- ER is mostly importing power in high renewable generation scenarios due to RE RPO requirements of ER which it shall not be able to meet from its own regional RE and it has to import power from neighbouring regions. ER is exporting power during Monsoon (February) evening and night off peak scenarios due to absence of Solar as well as low Wind generation in other regions.
- NER also imports as well as exports power in different scenarios. Mostly export of power shall take place in the Monsoon (August) and Summer (June) months due to high hydro generation during these seasons, whereas it shall import in Winter (February) scenario due to low hydro and RE RPO obligation.

Considering the above LGB for nine scenarios, load flow cases were prepared for detailed studies incorporating assessment of adequacy of Inter State Transmission System including inter-regional corridors planned to cater the power transfer requirement across the region in 2026-27 timeframe. Study results of the same have been discussed in subsequent sections.

## 3.2 Study Results and Analysis

Based on the load-generation scenarios for different regions, various studies have been carried out in PSSE. Transmission system planned and under implementation for various loads/generations scheduled to be commissioned for timeframe 2026-27 are also considered for conducting these studies. Based on the studies performed, results of the study are analysed and deliberated below-

### 3.2.1 Load Flow Studies

#### a) Inter-Regional Flows

Inter-regional flows between various regions, based on simulation studies for 2026-27 timeframe are summarised below in Table 3-2 for all the nine scenarios. Maximum and minimum flow between each inter-regional corridor are also highlighted in Table 3-2.

*Table 3-2:IR flow summary in MW*

| IR Flows | Aug'26 | | | Jun'26 | | | Feb'27 | | |
|---|---|---|---|---|---|---|---|---|---|
| Scenario No. / Corridor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | Solar Max | Peak Load | Off Peak | Solar Max | Peak Load | Off Peak | Solar Max | Peak Load | Off Peak |
| **WR-NR** | -4993 | 18628 | 16980 | -4505 | **24235** | 17642 | **-19915** | 4007 | 662 |
| **ER-NR** | **-8876** | -949 | -645 | -5268 | 3114 | 1995 | -5592 | **5412** | 1697 |
| **ER-WR** | -4628 | -4650 | **-6229** | -4034 | -5639 | -5404 | -417 | **2354** | 2116 |
| **ER-SR** | 3183 | 2692 | **2537** | 3379 | 2815 | 3386 | **5007** | 4107 | 4546 |
| **WR-SR** | -1505 | -8250 | -8556 | -3391 | **-9851** | -6546 | 8466 | 4759 | **8730** |
| **NER-ER** | 272 | -996 | -501 | **574** | -219 | -148 | -498 | -1073 | **-1164** |

From the table it can be seen that-

- Power on WR-NR corridor is flowing in both directions in different scenarios. Maximum power of the order of 24 GW is flowing from WR to NR in June evening peak scenario whereas maximum power flow of the order of 20 GW is flowing from NR to WR in February solar max scenario.
- Power on ER-NR corridor is flowing from NR to ER in solar max scenarios with maximum power of about 9 GW in August.
- Power on ER-WR corridor is flowing in both the directions i.e. ER to WR and WR to ER with maximum flow of 6.2 GW and 2.3 GW respectively.
- Power on ER-SR corridor is always flowing towards SR in all the scenarios with maximum flow of 5 GW and minimum flow of 2.5 GW.
- Power on WR-SR is flowing towards WR in Monsoon and summer season with a maximum flow of 10 GW whereas in winter season power is flowing towards SR with maximum flow of 8.7 GW.

Each inter-regional corridor comprises of multiple HVDC, 765 kV, 400 kV, 220 kV transmission lines. Loading on these tie lines for all nine scenarios along with their design limit are tabulated in **Annex-2.3.** Power flow exceeding the thermal design limit are highlighted in yellow in the said annexure. While analysing the annexure, it is observed that the most of the tie lines between the regions are loaded well within their design limit.

### b) Transmission Line Flows

All the ISTS and Intra-state 765 kV and 400 kV lines were monitored for any possible overloading in the base case prepared for nine scenarios. There are about 318 nos. of 765 kV lines and about 2281 nos. of 400 kV lines. Line flow pattern of these lines in all scenarios are tabulated at **Annex-2.4** and flows exceeding the 70% of thermal limit are highlighted. Summary of the results is shown below in Figure 3-11 & Figure 3-12:

*Figure 3-11:765kV Tr. line flow > 70% of thermal limit under base case*

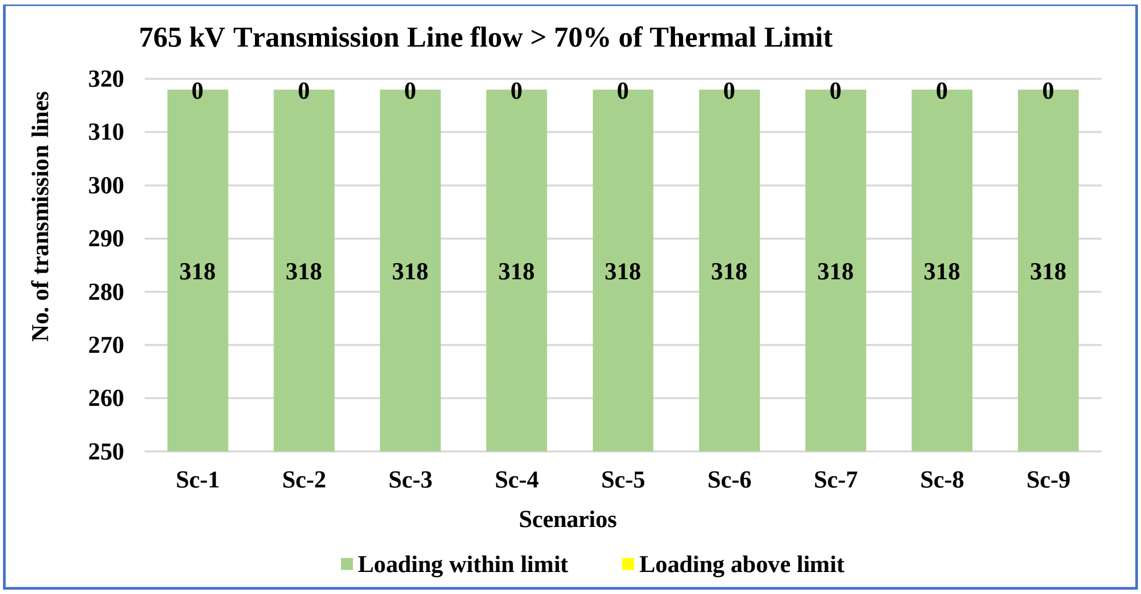
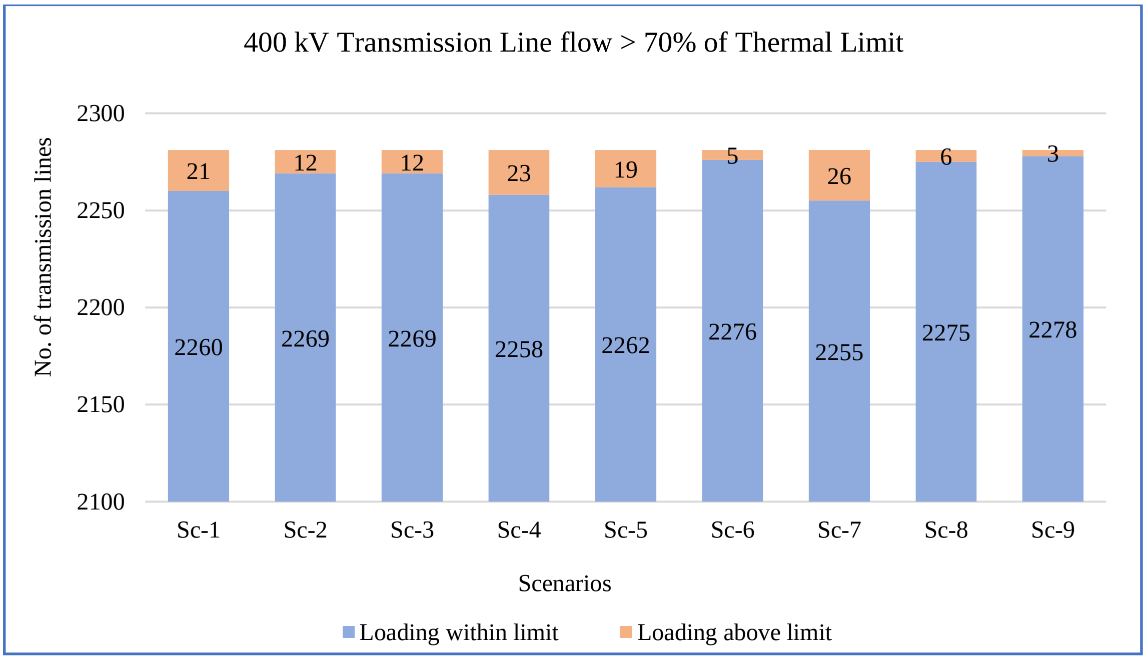
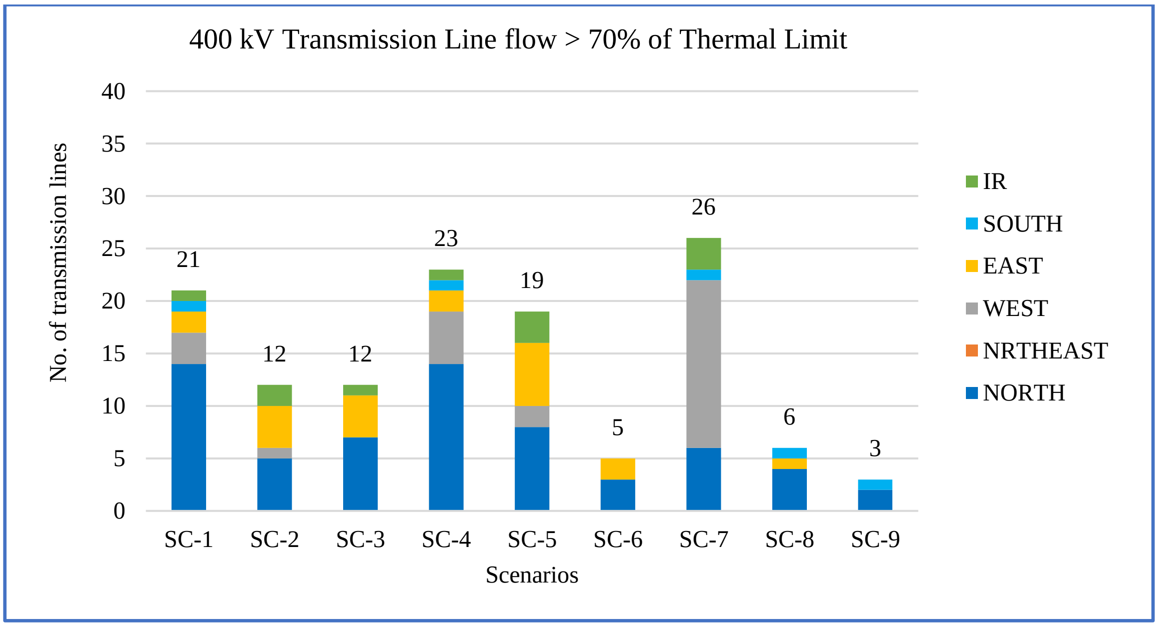


*Figure 3-12:400kV Tr. line flow > 70% of thermal limit under base case*



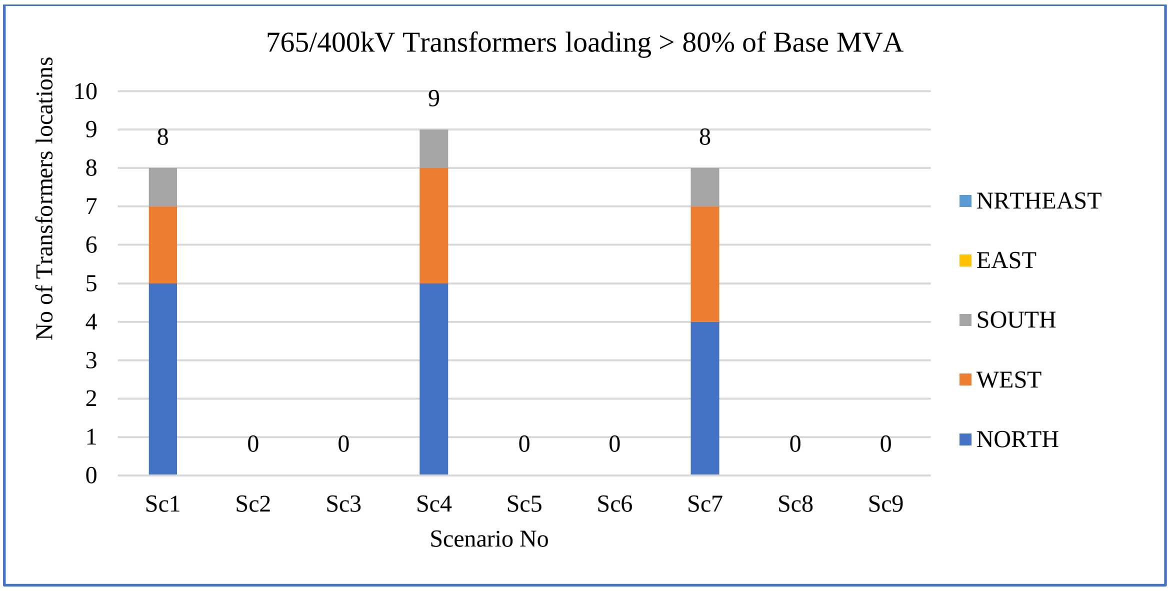




Power flow on all 765kV lines is below 70% of thermal limit in base case itself. About 21, 23 and 26 nos. of 400 kV lines in Scenarios-1, 4, and 7 (Solar max scenarios) respectively are loaded above 70% of the thermal limit. However, to understand the criticality of this loading, detailed contingency studies have been carried out, which are discussed in subsequent sections.

### c) Transformer Loadings

In the time frame under study, there would be about 294 nos. of 765/400 kV transformer at 119 nos. of 765/400 kV substations. Loading patterns of these transformers obtained from simulation studies are tabulated in **Annex 2.5** and loading more than 80% of their rating in any scenarios are also highlighted. Number of substations, where loading is more than 80% of rating in all scenarios are depicted in Figure 3-13 & Figure 3-14.

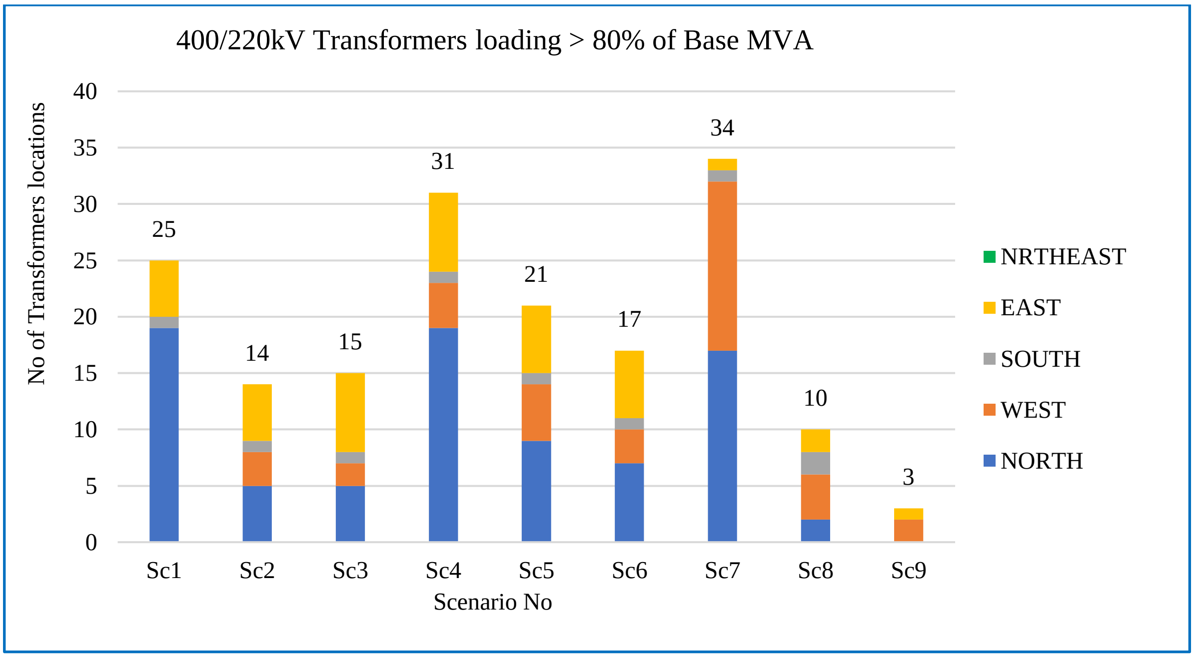
*Figure 3-13:765/400kV ICT Loading under base case*




Maximum number of substation where loading is above 80% of MVA rating are corresponding to solar max scenarios. These substations are located in northern, western and southern region due to non-availability of transformers under N-1 contingency at RE pooling stations.

Similar analysis was carried out for 400/220 kV transformers. There are 1401 nos. of transformers located at about 549 nos. of 400/220 kV stations.

*Figure 3-14:400/220kV ICT loading under Base Case*



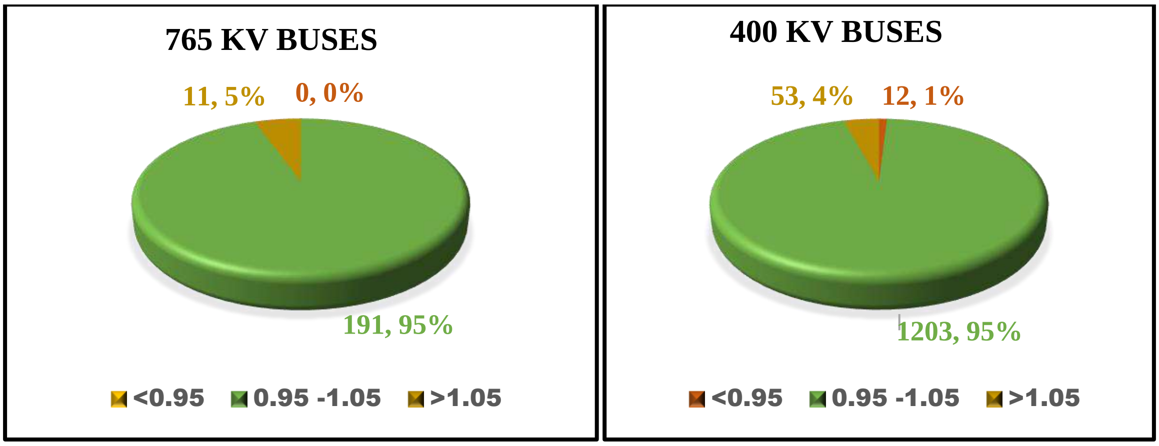

Under solar max scenarios viz. Scenarios 1, 4 and 7 about 25, 31 and 34 substations located in different region, where ICTs are getting loaded above 80% of MVA rating. The need for augmentation would depend upon the number of transformers, parallel paths availability etc. Hence simulation with contingencies is discussed in subsequent sections.

**d) Voltage Profile Analysis**

With injection of high amount of RE into the Indian Grid, it is expected that in the same day power flow on a line would reverse. Transmission lines associated with thermal and hydro would be lightly loaded in solar max scenarios. Though adequate reactive compensation is planned in the form of switchable line reactors, bus reactors, STATCOMs, SVCs at the time of inception of transmission projects. Impact of various shunt devices on voltages of all buses in all the scenarios are observed and analysed.

PU voltages of all 765 kV and 400 kV buses were observed in all the nine scenarios. Maximum and minimum voltage of each bus was identified from nine voltages available in nine scenarios. For voltage variation beyond ±0.05 pu from nominal voltage was considered as voltage violation. Maximum and minimum voltage of buses is considered to calculate the number of buses having voltage beyond 1 pu and voltage below 1 pu respectively. Results of the analysis is plotted below in Figure 3-15.

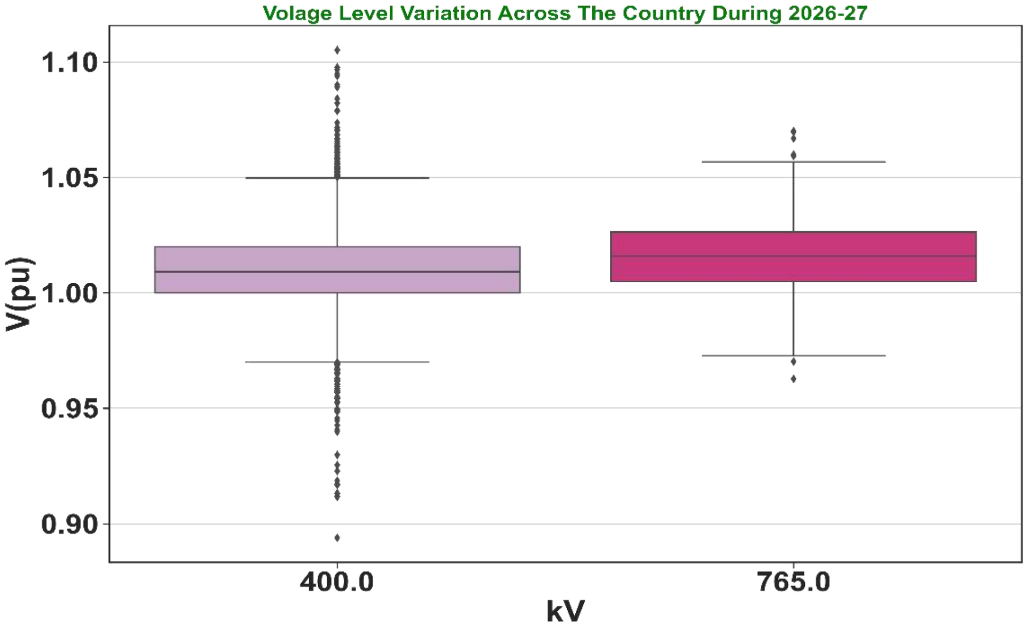
*Figure 3-15: Pie-chart showing number of 765 KV & 400 KV buses beyond & below 1 pu.*




From the above voltage plots it can be seen that around 95% of the buses at 765 kV level as well as at 400 kV level voltage are found to be in the range of 0.95 to 1.05 pu in All India Base case scenarios. There are around 11 nodes of 765 kV voltage and 53 Nodes at 400 kV voltage are having voltage beyond 1.05 pu in any one of the scenarios. Similarly, around 12 nodes at 400 kV are facing low voltage in one of the scenarios.

In all India network simulation analysis for 2026-27 timeframe, 765kV and 400kV Bus voltage variations under nine scenarios is presented in the Figure 3-16, wherein it is observed that the median of the 400kV and 765 kV bus voltage are 1.009 pu and 1.0158 pu respectively. 50% of the bus voltages under various scenarios lies between 1.00-1.01 pu for 400 kV buses and 1.00-1.015 for 765 kV buses. Highest voltage observed in any scenario at 400kV & 765 kV are 1.105 & 1.07 pu respectively and minimum voltage for observed in any scenario at 400kV & 765 kV are 0.894 & 0.963 pu respectively.

*Figure 3-16: Voltage level variation across the country during 2026-27*




Region wise Bus voltage variation in all nine scenarios is plotted in Figure 3-17, except North East region all other Regions i.e., Northern, Western, Southern and Eastern are experiencing over and under voltage at some of the 400kV buses. However, at 765kV Buses, only over voltages is observed in West, South and North.

*Figure 3-17: Region-wise voltage level variation profile during 2026-27*

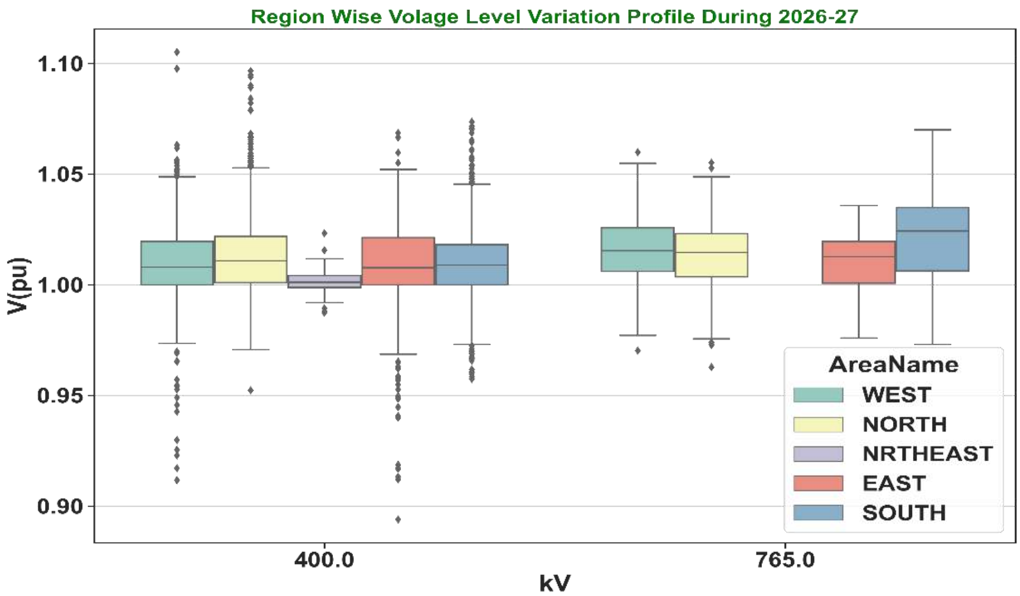
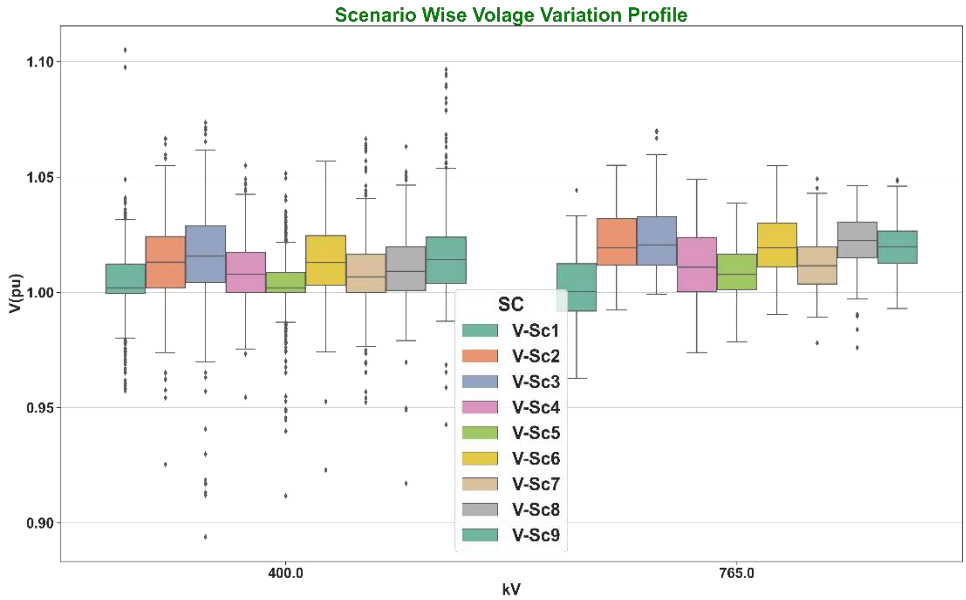


*Figure 3-18: Scenario wise voltage variation profile*




Scenario wise voltage variation for 400kV and 765kV bus is shown in Figure 3-18, wherein it is observed that voltage variation is relatively higher at 400 kV level. Further at 400 kV level maximum voltage is observed during winter night off peak scenario and at 765 kV level maximum voltage is observed during Monsoon night off peak scenario.

Details of the buses exceeding the voltage 1.05 pu and buses having voltage below the 0.95 pu in any of the scenario are enclosed at **Annex 2.6.** For buses experiencing low voltages, measures like switching of switchable line reactors, increasing operating voltage of nearby generators may be taken.

### 3.2.2 Contingency Analysis

Contingency analysis has been carried out on all the 765 kV & 400kV transmission lines, and 765/400 kV & 400/220 kV transformers to ascertain the loading levels under outage of any other 765 kV or 400 kV transmission element. Results of the analysis are discussed below:

#### a) Transmission Line

765kV line loadings beyond 3000 MW under N-1 was assessed first. Thereafter, to carry out a sensitivity analysis, number of lines loaded beyond 3200 MW and 3500 MW under N-1 contingency were also identified. The list of such lines is at **Annex 2.7** and the same has been summarised below in Figure 3-19 Figure 3-20 & Figure 3-21.

*Figure 3-19: 765kV Tr. line loadings>3000MW under N-1 Contingency*

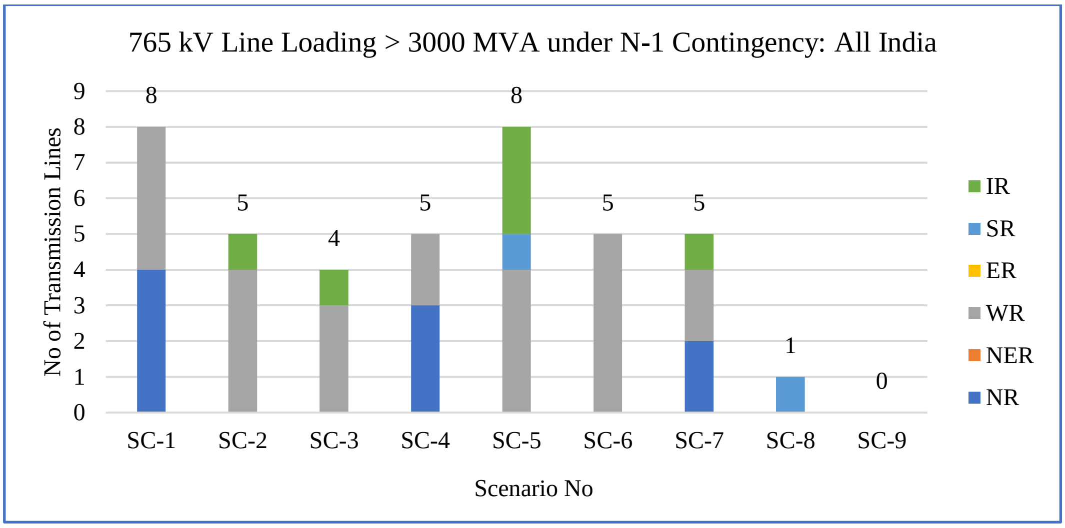



*Figure 3-20:765kV line loading>3200 MW under N-1 Contingency*

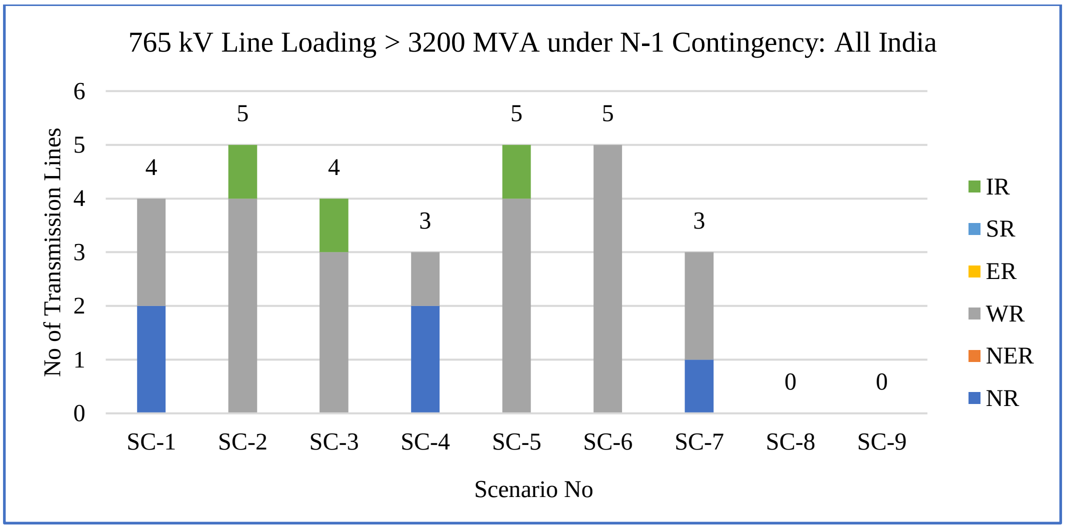
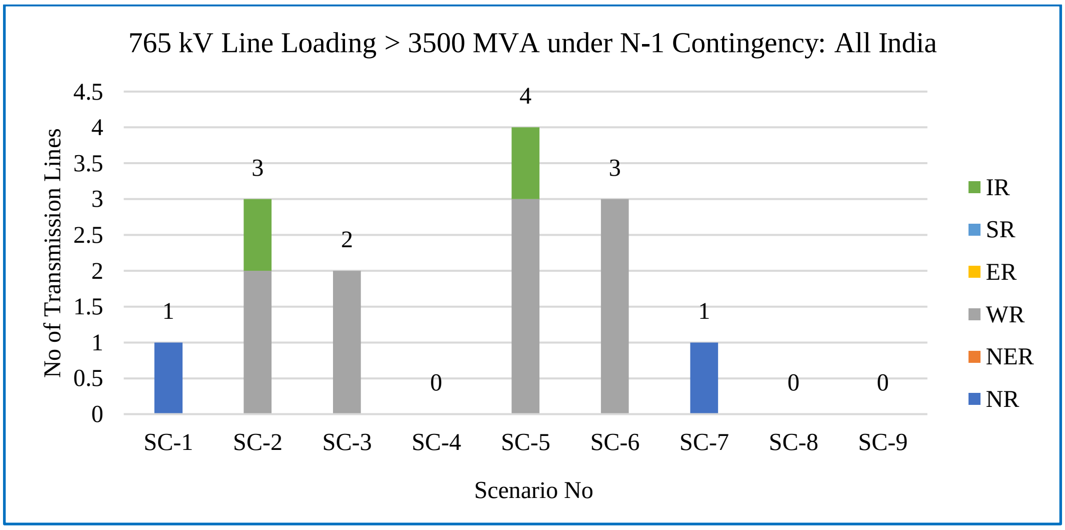



*Figure 3-21:765kV line loading>3500 MW under N-1 Contingency*



The most critical 765 kV lines are Champa-Kotra, Tamnar-Dharamjaygarh, Sasan-Vindhyachal Pool. Maximum loadings occurs during evening and night off peak scenarios. Detailed studies regarding the reason for the overloading and probable mitigation measures are discussed in respective regional chapters.

Further, for 400kV transmission lines, loading greater than 90% and 100% of thermal limit under N-1 Contingency has been assessed and the results are tabulated at **Annex 2.7.** The results are summarised below in Figure 3-22 & Figure 3-23.

*Figure 3-22:400kV line loading>90% of thermal limit under N-1 Contingency*

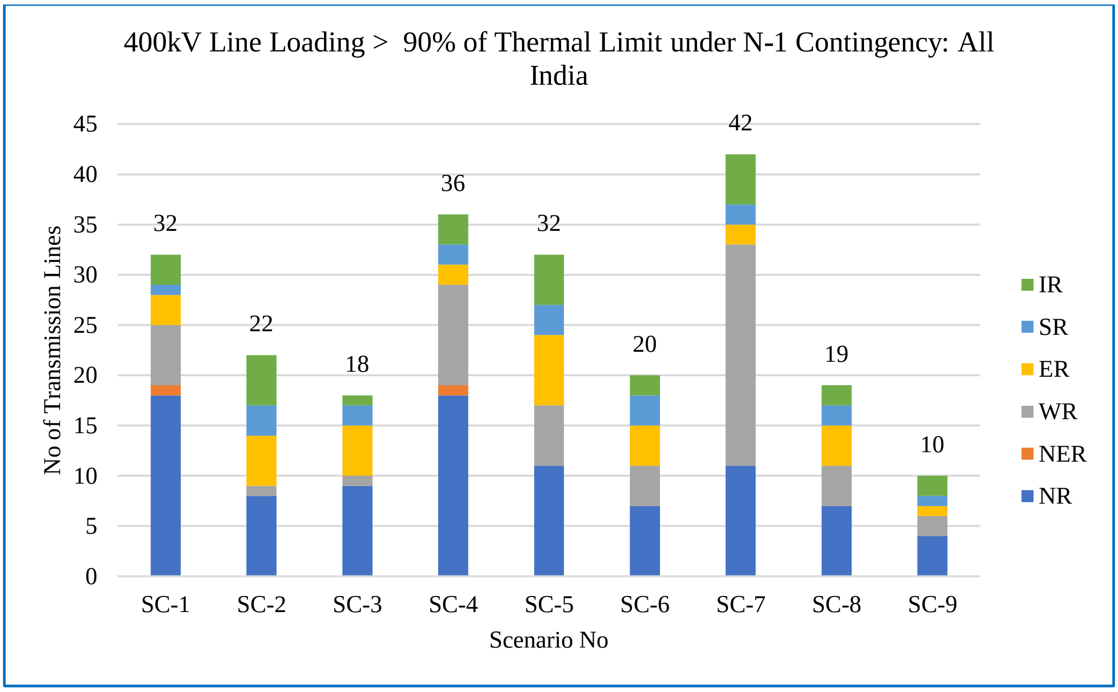
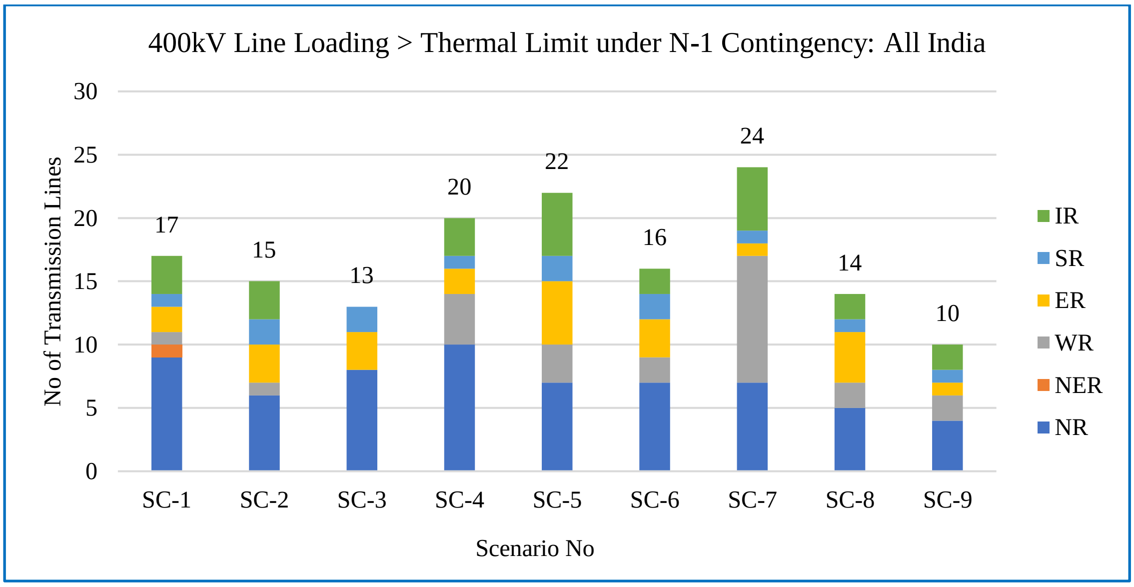



*Figure 3-23:400kV line loading>thermal limit under N-1 Contingency*




Max no. of 400kV lines on which loadings exceeds 90% and 100% of thermal limit are 42 and 24 respectively in Solar max scenarios i.e. Scenario-7. Further, detailed analysis and studies are being carried to plan additional systems, if any.

### b) Transformers

Number of substations where ICTs shall get loaded above 90% and 100% of MVA rating under N-1 contingency are depicted below in Figure 3-24 & Figure 3-25 for 765/400 KV ICT and Figure 3-26 & Figure 3-27 for 400/220 KV ICT . Detailed results are attached at **Annex 2.8.**

*Figure 3-24:765/400kV ICT loading≥90% of MVA rating under N-1 Contingency*

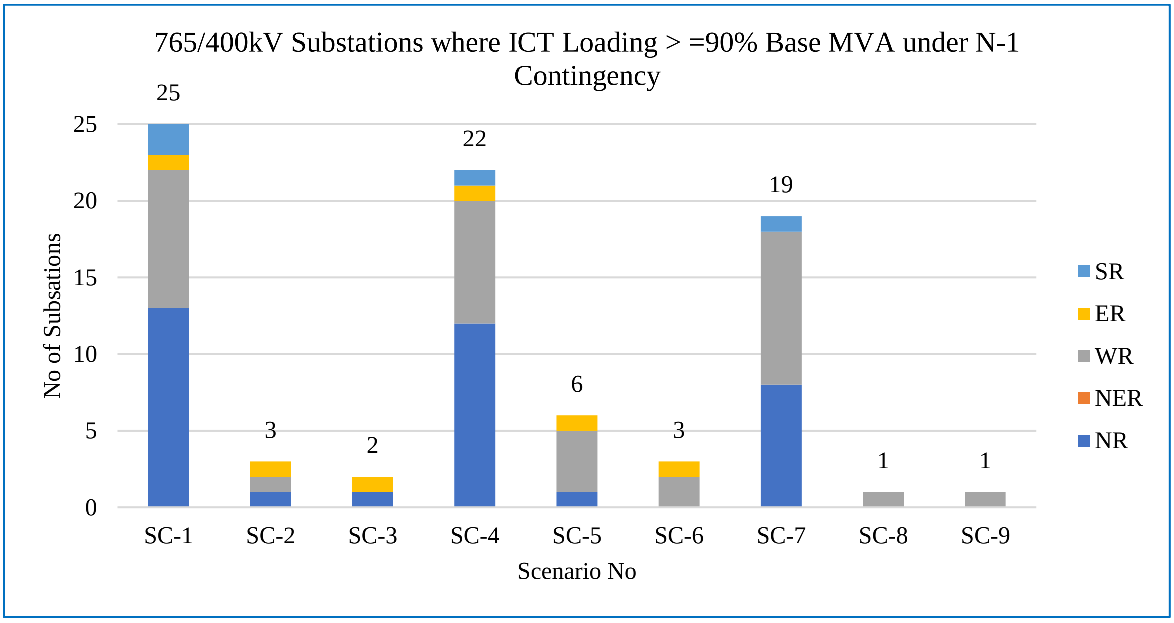
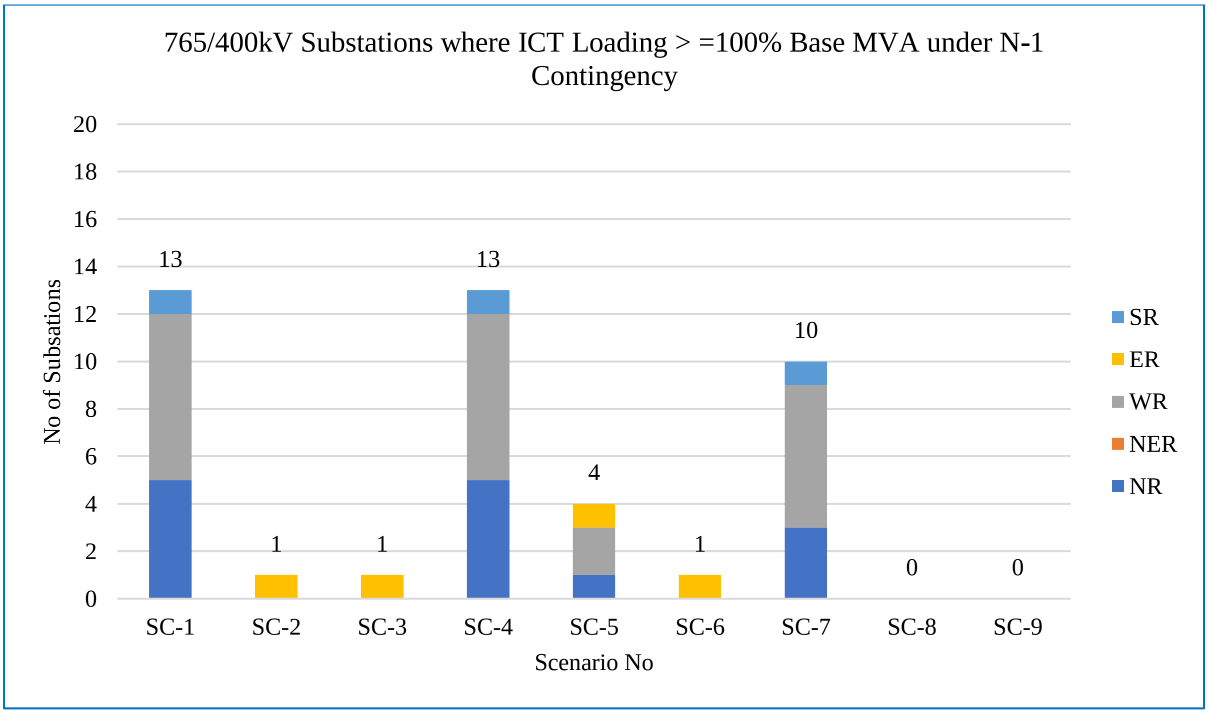



*Figure 3-25:765/400kV ICT loading≥100% of MVA rating under N-1 Contingency*




Maximum number of transformers exceeding the loading greater than MVA rating under N-1 contingency in each of the seasons are corresponding to Solar max scenarios viz. Scenarios-1, 4 and 7. Majority of these substations are RE pooling stations where ICTs have been planned considering N-0, as per Manual on Transmission Planning Criteria. The 13 locations corresponding to Scenario-4 where ICT loading violations have been observed are Bhiwani (PG), Khavda-I, II & III, Padghe(GIS), Navsari(New), Pune(PG), Kurnool, Bhadla-3, Fatehgarh-II, Bhiwani(SR). Thus, detailed studies are being carried out to plan for remedial measures.

*Figure 3-26:400/220kV ICT loadings≥ 90% of MVA rating under N-1 Contingency*

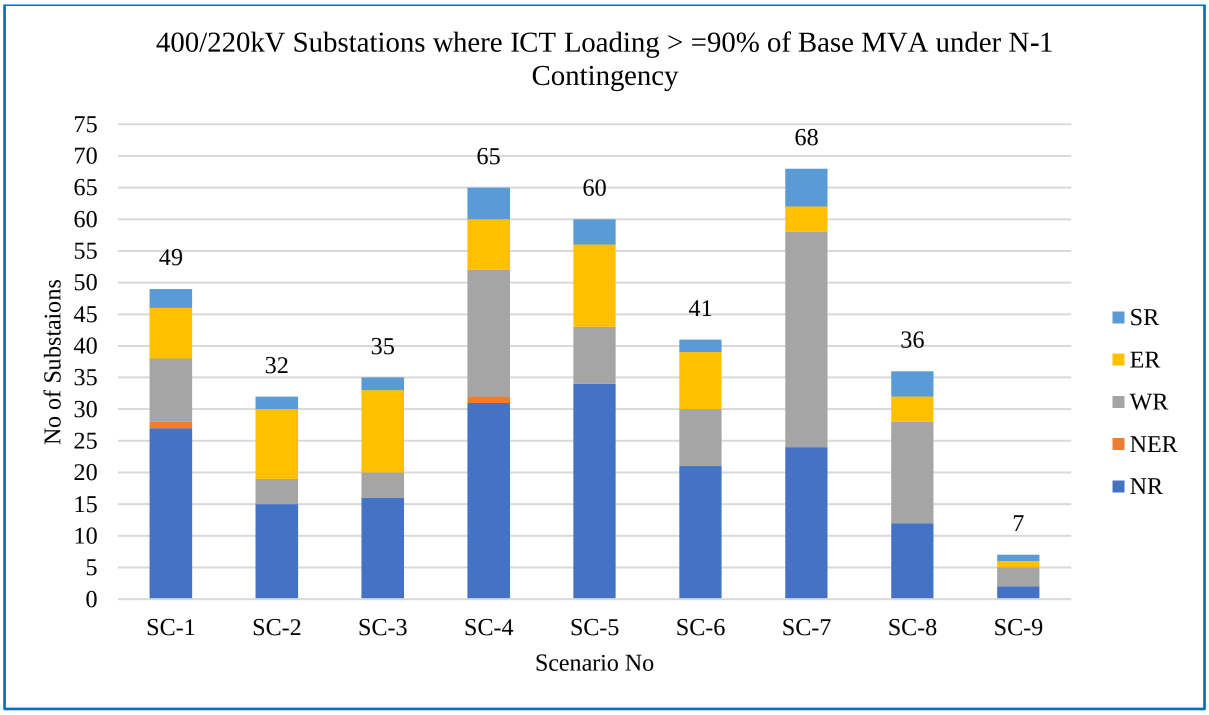
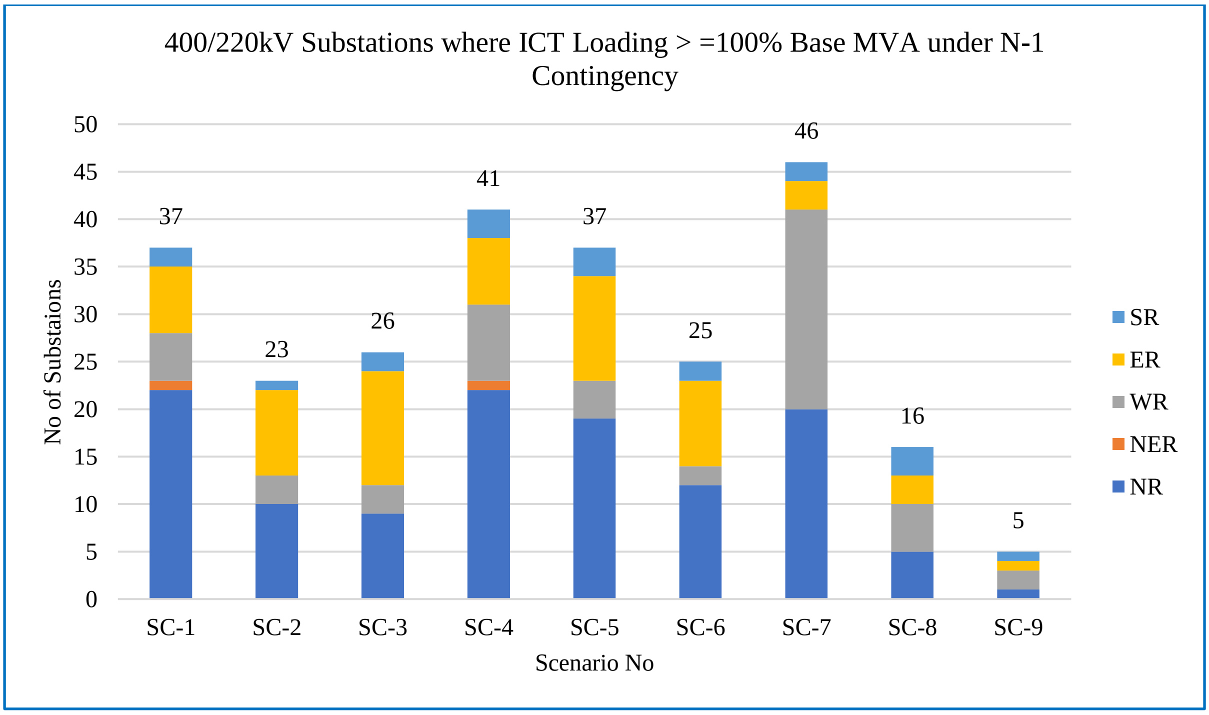



*Figure 3-27:400/220kV ICT loadings≥ 100% of MVA rating under N-1 Contingency*

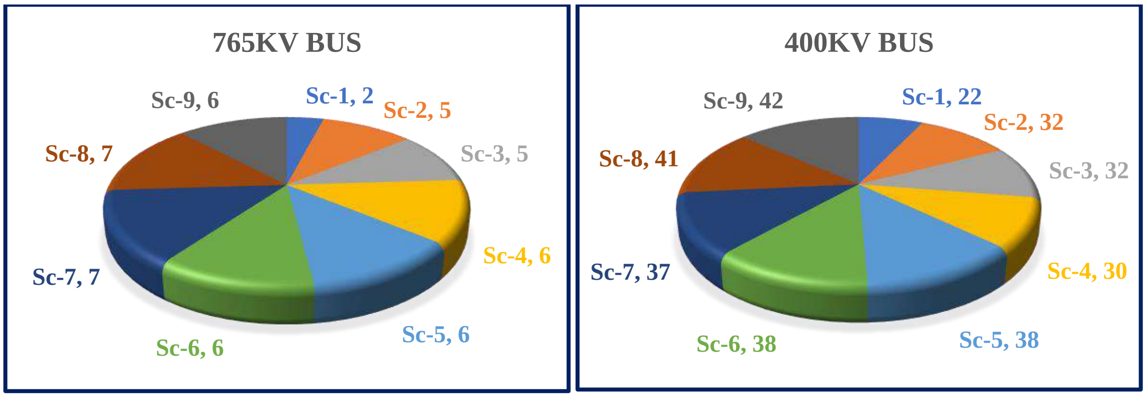


Maximum number of transformers exceeding the loading greater than MVA rating under N-1 contingency in each of the seasons are corresponding to Solar max scenarios viz. Scenarios-1, 4 and 7. Majority of these substations are RE pooling stations where ICTs have been planned considering N-0, as per Manual on Transmission Planning Criteria. Thus, some 46 no. of substations requires ICT augmentation, which are being studied in detail in respective regional chapters.

### 3.2.3 Short Circuit Analysis

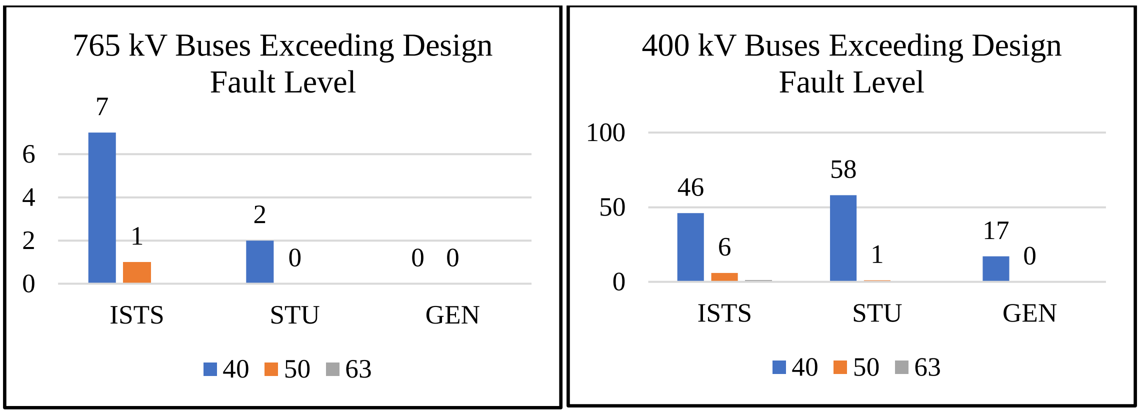
Short circuit level was calculated for all 765 and 400 kV buses on pan India basis. After finding the fault level for all buses exceeding the design fault level under any scenario were identified. Figure shows the number of 765 kV and 400 kV buses exceeding the design fault current under different scenarios. About 5 and 100 no. of 765 and 400 kV buses respectively were observed to be crossing the design fault current limit in Scenario-8 and Scenario-7 respectively. Details about the buses exceeding design fault current limit are attached at **Annex 2.9** under various scenarios.

*Figure 3-28: Pie-chart showing short circuit level 765 and 400 kV buses on pan India basis*




From the above charts it can be seen that number of fault level violations are highest in February scenario i.e. scenario-7,8, and 9. While identifying the reason for the same it is noticed that number of thermal machines on bar are maximum in February scenario. Hence fault contribution from these machines shall be maximum under these scenarios. Accordingly, scenario-8 of February is chosen to identify the number of violation taking place at ISTS/STU/Gen buses and same is represented below-

*Figure 3-29: Violation of fault level in Sc-8 at ISTS/STU/Gen buses at 765 kV & 400 kV levels*



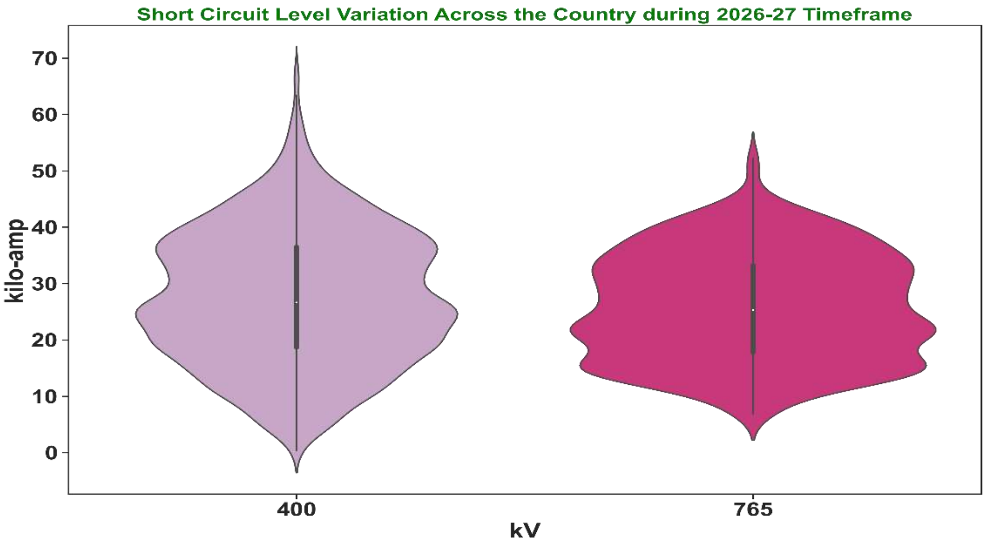
Further to understand the criticality of the case, maximum fault violation at buses are tabulated below in Table 3-3-

*Table 3-3: Maximum violation of fault level at ISTS/STU/GEN buses*

| | |
|---|---|
| ➢ 765 kV ISTS<br>▪ Bilaspur WR (40kA): 44kA<br>▪ Jabalpur Pool (50kA): 52kA | ➢ 400 kV ISTS<br>▪ Merrut(40kA): 64kA<br>▪ Padghe(50kA): 60kA |
| ➢ 765 kV STU<br>▪ Jaipur (40kA): 41kA | ➢ 400 kV STU<br>▪ Kudus(40kA): 62KA<br>▪ Maheshwaram-TS(50kA): 68kA |

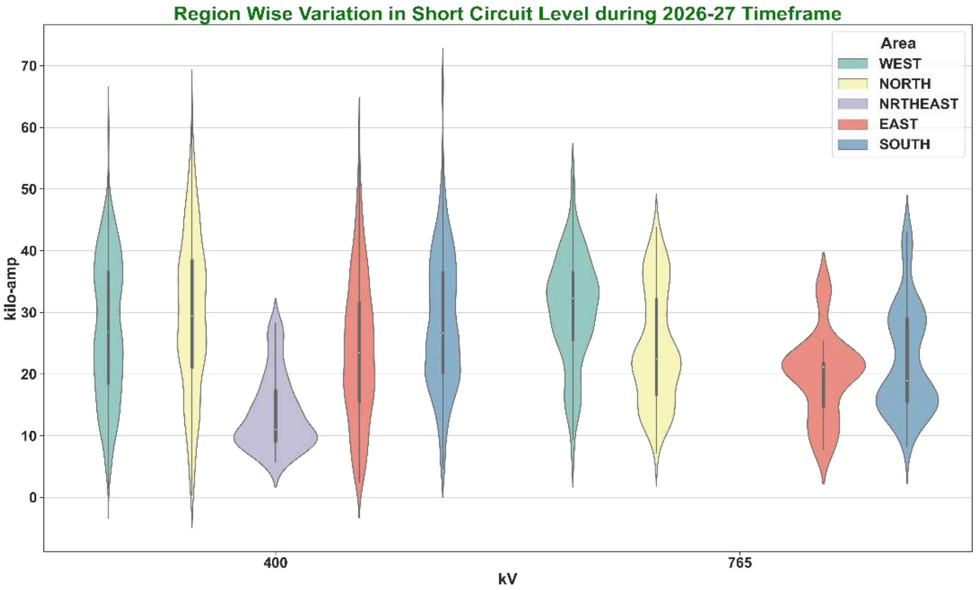
In all India network simulation analysis for 2026-27 timeframe, 765kV and 400kV buses short circuit levels under nine scenarios are presented in the violin plot at Figure 3-30. From the plot it can be observed that most of the 400 kV and 765 kV buses have short circuit level upto 35 kA and 30 kA respectively. The maximum short circuit level observed at 400 kV and 765 kV level is of the order of 68 kA and 52 kA respectively. Width of the violin plot indicate that short circuit levels of most of the 400 kV buses lie between 20 to 40 kA and 765 kV level lie between 15 to 25 kA.

*Figure 3-30: Short circuit level variation across the country during 2026-27 timeframe*



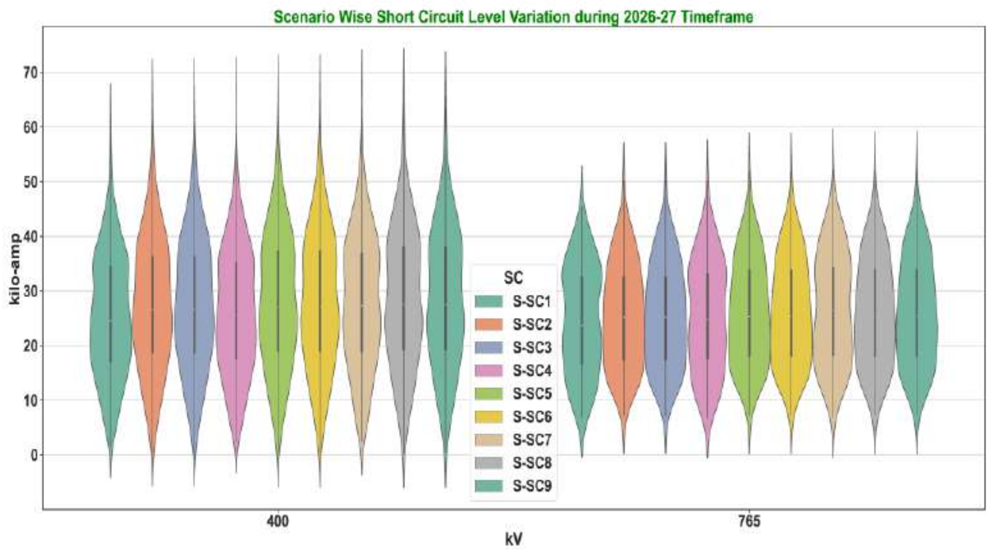

Region wise short circuit level in all nine scenarios is plotted in Figure 3-31. Maximum Short Circuit level observed at 400 kV and 765 kV bus lies in southern and western region respectively.

*Figure 3-31: Region wise variation in short circuit level during 2026-27 timeframe*




Scenario wise short circuit level for 400kV and 765kV bus is shown in Figure 3-32, wherein it is observed that under solar max scenario relatively lower short circuit level is observed..

*Figure 3-32: Scenario wise short circuit level variation during 2026-27 timeframe*



## 3.3 ISTS Expansion plan upto 2026-27

### 3.3.1 Summary of ISTS network

Region wise and year wise ISTS network expansion plan across the country upto FY 2026-2027 is enclosed in **Annex 2.10**. Summary of ckm addition, MVA addition and the broad estimated cost are tabulated below in Table 3-4, Table 3-5 & Table 3-6 respectively.

*Table 3-4: ckm addition*

| Sl. No. | FY | WR | SR | NR | ER | NER | Total |
|---|---|---|---|---|---|---|---|
| **1** | 2022-23 | 2,962 | 2,134 | 3,673 | 478 | 762 | **10,009** |
| **2** | 2023-24 | 3,134 | 1,010 | 1,240 | 265 | 450 | **6,099** |
| **3** | 2024-25 | 1,840 | 1,520 | 5,765 | - | 230 | **9,355** |
| **4** | 2025-26 | 2,100 | - | 2,304 | - | - | **4,404** |
| **5** | 2026-27 | - | - | 2,028 | - | - | **2,028** |
| | **Total** | **10,036** | **4,664** | **15,010** | **743** | **1,442** | **31,895** |

*Table 3-5: MVA addition*

| Sl. No. | FY | WR | SR | NR | ER | NER | Total |
|---|---|---|---|---|---|---|---|
| **1** | 2022-23 | 18,500 | 8,000 | 22,450 | 315 | 100 | **49,365** |
| **2** | 2023-24 | 32,500 | 14,000 | 5,000 | 1,000 | 320 | **52,820** |
| **3** | 2024-25 | 12,000 | 28,500 | 42,475 | - | 1,720 | **84,695** |
| **4** | 2025-26 | 12,000 | - | 11,330 | - | - | **23,330** |
| **5** | 2026-27 | - | - | 6,630 | - | - | **6,630** |
| | **Total** | **75,000** | **50,500** | **87,885** | **1,315** | **2,140** | **2,16,840** |

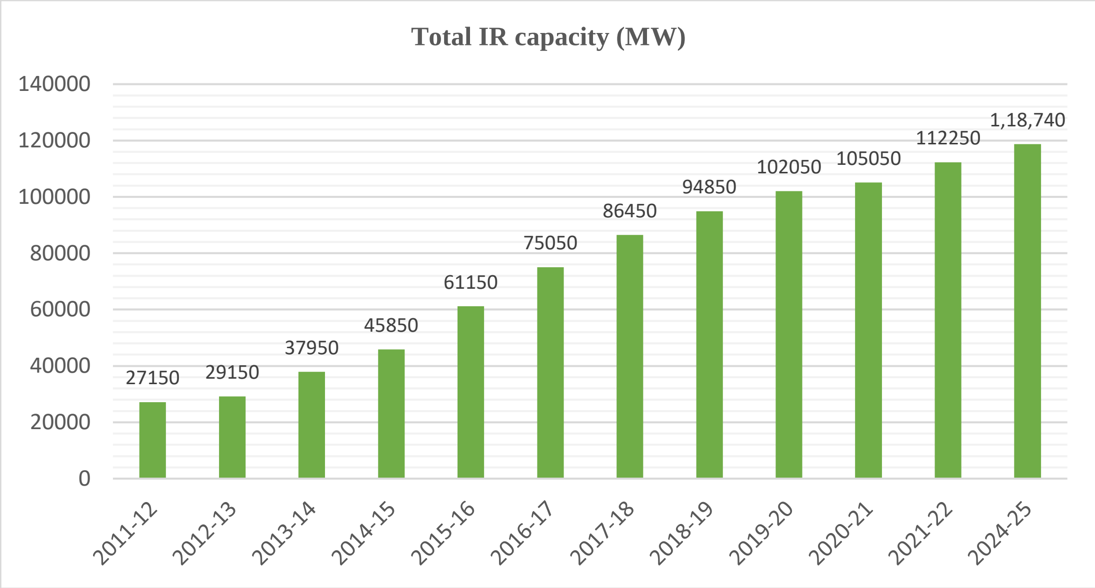
*Table 3-6:Broad estimated cost (in ₹ Cr.)*

| Sl. No. | FY | WR | SR | NR | ER | NER | Total |
|---|---|---|---|---|---|---|---|
| **1** | 2022-23 | 9,427 | 6,082 | 10,437 | 126 | 1,601 | **27,673** |
| **2** | 2023-24 | 9,703 | 4,014 | 4,200 | 760 | 402 | **19,079** |
| **3** | 2024-25 | 5,533 | 6,098 | 17,854 | - | 419 | **29,904** |
| **4** | 2025-26 | 6,043 | - | 14,482 | - | - | **20,525** |
| **5** | 2026-27 | - | - | 26,967 | - | - | **26,967** |
| | **Total** | **30,706** | **16,194** | **73,940** | **886** | **2,422** | **1,24,148** |

### 3.3.2 Inter-Regional (IR) Capacity

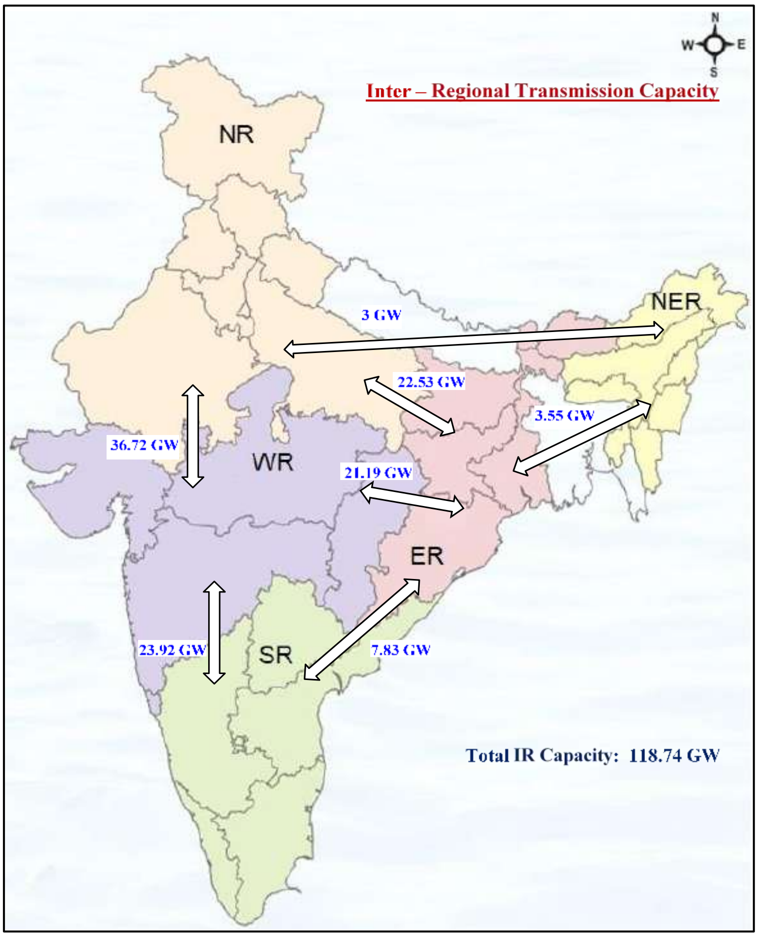
The progressive growth in Inter-Regional (IR) transmission capacity and till 2026-27 is given below in Table 3-4:

*Figure 3-33: Growth in IR Capacity (MW)*




Details of approved Inter Regional corridor capacity are attached at **Annex 2.11** for 2026-27 and the schematic of the same is given below in Figure 3-34.

*Figure 3-34: Inter-Regional Transmission Capacity in 2026-27*



# Chapter 4: Northern Region

Northern Region is connected to Western and Eastern Region through 765kV/400kV high capacity corridors along with Back to Back/ HVDCs. The thermal generating stations of Northern Regions are predominantly located in UP, Rajasthan and Haryana whereas hydro generation concentrated into J&K, HP and Uttarakhand. Further, Rajasthan is being a RE rich state comprise of lot of Solar & Wind capacity.

As of now Northern Region imports power from other regions during evening peak load period whereas it will export power to other regions during high RE scenarios in future.

## 4.1 Present Power Supply Scenario

As on Jan'2022, total Installed Capacity of Northern Region is about 110.3 GW and the peak demand met is about 73.3 GW. The state-wise breakup of installed capacity and peak demand is summarised at Table- 4-1 below.

*Table 4-1 Installed Capacity and Peak Demand of NR as on Jan'22*

*(All Fig in GW)*

| | Generation | | | | | | | | | Peak Demand |
|---|---|---|---|---|---|---|---|---|---|---|
| **State / UTs / Sector** | **Thermal** | | | | **Nuclear** | **Renewable** | | | **Grand Total** | |
| | ***Coal*** | ***Lignite*** | ***Gas*** | ***Total*** | | ***Hydro*** | ***RES*** | ***Total*** | | |
| **Chandigarh** | 0.04 | 0 | 0.02 | 0.06 | 0.01 | 0.10 | 0.05 | 0.16 | 0.22 | 0.43 |
| **Delhi** | 4.33 | 0 | 2.12 | 6.45 | 0.10 | 0.72 | 0.26 | 1.09 | 7.54 | 7.32 |
| **Haryana** | 8.64 | 0 | 0.69 | 9.32 | 0.10 | 2.32 | 1.09 | 3.51 | 12.83 | 12.12 |
| **Himachal Pradesh** | 0.15 | 0 | 0.06 | 0.21 | 0.03 | 3.07 | 1.03 | 4.13 | 4.34 | 2.03 |
| **Jammu & Kashmir** | 0.58 | 0 | 0.30 | 0.88 | 0.07 | 2.32 | 0.24 | 2.63 | 3.51 | 3.02 |
| **Punjab** | 8.52 | 0 | 0.41 | 8.94 | 0.20 | 3.81 | 1.77 | 5.77 | 14.71 | 13.56 |
| **Rajasthan** | 11.59 | 1.58 | 0.82 | 13.99 | 0.56 | 1.94 | 14.98 | 17.48 | 31.47 | 15.75 |
| **UP** | 20.41 | 0 | 0.55 | 20.96 | 0.29 | 3.42 | 4.45 | 8.17 | 29.13 | 24.97 |
| **Uttarakhand** | 0.49 | 0 | 0.52 | 1.01 | 0.03 | 1.98 | 0.91 | 2.91 | 3.93 | 2.47 |
| **Central unallocated** | 1.43 | 0 | 0.29 | 1.72 | 0.24 | 0.75 | 0 | 0.99 | 2.71 | 0 |
| **Total** | **56.19** | **1.58** | **5.78** | **63.55** | **1.62** | **20.43** | **24.78** | **46.84** | **110.39** | **73.31** |

*Source: CEA monthly report*

## 4.2 Envisaged Power Supply Scenario

As per the 19$^{th}$ EPS, Northern Region demand for 2026-27 timeframe is expected to increase to about 97GW. As per the inputs received from various stakeholders, total installed capacity of Northern Region for 2026-27 is expected to be about 165 GW. The state wise bifurcation of generation capacity and peak demand by 2026-27 is summarized below at Table 4-2

*Table 4-2 Northern Region Installed Capacity and peak demand (2026-27)*

*(All Fig in GW)*

| State / UTs / Sector | Generation (GW) | | | | | | | | Peak Demand (GW) |
|---|---|---|---|---|---|---|---|---|---|
| | Thermal | Hydro | Nuclear | Solar | Wind | Other RE | Gas | Total | |
| **Chandigarh** | - | - | - | - | - | - | - | - | 0.59 |
| **Delhi** | 0.51 | - | - | - | - | - | 1.46 | 1.97 | 8.75 |
| **Haryana** | 3.62 | 0.06 | - | 0.91 | - | - | - | 4.60 | 16.45 |
| **Himachal Pradesh** | - | 0.31 | - | - | - | - | - | 0.31 | 2.33 |
| **Jammu & Kashmir** | - | 1.22 | - | - | - | - | 0.18 | 1.40 | 4.48 |
| **Punjab** | 4.84 | 1.37 | - | 1.60 | - | - | - | 7.81 | 18.81 |
| **Rajasthan** | 10.01 | 0.55 | - | 10.31 | 6.40 | - | 0.18 | 27.45 | 20.13 |
| **UP** | 22.32 | 1.30 | - | 4.19 | - | - | - | 27.80 | 31.06 |
| **Uttarakhand** | - | 2.16 | - | - | - | - | - | 2.16 | 4.54 |
| **Central** | 11.44 | 15.10 | 4.42 | 53.08 | - | - | 1.76 | 85.80 | - |
| **IPP** | - | 4.10 | - | - | - | - | - | 4.10 | - |
| **Rooftop / Other RE** | - | - | - | 4.50 | - | 1.36 | - | 5.86 | |
| **NR** | **52.74** | **26.17** | **4.42** | **74.59** | **6.40** | **1.36** | **3.58** | **169.26** | **97.18** |

There is growth of around 32 % in Northern Region peak demand for 2026-27 from present time-frame. The state wise peak demand growth is tabulated in Table 4-3 below:

*Table 4-3 Increase in Peak Demand of Various States of Northern Region*

*(All Fig in MW)*

| Peak Demand (GW) | | | | |
|---|---|---|---|---|
| | **2021-22** | **2026-27** | **Difference** | **% Increase** |
| **Chandigarh** | 491 | 587 | 96 | 19.55% |
| **Delhi** | 7471 | 8751 | 1280 | 17.13% |
| **Haryana** | 12222 | 16451 | 4229 | 34.60% |
| **Himachal Pradesh** | 1898 | 2331 | 433 | 22.81% |
| **Jammu & Kashmir** | 3095 | 4482 | 1387 | 44.81% |
| **Punjab** | 14886 | 18809 | 3923 | 26.35% |
| **Rajasthan** | 14435 | 20131 | 5696 | 39.46% |
| **UP** | 23664 | 31064 | 7400 | 31.27% |
| **Uttarakhand** | 3180 | 4538 | 1358 | 42.70% |
| **Total** | **73770** | **97182** | **23412** | **31.74%** |

## 4.3 Load generation Balance

In the previous section, All India Load Generation Balance (LGB) for identified nine scenarios was prepared in consultation with CEA and POSOCO. This section elaborates the Load Generation Balance (LGB) of Northern Region. For Northern Region also, three points on the daily load curve i.e. Solar max (afternoon), Peak load (evening) and Off-peak load (night) have for three seasons viz. Monsoon (August), Summer (June) and Winter (February) have been considered. Load generation balance has been prepared considering the following despatch factors for the 9 scenarios and the same is given at Table 4-4.

*Table 4-4 Northern Region Generation Dispatch and Demand Factors*

| Scenario No & Name | Generation Dispatch Factors | | | | | | Demand Factors |
|---|---|---|---|---|---|---|---|
| | Hydro | Nuclear | Solar | Rooftop | Wind | Gas | |
| 1-Aug Solar Max | 70% | 80% | 90% | 50% | 50% | 0% | 82% |
| 2-Aug Peak Load | 95% | 80% | 0% | 0% | 70% | 85% | 88% |
| 3-Aug Night Off Peak | 70% | 80% | 0% | 0% | 60% | 65% | 80% |
| 4-Jun Solar Max | 70% | 80% | 90% | 60% | 50% | 0% | 88% |
| 5-Jun Peak Load | 95% | 80% | 0% | 0% | 70% | 85% | 104% |
| 6-Jun Night Off Peak | 70% | 80% | 0% | 0% | 60% | 60% | 86% |
| 7-Feb Solar Max | 30% | 80% | 95% | 60% | 10% | 0% | 70% |
| 8-Feb Peak Load | 60% | 80% | 0% | 0% | 35% | 85% | 74% |
| 9-Feb Night Off Peak | 30% | 80% | 0% | 0% | 10% | 30% | 46% |

Out of these nine scenarios, Scenario-5 (June evening peak) and Scenario-9 (Feb night off peak) corresponds to two extreme cases with respect to demand i.e. lowest demand (44.2 GW) and highest demand (101.5 GW) scenarios respectively. In all other scenarios, Northern Region demand is varying between these two demand scenarios as per demand factors. Based on LGB, state wise surplus/deficit in these scenarios is summarised in table 4-5. Further, both maximum surplus and deficit of each state is highlighted in table below:

*Table 4-5 : Drawl of various states from ISTS grid*

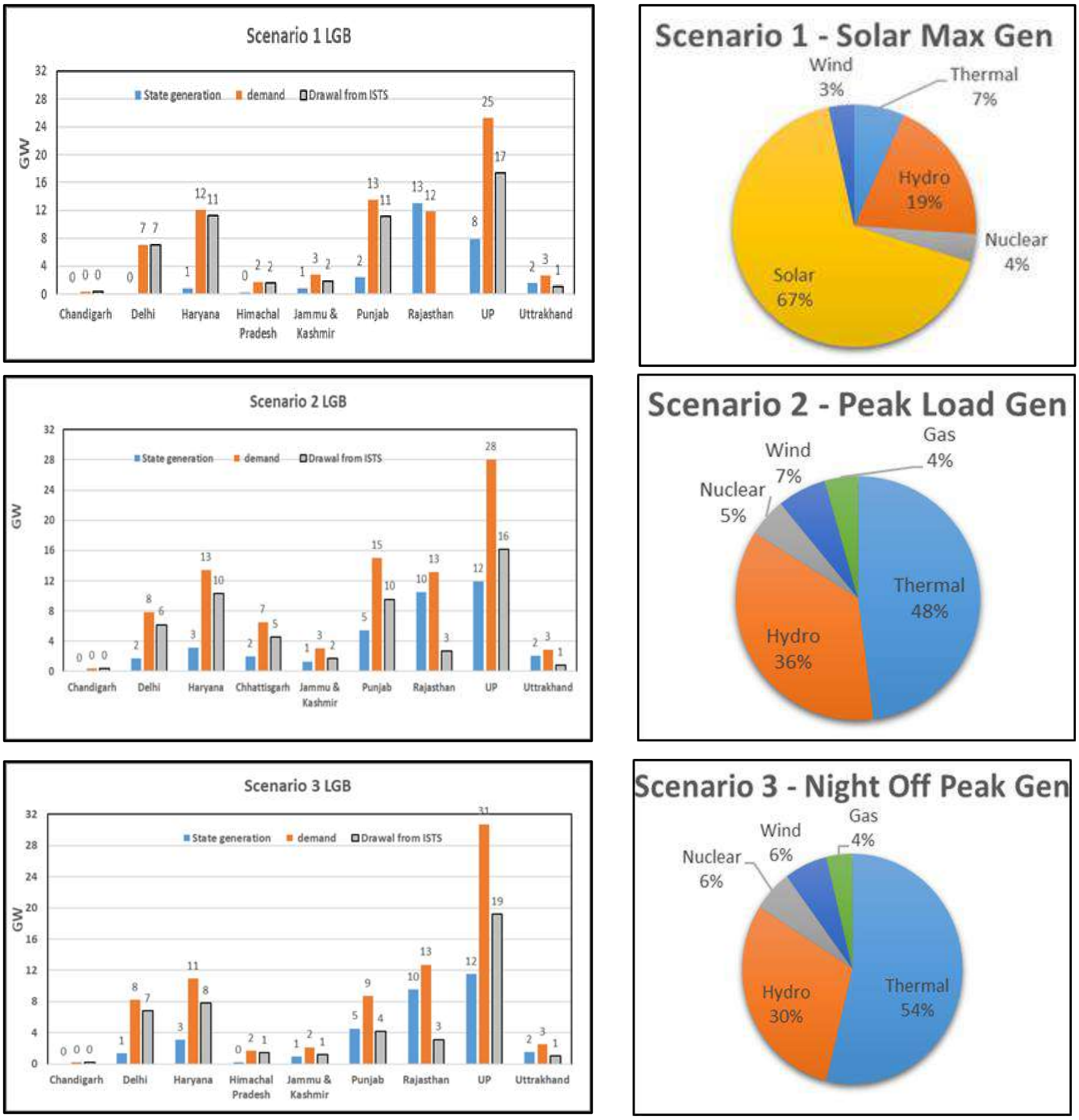
*(All Fig in MW)*

| Drawal from ISTS | Aug'26 | | | Jun'26 | | | Feb'27 | | |
|---|---|---|---|---|---|---|---|---|---|
| Scenario / State | 1<br>Solar Max | 2<br>Peak Load | 3<br>Off Peak | 4<br>Solar Max | 5<br>Peak Load | 6<br>Off Peak | 7<br>Solar Max | 8<br>Peak Load | 9<br>Off Peak |
| **Chandigarh** | 369 | 410 | 249 | 370 | 451 | 252 | 283 | 311 | 141 |
| **Delhi** | 7070 | 6180 | 6835 | 7203 | 7115 | 7842 | 4459 | 3212 | 1683 |
| **Haryana** | 11228 | 10300 | 7829 | 11420 | 11855 | 6676 | 7983 | 6612 | 2730 |
| **Himachal Pradesh** | 1510 | 4514 | 1488 | 1433 | 1718 | 1447 | 1881 | 1976 | 979 |
| **Jammu & Kashmir** | 1852 | 1698 | 1195 | 2057 | 2245 | 1412 | 3016 | 2826 | 2363 |
| **Punjab** | 11078 | 9559 | 4202 | 11934 | 13014 | 6028 | 4688 | 4682 | 2108 |
| **Rajasthan** | -1167 | 2669 | 3156 | 14 | 4076 | 6482 | 95 | 4254 | 4792 |
| **UP** | 17307 | 16183 | 19200 | 18541 | 18091 | 15217 | 8511 | 9753 | 4494 |
| **Uttarakhand** | 1072 | 819 | 1036 | 1285 | 1361 | 1646 | 1974 | 1579 | 1139 |
| **Central (-)** | 64764 | 27241 | 24972 | 65490 | 27637 | 23423 | 62105 | 22353 | 16460 |
| **IPP (-)** | 2872 | 3898 | 2872 | 2872 | 3898 | 2872 | 1231 | 2462 | 1231 |
| **Total** | **-17317** | **21192** | **17347** | **-14106** | **28391** | **20707** | **-30445** | **10390** | **2738** |

Considering the above LGB for nine scenarios, load flow cases were prepared for 2026-27 timeframe.

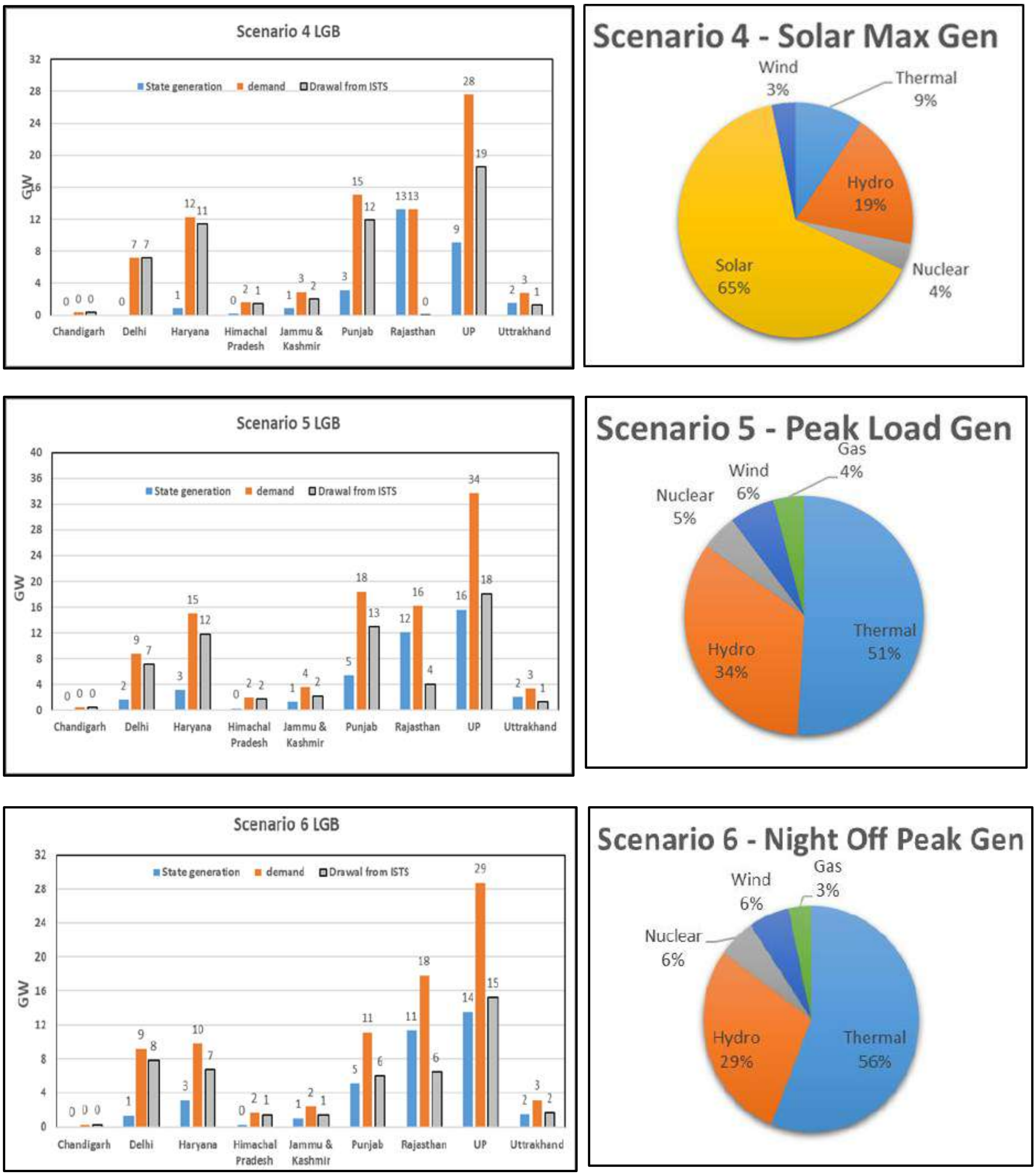
### 4.3.1 Monsoon Aug'26

*Figure 4-1 LGB For Monsoon Aug'2026*



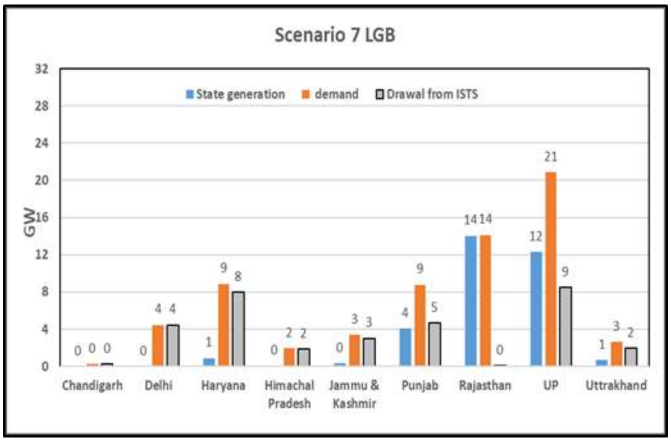
### 4.3.2 Summer Jun ’26

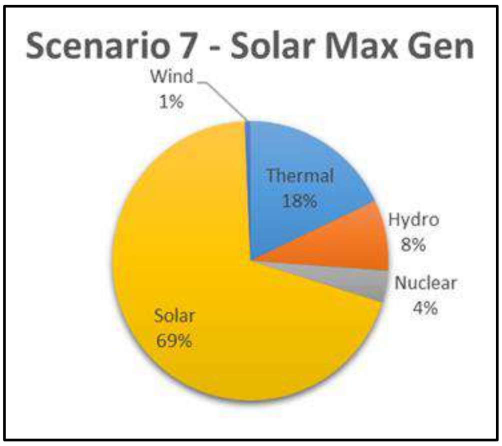
*Figure 4-2 LGB For Summer June’2026*

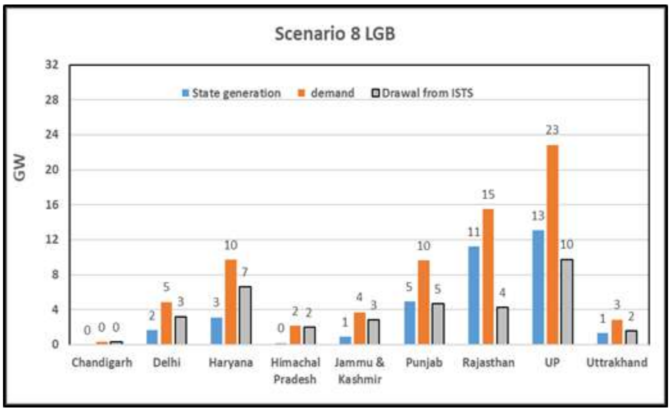


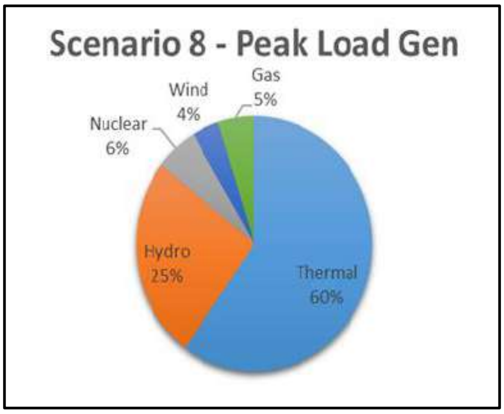
### 4.3.3 Winter Feb '27

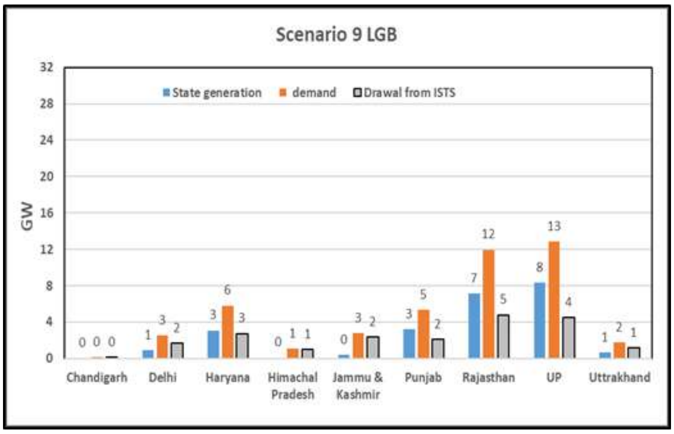
*Figure 4-3 LGB For Winter Feb'2027*

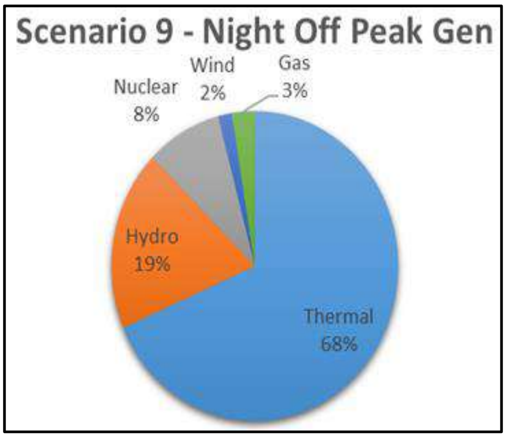


### 4.4 ISTS Network

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

**A) Himachal Pradesh:**

**I. Transmission system for evacuation of power from Kaza Solar Power Project (880 MW)**

SJVN is developing a Solar power park (880 MW) in Lahul & Spiti (Kaza) in Himachal Pradesh. SJVN is also granted Stage-I connectivity in this regard. In the 4th NRPC(TP) meeting held on 05.10.21, Transmission system to provide connectivity to Kaza Solar Power Project was discussed & agreed. It was also decided that for transfer of power beyond Wangtoo S/s (HPPTCL), a high-capacity corridor would be planned. In Joint Study Meeting was held on 24.12.2021 with CEA, POSOCO, HVPN, PTCUL, HPPTCL, UPPTCL and other STUs of Northern region by CTU transmission system for evacuation of power from Kaza Solar Power Project (880MW) beyond Wangtoo was finalized. The above scheme was also discussed in the 2nd Consultation Meeting for Evolving Transmission Schemes in Northern Region (CMETS-NR) held on 29/12/2021 as well as 50th NRPC held on 28.01.2022, wherein transmission scheme comprising connectivity and evacuation system for Kaza Solar-park was agreed.

Further SJVN vide letter dated 21.02.22 revised the commissioning schedule progressively from Mar'25

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

| Sl. No. | Scope of the Transmission Scheme | Implementation time-frame | Total Estimated Cost (Rs. Cr) |
|---|---|---|---|
| 1. | a) Establishment of 3x315 MVA (10x105 MVA single phase units including one spare) $ 400/132kV Kaza PS (GIS)<br>Future Scope at Kaza Pooling Station:<br>Space provision for:<br>i. 5 nos. of 132 kV line bays for future projects#<br>ii. 2 nos. of 400/132 kV Transformers<br>b) Kaza-Wangtoo (HPPTCL) 400 kV D/c (Quad) line along with the associated 400 kV bays at both ends (Line capacity shall be 2500 MVA per circuit at nominal voltage) | Matching with Kaza Solar Park i.e. Mar' 25 | Rs 3251 Cr |

| Sl. No. | Scope of the Transmission Scheme | Implementation time-frame | Total Estimated Cost (Rs. Cr) |
|---|---|---|---|
| | c)1x80 MVAR switchable line reactor on each circuit at Kaza end of Kaza- Wangtoo 400 kV D/c line<br>d) 2x80 MVAr (420kV) Bus Reactors at Kaza PS<br>e)Wangtoo (HPPTCL) - Panchkula (PG) 400 kV D/c (Twin HTLS*) Line along with 80 MVAr switchable line reactor at Panchkula end at each circuit-210 Km<br>*$ In case of transportation constraints, 5x200 MVA ICTs (16x66.67 MVA, 1-phase unit including one spare unit) shall be considered*<br>*# 132 kV line bays (9 Nos.) at Kaza PS for termination of lines from 7 pockets of solar projects of SJVNL shall be under applicant scope for implementation. Space provision to kept additionally for above 9 nos. bays.*<br>** with minimum capacity of 2100 MVA on each circuit at nominal voltage* | | |

The scheme has been discussed in the the 8th NCT meeting for approval. The schematic of Transmission system for evacuation of power from Kaza Solar Power Project is under

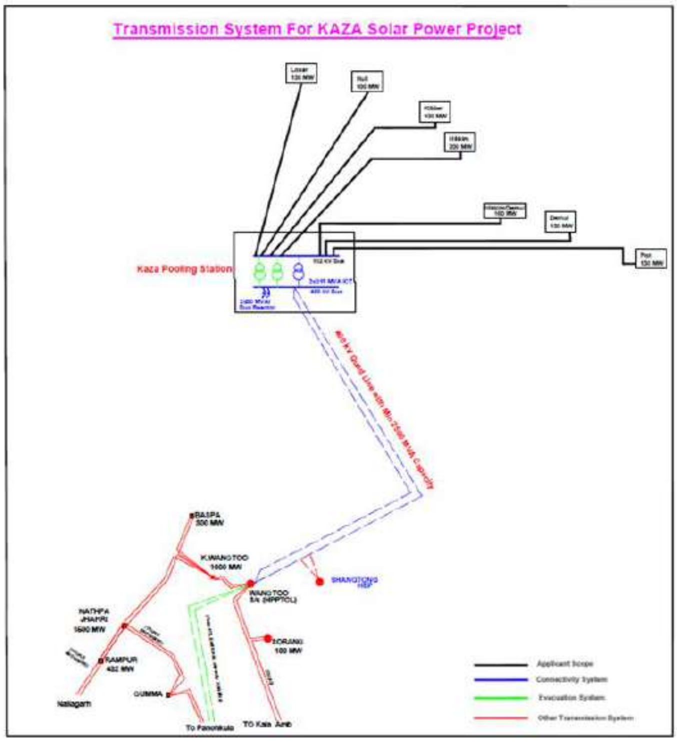



*Figure 4-4: Schematic of Transmission system for evacuation of power from Kaza Solar Power Project*

## II. Transmission system for evacuation of power for Luhri Stage-I (210MW) to be developed by SJVN Limited

Transmission scheme for evacuation of power from proposed Luhri St-I (210MW) HEP. Luhri-II (172 MW) & Sunni Dam (382 MW) near Shimla/Mandi/Kullu in HP was agreed in 3rd meeting of NRPC (TP) held on 19.02.2021 and further taken up for discussion in the 5th meeting of NCT held on 25.08.2021 and 02.09.2021, wherein it was informed that NTPC has forwarded some observation regarding the availability of space at Koldam S/s (NTPC) for 2 nos. of 400kV line bays. Therefore, the scheme was deferred and decided to be taken up again after resolution of the issue

Based on detailed deliberations in Joint Study meeting held on 21.01.22, transmission scheme for evacuation of power from Luhri St-I was finalized. Existing ISTS system beyond Koldam/Ropar would also facilitate transfer of power from Luhri-I HEP

SJVN is also granted LTA for Luhri HEP St-I (Target NR- 210 MW). The above scheme was discussed & agreed in 3rd Consultation Meeting for Evolving Transmission Schemes in Northern Region (CMETS-NR) held on 28.01.2022

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

| Sl. No. | Scope of the Transmission Scheme | Implementation time-frame | Total Estimated Cost (Rs. Cr) |
|---|---|---|---|
| 1. | ➢ Establishment of 7x105 MVA, 400/220kV Nange GIS Pooling Station<br>Future provisions: Space for<br>• 400/220kV ICTs (315 MVA with single phase units) along with associated bays: 3 nos.<br>• 400 kV line bays along with switchable line reactor: 3 nos.<br>• 220 kV line bays: 10 nos.<br>➢ Nange (GIS) Pooling Station – Koldam 400 kV D/c line* (Triple snowbird) – 40 km<br>➢ Bypassing one ckt of Koldam – Ropar/Ludhiana 400kV D/c line (Triple snowbird) at Koldam and connecting it with one of the circuit of Nange-Koldam 400kV D/c line(Triple snowbird), thus forming Nange- Ropar/ Ludhiana one line (Triple snowbird)<br>➢ 1x50 MVAR switchable line reactor at Ropar end of Nange- Ropar/ Ludhiana 400kV line | Matching time frame of Luhri Stage-I HEP i.e. April, 2025 | Rs 432 Cr |

| Sl. No. | Scope of the Transmission Scheme | Implementation time-frame | Total Estimated Cost (Rs. Cr) |
|---|---|---|---|
| | ➢ 1 no. of 400kV line bay at Koldam S/s for termination of Nange (GIS) Pooling Station – Koldam 400 kV line<br>➢ 125 MVAR (420kV) Bus Reactor at Nange (GIS) PS (1-Ph units along with one spare unit)<br>➢ 125 MVAR (420kV) Bus Reactor at Koldam S/s (1-Ph units along with one spare unit) | | |

***D/c line will be upto Koldam, however only one circuit is to be terminated at Koldam while second circuit would be connected to bypassed circuit of Koldam – Ropar/Ludhiana 400kV D/c line***

The scheme has been sent to NCT for approval in its ensuing meeting. The schematic of Transmission system for evacuation of power from Luhri Stage-I (210MW) is under

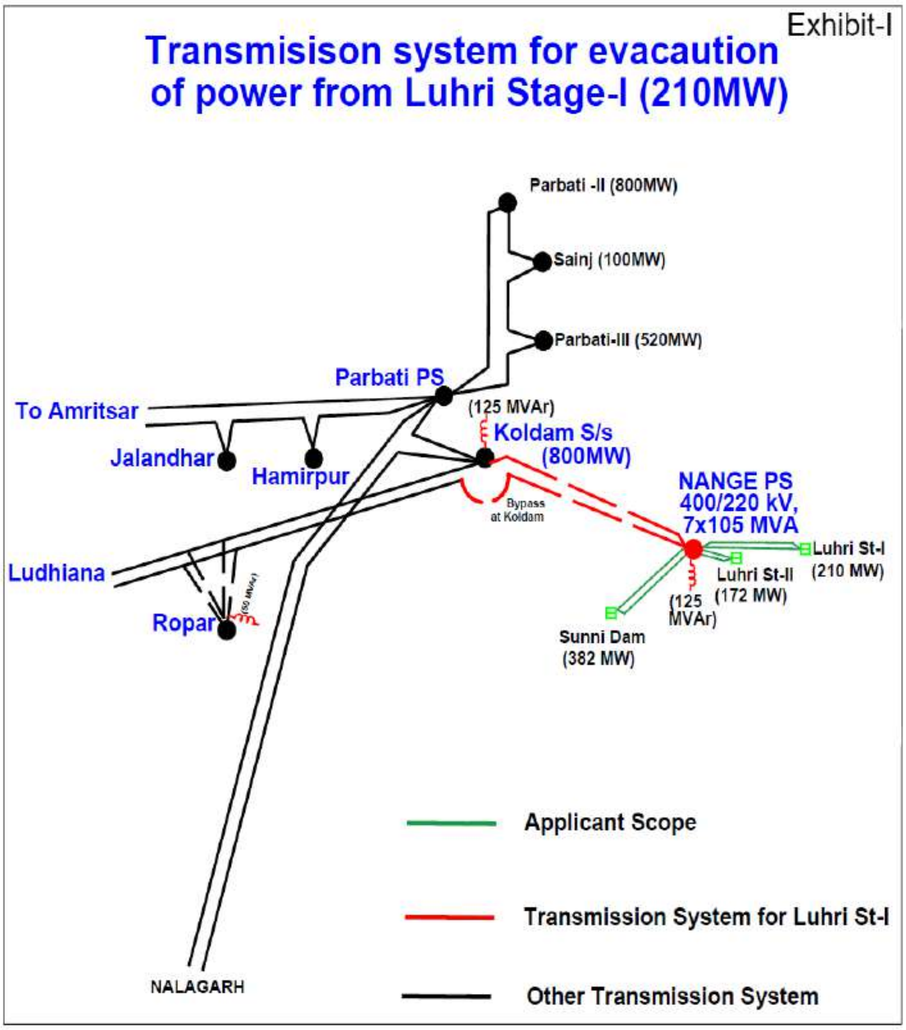



*Figure 4-5: Schematic of Transmission system for evacuation of power from Luhri-I HEP*

**B)Jammu and Kashmir**

## I. Comprehensive transmission scheme for Power Evacuation from proposed HEPs in J&K

A Comprehensive master plan for evacuation of power from various upcoming hydro generation projects in J&K (Pakaldul HEP (1000 MW), Kiru HEP (624 MW), Ratle HEP (850 MW), Uri I Stage II HEP (240 MW), Kwar HEP ( 540 MW), Dulhasti St II HEP (260 MW)) is evolved.

Out of above connectivity and LTA application for Pakaldul HEP (1000MW) is already granted and for that transmission system is under bidding matching with generation schedule. Connectivity scheme for Ratle HEP is also agreed in 4th NRPC(TP) meeting held on 05.10.21 & 12.02.21 and 3rd CMETS-NR meeting held on 28.01.22.

As part of comprehensive transmission scheme, transmission scheme requirement for hydro generation projects scheduled by 2026-27 i.e Kiru HEP (624 MW) and Ratle HEP (850 MW is envisaged in first phase. Both the projects proposed to be interconnected to 400kv Kishtwar S/s. The details of scheme (For Kiru : S.No 1& 2, For Ratle : S.No. 3&4) evacuation of power beyond Kishtwar S/s is as under

**Tentative Scope of work along with Cost and Implementation time-frame**

| Sl. No. | Scope of the Transmission Scheme | Implementation time-frame | Tentative Estimated Cost (Rs. Cr) |
|---|---|---|---|
| 1. | 400kV Kishenpur Kishtwar D/c (2nd ) (Quad) | Jun'25 | Rs 1250 Cr |
| 2 | 400kV New Wanpoh - Samba D/c (existing) line (bypassing of 400kV New Wanpoh – Kishenpur D/c & Samba – Kishenpur D/c at Kishenpur) | | |
| 3 | Upgradation of Kishenpur - Moga D/c line at 765kV level (at present charged at 400kV) | Nov'25 | |
| 4 | Upgradation of Kishenpur S/s at 765kV level (4x800MVA) | | |

***Transmission system upto Kishtwar S/s to be implemented by the HEP developer***

The above scheme will be taken up in forthcoming Consultation Meeting with stakeholder for deliberations. The schematic of proposed Transmission system is under.

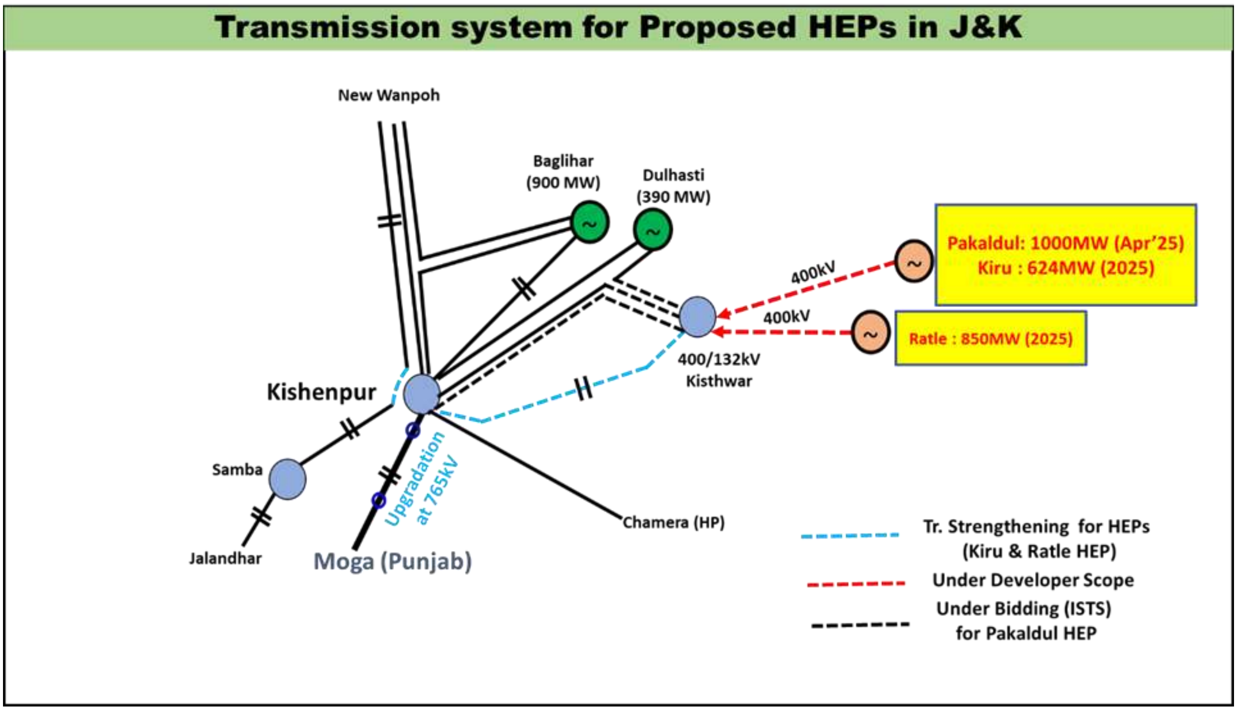



*Figure 4-6: Schematic of Transmission system for proposed HEPs in J&K*

## C) Haryana

### I. HVPNL proposal for Intra state transmission schemes involving Interstate connection with ISTS elements

HVPNL intra-state proposal involving interconnection with ISTS elements was discussed among CEA, CTU, HVPNL, BBMB, POWERGRID and POSOCO. Subsequently, HVPNL have provided the time schedule for transmission works to be implemented under ISTS.

Composite Inter state transmission scheme for inter-connection of HVPNL proposed intra-state transmission schemes with ISTS elements agreed for implementation is as under:

- Augmentation with 1x500MVA, 400/220kV transformer (3rd) at 400/220kV Bahadurgarh (PG) S/s– **Jul'24.**
- 2 nos of 220 kV line bays at 400/220 kV Bahadurgarh (PG) S/s (for 220 kV D/c line from Kharkhoda pocket B) - **Jul'24**
- 2 nos of 220 kV line bays at 400/220 kV Bahadurgarh (PG) S/s (for 220kV METL – Bahadurgarh (PG) D/c line) – **Mar'24**
- Augmentation with 1x500MVA, 400/220kV transformer (3rd) at 400/220kV Jind (PG) S/s – **Dec'23**
- 2 nos of 220 kV line bays at 400/220 kV Sonepat (PG) S/s (for 220 kV D/c line from Kharkhoda pocket A) - **Jul'24**

**Total Estimated Cost : Rs 117 Cr.**

HVPNL have confirmed that network for unutilised/ under implementation bays at 400/220 kV Bahadurgarh (PG), 400/220 kV Sonepat (PG) & 400/220 kV Jind (PG) Substations are already planned. Therefore, the approval of 220kV line bays requested in the above scheme