

### Appendix- III

#### Procedure for calculation of Transmission System Availability

1. The transmission elements shall be grouped into following categories for the purpose of calculation of availability of Regional Transmission Systems :
  - i) AC transmission lines: Each circuit of AC transmission line shall be considered as one element.
  - ii) Inter-Connecting Transformers (ICTs): Each ICT bank (three single phase transformer together) shall form one element.
  - iii) Static VAR Compensator (SVC): SVC along with SVC transformer shall form one element. However, 50% credit to inductive and 50% to capacitive rating shall be given.
  - iv) Switched Bus Reactor: Each switched Bus Reactor shall be considered as one element.
  - v) HVDC lines: Each pole of HVDC line along with associated equipment at both ends shall be considered as one element.
  - vi) HVDC back-to-back station: Each block of HVDC back-to-back station shall be considered as one element. If associated AC line (necessary for transfer of inter-regional power through HVDC back-to-back station) is not available, the HVDC back-to-back station block shall also be considered as unavailable.
  
2. The Availability of Regional Transmission system shall be calculated as under:

% System Availability

$$= \frac{o \times AV_o + p \times AV_p + q \times AV_q + r \times AV_r + s \times AV_s + t \times AV_t}{o + p + q + r + s + t} \times 100$$

Where

o	is	Total number of AC lines.
AV <sub>o</sub>	is	Availability of o number of AC lines.
p	is	Total number of HVDC poles.
AV <sub>p</sub>	is	Availability of p number of HVDC poles.
q	is	Total number of ICTs.
AV <sub>q</sub>	is	Availability of q number of ICTs.
r	is	Total number of SVCs.
AV <sub>r</sub>	is	Availability of r number of SVCs.
s	is	Total number of switched bus reactors
AV <sub>s</sub>	is	Availability of s number switched bus reactors

t is Total number of HVDC back-to-back station blocks.  
 $AV_t$  is Availability of t number of HVDC back-to-back station blocks

3. The weightage factor for each category of transmission elements shall be as under:
  - (a) For each circuit of AC line – Surge Impedance Loading for Uncompensated line (SIL) multiplied by Circuit Km.  
 SIL rating for various voltage level and conductor configuration is given in **Annexure-I** to this Appendix.  
 For inter regional AC lines, 50% of the weightage factor shall be allocated to each Region.
  - (b) For each HVDC pole – The rated MW capacity x Circuit Km.
  - (c) For each ICT bank – The rated MVA capacity.
  - (d) For SVC – The rated MVAR capacity (inductive & capacitive).
  - (e) For switched Bus reactor – The rated MVAR capacity.
  - (f) For HVDC back-to-back station connecting two Regional grids – 50% of the rated MW capacity of each block to each region.
4. The availability for each category of transmission elements shall be calculated based on the weightage factor, total hours under consideration and non-available hours for each element of that category. The formulae for calculation of Availability of each category of the Transmission elements are as per **Annexure-II** to this Appendix.
5. The transmission elements under outage due to following reasons not attributable to POWERGRID shall be deemed to be available:
  - i) Shut down of POWERGRID transmission elements availed by other agency/agencies for maintenance or construction of their transmission system.
  - ii) Manual tripping of POWERGRID line due to over voltage and manual tripping of switched bus reactor as per the directions of RLDC.
6. Outage time of POWERGRID transmission elements for the following contingencies shall be excluded from the total time of the element under period of consideration.

- i) Outage of elements due to acts of God and force majeure events beyond the control of POWERGRID. However, onus of satisfying the Member Secretary, REB that element outage was due to aforesaid events and not due to design failure shall rest on POWERGRID. A reasonable restoration time for the element shall be allowed by Member Secretary, REB and any additional time taken by POWERGRID for restoration of the element beyond the reasonable time shall be treated as outage time attributable to POWERGRID. Member Secretary REB may consult POWERGRID or any expert for estimation of restoration time. Circuits restored through ERS (Emergency Restoration System) shall be considered as available.
  - ii) Outage caused by grid incident/disturbance not attributable to POWERGRID, e.g. faults in substation or bays owned by other agency causing outage of POWERGRID elements, tripping of lines, ICTs, HVDC back-to-back stations etc. due to grid disturbance. However, if the element is not restored on receipt of direction from RLDC while normalising the system following grid incident/disturbance within reasonable time, the element will be considered not available for whole period of outage and outage time shall be attributable to POWERGRID.
7. If the outage of any element causes loss of generation at Central Sector Station(s) then the outage period for that element should be deemed to be twice the actual outage period for the day(s) on which such loss of generation has taken place.

## ANNEXURE-I

### SURGE IMPEDANCE LOADING (SIL) OF AC LINES

<b>S.No.</b>	<b>Line voltage (kv)</b>	<b>Conductor Configuration</b>	<b>SIL (MW)</b>
1	765	Quad Bersimis	2250
2	400	Quad Bersimis	691
3	400	Twin Moose	515
4	400	Twin AAAC	425
5	400	Quad Zebra	647
6	400	Quad AAAC	646
7	400	Tripple Snowbird	605
8	400	ACKC(500/26)	556
9	400	Twin ACAR	557
10	220	Twin Zebra	175
11	220	Single Zebra	132
12	132	Single Panther	50
13	66	Single Dog	10

## ANNEXURE-II

Formulae for calculation of Availability of each category of transmission elements

$$AV_o(\text{Availability of } o \text{ no. of AC lines}) = \frac{\sum_{i=1}^o \frac{W_i(T_i - T_{NAi})}{T_i}}{\sum_{i=1}^o W_i}$$

$$AV_p(\text{Availability of } p \text{ no. of HVDC pole}) = \frac{\sum_{j=1}^p \frac{W_j(T_j - T_{NAj})}{T_j}}{\sum_{j=1}^p W_j}$$

$$AV_q(\text{Availability of } q \text{ no. of ICTs}) = \frac{\sum_{k=1}^q \frac{W_k(T_k - T_{NAk})}{T_k}}{\sum_{k=1}^q W_k}$$

$$AV_r(\text{Availability of } r \text{ no. of SVCs}) = \frac{\left[ \sum_{l=1}^r \frac{0.5 W_{Il} (T_{Il} - T_{NAIl})}{T_{Il}} + \sum_{l=1}^r \frac{0.5 W_{Cl} (T_{Cl} - T_{ACl})}{T_{Cl}} \right]}{\left[ \sum_{l=1}^r 0.5 W_{Il} + \sum_{l=1}^r 0.5 W_{Cl} \right]}$$

$$AV_s(\text{Availability of } s \text{ no. of Switched Bus reactors}) = \frac{\sum_{m=1}^s \frac{W_m(T_m - T_{NA m})}{T_m}}{\sum_{m=1}^s W_m}$$

$$AV_t(\text{Availability of } t \text{ no. of HVDC Back-to-back Blocks}) = \frac{\sum_{n=1}^t \frac{W_n(T_n - T_{NA n})}{T_n}}{\sum_{n=1}^t W_n}$$

Where  $W_i$  = Weightage factor for  $i^{\text{th}}$  transmission line  
 $W_j$  = Weightage factor for  $j^{\text{th}}$  HVDC pole  
 $W_k$  = Weightage factor for  $k^{\text{th}}$  ICT  
 $W_{Il}$  &  $W_{Cl}$  = Weightage factors for inductive & capacitive operation of  $l^{\text{th}}$  SVC  
 $W_m$  = Weightage factor for  $m^{\text{th}}$  bus reactor  
 $W_n$  = Weightage factor for  $n^{\text{th}}$  HVDC back to back block.

$T_i, T_j, T_k, T_{Il}, T_{Cl}, T_m$  &  $T_n$  - The total hours of  $i^{\text{th}}$  AC line,  $j^{\text{th}}$  HVDC pole,  $k^{\text{th}}$  ICT,  $l^{\text{th}}$  SVC (Inductive Operation),  $l^{\text{th}}$  SVC (Capacitive Operation),  $m^{\text{th}}$  Switched Bus Reactor &  $n^{\text{th}}$  HVDC back-to-back block during the period under consideration (excluding time period for outages not attributable to POWERGRID for reasons given in Para 6 of the procedure)

$T_{NAi}$ ,  $T_{NAj}$ ,  $T_{NAk}$  - The non-availability hours (excluding the time period for outages not attributable to POWERGRID taken as deemed availability as per Para 5 of the procedure) for  $i^{th}$  AC line,  $j^{th}$  HVDC pole,  $k^{th}$  ICT,  $T_{NAIl}$ ,  $T_{NACl}$ ,  $T_{NAM}$ ,  $l^{th}$  SVC (Inductive Operation),  $l^{th}$  SVC (Capacitive Operation),  $m^{th}$  Switched Bus Reactor &  $n^{th}$  HVDC back-to-back block .  
 $T_{NAn}$