Regulation of Power System

TRANSMISSION PLANNING AND SECURITY STANDARDS

1. SCOPE:

The scope of work in long and medium term perspective planning involves integrated approach for evacuating power from different generating stations, irrespective of their ownership, and delivering it to the beneficiaries over an optimally designed power transmission system with reliability, security and economy. The power system in Karnataka has to be planned in such a manner that the power received from all the power plants and the share of power from southern grid from neighboring states can be transmitted without constraints to different beneficiaries as per their allocated shares, maintaining a reasonably good voltage profile, stability conditions and redundancy criteria.

2. TRANSMISSION PLANNING:

The transmission planning for the state should be developed to achieve a strong co-ordinated power system for the southern region with an ultimate objective of evolving a national grid, where substantial inter-regional transfers can be achieved with optimized utilization of available generation capacity to provide a high standard of supply to beneficiaries with acceptable reliability and at reasonable cost.

3. SYSTEM STUDIES:

The correct load to be supplied from various sub-stations at steady state at the acceptable frequency of 50 plus or minus 0.05 Hz and the future load development has to be assessed after making a detailed study of the present conditions and a load survey. A reasonable estimate of transmission losses shall also be included to arrive at the required peak generating capacity. The system is to be further evolved based on the following power system studies:

1. Load flow
2. Short Circuit
3. System stability- Steady state
4. System stability-transient
5. EMTP Studies to determine switching/temporary over voltages.

These studies require suitable computer programs. Mathematical models of Generation, Transmission and load shall be prepared separately for each year of a plan period assessing probable year of commissioning of particular generating stations, lines, sub-stations, additional transformers in existing sub-stations etc, based on the system network for the year in question with all the generation and load buses properly located. Inter connections with the southern grid through neighboring states at 400KV and 220KV levels shall have to be incorporated.

Appropriate equivalent circuit models shall be used to take into account the fault level at the interconnection points. The interconnection buses shall be represented as generation buses and hence the respective loads at these buses shall also be included in the modeling. Studies shall be carried out both for peak load and minimum load conditions.

4. SYSTEM DATA:

To arrive at a reasonably accurate load forecast and for conducting studies, compilation and updating of system data is absolutely necessary. Subsequent to the introduction of 400KV as the main transmission voltage, many 220KV & 110KV lines have become sub transmission voltages and many sub-stations are introduced in these lines either by looping in and looping out or by just Tee-off. The system parameters have undergone considerable change and it is necessary to update the data correctly either by the survey of the correct line lengths and conductor configurations or preferably by direct measurement of the line impedance values whenever and wherever possible. All the system data shall be the same for both the planning standards and operation standards. The loads shall be modeled at 220KV, 110KV and 66KV buses. The annual minimum load shall be taken as a percentage of annual peak demand as prevailing in the base year. Wherever data is not available, the load power factor at 110/66 KV levels can be taken as 0.85 lag / 0.90 lag for peak load / light load conditions for normal loads and 0.75 lag/ 0.85 lag for predominantly agricultural loads. Where power factor is less the figures specified above, respective utilities shall bring the power factor to the above limits by providing shunt capacitors at appropriate places. CEA norms as given in the manual on transmission planning criteria shall be followed for all other parameters for conducting system studies wherever data is not available.

5. GENERATION:

For peak load conditions, different generation mixes of various power stations, resulting in an optimal average cost shall be determined by conducting the required number of load flow studies, or using well developed computer program package to determine the same. For the minimum load conditions, the generator, which must run, shall be used in conjunction with the most economical thermal generation. The generation dispatch for the purpose of sensitivity analysis corresponding to a complete closure of major generating stations (separate studies to be conducted for closure of one major G.S. at a time) shall be worked out by increasing the generation at other stations to the extent possible keeping in view the maximum likely availability at those stations. Transmission constraints will have to be addressed properly. Studies shall be repeated for normal and contingency conditions as required in the security standards.

6. PLANNING CRITERIA:

The steady state voltage limits permissible for transmission and subtransmission voltages are as follows:

System voltage KV- rms. Maximum KV Minimum KV
400 420 380
220 245 198
110 124 100
66 72 58
33 36 30
11 12 10

The above limits may be exceeded only during outages of 400KV lines and in such cases it is necessary to supply dynamic VAR resources at sensitive nodes. Under normal operations when all the system elements are healthy, under the normal tap positions of the power transformers at the sending end, the system voltages at various levels at the tail end of the lines shall be as close to the nominal voltage as possible. The tap positions may be increased or decreased at peak load or off load conditions respectively.

The system should withstand satisfactorily the outage of any 2 circuits of 110KV or 220KV lines or any one circuit of 400 KV line with voltage and frequency levels remaining within prescribed limits. The system shall remain in synchronism even in case of a single line to ground fault or three phase faults, assuming successful clearance of fault by the protective devices.

Adequate margin shall be available, in terms of voltage and steady state oscillating stability.

The voltage angles between consecutive sub-stations should be in the region of 30 degrees.

7. LINE LOADING LIMITS:

The capacity of EHV line shall be the least of the following:

1. Thermal limit: - Some of the old transmission lines in the Karnataka grid are designed for a maximum operating temperature of 55º C, Subsequently 65º C was adopted. At present the same is raised to 75º C for ACSR conductors and 85º C for AAAC conductor as per IS 802 Part-I Sec.1.
2. Sag criteria: - This depends on the actual conductor temperature and minimum required ground clearance as per I.E. rules.
3. Steady State Stability limits. The guide lines as per CEA's Manual for

transmission planning criteria shall be adopted.

8. OPTIONS FOR STRENGTHENING OF TRANSMISSION NETWORK:

The following options are to be considered to evolve an optimal planning and design of transmission system.

1. Addition of lines to avoid over loading of the existing lines.
2. Next higher voltage may be considered where three or more circuits of the same voltage class are envisaged between two sub stations.
3. Reconductoring of old ACSR with all aluminum alloy conductors on the existing supports wherever permissible.
4. Use of ‘V’ string or polymer insulators to prevent conductor swing and to increase clearances.
5. Introduction of additional panel in the tower structure suitably to increase ground clearance, wherever permissible in design, since the older lines are designed with a higher factory of safety.
6. Replacement of metal cross arms with insulated cross arms and reconductoring.
7. Reinforcement of tower legs with additional steel sections wherever possible.
8. Uprating the transmission system wherever possible, to next higher voltage.
9. Application of series capacitors in the existing transmission lines to increase power transfer capability.

The choice shall be based on cost, reliability and right of way requirements, energy losses, down time etc.

Only double circuit towers shall be used in all future lines up to and including 220KV. In case of transmission system associated with nuclear power stations there shall be two independent sources of power supply for the purpose of providing start up power. Further the angle between start up power sources and the NPP switchyard should be as far as possible maintained within 10 degrees.

The evacuation system for sensitive power stations viz nuclear power stations shall be planned so as to terminate it at large load centers to facilitate islanding of the power station in case of contingency.

Thermal/nuclear generating units shall not normally run at leading power factor. However, for the purpose of charging, generating unit may be allowed to operate at leading power factor as per the respective capability curves.

9. SECURITY STANDARDS:

a. Steady State Stability:

The system shall be planned to withstand satisfactorily without any load shedding or altering the generation at power stations for at least, the following outage conditions:

1. 2 Circuits of 110KV or 220KV lines.
2. One circuit of 400KV line.
3. One interconnecting transformer.
4. One largest capacity generator.

The above contingencies shall be considered assuming a precontingency system depletion (planned outage) of another 220 KV double circuit line or 400 KV single circuit line in another corridor and not emanating from the same substation. All the generating plants shall operate within their reactive capability curves and the network voltage profile shall also be maintained with in the specified voltage limits.

a. <u>Transient Stability:</u>

   The system shall be designed to maintain synchronism and system integrity under the following disturbances.

1. Outage of the largest size generator in southern grid.
2. (a) A single line to ground fault on a 400KV line, single pole opening of the faulted phase (5 cycles) with unsuccessful reclosure (dead time 1 sec) followed by 3 pole opening (5 cycles) of the faulted line.

   (b) System shall be capable of withstanding a permanent fault on one of the circuits of 400 KV D/C line when both circuits are in service and a transient fault when the system is already depleted with one circuit under maintenance/outage. Accordingly 3 Pole opening (100 m. see) of the faulted circuit shall be considered when both circuits are assumed in operation (single pole opening and unsuccessful auto-reclosure is not considered generally in long 400 KV D/C lines since the reclosure facility is by passed when both circuits are in operation, due to difficulty in sizing of neutral grounding reactors) and single pole opening (100 m sec.) of the faulted phase with successful reclosure (dead time 1 sec) when only one circuit is in service.
3. A permanent 3-phase fault with duration of 8 cycles on 220KV or 110KV line assuming 3-pole opening. No stability studies are required for radial lines.

<u>10. SUBSTATION PLANNING CRITERIA:</u>

For meeting a particular quantum of load the number of sub-stations required depend upon the choice of voltage levels, the MVA capacity and the number of feeders permissible etc. The number of EHT / HT transformers, interconnecting transformers shall also be considered in planning to take care of contingencies of planned/forced outages. The rupturing capacity of circuit breakers shall have a 20 percent margin to take case of increase in short circuit levels as the system grows. The following criteria can be adopted:

The capacity of any single sub-station at different voltage levels shall not normally exceed:

400 KV	1000 MVA
220 KV	320 MVA
110 KV	150 MVA

Size and number of interconnecting transformers (ICTs) shall be planned in such a way that the outage of any single unit would not overload the remaining ICTs or the underlying system.

Size and number of EHT/HT transformers shall be planned in such a way that in the event of outage of any single unit, the remaining EHT/HT transformers would still supply 80% of the load.

The rated rupturing capacity of the circuit breakers in any sub-station shall not be less than 120% of the maximum fault levels at that sub-stations (The 20% margin is intended to take case of increase in short circuit levels as the system grows). The standard rating capacity of switchgear at different voltage levels are as follows:

110 KV	31 KA
220 KV	40 KA
400 KV	40 KA

11. REACTIVE COMPENSATION:

As per I E rules, the power factor of the consumer shall not be less than 0.85 lag for normal working load. Adequate reactive compensation shall be provided and the power factor at 220KV and higher voltages shall not be less than 0.95 lag to avoid the need for VAR transfer from high voltage to the low voltage system. Shunt capacitors shall be installed for this purpose on lower voltage side, say 110KV, 66KV, 33KV and 11KV.

Suitable shunt reactors shall be provided at 400KV Sub-stations for controlling voltages within the limits prescribed. The step changes shall not cause a voltage variation exceeding 5%.

Suitable line reactors shall be provided to enable charging of 400KV lines without exceeding the voltage limits specified.