

## **Ancillary Service Management in Restructuring of Power Industry**

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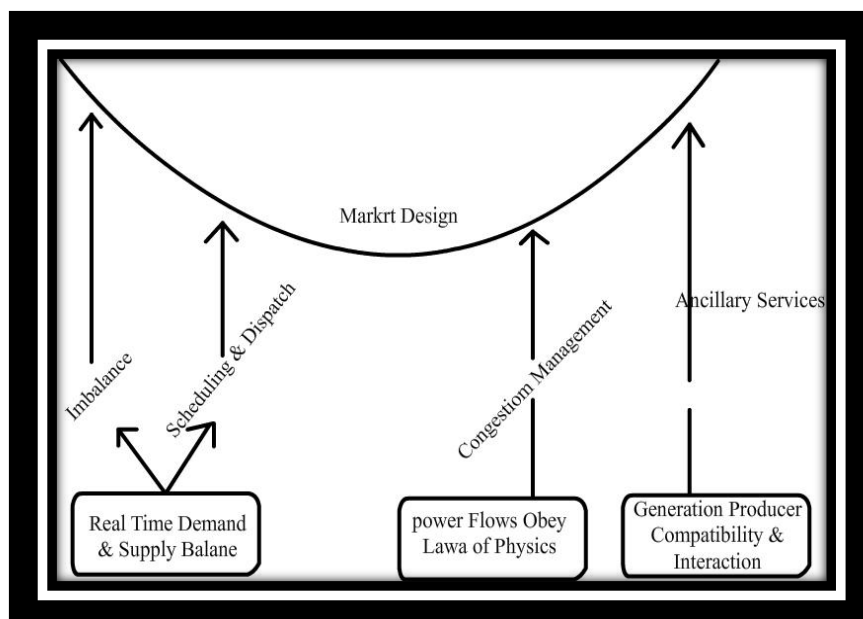
**Abstract-** Ancillary services are defined as all those activities on the interconnected grid that are necessary to support the transmission of power while maintaining reliable operation and ensuring the required degree of quality and safety. Ancillary services may include scheduling and dispatch, frequency regulation, voltage control, generation reserves, etc. There are some services which can be provided competitively and some services which come under the direct control of the system operator.

**Keywords-** Ancillary Services, Restructuring of Power Industry, Market Design, Congestion Management, Scheduling and Dispatch.

### **I. INTRODUCTION**

The System Operator has to achieve the global load-generation balance at all times. Responsibility of the system operator to keep the system in synchronism and operate it reliably. These activities are known as ancillary services. Even though the power industry has been deregulated, the technical activity of control and operation remains the same. The manner in which some of the facilities are procured or provided by the system operator may change, depending upon the type of control. In the vertically integrated era, whole of the resources required to take corrective control actions are under the control of a single utility. This is not the case under competitive environment. Some of the resources required for control of the system belong to other entities.

### **II. Four Pillars of Market Design (Market Architecture)**



*Figure-1 Four Pillars of Market Design*

There are four pillars of Market Design. 1) Imbalance 2) Scheduling and Dispatch 3) Congestion Management 4) Ancillary Services

**What Do You Mean By Ancillary Services?** Ancillary services are defined as all those activities on the interconnected grid that are necessary to support the transmission of power while maintaining reliable operation and ensuring the required degree of quality and safety. Ancillary services may include scheduling and dispatch, frequency regulation, voltage control, generation reserves, etc. There are some services which can be provided competitively and some services which come under the direct control of the system operator.

### **III. Types of Ancillary Services**

A large number of activities on the interconnected grid can be termed as ancillary services. During the process of defining the ancillary services, some proposals tried to define 60 different ancillary services! In order to remove this large discrepancy, the North American Electric Reliability Council (NREC) along with Electric Power Research Institute (EPRI) has identified 12 functions as ancillary services.

**Regulation:** The use of generation or load to maintain minute-to-minute generation-load balance within the control area.

**Load Following:** Load following is the use of online generation equipment to track the intra and inter-hour changes in customer loads.

**Energy Imbalance:** The use of generation to meet the hour-to-hour and daily variations in load.

**Operating Reserve (Spinning):** The provision of unloaded generating capacity that is synchronized to the grid and can immediately respond to correct for generation-load imbalances, caused by generation and /or transmission outages and that is fully available for several minutes.

**Operating Reserve (Supplemental):** The provision of generating capacity and curtailable load to correct for generation-load imbalances, caused by generation and or transmission outages, and that is fully available for several minutes. However, unlike spinning reserves, supplemental reserve is not required to respond immediately.

**Backup Supply:** This service consists of supply guarantee contracted by generators with other generators or with electrical systems, to ensure they are able to supply their consumers in case of scheduled or unscheduled unavailability.

**System Control:** This activity can be compared with the functions of the brain in the human body. System control is all about control area operator functions that schedule generation and transactions and control generation in real time to maintain generation load balance.

**Dynamic Scheduling:** It includes real-time metering, tele-metering along with computer software and hardware to virtually transfer some or all of generator's output or a customer's load from one control area to another.

**Reactive Power and Voltage Control Support:** The injection or absorption of reactive power from generators or capacitors to maintain system voltages within required ranges.

**Real Power Transmission Losses:** This service is necessary to compensate for the difference existing between energy supplied to the network by the generator and the energy taken from the network by the consumer.

**Network Stability Services from Generation Sources:** Maintenance and use of special equipment (e.g., PSS, dynamic braking resistances) to maintain secure transmission system.

**System Black Start Capability:** The ability of generating unit to proceed from a shutdown condition to an operating condition without assistance from the grid and then to energize the grid to help other units start after a blackout occurs.

#### IV. Classification of Ancillary Services

➤ **Services required for routine operation:** These are the services which the system operator requires quite frequently.

- (a) System control
- (b) Reactive power support
- (c) Regulation
- (d) Load following
- (e) Energy imbalance
- (f) Real power loss displacement

➤ **Services required to prevent an outage from becoming a catastrophe:** These services prevent the system from going out of step even if a major event occurs. These do not come into picture on daily basis.

- (a) Spinning reserve
- (b) Supplemental reserve
- (c) Network stability services

➤ **Services needed to restore a system after blackout:** Re-energizing the system after complete blackout requires support from certain generating stations, which can pickup generation even in the absence of external electricity support. Such generating units provide the system black start capability. These services are very rarely used.

#### V. Load Generation Balancing Related Services

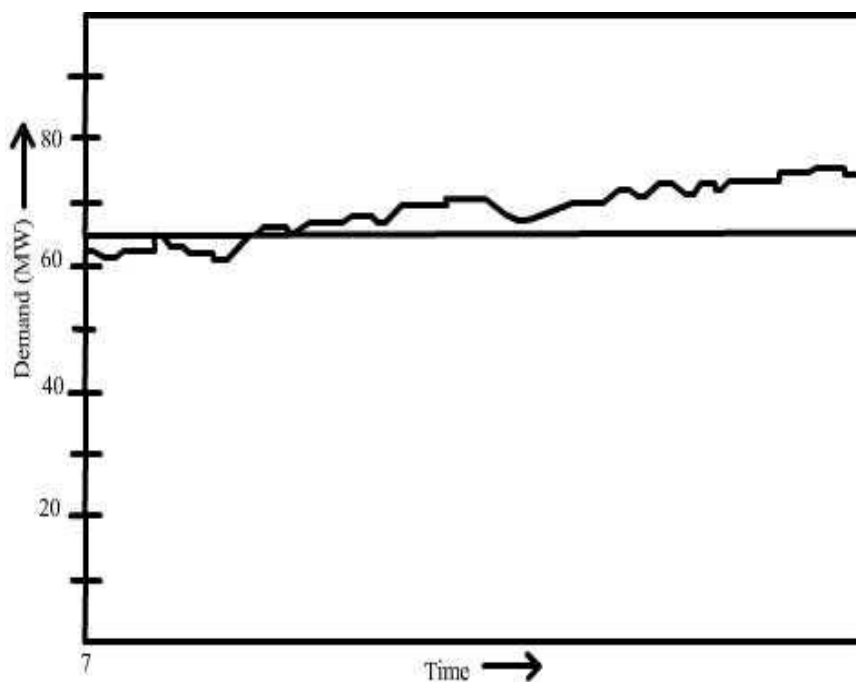


Figure-2 Components of a load

The first element is the average load, 65 MW over the one hour shown in this case. The second element is the trend during the hour. Here, this element increases from -5 MW at 7 am to +10 MW at 8 am. The third element is the rapid fluctuations in load. Here, the fluctuations range over  $\pm 2$  MW. Combined, the three elements yield a load that ranges from 60 to 75 MW during this hour.

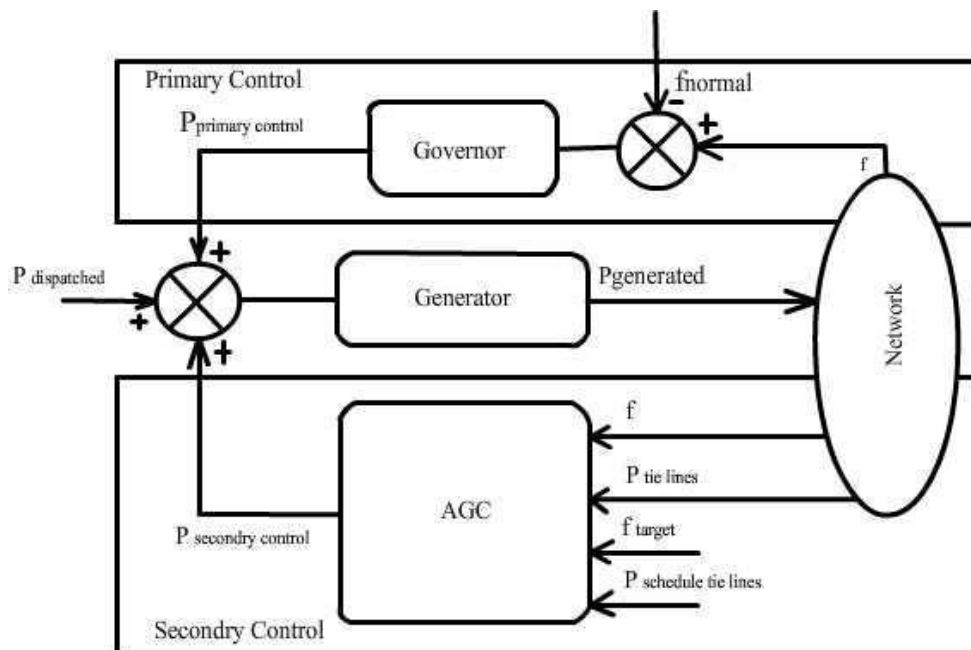


Figure-3 Frequency Regulation

Regulation is the use of on line generating units to maintain the system frequency, minimize the differences between actual and scheduled power flows, and match generation to load. The frequency regulation consists of two modes of operation, primary regulation and secondary regulation. The primary regulation is the governor action with certain droop characteristic, while secondary regulation pertains to Automatic Generation Control (AGC).

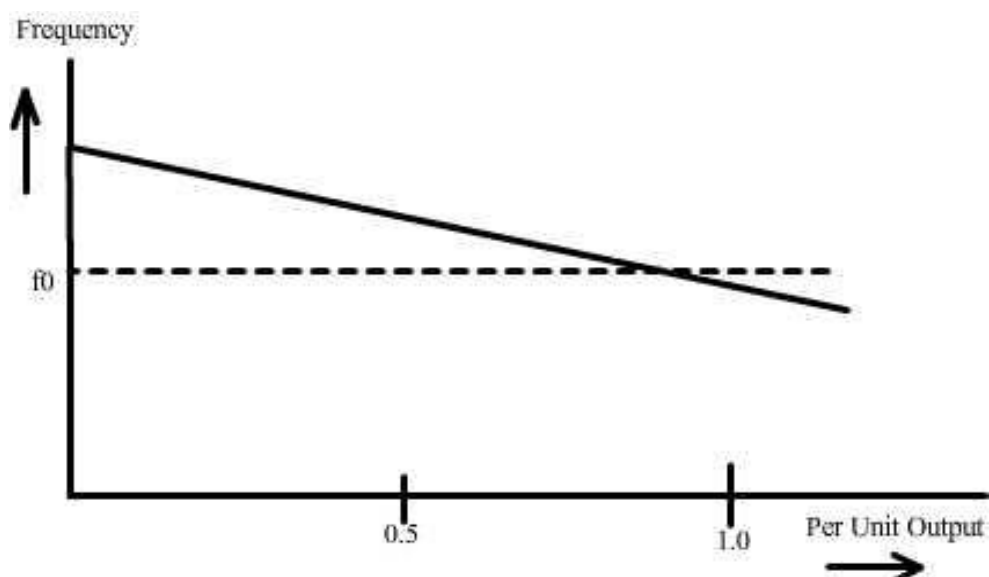


Figure-4 Generator droop characteristics

Above figure-4 shows generator droop characteristics. We can see that as per unit output of generator increases the frequency decreases.

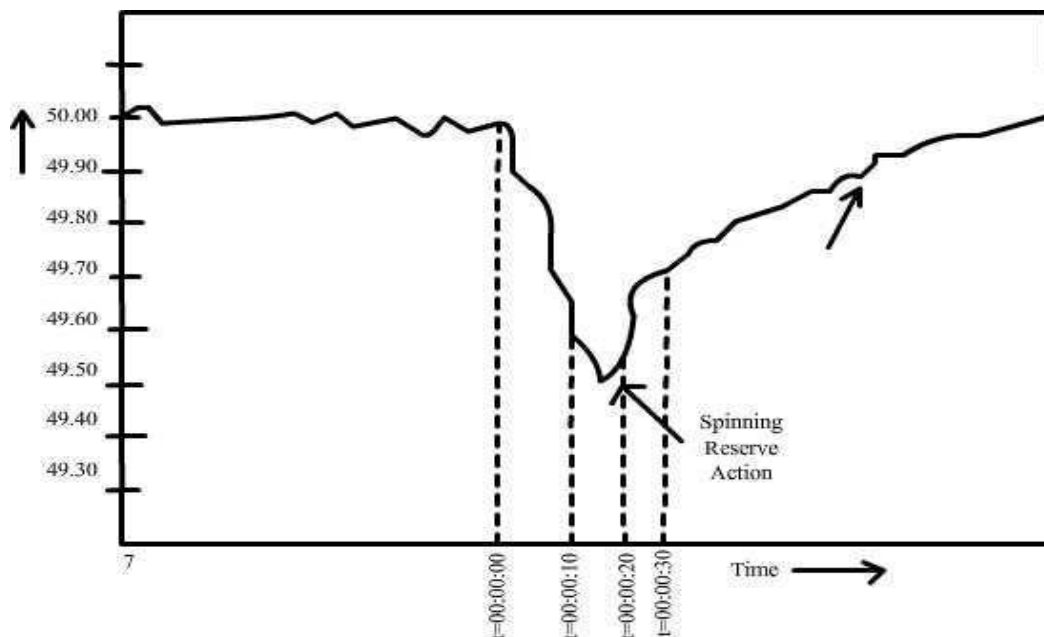


Figure-5 Spinning Reserve Services

**Spinning reserve services-** The spinning reserves must start responding quickly to the frequency change. These reserves are available in the form of synchronous generators that are synchronized with the grid. This response must be available within 10s and should be sustainable for further 20s. The spinning reserve is the unused capacity which can be activated on decision of the system operator and which is provided by devices which are synchronized to the network and able to affect the active power.

**Supplemental reserve services-** The units providing supplemental services need not start responding immediately. The supplemental reserve services are provided by the generators that have fast start-ups such as gas /oil fired generators /hydro generators. This response must be fully available within 30s of the incidence and must be sustainable for further 30 minutes.

**Black Start Capability Service:** A blackout is a rare contingency. It is important to restore power as fast as possible. The system operator is responsible for restoring the system to normal operating state as soon as possible. Restarting of large thermal power plants requires major portion of electric power for its auxiliaries. The electric power resources like hydro plants, diesel generators, etc., can be started without help from the grid.

## VI. How to Obtain Ancillary Services?

There are two ways of obtaining the ancillary services:- In the first case, provision of ancillary services is made mandatory for the participant who wishes to take part in the energy market. The other way is to obtain the services on commercial basis. Here, the services can be obtained based on long term contracts or daily competitive market.

**Co-optimization of Energy and Reserve Services:** During early days, energy and reserve were traded in different markets. These markets were cleared successively in a sequence. The market for reserve would clear first and then the energy market would be cleared. Various products offered by a generator are strongly interlinked. Energy and reserve should be offered in joint markets and these markets should be cleared simultaneously to minimize the overall cost of reserve and energy.

## **VII. CONCLUSION**

A large number of activities on the interconnected grid can be termed as ancillary services. During the process of defining the ancillary services, some proposals tried to define 60 different ancillary services! In order to remove this large discrepancy, the North American Electric Reliability Council (NREC) along with Electric Power Research Institute (EPRI) has identified 12 functions as discussed above as ancillary services. The System Operator has to achieve the global load-generation balance at all times. Responsibility of the system operator to keep the system in synchronism and operate it reliably. These activities are known as *ancillary services*. Even though the power industry has been deregulated, the technical activity of control and operation remains the same. The manner in which some of the facilities are procured or provided by the system operator may change, depending upon the type of control. In the vertically integrated era, whole of the resources required to take corrective control actions are under the control of a single utility. This is not the case under competitive environment. Some of the resources required for control of the system belong to other entities.

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