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Power System Planning

Scope — Significance — Computer Programmes — Generation Planning — Transmission Planning.

51.1. SCOPE OF POWER SYSTEM PLANNING AND DESIGN

Planning and designing has become important and continuous activity. Older equipments and systems are being replaced by the new. The overall planning and designing is divided into the following categories :

— Energy resources and generation planning considering alternative sources of energy.
— Transmission planning including planning of interconnections.
— Distribution planning including planning of load centres.

Planning and design activities are influenced by the following aspects:

— Changing requirements of consumers, increasing loads over large geographical area away from generating stations.
— Changing pattern of energy resources of generation methods.
— Feedback of *System studies* and experience leading to better design of systems and equipments.
— New software.
— Availability of new, superior technologies, *e.g.* HVDC, Fibre-optic data transmission, FACT, SVS.
— Obsolescence of old products and systems, *e.g.* small isolated generating stations; bulk oil breakers, electro-mechanical relays.
— Increasing use of power electronics.
— Increasing use of microprocessor, digital computer based, programmable systems for protection, control and automation.
— Increasing use of SCADA, AGC, DAC systems.*

51.2. SIGNIFICANCE OF SYSTEM PLANNING AND DESIGN

Good system planning and design has the following objectives :

— Sufficient, continuous supply of electrical energy to all the consumers over wide geographical area at lowest possible cost at specified voltage and frequency.
— Highest possible security and reliability of supply.
— Most economic generation, transmission and distribution.
— Optimum use of energy resources.

*SCADA	:	Supervisory Control and Data Acquisition.
AGC	:	Automatic Generation Control.
DAC	:	Distribution Automation and Control.
ES	:	Expert System.
AI	:	Artificial Intelligence.

These are difficult due to the following :

— Decision regarding choice of equipment have long term effect (15 to 30 years) and equipments may become obsolete in less time (2 to 10 years)
— Sources of energy for generation of electrical power are scattered away from load centres and there are many alternatives : *e.g.*

e.g. coal for thermal plants, water resources for hydroplants, nuclear, geothermal, wind, solar, tidal, waste, etc.

— Electrical energy cannot be stored in large quantities economically some new techniques such as pumped storage; battery and fuel cell systems, compressed air systems etc. are used upto a few MW.
— Alternative forms of transmission are available *e.g.* AC, HVDC. SF_6 Gas Insulated Cables (GIC) underground cables etc.
— Economic analysis has uncertainties regarding cost of fuels, escalations in capital cost of future projects, interest rates etc.
— Planning decisions are influenced by load management techniques.

51.3. COMPUTER PROGRAMMES FOR PLANNING

The planners formulate several alternatives especially for generation planning and transmission system planning. Each alternative has lengthy and complex formulations. The following computer programmes are used for expansion planning and simulation. These programmes may be used separately or with any other programme as per requirement of the problem.

1. Load growth and load shape Model Programme.
2. Generation Growth Programme.
3. Transmission Growth Programme.
4. Investment costing.
5. Generation Production Costing.
6. Organisation Financial model programme.

Local Growth and Load Shape Model Programme accepts the hour by hour load data of earlier years and gives predicted, tabulation of load shape during a day for all the days of a year. These predictions are used for simulation of generation growth programme.

General Growth Programme compares the installed generating capacity with the predicted load growth. The risks of capacity shortage are predicted. Alternative generation growth strategies are formulated by using different alternatives.

Transmission Growth Programme is used for determining the voltage levels, routes, required year of installation for various future transmission lines and sub-stations.

The output of transmission growth programme are used for planning expansion of back bone transmission network underlying main transmission network to match the planned generation growth.

Investment Costing Programme is used for predetermining the investments for the generation growth and transmission growth.

Generation Production Costing Programme simulates the fixed and running costs on the basis of present rates and likely price-rise and computes the future production costs. The results of investment costing programme are also considered.

Organisation's Financial Model Programme is used for predicting the influence of investment decisions on the overall balance sheet, cash-inflow and cash-outflow predictions.

For the Organisation's Financial Model needs the following inputs : generation and transmission costs of every year, details of the organisation financial structure, accounting data, management information reports.

The organisation financial model programme can simulate the monthly basis and the necessary capital investment for generation and transmission growth for that month can be predicted.

Table 51.1 gives the details about Generation Planning.

Table 51.2 gives details about Transmission Planning.

Table 51.1. Aspects About Generation Planning

Basic Questions	*Inputs*	*Remarks*
1. How much installed capacity during next 20, 10, 5, 1 years. How much shall be the excess capacity ?	— Load forecasts — Prediction of outages : Planned and unplanned Maintenance schedules	— Generation growth programme — Planned Capacity should be in excess of predicted requirements.
2. What shall be unit size, type of unit? (*e.g.* 200 MW, 500 MW)	— Loss-of-load probability (LOLP) analysis.	— Prediction of LOLP for various sizes, types of units and comparison of their outage characteristics.
3. What type of generation ? — Steam (thermal) — Hydro — Nuclear	— Available natural resources and technology. — Further capital investment cost of different types of generating stations. — Future running cost (fuel, efficiency) — Future reliability, outage possibility. — Environment factors.	— Decision based on predicted one year cost considering capital and running cost.
4. What should be scheduled generation of Hydro and Thermal Stations.	— Data regarding hydro reserves throughout the year — Cost of hydro and thermal generation	— Hydro thermal co-ordination based on available energy resources, optimum utilization and economic generation.
5. What should be generation commitment of a station, an area and the Total System	— Load frequency control as first priority. — Economic generation as second priority.	— National local control centre decides total generation and instruct scheduled interchange to each area. — Individual area decides total required generation of that area for meeting its load/frequency and committed interchange.

Table 51.2. Aspects About Transmission Planning

Basic Questions	*Inputs*	*Remarks*
1. Configuration of Transmission, system Which new circuits ? Which new tie-lines ? Which new sub stations ?	— Existing network data — Locations and magnitudes of all future generating stations — Locations and magnitudes of all future load centres. — Annual study of generation growth and load growth — Short and long range plans of generation and load.	— Existing network used as starting point. — Long range planning. — Short-term planning of transmission. — Alternative expansion plans of transmission. — Matching transmission growth with load growth and generation growth.
2. What voltage levels ?	— Length and power of transmission line — Economical voltage level — Power handling capacity required per circuit — Existing voltage levels.	— Voltage levels are standardised for 1. Backbone transmission network 2. Primary transmission 3. Secondary transmission 4. Special cases such as very long lines
3. EHV-AC or HVDC ?	— System studies and requirements — Economic studies.	— EHV-AC used for backbone net work primary transmission : — HVDC used for long high power lines and interconnections
4. Technique for Compensation Reactive power Planning.	— Load flow studies — Dynamic stability studies	— SVS used at various substation buses.
5. Which inter connections	— Overall policy — Geographical locations of adjacent independently controlled AC Networks — Load cycles of networks and available capacity for interchange — Agreement between the organisations.	— Interconnections are either EHV-AC/HVDC/HVDC back to back. — Interconnections are planned on the basis of long range transmission plants.
6. What should be location of sub-stations and types of sub-stations	— Location selected on the basis of locations of load centers, generating stations, transmission routes.	Types : — Outdoor open terminal — Indoor SF_6 insulated GIS — HVDC — Indoor metal clad for medium voltages.
7. What should be the communication chemicals	— Telephones — Power-line carrier — Radio link.	
8. What should be controlled strategy.	— Fully automatic unmanned — Semi-automatic...only control supervisors.	

Summary

The load, generation and transmission grow continuously. The long-range and short-term planning are essential for :

— Planning of generation.

— Planning of transmission and distributions.

The planning should aim at excess capacity *i.e.*, installed capacity should be more than predicted demand. Various aspects about generation planning, transmission planning and system studies have been summarised in Tables 51.1 and 51.2.