substation shall be planned in such way that it shall have maintainability, operation flexibility, security and reliability.

5.3.3 Bus switching scheme shall be as per Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2022 and its amendments or re-enactment thereof. Bus section shall be planned in such a way that feeders are adequately distributed with respect to power flow with bus sectionalizers open condition. Further, sectionaliser arrangement may be implemented also keeping in view transformation capacity in each section, fault current rating adopted, number of feeders etc.

5.4 Reactive Power compensation

5.4.1 General:

5.4.1.1 Requirement of reactive power compensation through shunt capacitors, shunt reactors (bus reactors or line reactors), static VAr compensators, fixed series capacitor, variable series capacitor (thyristor controlled) or other FACTS devices shall be assessed through appropriate studies.

5.4.1.2 Near to large RE complex(es) synchronous condenser(s) may be planned for dynamic voltage support, in addition to FACTS devices.

5.4.1.3 While planning of bus capacitors/reactors, aspects such as voltage sensitivity due to switching of these devices, size, reliability (contingency) etc. shall be considered.

5.4.1.4 Space provision for converting fixed line reactors/switchable line reactors to be usable as bus reactors after line opening with bypass arrangement for NGR/control switching.

5.4.1.5 RE generators to have provision to operate the generators in voltage control mode, fixed-Q and power factor control mode as per the grid requirements.

5.4.1.6 While planning Bus Reactor (BR), size, reliability aspect (outage of BR), etc. may be taken care of.

5.4.2 **Shunt capacitors**

5.4.2.1 Reactive Compensation shall be provided as far as possible in the low voltage systems with a view to meet the reactive power requirements of load close to the load points, thereby avoiding the need for VAr transfer from high voltage system to the low voltage system. In the cases where network below 132 kV/220 kV voltage level is not represented in the system planning studies, the shunt capacitors required for meeting the reactive power requirements of loads shall be provided at the 132 kV/220 kV buses for simulation purpose.

5.4.2.2 It shall be the responsibility of the respective utility to bring the load power factor as close to unity as possible by providing shunt capacitors at appropriate places in their system.

5.4.2.3 Reactive power flow through 400/220 kV or 400/132 kV or 220/132(or 66) kV or 220/33kV ICTs, shall be minimal. Wherever voltage on HV side of such an ICT is less than 0.975 pu no reactive power shall flow down through the ICT. Similarly, wherever voltage on HV side of the ICT is more than 1.025 pu no reactive power shall flow up through the ICT. These criteria shall apply under the N-0 conditions. It shall be responsibility of respective STU to plan suitable reactive compensation in their network including at 220 kV and 132 kV levels connected to ISTS, in order to fulfil this provision.

5.4.3 Shunt reactors

5.4.3.1 Bus reactors shall be provided at EHV substations for controlling voltages within the limits (defined in the Paragraph: 4.3(a)) without resorting to switching-off the lines. The bus reactors may also be provided at generation switchyards to supplement reactive capability of generators. The size of reactors should be such that under steady state condition, switching on and off of the reactors shall not cause a voltage change exceeding 5%. The standard sizes (MVAr) of reactors are:

Voltage Level	Standard sizes of reactors (in MVAr)
132 kV (3-ph unit)	12.5 and 25 (rated at 145 kV)
220 kV (3-ph unit)	50, 25 (rated at 245 kV)
400 kV (3-ph unit)	50, 63, 80,125 and 250 (rated at 420 kV)
765 kV (1-ph unit)	80 and 110 (rated at $765/\sqrt{3}$ kV)

5.4.3.2 Fixed line reactors may be provided to control power frequency temporary over-voltage (TOV) after all voltage regulation action has taken place within the limits as defined in Paragraph: 4.3(b) under all probable operating conditions.

5.4.3.3 Line reactors (switchable/ controlled/ fixed) may be provided if it is not possible to charge EHV line without exceeding the maximum voltage limits given in Paragraph: 4.3(a). The possibility of reducing pre-charging voltage of the charging end shall also be considered in the context of establishing the need for reactors.

5.4.3.4 The line reactors may be planned as switchable wherever the voltage limits, without the reactor(s), remain within limits specified for TOV conditions given at Paragraph: 4.3(b).

5.4.4 Shunt FACTS devices

5.4.4.1 Shunt FACTS devices such as Static VAr Compensation (SVC) and STATCOM shall be provided where found necessary to damp the power swings and provide the system stability under conditions defined in the ‘Reliability Criteria’ (Paragraph 4.4). As far as possible, the dynamic range of static compensators shall not be utilized under steady state operating condition.

5.4.5 Synchronous Condenser

5.4.5.1 A synchronous condenser (SC) is a synchronous machine operating without a prime mover. Reactive power output regulation of SC is performed by regulating the excitation current. The level of excitation determines if the synchronous condenser generates or consumes reactive power. SC provides improved voltage regulation and stability by continuously generating/absorbing reactive power, improved short-circuit strength and frequency stability by providing inertia.

5.4.5.2 The conventional power stations could be refurbished to a synchronous condenser, thereby potentially reducing initial capital cost. A synchronous condenser consumes a small amount of active power from the system to cover losses. As many gas and coal-based synchronous generators approach the end of their life, the retiring of a plant can possibly create a reactive power deficit at the local network, which may impact voltage stability. The conversion of the existing generator to a synchronous condenser can be potentially economical and effective.

5.4.5.3 Operating Hydro generators in synchronous condenser mode may be a possible way for voltage control with the existing resources, which may be explored to regulate voltage in grid locally and thus preventing the switching of other elements for voltage control purpose, which in turn help in keeping the system reliability intact.

Chapter 6 ADDITIONAL CRITERIA

6.1 Wind / Solar / Hybrid projects

6.1.1 All the generation projects based on renewable energy sources shall comply with Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007 and its amendments or re-enactment thereof, for which requisite system studies shall be carried out by renewable generation project developer.

6.1.2 Connectivity/GNA quantum shall be considered while planning the evacuation system, both for immediate connectivity with the ISTS/Intra-STS and for onward transmission requirement.

6.1.3 As the generation of energy at a wind farm is possible only with the prevalence of wind, the thermal line loading limit of the lines connecting the wind farms to the pooling substations may be assessed considering 12 km/hour wind speed.

6.2 Nuclear power stations

6.2.1 In case of transmission system associated with a nuclear power station, there shall be two independent sources of power supply for the purpose of providing start-up power. Further, the angular separation between start-up power source and the generation switchyard should be, as far as possible, be maintained within 10 degrees.

6.2.2 The evacuation system shall generally be planned so as to terminate it at large load centres to facilitate islanding of the power station in case of contingency.

6.2.3 Adequate reactive power compensation shall be provided at generation switchyard so as to maintain power factor in accordance with Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007 and its amendments or re-enactment thereof.

6.3 HVDC Transmission System

6.3.1 The option of HVDC bipole may be considered for transmitting bulk power (more than 2000 MW) over long distance (preferably more than 700 km). HVDC transmission may also be considered in the transmission corridors that have AC lines carrying heavy power flows (total more than 5000 MW) to control and supplement the AC transmission network.

6.3.2 The ratio of fault level in MVA at any of the convertor station (for conventional current source type), to the power flow on the HVDC bipole shall not be less than 3.0 under any of the load-generation scenarios given in chapter-3 and reliability criteria given at Paragraph: 4.4. Further, in areas where multiple

Conventional HVDC bipoles are feeding power (multi infeed), the appropriate studies may be carried at planning stage so as to avoid commutation failure.

6.4 Zone-3 settings

6.4.1 The transmission utilities shall ensure that zone-3 relay settings of the transmission lines is such that they do not trip at extreme loading of line. For this purpose, the extreme loading may be taken as 120% of thermal current loading limit and assuming 0.9 per unit voltage (i.e. 360 kV for 400 kV system, 689 kV for 765 kV system). In case it is not practical to set the Zone-3 in the relay to take care of above, the transmission licensee/owner shall inform CEA, CTU/STU and RLDC/SLDC along with setting (primary impendence) value of the relay. Mitigating measures shall be taken at the earliest and till such time the permissible line loading for such lines would be limited to as calculated from relay impedance assuming 0.95 pu voltage, provided it is permitted by stability and voltage limit considerations as assessed through appropriate system studies.

6.5 Resiliency

6.5.1 The IEEE Technical Report PES-TR65 defines resilience as “The ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such an event”. This may also be simply defined as “The ability to protect against and recover from any event that would significantly impact the grid”.

6.5.2 **Resilience v/s Reliability:**

The IEEE defines Reliability as “The probability that a system will perform its intended functions without failure, within design parameters, under specific operating conditions, and for a specific period of time.” Further different utilities worldwide have defined and developed different reliability standards for robustness, resourcefulness, rapid recovery and adaptability of their power systems.

The IEEE Technical Report PES-TR83 states that reliability is a system performance measure, and resilience is a system characteristic. Generally better reliability results in better resilience and vice versa. However, in some cases, a highly reliable system may have lower resilience and vice versa. The primary difference between reliability and resilience is that resilience encompasses all events, including “High Impact – Low Frequency” events commonly excluded from the reliability calculations.

6.5.3 Resilience Evaluation: Several frameworks and methods for advancing resilience evaluation have been developed in the last decade. These frameworks can be grouped into two general categories: qualitative and quantitative frameworks.

i) Qualitative Frameworks: Qualitative frameworks usually evaluate the power system's resilience, along with other interdependent systems, such as information systems, fuel supply chain, and other such infrastructures. These frameworks evaluate resilience capabilities such as preparedness, mitigation, response, and recovery. Qualitative frameworks are appropriate for long-term planning because they provide a comprehensive and holistic depiction of system resilience.

ii) Quantitative Frameworks: Quantitative frameworks are based on the quantification of system performance. Resilience is quantitatively evaluated based on the reduced magnitude and duration of deviations from the targeted or acceptable performance. Quantitative resilience metrics should be: 1) performance-related, 2) event-specific, 3) capable of considering uncertainty, and 4) useful for decision-making.

An effective resiliency framework should strive to minimize the likelihood and impacts of a disruptive event from occurring and provides the right guidance and resources to respond and recover effectively and efficiently when an incident happens. This can be accomplished by applying the framework towards assessing and developing a mitigation program with the five main focus areas: Prevention, Protection, Mitigation, Response, and Recovery.

6.5.4 The Recommended Measures in the "Report of Task Force on Cyclone Resilient Robust Electricity Transmission and Distribution Infrastructure in the Coastal Areas" accepted by Ministry of Power vide letter dated 10th June, 2021 for Creating Resilient Transmission Infrastructure may be referred.

6.6 Economic Analysis

6.6.1 In order to identify the most suited techno-economical transmission system, it is essential to carry out economic analysis of planned alternatives. Therefore, to carry out cost-benefit/economic analysis for each of the planned alternatives, following estimated figures may be computed.

a) project cost,
b) annual transmission charges and
c) impact on the existing total annual transmission charges.

6.7 Right of Way (RoW)

6.7.1 For laying electricity transmission lines, licensee erects towers at stipulated intervals and conductors are strung on these towers maintaining a safe height depending on the voltage and other geographical parameters. The tower base area and corridor of land underneath the strung conductors between two towers forms RoW. The maximum width of RoW corridor is calculated on the basis of tower design, span, wind speed, maximum sag of conductor and its swing plus other requirement of electric safety.

6.7.2 In order to reduce RoW, the technological options for reducing the tower footing/base, area/corridor requirements may be explored.

6.7.3 Central Electricity Authority (Technical Standards for Construction of Electric Plants and Electric Lines) Regulations, 2022, provides that, Right of way for transmission lines shall be optimized keeping in view the corridor requirement for the future by adopting suitable alternative of multi-circuit or multi-voltage lines as applicable. Following may be adopted to optimise RoW utilisation:

- Application of Series Capacitors, FACTS devices and phase-shifting transformers in existing and new transmission systems to increase power transfer capability.
- Up-gradation of the existing AC transmission lines to higher voltage using existing line corridor.
- Re-conductoring of the existing AC transmission line with higher ampacity conductors.
- Use of multi-voltage level and multi-circuit transmission lines.
- Use of narrow base towers and pole type towers in semi-urban / urban areas keeping in view cost and right-of-way optimization.
- Use of HVDC transmission – both conventional as well as voltage source convertor (VSC) based.

Annexure- I

Template Data Format for Transmission Planning

1. STU can provide input as per the format enclosed.
2. Unless specified, all elements specified in the list shall be treated as of STU
3. Data required includes Substations (Bus), Lines and Transformers connected to the Station (Bus), Generations, Loads and shunt MVAR list.
4. Once the existing data is finalized, year wise data may be provided in the format given here with time frame.
5. The bus number shall be a 6 digit number which will be formed as shown in the table below:

Zone/State		Voltage	Unique Bus Number		
D_1	D_2	D_3	D_4	D_5	D_6

For this purpose Zone/State and Voltage level numbering shall be considered as under:

A. Zone/State numbering schema

D_1D_2	ZONE/STATE	D_1D_2	ZONE/STATE
10	CHANDIGARH	34	GOA
11	JAMMU & KASHMIR	35	GUJARAT
12	HIMACHAL PRADESH	36	MADHYA PRADESH
13	PUNJAB	37	MAHARASTRA
14	HARYANA	41	BIHAR
15	DELHI	42	ODISHA
16	RAJASTHAN	44	WEST BENGAL
17	UTTAR PRADESH	47	JHARKHAND
18	LADDAKH	49	SIKKIM
19	UTTARAKHAND	50	ANDHRA PRADESH
21	ASSAM	51	TELANGANA
22	ARUNACHAL PRADESH	52	KARNATAKA
23	MEGHALAYA	53	KERALA
24	NAGALAND	54	TAMILNADU
25	MANIPUR	57	PUDUCHERRY
26	MIZORAM	61	NEPAL
27	TRIPURA	62	BHUTAN
31	CHATTISGARH	63	BANGLADESH
32	DAMAN AND DIU	64	MYANMAR
33	DADRA AND NAGAR HAVELI	65	SRI LANKA

B. Voltage level numbering schema

Voltage Level (kV)	D_3
765	7
400	4
230	2
220	2
132	1
110	1
66	0
33	0
11	0

The code for zone/state may be changed, if required.

6. The code assignment for owner for identification of type of generator based on source of fuel & sector shall be considered as under:

A. Sector numbering schema

Number (1st Digit)	Sector	Short Description
1	Central Sector	Cent
2	State Sector	State
3	Central IPP	C-IPP
4	State IPP	S-IPP

B. Fuel numbering schema

Number (2nd Digit)	Source of Fuel
1	Coal
2	Hydro
3	Gas
4	Nuclear
5	Wind
6	Solar
7	Hybrid
8	Other

C. Owner numbering schema

Owner allocation (Sector + Fuel) for Central Sector	
Owner No.	Owner Description
11	Cent-Coal
12	Cent-Hyd
13	Cent-Gas
14	Cent-Nucl
15	Cent-Wind
16	Cent-Solar
17	Cent-Hyb
18	Cent-oth

Similarly owner allocations to be made for State sector, Central IPP & State IPP

The above codes may be changed, if required.

7. Template Data Format:

a. Substation (**List-1**): Consists of buses represented in the file along with name and voltage level, availability of Load and injection by generator

b. Transmission lines (**List-2**): Consists of lines along with names of the substations interconnected by them with line length, and line reactors if any.

c. Generator connected (**List-3**): Various generating stations of the state modelled in the file along with parameters are given in the list with values like P_{max}, P_{min}, Q_{max}, Q_{min}, M_{base}, R_{source} , R_{Tran}, X_{source} and X_{Tran}

d. Loads (**List-4**): Loads considered, both P and Q

e. Shunt (**List-5**): For FIXED bus shunt includes shunt capacitor or bus reactors.

f. Transformer (**List-6**): Substation Name, from and to bus Volt, Tap Position, Number of transformers, Transformer MVA, % Impedance.

g. 2-terminal HVDC (LCC) (**List-7**): Rectifier & Inverter Substation Name, Control Mode, Schedule Voltage, Max. & Min. firing angle, Primary Base Voltage, Bridges in series, DC Resistance, Rated Power

h. 2-terminal HVDC (VSC) (**List-8**): Converter-1&2 Substation Names, Control Mode, losses, Schedule Voltage, AC current, Max & Min Reactive Capability, Rated Power

i. FACTS & STATCOM (**List-9**): Substation Name, Control Mode, P & Q setpoint,, Size
j. Switched Shunt (**List-10**): Substation Name, Control Mode, Remote Bus, Step Size.

Similarly, for every year additional element and load – generation may be given in the above format.

Annexure-I / List-1

Bus Data

Data as on Month of the Year						
Sl. No. (Define Bus no)	**Name of the S/s or bus - Max. 12 characters**	**Voltage Level (765/400/230/220/132/110/66/33 kV)**	**Load Bus (Yes/No)**	**Generator bus (Yes/No)**	**Remarks (Existing/ Under construction/ Planned)**	**Year of Commissioning**
XXXXXX	AAA	765/400				
XXXXXX	BBB	400/220				
XXXXXX						

Annexure-I / List-2

Line Data

Note: *1) Unit id or circuit id or representative. If circuit id or unit id is 2, it represents 2 unit or line or transformer etc.*

2) Unless otherwise specified – Based on conductor configuration and Line voltage, standard parameters will be assumed as per this planning criteria.

Data as on Month of the Year																				
									Either in actuals or in pu on 100MVA base			in MVA	in MVA		in pu on 100MVA base		in pu on 100MVA base			
From BUS (Name)	To BUS (Name)	CKT id	Length (km)	Line voltage (kV)	Line Type (S/c or D/c or Multi Ckt)	Conductor type (e.g. AL59/ ACSR MOOSE / HTLS/Zebra etc.)	Conductor Configuraton (Single/Twin /Tripple/ Quad/ Hexa)	Design Ambient / Conductor or Temperature	R in pu	X in pu	B in pu	Rate A (SIL Loading)	Rate B	Rate C	GI	BI line reactor at from bus end in pu (Fixed / Switchable)	GJ	BI line reactor at To bus end in pu(Fixed / Switchable)	Remarks (Existing / under construction/ planned)	Year of Commissioning
AAA	BBB	1	291	765	D/c	Zebra	Hexa	45/75	XX	XX	XX	2200	3000		XXXXXX	-2.4 (Fixed)	XXXXXX	-2.4 (Switchable)		
AAA	BBB	2	291	765	D/c	Zebra	Hexa		XX	XX	XX	2200	3000			-2.4 (Fixed)		-2.4 (Switchable)		
BBB	CCC	1	208	765	S/c	Bersimis	Quad		XX	XX	XX	2200	3000			0		-2.4 (Switchable)		
DDD	CCC	2	208	765	S/c	Bersimis	Quad		XX	XX	XX	2200	3000			0		-2.4 (Switchable)		
DDD	KKK	1	75	220	D/c	ZEBRA	Single		XX	XX	XX	130								
CCC	EEE	2	75	220	D/c	ZEBRA	Single		XX	XX	XX	130								
CCC	FFF	1	77	132	D/c	PANTHER	Single		XX	XX	XX	65								
GGG	SSS	2	77	132	D/c	PANTHR	Single		XX	XX	XX	65								
GGG	CCC	1	44	220	D/c	ZEBRA	Single		XX	XX	XX	130								

Annexure-I / List-3

Generator Data

Note:

1) *Unit id or circuit id or representative. If circuit id or unit id is 2, it represents 2 unit or line or transformer etc.*
2) *In case of RE generators, aggregated generation (lumped) at STU/Developer PS may be defined.*
3) *The load shall be adjusted as per season and despatch considered. If already adjusted, it may be mentioned.*

Fuel Type	Coal	Hydro	Gas	Nuclear	Wind	Solar	Standalone Storage
ID No format	T, T1 to T9	H, H1 to H9	G, G1 to G9	N, N1 to N9	WF (Wind farms), W1 to W9	SP (Solar Parks), S1 to S9	

State	**SOLAR ROOF TOP CAPACITY IN MW**			
	By 2022	**By 2023**	**By 2024**	**By 2025….**

RE	**RPO Commitment (%)**			
	By 2022	**By 2023**	**By 2024**	**By 2025…**
Solar				
Non Solar				

Hydro	**HPO Commitment (%)**			
	By 2022	**By 2023**	**By 2024**	**By 2025…**
Hydro				

Data as on Month of the Year																			
Bus Name	Voltage Level (kV)	GT voltage rating	GT MVA Rating or PF	Fuel Type	Unit Id	Unit size	Owner (State/ Private)	P_{max} Gen capacity (MW)	P_{min} Technical Min (MW)	Q_{Max} (Mvar)	Q_{Min} (Mvar)	Mbase (MVA)	R Source (pu)	X Source (pu)	R_{Tran} (pu on machine MVA base) of GT	X_{Tran} (pu on machine MVA base) of GT	In Case of RE generation control mode	Power factor	Year of Commissioning
AAA	13	13/220 kV	248	Coal	T1	210	State						0	0.2	0	14.50%			
AAA	13	13/220 kV	248	Coal	T2	210	Private						0	0.2	0	14.50%			
BBB	11	13/220 kV	175	Hydro	H1	155							0	0.32	0	14.50%			
DDD	11	13/220 kV	175	Hydro	H2	155							0	0.32	0	14.50%			
DDD	15	13/220 kV	150	Gas	G1	130							0	0.18	0	14.50%			
CCC	23	15.5/220	249	Nuclear	N1	220							0	0.23		14.50%			
CCC	22			Wind	W1	50										14.50%			
GGG				Solar	S1	200										14.50%			

Annexure-I / List-4

Load Data

Note:

1) *Quarter wise load can be indicated bus wise or as a percentage of maximum load.*
2) *The load shall be adjusted as per season and despatch considered. If already adjusted it may be mentioned.*

Data as on Month of the Year (for 20XX year)					**2023-24….**		
Bus Name (132kV/110/66/33kV) (Max. 12 character)	**Voltage level (220kV / 132kV/ 110kV) Load is connected to**	**Active Load (MW) (P_{max})**	**Reactive Load (QL) or Power factor for Peak load case**	**Reactive Load (QL) or Power factor for off-peak load case**	**Active Load (MW) (P_{max})**	**Reactive Load (QL) or Power factor for Peak load case**	**Reactive Load (QL) or Power factor for off-peak load case**
ABC	220	120			130		
DEF	132	85			95		
XYZ	220	150			160		
ABC	220	220			240		

	Roof top solar adjusted YES/NO	**2022-23**		**2023-24**		**2024-25…**	
		Peak	**Off-Peak**				
Maximum Load							
Quarter-1		80%	50%				
Quarter-2		75%	55%				
Quarter-3		80%	50%				
Quarter-4		80%	50%				

Annexure-I / List-5

Fixed Shunt Data

Note:

1) *Unit id or circuit id or representative. If circuit id or unit id is 2, it represents 2 unit or line or transformer etc.*
2) *Reactors to be shown negative.*

Data as on Month of the Year					
S.No.	**Bus Name (765kV/400kV/230kV/132kV)**	**Voltage level (132kV/ 110kV)**	**Id**	**MVAR**	**Year of Commissioning**
	ABC	765	1	-240	
	DEF	765	2	-240	
	XYZ	765	1	-240	
	TUV	765	2	-240	
	GHI	132	1	100	
	JKL	220	1	150	
	PQR	132	2	70	
	RST	220	1	253	
	MNO	400	1	-80	
	WXY	400	1	-80	

Annexure-I / List-6

Transformer/ ICT Data

Note:

1) Unit id or ckt id or representative. If ckt id or unit id is 2, it represents 2 unit or line or transformer etc.

Data as on Month of the Year										
From BUS No.	**To BUS No.**	**CKT**	**Voltage level (kV) (to bus no)**	**No of taps**	**Voltage change /step**	**Tap Positions**	**MVA Rating (Rate A)**	**Winding MVA Base**	**% Impedance on transformer base**	**Year of Commissioning**
AAAAA8	AAAAA4	1	765/400	17	1.25%	8	1500	1500	12.50%	
BBBBB8	BBBBB4	1	765/400	17	1.25%	8	1500	1500	12.50%	
CCCCC8	CCCCC4	1	765/400	17	1.25%	8	1500	1500	12.50%	
DDDDD8	DDDDD4	1	765/400	17	1.25%	8	1500	1500	12.50%	
EEEEE8	EEEEE4	1	765/400	17	1.25%	8	1500	1500	12.50%	
FFFFF4	FFFFF2	1	400/220	17	1.25%	8	500	1500	12.50%	
GGGGG4	GGGGG2	1	400/220	17	1.25%	8	300	1500	12.50%	
BBBBB1	BBBBB2	1	220/132	17	1.25%	8	100	1500	12.50%	

Annexure-I / List-7

2-TERMINAL HVDC (LCC)

Data as on Month of the Year															
Line						Converter									
Rectifier Bus	Inverter Bus	Control Mode (Blocked, Power, Current)	Set Val (Amp or MW)	Rdc (Ohm)	Schedule Voltage (kV)	Max. Firing angle (deg)	Min. Firing angle (deg)	Bridges in series (nos.)	Primary Base (kV)	Commutating Resistance	Commutating Reactance	Tap setting (pu)	Max. Tap setting	Min. Tap setting	Year of Commissioning
AAAAA8	AAAAA4	Power	1000	10.7	500	17.5	12.5	2	400	0.3	7.8	1.03	1.2	0.85	
BBBBB8	BBBBB4														

Annexure-I / List-8

2-TERMINAL HVDC (VSC)

Data as on Month of the Year													
Converter Bus -1	**Converter Bus -2**	**Control Mode (Blocked/ Power/ Voltage)**	**Set Val (kV or MW)**	**Rdc (Ohm)**	**A loss (kW)**	**B loss (kW/ Amp)**	**Schedule Voltage (kV)**	**AC Current rating (amp)**	**Max. Reactive Power (MVAr)**	**Min. Reactive Power (MVAr)**	**RMPCT (%)**	**Year of Commissioning**
AAAAA8	AAAAA4	Power	1000	10.7	5000	2.5	500	3300	2000	-2000	50	
BBBBB8	BBBBB4											

Annexure-I / List-9

STATCOM

Data as on Month of the Year													
Bus Number	**Control Mode (Blocked, Normal)**	**P set point (MW)**	**Q Setpoint (MVAr)**	**V send Setpoint**	**Shunt Max (MVA)**	**RMPCT (%)**	**Bridge Max (MW)**	**V Term Max (pu)**	**V Term Min (pu)**	**V series Max (pu)**	**I series Max (pu)**	**Dummy series X(pu)**	**Year of Commissioning**
AAAAA8	Power												
BBBBB8													

Annexure-I / List-10

Switched Shunt

Data as on Month of the Year													
Bus Number	**Control Mode (Locked, Continuous Cntrl Voltage, Cntrl Plant MVAr)**	**Vhi (pu)**	**Vlo (pu)**	**Remote Bus**	**RMPCT (%)**	**B init (MVAr)**	**Blk 1 Steps**	**Blk 1 B step (Mvar)**	**Blk 2 Steps**	**Blk 2 B step (Mvar)**	**Blk 3 Steps**	**Blk 3 B step (Mvar)**	**Year of Commissioning**
AAAAA8	Power												
BBBBB8													

Annexure- II

DATA FOR TRANSMISSION PLANNING STUDIES

Table- I(a)

(Line parameters (per unit / km / circuit, at 100 MVA base)

Actual system data based on actual tower dimensions, wherever available, should be used. In cases where data is not available standard data given below can be assumed:

Voltage (kV)	Config.	Type of conductor	Ckt	Positive sequence			Zero sequence		
				R	X	B	R_0	X_0	B_0
765	Quad	@ACSR Bersimis	S/C	1.951E-6	4.880E-5	2.35E-2	4.500E-5	1.800E-4	1.406E-2
	Hexa	@ACSR Zebra	D/C	2.096E-6	4.360E-5	2.66E-2	3.839E-5	1.576E-4	1.613E-2
	Hexa	#ACSR Zebra	D/C	2.076E-6	4.338E-5	2.675E-2	3.662E-5	1.582E-4	1.605E-2
	Hexa	#AL59 (61/3.08)	D/C	2.056E-6	4.351E-5	2.671E-2	3.660E-5	1.583E-4	1.609E-2
400	Twin	ACSR Moose	S/C	1.862E-5	2.075E-4	5.55E-3	1.012E-4	7.750E-4	3.584E-3
	Twin	ACSR Moose	D/C	1.800E-5	1.923E-4	6.02E-3	1.672E-4	6.711E-4	3.669E-3
	Twin	AL59 (61/3.31)	D/C	1.871E-5	1.946E-4	5.980E-3	1.556E-4	6.777E-4	3.650E-3
	Twin	ACSR Lapwing	S/C	1.230E-5	1.910E-4	6.08E-3	6.685E-5	7.134E-4	3.926E-3
	Twin	ACSR Lapwing	D/C	1.204E-5	1.905E-4	6.08E-3	1.606E-4	6.651E-4	3.682E-3
	Twin	Moose eq. AAAC	S/C	1.934E-5	2.065E-4	5.67E-3	1.051E-4	7.730E-4	3.660E-3
	Triple	ACSR Zebra	S/C	1.401E-5	1.870E-4	5.86E-3	7.616E-3	6.949E-4	3.783E-3
	Triple	ACSR Snowbird	D/C	1.193E-5	1.721E-4	6.733E-3	1.477E-3	6.499E-4	3.950E-3
	Quad	ACSR Zebra	S/C	1.050E-5	1.590E-4	6.60E-3	5.708E-3	5.940E-4	4.294E-3
	Quad	ACSR Bersimis	S/C	7.416E-6	1.560E-4	7.46E-3	4.031E-3	5.828E-4	4.854E-3
	Quad	ACSR Moose	S/C	9.167E-6	1.580E-4	7.32E-3	1.550E-4	6.250E-4	4.220E-3
	Quad	ACSR Moose	D/C	9.177E-6	1.582E-4	7.33E-3	1.557E-4	6.246E-4	4.237E-3
	Quad	AL59 (61/3.31)	D/C	9.506E-6	1.594E-4	7.299E-3	1.439E-4	6.318E-4	4.221E-3
	Quad	Moose eq. AAAC	S/C	9.790E-6	1.676E-4	6.99E-3	5.320E-3	6.260E-4	4.510E-3
	Twin	ACSR Moose	S/C	4.304E-5	5.819E-4	1.98E-3	4.200E-4	2.414E-3	1.107E-3

Voltage (kV)	Config.	Type of conductor	Ckt	Positive sequence			Zero sequence		
				R	X	B	R_0	X_0	B_0
220	Single	ACSR Zebra	S/C	1.440E-4	8.220E-4	1.41E-3	4.231E-4	2.757E-3	8.843E-4
	Single	ACSR Drake	S/C	1.800E-4	8.220E-4	1.41E-3	6.1E-4	2.56E-3	8.050E-4
	Single	ACSR Moose	S/C	1.547E-4	8.249E-4	1.42E-3	4.545E-4	2.767E-3	8.906E-4
	Single	ACSR Kunda	S/C	1.547E-4	8.249E-4	1.42E-3	4.545E-4	2.767E-3	8.906E-4
	Single	AAAC Zebra	S/C	1.547E-4	8.249E-4	1.42E-3	4.545E-4	2.767E-3	8.906E-4
	Single	ACSR Zebra	D/C	1.416E-4	8.227E-4	1.407E-3	5.398E-4	2.676E-3	8.869E-4
	Single	ACSR Moose	D/C	1.152E-4	8.078E-4	1.433E-3	5.137E-4	2.661E-3	9.074E-4
	Twin	ACSR Zebra	D/C	7.049E-5	5.842E-4	2.006E-3	4.692E-4	2.437E-3	1.132E-3
	Twin	ACSR Moose	D/C	5.772E-5	5.767E-4	2.003E-3	4.563E-4	2.429E-3	1.118E-3
	Twin	AL59 ZEBRA	D/C	7.027E-5	5.885E-4	1.973E-3	4.672E-4	2.442E-3	1.118E-3
	Twin	AL59 Moose	D/C	6.132E-5	5.851E-4	1.990E-3	4.583E-4	2.438E-3	1.127E-3
132	Single	ACSR PANTHER	D/C	7.823E-4	2.323E-3	4.950E-4	1.957E-4	7.606E-3	3.138E-4
66	Single	ACSR DOG	D/C	6.299E-3	1.024E-2	1.242E-4	1.103E-2	3.305E-2	8.171E-5

@: With 15m ground clearance

#: With 18m ground clearance

Table- I(b)

The resistance data (in Ω/km) for **Zebra conductor equivalent** size is given in following Table. The reactance(X) and susceptance (B) values of line mainly depend on the tower configuration, and therefore the X and B values (in per unit / km / circuit) may be taken from Table I(a) above for similar configuration.

Name of Conductor	Stranding/wire diameter (mm)		Overall diameter (mm)	DC Resistance (Ω/km)	AC Resistance values at different temperatures (in Ω/km)		
	Al/Al alloy wire	steel wire		20^{o} C	$75\ ^{o}$ C	$85\ ^{o}$ C	$95\ ^{o}$ C
ACSR	54/3.18	7/3.18	28.62	0.06868	0.08686	0.08968	NA
AAAC	61/3.19	NA	28.71	0.06819	0.08269	0.08511	0.08754
AL59	61/3.08	NA	27.72	0.06530	0.07998	0.08243	0.08488

Table- I(c)

The resistance data (in Ω/km) for **Bersimis conductor equivalent** size is given in following Table. The reactance(X) and susceptance (B) values of line mainly depend on the tower configuration, and therefore the X and B values (in per unit / km / circuit) may be taken from Table I(a) above for similar configuration.

Name of Conductor	Stranding/wire diameter (mm)		Overall diameter (mm)	DC Resistance (Ω/km)	AC Resistance values at different temperatures (in Ω/km)		
	Al/Al alloy wire	steel wire		20^{o} C	$75\ ^{o}$ C	$85\ ^{o}$ C	$95\ ^{o}$ C
ACSR	42/4.57	7/2.54	35.04	0.04242	0.05451	0.05622	NA
AAAC	61/4.0	NA	36.00	0.04337	0.05350	0.05502	0.05654
AL59	61/4.02	NA	36.18	0.03840	0.04814	0.04955	0.05097

Table- I(d)

The resistance data (in Ω/km) for **Moose conductor equivalent** size is given in following Table. The reactance(X) and susceptance (B) values of line mainly depend on the tower configuration, and therefore the X and B values (in per unit / km / circuit) may be taken from Table I(a) above for similar configuration.

Name of Conductor	Stranding/wire diameter (mm)		Overall diameter (mm)	DC Resistance (Ω/km)	AC Resistance values at different temperatures (Ω/km)		
	Al/Al alloy wire	steel wire		20^{o} C	$75\ ^{o}$ C	$85\ ^{o}$ C	$95\ ^{o}$ C
ACSR	54/3.53	7/3.53	31.77	0.05552	0.07046	0.07273	NA
AAAC	61/3.55	NA	31.95	0.05506	0.06719	0.06914	0.07109
AL59	61/3.52	NA	31.70	0.0501	0.06190	0.06377	0.06564
AL59	61/3.31	NA	29.79	0.0566	0.06961	0.07173	0.07385

Table- I(e)

The resistance data (in Ω/km) for **Panther conductor equivalent** size is given in following Table. The reactance(X) and susceptance (B) values of line mainly depend on the tower configuration, and therefore the X and B values (in per unit / km / circuit) may be taken from Table I(a) above for similar configuration.

Name of Conductor	Stranding/wire diameter (mm)		Overall diameter (mm)	DC Resistance (Ω/km)	AC Resistance values at different temperatures (Ω/km)		
	Al/Al alloy wire	steel wire		20° C	75 ° C	85 ° C	95 ° C
ACSR	30/3.0	7/3.0	21.00	0.1390	0.17029	0.17586	NA
AAAC	37/3.15	NA	22.05	0.1151	0.13848	0.14261	0.14674
AL59	37/3.08	NA	21.56	0.1075	0.13060	0.13466	0.13873

Table- I(f)

Name of Conductor	Stranding/wire diameter (mm)		Overall diameter (mm)	DC Resistance (Ω/km)	AC Resistance values at different temperatures (Ω/km)		
	Al wire	steel wire		20° C	75 ° C	85 ° C	95 ° C
ACSR Snowbird	42/3.99	7/2.21	30.57	0.05516	0.07024	0.07248	NA
ACSR Lapwing	45/4.78	7/3.18	38.22	0.0358	0.04632	0.04775	NA

Note:

ACSR - Aluminum Conductor Steel Reinforced

AAAC - All Aluminum Alloy Conductor, corresponding to 53.0% of IACS (based on IEC standard)

AL 59 - High conductivity Aluminium Alloy Conductor as per IS-398, Part-6

Any conductor other than above shall be as per IS 398. In case Indian Standards is not available for the same, IEC/ IEEE or equivalent international Standards and codes shall be followed.

Table- I(g)

Single core XLPE Copper Cable

Voltage level	Cross Section area of conductor (Sq. mm.)	Max. DC resistance @ 20 deg C (ohm/Km)	Max. AC resistance @ 90 deg C (ohm/Km)	Max. Electrostatic capacitance (microfarads /Km)	Approx. Current carrying capacity Laid direct in ground at 30deg C (A)	Approx. Current carrying capacity in air at 40 deg C ambient (A)
132 kV	800	0.022	0.032	0.22	725	1190
220 kV	2500	0.007	0.013	0.27	1315	2290

Note: These are indicative values which may vary as per laying condition and cable design etc.

Table- II

(Thermal Loading Limits of Transmission Lines)

Actual system data, wherever available, should be used. In cases where data is not available standard data given below can be assumed. Data for some new conductors which are equivalent to ACSR Zebra/Bersimis/Moose/Panther/Snowbird/Lapwing are also given in following tables:

Thermal Loading Limits for ACSR Zebra equivalent Conductors:

Name of Conductor	Stranding/wire diameter (mm)		Ambient Temperature (ºC)	Ampacity for Maximum Conductor Temperature (ºC)			
	Al/Al alloy wire	steel wire		65 º C	75 º C	85 º C	95 º C
ACSR Zebra	54/3.18	7/3.18	40	451	626	756	NA
			45	328	546	694	NA
			48	222	492	654	NA
			50	103	453	625	NA
AAAC	61/3.19	NA	40	461	642	776	887
			45	335	560	713	834
			48	227	505	671	800
			50	104	464	642	776
AL59	61/3.08	NA	40	469	649	783	894
			45	343	567	719	840
			48	237	512	678	806
			50	123	471	648	782

Thermal Loading Limits for ACSR Bersimis equivalent Conductors:

Name of Conductor	Stranding/wire diameter (mm)		Ambient Temperature (ºC)	Ampacity for Maximum Conductor Temperature (ºC)			
	Al/Al alloy wire	steel wire		65 º C	75 º C	85 º C	95 º C
ACSR Bersimis	42/4.57	7/2.54	40	569	816	997	NA
			45	389	706	912	NA
			48	217	630	856	NA
			50	NA	574	817	NA
AAAC	61/4.0	NA	40	573	827	1013	1166
			45	387	714	926	1093
			48	206	637	870	1047
			50	NA	580	830	1015

AL59	61/4.02	NA	40	604	872	1069	1229
			45	408	754	977	1153
			48	215	672	917	1104
			50	NA	611	875	1070

Thermal Loading Limits for ACSR Moose equivalent Conductors:

Name of Conductor	Stranding/wire diameter (mm)		Ambient Temperature (ºC)	Ampacity for Maximum Conductor Temperature (ºC)			
	Al/Al alloy wire	steel wire		65 º C	75 º C	85 º C	95 º C
ACSR Moose	54/3.53	7/3.53	40	501	707	858	NA
			45	354	614	787	NA
			48	222	551	740	NA
			50	NA	504	707	NA
AAAC	61/3.55	NA	40	512	724	881	1010
			45	361	629	808	948
			48	225	565	760	909
			50	NA	517	726	882
AL59	61/3.52	NA	40	534	754	916	1049
			45	377	655	840	985
			48	237	588	790	944
			50	NA	538	755	916
AL59	61/3.31	NA	40	503	703	852	975
			45	362	613	782	916
			48	239	552	736	878
			50	88	507	704	852

Thermal Loading Limits for ACSR Panther equivalent Conductors:

Name of Conductor	Stranding/wire diameter (mm)		Ambient Temperature (ºC)	Ampacity for Maximum Conductor Temperature (ºC)			
	Al/Al alloy wire	steel wire		65 º C	75 º C	85 º C	95 º C
ACSR Panther	30/3.0	7/3.0	40	317	424	505	NA
			45	244	374	465	NA
			48	187	341	440	NA
			50	136	317	422	NA
AAAC	37/3.15	NA	40	352	474	566	643
			45	269	418	522	605
			48	204	380	493	582
			50	144	353	473	565

Name of Conductor	Stranding/wire diameter (mm)		Ambient Temperature (ºC)	Ampacity for Maximum Conductor Temperature (ºC)			
	Al/Al alloy wire	steel wire		65 º C	75 º C	85 º C	95 º C
AL59	37/3.08	NA	40	362	486	580	658
			45	278	429	535	619
			48	212	390	505	595
			50	152	362	485	578

Thermal Loading Limits for following ACSR Conductors

Name of Conductor	Stranding/wire diameter (mm)		Ambient Temperature (ºC)	Ampacity for Maximum Conductor Temperature (ºC)			
	Al wire	steel wire		65 º C	75 º C	85 º C	95 º C
ACSR Snowbird	42/3.99	7/2.21	40	502	703	853	NA
			45	358	613	782	NA
			48	232	550	736	NA
			50	63	505	703	NA
ACSR Lapwing	45/4.78	7/3.18	40	615	896	1101	NA
			45	405	772	1006	NA
			48	187	686	944	NA
			50	NA	622	899	NA

The above data has been calculated based on following assumptions:

- Elevation above sea level = 0 m
- Solar radiations = 1045 W/m2.
- Wind velocity considering angle between wind & axis of conductor as 90 degrees = 0.56 m/sec
- Solar Absorption Coefficient = 0.8
- Emissivity Coefficient = 0.45
- Effective angle of incidence of sun’s rays= 90 deg

Note: Generally, the ambient temperature may be taken as 45 deg Celsius; however, in some areas like hilly areas where ambient temperatures are less, the same may be taken after due calculation given in IS-9676.

High Temperature Low Sag conductors (HTLS)

HTLS conductors are capable of being operated continuously at temperatures as high as 250º C without any degradation in mechanical or electrical properties. However, in such conductors, the increase in sag is not linear at all temperatures because above a certain temperature called ‘knee point temperature’, the conductor experiences a sag increase due to the expansion of core alone (coefficient of linear expansion of core wires are comparatively lower than the complete conductor). This is because of the higher thermal expansion rate of aluminium which causes all the stress of the conductor to be borne by the core beyond the knee point temperature. Therefore, beyond the knee point temperature, the new expansion coefficient of the conductor will be the same as that of the core, resulting in relatively low sag increase when operated at high temperature.

Indicative parameters of HTLS conductor:

Transmission Line	Ampacity of HTLS per conductor	Minimum Conductor diameter (mm)	Maximum DC Resistance at 20°C (Ω/km)	Sub-conductor Spacing (mm)
400 kV Transmission line with Twin HTLS conductor	------ A*	28.62	0.05552	450
220 kV transmission line with single HTLS conductor	-------A*	25	0.06868	NA

*Ampacity shall be decided based on actual MVA capacity of circuit.

Some of the common types of HTLS conductors are as follows:

1. Aluminium Conductor Steel Supported Conductor
2. INVAR Conductor
3. GAP Conductor
4. Composite core Conductor

Note: Any new technology can be adopted which follows any National/International standard for design, safety and corresponding testing.

<u>Table- III</u>

(Transformer Reactance)

Actual system data, wherever available, should be used. In cases where data is not available standard data given below can be assumed:

Type of Transformer	Transformer reactance X_t (at its own base MVA)
Generator transformer (GT)	14 – 15 %
Inter-Connecting Transformer (ICT)	12.5 % (for 400 kV and below) 14% (for 765 kV)

Data for Transient Stability Studies

Table- IV

(Voltage and Frequency Dependency of Load)

Actual system data, wherever available, should be used. In cases where data is not available standard data given below can be assumed:

Load	Voltage Dependency of the system loads	Frequency Dependency of the system loads
Active loads (P)	$P = P_0\left(V/V_0\right)$	$P = P_0\left(f/f_0\right)$
Reactive loads (Q)	$Q = Q_0\left(V/V_0\right)^2$	Q can be taken as independent of frequency. However, if appropriate relationship is known, Q may also be simulated as dependent on frequency, on case to case basis.
(where P_o, Q_o, V_o and f_o are values at the initial system operating conditions)		

Table- V

(Modelling for Machines)

Actual system data, wherever available, should be used. In cases where data is not available standard data given below can be assumed:

Table- V(a) : 'Typical parameters for Thermal and Hydro Machines'

MACHINE PARAMETERS	MACHINE RATING (MW)				
	THERMAL				HYDRO
	800 (Mundra)	660 (Sipat-I)	500 (Simhadri-II)	210	200
Rated Voltage (kV)	26.00	24.00	21.00	15.75	13.80
Rated MVA	960.00	776.50	588.00	247.00	225.00
Inertia Constant (H)	4.50	4.05	4.05	2.73	3.50
Reactance					
Leakage (X_L)	0.18	0.188	0.147	0.18	0.16
Direct axis (X_d)	2.07	2.00	2.31	2.23	0.96
Quadrature axis (X_q)	2.04	1.89	2.19	2.11	0.65
Transient Reactance					
Direct axis (X'_d)	0.327	0.265	0.253	0.27	0.27
Quadrature axis (X'_q)	0.472	0.345	0.665	0.53	0.65

MACHINE PARAMETERS	**MACHINE RATING (MW)**				
	THERMAL				**HYDRO**
	800 (Mundra)	**660 (Sipat-I)**	**500 (Simhadri-II)**	**210**	**200**
Sub-transient Reactance					
Direct axis (X''_d)	0.236	0.235	0.191	0.214	0.18
Quadrature axis (X''_q)	0.236	0.235	0.233	0.245	0.23
Open Circuit Time Const.					
Transient					
Direct axis (T'_{do})	8.60	6.20	9.14	7.00	9.70
Quadrature axis (T'_{qo})	1.80	2.50	2.50	2.50	0.50
Sub-transient					
Direct axis (T''_{do})	0.033	0.037	0.04	0.04	0.05
Quadrature axis (T''_{qo})	0.05	0.20	0.20	0.20	0.10

Table: V(b) - 'Typical parameters for Exciters'

Typical Parameters	**Hydro**	**Thermal**	
		< 210 MW	**> 210 MW**
Transdu. Time Const. (TR)	0.040	0.040	0.015
Amplifier gain (KA)	25 – 50	25 – 50	50 -200
Amplif.Time Const.(TA)	0.04 – 0.05	0.04 – 0.05	0.03 – 0.05
Regulator limiting voltage			
Maximum (VR_{max})	4.0	6.0	5.0
Minimum (VR_{min})	-4.0	-5.0	-5.0
Feedback signal			
Gain (KF)	0.01	0.01	0.01
Time Constant (TF)	1.00	1.00	1.00
Exciter			
Gain(KE)	1.0	1.00	1.00
Time Constant (TE)	0.7	0.3	0.3

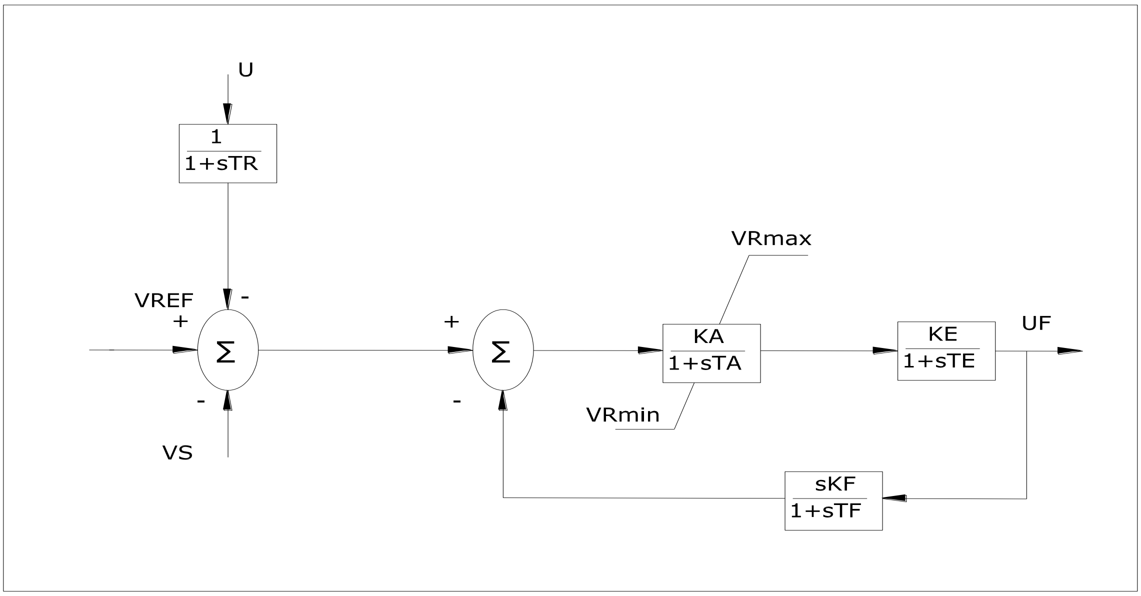
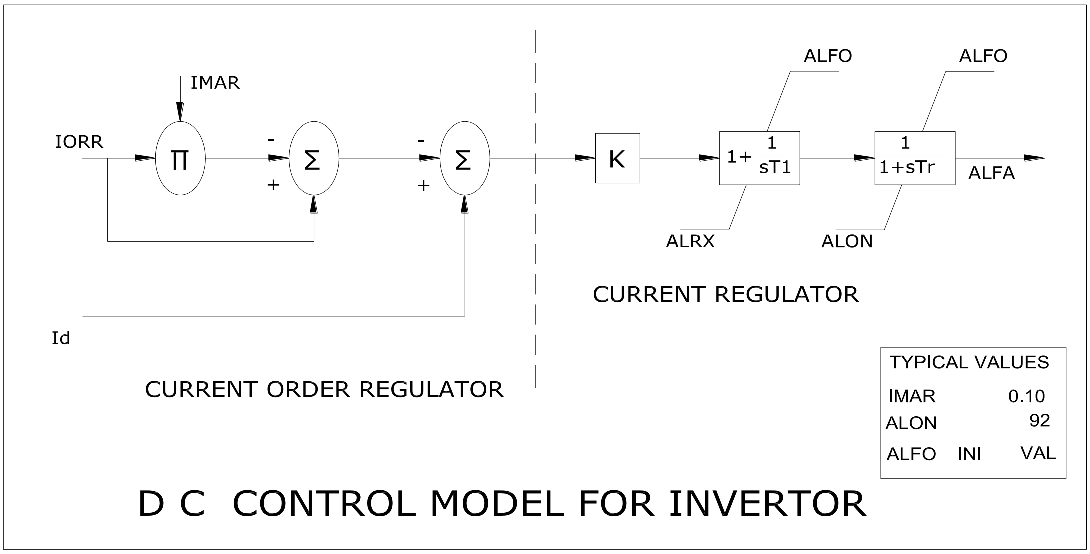


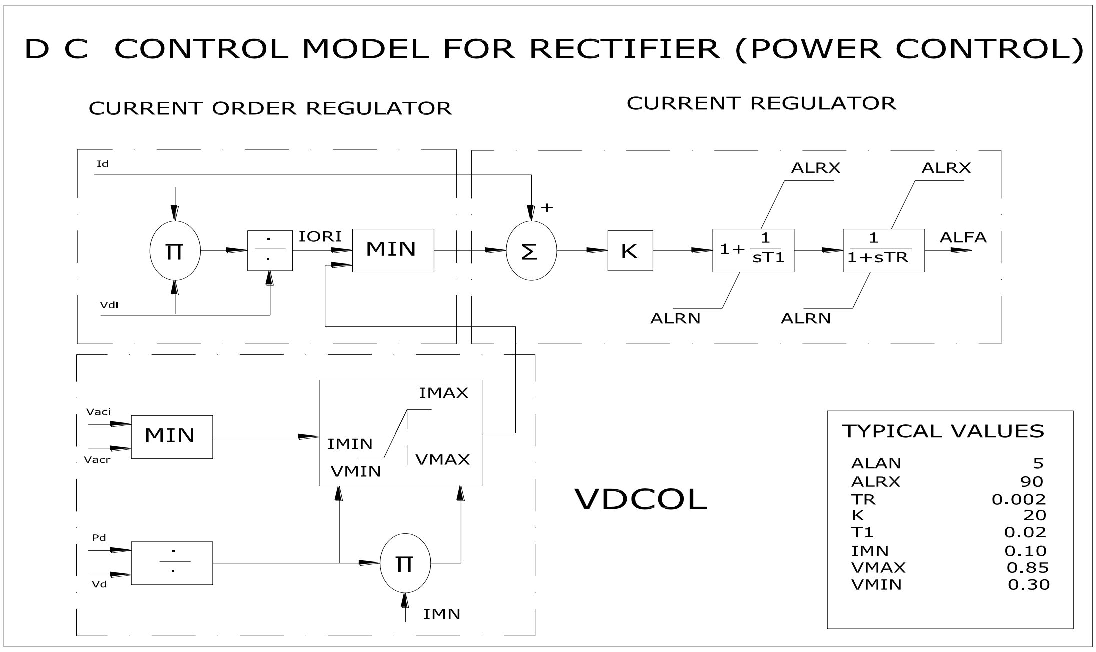
Table- VI

(Modeling for HVDC)

Actual system data, wherever available, should be used. In cases where data is not available standard data given below can be assumed:

HVDC Data: No standardized DC control model has been developed so far as this model is usually built to the load requirements of the DC terminals. Based on the past experience in carrying out stability studies, the following models are suggested for Rectifier and Invertor terminals.





ALAN	5
ALRX	90
TR	0.002
K	20
T1	0.02
IMN	0.10
VMAX	0.85
VMIN	0.30

Annexure- III

Table-I

(Load Factors)

To replicate and simulate seasonal power requirement variations on annual basis, three load-generation scenarios within a day in three different seasons may be chosen. Three points on load curves were identified for each day i.e. Day Peak load (Solar max i.e. afternoon), Evening Peak load and Night off-peak load. Further, the same was carried out for three seasons viz. Monsoon, Summer and Winter. Accordingly, load factors are prepared as below:

Season	Monsoon			Summer			Winter		
Scenarios	Day Peak	Evening Peak	Night off-Peak	Day Peak	Evening Peak	Night off-Peak	Day Peak	Evening Peak	Night off-Peak
Region	%	%	%	%	%	%	%	%	%
All India	83%	89%	78%	91%	100%	86%	90%	87%	69%
NR	82%	88%	80%	88%	104%	86%	70%	74%	46%
WR	76%	80%	70%	89%	90%	83%	99%	86%	70%
SR	74%	76%	63%	80%	85%	71%	94%	86%	70%
ER	83%	97%	88%	84%	99%	84%	69%	81%	54%
NER	69%	93%	72%	64%	83%	62%	55%	79%	42%

Note: The above factors may be revised from time to time.

Table-II

(Capacity Factors – for Renewable Energy Source (wind/solar) generation)

Capacity factor, considering diversity in wind/solar generation, is the ratio of maximum generation available at an aggregation point to the algebraic sum of capacity of each wind machine / solar panel connected to that grid point. Actual data, wherever available, should be used. In cases where data is not available the Capacity factor (in %) may be calculated using following factors:

Table-II(a)

Capacity Factor for Solar Generation

Season	Monsoon			Summer			Winter		
Scenarios	Day Peak	Evening Peak	Night off-Peak	Day Peak	Evening Peak	Night off-Peak	Day Peak	Evening Peak	Night off-Peak
Region	%	%	%	%	%	%	%	%	%
NR	90%	0%	0%	90%	0%	0%	90%	0%	0%
WR	80%	0%	0%	85%	0%	0%	90%	0%	0%
SR	80%	0%	0%	85%	0%	0%	90%	0%	0%
ER	80%	0%	0%	85%	0%	0%	90%	0%	0%
NER	80%	0%	0%	85%	0%	0%	90%	0%	0%

Table-II(b)

Capacity Factor for Wind Generation

Season	Monsoon			Summer			Winter		
Scenarios	Day Peak	Evening Peak	Night off-Peak	Day Peak	Evening Peak	Night off-Peak	Day Peak	Evening Peak	Night off-Peak
Region	%	%	%	%	%	%	%	%	%
NR	50%	70%	60%	50%	70%	60%	10%	35%	10%
WR	55%	75%	65%	55%	75%	65%	10%	20%	20%
SR	55%	75%	65%	55%	75%	65%	0%	20%	0%
ER	0%	0%	0%	0%	0%	0%	0%	0%	0%
NER	0%	0%	0%	0%	0%	0%	0%	0%	0%

Note: The above factors may be revised from time to time.

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Contributing Organisations

The following Organizations contributed through their valuable suggestions and comments on the Manual.

S.No	Organisation
1.	Central Electricity Authority (CEA)
2.	Southern Regional Power Committee (SRPC)
3.	Central Transmission Utility of India Limited (CTUIL)
4.	Grid Controller of India Limited (erstwhile POSOCO)
5.	Nuclear Power Corporation of India Limited (NPCIL)
6.	Power Grid Corporation of India Limited (POWERGRID)
7.	SJVN Limited (SJVNL)
8.	Solar Energy Corporation of India Limited (SECI)
9.	Tamil Nadu Transmission Corporation Limited (TANTRANSCO)
10.	Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO)
11.	Transmission Corporation of Telangana Limited (TSTRANSCO)
12.	Transmission Corporation of Andhra Pradesh Limited (APTRANSCO)
13.	Gujarat Energy Transmission Corporation Limited (GETCO)
14.	Punjab State Transmission Corporation Limited (PSTCL)
15.	Uttar Pradesh Power Transmission Corporation Limited (UPPTCL)
16.	Madhya Pradesh Power Transmission Company Limited (MPPTCL)
17.	Assam Electricity Grid Corporation Limited (AEGCL)
18.	West Bengal State Electricity Transmission Company Limited (WBSETCL)
19.	Danish Energy Agency
20.	International Solar Alliance
21.	Federation of Indian Chambers of Commerce and Industry (FICCI)
22.	Wind Independent Power Producers Association
23.	Siemens Limited
24.	Siemens Limited India, Smart Infrastructure
25.	FLUENCE – A SIEMENS and AES Company
26.	Hitachi Energy India Limited.
27.	Tata Power Company Limited
28.	Adani Power Limited (APL)
29.	Sterlite Power
30.	IPR Technologies Pvt Ltd, Bangalore
31.	Panacean Enterprise Private Limited
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