MINUTES OF DISCUSSION WITH CENTRAL HYDRO GENERATORS ON IMPLEMENTATION IF HYDRO AS FRAS – AGENDA ITEM OF 18TH TECHNICAL COMMITTEE MEETING OF FORUM OF REGULATORS (FOR)

Venue	:	Upper Ground Floor, CERC New Delhi
Date	:	13-03-2018
List of Participants	:	At **Annexure – 1(Enclosed)**

A special meeting with Central Hydro Generators on implementation of Hydro Power as FRAS (Agenda Item 4 of 18th Technical Committee) was held under the Chairmanship of Shri P.K Pujari, Chairperson CERC & FOR on 13th March 2018.

Discussion/Decision Points

1. Sh. AS Bakshi, Member in his opening remarks welcomed the participants to the special meeting to discuss the implementation of Fast Response Ancillary Service (FRAS) through Hydro Power. He mentioned that a preliminary discussion om the issue was held in the 18th Meeting of the FOR Technical Committee held on 23rd February 2018. The subject needed further deliberations as the hydro stations wanted more time for studying the proposal and hence, this special meeting with the Central Sector Hydro Generators was convened.

2. Dr. SK Chatterjee, Jt. Chief (RA) gave the background regarding the need for introduction of fast ancillary services through hydro generating stations. He mentioned that the present implementation of ancillary services is predominantly utilizing the thermal generating stations which have ramping limitations and hence the need for a fast response ancillary service. He mentioned that a detailed Agenda Note (enclosed at ***Annex-II***) was circulated for discussion of the FRAS during the 18th Meeting of the FOR Technical Committee and the same was also circulated ahead of this meeting. He requested POSOCO to make a presentation on the proposed FRAS to explain the proposal and bring out the key issues for deliberation.

3. POSOCO gave a presentation (enclosed at ***Annex-III***) on the proposed Fast Response Ancillary Service from hydro generators. The following key-points were highlighted in the presentation by POSOCO:

    a. The important statistics pertaining to the implementation of the Reserve Regulation Ancillary Services (RRAS) were presented and the benefits derived from ancillary services in terms of improved frequency profile and reliability support were mentioned. The key learnings during the last two years were also highlighted.

    b. The challenges being faced included the need for revision of the DSM price vector, expanding the ambit of the ancillary services, gate closure provisions, need for implementation of ancillary services from hydro stations, performance monitoring and IT/automation requirements.

    c. Thermal generation is a 'ramp limited' resource whereas hydro is a 'energy limited' resource with other constraints (other than power generation constraints). Hydro generators can provide fast response and peaking support.

    d. Fast responding ancillary service from hydro stations was primarily being proposed for 'regulation service' from storage/pondage based hydro stations for example to handle the hour-boundary frequency spikes.

    e. Scheduling is proposed to be carried out at 5-minute interval which would be dovetailed into 15-minute existing scheduling.

    f. All constraints declared by the hydro stations would be honored and the total energy delivered over the day would be maintained as declared by the hydro station. The total energy dispatched under FRAS is proposed to be squared off by the end of the day.

    g. Triggering of FRAS would be based on a stack prepared based on the balance energy available in the hydro station (marginal cost of hydro is zero), whereas the despatch in the case of thermal generators was based on variable charges of the station.

h. Schedules of the beneficiaries would not be disturbed in the despatch of FRAS.

i. Payment for FRAS would be based on 'mileage' basis similar to the methodology adopted for AGC pilot implemented.

j. Fast communication of triggering instruction, incorporation in the schedules and response by hydro generators required fast communication between NLDC and hydro generating stations.

k. A pilot project in at least one hydro station each in Northern, Eastern and North-Eastern Regions was proposed with 5-minute scheduling, metering and accounting.

4. POSOCO mentioned that prior to this meeting, a meeting was also convened at NLDC on the 9th of March 2018 where representatives of hydro generators (NHPC, SJVN, BBMB, THDC, NEEPCO and NTPC) and CEA participated. Detailed deliberations also took place in this meeting regarding the data exchange requirement for despatch of FRAS. POSOCO mentioned that broad consensus was achieved regarding the following during the meeting:

a. FRAS Implementation

b. Primary Response improvement through droop settings

c. 5-Minute scheduling, despatch and settlement on pilot basis

d. Other ancillary services – reactive power, black start

e. Need for fast communication of instructions

POSOCO also mentioned that a format for data collection regarding type of plant, installed capacity, machine type, forbidden zones, cavitation zones, ramp rates, startup times etc. was shared with the hydro stations for submission of data. All hydro stations had provided data as per the format.

5. The hydro generators mentioned that suitable incentive should also be made available for the hydro generators participating in the mechanism which should be on lines similar to that for the thermal generators. Responding to this, Member CERC

mentioned that CERC would take a view and decide on the issue in due course. All Generators were requested to provide detailed comments on the approach paper within 15 days. Generators were also requested to provide feedback regarding data/basis for an appropriate incentive mechanism.

6. The droop setting for hydro stations is mandated to be in the range of 0-10% as per CEA Standards and within 3-6% as per IEGC. It was mentioned by the hydro generators that this setting was presently in the range of 4-6%. POSOCO requested that the droop setting may be lowered so as to obtain faster response from hydro generators which are capable of providing such response. The hydro generators agreed to revert on this after detailed deliberations with the respective technical teams.

7. The proposal of POSOCO for implementation of a pilot project in at least one hydro station each in Northern, Eastern and North-Eastern Regions with 5-minute scheduling, metering and accounting was deliberated. It was mentioned that this would help gain experience in not only the ancillary services but also provide valuable learnings regarding 5-minute scheduling, metering, accounting and settlement. This pilot will also provide learnings for implementation of other competing resources like Battery Storage, Demand Response as Ancillary Services.

8. The proposal for implementation of pilot project was agreed and it was suggested that CERC may issue directions for implementation of the proposed pilot project to POSOCO. Responding to a query regarding the possible timeframe for implementation of the pilot, POSOCO mentioned that considering procurement, software development and the onset of high hydro season from July to September, the feasible timeline is from October 2018.

9. The present proposal for FRAS was for only those hydro stations whose tariff is determined or adopted by CERC. It was suggested that merchant hydro generators and state generators may also be included. After deliberations it was decided that inclusion of merchant plants would be considered subsequently and a pre-requisite for inclusion of state hydro stations was that SAMAST should have been implemented for the concerned state hydro station.

10. After detailed deliberations on various aspects, there was a general consensus that the FRAS proposal should be considered and pursued for implementation. FRAS could be

implemented in hydro stations whose tariff is determined or adopted by CERC to begin with and the ambit could be expanded to include other merchant/state generators in due course of time. Further, POSOCO would implement a pilot project in at least one hydro station each in Northern, Eastern and North-Eastern Regions with 5-minute scheduling, metering and accounting. The issue could be brought up in the next FOR meeting so that state generators could also be included in the projects soon.

11. Dr. SK Chatterjee, JCRA summarized the deliberations held during the meeting and decisions taken thereon. He also mentioned that actions were being taken for expanding the ambit of the existing ancillary services and implementing a market-based procurement mechanism. The need for capacity building of various stakeholders including discoms, SLDCs, STUs on important issues are being deliberated especially market design, complementary market mechanisms like Ancillary services, FRAS etc, was reiterated. It was noted and agreed that POSOCO could lend support to this endeavour.

12. The hydro generators were requested to provide their feedback on the proposed FRAS within 15-days. Since NEEPCO could not join this meeting, it was agreed that a meeting with NEEPCO would be held in the next meeting of the Technical committee.

13. The meeting ended with a vote of thanks to the Chair.

Annexure-1

LIST OF PARTICIPANTS AT THE SPECIAL MEETING WITH CENTRAL HYDRO GENERATORS ON IMPLEMENTATION OF HYDRO AS FRAS

1	Shri. P.K. Pujari, Chairperson	CERC
2	Shri. A. S. Bakshi, Member	CERC
3	Dr. M.K Iyer, Member	CERC
4	Shri Sanoj kumar Jha, Secretary	CERC
5	Shri.V.K. Kalra, Member	BBMB
6	Shri. T. Rout, Chief(Legal)	CERC
7	Shri. S.C. Srivastava, Chief (Engg.)	CERC
8	Shri. S.K. Chatterjee, JC(RA)	CERC
9	Shri J.S. Bawa, Chief (Engg.)	CEA
10	Shri. Rakesh Kumar, Dir.(HPP&I)	CEA
11	Shri K.V.S. Baba, CMD	POSOCO
12	Shri. S.R. Narasimhan, GM	NLDC, POSOCO
13	Shri S.S. Barpanda, GM	NLDC, POSOCO
14	Shri Samir Saxena, DGM	NLDC, POSOCO
15	Smt. Rashmi Nair, DC(RA)	CERC
16	Shri. H.L. Arora (DCT)	THDCIL

17	Shri.L.P. Joshi, AGM	THDCIL
18	Smt. Abha Saini, CE	BBMB
19	Shri.Anil Gautam, DvilPR	BBMB
20	Shri. Kuldeep Singh, PC	BBMB
21	Shri. R. V. Bansal Dir. (Electrical)	BBMB
22	Shri. B. Singh, Liason Officer	BBMB
23	Shri Gurdeep Singh, CMD	NTPC
24	Shri A.K. Gupta, Dir (Comml)	NTPC
25	Shri. Jauardon Choudhary ED (O&M)	NHPC
26	Shri. M.K. Mittal Dir. (Fin.)	NHPC
27	Shri.Shyam Kumar, DGM(Comml)	NHPC
28	Shri K.V.N. Pawan Kumar, Dy. Mgr.	NLDC, POSOCO
29	Shri. Siddharth Arora, RO	CERC

Agenda Note For FOR Technical Committee Meeting
Introduction of Fast Response Ancillary Services (FRAS)
from Hydro Generating Stations

1. Background

The total present installed capacity of hydropower stations is 44 GW comprising of 15,658 MW regional entity hydropower stations (the balance being intra-state stations). Based on plant type the regional entity hydro stations comprise of 3766 MW Storage type, 5678 MW pondage type and 6214 MW run-of-the-river type.

The *Report on Operational Analysis for Optimization of Hydro Resources & facilitating Renewable Integration in India* by the Forum of Load Despatchers (FOLD) has recommended utilization of the hydro generation for provision of Ancillary Services. The relevant extracts from the Report are enclosed at Annex – I for ready reference. Hydro generating stations are capable of providing fast ramping capability and they can be gainfully utilized for regulation services to meet the system requirements. The present formulation under ancillary services is based on fixed charges, variable charges and a pre-specified markup.

This needs to be reviewed and redesigned for hydro stations in view of the following:

(a) Hydro stations are "*energy limited resources*" unlike the thermal stations (coal based) which are "*ramp limited resources*"
(b) Hydro stations are also subject to limitations/constraints in terms of water inflows as well as the quantum of water that can be released based on reasons other than power generation requirements
(c) CEA (Technical Standards for Connectivity to the Grid) Regulations, 2007 and CEA (Technical Standards for Connectivity to the Grid) Regulations, 2013 mention the following:

> *"All generating machines irrespective of capacity shall have electronically controlled governing system with appropriate speed/load characteristics to regulate frequency. The governors of thermal generating units shall have a droop of 3 to 6% and those of hydro generating units 0 to 10%."*

Hydro stations can thus respond very quickly and much faster than thermal/gas stations or in other words, these are more suitable for handling sharp changes/fluctuations such as those observed at the hour boundary.
(d) The marginal cost for hydro generation is 'zero' and the segregation of fixed and variable charges in case of hydro is only notional. Thus, the present model of ancillary services which relies on payment of fixed charges, variable charges and incentive is found to be incompatible for hydro stations.

2. Proposed Methodology for Fast Response Ancillary Services (FRAS)

In view of the special characteristics mentioned above, the flexibility and fast response provided by storage and pondage hydro may be harnessed under a framework of Fast Response Ancillary Services for providing frequency regulation services.

The proposed methodology is discussed below.

2.1. Triggering and Despatch of FRAS

Triggering of RRAS from hydro stations may only be used for short durations such as handling hour boundary frequency changes, sudden changes in demand, ramp management, grid contingency, etc. As the hydro stations are mainly "*energy limited resources*" it is proposed that the net energy scheduled under RRAS Up and RRAS Down should be made zero for each hydro station within the day. Hydro is a fast responding resource and would help to arrest the frequency spikes. With increasing quantum of renewable penetration, fast response ancillary can also act as a mechanism to handle the intermittency.

Given the fact that the marginal cost is zero for hydro, it implies that the despatch decision has to be based on criteria other than the variable charges.

Accordingly, an alternate mechanism based on the following parameters is proposed:

- Total energy available declared for the day by the station, E_a
- Total energy scheduled during the day up to the time of despatch, E_g
- Balance energy available for increasing generation, ($E_b = E_a - E_g$)
- Maximum MW that can be delivered, P_{max}
- Minimum MW that needs to be maintained, P_{min}
- Total energy consumed under RRAS Up, E_{up}
- Total energy conserved as RRAS Down, E_{down}
- Net position of RRAS, $E_{net} = E_{up} - E_{down}$ (should be made zero as early as possible before the end of the day)

The following shall form the basis of FRAS despatch:

(a) Reservoir based stations should be given priority in despatch over pondage based stations.

(b) For FRAS Up instruction, a stack of generating stations shall be prepared sorted in descending order on available 'Balance Energy (E_b)'. The operator shall give FRAS Up instruction to the station with maximum E_b honoring the constraint imposed by maximum possible generation.

(c) For FRAS Down instruction, a stack of generating stations shall be prepared sorted in ascending order on available 'Balance Energy (E_b)'. The operator shall give FRAS Down instruction to the station with minimum E_b honoring the constraint imposed by minimum possible generation.

(d) Instructions under FRAS shall be issued as a combination of Up and Down instructions such that over the course of the day, the net energy position, $E_{net} = 0$.

The fast response ancillary services (akin to fast tertiary) from hydro would be despatched normally for a maximum of 2 – 3 time blocks of fifteen-minutes or part thereof.

Subsequently, the despatch under normal/existing RRAS from the thermal based stations (akin to slow tertiary) can replace this fast response ancillary service.

It may so happen that because of despatch of hydro under ancillary (up or down), it becomes necessary to give a counter instruction (down or up) during say hours where frequency is low or congestion is taking place. In such case, despatch under ancillary from thermal (coal / gas based) stations shall be used so as to ensure that the E_{net} of hydro under FRAS becomes zero by the end of the day.

2.2. Scheduling

The present methodology of normal scheduling would be continued as it is in the RLDCs. The schedules of the constituents/beneficiaries shall not be disturbed in the process of FRAS despatch. The FRAS schedules shall be issued separately by NLDC for 5-minute intervals and sent to the hydro generators. This will facilitate provision of flexibility in a shorter time frame. These 5-minute schedules will also be aggregated to 15-minute despatch schedules so that they are made compatible with the existing scheduling philosophy for settlement and deviation accounting purposes.

Similar to the existing VAE (which may be referred as VAE-T corresponding to thermal generation), there is a need to delink-the counterparty for scheduling of hydro under FRAS with the schedules of the beneficiaries. Hence, a "Virtual Ancillary Entity – Hydro or VAE-H" may be created in each regional pool which shall act as the counterparty to the FRAS schedules given to the hydro stations in the concerned region. In effect, all efforts shall be made to make energy scheduled to VAE-H equal to zero at the end of the day.

One example where hydro despatch under ancillary is useful is the case of reducing spikes in the frequency at each hour boundary. In such cases, ancillary from hydro can be despatched by giving a down-instruction 5 minutes before the hour boundary and again increasing by giving an up-instruction at 5 minutes after the hour boundary thereby reducing the generation for 10 minutes. In order to implement this feature, the scheduling of FRAS (from hydro) itself can be migrated from 15-minutes to 5-minutes at NLDC. This would be aggregated to 15-minutes, transmitted and interfaced with the existing scheduling software at the RLDCs.

2.3. Communication to the Generating Stations

As the response from hydro stations is quite fast, the despatch instruction (trigger) may be given few minutes in advance of the expected time when the response is required by the operator. The FRAS despatch instruction may be incorporated in the software applicaiton to be put in place by NLDC and communicated telephonically/through emails/SMS or through the common SCADA screen to the generating stations. The other/routine schedules would continue to be communicated as per existing methodology.

2.4. Accounting and Settlement

For FRAS instructions given to the hydro stations, the payment shall be made on the basis of mileage. The mileage during the day may be computed as follows:

(a) Net energy is $E_{net} = \Sigma E_{up} - \Sigma E_{down}$ (in MWh) *(should be zero over the day)*

(b) Mileage $E_m = \Sigma | E_{upt} | + \Sigma | E_{downt} |$ (in MWh)

Further,

- No additional fixed charge or variable charges to be paid for the FRAS schedules
- Existing fixed charges and variable charges shall continue to be paid by the beneficiaries for the normal schedules as per existing practice
- The total energy despatched for hydro under FRAS is to be made zero and hence, no energy charges shall be payable to the hydro stations
- Incentive may be paid on mileage basis at the rate of say, 10 paise per kWh both for 'up' and 'down' regulation provided by the hydro station.

Annex – I

Report on Operational Analysis for Optimization of Hydro Resources & facilitating Renewable Integration in India

Extracts Related to Ancillary Services from Hydro Stations

10.4 Ancillary Services from hydro power stations

a) Frequency Control

i. Reserves regulation Ancillary Service(RRAS)

Hydro generators has better load following behavior compared to the thermal & nuclear units. Thus, the reservoir based hydro generators are better placed to contribute to the reserves regulation ancillary services under the CERC (Ancillary Services Operation) Regulations-2015. This would encourage the hydro generators to participate in tertiary frequency control to render the necessary regulation services. Thus, all the hydro power stations, especially the storage & pondage type stations may be brought under the deviation settlement mechanism so as to make them eligible for participate under the RRAS mechanism. Further, enabling regulations may be brought by the SERCs to bring the intra-state hydro units under the frame work of reserve regulation ancillary services.

ii. Automatic generation control (AGC)

Secondary frequency control in the form of automatic generation control (AGC) from the hydro generating stations is necessary in line with the CERC order of October 2015 on operationalization reserves. A pilot project on AGC is under implementation by the NLDC and NTPC Ltd. Dadri Power station in northern region. Similar initiatives may be considered for hydro power stations also. To start with, the CERC regulated, central sector hydro power stations may be brought under the ambit of AGC. Based on the experience for a reasonable period (say 6 months), intra-state hydro power stations may be considered with commensurate provisions in tariff regulations.

iii. Primary Response

As discussed in chapter 3 the primary response from the hydro power stations has been in the range of 10% to 90%. The 5th amendment to the Indian Electricity Grid Code(IEGC) mandates for setting aside a margin for primary frequency response at the time of scheduling of generators by RLDCs and ensuring that the generating stations are never operated at valve-wide-open (VWO) condition. The grid code mandates for automatic governor action from all hydro power stations of capacity 25 MW or above. Similarly the CERC (Terms & conditions of tariff) Regulations 2014-19) has a provision of reduction of rate of return on equity (RoE) for non-availability of governor action. Similar regulatory provisions may be introduced at Intra-state level to obtain adequate primary response from intra-state hydro power stations.

b) Voltage Control

As discussed in chapter 3 some of the large capacity hydro power stations in the country have significantly contributed to the voltage stability of the grid by absorbing reactive power from the extra high voltage (EHV) grid by running as synchronous condenser during off-peak hours. Presently the synchronous condenser operation of hydro power stations is being done as per instructions of system operators (RLDCs/SLDCs) under the regulatory framework of grid code. The static reactive power (VAR) exchange by a load serving entity with the EHV grid (at a voltage level > 33 kV) is priced at Rs. 13.5 paise/ KVArh under the grid code

(IEGC) for keeping voltage within 97% to 103% of nominal value. This provision excludes the generating stations. Thus, an incentive scheme linked to the dynamic reactive support from hydro power stations running as synchronous condensers may be considered by the appropriate commission to promote this essential ancillary service for the EHV grid.

c) Black-start service

Black start service is an essential and unique service available from a limited number of power stations in the country. The black start capability demonstrated by hydro power stations across the country has been summarized in chapter-3. At present most of the black-start capable power stations in the country are hydro power stations. However, the success rate of black start from a hydro power station depends largely on healthiness of the black start diesel generator (BSDG) sets available at the power station. Further, most of the black start capable hydro stations have a single BSDG set with no redundancy. This seriously limits the reliability of a black start capable hydro station in terms of adequacy. Thus, the working group recommends for provision of redundant black start DG sets at all the hydro power stations who have demonstrated black start capability in the past.

The black start capable hydro stations are strategic sub-stations from the view point of grid resiliency. Reliable & uninterrupted supply of survival power to these stations ensures disaster preparedness & resilience of the entire grid. Hence, there must be provision for alternate grid supply at lower voltage level (say 132 kV & below) to these hydro power stations to ensure redundancy of survival power. Such transmission lines may be kept healthy at all times through regular surveillance & maintenance so that non-availability survival power does not hinder the hydro power station in providing black start service.

At present the black start capable power stations are mandated under the grid code to demonstrate black start capability once in every six months through conduction of mock drills, under intimation to respective RLDCs and SLDCs. However, there is no scheme for incentivizing black start service rendered by the hydro power stations. In the absence of any compensation the upcoming hydro stations may not be inclined to have this facility. Thus, it is recommended that the appropriate commission may consider having a provision of financial incentive on annual basis which may be linked to compliance to the relevant stipulations of Indian Electricity Grid Code (IEGC) as certified by the respective RLDCs and SLDCs.

Details of Hydro Stations								
(16th February 2018 to 15th March 2018)								
Sl No	Name of Hydro Electric Power (HEP) Generating Station	Region	Installed Capacity (MW)	Fixed cost (Paisa / kWh)	Variable cost (Paisa/ kWh)	Ramp Up (MW/ Block)	Ramp Down (MW/ Block)	Technical Minimum (MW)
1	Bairasiul HEP	NR	180	96	96	180	180	50
2	Chamera-II HEP	NR	300	99	99	300	300	70
3	Chamera-I HEP	NR	540	111	111	540	540	170
4	Teesta-V HEP	ER	510	116	116	150	150	150
5	Uri HEP Stage - I	NR	480	81	127	480	480	200
6	Naptha Jhakri HEP	NR	1500	119.1	119.1	1500	1500	200
7	Rampur HEP	NR	412	161.3	161.3	412	412	50
8	Salal HEP	NR	690	58	170	690	690	90
9	Dhauliganga HEP	NR	280	151	151	280	280	60
10	Rangit HEP	ER	60	183	183	60	60	17
11	Tanakpur HEP	NR	94.2	157	157	94.2	94.2	12
12	Koteshwar HEP	NR	400	195.5	195.5	400	400	90
13	Chamera-III HEP	NR	231	212	212	231	231	40
14	Koldam HEP	NR	1000	217.1	217.1	800	800	600
15	Parbati HEP Stage-III	NR	520	274	274	520	520	80
16	Sewa-II HEP	NR	120	216	236	120	120	11
17	THDC India Ltd	NR	1000	299.8	299.8	1000	1000	125
18	Dulhasti HEP	NR	390	279	328	390	390	110
19	Uri HEP Stage - II	NR	240	241	328	240	240	40
		Total	**8947**					

Introduction of Fast Response Ancillary Services (FRAS) from Hydro Generating Stations

Discussion with Central Hydro Generators on Implementation of Hydro as FRAS

Central Electricity Regulatory Commission

13th March, 2018

Reserve Regulation Ancillary Services – At a Glance

(April, 2016 – January, 2018)

RRAS Providers: 54 Nos.

Capacity under RRAS: 55 GW

Highest Variable Charge ~ Rs. 10.25 / Unit (Auraiya LF– NR)

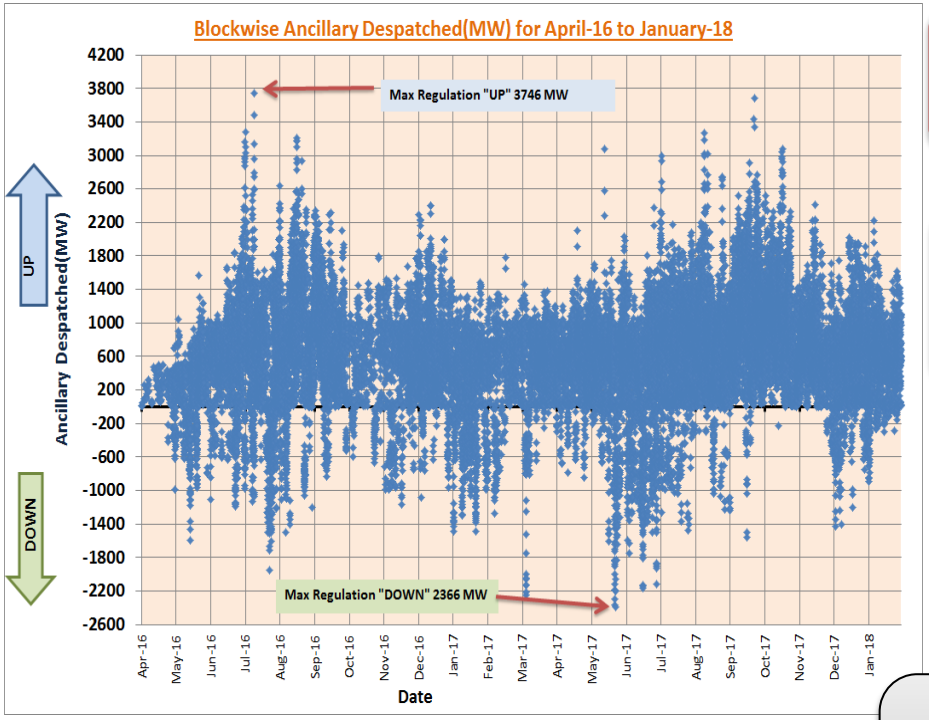
Lowest Variable Charge ~ Rs. 1.06 / Unit (Sipat-I – WR)

Maximum 'Up' Regulation : 3746 MW

Maximum 'Down' Regulation : 2366 MW

Energy Despatched: Down – 1 MU / day (0.03 % Energy met)

Energy Despatched: Up – 7 MU / day (0.2 % of Energy met)



Avg. Daily Number of RRAS Instructions : 07 to 08 Nos.

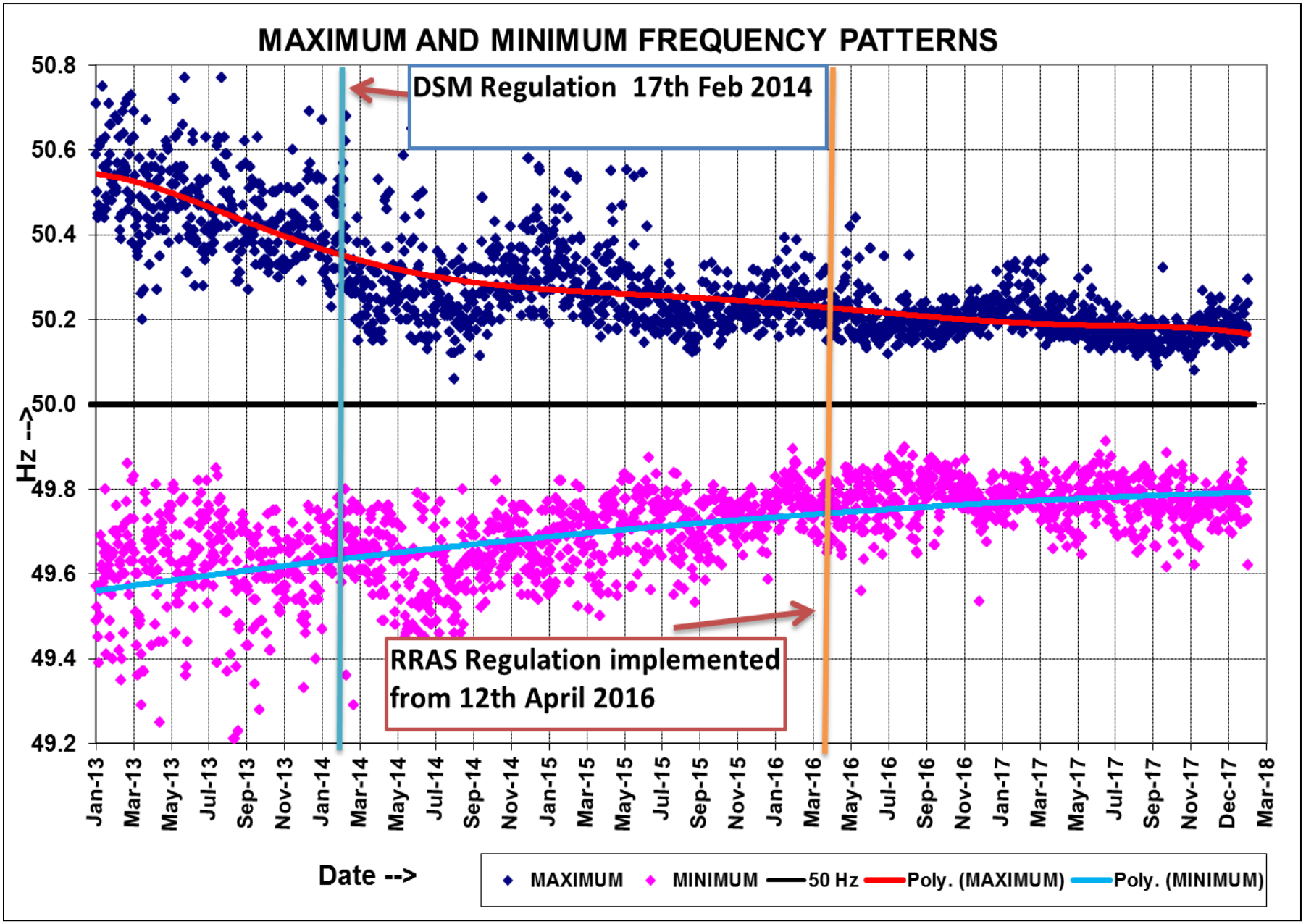
Average Cost for Regulation Up Despatch: ₹ 4.63/ Unit

Mark Up paid to RRAS provider- 50 Paise/Unit

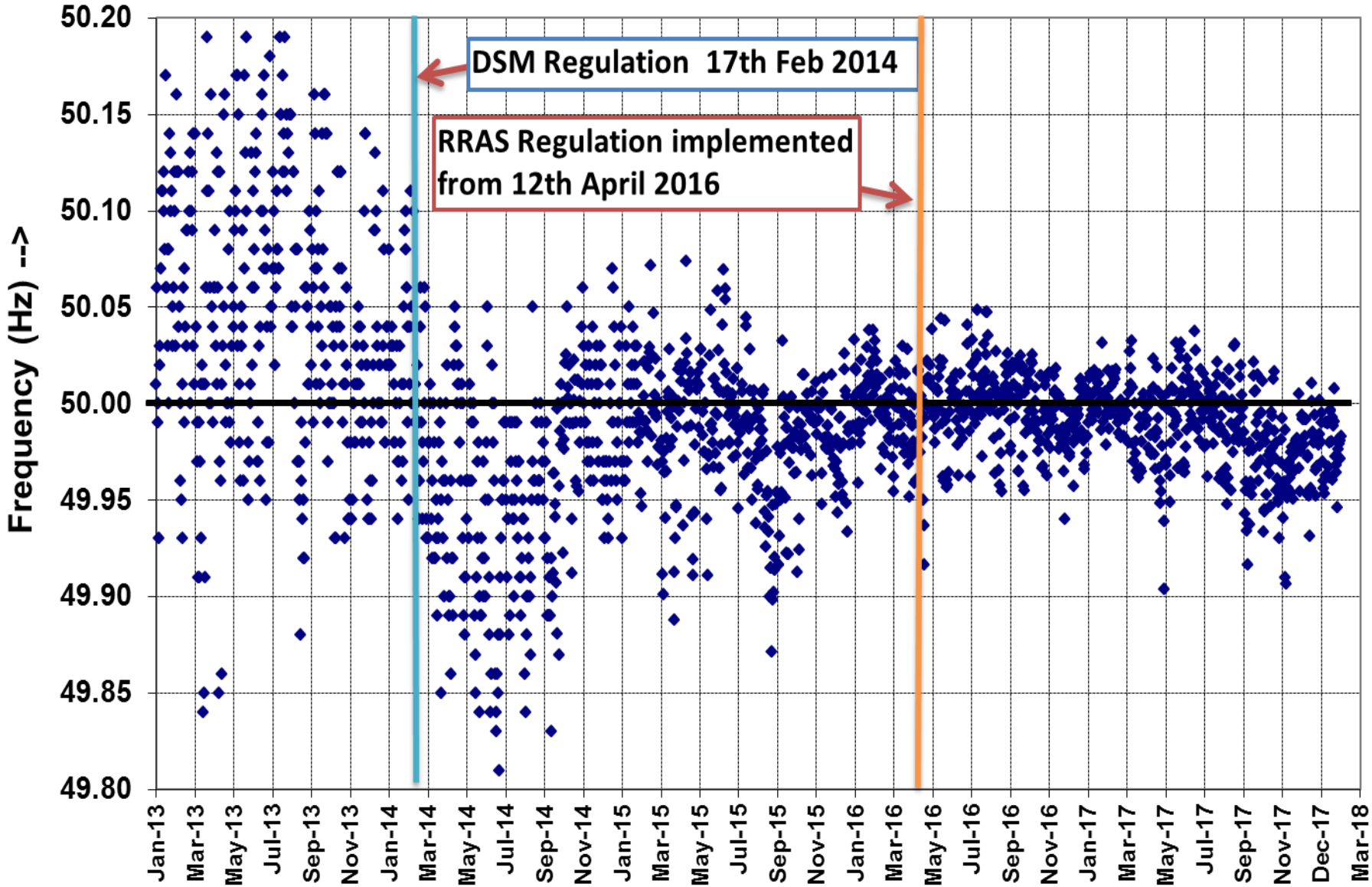
Average Variable charges retained by RRAS providers 54 Paise/Unit

Average variable Charge refunded to DSM Pool for Regulation Down : ₹ 1.62/ Unit

Improvement in Frequency Profile



Pattern of Average Frequency



Key Learnings

- Optimization Layer over Coordinated Multilateral Scheduling
- Improved Frequency Profile
- Ramp Management
- Real Time Congestion Management
- Grid Resilience
- Reliability Support
- Fixed & Variable Costs in Public Domain
- Freedom and Choice Retained

Challenges Ahead

- Revision in DSM vector
- Enlarging the Ambit
- Hydro Scheduling under Ancillary Services
- Gate Closure
- Automation, IT and Manpower
- Performance Monitoring

Hydro Power – A Flexible Solution

- **Hydro Power - a source of Flexibility & Reliability**
  - Overload capability
  - Peaking support
  - Fast ramping
  - Primary Response
  - Voltage Regulation
  - Black Start Capability
- **Need to Increase the Ambit of Ancillary Services**

Recommendations and Mandate

- Ministry of Power, GOI
  - Tariff Policy, 2016
  - Technical Committee on Renewable Integration, 2016
  - Sub-Committee on shifting Hydro power stations from Base Station to Peak Station, 2017
- CEA National Electricity Plan, 2016
- NITI Aayog - India's Renewable Electricity Roadmap, 2015

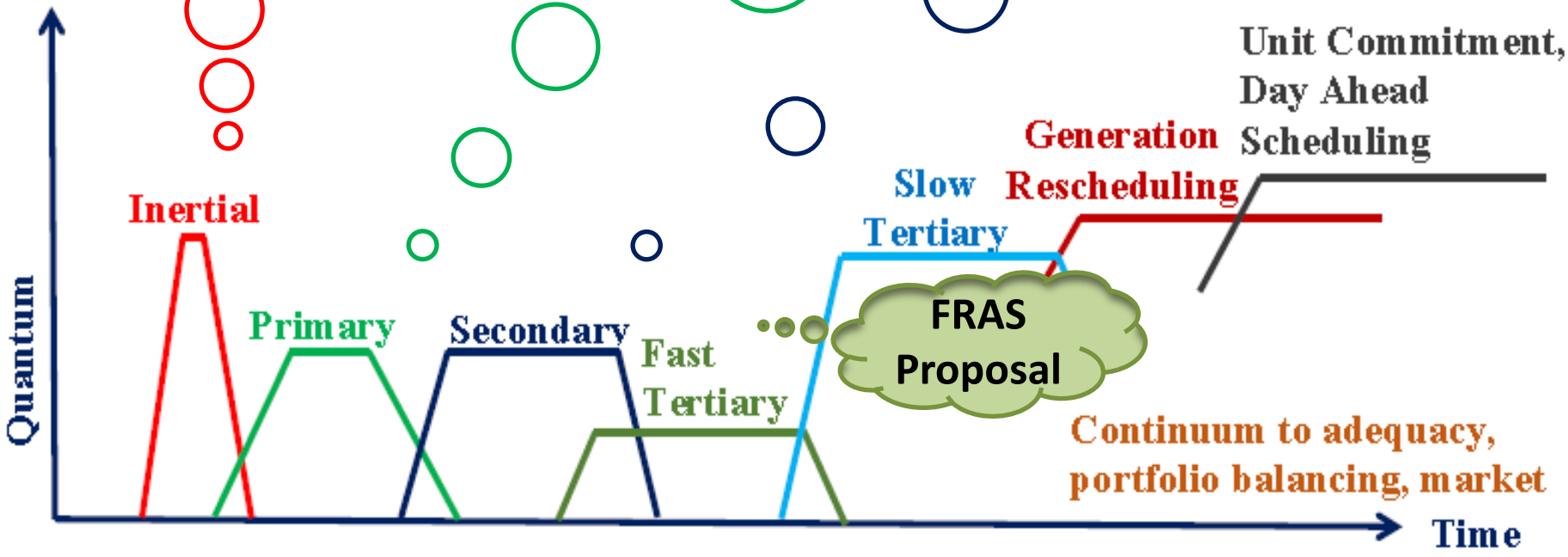
- FOLD-POSOCO Report on Operational Analysis for Optimization of Hydro Resources & facilitating Renewable Integration in India, 2017
  - **Scope for Optimization & Flexible operation along with Economic Gains**
  - **SAMAST - Need for Multi-part Hydro Tariff, Incentive for Flexibility**
  - **Bringing Hydropower Stations under Ancillary Services**

Role of Hydro in System Balancing in India

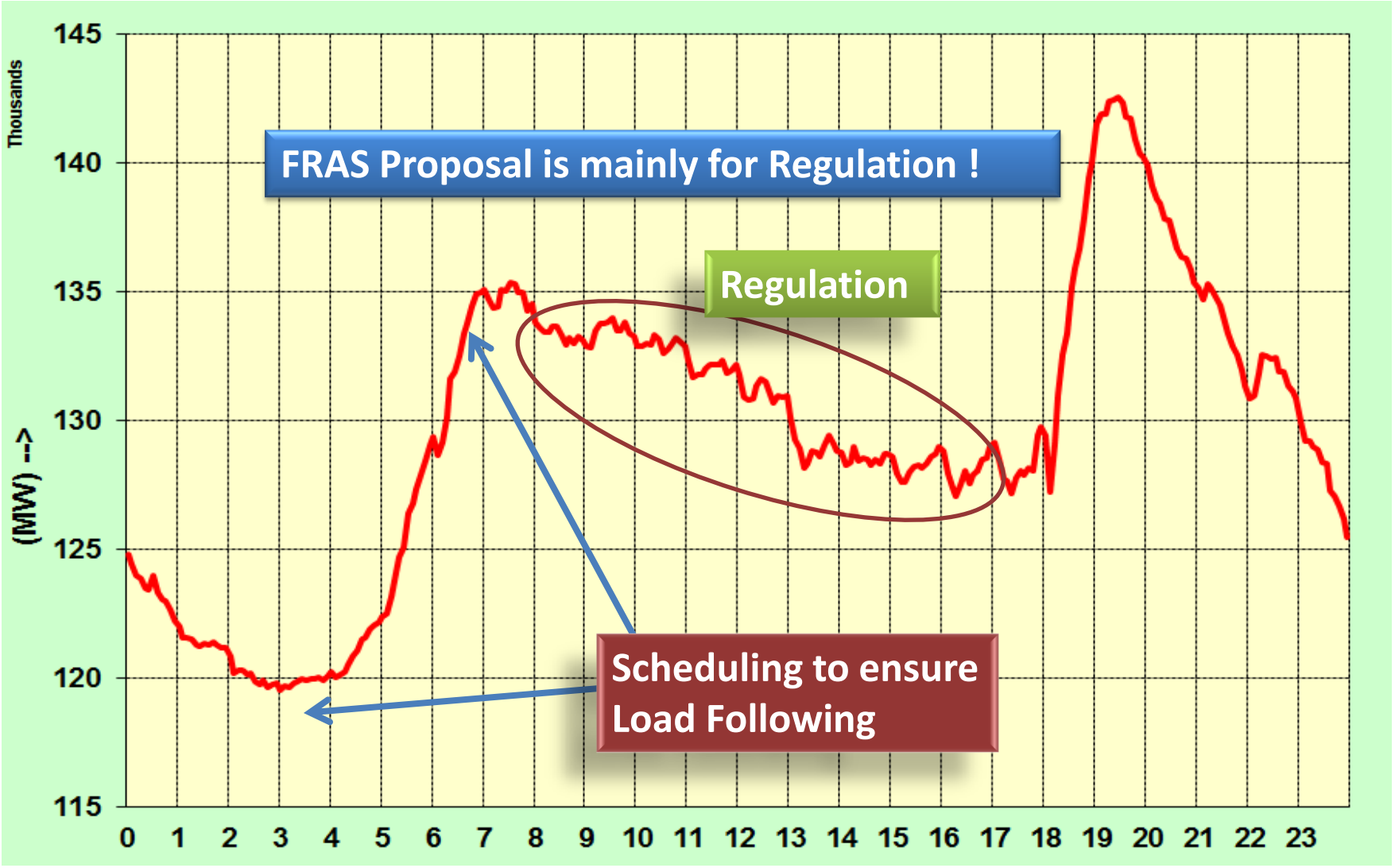
Inertia Decreasing, 175 GW RE, Need to have more hydro machines

Mandated as per Grid Code for all; Need for faster response from Hydro

AGC Pilot Project Operational; Hydro stations may be put on AGC on pilot basis



Load Following and Regulation



Present Regulatory Provisions

- **CERC (Ancillary Services Operations) Regulations, 2015**

5. Eligibility for participation for Reserves Regulation Ancillary Services (RRAS)

5.1. All Generating Stations that are regional entities and whose tariff is determined or adopted by the Commission for their full capacity shall provide RRAS.

- NR and ER Hydro generators provide RRAS data on monthly basis

- **CERC Approved Detailed Procedure for Ancillary Services Operations**

4.9. Hydro generation, within the total energy dispatch constraints, is providing the peaking support including ramping and normally, there is no un-despatched power. However, in case of exigencies or otherwise, the hydro stations would also be considered for despatch under Ancillary Services by the Nodal Agency.

Present Issues in Hydro Scheduling under RRAS

Need for fast regulation service and ramping support

Hydro : Energy limited Resource

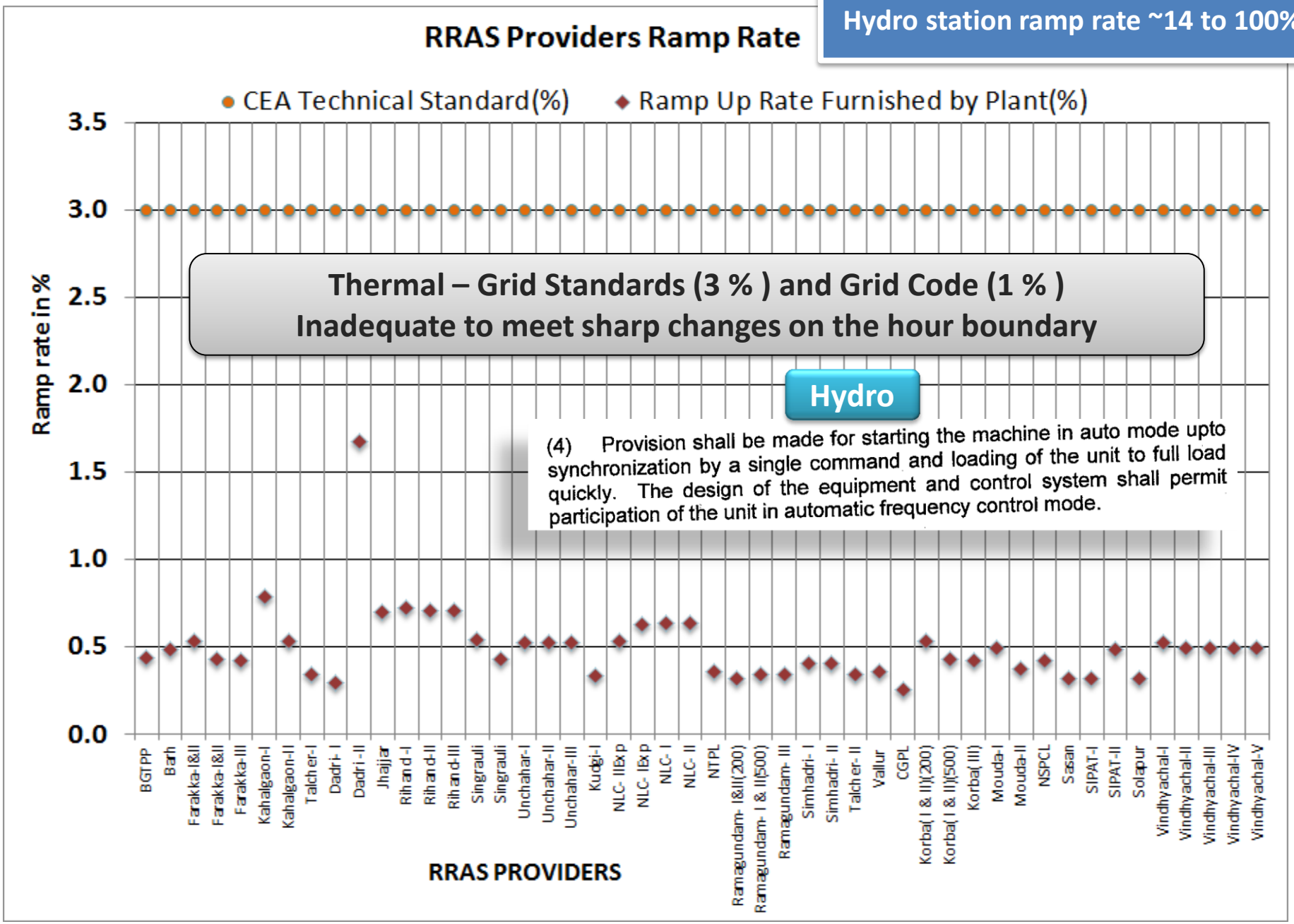
Thermal: Ramp limited Resource

Other than power generation commitments

Marginal Cost is zero

And hence, FRAS Proposal…

Hydro station ramp rate ~14 to 100%



Sl No	Name	Utility	Region	Type (S/R/P)	I/C (MW)
1	Teesta-V	NHPC	ER	R	510
2	Rangit			R	60
3	Bairasiul		NR	P	180
4	Chamera-II			P	300
5	Chamera-I			P	540
6	Uri Stage – I			R	480
7	Salal			R	690
8	Dhauliganga			P	280
9	Tanakpur			R	94.2
10	Chamera-III			P	231
11	Parbati III			P	520
12	Sewa-II			P	120
13	Dulhasti			P	390
14	Uri Stage – II			R	240
15	Naptha Jhakri	SJVN		P	1500
16	Rampur			P	412
17	Tehri	THDC		S	1000
18	Koteshwar			S	400
19	Koldam	NTPC		P	800
20	Kopili	NEEPCO	NER	S	200
21	Kopili-II			S	25
22	Khandong			S	50
23	Ranganadi			P	405
24	Loktak	NHPC		S	105
25	Pong	BBMB	NR	S	396
26	Dehar			R	990
27	Bhakra complex			S	1379
			Total		**12297**

Type	MW
Storage (S)	3555
RoR with Pondage (P)	5678
RoR (R)	3064
Total	12297

Proposal - Fast Response Ancillary Service (1)

- Stack of hydropower stations
  - Based on MW regulation possible by plant, balance energy etc.
  - Factoring congestion

- Despatch Instructions from Nodal Agency
  - FRAS Regulation Up (maximum available balance energy/reserve/MW)
  - FRAS Regulation Down (minimum available balance energy/reserve/MW)

- Net energy squared off for each hydro station same day
  - Combination of FRAS Regulation Up and Down despatch instructions

- Only for short durations

- Reservoir based stations priority over pondage based stations

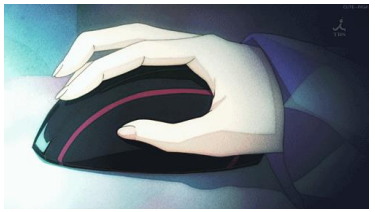
Proposal - Fast Response Ancillary Service (2)

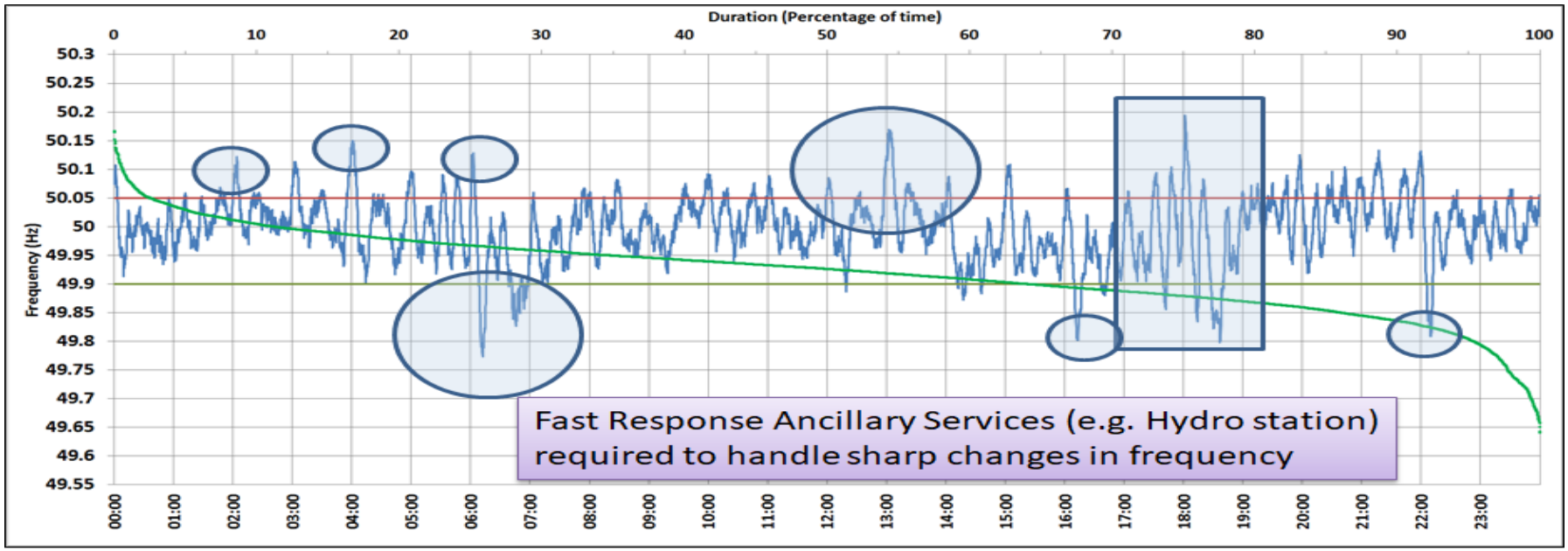
- Scheduling
  - 5 - minute FRAS despatch schedules by Nodal Agency
    - Aggregated (3 five minute blocks)
    - Compatibility with the existing scheduling philosophy
    - Settlement and deviation accounting purposes
  - Regional Virtual Ancillary Entity – Hydro or VAE-H
    - Counterparty to FRAS despatch instructions

- Accounting and Settlement
  - No fixed charge or variable charges to be paid
  - Incentive on mileage basis
    - $E_m = \Sigma \mid E_{up} \mid + \Sigma \mid E_{down} \mid$
    - To be decided by the Commission

Triggering Criteria

- Hour boundary frequency changes
- Sudden changes in demand
- Ramp management
- Grid contingency
- RE Variation





<49.7	<49.90	<49.97	49.7-49.8	49.8-49.9	49.9-50.0	50.0-50.1	50.1-50.2	49.90-50.05	49.7-50.2	49.97-50.03	50.05-50.1	>50	>50.03	>50.05	>50.2
0.00	4.61	29.05	0.21	4.40	44.47	48.37	2.56	79.22	100.00	43.31	13.65	50.86	27.64	16.17	0.00

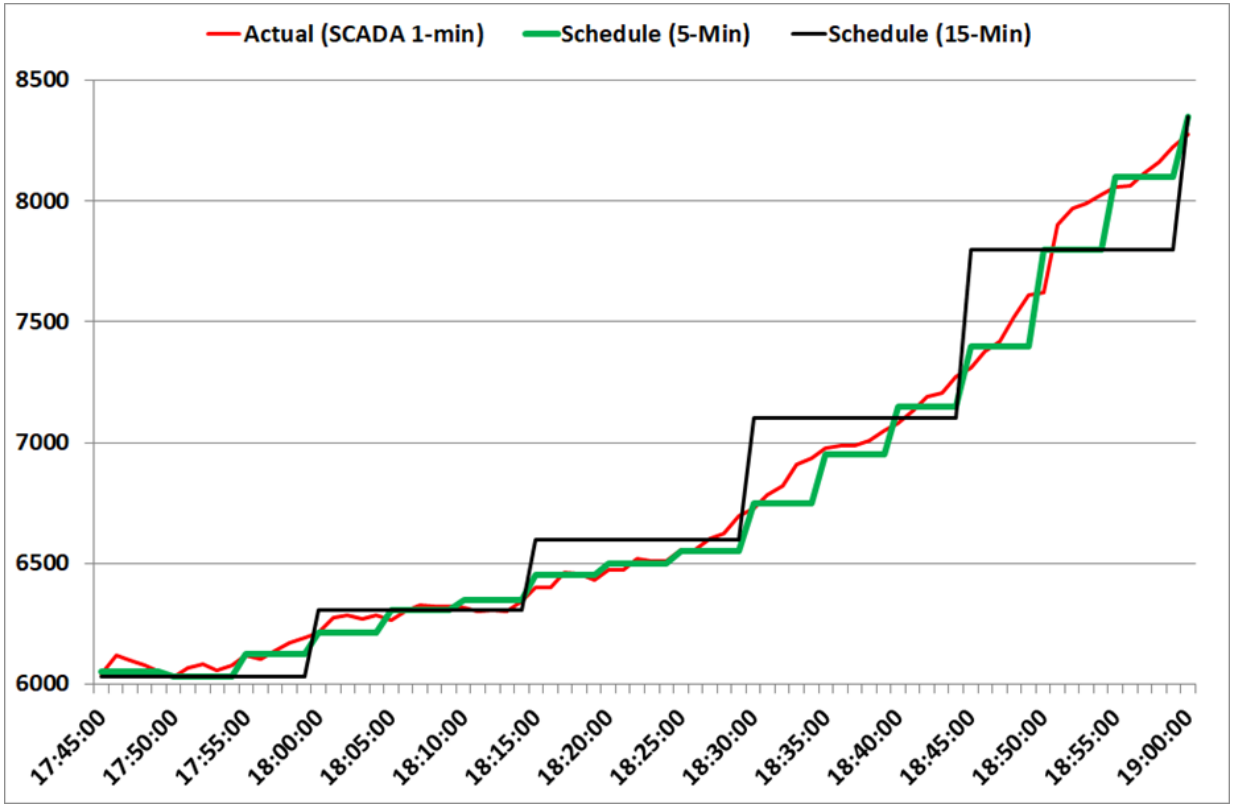
Average Frequency :	49.997	Frequency Variation Index :	0.032	Standard Deviation :	0.056	Mileage	45.61

Honouring Constraints

- Drinking Water
- Irrigation
- Contractual Obligations with State Government
- Weather Phenomena, Monsoon etc.
- Legacy Control System
- Wildlife
- Water level and Head
- High Silt, flash floods, Cloud burst, Land slides
- Shortage of Skilled and Unskilled Manpower
- Acidic Corrosion and Erosion
- Special Occasions like Water Sport activities, Snan, Mela etc.
- Any other…

Scheduling and Settlement

- FOR Technical Committee Sub-Group
  - Introduction of Five Minute Scheduling, Metering, Accounting and Settlement in Indian Electricity Market
  - Pilot Project Envisaged - in Parallel with 15-Minute Framework
- Three Regions (NR, ER and NER) – Central Sector Hydro Stations
  - 05 Minute Scheduling, 05 Minute Metering, 05 Minute Deviation Settlement

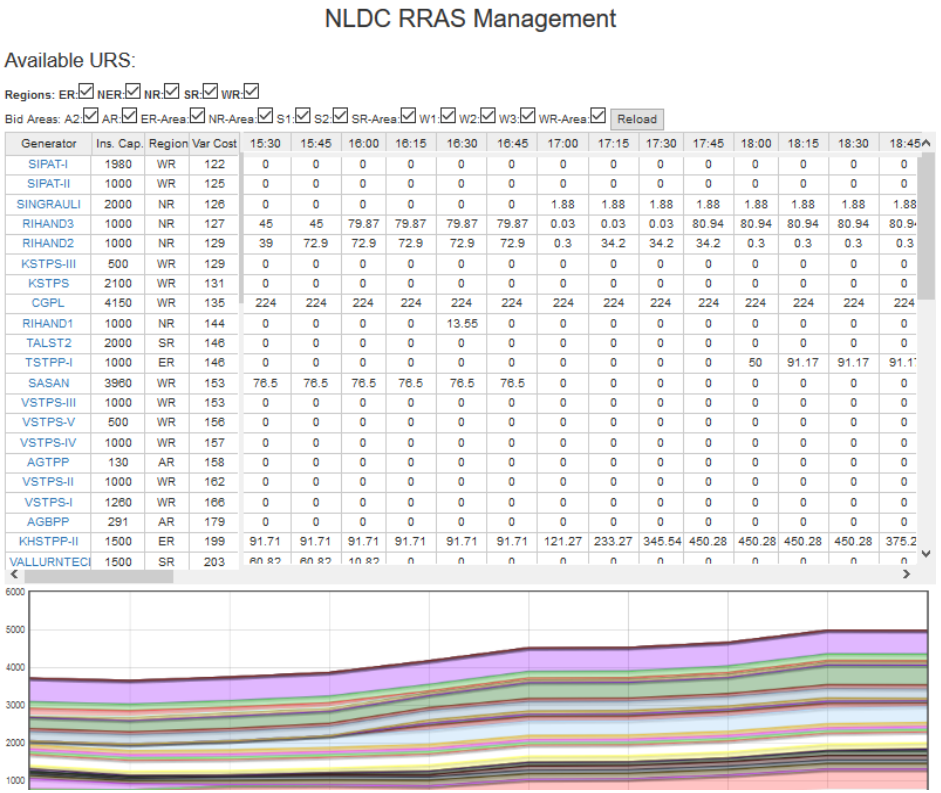


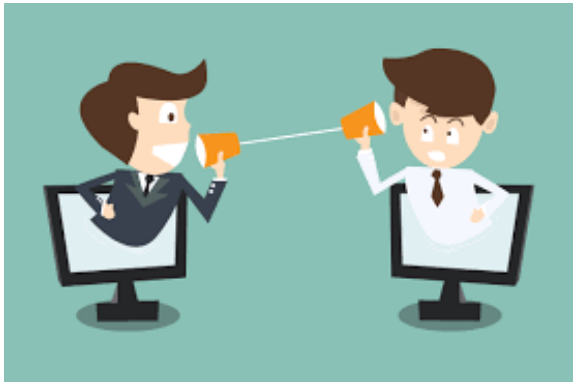
Data Exchanges

- **NLDC/RLDCs with FRAS Providers**
  - Web based Automated Solution
  - Technical Details for FRAS Despatch
  - Telephonic/SMS/E-mail

- **FRAS Providers and RPCs**
  - Ancillary Services information
  - Accounting & Settlement

- **Information on NLDC Website**
  - FRAS Instruction Summary
  - Monthly report
  - FRAS Providers details





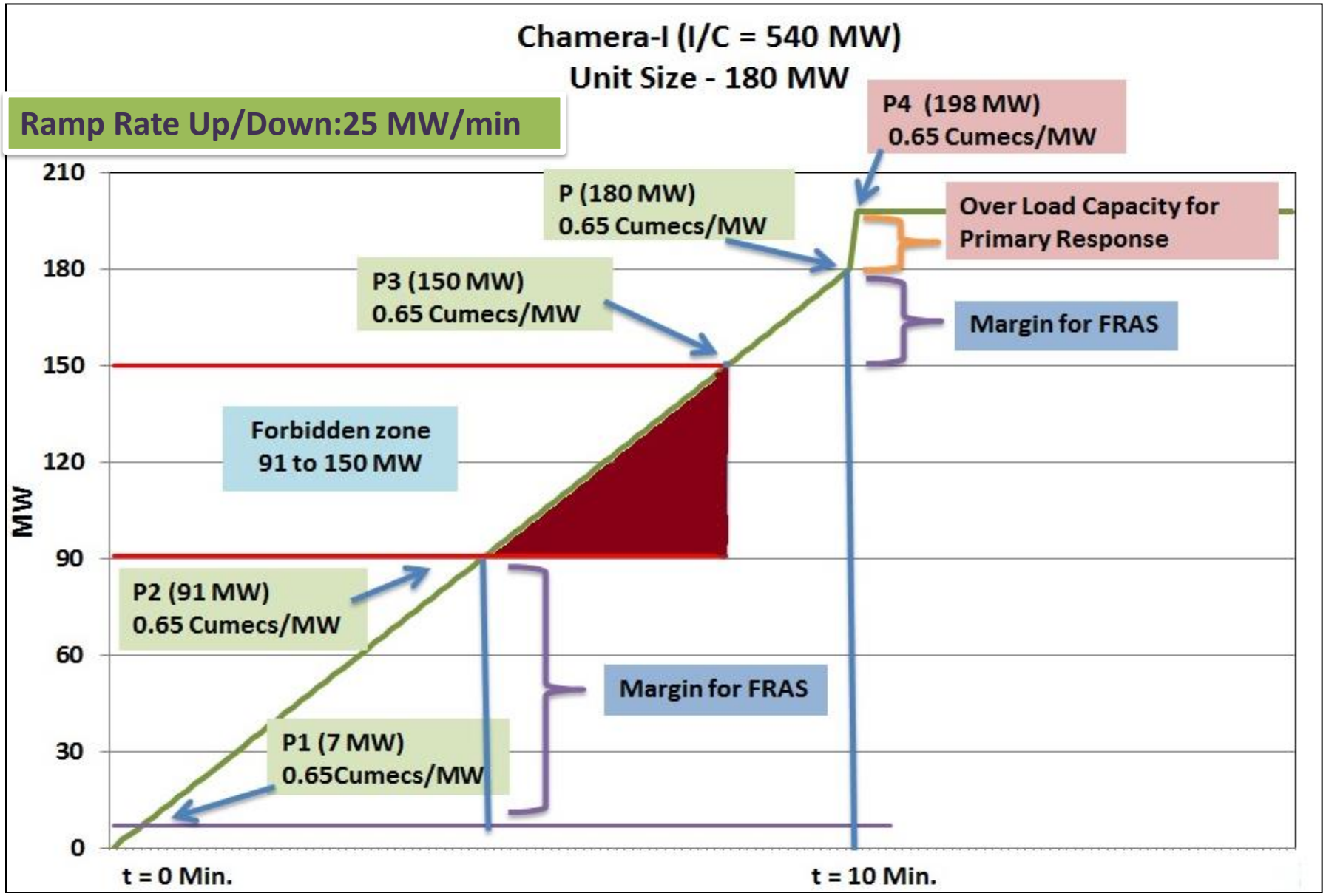
Discussion with Central Sector Hydro Generators

- Meeting held on 09th March, 2018 at NLDC, Delhi
- Participants
  - CEA, NHPC, SJVN, BBMB, THDC, NEEPCO, NTPC and POSOCO
- Deliberations held & broad consensus achieved
  - FRAS Implementation
  - Primary Response improvement through droop settings
  - 5-Minute scheduling, despatch and settlement on pilot basis
  - Other ancillary services – reactive power, black start
  - Need for fast communication of instructions
- Mark up for regulation– to be decided by CERC
- Data template circulated
  - Received data from NHPC, NTPC, BBMB, NEEPCO, THDC

Information Requirement of Hydro Units

- Installed capacity of unit =P
- Start time; standstill to synchronization of unit to grid (in minutes)
- Minimum load at which unit stably run after synchronization (MW) - P1
- Forbidden zone or high cavitation zone (From MW to MW) - P2 to P3
- Maximum loading possible on unit (continuous) P4 (Note; range from P to P4 should be normally available for primary response unless it is a case of overflowing hydro)
- Cumecs/MW for P1, P3, P and P4 generation level as well as cumecs from standstill to synchronization. Which value is used for declaring MWh capability?
- How many units can be started simultaneously or is it sequential operation? The constraints in this regard.

Sample Hydro Station Data



Further Steps…

- Regulatory Interventions
  - CERC (Ancillary Services Operations) Regulations, 2015
  - Detailed Procedure
- Software Upgradation
- Communication Infrastructure Augmentation
- Capacity Building
  - LDC and Hydro Generators Personnel

A Small Step for Hydro

A Giant Leap for Indian Power System

Thank You !