SAGAR A. WADI
SHAMREENA VERGHESE
V. BALAJI
V. SURESH
and
G. ANBUNESAN

Ancillary services in Indian power system – implementation challenges

Reserve regulatory ancillary service (RRAS) was implemented on 12th April 2016 in Indian power system to empower the system operator to maintain the frequency in IEGC band, regulate line loadings, loss of generation or load, etc. This paper discusses the challenges in implementation of RRAS.

Keywords: RRAS (reserve regulatory ancillary services), FGMO (free governor mode operation), AGC (automatic generation control), CERC (central electricity regulatory commission)

1.0 Introduction

Ancillary services are those functions performed to support the basic services of generation, transmission, energy supply and power delivery, required for the reliable operation of the power system. Ancillary services is one of the four pillars required for mature and stable power market [1] as shown in Fig.1. While FGMO is a primary response and AGC is a secondary response, RRAS in the Indian context is a fast acting tertiary response in a power system. National Electricity policy mandates spinning reserves to combat frequency fluctuations. Implementation of ancillary services became all the more essential as India is bracing for integration of 175GW of RE by 2022. The system operator is left with no other tool than RRAS mechanism, to maintain the load and generation balance unlike the beneficiary states who have full autonomy for requisition from the ISGS as per their entitlement (under the decentralised dispatch mechanism adopted in India).

CERC the central regulator had notified RRAS regulation on 13th August 2015. There are about 54 RRAS service providers aggregating to a total installed capacity of 55 GW with a variable cost ranging from Rs.1.25/u to Rs.8.12/u

Usually, at a given point of time, about 2000-12000MW of URS (unrequsition surplus) power from ISGS is available as shown in Fig.2. This power is a hot spinning reserve readily available for dispatch as RRAS up regulation. Similarly, for RRAS down regulation, the generation can be backed down up to technical minimum of the respective generating unit.

2.0 Modus operandi

During real time operations, NLDC (national load despatch centre) kicks off reserve regulatory ancillary service (RRAS) up or down from the generating station who are regional entity and whose tariff for full capacity is determined by CERC on the following criteria: (i) Extreme weather forecasts and/or special days such as festival/general holiday day etc.; (ii) Generating unit or transmission line outages; (iii) Trend of load met; (iv) Trends of frequency; (v) Any abnormal event such as outage of hydro generating units due to silt, coal supply blockade etc.; (vi) Excessive loop flows leading to congestion; (vii) Grid voltage in the important nodes downstream/upstream of the corridor is beyond the operating range; (viii) Excess power flow in a corridor violating (n-1) criterion.

When additional generation is required to be added to the grid, the RRAS up is triggered by dispatching the un-requisitioned surplus (URS) from the merit order stack (lowest to highest) based on the variable cost to a virtual ancillary entity (VAE). Similarly, when generation is required to be reduced in the grid, the RRAS down (highest to lowest variable charge) is triggered by reducing the generation from the ISGS by notionally scheduling power from the virtual ancillary entity (VAE) to the concerned ISGS.

The services will start or stop with one time block notice effective from the earliest 15 minute time block. The original beneficiaries have the first right to recall the URS power during the period of RRAS up service or surrender during the RRAS down service

3.0 Commercial settlement mechanism

Weekly accounts are issued along with deviation settlement account for the RRAS up or down service of each participant generator. The RRAS up service provider would be paid fixed charges, variable charges and a mark up price of Ps 50/u (as an incentive). The fixed charges would be passed on to the

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Messrs. Sagar A. Wadi, Engineer (Maket Operation), V. Balaji, Dy. General Manager, V. Suresh, Head-System Operatio9n, Operation Services and System Logistics, G. Anbunesan, General Manager, and Ms. Shamreena Verghese, Chief Manager, Shamreena Verghese, Chief Manager, SRLDC, POSOCO, Bengaluru

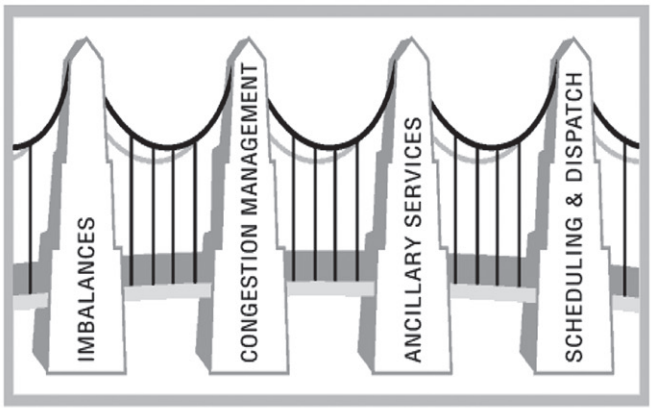


Fig.1: Ancillary as one of the 4 pillars of market

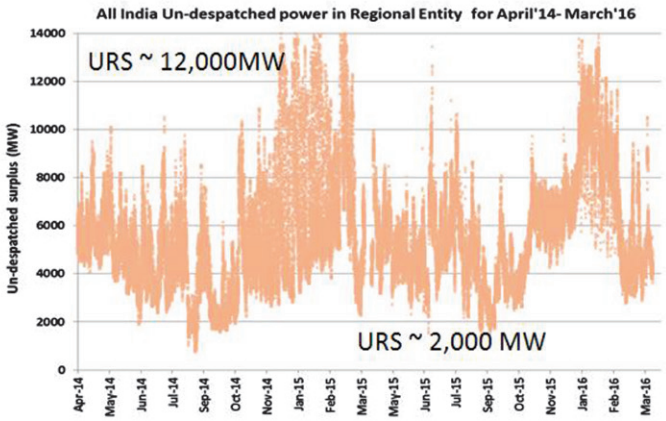
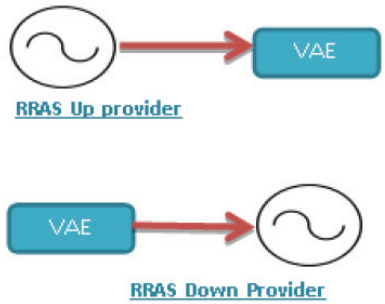


Fig.2: Availability of URS power



Schedule under RRAS down service to generating station		
Beneficiary	RRAS down requisition from VAE	Total
1000	–50	950
Schedule under RRAS up service to generating station		
Beneficiary	RRAS up requisition from VAE	Total
1000	50	1050

Fig.3: Modus operandi of RRAS up and down service to/from VAE

original beneficiary whose URS power was utilized for regulation up. Similarly in RRAS down, RRAS provider would refund 75% of the energy charges to the DSM pool. Balance 25% would retain by the RRAS provider as incentive. Any deficit in the payable and receivable amounts would be met from the surplus funds available in the DSM pool.

4.0 Learning experience so far

On 30th and 31st Aug 17, there was a wide fluctuation in wind generation from 11600 MW to 5300MW. RRAS up regulation over 1600 MW and down service up to 120MW were triggered for the fall and rise as seen in Figs.4 and 5.

So far a maximum RRAS up service of 3746 MW and down regulation of 1946MW was triggered. In terms energy, a maximum RRAS up of 6Mu (0.2% of energy met) in a day and a down regulation of 1Mu (0.03% of Energy met) in a day were triggered.

From 12-04-16 to 10-01-18, a total energy of 5347 Mu (~2% of total energy) was dispatched under RRAS Up service. Similarly, 459Mu of energy was dispatched under RRAS down service. A total no. of 4336 RRAS up and 640 RRAS down instructions were triggered on various criteria as shown Fig.6.

The average cost of up regulation worked out to ~Rs.4.34/u and down regulation of ~ Rs. 1.53/u. Daily about 6-7 RRAS triggering instructions were issued. This mechanism has provided resilience to grid in handling low probability high impact events and extreme weather conditions without depriving the states of their freedom to requisition.

5.0 Implementation difficulties experienced

A. Slow ramp down and ramp up rates of the generating units

As system demand ramps sharply, it requires RRAS services at higher ramp rates, but the RRAS services have limited ramp rates due to inherent inertias in the boiler, turbine and generator sets.

Thermal machines have inherently have slow ramp up compared to hydel machines. While ramp up rates are relatively slower, the ramp down rates are higher in both categories. The ramp up/down cycles come with lower machine efficiencies, higher wear and tear and increased emissions of SO_X and NO_X. Typical ramp rates of various types of machines are shown in Fig.7.

B. Simultaneous schedules of RRAS and recall/ surrender by beneficiary

Daily during load change over time, some of the beneficiary states shed chunk of loads leading to significant under-drawl and thereby rise in frequency. To address this problem states surrender their share from the generating

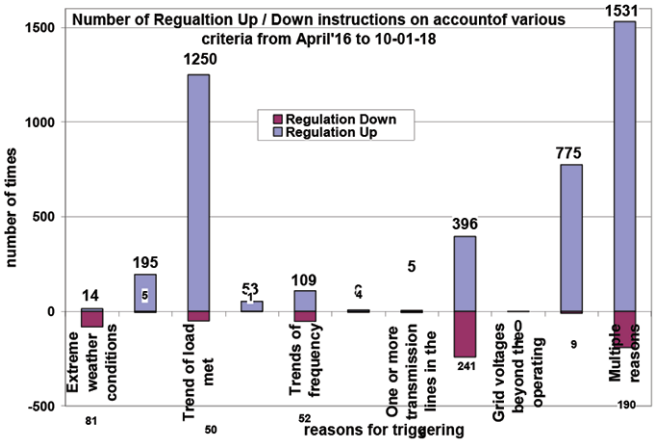


Fig.4: No. of times RRAS was triggered

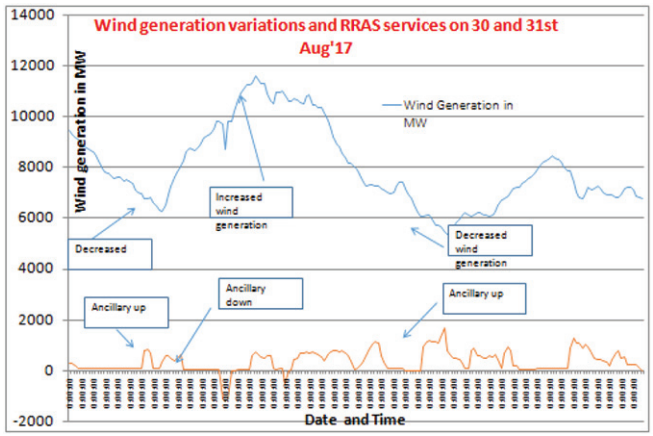


Fig.5: RRAS up regulation to balance wind generation variation

stations and simultaneously the ancillary down service also might be triggered suitably accommodating the station ramp rates. After the change over is finished, loads rise steeply requiring restoration of the generation to the normal levels. While doing so, ramp up rates declared by the generator are to be honoured while increasing the requisition and reducing the RRAS down service. Due to sharing of the ramp schedules among the beneficiaries and RRAS, the duration is getting extended which is not the intended aim.

C. Enhanced requirement of RRAS due to full exploitation of volume cap limits in DSM

As per the regulations, to take care of the inadvertent deviations, regional entities are permitted certain volume limits (to the extent of 12% of the schedule or 150MW or 250MW in case of renewable rich states). Often many entities tend to utilise their full limits leading to enhanced requirement of RRAS services. In an all India grid, there are about 32 entities on drawl side and over 50 on the injection side. Typically simultaneous deviation of all India level occurred to an extent of 2000MW as shown in Fig.8 in addition to the normal system requirements, arranging for such a huge quantum the deviations also of service is a Herculean task considering the above limitations.

D. Short fall in funds for payment to RRAS service providers

Most of the times, energy scheduled in RRAS up services would be more than that in down service, due to which there would be a deficit. As per deviation regulations, drawee entities are charged at a higher penal rate for their over-drawls whereas the APM generating entities are compensated at lower rates. Including additional charges, there remains a surplus amount in the pool. Such surplus amount is utilized for settlement of the RRAS services.

Sometimes, there are defaults in the payments of the deviation charges, due to which funds may not be available for paying the RRAS up service providers. Implementation of national pool may solve the problem to some extent.

Efforts are being made to address the above issues in consultation with the regulator

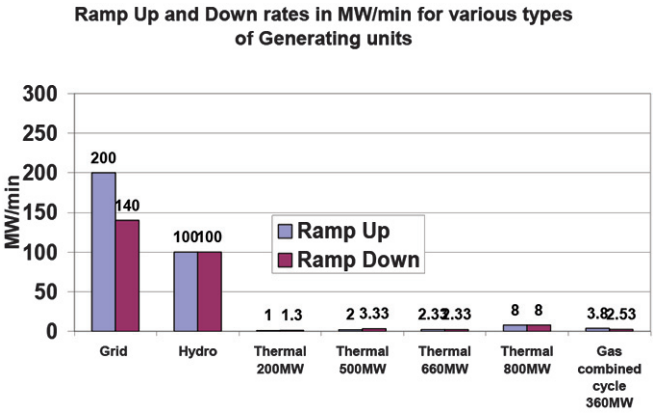


Fig.6: Typical ramp rates of machines vs. grid requirement

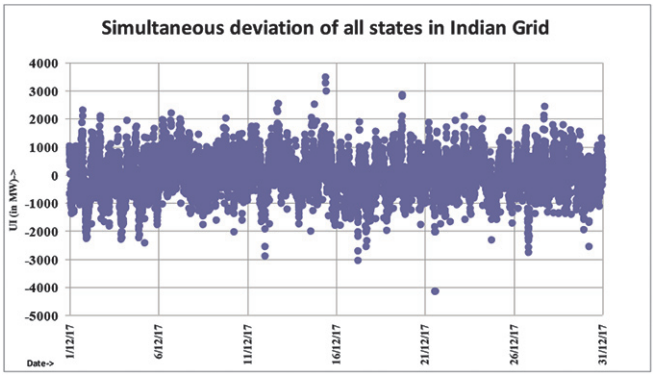


Fig.7: Simultaneous deviation of all states in Indian grid

6.0 Future scope

Proposal for moving to 5 minute settlement system is under active consideration of the regulator. With this assessment of the requirement of ancillary services is expected to be more accurate. In future, the IPPs and state generators also can be brought under the ambit of RRAS mechanism. New ancillary products can be introduced for incentivising hydro

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