Ancillary Services Management

Types and Provisions for Ancillary Services

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Introduction

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.

Major Ancillary Services

Some major ancillary services are:

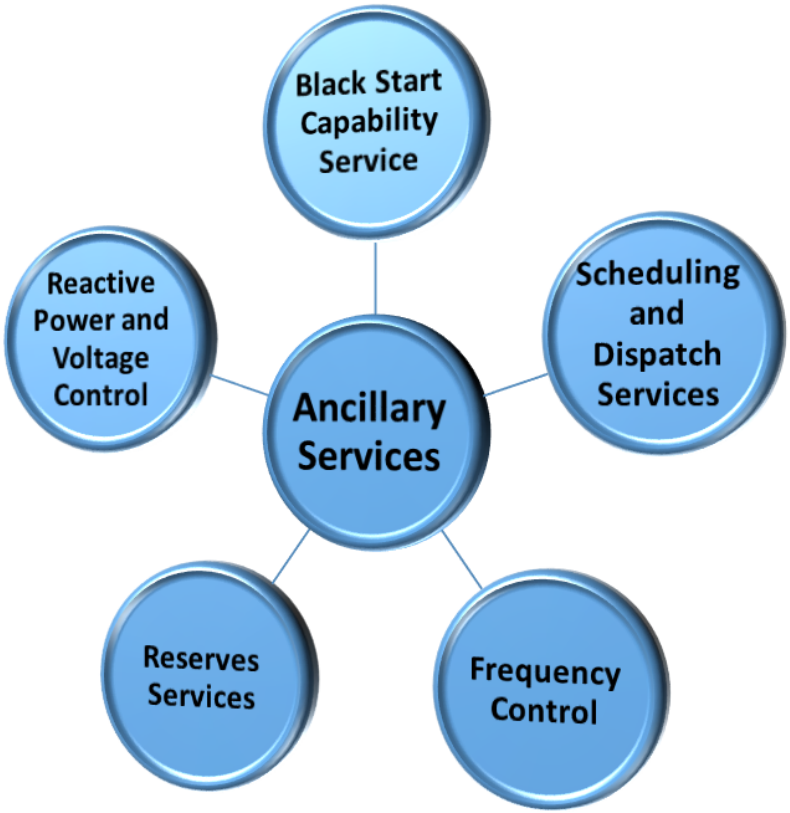

Figure: Major Ancillary Services

Frequency Control

Major Ancillary Services

Operation of ac interconnections is possible only because a balance is maintained between the supply and the demand within a control area, taking into account any scheduled interchange of power with other control areas.

The concept of area control error (ACE) has been developed as a criterion that indicates the deviation from scheduled interchange plus the frequency bias.Mathematically ACE can be written as,

Frequency Control
Major Ancillary Services

The first term in the ACE equation denotes the control area's load generation balance with the rest of the interconnection, and the second term reflects the interconnection's frequency deviation from the reference.

Primary Frequency Control

Frequency Control

When a disturbance takes place in the system, there is a mismatch in the load-generation balance and the frequency dips. The frequency dip is instantaneously followed by an increase in generation initiated by governor response.

This instantaneous generation increase combined with some frequency-dependent load reduction helps arrest any further fall in the frequency.

Without any other action, the system will operate at a new steady-state frequency that's slightly less than nominal. This is commonly known as governor regulation action or sometimes, primary frequency control.

Secondary Frequency Control

Frequency Control

To restore the system to nominal frequency, the generation set point of the unit should be re-adjusted based on the new generation-load balance.

In many instances in the US, this is done through an automatic secondary control action, known as the Automatic Generation Control (AGC) , while in most of the European countries this is achieved through manual adjustment of the supply to balance the load. This is thus referred to as secondary frequency control.

Reserves Services
Major Ancillary Services

Operating reserve in a system is a measure of its ability to increase the generation in order to take care of contingencies such as generation outage or shortfall.
The system must be in a position to respond to any such unforeseen event and to ensure that the demand supply balance is maintained.
In order to do this, the ISO must arrange for operating reserves in the system, which are capable of providing for additional generation margins with response time ranging from few seconds to several minutes, to bring into application.

Reactive Power and Voltage Control Service

Major Ancillary Services

System voltages need to be maintained within acceptable limits at all times.

In order to achieve this, the ISO has to provide a voltage control service wherein the reactive power sources including generating units can be called upon to provide the requisite support.

The amount of reactive power/ voltage control service required is determined from systems-level simulations based on the reactive power support necessary to maintain system voltages within limits.

Black Start Capability Service

Major Ancillary Services

A major breakdown of a power system is a contingency that is rare but one that nevertheless does occur.
In order to reduce the economical and social consequences it is important to restore power as fast and as securely as possible. A restoration process can be initiated with assistance from neighboring areas by tie lines or at stations with black-start capability.
Two major problems associated with the restoration process are the voltage and frequency control.

Black Start Capability Service

Major Ancillary Services

In a deregulated environment, the problem is further complicated by the presence of multiple independent generators and transmission companies.

The ISO, in addition to its other functions, is also entrusted with the responsibility of procuring black-start capability for the system and ensuring that the system is restored back to normal operating state in the shortest possible time.

Scheduling and Dispatch Services

Major Ancillary Services

This service is only applicable to systems in which the ISO performs the scheduling and dispatch functions.

The service consists of all administrative tasks required to schedule and control the functions within the boundaries of the ISO control area. Market participants are normally charged a monthly fee for this service.

This is not applicable to the bilateral contract-dominated Nordic power systems since generation scheduling is outside the purview of the ISO.

12 typical Ancillary Services

The North American Electric Reliability Council (NREC) along with Electric Power Research Institute (EPRI) has identified 12 functions as ancillary services.
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- Reactive Power and Voltage Control Support

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- Real Power Transmission Losses
- Network Stability Services from Generation Sources
- System Black Start Capability

Classification of Ancillary Services

There can be various ways of classifying the above ancillary services. One common approach would be to identify when and how frequently these services are required by the system operator. Thus, three groups can be formed:

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- Services required for routine operation
- Services required to prevent an outage from becoming a catastrophe
- Services needed to restore a system after blackout

Services required for routine operation

Classification of Ancillary Services

These are the services which the system operator requires quite frequently. Some of these may be required to provide corrective action on minute-to-minute basis. Following services can be grouped under this category:

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- Energy imbalance
- Real power loss displacement

Services required to prevent an outage from becoming a catastrophe

Classification of Ancillary Services

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, or rather; no proactive measures are required to be taken either by the system operator or the service provider on daily basis. Their effectiveness is sensed only under contingent situation. Following services fall under this category:

- Spinning reserve

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- Supplemental reserve

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- Spinning reserve
- Supplemental reserve
- Network stability services

Services needed to restore a system after blackout

Classification of Ancillary Services

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.

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Mandatory provision of ancillary services

In this approach, before a participant is connected to the grid, it has to make sure that it is in a position to provide the ancillary services mandated by the system operator. The system operator lays down the rules to be followed by the participants. The rules for the connection to the grid can be:

- The generator should be equipped with droop characteristics of 5%. This helps in frequency regulation.

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- The generator should be equipped with droop characteristics of 5%. This helps in frequency regulation.
- The generator should be able to operate in a power factor range of 0.85 lead to 0.9 lag. It should be equipped with Automatic Voltage Regulator (AVR).

Mandatory provision of ancillary services

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- The approach does not leave room for technological or commercial innovation.
- Some units may be unable to provide some of the services. For example, nuclear power plants can not be subjected to rapid changes in its output. Hence, same set of rules can not be applied to all the participants.

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Markets for Ancillary Services

The economic disadvantages and difficulty of practical implementation of compulsory services necessitates introduction of competition in at least some of the ancillary services. The preferred form of mechanism depends on the type of the ancillary service.

- Services like black start capability can be procured on long term basis. These are the services in which the amount of service provided does not change much with the time. Also, this amount does not depend on the activity of the spot market.

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- The system operator may run a separate market for regulation asking generators to submit their up and down regulation bid.
- The system operator may make a long term contract for some part of the reserve requirement, while it can obtain remaining reserve requirement through short term market mechanism.

Co-optimization of Energy and Reserve Services

Setting the price for ancillary services at the right level is not easy because the procurement of a particular ancillary service often cannot be decoupled from the procurement of electrical energy or other related services.

In the early years of competitive electricity markets, this issue was not fully understood. Energy and each type of reserve were traded in separate markets. These markets were cleared successively in a sequence determined by the speed of response of the service.

The idea was that resources that had not been successful in one market could then be offered in other markets where the performance requirements are not as demanding. Bids that were successful in one market would not be considered in the subsequent ones.

Co-optimization of Energy and Reserve Services

There is now a wide consensus that energy and reserve should be offered in joint markets and that these markets should be cleared simultaneously to minimize the overall cost of providing electrical energy and reserve.

This co-optimization is necessary because of the strong interaction between the supply of energy and the provision of reserve. To get a more intuitive understanding of this interaction, consider that to provide spinning reserve, generators must operate part-loaded.

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- The efficiency of the generators that provide spinning reserve may be less than it would be if they were running at full load. These generators therefore may need to be paid more for the energy that they provide.
- Meeting the reserve requirements will therefore increase the price of electrical energy.

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Opportunity Cost

The opportunity cost, or alternative cost, of making a particular choice is the value of the most valuable choice out of those that were not taken.

When an option is chosen from alternatives, the opportunity cost is the "cost" incurred by not enjoying the benefit associated with the best alternative choice.

The New Oxford American Dictionary defines it as "the loss of potential gain from other alternatives when one alternative is chosen."

In simple terms, opportunity cost is the benefit foregone from the next best alternative that is not selected. Opportunity cost is a key concept in economics, and has been described as expressing "the basic relationship between scarcity and choice".

Opportunity Cost

The meaning of the concept of opportunity cost can be explained with the help of following examples:

- The opportunity cost of the funds tied up in one's own business is the interest (or profits corrected for differences in risk) that could be earned on those funds in other ventures.
- The opportunity cost of the time one puts into his own business is the salary he could earn in other occupations.
- The opportunity cost of using a machine to produce one product is the earnings that would be possible from other products.
- The opportunity cost of using a machine that is useless for any other purpose is nil, since its use requires no sacrifice of other opportunities.

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England and Wales
International Aspects

The transmission grid of England and Wales is operated by National Grid Company (NGC), which is also responsible for managing ancillary services.
The costs associated with the provision of ancillary services are recovered from the consumers through uplift in transmission payment mechanism.

Voltage Control

England and Wales

Provision of this service is required from all the generation units with a capacity over 30 MW.

Voltage must be kept within the range of Vnom+- 10% for 400, 275 and 132 kV networks and the power factor (PF) between 0.85 capacitive and 0.95 inductive.

The main costs associated with this service correspond to capacity and operation.

Frequency Control
England and Wales

The system operator (SO) is required to keep the frequency between 49.5 and 50.5 Hz. In the case of a contingency, the frequency is allowed to drop under 49.5 Hz, but for not more than 1 minute.

Primary Frequency Control

Frequency Control

The supply of primary frequency regulation is mandatory for all the generators with an installed capacity of over 50MW, which must provide the service in continuous time. Generators are set for a droop of 3–5%.

Large consumers can provide primary frequency regulation through load shedding, where a response period of 10 s and a duration period of 20 s are required.

The costs associated with the service are generally traded through annual bilateral contracts.

Consumers pay for this service through an increase in their electricity payment which includes capacity, operation and compensation.

Secondary Frequency Control

Frequency Control

The service of secondary frequency regulation is considered as a commercial service and it is not considered as a mandatory provision. Generators provide it using AGC.

For those that provide the service, a response time of 30 s and a duration period of 30 min are required.

As in the previous case, the costs associated with this service are difficult to identify, and they are traded based on annual bilateral contracts and competitive auctions.

Nordic Countries
International Aspects

Ancillary services are traded in a real-time market managed by the transmission system operators. The costs associated with ancillary services are directly transferred to the users through the transmission payment.

Voltage Control
Nordic Countries

The local provision of voltage control and reactive power is mandatory for all the system generators.
A response time of 5 s is required and the service must be supported for the period that is needed.
The costs associated with the service are low, since the provision is in charge of the hydraulic generators, and the transaction mechanism corresponds to annual contracts at a fixed price.

Frequency Control
Nordic Countries

The system frequency is required to be within the range of 49.5 and 50.5 Hz.
The service of primary frequency regulation must be provided within 30 s after being requested by the system operator and must be supported for the period that is needed.
The required quantity is locally calculated in every country. This is an obligatory service for all the generation units, where they are required to keep a droop between 2 and 5%. The transaction mechanism corresponds to annual contracts. The suppliers get a payment for capacity and other for operation, and the consumers pay through the transmission tariff.

Frequency Control
Nordic Countries

The service of secondary frequency regulation is only considered an ancillary service when it is provided in the case of a contingency.
For this service, a response time of 15 minutes and a minimal provision period of 4 hours is required. The costs associated with secondary frequency regulation are minor, since this provision is in charge of hydraulic generators.
The provision is assured through competitive offers. The consumers pay through the transmission tariff.

California, USA
International Aspects

After the power market crisis of 2001, the Californian ISO (CAISO) redesigned its electric energy market. It then introduced the concept of available capacity (ACAP), whose objective is to allow the ISO to verify in advance the availability of enough resources to satisfy the customer load as well as reserves.
In the new market structure, the energy market, the ancillary service market and the congestion management market are jointly optimized.

Voltage Control
California, USA

In the California system, the ISO procures reactive power support services on long-term contracts from reliable must-run generating units.
The actual short-term requirement is determined on a day-ahead basis, after the real power market is settled and the energy demand and schedules are known.
Thereafter the ISO determines the location-wise amount of reactive power required based on system power flow analysis.
The generators are mandated to provide reactive power within the power factor range of 0.90 lag to 0.95 lead.

Frequency Control
California, USA

Primary frequency regulation and secondary frequency regulation are not mandatory services. There exists up and down service regulation. The costs associated with this service correspond to capital, operation, fuel, and reduced efficiency costs, etc. For secondary frequency regulation, the service must be available in 10 min and should be supported for at least 2 hours.
The system operator calculates the quantity required of the service according to a criteria that takes care of demand and contingency. The quantity required generally comes close to 3% of the maximum demand of the system

New York, USA
International Aspects

In the New York control area, ancillary services are provided by the New York ISO (NYISO) or procured by the transmission customers and suppliers themselves.
The NYISO coordinates the provision of all ancillary services and directly arranges for those services that are not self-supplied.
Depending on the nature of the services, either market-based or embedded cost-based prices are used to price these services.

Voltage Control
New York, USA

Generating resources, which operate within their capability limits, are directed by NYISO to produce / absorb reactive power to maintain voltages within their limits. The pricing method for the reactive power support service is an embedded cost. The cost of reactive power support includes the following:

- The total annual embedded cost for payment.
- Any applicable lost opportunity cost to provide reactive power service.
- Total of prior year payments to suppliers of reactive power service less the total of payments received by the NYISO from transmission customers in the prior year for reactive power service.

Frequency Control
New York, USA

This service is accomplished by committing on-line generators, predominately through the use of automatic generation control, to follow moment-to-moment changes in load.
Regulation service is bid into the market by individual units that have AGC capability and that wish to participate in the regulation market. Bid information includes regulation response rate (MW/min) and regulation availability rate ($/MW).

Australia
International Aspects

Initially, the ancillary services were traded through long term bilateral contracts between National Electricity Market Management Company (NEMMCO) and the service suppliers.
Since 2001, frequency control ancillary services are traded in competitive spot markets.

Voltage Control
Australia

The energy code of Australia requires the power factor to be between 0.9 inductive and 0.93 capacitive.
Optionally, generators can produce and absorb reactive power or operate the generation unit as a synchronous condenser. The service provision is managed through annual bilateral contracts.

Frequency Control

Australia

In this service, it is expected that the system's frequency varies only in the range of 50 +- 0.1 Hz. The system operator can request additional amounts of primary frequency regulation, up or down.
A response period from 6 to 60 s is required and the service should be supplied during 90 s. Generators with AGC are in charge of the service provision which is managed through annual bilateral contracts.
The suppliers get payments for enabling and compensation. Secondary frequency regulation is provided by generators, load shedding or fast connection generation units.
This service is required in a period of 5 min and the period by which the service should be supplied is not specified. The provision of the service is managed through annual bilateral contracts. Payments are carried out for enabling and compensation.

Thank you!