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Road Map to Develop Ancillary Services Model for Indian Electricity Scenario

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In electricity industry, ancillary services are complimentary services that interact the production of energy. Specifically, ancillary services are those functions performed by power systems with regards to generation, transmission and distribution of electricity to facilitate technical and commercial transactions. These services are provided by the same equipment that generate and transmit electricity in support of the main services of electric energy. Despite considerable costs of ancillary services, these services are important for bulk-power reliability as well as for the support of commercial transactions. In power markets, the availability of sufficient ancillary services makes power systems reliable and transactions deliverable.

- **Ancillary Services in Deregulated Electricity Markets**

Ancillary services are defined as all those required for the reliable delivery of electricity. Ancillary services can be broadly grouped under one of the three major categories, (i) Frequency Control Ancillary Services (FCAS), (ii) Network Controlled Ancillary Services (NCAS), and (iii) System Restart Ancillary Services (SRAS). Classification details of ancillary services have been shown in fig.1.

Maintaining the frequency at its target value requires that the active power produced and/or consumed be controlled to keep the load and generation in balance. A certain amount of active power, usually called *frequency control reserve*, is kept available to perform this control. The *positive frequency control reserve* designates the active power reserve used to compensate for a drop in frequency. On the other hand, the deployment of *negative frequency control reserve* helps to decrease frequency during off peak hour. Three levels of controls are generally used to maintain this balance between load and generation. Primary frequency control is a local automatic control that adjusts the active power generation of generating units and the consumption of controllable loads to restore quickly the balance between load and generation which counteracts frequency variations. In particular, it is designed to stabilize the frequency following sudden outages of generation or load. It is thus indispensable for the stability of power systems. All the generators that are located in a synchronous zone and are fitted with a speed governor perform this control automatically. The demand side also participates in this control through the self-regulating effect of frequency-sensitive loads such as induction motors or the action of frequency-sensitive relays which disconnect or connect some loads at given frequency thresholds. The provision of this primary control is subject to some constraints. Some generating units that increase their output in response to a frequency drop can not sustain this response for an infinite period of time. Their contribution must therefore be replaced before it runs out. Secondary frequency control is a centralized automatic control that adjusts the active power production of the generating units to restore the frequency and interchanges with other systems to their target values following an imbalance. In other words, while primary control limits and stops frequency excursions, secondary control brings the frequency back to its target value. Only the generating units that are located in the area where the imbalance originated should participate in this control. Note that loads generally do not participate in secondary frequency controls. This type of control mechanism is termed as load frequency control (LFC) or automatic generation control (AGC). Tertiary frequency control refers to manual changes in the dispatching and commitment of generating units. This control is used to restore the primary and secondary frequency control reserves, to manage congestions in transmission network, and to bring the frequency and the interchanges back to their target values. Some aspects of tertiary control relate to the trading of energy for balancing purposes.

The overall task of regulating the voltage can be organized into a three level hierarchy as shown in fig.1. Primary voltage control is a local automatic control that maintains the voltage at a given bus (at the generating bus) at its set point. Automatic voltage regulator (AVR) fulfills this task. Other controllable devices, such as static voltage compensators (SVC), can also participate in this primary voltage control. Secondary voltage control is a centralized automatic control that coordinates the actions of local regulators in order to manage the injection of reactive power within a regional voltage zone. Tertiary voltage control refers to the manual optimization of reactive power flows across the power system.

Power flow control ancillary services (PFCAS) are provided to maintain the power flow through an interface within the physical limit. This can be done by placing some FACTS controllers, and which must be compensated based on it usage.

System restart ancillary services (SRAS) are reserved for contingency situations in which there has been a whole or partial system blackout and the electrical system must be restarted.

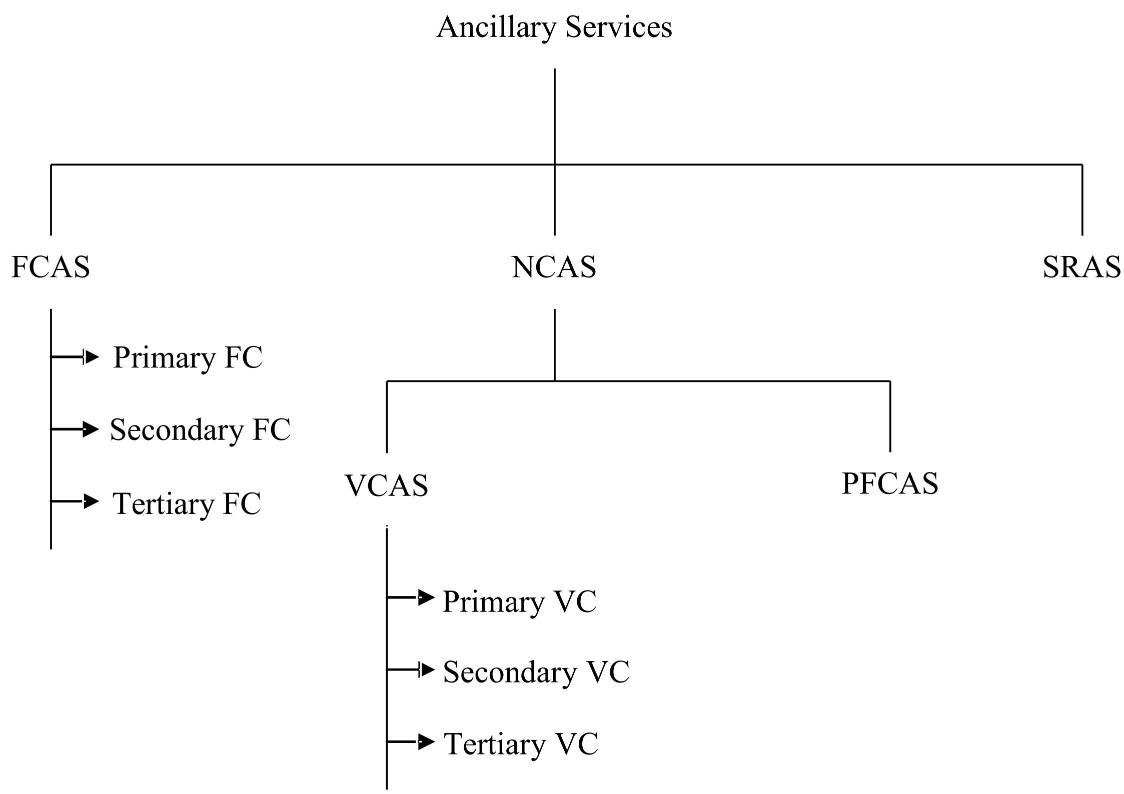

Fig 1: Classification of ancillary services

System operator can acquire ancillary services through two procurement methods: compulsory provision and market based (bilateral contracts, tendering and spot market) provision.

Compulsory provision means that a certain class of network users (typically large generators) is required to provide a fixed amount of a given ancillary services, upon request from TSO (when system operator owns the transmission system) as part of their connecting conditions. This simplified provision has two main consequences. First, the volume of ancillary services provided may exceed what is actually needed, imposing unnecessary costs on the providers. Second, compulsory provision does not necessarily minimize costs, because potentially low cost providers are treated on the same basis as more expensive ones.

When a TSO procures an ancillary service using bilateral contracts, it negotiates with each provider the quantity, quality and price of the service to be provided. Such negotiations remove the two problems associated with compulsory provision. However bilateral contracts have disadvantages. First, since their terms are usually not disclosed to third parties, this form of procurement lacks transparency. Second, bilateral negotiation can be long, complex and costly. Third, because of high transaction cost of bilateral contracts, price and volume are often fixed for a long time. This will inevitably be detrimental to one of the parties if market conditions change.

The third and fourth procurement methods involve the development of a tendering process or the creation of a spot market. Drawing a line between these two methods is not always easy. Both methods enhance transparency and foster competition. On the down side, they have high data management costs and may facilitate the exercise of market power by some participants.

- **Prevalent Ancillary Services Provision in Indian Electricity Industry**

In present Indian electricity scenario, the provision of ancillary services are either embedded with real power supply or made with certain regulatory basis. Availability based tariff (ABT) mechanism provides frequency linked incentives/penalties to beneficiaries/suppliers. In the ABT, a two part tariff is supplemented with a charge for unscheduled interchange (UI) for the supply and consumption of energy in variation from the pre-committed daily schedule and depending on grid frequency at that point of time. Hence, the compensation for frequency control has been made embedded with the real power tariff structures. Frequency control ancillary service by UI mechanism has been provided through a spot market which determines the price by using an incentive/penalty based approach designed by Central electricity regulatory commission (CERC).

Similarly, for provision and control of reactive power, certain fixed price has been charged. According to Indian Electricity Grid Code (IEGC) prepared by CERC, (i) beneficiaries pays for VAr drawal when voltage is below 97% at point of drawal, (ii) beneficiaries pays for VAr return when voltage is above 103% at point of return, (iii) beneficiaries gets paid for VAr return when voltage is below 97% at point of return, and (iv) beneficiaries gets paid for VAr drawal when voltage is above 103% at point of drawal. The charges/payment for VArs have been made at a nominal paise/kVArh rate as may be specified by CERC from time to time, and was between beneficiaries and regional pool account for VAr interchanges.

- **Proposed Ancillary Services Model in an Envisioned Indian Electricity scenario**

With the emergence of unbundling in electricity supply industry (ESI), Indian power sector was on the verge of restructuring process during nineties. Enactment of Electricity Act 2003 paved the way for stimulating competition in bulk as well as retail power markets with de-licensing of thermal generations, open access and multiple licensing. The envisioned market structure is as shown in fig 2.

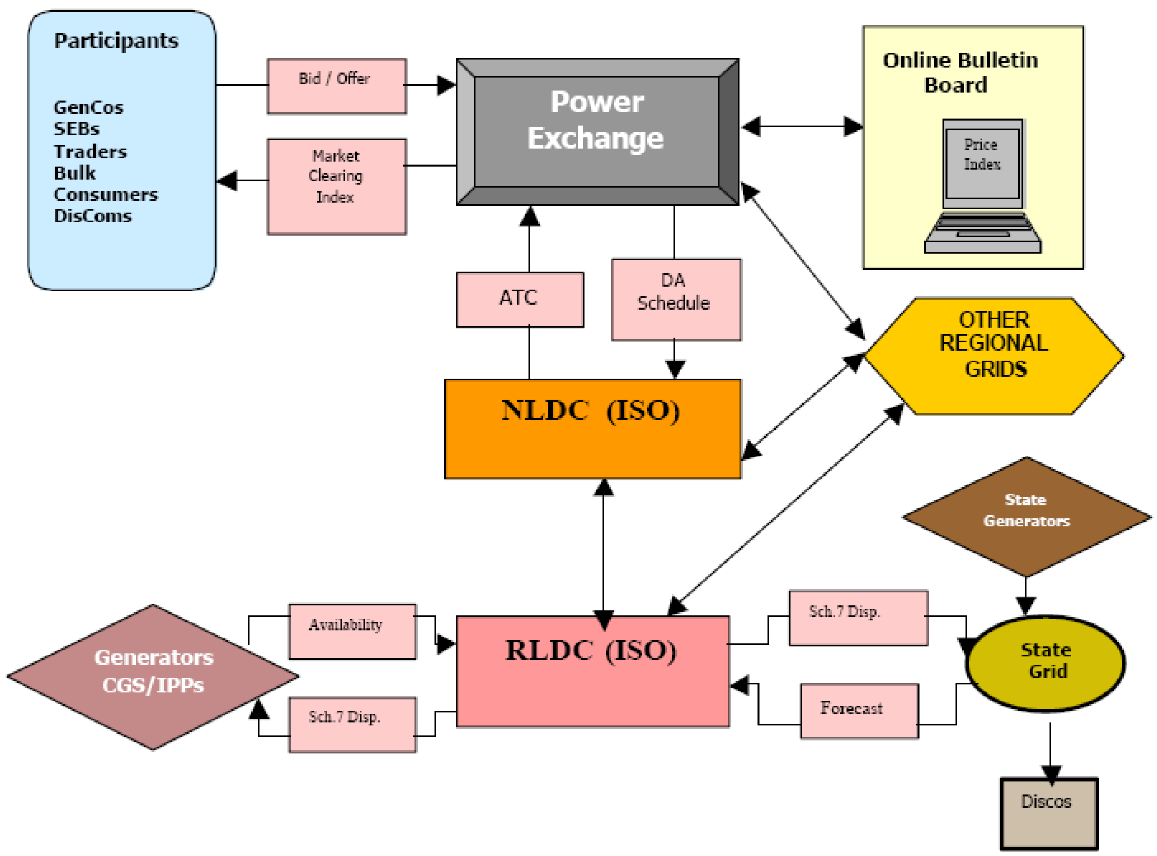

Fig 2: An envisioned Indian power market scenario.

Though UI mechanism is the most reliable existing balancing mechanism suitable for Indian electricity scenario, in addition certain market mechanism will encourage the participation of suppliers (GENCOs, CPSUs, pvt. licensees, IPPs, CPPs), beneficiaries (DISCOs, pvt. licensees) and transmission operators (CTUs, STUs, pvt. licensees) in providing ancillary services. Fixed price mechanism towards reactive power pricing never considers the actual cost incurred or lost opportunity for VAr generation from different devices. Therefore, it is necessary to formulate a market based mechanism for VAr management.

In the design of an ancillary services market there are a number of choices that can be considered.

- The time frame for market can be short term or long term.
- The market can be bilateral or competitive bid based.
- The procurement can be sequential or simultaneous.
- Settlement rules can be: price based on bid type, price based on usage type, marginal price or pay as bid.
- Recovery (charging) can be: energy uplift, use of system charge or other methods.

With the emergence of a decentralized model as shown in fig 2, national power exchange (PX) will be formed along side RLDCs and SLDCs as system operators (SOs) to plan and provide ancillary services taking into account all the market participants. The following are the proposals towards designing ancillary services model for Indian power industry.

- Bid based reserve market model can be designed to provide primary and secondary frequency control at regional level as well as national level along side the day ahead (DA) main market.
- Some balancing market mechanism can be devised to provide tertiary frequency control, which must clear just before the real time dispatch of energy.
- Some kind of incentive/penalty based localized VAr spot market model can be devised by considering the incurred and lost opportunity cost for producing reactive power from different devices.

Deliverables that can be obtained from this research work is as follows.

- Development of suitable reserve market model for Indian power industry scenario.
- Development of real time balancing market mechanism and its comparison with UI mechanism.
- Assessing the suitability of zonal reactive power market model for Indian electricity scenario.