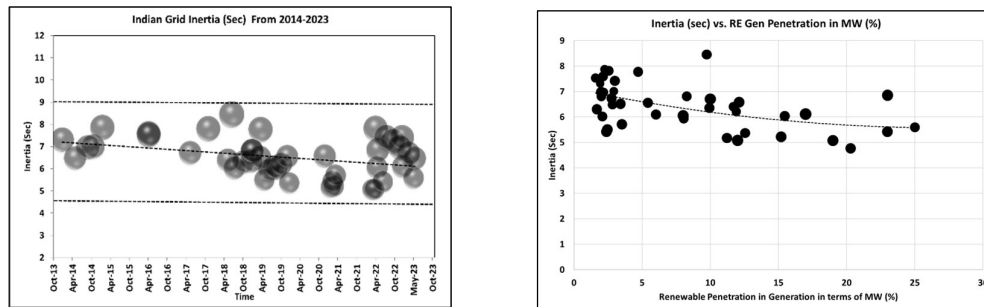


Figure 2: Reducing trend of Indian grid inertia with increasing penetration of renewable

6. The figure – 3 & figure – 4 indicate that inertia is low during the solar - peak hours due to high penetration of solar & lower availability of kinetic energy from the generators. [Source: Grid-India Report on Assessment of Inertia in Indian Power System]

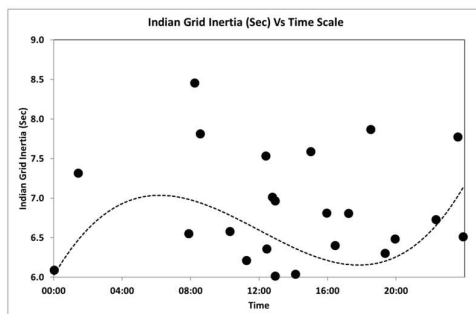


Figure 3: Grid Inertia vs Time of Day

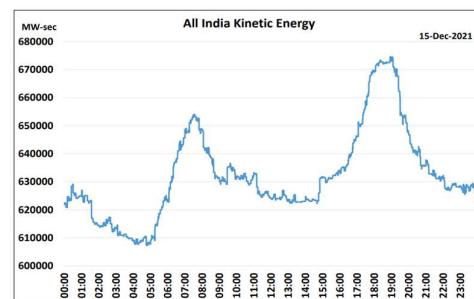


Figure 4: Sample daily kinetic energy curve for All Indian Grid

7. Thermal power plants can also absorb and inject reactive power into the grid thereby helping in efficient voltage control and dynamic reactive power support. The Excitation system and Automatic Voltage Regulator (AVR) in the case of synchronous machines help maintain the bus voltage at a desired level and contribute to local voltage control. This can be helpful in addressing the low voltage-related issues in the load centres experienced during peak demand periods. Annexure – 2(a) gives the trend of bus voltages for some of the nodes in Rajasthan experiencing voltage issues and the expected voltage support (through simulation studies) by additional nearby thermal units.
8. Further, an analysis through PSS/E simulation platform also indicate that the unavailability of thermal generators (synchronous machines) in the Chhabra – Kalisindh – Kawai complex in Rajasthan deteriorates the transient stability of the system. The results are given as Annex-2(b).
9. Presently, due to sizable proportion of on-bar synchronous capacity, the Indian power system is comfortably placed with respect to inertial response. Maintaining adequacy of power system inertia would be crucial in the future grid with high share of asynchronous generation resources. Addressing the potential issues of low inertia, reduced fault current capability, adverse transient stability in the high renewable potential states would require a minimum

number of synchronous machines to be available on bar during high renewable generation periods of the day. Studies need to be conducted in the planning horizon by the system planners and the same needs to be considered in the planning of transmission schemes in Rajasthan, Gujarat and other high renewable potential complexes. Synchronous condensers, Grid-forming inverters capable of providing synthetic inertia, adequate reactive power support etc. are some of the potential solutions which can be explored to address the above-mentioned issues which are likely to arise in the high RE potential complexes.

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Annexe-2(a)

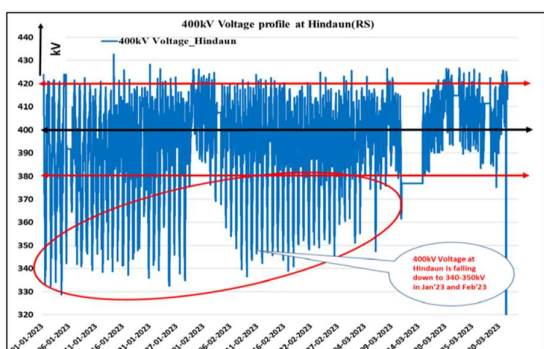


Figure 5: Voltage Profile of 400 kV Hindaun for Q4 of 2022-23

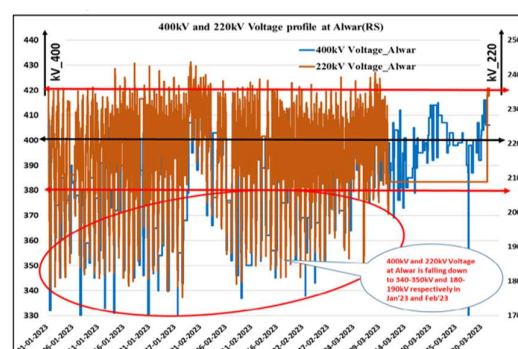


Figure 6: Voltage Profile of 400 kV & 220 kV Alwar for Q4 of 2022-23

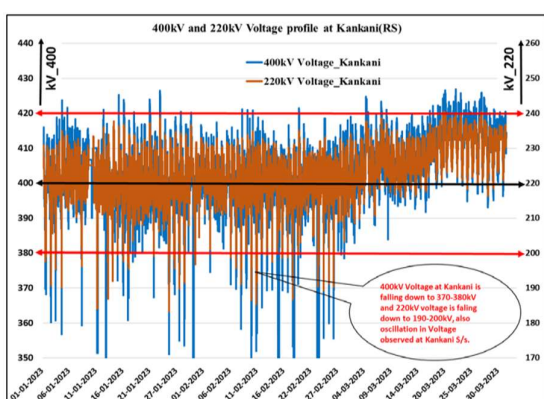


Figure 7: Voltage Profile of 400 kV & 220 kV Kankani for Q4 of 2022-23

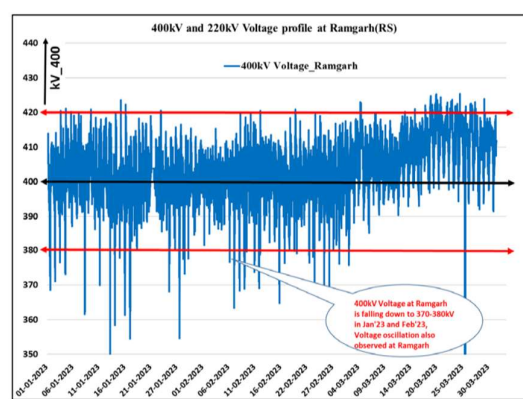


Figure 8: Voltage Profile of 400 kV & 220 kV Ramgarh for Q4 of 2022-23

Bus Name	Base Voltage (kV)	Change in Bus Voltage by turning on the 660 MW Unit at Chhabra & 800 MW Unit at Kalisindh (kV)	Bus Name	Base Voltage (kV)	Change in Bus Voltage by turning on the 660 MW Unit at Chhabra & 800 MW Unit at Kalisindh (kV)
ANTA	765	5.4	KOTA	400	1.8
PHAGI	765	2.9	KAWAI	400	1.7
AJMER_765	765	2.6	CHITTORGARH	400	1.5
CHITTOR_765	765	2.3	AJMER	400	1.5
BHADLA II-PG	765	1.9	MERTA	400	1.4
FATEHGARH-II	765	1.8	AJMER_PG	400	1.4
BHADLA-PG	765	1.7	PHAGI_400	400	1.4
BIKANER-PG	765	1.4	CHITTOR_PG	400	1.4
HINDAU-4	400	2.9	HERAPU-4	400	1.4
CHABRA-4	400	2.8	KANKANI	400	1.3
ANTA-4	400	2.4	JODHPU-4	400	1.3
ALWAR_GSS	400	2.3	KOTA	400	1.8
BHILWA-4	400	1.9	RAMGARH_GSS	400	1.2

Annexe-2(b)

Plant Name in the Kawai – Kalisindh Complex of Rajasthan	Present I/C of the Plant	Units on Bar in Case – I (Red Plots in Annexe - 1)	Units on Bar in Case – II (Green Plots in Annexe - 1)
Chhabra TPS, Rajasthan	2x660 + 4x250 MW	2x660 + 2x250 MW	1X660 MW
Kali Sindh TPS, Rajasthan	2x600 MW	2x600 MW	1x600 MW
Kawai TPS, Rajasthan	2x660 MW	2X660 MW	2X660 MW
Critical Clearing Time for a 3 – Phase Fault at 765 kV Anta Bus <i>(After which the system becomes transient unstable)</i>		300 ms	250 ms

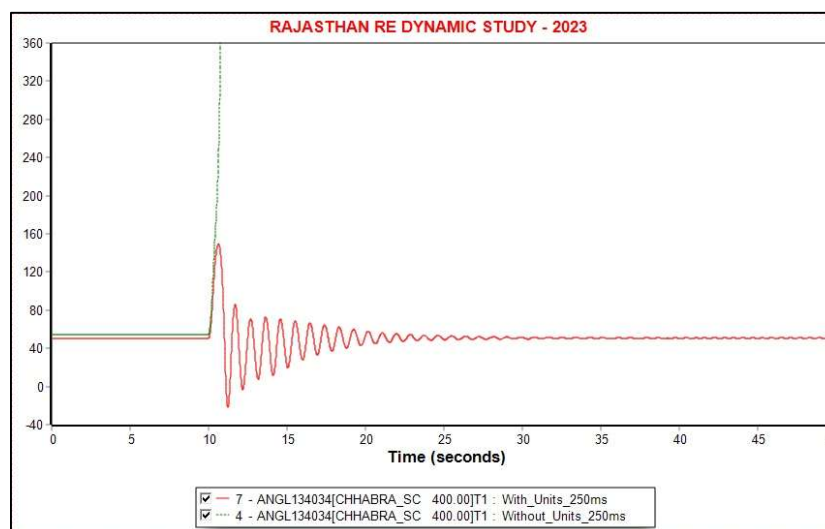


Figure 9: Rotor Angle of Chhabra Unit - 1 (in degrees) for a Three Phase Fault of 250 ms duration at 765 kV Anta Bus (Red: Case - I, Green: Case - II)

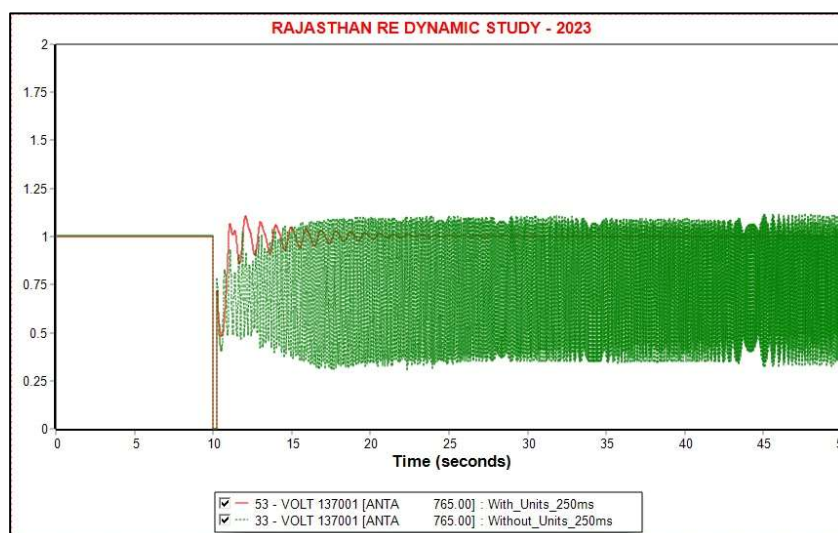


Figure 10: Bus Voltage of 765 kV Anta (in pu) for a Three Phase Fault of 250 ms duration at 765 kV Anta Bus (Red: Case - I, Green: Case - II)