

Module 1 : Introduction

Lecture 2 : Why make interconnections?

Objectives

In this lecture you will learn the following

- Why are power systems interconnected?
- What is the concept of reliability? Why is it more economical to interconnect a power system?
- Identifying the major elements of a practical interconnected power system.

Reliability and Economy are the main reasons for interconnecting power systems

Reliability implies that with a large interconnected grid, the loss of a system component like a major transmission line or generator will have minor impact on system. When one device fails, another one makes up for the loss. In a practical grid, there exists more than one path connecting a load to each generator. Thus the loss of one transmission line or tripping of one generator does not usually interrupt power to a load.

Economy implies that electricity can be obtained from where it is cheap. It is more economical to operate large generators 24 hours a day at full capacity (base load stations), catering not to a particular load, but pooling power into the grid and to be used by many connected loads. A few generators which can be started almost instantaneously can then act as reserves to cater to sudden increases in load (peak load stations). Generally steam stations are run as base load stations while reservoir based hydro-stations and gas stations act as peak load stations. The possibility of sharing reserves in interconnected systems also results in smaller reserve requirements. Different regions in a grid may face peak demand at different times of the day. Therefore the total system peak demand is smaller than the sum of the individual peaks of various regions.

However, extensive interconnections also mean that a disturbance in one part of the system may quickly spread to the entire system, leading to tripping of loads/generators, and may even make interconnected system operation unviable. For example, some large disturbances may make it impossible for generators to run in synchronism. In case interconnected system operation becomes unviable, the system must "gracefully" split into smaller systems (**islands**). However, if the control and protection systems are inadequate to face this eventuality, a complete blackout may also occur, leading to loss of service to millions of consumers.

However, grid failures are rare ("the lights are always on") and one may justifiably ask a question : how does the whole system work so well? After all, for well designed power systems, power is available on demand and can be obtained by simply "paralleling" the load on the grid. Similarly, a synchronous machine driven by a prime-mover can be synchronised with a grid and may supply power to it. Of course, all this is subject to certain constraints which we shall study in the next module.

A great deal of prior planning and control during operation is required to make an inter-connected network capable of catering to a certain level of power flow and prevent blackouts.

Example of a large power system

Western Region of the WR-ER-NER Synchronous Grid: A description

This region has the largest inter-connected network in the country, comprising the states of Chattisgarh, Goa, Gujarat, Maharashtra, Madhya Pradesh, besides Union territories of Daman and Diu, and Dadra and Nagar Haveli. In 2002, the installed capacity was 31.5 GW with 13.8% hydro, 66% thermal- coal, 15.9% gas/liquid fuel, 2.4% nuclear and wind

1.9%.

The generation is owned by State Electricity Boards, NTPC(National Thermal Power Corporation) and NPC(Nuclear power corporation), besides some Independent Power Producers (IPPs).

Generation

The western region has major generating stations of Korba TPS (Thermal Power Station)-2100 MW, Vindychal TPS–2260 MW, Korba (West) –840 MW, Korba (East) –400 MW, Sanjay Gandhi TPS –820 MW, Chandrapur TPS –2340 MW, Amarkantak TPS –300 MW etc., located in the eastern part of the region.

The major hydro stations in the region are at Koyna –1960 MW, Bansagar –315 MW, Ukai –300 MW, Tata –444 MW. The western part of the grid has thermal generating stations of Trombay –1330 MW, Wanakbori –1470 MW, Ukai –850 MW, Nasik –910 MW, and nuclear generating units at Tarapur –320 MW and Kakrapur –440 MW.

The major load centers in the region are located at the western part of the region and bulk of the power flow is from eastern to western part of the region.

Bulk (EHV) Transmission

The 400 kV system consists of three main corridors.

The upper corridor links Vindychal TPS-Itarsi via Satna-Bina-Bhopal. The second evacuation corridor is from Korba TPS-Bhilai/Raipur and bifurcates thereafter into middle and lower (third) corridors.

The middle corridor links Bhilai-Koradi-Bhusawal-Bableshwar-Padghe-Kalwa.

The lower (third) corridor consists of Raipur-Chandrapur-Parli-Karad-Lonikhand and Kalwa/Padghe linked together.

The upper and middle corridor are interlinked by 400 kV Itarsi-Satpura-Bhilai, Itarsi-Dhule links and also Vindychal TPS-Korba TPS links. Further North MP loads are fed on 400 kV Vindychal-Satna-Bina links and 400 kV Itarsi-Bhopal-Bina links. The generation of Koyna stage IV is connected to Karad and Lonikhand by 400 kV lines.

Another important bulk transmission corridor in the region is ± 500 kV, 1500 MW HVDC from Chandrapur-Padghe. The Western region is connected to southern region and northern region through DC systems (*asynchronous links*) at Bhadrawati (1000 MW) and Vindychal (500 MW) respectively. Note that the operating frequency of the northern and southern grids need not be the same as the western region.

The western regional grid operates *in synchronism* with the eastern grid and is interconnected to it by 400 kV lines between Raipur and Rourkela.

Can you identify the lines and generators mentioned in the map of western region of the WR-ER-NER grid as shown on the right- only major lines are shown ? (courtesy: WRLDC Mumbai, <http://www.wrlcdc.com/WR%20map-20Oct03.jpg>)

(click to enlarge figure)



Recap

In this lecture you have learnt the following

- Power Systems are interconnected to ensure reliability and economy
- Reliability ensures that a loss of an element has a minor impact on system operation
- Interconnected power systems can utilise the economy associated with larger power plants (as opposed to many small ones). Also diversity in time of peak demand within a grid ensures that total peak demand is less than sum of peak demand of individual loads.
- A practical power system in our country is studied as an example.