Appendix- III

Procedure for calculation of Transmission System Availability

1. Transmission System Availability shall be calculated separately for each Regional Transmission System and inter-regional transmission system .The transmission elements shall be grouped into following categories for the purpose of calculation of availability of 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 Bi-pole links: Each pole of HVDC link 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 AC and HVDC portion of Transmission system shall be calculated as under:

% System Availability for AC system

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

% System Availability for HVDC system

$$= \frac{s \times AV_x + t \times AV_t}{s + t} \times 100$$

Where

o is Total number of AC lines.

AV_o	is	Availability of o number of AC lines.
p	is	Total number of switched bus reactors .
AV_p	is	Availability of p number of switched bus reactors.
q	is	Total number of ICTs.
AV_q	is	Availability of q number of ICTs.
r	is	Total number of SVCs.
AV_r	is	Availability of r number of SVCs.
s	is	Total number of HVDC poles
AV_s	is	Availability of s number of HVDC poles
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. However, for the voltage levels and/or conductor configurations not listed in Annexure-I, appropriate SIL based on technical considerations may be used for availability calculation under intimation to long-term transmission customers.

(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 –Rated MW capacity of each block.

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 the transmission licenseeshall be deemed to be available:

i) Shut down of transmission elements availed by other agency/agencies for maintenance or construction of their transmission system.

ii) Manual tripping of line due to over voltage and manual tripping of switched bus reactor as per the directions of RLDC.

6. Outage time of 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 the transmission licensee. 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 the transmission licensee. A reasonable restoration time for the element shall be allowed by Member Secretary, REB and any additional time taken by the transmission licensee for restoration of the element beyond the reasonable time shall be treated as outage time attributable to the transmission licensee. Member Secretary REB may consult the transmission licensee 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 the transmission licensee, e.g. faults in substation or bays owned by other agency causing outage of the transmission licensee's 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 the transmission licensee.

7. If the outage of any element causes loss of generation at ISGS then the outage period for that element shall 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

S.No.	Line voltage (kv)	Conductor Configuration	SIL (MW)
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(Availability of o no. of AC lines) $= \sum_{i=1}^{o} \frac{Wi(Ti - T_{NA}i)}{Ti} \Big/ \sum_{i=1}^{o} Wi$

AV_p(Availability of p no. of HVDC pole) $= \sum_{j=1}^{p} \frac{Wj(Tj - T_{NA}j)}{Tj} \Big/ \sum_{j=1}^{p} Wj$

AV_q(Availability of q no. of ICTs) $= \sum_{K=1}^{q} \frac{Wk(Tk - T_{NA}k)}{Tk} \Big/ \sum_{k=1}^{q} Wk$

AV_r(Availability of r no. of SVCs) $= \left[\sum_{l=1}^{r} 0.5\frac{W_Il\,(T_Il - T_{NAI}l)}{T_Il} + \sum_{l=1}^{r} 0.5\, W_Cl\,\frac{(T_Cl - T_{AC}l)}{T_Cl} \right] \Big/ \left[\sum_{l=1}^{r} 0.5 W_Il + \sum_{l=1}^{r} 0.5\, W_Cl \right]$

AV_s(Availability of s no. of Switched Bus reactors) $= \sum_{m=1}^{s} \frac{Wm(Tm - T_{NA}m)}{Tm} \Big/ \sum_{m=1}^{s} Wm$

AV_t (Availability of t no. of HVDC Back-to-back Blocks) $= \sum_{n=1}^{t} \frac{Wn(Tn - T_{NA}n)}{Tn} \Big/ \sum_{n=1}^{t} Wn$

Where Wi = Weightage factor for i^{th} transmission line
Wj = Weightage factor for j^{th} HVDC pole
Wk = Weightage factor for k^{th} ICT
W_Il & W_Cl = Weightage factors for inductive & capacitive operation of l^{th} SVC
Wm = Weightage factor for m^{th} bus reactor
Wn = Weightage factor for n^{th} HVDC back to back block.

Ti, Tj, Tk, T_Il, T_Cl, - Tm & Tn The total hours of i^{th} AC line, j^{th} HVDC pole, k^{th} ICT, l^{th} SVC (Inductive Operation), l^{th} SVC (Capacitive Operation), m^{th} Switched Bus Reactor & n^{th} HVDC back-to-back block during

	the period under consideration (excluding time period for outages not attributable to transmission licensee for reasons given in Para 6 of the procedure)
$T_{NA}i$, $T_{NA}j$, $T_{NA}k$ - $T_{NAI}l$, $T_{NAC}l$, $T_{NA}m$, $T_{NA}n$	The non-availability hours (excluding the time period for outages not attributable to transmission licensee taken as deemed availability as per Para 5 of the procedure) for i^{th} AC line, j^{th} HVDC pole, k^{th} ICT , l^{th} SVC (Inductive Operation), l^{th} SVC (Capacitive Operation), m^{th} Switched Bus Reactor & n^{th} HVDC back-to-back block .