Ancillary Services in India- Evolution, Implementation and Benefits

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***Abstract* — This paper discusses the evolution, implementation and benefits of Ancillary Services Operations in Indian Electricity Market. The authors present the core principles of Ancillary Services Operations as introduced by the Central Electricity Regulatory Commission (CERC) along-with the implications on the stakeholders of the Indian electricity market. The authors have analyzed the benefits of the Ancillary Services Operations in terms of secure and reliable grid operation, renewable energy integration, frequency support, utilization of un-despatched surplus and congestion management.**

Keywords—Ancillary Services, Indian Electricity Market, Renewable Integration, Power system Operation

I. Introduction

Ancillary Services have been an integral part of the electricity ecosystem all over the world. The basic services such as frequency and voltage control are embedded in the electricity supply system, starting from power generation at generator end, transmission to the load centre and lastly, power delivery to all the consumers. To enable provision of these basic services, specific support services are required to complement reliable and efficient grid operation. These support services which act as "Value-added Services" are known as 'Ancillary Services' as depicted in Figure 1. These services are procured and despatched by the System Operator.

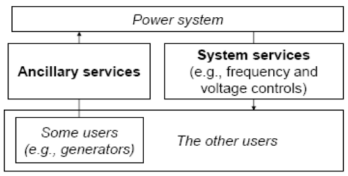

Figure 1: System Services and Ancillary Services[1]

The definition of Ancillary Services pertinent to the Electricity Industry as given by Eric Hirst and Brendon Kirby [1] is quoted below:

"*Ancillary services are those functions performed by the equipment and people that generate, control, transmit, and distribute electricity to support the basic services of generating capacity, energy supply, and power delivery.*"

Ancillary Services consist of services required for maintaining load – generation balance (frequency control), maintaining voltage and reactive power support and maintaining generation & transmission reserves.

Historically, ancillary support services were provided by the vertically integrated utilities along with the energy supply services. With the advent of unbundling process and private sector participation, as the number of Utilities has increased manifold, the System Operator is now responsible for procuring such services (either regulated or through Market), so as to ensure reliable and secure grid operation. Hence, it has become necessary to define measure and pay for these services.

II. Evolution of Ancillary Services in India

CERC Indian Electricity Grid Code Regulations, 2010 (IEGC) define Ancillary Services as below:

"…Regulation 2(1) (b)

Ancillary Services" means in relation to power system (or grid) operation, the services necessary to support the power system (or grid) operation in maintaining power quality, reliability and security of the grid, eg. active power support for load following, reactive power support, black start etc.;…"

CERC (Unscheduled Interchange) Regulations, 2009 mandated NLDC to provide Ancillary Services. In this direction, in 2010, an Approach Paper on Ancillary Services in Indian Context [2] was submitted by National Load Despatch Centre (NLDC) to CERC, which in turn, directed for stakeholder consultations on the approach paper.

The approach paper proposed three major categories of Ancillary Services namely Load Generation Balancing Service, Network Control Ancillary Services and System Restart Ancillary Services. The paper recommended the use of undespatched generation in the form of un-requisitioned surplus (URS). Also, utilization of peaking gas power plants and pumped storage hydro generating stations was envisaged for providing load generation balancing service as well as Power Flow Control Ancillary Service. Further, the use of hydro stations as synchronous condenser for providing reactive power support and introduction of black start as an ancillary service for hydro, gas and combined cycle stations which have black start capability was deliberated.

In March 2012, CERC Central Advisory Committee (CAC)[3] expressed the need for introduction of ancillary services in India for better security and reliability of grid operation, after due deliberation amongst the stakeholders. In this direction, a national level workshop was organized in June, 2012 by the Forum of Load Despatchers (FOLD) [4] to

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explain the various aspects of ancillary services mechanism in Indian context to the stakeholders.

In 2013, CERC floated staff paper on "Introduction of Ancillary Services in Indian Electricity Market" [5]. The staff paper discussed about the types of Ancillary Services such as the real power support services or Frequency Support Ancillary Services/ Load following, Voltage or reactive power support services and Black start support services. It was envisaged that the generators having surplus capacity, (i.e. either un-requisitioned surplus capacity by the beneficiaries of that capacity or generators who could not sell their capacity in the market and/or surplus captive capacity) may be allowed to bid into the power exchange, in a separate market segment.

Pursuant to above, CERC floated draft Regulation on Ancillary Service operation in May, 2015 inviting stakeholder suggestions. Some apprehensions were raised by the stakeholders regarding triggering criteria, eligibility of generators, minimum dispatch certainty, pricing considerations, payment security mechanism and incentive & penal provisions etc. There were also reservations from state utilities on implementation of Ancillary Services with the major concern being that it would lead to operation of costly plants leading to rise in electricity prices.

After stakeholder consultations, CERC decided that, in order to meet current requirement, tertiary frequency control through utilization of un-despatched surplus capacity available in generating stations at the inter-state level, whose tariff is determined/adopted by CERC, may be introduced as Reserve Regulation Ancillary Service (RRAS).

Variable cost of RRAS provider will be considered for merit order despatch. To facilitate Congestion management, transmission constraints (both inter-regional and intra-regional) are considered during despatch of RRAS thereby effectively making this a 'security constrained economic despatch'. Both fixed charges and variable charges are to be paid to the RRAS providers, which in turn refunds the fixed charges to the original beneficiary in proportion to the power surrendered. The refund of fixed charges to the beneficiary(ies) and mark-up paid to the RRAS provider act as an incentive for the beneficiaries and the RRAS providers respectively.

Ministry of Power, Government of India constituted Technical Committee on Large scale integration of Renewable Energy, Need for Balancing, Deviation Settlement Mechanism and other associated issues. The Committee in its report [6] also recommended that Ancillary Services need to be put in place as they provide a framework for operationalizing the spinning reserves, address congestion management issues and facilitate optimization at Regional & National Level and thereby facilitate integration of renewables too. Tariff Policy has been also amended in January 2016, which mandates the implementation of Ancillary Services.

CERC (Ancillary Services Operations) Regulations were notified on 13th August, 2015[7]. CERC, in February, 2016, set the mark-up for participation in Regulation 'Up' RRAS at 50 paise/kWh. The Detailed Procedures were also approved by CERC. Thus, with active support provided by way of policy initiatives by the Ministry of Power and the requisite regulatory framework by CERC, the Ancillary Services were launched by the Nodal Agency i.e. NLDC in coordination with RLDCs on 18th April, 2016.

III. Salient Features of Ancillary Services in India

All the Generators, that are Regional Entities, and whose tariff for the full capacity is determined or adopted by the CERC have been mandated to provide Ancillary Services as RRAS Providers.

NLDC, through the RLDCs, has been designated as the Nodal Agency for Ancillary Services Operations. The Nodal Agency prepares the Merit Order Stack based on the variable cost of generation.

The Triggering Events for Ancillary Services despatch have been defined in the Regulations such as extreme weather /special day, generating unit or transmission line outages, trend of load met and frequency, any abnormal event such as outage of hydro generating units due to silt, etc., excessive loop flows, trend of computed Area Control Error (ACE) at regional level, and recall by the original beneficiary.

A Virtual regional entity called "Virtual Ancillary Entity (VAE)" has been created in the respective Regional Pool for scheduling and accounting. The quantum of RRAS instruction, by the Nodal Agency, is being directly incorporated in the schedule of RRAS providers.

The RRAS instruction may be scheduled to the VAE in any one or more Regional Grids. The deviation in schedule of the RRAS Providers, beyond the revised schedule, is being settled as per the CERC Deviation Settlement Mechansim (DSM) Regulations. The energy despatched under RRAS is deemed delivered ex-bus.

Nodal Agency directs the RRAS Provider to withdraw RRAS, on being satisfied, that the circumstances leading to triggering of RRAS Services have been normalized.

The RRAS Energy Accounting is being done by the respective Regional Power Committee (RPC) on weekly basis along with DSM Account, based on interface meters data and schedule. A separate RRAS statement is being issued by RPC along with Regional DSM Account. Any post-facto revision in rates/charges by RRAS providers is not permitted.

In case of RRAS Up, fixed and variable charges are payable to the RRAS providers from the pool. In case of RRAS Down, 75 percent of the variable charges are payable by RRAS providers to the pool and fixed charges are reimbursed by RRAS providers to the original beneficiaries.

It has been stipulated in the Regulations that no commitment charges would be payable to the RRAS providers. There are penalties for sustained failure to provide RRAS and violation of directions of RLDC.

IV. RRAS Despatch Mechanism

Nodal Agency i.e. NLDC has indigenously developed the Web-based Reserve Regulation Ancillary Services software application (Figure 2). The Declared Capability (DC),

Schedule, Un-despatched power (DC – Schedule or URS), Technical Minimum, Minimum Run Time, module capacity and Schedule under Ancillary Services have been made available for each RRAS Provider through the web based portal of the Nodal Agency/concerned RLDC.

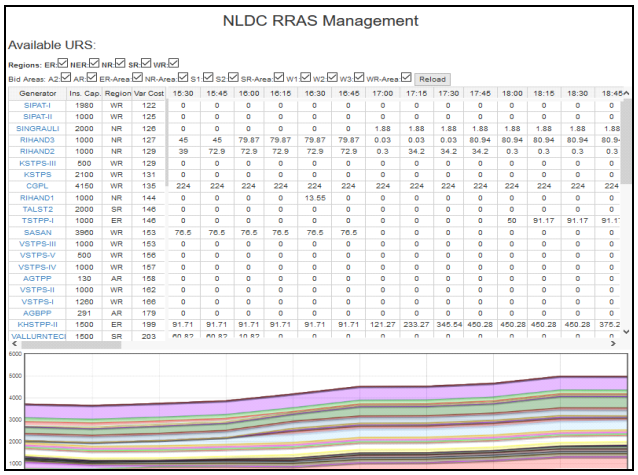

Figure 2: Nodal Agency Web Based Portal

The RRAS providers are stacked based on the variable cost. Available reserves over the next few hours are monitored (Figure 3). The System Operator personnel visualize the requirements for Ancillary services despatch based on the information available at the Control Room SCADA screen depicted in Figure 4.

System operator is taking cues from the weather forecast, historical frequency profile, load forecast, hot & cold reserves along with real time system conditions while taking RRAS despatch decisions. After confirmation with the triggering criteria, Regulation Up/Down despatch instructions is given to the concerned RRAS Providers, through the respective RLDCs, for further action.

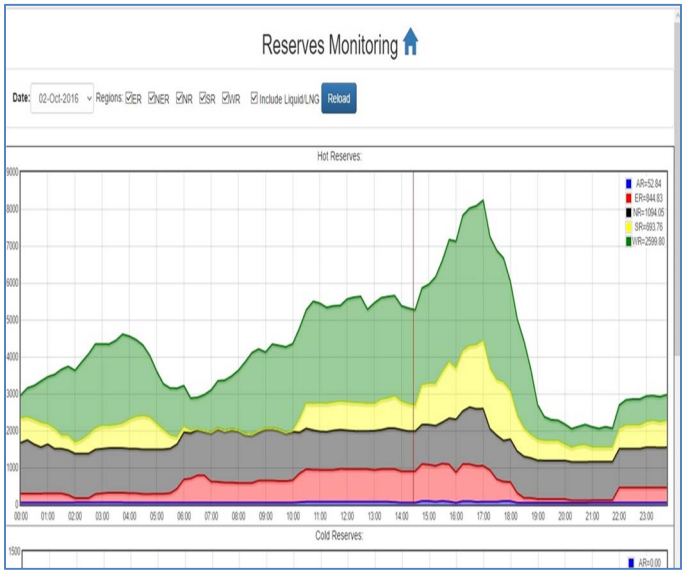

Figure 3: SCADA Display of RRAS Providers Stack

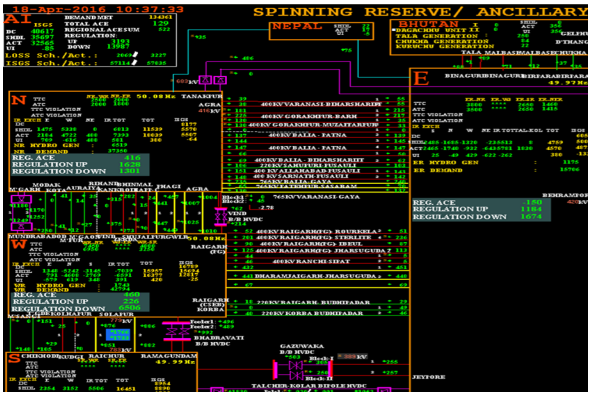

Figure 4: SCADA Display of Ancillary Services

V. Implementation Experience

A. *Extreme Weather Conditions - 23rd May, 2016*

- *00:00 to 07:30 hrs, Regulation Down*
- *08:30 to 11:15 hrs, Regulation Down*
- *13:30 to 16:15 hrs, Regulation UP*
- *18:45 to 24:00 hrs, Regulation Up*
- Effect of RRAS: Frequency Improvement [Fig. 5]

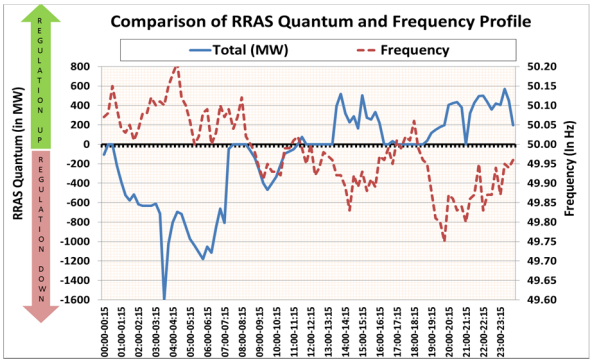

Figure 5: RRAS Quantum and Frequency Profile

B. *Relieving Inter-Regional Congestion – 18th May, 2016*

- *765 kV Agra-Gwalior I line shutdown*
- *12:30 to 16:30 hrs.*
- *Regulation Up Northern & Eastern Region - 300 MW*
- *Regulation Down in Western Region - 500 MW*
- Effect of RRAS: Relieving Congestion[Fig. 6]

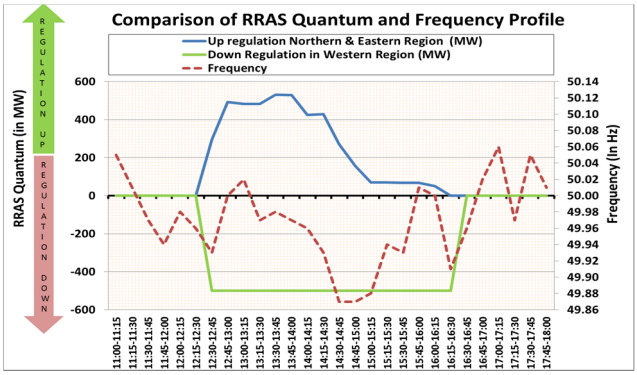

Figure 6: RRAS Quantum and Frequency Profile

C. Low Frequency – High Demand - 26th April, 2016

- *11:00 To 11:45 hrs, Regulation UP - 439 MW*
- *12:30 to 13:00 hrs, Regulation UP - 395 MW*
- *Effect of RRAS: Frequency improvement*[Figure 7]

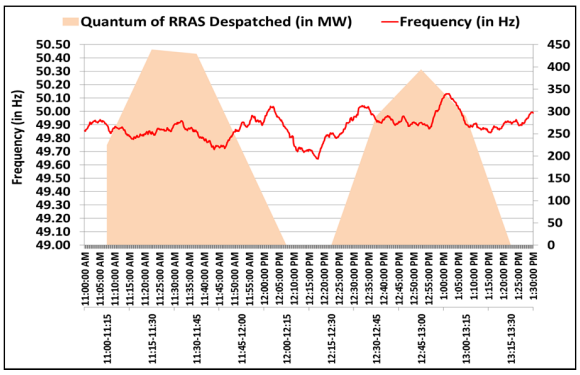

Figure 7: RRAS Quantum and Frequency Profile

D. HVDC Pole Tripping - 28th April, 2016,

- *RRAS despatch : 14:45 To 17:00 hrs,*
- *Regulation UP - 300 MW*
- Effect of RRAS: Frequency improvement[Figure 8]

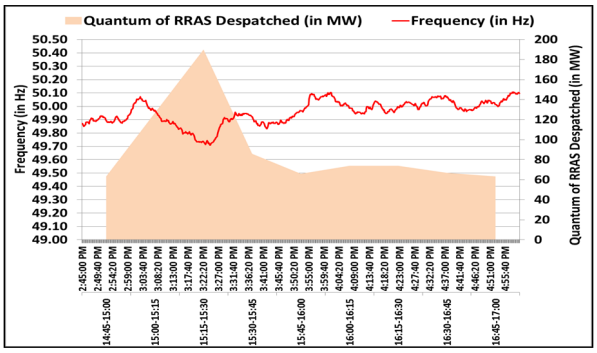

Figure 8: RRAS Quantum and Frequency Profile

E. Despatch of RRAS from April –September, 2016

A total of 988 RRAS UP instructions and 220 RRAS DOWN instructions were given by Nodal Agency to more than 50 Nos. RRAS Providers. The maximum RRAS UP quantum was 3273 MW and the maximum RRAS DOWN quantum was 1946 MW (Figure 9).

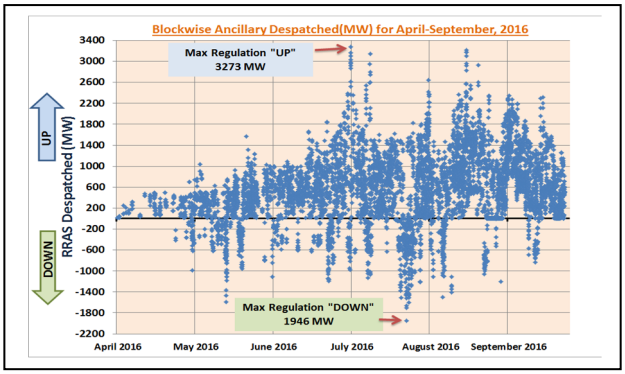

Figure 9: Block-wise Ancillary Despatched

VI. Ancillary Services – System Operators' Tool

A. Secure and Reliable Operation of All India Synchronous Grid

In December, 2013, the Southern Grid was synchronized with the NEW Grid, thereby making one synchronous system pan-India. The enhanced interconnection capacity has facilitated economy interchange across regions. The cheaper power from the surplus regions is replacing costlier power in the deficit regions. Therefore, RRAS has aided system operator to ensure secure and reliable grid operation by facilitating flexible operation in existing conventional generation fleet without any additional CAPEX.

B. Renewable Energy Integration

Renewable energy generation is variable in nature (diurnal & seasonal). RRAS acts a tool in the hands of system operator to manage the variability of renewable generation, presently concentrated in certain parts of the country. Other suitable mechanisms like more frequent market iterations and clearing with new market products are also required. Also, Pumped Storage Plants, which can be dispatched through Ancillary Services, are required for balancing renewable sources of energy.

C. Frequency Control Support Service

RRAS has facilitated the reduction of the frequency fluctuations within the IEGC stipulated band. However, RRAS alone may not ensure stability in the real time system frequency. This underlines the necessity of primary and secondary frequency controls in the system.

D. Utilization of Un-despatched Surplus in Inter-State Generating Stations (ISGS)

Presently, generation in some of the ISGS is not getting dispatched as it is not being requisitioned by the beneficiaries based on merit order considerations. Figure 10 illustrates the URS available in ISGS Stations for the period 1st April, 2014 till 31st March, 2016.

As per CERC Regulations, the despatch of such un-requisitioned surplus in particular ISGS can be done through RRAS if the beneficiaries of that ISGS do not requisition power. The generator can also sell the un-requisitioned power in the electricity market. Hence, utilization of URS of ISGSs through RRAS equips the system operator with a tool to have secure and reliable grid operation, particularly, for frequency support and congestion management.

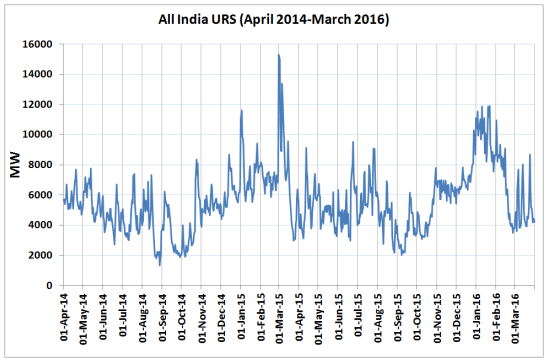

Figure 10: All India URS (1st Apr, 2014 till 31st Mar, 2016)

E. Congestion Management

One of the objectives of Ancillary Services in India is to relieve congestion in the transmission network. Inter-regional and intra-regional congestion are being considered while dispatching the RRAS and, segregate the merit order stack on a region-wise/bid-area wise basis as per the anticipated congestion. It will bring in more economy & efficiency in grid management with the help of both regulation up and regulation down service in case of Contingencies.

F. Regulatory framework for Reserves

Section 5.2.3 of the National Electricity Policy (NEP, 2005) specifies a 5% spinning reserve requirement at the national level. CERC issued the Roadmap to operationalize Reserves in the country vide order dated 13th October, 2015 [8]. The salient features are as follows:

- Grid operators to have access to Spinning Reserves
- Mandates Primary Reserves as well as Automatic Generation Control (AGC) for enabling Secondary Reserves.
- All generating stations that are regional entities must plan to operationalize AGC along with reliable telemetry and communication
- Communication infrastructure must be planned by the CTU and developed in parallel, in a cost-effective manner.
- NLDC/RLDCs/SLDCs would need technical upgrades as well as operational procedures to be able to send automated signals to these generators
- Regulated framework to be evolved for identification and utilizing of spinning reserves
- In the long term, a market based framework is required for efficient provision of secondary reserves from all generators across the country.
- The States must undertake separate scheduling and energy accounting of all generating and load entities.

VII. International Experience

A. Brazil

The types of Ancillary Services that are regulated by ANEEL –Agência Nacional de Energia Elétrica (the Brazilian Electric Energy Agency) [9], and provided in the Brazilian Interconnected Power System are:

- Primary and Secondary frequency control
- Primary and Secondary power reserve
- Prompt reserve
- Reactive power support
- Black start
- Special Protection System (SPS)

These services are provided mainly by Generation Agents and reimbursed through the Ancillary Services Agreement (ASA).

These contracts refund the Agents fixed costs and variable costs (O&M) for extending the provision of such Ancillary Services.

B. Australia

The various ancillary services in the Australian National Electricity Market [10] are:

- Frequency Control Ancillary Services (FCAS): Regulation Raise and Lower Services correct the supply and demand balance in response to minor deviations in demand or generation. Contingency frequency control services are provided for correcting the supply-demand balance following a major imbalance event, such as the failure of a generating unit or transmission line
- Network Control Ancillary Services (NCAS):There are two types – voltage control (usually through generators with automatic voltage regulators (AVC) and synchronous condensers) and network loading control
- System Restart Ancillary Services (SRAS)

C. United Kingdom

Ancillary and "Other Services" are part of the Balancing Mechanism and are procured from both authorized electricity operators (AEOs), who own and operate generators, and other commercial entities, generally load customers or aggregators with backup generators and demand response resources. Size eligibility requirement is 3 MW or more for any individual load. Customer loads are only eligible to provide frequency response and reserve services, either as a direct customer or as part of a load block aggregated by a retail provider.

National Grid Company (NGC) [11] whenever possible seeks competitive procurement of ancillary services. NGC selects the lowest cost bid meeting the contract requirements. NGC negotiates bilateral contract with individual service providers for services with insufficient competition.

D. California ISO-United States of America(USA)

After managing congestion and allocating transmission, the California ISO [12] conducts a day-ahead market for four ancillary services, regulation, spinning reserves, non-spinning reserves, and replacement reserves.

- The ISO procures regulation services from generators that are equipped to respond to its automatic generation control (AGC) signals. These signals direct generators to increase or reduce generation on a minute-to-minute basis so that system frequency is maintained within a range dictated by reliability considerations.
- Spinning reserves are on-line and synchronized with the system so that they can begin producing power as soon as they are called upon.
- Non-spinning reserves are offline but are fully available within ten minutes.
- Replacement reserve is capacity that can be delivered as energy within one hour.

Suppliers submit bids for these four markets with their day-ahead energy schedules, offering both a capacity

and an energy bid. Winning bidders are chosen solely on the basis of their capacity bids; the energy bids are used to determine whether the plant will be run in the real-time spot market.

The ISO resolves the four ancillary service markets in sequence, procuring regulation first and replacement reserves last. Thus, suppliers do not need to decide in advance which ancillary service they would like to offer. Ancillary services costs are allocated pro-rata based on the scheduling coordinator's load and resource mix.

VIII. Conclusion

With the introduction of ancillary services, all the four pillars of the market design i.e. imbalances, congestion management, ancillary services and scheduling and despatch [13] have been implemented in the India.

Ancillary Services has been implemented through an *"Indianized"* solution and envisages harnessing of un-requisitioned surplus in ISGS, addresses congestion management issues and facilitates optimization at Regional & National Level [14] and thereby facilitates integration of renewables too.

Several challenges have been faced in the implementation of the Ancillary services such as 'gate closure' in the scheduling process, mandating the quantum of reserves to be maintained, better load & renewable forecasting, need to be addressed. The next step is to bring hydro power plants under the ambit of RRAS and finally, co-optimization of day-ahead de-centralized scheduling and real time centralized RRAS despatch.

In future, a market based Ancillary Services framework may be considered thereby facilitating inclusion of IPPs, wind and solar power plants, etc. under RRAS.

Further, with increasing penetration of renewables, a similar mechanism for reserves and ancillary services needs to be implemented in the states. In this direction, FOR approved Report on Scheduling, Accounting, Metering and Settlement of Transactions in Electricity (SAMAST) [15] for intra-state accounting and settlement system. It recommends demarcation of Interface boundary & identification of Pool Members, adequate Interface Energy Meters (5-min) with AMR infrastructure, sacrosanct Ex-Ante Schedule, energy book keeping in line with the basic accounting principles, simple, robust, scalable but dispute-free Settlement System, administration of transmission losses, reactive energy pricing with transparency, integrity and probity of accounts.

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