**MEETING OF 'FOR' TECHNICAL COMMITTEE SUB GROUP ON IMPLEMENTATION OF HYDRO AS FRAS AND ITS CASCADING EFFECTS ON DOWNSTREAM PROJECTS**

| | | |
|---|---|---|
| Venue | : | Classic Hill Top Resort, Mussoorie Road, Dehradun |
| Date | : | 07-06-2018 |
| List of Participants | : | At **Annexure –1(Enclosed)** |

1. A meeting of FOR Technical Committee Sub-Group on implementation of Hydro as FRAS and its Casceding effects on downstream projects was held on 7thJune2018 at Dehradun. The meeting was convened under the Chairmanship of Shri A.S Bakshi, Member CERC. Shri Bakshi welcomed all the participants of the meeting and thanked the THDC for hosting this meeting.

2. Dr. Sushanta.K.Chatterjee, Joint Chief (RA), CERC welcomed all the participants and special invitees and highlighted the agenda items scheduled for the meeting.

**Discussions on the Agenda**

**1. Agenda Item No. 1:**

**(I) Background of Standing Technical Committee of FOR**

a. Dr. Chatterjee made a presentation **(Annexure-II)** on the background and key initiatives of the Technical Committee. He informed that the Technical Committee of Forum of Regulators (FOR) was formed under the Chairmanship of Member CERC, Shri A.S. Bakshi, comprising Technical Members of State Commissions of renewable rich States to facilitate roll-out ofFramework on Forecasting, Scheduling and Deviation Settlement of wind & solargenerators in RE rich states. The Committee during the last two and half years met 19 times.

b. Further, Dr. Chatterjee underscored that the key initiatives of the Committee, inter alia include, Report on Scheduling, Accounting, Metering and Settlement of Transactions in Electricity(SAMAST), Model Framework for Forecasting, Scheduling and DeviationSettlement for RE sources at the State level, Model Deviation Settlement Mechanism (DSM) Regulations, examination of issues related to Regional Co-operation foroptimum utilization of Generation Resources, Report on roll-out of Smart Meters, Model Regulations for Intra-State Hydro Generating Stations, Report on introductionof 5-minute Time Block etc and Introduction of Fast Response Ancillary Services (FRAS) from Hydro Generating Stations

**(II) Status of Implementation of:**

**a.** SAMAST Report in Hilly States

**b.** Forecasting, Scheduling and Deviation Settlement in Hilly States

**c.** Update by other States

c. **Himachal Pradesh**: Inter-State entities have been identified. Assessment of meters &, IT Infrastructure completed. The DSM Regulations of the State are in final stages and the Grid Code is also being brought out. It was highlighted that the DPR for SAMAST is yet to be made. Shri Bakshi offered assistance of the Consultant to HPERC in preparing the DPR.

d. **Andhra Pradesh**: Shri. P.Rama Mohan, Member APERC updated that APERC notified the F&S regulations in Aug. 2017 and its implementation started from 1st January 2018. However, the commercial implication will begin after 6 months i.e. from 1st July 2018. Further, he provided the following details highlighting the month-wise improvement in the forecast being received for wind and solar projects and the percentage of deviation remaining within 15% of band.

| Month | Installed Capacity (MW) | Forecast Received (MW) | % of forecast received | Deviation less than +- 15% | Approx. penalty that can be levied (INR Lakhs) |
|---|---|---|---|---|---|
| Jan' 18 | 6000 | 854 | 14.23% | 92% | 17.7 |
| Feb' 18 | 6000 | 1561 | 26.02% | 85% | 69.83 |
| Mar' 18 | 6175 | 4800 | 77.73% | 97% | 26 |
| Apr' 18 | 6175 | 5500 | 89.07% | 95% | 21 |
| May' 18 | 6175* | 5588** | 90.49% | | |

**Wind-3966MW, Solar-2209*

*** Wind-3616MW, Solar-1972MW*

e. **Karnataka**: DPR for SAMAST implementation has been submitted and is currently with POSOCO

f. **Kerala**: Shri Preman Dinaraj, Chairperson KSERC updated that the State Govt. announced incentives for 500 MW rooftop solar projects asagainst the current installed capacity of 280 MW of RE in Kerala. Shri Dinaraj further highlighted that large scale roof-top solar in the State would result in other generators stranded. Hydro resources are meant for evening peak and cannot be utilized for balancing variations during the day time.

g. Further, it was highlighted that there is a wide diversity in Load pattern across the country. Load pattern in Northern and Southern region are in opposite direction. Dr. Chatterjee underscored that this issue can be addressed by bringing in Real Time Market (RTM) as RTM will give Discoms a multi-lateral platform to meet their real time energy needs.

**2. Agenda Item No. 2: Presentation on:**

- Demand Pattern Analysis/Load Forecasting for Hilly States

a. Shri KVN Pawan Kumar, Dy. Manager, POSOCO, presented on the Demand Pattern Analysis/Load Forecasting for Hilly States **(Annexure-III).** He highlighted that at national level there are about 5 factors, namely, Weather Conditions-Temperature, Economic Factor, Holidays Vs Weekdays, Festivals and Diversity, which affect the Demand Met pattern.

b. Shri Pawan Kumar demonstrated with charts the Hourly Demand Met pattern, Daily energy Consumption pattern, Annual Demand Duration Curve and Maximum Demand Met for the State of Himachal Pradesh and Uttrakhand.

**3. Agenda Item No. 3: Presentation on:**

- Implementation experience of Ancillary Services

a. Shri. K.V.S Baba, CMD POSOCO, presented the Implementation experience of Ancillary Services **(Annexure-IV).** Based on CERC's order on Roadmap for Reserves, Shri Baba highlighted the capacity requirement under Primary, Secondary and Tertiary reserves. He highlighted the regulatory evolution Ancillary Services Operations along with timeline.

a. The improvement in Frequency Profile over the years was highlighted. Further, it was underscored that about 80-85% of time, the frequency is remaining within the desired range. The schematic of System Balancing in India was also presented.

b. 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

c. He briefed about the RRAS and the roles of various agencies/service providers and RPCs under RRAS. Further, it was highlighted that Avg. Daily Energy Despatched under Up Regulation is about 9MUs/day and under Down Regulation is about 1MU/day.

d. Triggering criteria of Ancillary Services were also presented. Further, Shri Baba listed out the key experiences of RRAS and the way forward for Ancillary Services like utilizing Hydro as FRAS, harnessing Pump Storage Plants, Participation of Merchants/IPPs, Black Start Ancillary Services etc.

**4. Agenda Item No. 4: Presentation on:**

**(I) Hydro as Fast Response Ancillary Services (FRAS)**

a. Shri S.C Saxena, DGM POSOCO made a presentation **(Annexure-V)** on Hydro as Fast Response Ancillary Services (FRAS). Shri Saxena underscored that 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

b. 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.

**c.** 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

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

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

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

g. Further, ShriSaxena underscored the advantages of utilizing the Hydro as FRAS. A list of Hydro Stations which could be potential candidates for FRAS was also presented.

h. It was informed that in the last FOR Meeting, held on 9th April 2018, POSOCO requested 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.

i. ShriSaxena also informed about the various meetings held at CERC and NLDC with CEA and other central hydro generators on the same subject and the data/information which has been requested from these generators. He underscored that a broad consensus has been reached among the generators on implementation hydro as FRAS.

**(II) Cascading Impact of FRAS through Hydro on Downstream Projects**

a. Shri R.K Porwal, DGM System operations, POSOCO made a presentation **(Annexure-VI)** on Cascading Impact of FRAS through Hydro on Downstream Projects. He differentiated between the projects which are 'in tandem' and are in 'cascade' with the FRAS through Hydro. The schedule of 'in tandem' plants has to be modified together.

b. It was underscored that Nathpa-Jhakri& Rampur hydro projects are in tandem while the Chamera-III &Chamera-II, Tehri&Koteshwar, Bhakra-Beas, Kopili – Kopili-II &Khandong and Ranganadi& Pare are cascading projects.

c. Further, it was underscored that there is no significant impact of cascading on downstream projects in FRAS. It was also summarized that:

    a. There is minimal operational constraint regarding FRAS despatch from reservoir/pondage based stations

    b. There is minimal impact on the state sector HEPs on account of FRAS despatch in the central sector plants

    c. All those constraints shall be honoured during despatch of FRAS which, at present, are being considered while scheduling of hydro plants byrespective RLDCs

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

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**Annexure-1**

**LIST OF PARTICIPANTS FOR MEETING OF 'FOR' TECHNICAL COMMITTEE SUB GROUP ON IMPLEMENTATION OF HYDRO AS FRAS AND ITS CASCADING EFFECTS ON DOWNSTREAM PROJECTS**

| | | |
|---|---|---|
| 1 | Shri A. S. Bakshi, Member | CERC |
| 2 | Dr. M.K Iyer, Member | CERC |
| 3 | Shri S.K.B.S Negi, Chairperson | HPERC |
| 4 | Shri Preman Dinaraj, Chairperson | KSERC |
| 5 | Sh. M K Shankaralinge Gowda, Chairperson | KERC |
| 6 | Shri P. Rama Mohan, Member | APSERC |
| 7 | Dr. S.K. Chatterjee, JC(RA) | CERC |
| 8 | Shri K.V.S Baba, CMD | POSOCO |
| 9 | Shri S K Soonee, Advisor | POSOCO |
| 10 | Shri Janardhan Choudhary, ED, | NHPC |
| 11 | Shri H L Arora, Director (Tech.) | THDC |
| 12 | Shri Nand Lal Sharma, CMD | SJVNL |
| 13 | Smt. Abha Saini, CE | BBMB |
| 14 | Shri S S Barpanda, GM, | NLDC, POSOCO |
| 15 | Shri H K Chawla, DGM | NRLDC, POSOCO |
| 16 | Shri R.K Porwal, DGM | NRLDC, POSOCO |

| | | |
|---|---|---|
| 17 | Shri S C Saxena, DGM | NLDC, POSOCO |
| 18 | Shri Anupam Kumar, Dy. Manager | NLDC, POSOCO |
| 19 | Shri K V N Pawan Kumar, Dy. Manager | NLDC, POSOCO |

# Update on FOR Technical Committee on Implementation of Framework for Renewables at the State Level

JUNE 7TH , 2018

'FOR' TECHNICAL COMMITTEE SUB GROUP ON IMPLEMENTATION OF HYDRO AS FRAS AND ITS CASCADING EFFECTS ON DOWNSTREAM PROJECTS

TEHRI

# FOR Technical Committee on Implementation of Framework on Renewables at State level

- Committee formed under chairmanship of Member CERC, Shri A.S. Bakshi
- Comprises Technical Members of State Commissions of RE rich states, viz.

| | |
|---|---|
| Andhra Pradesh; | Rajasthan |
| Gujarat; | Tamil Nadu |
| Karnataka; | Madhya Pradesh |
| Maharashtra; | Telangana |

- With evinced interest, West Bengal & Kerala became permanent special invitees
- Committee's mandate* is to ensure timely action by States on:
  - Deployment of Framework on Forecasting, Scheduling and Deviation Settlement of wind & solar generators;
  - Implementation of Availability Based Tariff (ABT) framework;
  - Introduction of Ancillary Services and Reserves;
  - Implementation of Automatic Generation Control (AGC) and primary control

(* mandate expanded subsequently)

# Key Initiatives by the Technical Committee



1. Report on Scheduling, Accounting, Metering and Settlement of Transactions in Electricity (SAMAST)
2. Model Framework for Forecasting, Scheduling and Deviation Settlement for RE sources at the State level
3. Model Deviation Settlement Mechanism (DSM) Regulations
4. Sub-group on Regional Co-operation for optimum utilization of Generation Resources
5. Report on roll-out of Smart Meters
6. Model Regulations for Intra-State Hydro Generating Stations
7. ***Report on Introduction of 5 Minute Time Block***
8. ***Introduction Of Fast Response Ancillary Services (FRAS) from Hydro Generating Stations***

# Modus Operandi of the Technical Committee



- So far, Committee has held 19 Meetings (additional 3 special meetings)
- Visits to six member States and NE Region since inception
- Senior officers of respective State SLDC, Discoms, TRANSCO, etc. are invited
- In-depth analysis of status of host state w.r.t. critical regulatory frameworks such as DSM and SAMAST, in addition to hydro resource utilization, load forecasting, etc.
- Sharing of experiences and best practices among the States
- Participants from other states of the respective region
- Consultant to the Committee assists States in drafting DPR & Regulations

*Renewed vigour at State level to fast-track execution of Committee's recommendations is critical*

# (1) SAMAST: Scheduling, Accounting, Metering and Settlement of Transactions in Electricity (SAMAST) Report



- Sub-Committee constituted at 2nd meeting of Technical Committee
  - Survey of prevailing infrastructure and procedures in 28 States, one-on-one interaction with SLDCs of 13 States

- SAMAST is the building block for advancing States towards intra-state grid discipline, smooth inter-State transactions, integration of renewables, etc.

- SAMAST report encompasses following requirements for implementation:
  - Hardware, including metering
  - IT infrastructure
  - Communication systems
  - Energy Accounting system and Settlement procedures
  - State Regulatory Pool Account
  - Human resources
  - Governance structures

# Update on implementation of SAMAST



- Model DPR and Model Implementation Roadmap shared
- FOR endorsed the 'Report on SAMAST' at 55th meeting (22nd Jul 2016)
- So far **only 5 States** have submitted final DPRs, and 6 States are in the process of finalizing the DPR.
- Part funding sought & sanctioned from Power System Development Fund (PSDF)
  - Madhya Pradesh Rs. 3.6 Cr
  - Rajasthan Rs. 11.86 Cr
  - Tamil Nadu Rs. 11.98 Cr
  - AP, Telengana, WB & Haryana submitted DPR for financial support
- ALL other States urged to – 1) create group to drive implementation of SAMAST- representatives from SLDC, concerned RLDC & RPC;
  (2) fast-track preparation of DPR and subsequent activities

# (2) State level F&S Framework on Renewables



- FOR endorsed Model Regulations for State Level Forecasting & Scheduling Framework, as prepared by FOR Secretariat, at the 50th FOR Meeting (30.9.15)
- Critical for ensuring grid discipline of RE generators & robust management of variable RE power by SLDCs.
- Technical Committee deliberated upon the Framework in detail. At the 6th meeting of the Committee (held 22nd Aug 2016), consensus was reached on following key aspects:
  - Qualified Coordinating Agency (QCA)
  - Operationalization of Virtual Pool and de-pooling mechanism
  - Funding the deficit in State Imbalance Pool
  - Mechanism for DSM for inter-state transactions of embedded entities
  - Metering arrangement
- Key Highlights of the Model Regulations can be found here

# Status Update on implementation of the RE Framework at the State level



**Current Status:**

- Final Regulations issued by 9 SERCs/JERC
  - Andhra Pradesh
  - Chhattisgarh
  - Jharkhand
  - Karnataka
  - Rajasthan
  - Madhya Pradesh
  - Telangana
  - Tripura
  - JERC of Mizoram and Manipur
- Draft Regulations issued by 6 SERCs
  - Gujarat
  - Maharashtra
  - Odisha
  - Tamil Nadu
  - Punjab
  - Haryana
- Comparison of F&S Regulations of selected Member States vis-à-vis FOR Model Regulations can be find here

# (3) Model Deviation Settlement Mechanism (DSM) Regulations



- To facilitate scheduling, energy accounting and deviation settlement of all grid-connected entities (buyers & sellers), while ensuring intra-state grid discipline. *Critical for States to know which entity causes deviations to what extent.*

- Model Regulations agreed in principle at the 8th meeting of the Committee held on 2nd Dec 2016.

- FOR endorsed the Regulations at its 57th Meeting held on 16th Dec 2016: http://www.forumofregulators.gov.in/Data/Working_Groups/DSMR.pdf

- States update:
  - Chhatisgarh has notified Intra-state ABT and DSM Regulations on 7th Nov 2016
  - Uttarakhand notified DSM Regulations on 6th Feb 2017
  - Tamil Nadu , Haryana are currently working on state-level DSM Regulations

- Key Highlights of the Model DSM Regulations can be found here

# (4) Sub-group on Regional Cooperation for Optimum Utilization of Generation Resources



- Increasing penetration of VRE needs sharing of generation resources across States for balancing purposes
- Sub-group constituted comprising of stakeholders from Northern, Western and Southern Region, headed by Member Secretaries of respective RPCs
- Mandated to examine feasibility and modality of co-operation for ensuring optimum utilization of generation resources.
- RPCs convened various meetings in respective regions
- Meeting of the Heads / Representatives of the Sub-Groups convened on 18th Aug 2017 at CERC
- At the 18th Meeting of the Technical Committee, a presentation was made before members on this subject where 7 options were provided for Intra Day/Hour ahead transaction
- The members of the Committee decided to go ahead with Option 6 (Pool based on auction for intra-day on hourly basis)
- Same was presented at the 63rd Meeting of FOR and the Forum endorsed the recommendation of Technical Committee
- 7 Options can be accessed here

# (5) Report on roll-out of Smart Meters



- Tariff Policy 2016 mandates introduction of Smart Meters
- Technical Committee was assigned to study advantages, costs, technical feasibility and total requirement of smart meters & provide recommendations
- Discussions held with various meter manufacturers, ISGF, DISCOMs & Industry Experts were held
- Based on discussions, CERC team prepared a report on **"Proposed implementation plan for roll out of Smart Meters"**
- Report includes detailed analysis of various aspects of such a roll-out:
  - Features of Smart Meters;
  - Provision of Time of Use Tariff;
  - Benefit to Consumers & Utilities;
  - Estimated Cost;
  - Financing options;
  - Total Requirement, etc
- Report was presented at the 15$^{th}$ Meeting of the Technical Committee. Committee members unanimously agreed to the findings of the report

# (6) Model Regulations for Intra-State Hydro Generating Stations



- Hydro generation an important source of flexibility to manage challenges of large scale renewable integration into the grid

- In June 2017, POSOCO released Report on "Operational Analysis for Optimization of Hydro Resources & facilitating Renewable Integration in India"

- Key observations of this report:
  - Many existing hydro generating stations can achieve better peaking capability, while honouring associated hydrological constraints & obligations of flood control, drinking water supply & irrigation requirements
  - CERC regulated hydro power stations are providing better peaking compared to intra-state-hydro power stations
  - CERC Regulations have provisions for two-part tariff where-in flexibility services like daily peaking capability & annual mechanical availability of units have been linked to recovery of capacity charge

# Evolution of Model Regulations for Hydro



- At the 13th Meeting of the Technical Committee, POSOCO presented on 'Optimization of Hydro resources'. Key highlights:
  - Hydro total installed capacity ~45 GW, about 16 GW are ISTS projects and balance within the States
  - With optimum utilization, hydro can be significantly used for peaking demand
  - Can enhance PLF of thermal plants by ensuring hydro plants are not run during off-peak hours
  - States are also required to adopt aforementioned CERC principles in the state-level hydro tariff regulations
- At the 14th meeting, POSOCO presented the Model Regulations. Same were endorsed by the Committee and recommended for consideration by FOR
- Model Regulations were endorsed in principle by FOR at the 61st FOR Meeting held on 22nd Sept 2017
- Key Highlights of the Model Regulations are as here.

# (7) Report on Introduction of 5-minute Time Block



- Tertiary reserves ancillary services implemented at ISTS level - actions at power plant happen 16-30 mins after instruction by NLDC
- Secondary regulation services through Automatic Generation Control (AGC) necessitates moving to 5-minute settlement (atleast for plants under AGC)
- 5-minute scheduling and settlement offers many advantages- reduction of requirement of reserves, reduction in variability, robust price discovery closer to real time and bringing out the value of flexibility, lowering of overall system costs, etc.
- Sub-group constituted comprising CEA, CTU, RPCs, POSOCO and CERC- prepared a roadmap for implementation (including requirements for infrastructure, standards and regulations)

Pilot of 5-minute meters:

- 5-Minute Meter testing was conducted, witnessed jointly by representatives of POSOCO (NLDC, WRLDC), POWERGRID, Gujarat SLDC and Meter Manufacturers
- **At 63rd Meeting of FOR, Forum endorsed the report and directed to conduct 5-Minute metering pilot project**

# (8) Hydro as FRAS



- Hydro generating stations are capable of providing a fast ramping capability
- Can be gainfully utilized for frequency regulation services to meet the system requirements
- The total energy despatched for hydro under FRAS is to be made zero and hence, no energy charges shall be payable
- A presentation on FRAS from Hydro Generators was made at the 63rd Meeting of FOR
- The Forum endorsed the recommendations of the Technical Committee for pilot studies on FRAS for Hydro, along with pilot studies on 5-Minutes Scheduling, Metering, Accounting and Settlement

# SAMAST Implementation Status



***Status of SAMAST Implementation in Hilly States***

# Profile of Uttarakhand




| RE Gen. Sources | Wind | SHP | Bio-Energy | Solar | Total |
|---|---|---|---|---|---|
| Gen. Potential (MW) | 534 | 1708 | 29 | 16800 | 19071 |

Peak Demand: 2037 MW (2016-17)
Supply: 2037 MW
No. of Sub-stations: 37 (as on 31.05.2014)
*(Ref.: LGBR 2017-18 Report & PTCUL website)*

## Generation Capacity of Uttarakhand

| Generation sources | State owned MW (UJVNL) | Central Sector MW |
|---|---|---|
| Coal | 0 | 343 |
| Gas | 0 | 70 |
| Hydro | 1252 | 476 |
| RE | 68 | 0 |
| Total (MW) | 1320 | 920 |

- Total Gen Cap. : 3356 MW
- IPPs : 1117 MW

*(Ref.: CEA, March 2018)*

No. of Distribution Licensees: 1 no. (UPCL)
No. of Transmission Licensees: 1 no. (PTCUL)
No. of OA Consumers : 79 no. (LTOA/MTOA/STOA)
*(Ref.: FOR - SAMAST Report, 2016)*

Regulatory Developments:

- Uttarakhand falls under **Category 'B'** of SAMAST report
- Thermal Gen. payment on **Scheduled** basis & Hydro gen. on **Actual** basis
- Draft MYT Tariff Regulations 2018, specifies provision of Capacity Charge and EC of Thermal & Hydro generators
- State Electricity Grid Code, 2016
- **UERC DSM Regulations, 2017 in line with CERC DSM Regulations ( Excl.RE Gen for DSM but needs to submit schedule to SLDC)**
- UERC Open Access Regulations, 2015, specifies treatment to the deviation of partial/full OA consumers and generators.

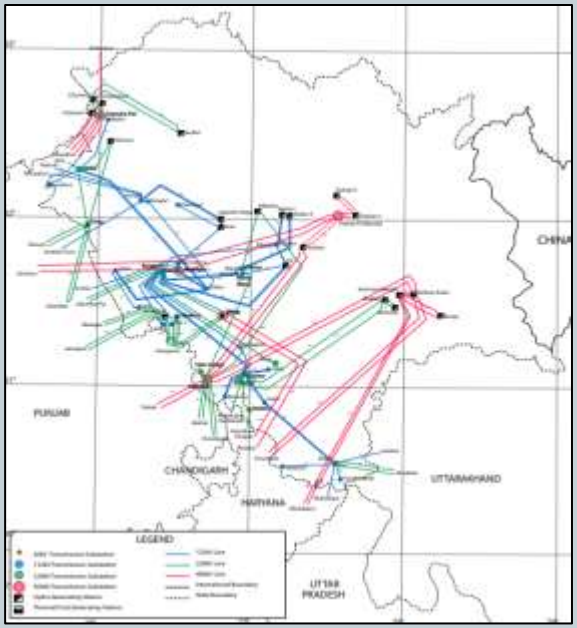
# Profile of Uttarakhand



- During Preparation of SAMAST Report, Uttarakhand was categorised under 'B' Category as Deviation treatment was specified and implemented for OA Customers.
- UERC on 18th February,2017 notified the Intra-State DSM Regulations which are inline with CERC DSM Regulations (CERC Price vector, provision of volume limits, Zero crossing).
- Date of implementation of UERC DSM Regulations is 1 April, 2018.
- Explanatory memorandum of DSM Regulations, considers that, period of 13 months will be useful for all stakeholders for developing necessary framework for implementation of Intra-State DSM.
- **As per the Status provided by UERC (March, 2017), following activities has been completed:**
  - Identification of Intra-State Entities
  - Demarcation of boundaries for Intra-State Entities.
  - Assessment of meters &, IT Infrastructure
  - Other activities would be implemented in line with SAMAST report after the notification of the Intra-State ABT & proposed State Grid Code Regulations, 2016

# Profile of Himachal Pradesh






| RE Gen. Sources | Wind | SHP | Bio-Energy | Solar | Total |
|---|---|---|---|---|---|
| Gen. Potential (MW) | 64 | 2398 | 144 | 33840 | 36446 |

Peak Demand: 1499 MW (2016-17)
Supply: 1499 MW
No. of Sub-stations: 13 no. of Substations
*(Ref.: LGBR 2017-18 Report & HPPTCL website)*

## Generation Capacity of Himachal Pradesh

| Generation sources | State owned MW (HPPCL & HPSEBL) | Central Sector MW |
|---|---|---|
| Coal | 0 | 183 |
| Gas | 0 | 62 |
| Hydro | 695 | 1224 |
| RE | 257 | 0 |
| Total MW | 951 | 1498 |

- Total Gen Cap. : 4039 MW
- IPPs : 1589 MW

*(Ref.: CEA, March 2018)*

No. of Distribution Licensees: 1 no. (HPSEBL)
No. of Transmission Licensees: 1 no. (HPPTCL)
No. of OA Consumers : 12 nos. (LTOA/MTOA/STOA)
*(Ref.: FOR - SAMAST Report, 2016)*

Regulatory Developments:

- Himachal Pradesh falls under Category 'D' of SAMAST report
- Hydro gen. on Scheduled basis
- HPERC MYT Hydro Tariff Regulations 2011, specifies provision for determination of Capacity Charge and Energy Charge of Hydro generators
- State Electricity Grid Code, 2008
- HPERC Open Access Regulations 2010, specifies treatment to the deviation of OA consumers and generators

***Himachal Pradesh has not submitted SAMAST status report to FOR Technical Committee***

# SAMAST Implementation Status



***Status of SAMAST Implementation in Karnataka, Kerala & AP***

# Profile of Karnataka



| RE Gen. Sources | Wind | SHP | Bio-Energy | Solar | Total |
|---|---|---|---|---|---|
| Gen. Potential (MW) | 13593 | 4141 | 1581 | 24700 | 44015 |

**Peak Demand:** 10261 MW (2016-17)
**Supply:** 10242 MW
No. of Sub-stations: 1514 (as on 31.03.2018)
*(Ref.: LGBR 2017-18 Report & KPTCL website)*

## Generation Capacity of Karnataka

| Generation sources | State owned MW (KPCL) | Central Sector MW |
|---|---|---|
| Coal | 5020 | 2829 |
| Gas | 0 | 0 |
| Hydro | 3600 | 0 |
| RE | 155 | 0 |
| Total in MW | 8903 (Diesel-128) | 3527 (Nuclear-698) |

- **Total Gen Cap. : 26697 MW**
- **IPPs : 14267 MW**

*(Ref.: CEA, March 2018)*

**No. of Distribution Licensees/SEZ**: 8 nos. (BESCOM, HESCOM, MESCOM, GESCOM, CESC, AEQUS SEZ, Mangalore SEZ and HRECS)
**No. of Transmission Licensees:** 1 no. (**KPTCL** – Exclusive Wires Company); [PCKL – Responsible for bulk power purchase and capacity addition activity]
**No. of OA Consumers :** 68 no. (LTOA/MTOA/STOA) *(Ref.: FOR - SAMAST Report, 2016)*

**Regulatory Developments:**

- Karnataka falls under **Category 'B'** of SAMAST report
- Thermal and Hydro Gen. payment on **Scheduled** basis
- KERC Generation Tariff Regulations 2014, specifies provision of Capacity Charge and Energy Charge of Thermal & Hydro generators
- KERC State Electricity Grid Code, 2015
- **KERC (Forecasting, Scheduling, Deviation Settlement and Related Matters for Wind and Solar Generation Sources) Regulations, 2015**
- KERC (Terms and Conditions of Open Access) Regulations, 2004, specifies treatment to the deviation of OA Cons. & Gen

# Status of SAMAST implementation in Karnataka



- SAMAST Report has categorized Karnataka State under 'B' Category as Deviation treatment is specified and implemented for OA Customers as per **KERC Order No. B/09/5 dated 20th June, 2006 for implementation of Intra-State ABT**.
- Karnataka has submitted the SAMAST DPR for **Implementation of Integrated system for Scheduling, Accounting, Metering and Settlement of Transactions (SAMAST)** system in SLDC Karnataka to PSDF on **22 December, 2017**. *(Ref: PSDF Status as on 05 March, 2018)*
- KERC on 31th May, 2016 notified the F&S Regulations which are inline with FOR Model F&S Regulations.
- Implementation of KERC F&S Regulations has been stated from 1st June, 2017.

# Profile of Kerala




| RE Gen. Sources | Wind | SHP | Bio-Energy | Solar | Total |
|---|---|---|---|---|---|
| RE Gen. Potential (MW) | 837 | 704 | 1080 | 6110 | 8732 |

**Peak Demand:** 4132 MW ( 2016-17)
**Supply:** 3996 MW
No. of Sub-stations: 393 (as on 28.02.2018)
*(Ref.: LGBR 2017-18 Report & KSEB website)*

## Generation Capacity of Kerala

| Generation sources | State owned MW (KSEBL) | Central Sector MW |
|---|---|---|
| Coal | | 1143 |
| Gas | | 360 |
| Hydro | 1882 | |
| RE | 151 | 50 |
| Total in MW | 2192 (Diesel-160) | 1915 (Nuclear-362) |

- Total Gen Cap. : 5075 MW
- IPPs : 967 MW

*(Ref.: CEA, March 2018)*

**No. of Distribution Licensees /SEZ**: The Strategic Business Unit-Distribution of KSEBL (Regions – South, Central, North & North Malabar) and Cochin SEZ
**No. of Transmission Licensees:** Transmission SBU of KSEBL (North & South zones)
**No. of OA Consumers** : 12 no. (LTOA/MTOA/STOA) *(Ref.: FOR - SAMAST Report, 2016)*

**Regulatory Developments:**

- Kerala falls under **Category 'B'** of SAMAST report
- Thermal Gen. payment on **actual** basis and Hydro gen. on **scheduled** basis
- KSERC (Terms and conditions of determination of Tariff) Reg., 2014, specifies provision of Capacity Charge and Energy Charge of Thermal & Hydro generators State Electricity Grid Code, 2005
- KSERC (Connectivity and Intra-State Open Access) Regulations 2013, specifies treatment to the Deviation of OA Customers

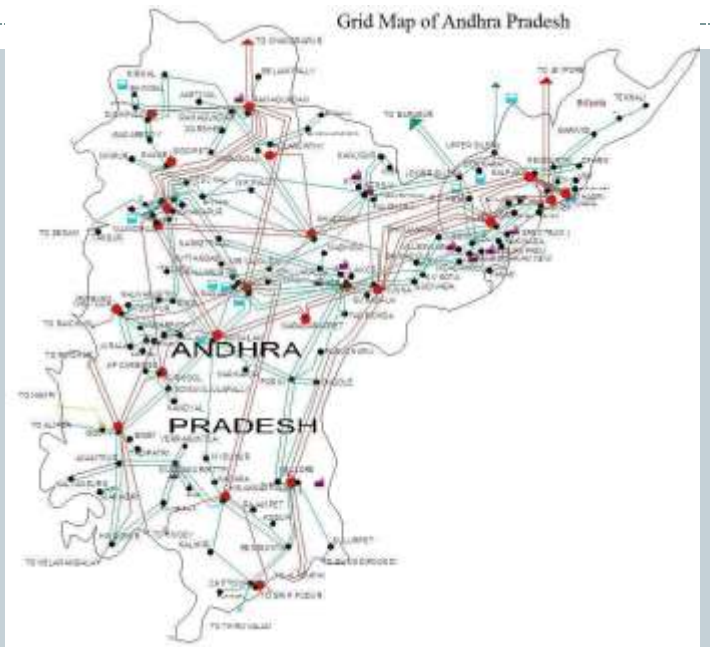
# Status of SAMAST implementation in Kerala



- SAMAST Report has categorized Kerala State under 'B' Category as Deviation treatment is specified and implemented for OA Customers as per **KSERC (Connectivity and Intra-state Open Access) Regulations, 2013.**
- **SAMAST DPR for Kerala is yet to be prepared.**
- **Following activities need to be completed:**
  - Identification of Intra-State Entities
  - Demarcation of boundaries for Intra-State Entities.
  - Assessment of meters &, IT Infrastructure
  - Other activities would be implemented in line with SAMAST report after the notification of the Intra-State ABT.

# Profile of Andhra Pradesh






## Generation Capacity of Andhra Pradesh (in MW)

| Generation sources | State owned | Central Sector | Pvt. Sector |
|---|---|---|---|
| Coal | 5010 | 1674.56 | 3873.88 |
| Gas | 235.40 | 0 | 3694.12 |
| Diesel | 0 | 0 | 36.80 |
| Nuclear | | 127.27 | 0 |
| Hydro | 1673.60 | 0 | 0 |
| RE | 48.75 | 250 | 6427.13 |
| Total in MW | 6967.75 | 2051.83 | 14031.93 |

**Total Gen Cap. : 23051.51 MW**
*(Ref.: CEA, March 2018)*

No. of Distribution Licensees: 2 no. (APSPDCL, APEPDCL)
No. of Transmission Licensees: 1 no. (APTRANSCO)
No. of OA Consumers : 10 no. (Interstate - LTOA/MTOA/STOA)
*(Ref.: FOR - SAMAST Report, 2016)*

| RE Gen. Sources | Wind | SHP | Bio-Energy | Solar | Total |
|---|---|---|---|---|---|
| Gen. Potential (MW) | 14497 | 978 | 1001 | 38440 | 54916 |

Peak Demand: 7969 MW (2016-17)
Supply: 7965 MW
No. of Sub-stations:302 (as on Feb,2018)
*(Ref.: LGBR 2017-18 Report & APTRANSCO website )*

**Regulatory Developments:**

- Andhra Pradesh falls under **Category 'B'** of SAMAST report
- Generation Tariff Regulations, 2008 (Regulations No. 2008) specifies provision of Annual Fixed Charge and EC of Thermal & Annual Capacity Charge and EC for Hydro generators
- AP Code of Technical Interface, 2014 (Electricity Grid Code)
- APERC F&S Regulations, 2017
- APERC Open Access Regulations, 2005/ APERC (Interim Balancing and Settlement Code for Open Access Transactions, 2006) specifies treatment to the deviation of partial/full OA consumers and generators.

# Status of SAMAST implementation in Andhra Pradesh



- SAMAST Report has categorised Andhra Pradesh State under 'B' Category as Deviation treatment is specified and implemented for OA Customers.
- As per the Status report with FOR Technical Committee, Andhra Pradesh has submitted final DPR for SAMAST implementation.
- APERC on 19th August, 2017 notified APERC (Forecasting, Scheduling and Deviation Settlement of Solar and Wind Generation Regulation, 2017).The date of implementation of APERC F&S Regulations was 21st August, 2017.
- Implementation started from 1st Jan 2018 while levy and collection of deviation charges shall commence from 1st July 2018

# SAMAST Implementation Status



***Preparedness of North Eastern States for DSM implementation at state level***

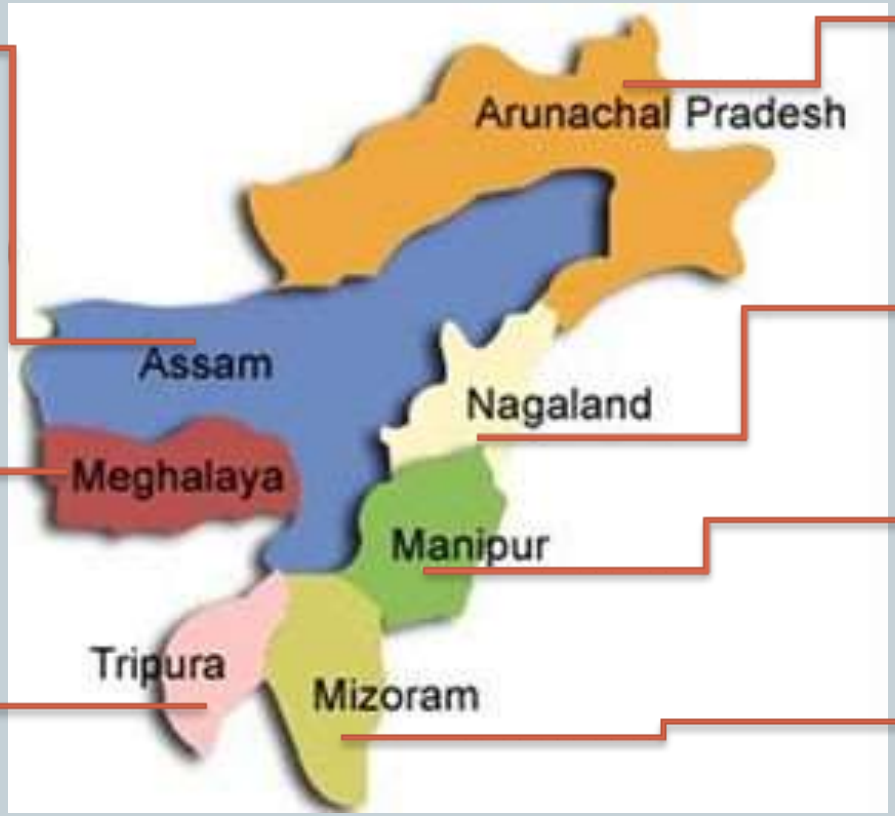
# North Eastern Region: Overview



1505 MW (APGCL, NTPC, NEEPCO; SLDC, Kahelipara, Guwahati)

558 MW (NEEPCO, MECL; SLDC, Shillong

727 MW (NEEPCO, OTPC, TSECL; SLDC, Agartala)




279 MW (NEEPCO; SLDC, Itanagar)

155 MW (NEEPCO; SLDC, Dimapur)

233 MW (NHPC, MPDC; SLDC, Imphal)

192 MW (NEEPCO; SLDC, Aizawl)

- Total installed capacity of North Eastern Region is 3917 MW, which includes 266 MW of Central – Unallocated share.
- Regional Peak Demand: 2487 MW; Peak met: 2475 MW *(Ref: Data for 2016-17 from LGBR 2017-18 report)*

# Salient features of North-East Region Power System



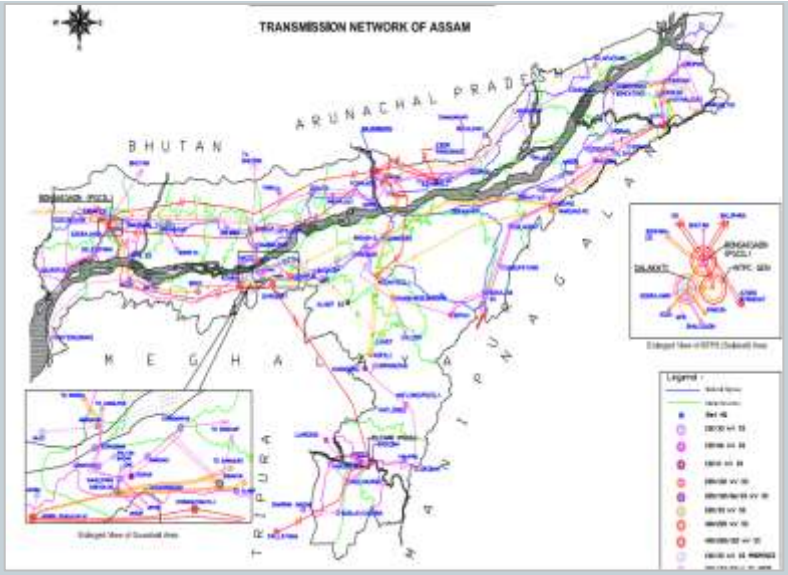
- Constituent states : Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland and Tripura, so called the Seven Sisters of NER.
- Central Sector agencies : NEEPCO, NHPC, POWERGRID, OTPC, NETC.
- Total installed capacity of the region : 3917 MW *(As on 31.03.2018)*
- **Hydro : Thermal ratio- 37:63 (Hydro-1342 MW & Thermal-2292 MW)** *(CEA, March 2018)*
- Regional Peak Demand: 2487MW |Peak met: 2475 MW *(LGBR-2017-18 Report)*

| S No. | State | Under Management/Control of | SLDC |
|---|---|---|---|
| 1 | Assam | Assam Electricity Grid Corporation Limited (AEGCL) | SLDC, Kahelipara, Guwahati |
| 2 | A. P. | The Dept. of Power, Govt of A.P. | SLDC, Itanagar |
| 3 | Meghalaya | Meghalaya Power Transmission Corporation Limited (MePTCL) | SLDC, Shillong |
| 4 | Manipur | Manipur State Power Company Limited (MSPCL) | SLDC, Imphal |
| 5 | Mizoram | The Power & Electricity Dept., Govt of Mizoram | SLDC, Aizawl |
| 6 | Nagaland | The Dept. of Power, Govt of Nagaland | SLDC, Dimapur |
| 7 | Tripura | Tripura State Electricity Corporation Limited (TSECL) | SLDC, Agartala |

*Source: NERLDC Website*

# Profile of Assam

30




## Generation Capacity of Assam

| Generation sources | State owned MW (APGCL) | Central Sector MW |
|---|---|---|
| Coal | | 279 |
| Gas | 288 | 436 |
| Hydro | 100 | 331 |
| RE | 30 | |
| Total in MW | 418 | 1046 |

- Total Gen Cap. : 1505 MW
- IPPs : 41 MW

*(Ref.: CEA, March 2018)*

No. of Distribution Licensee: 1 no. (APDCL - Assam Power Dist. Co. Ltd)
No. of Transmission Licensee: 1 no. (AEGCL - Assam Electricity Grid Co. Ltd.)
No. of OA Consumers : 14 no. (LTOA/MTOA/STOA)
*(Ref.: FOR - SAMAST Report, 2016)*

| RE Gen. Sources | Wind | SHP | Bio-Energy | Solar | Total |
|---|---|---|---|---|---|
| Gen. Potential (MW) | 112 | 239 | 220 | 13760 | 14330 |

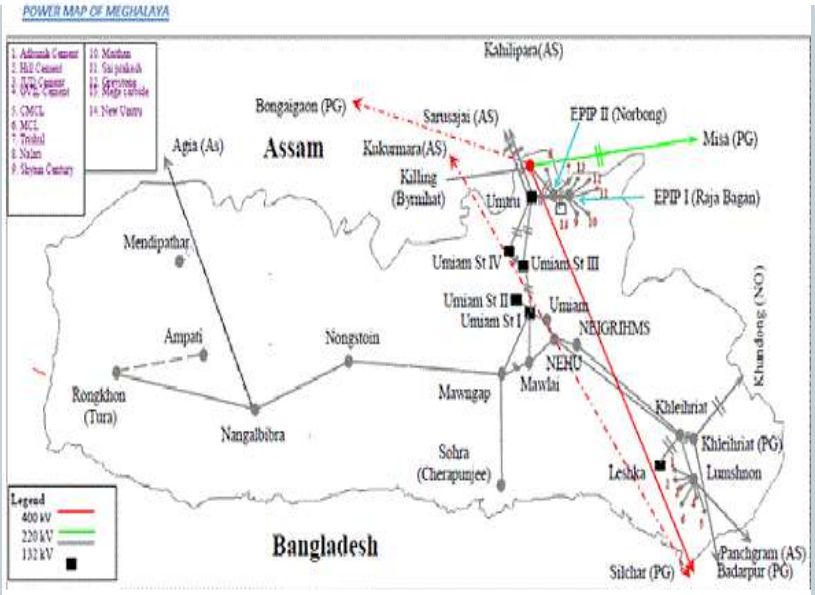
**Peak Demand**: 1673 MW ( 2016-17)
**Supply:** 1633 MW
**No. of Sub-stations:** 63 no. of Substations (as on July, 2017)
*(Ref.: LGBR 2017-18 Report & AEGCL website)*

**Regulatory Developments:**

- Assam falls under **Category 'D'** of SAMAST report
- Thermal Gen. payment on **actual** basis and Hydro gen. on **scheduled** basis
- AERC MYT Tariff Regulations, 2015 and its amendments, specifies provision of determination of Capacity Charge and Energy Charge of Hydro generators and thermal generators
- State Electricity Grid Code, 2004
- AERC (Open Access) Regulations 2005, specifies treatment to the Deviation of OA generators/consumers
- Draft AERC (Terms and Conditions for Open Access) Regulations, 2018 published for public comments on 7 Feb,2018

# Profile of Meghalaya






| RE Gen. Sources | Wind | Small Hydro | Bio-Energy | Solar | Total |
|---|---|---|---|---|---|
| Gen. Potential (MW) | 82 | 230 | 13 | 5860 | 6185 |

**Peak Demand:** 331 MW (2016-17)
**Supply:** 331 MW
No. of Sub-stations: 20 no. of Substations
*(Ref.: LGBR 2017-18 Report & MePTCL/SLDC website)*

## Generation Capacity of Meghalaya

| Generation sources | State owned MW (MePGCL) | Central Sector MW |
|---|---|---|
| Coal | | 30 |
| Gas | | 110 |
| Hydro | 322 | 65 |
| RE | 31 | |
| Total in MW | 353 | 205 |

- Total Gen Cap. : 558 MW
- IPPs : 0.02 MW

*(Ref.: CEA, March 2018)*

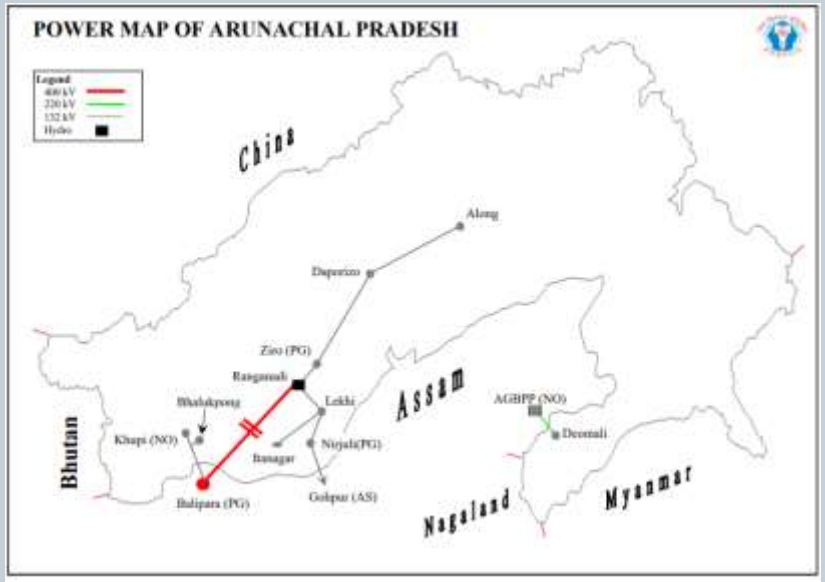
No. of Distribution Licensee: 1 no. (MePDCL)
No. of Transmission Licensee: 1 no. (MePTCL)
No. of OA Consumers : 7 no. (LTOA/MTOA/STOA)
*(Ref.: FOR - SAMAST Report, 2016)*

Regulatory Developments:

- Meghalaya falls under **Category 'B'** of SAMAST report
- Generators payment on scheduled basis
- MYT Tariff Regulations, 2014 and its amendments, MSERC MYT Regulation specifies provision determination of Capacity Charge and Energy Charge of generators
- State Electricity Grid Code, 2012 and its amendments
- MSERC Terms & condition of Open Access Regulations, 2012, specifies treatment to the Deviation of OA generators/consumers

# Profile of Arunachal Pradesh

32




| RE Gen. Sources | Wind | SHP | Bio-Energy | Solar | Total |
|---|---|---|---|---|---|
| Gen. Potential (MW) | 236 | 1341 | 8 | 8650 | 10236 |

**Peak Demand:** 148 MW (2016-17)
**Supply:** 140 MW

## Generation Capacity of Arunachal Pradesh

| Generation sources | State owned MW (DHPD & APEDA) | Central Sector MW |
|---|---|---|
| Coal | | 25 |
| Gas | | 47 |
| Hydro | | 97 |
| RE | 105 | |
| Total in MW | 105 | 169 |

- Total Gen Cap. : 279 MW
- IPPs : 5 MW

*(Ref.: CEA, March 2018)*

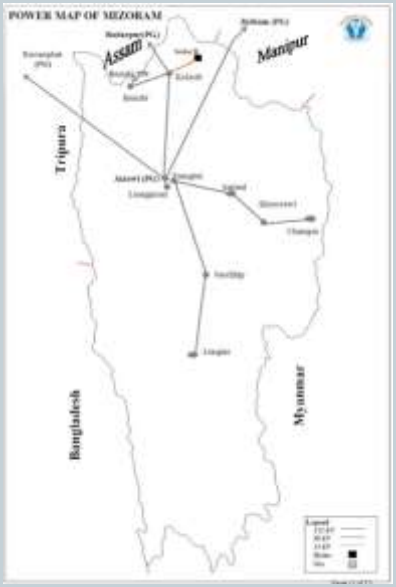
No. of Distribution Licensees: 1 no. (Dept. of Power Arunachal Pradesh)
No. of Transmission Licensees: 1 no. (Dept. of Power Arunachal Pradesh)
No. of Generation Company: 2 nos. Department of Hydro Power Development (DHPD) & Ar. Pradesh Energy Development Agency (APEDA)

Regulatory Developments:

- Arunachal Pradesh falls under **Category 'D'** of SAMAST report
- Hydro generator payment on **scheduled** basis
- MYT Tariff Regulations, 2013, APSERC MYT Regulation specifies provision of determination of Capacity Charge and Energy Charge of Hydro generators
- State Electricity Grid Code, 2012
- APSERC (Terms and Conditions for Open Access) Regulations 2012, specifies treatment to the Deviation of OA generators/consumers

# Profile of Mizoram






Generation Capacity of Mizoram

| Generation sources | State owned MW (P&E Dept. of Mizoram) | Central Sector MW |
|---|---|---|
| Coal | | 21 |
| Gas | | 40 |
| Hydro | | 94 |
| RE | 36 | |
| Total in MW | 36 | 155 |

- Total Gen Cap. : 192 MW
- IPPs : 0.20 MW

*(Ref.: CEA, March 2018)*

No. of Distribution Licensee: 1 no. (Power & Electricity Dept. of Mizoram)
No. of Transmission Licensee: 1 no. (Power & Electricity Dept. of Mizoram)

| RE Gen. Sources | Wind | SHP | Bio-Energy | Solar | Total |
|---|---|---|---|---|---|
| Gen. Potential (MW) | - | 169 | 3 | 9090 | 9261 |

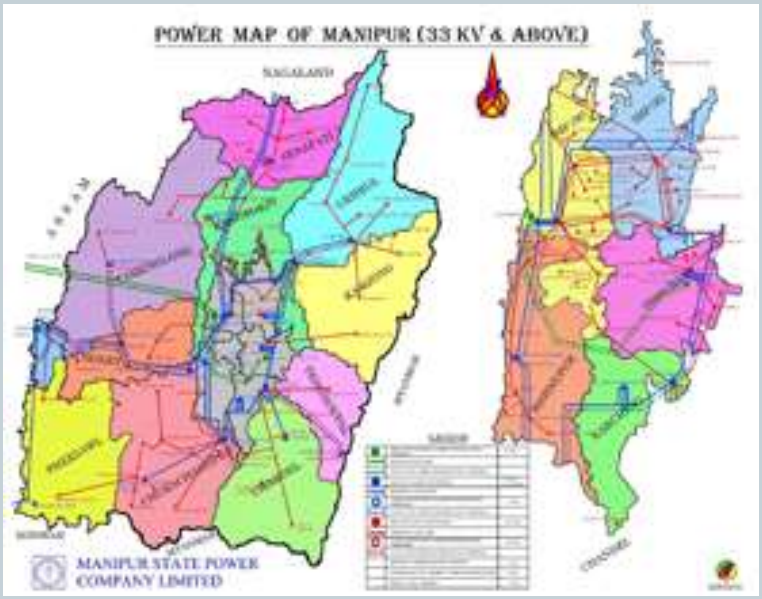
**Peak Demand**: 98 MW (2016-17)
**Supply:** 98 MW
No. of Sub-stations: 52 no. of Substations
*(Ref.: LGBR 2017-18 Report and Power & Electricity Dept. of Mizoram)*

**Regulatory Developments:**

- Mizoram falls under **Category 'D'** of SAMAST report
- Thermal Gen. payment on **Scheduled** basis and Hydro gen. on **Actual** basis
- **JERC (Forecasting, Scheduling, Deviation Settlement and Related Matters of Solar and Wind Generation Sources) Regulations, 2016**
- MYT Tariff Regulations, 2014, JERC MYT Regulation specifies provision determination of Capacity Charge and Energy Charge of generators
- State Electricity Grid Code, 2010 and its amendments
- Terms and Conditions of Open Access Regulations, 2010, specifies treatment to the Deviation of OA generators/consumers

# Profile of Manipur






| RE Gen. Sources | Wind | SHP | Bio-Energy | Solar | Total |
|---|---|---|---|---|---|
| Gen. Potential (MW) | 56 | 109 | 15 | 10630 | 10811 |

**Peak Demand:** 163 MW (2016-17)
**Supply:** 163 MW
No. of Sub-stations: 95 no. of Substations
*(Ref.: LGBR 2017-18 Report & MSPCL petition)*

## Generation Capacity of Manipur

| Generation sources | State owned MW (MSPCL) | Central Sector MW |
|---|---|---|
| Coal | | 31 |
| Gas | | 72 |
| Hydro | | 89 |
| RE | 5 | |
| Total in MW | 41 (Diesel-36 MW) | 192 |

- Total Gen Cap. : 233 MW
- IPPs : 0.06 MW

*(Ref.: CEA, March 2018)*

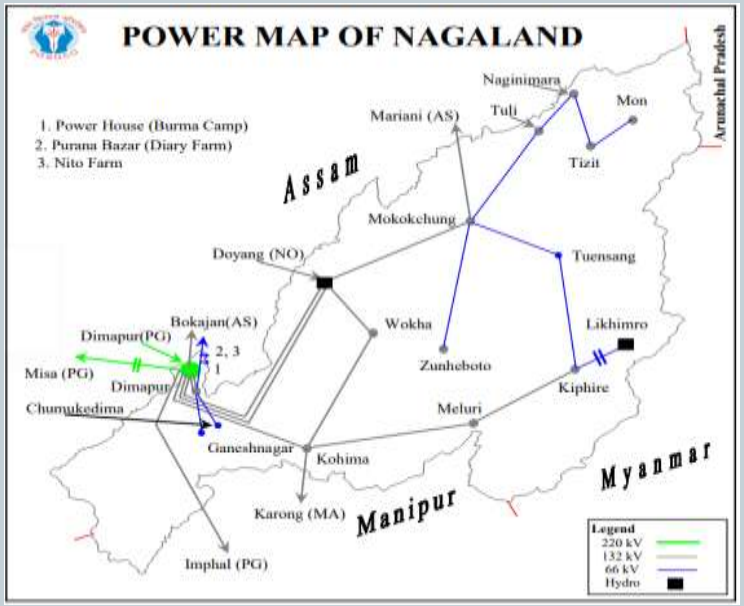
No. of Distribution Licensees: 1 no. (MSPDCL)
No. of Transmission Licensees: 1 no. (MSPCL - Manipur State Power Co. Ltd.)

Regulatory Developments:

- Manipur falls under **Category 'D'** of SAMAST report
- Thermal Gen. payment on **Scheduled** basis and Hydro gen. on **Actual** basis
- **JERC (Forecasting, Scheduling, Deviation Settlement and Related Matters of Solar and Wind Generation Sources) Regulations, 2016**
- MYT Tariff Regulations, 2014, JERC MYT Regulation specifies provision determination of Capacity Charge and Energy Charge of generators
- State Electricity Grid Code, 2010 and its amendments
- Terms and Conditions of Open Access Regulations, 2010, specifies treatment to the Deviation of OA generators/consumers

# Profile of Nagaland






| RE Gen. Sources | Wind | SHP | Bio-Energy | Solar | Total |
|---|---|---|---|---|---|
| Gen. Potential (MW) | 16 | 197 | 10 | 7290 | 7513 |

**Peak Demand:** 148 MW (2016-17)
**Supply:** 147 MW

## Generation Capacity of Nagaland

| Generation sources | State owned MW (DoPN) | Central Sector MW |
|---|---|---|
| Coal | | 21 |
| Gas | | 49 |
| Hydro | | 53 |
| RE | 31 | |
| Total in MW | 31 | 124 |

- Total Gen Cap. : 155 MW
- IPPs : 1 MW

*(Ref.: CEA, March 2018)*

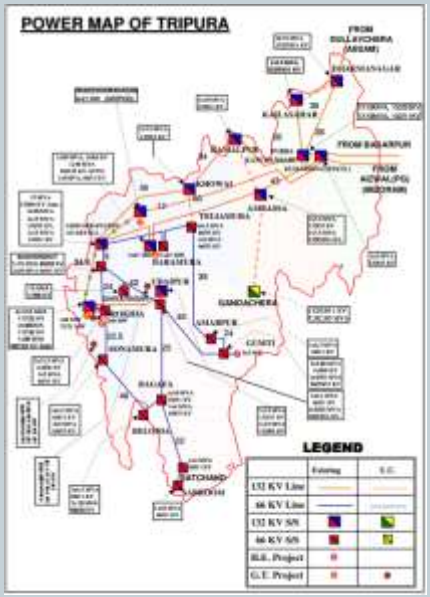
No. of Distribution Licensees: 1 no. (Department of Power, Nagaland)
No. of Transmission Licensees: 1 no. (Department of Power, Nagaland)

**Regulatory Developments:**

- Nagaland falls under **Category 'D'** of SAMAST report
- Thermal Gen. payment on **Scheduled** basis and Hydro gen. on **Actual** basis
- MYT Tariff Regulations 2016, NERC MYT Regulation specifies provision determination of Capacity Charge and Energy Charge of Thermal & Hydro generators
- State Electricity Grid Code, 2012
- NERC (Terms and Condition for Intra-State Open Access Reg.), 2012

# Profile of Tripura






## Generation Capacity of Tripura

| Generation sources | State owned MW (TSECL) | Central Sector MW |
|---|---|---|
| Coal | | 37 |
| Gas | 170 | 437 |
| Hydro | | 63 |
| RE | 16 | 5 |
| Total in MW | 186 | 542 |

- Total Gen Cap. : 727 MW
- IPPs : 0.09 MW

*(Ref.: CEA, March 2018)*

No. of Distribution Licensee: 1 no. (TSECL)
No. of Transmission Licensee: 1 no. (TSECL)

| RE Gen. Sources | Wind | SHP | Bio-Energy | Solar | Total |
|---|---|---|---|---|---|
| Gen. Potential (MW) | | 47 | 5 | 2080 | 2131 |

**Peak Demand**: 284 MW (2016-17)
**Supply:** 284 MW
No. of Sub-stations: 16 no. of Substations
*(Ref.: LGBR 2017-18 Report & TSECL website)*

**Regulatory Developments:**

- Tripura falls under **Category 'D'** of SAMAST report
- Generators payment on **scheduled basis**
- **TERC (Forecasting, Scheduling, Deviation Settlement and Related Matters of Solar and Wind Generation Sources) Reg., 2016**
- MYT Tariff Regulations 2015, TERC MYT Regulation specifies provision determination of Capacity Charge and Energy Charge of generators
- State Electricity Grid Code, 2010
- TERC Terms and condition of Intra-State Open Access Regulations, 2010, specifies treatment to the Deviation of OA generators/consumers

# SAMAST Status: North-East States



| Sr. | Activities | Assam | Meghalaya | Manipur | Mizoram | Nagaland | Tripura | Ar. Pradesh |
|---|---|---|---|---|---|---|---|---|
| 1 | Meeting with SAMAST Group of NE region | Completed | Completed | Completed | Completed | Completed | Completed | Completed |
| 2 | Assessment of meters | 700 Nos | 589 Nos | 500 Nos | 413 Nos | 198 Nos | 366 Nos | 121 Nos |
| 3 | Assessment of AMR Requirement | Completed | Completed | Completed | Completed | Completed | Completed | Completed |
| 4 | Assessment of IT Infrastructure | Completed | Completed | Completed | Completed | Completed | Completed | Completed |
| 5 | Utility Software identification | Completed | Completed | Completed | Completed | Completed | Completed | Completed |
| 6 | Preparation of BOQ & DPR | Completed | Completed | Completed | Completed | Completed | Completed | Completed |
| 7 | Submission to PSDF Committee | 25.05.2018 | | | | | | |

- NERPC and NERLDC co-ordinated all the activities of preparation of SAMAST DPR for each state in N-E region.
- Consultant Idam Infra was invited by NERLDC and NERPC for discussions with all SLDCs in N-E region.
- Idam Infra attended the meetings on 14$^{th}$ and 16$^{th}$ May,2018 in Meghalaya and Guwahati and guided all the SLDCs for assessment of interconnections points, metering requirement, communication infrastructure, preparation of estimates of DPR
- Based on discussions during meeting dated 16 May 18 , all SLDCs in N-E region finalised the DPRs and sought approval of their management and submitted the DPRs to PSDF committee through NERPC.

# Cost Comparison of NER SAMAST DPRs



| Name | No of Meters | Cost of Meter in Rs. Lakh | Cost/Meter in Rs. Lakh | Cost of HW/SW in Rs. Lakh | Project Cost of SAMAST in Rs. Lakh | CT/PT replacement Cost in Rs. Lakh | GRAND Total in Rs. Lakh |
|---|---|---|---|---|---|---|---|
| AP | 121 | 55.7 | 0.461 | 1287.6 | 1343.3 | 0.0 | 1343.3 |
| Assam | 700 | 322.5 | 0.461 | 1530.8 | 1853.3 | 157.6 | 2010.9 |
| Manipur | 589 | 284.9 | 0.484 | 1561.6 | 1846.5 | 1685.5 | 3532.0 |
| Meghalaya | 374 | 180.9 | 0.484 | 1467.0 | 1647.9 | 229.3 | 1877.2 |
| Mizoram | 413 | 190.3 | 0.461 | 1435.7 | 1626.0 | 200.0 | 1825.9 |
| Nagaland | 198 | 91.2 | 0.461 | 1335.9 | 1427.1 | 445.0 | 1872.2 |
| Tripura | 366 | 168.6 | 0.461 | 1343.1 | 1511.7 | 1339.3 | 2851.0 |
| Total | 2761 | 1294.0 | | 9961.8 | 11255.8 | 4056.6 | 15312.5 |

Note:

- Cost per meter including GST : Rs. 46100/- ( Rs. 48400/- including 5% Freight and insurance)
- CT/PT replacement cost included considering replacement of those inferior to 0.5 class accuracy.
- All cost figures as per budgetary quote of M/S Kalkitech (Lowest of M/S L&T, M/S Secure Meters and M/S Kalkitech)

# THANK YOU

## FOR QUESTIONS, PLEASE WRITE TO:

JCRA@CERCIND.GOV.IN

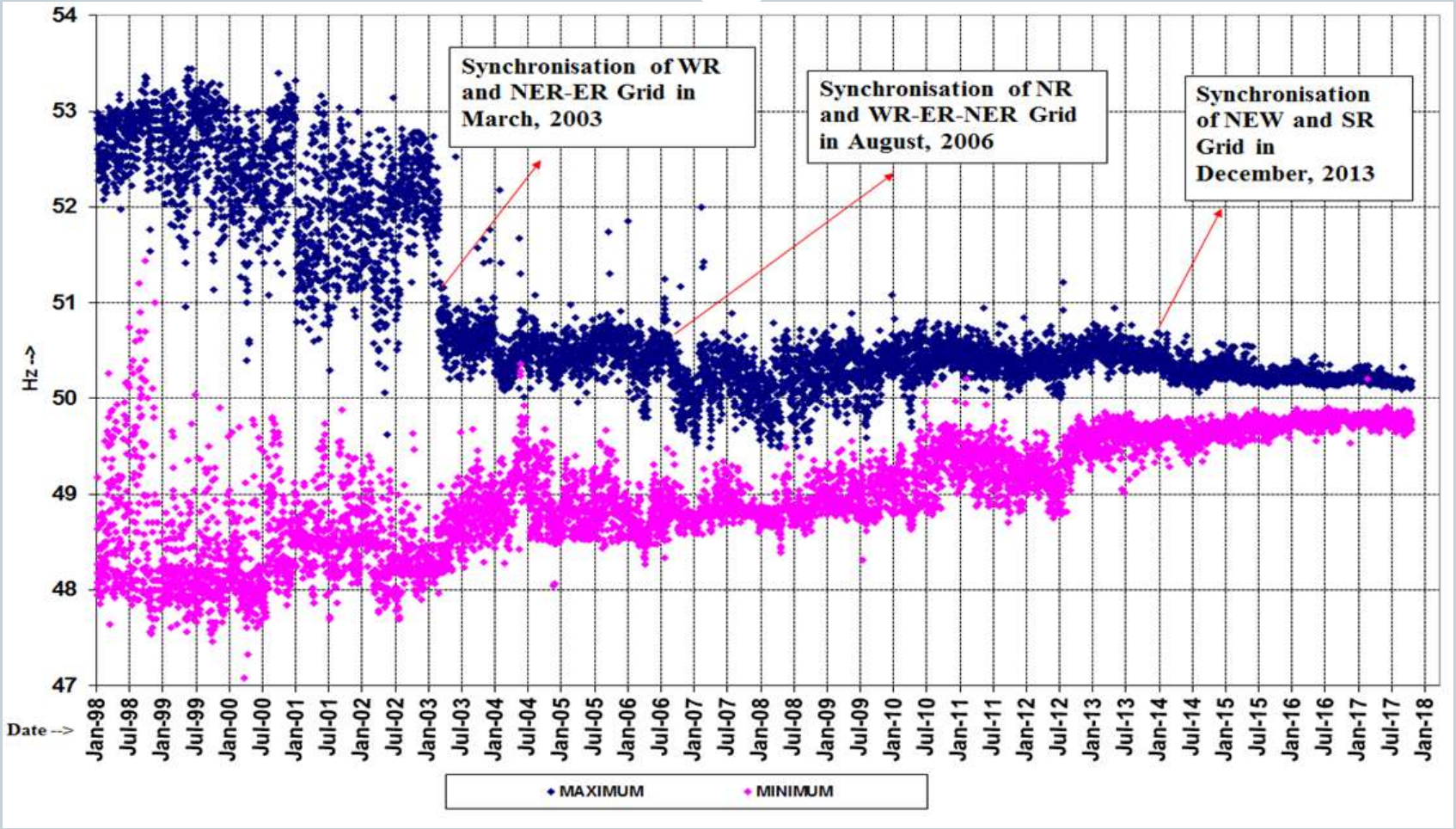
# DSM framework at regional level : historical developments



- **DSM mechanism was introduced in various regions in stages**
  - Western (1-Jul-2002), Northern (1-Dec-2002), Southern (1-Jan-2003), Eastern (1-Apr-2003) and North-Eastern (1-Nov-2003)
- **The main objectives of introduction of DSM mechanism at regional level have been:**
  - Encourage grid discipline
  - Economic load dispatch
  - Accounting of exchange of energy and capacity
  - Encourage higher availability
- **Key benefits of DSM mechanism at regional level**
  - Improved grid frequency
  - Reduced frequency variations
  - Reduction of number of interruptions/grid failures
- **Successful implementation of DSM at regional level has firmed up belief that DSM mechanism (similar to mechanism at regional level) should be introduced at the State level**

# Maximum and Minimum Frequency Profile[7]

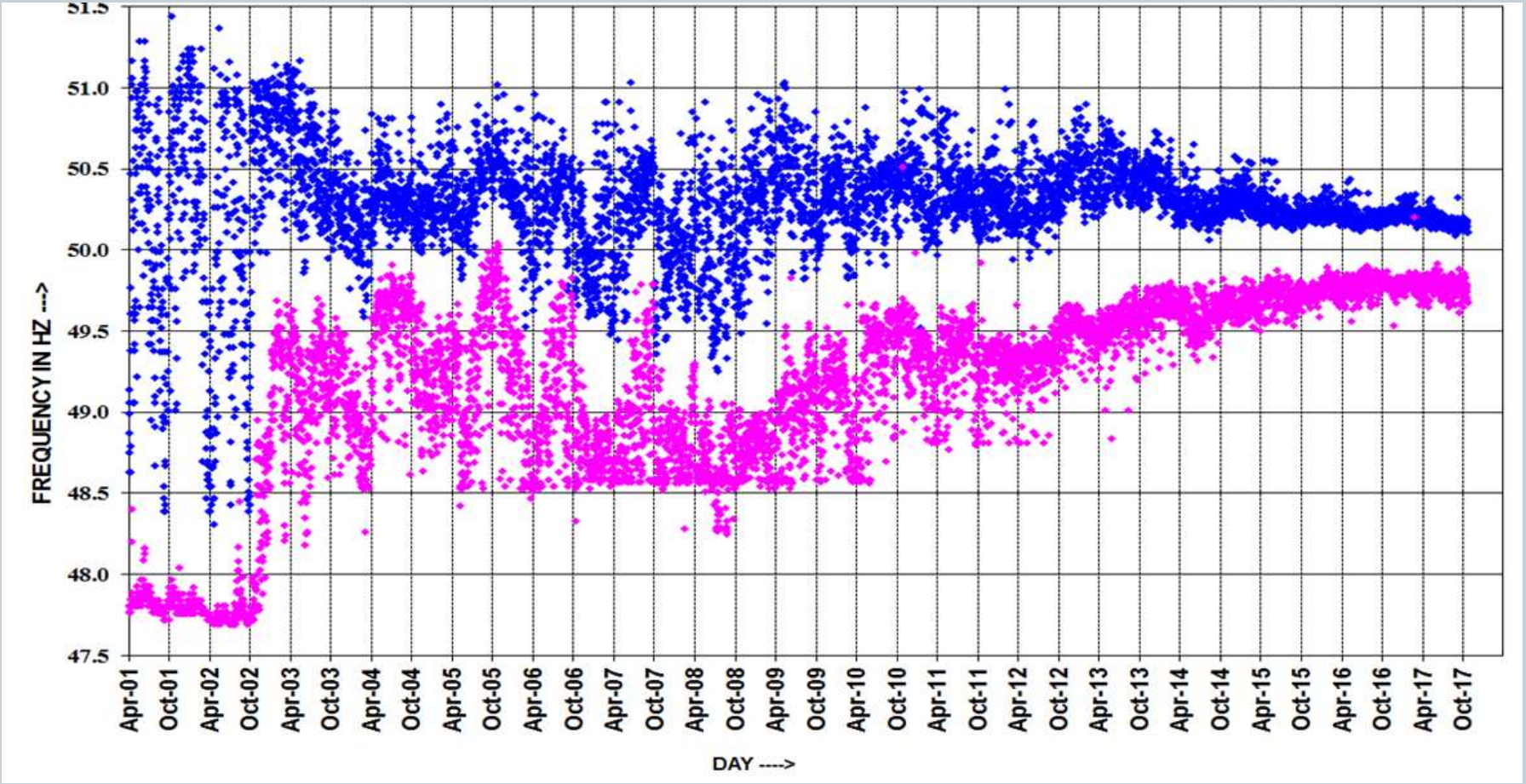





[7] – Based on ER / NEW Grid Data Source : POSOCO and CERC

# Maximum and Minimum Frequency Profile Southern Region[8]



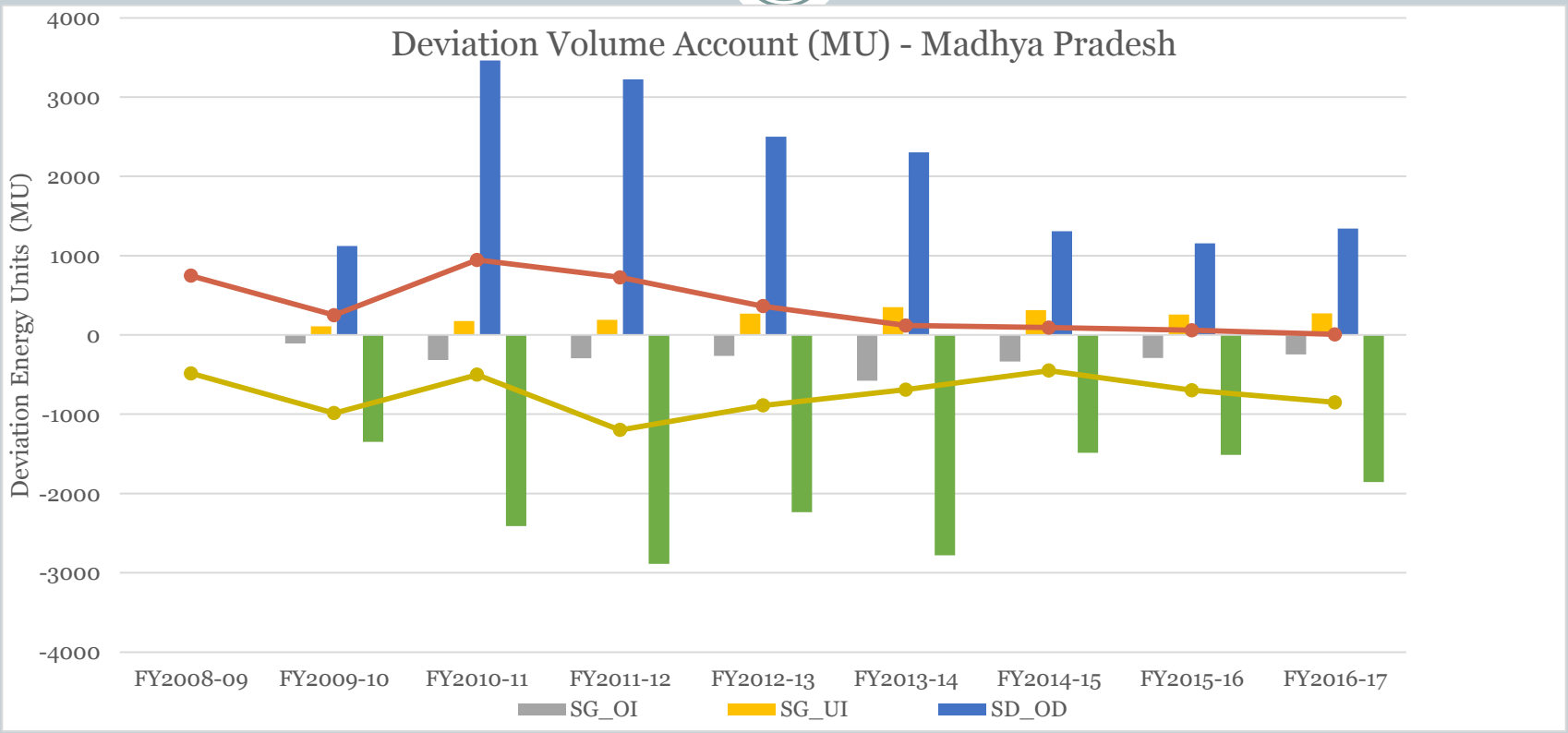



[8] – Based on SR Grid Data till Dec'14 and All India Grid data thereafter

Source : POSOCO and CERC

# Madhya Pradesh : Deviation Account (MU) FY09 to FY17

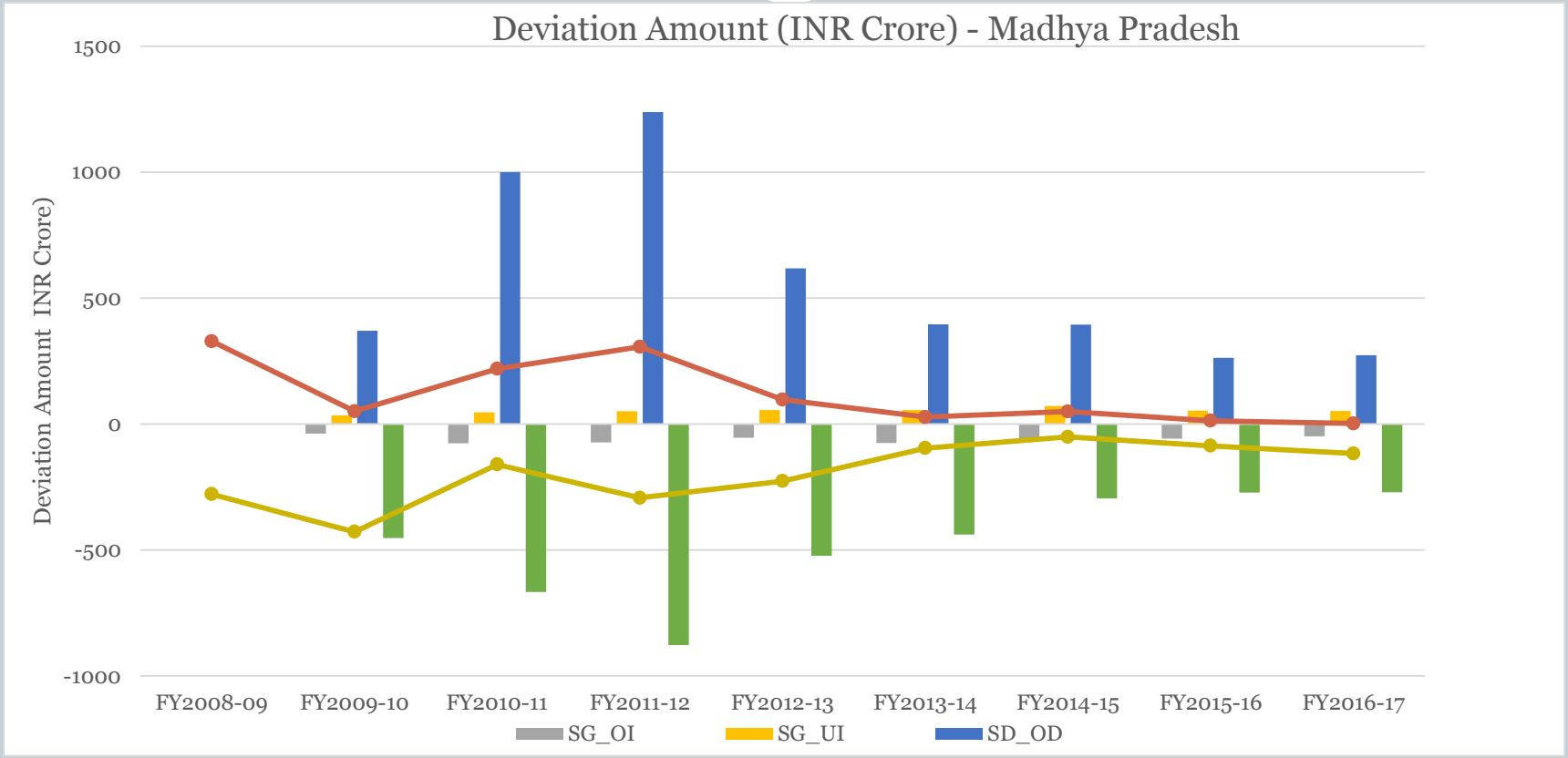





- Pre DSM and Post DSM (at state level) : significant improvement over the period
- Improvement in Balancing/Deviation management by Intra-state entities over the period
- Share of energy units handled at state periphery is ~ 35% of total energy units handled for intra-state entities

# Madhya Pradesh : Deviation Amount (INR Cr) FY09 to FY17

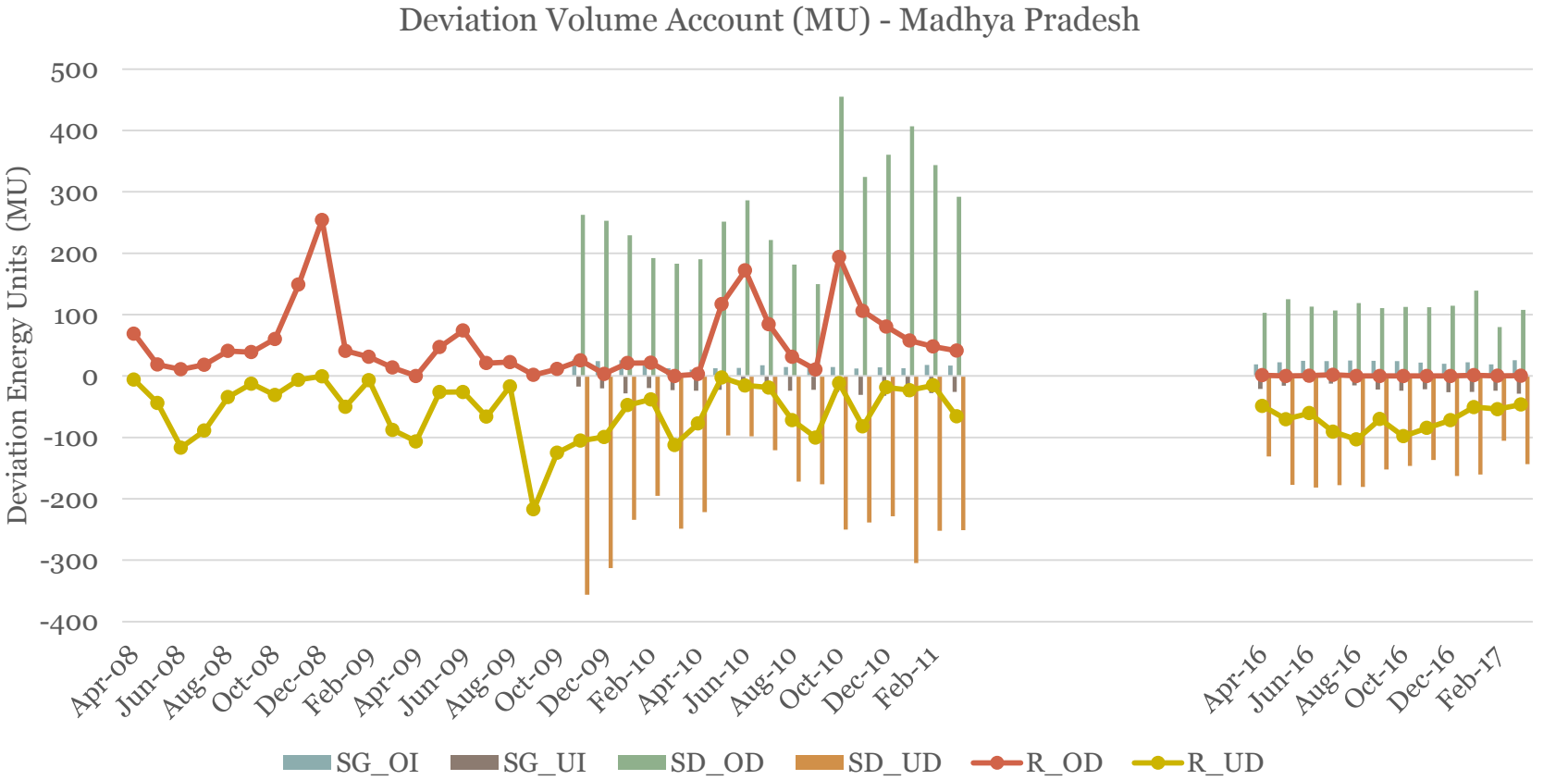





- Pre DSM and Post DSM (at state level): Improvement in Regional UI (payable/receivables) management
- No significant cost implications for Intra-state entities.
- Causer pays principle well established.

# Madhya Pradesh : Deviation Account (MU) FY09 to FY17

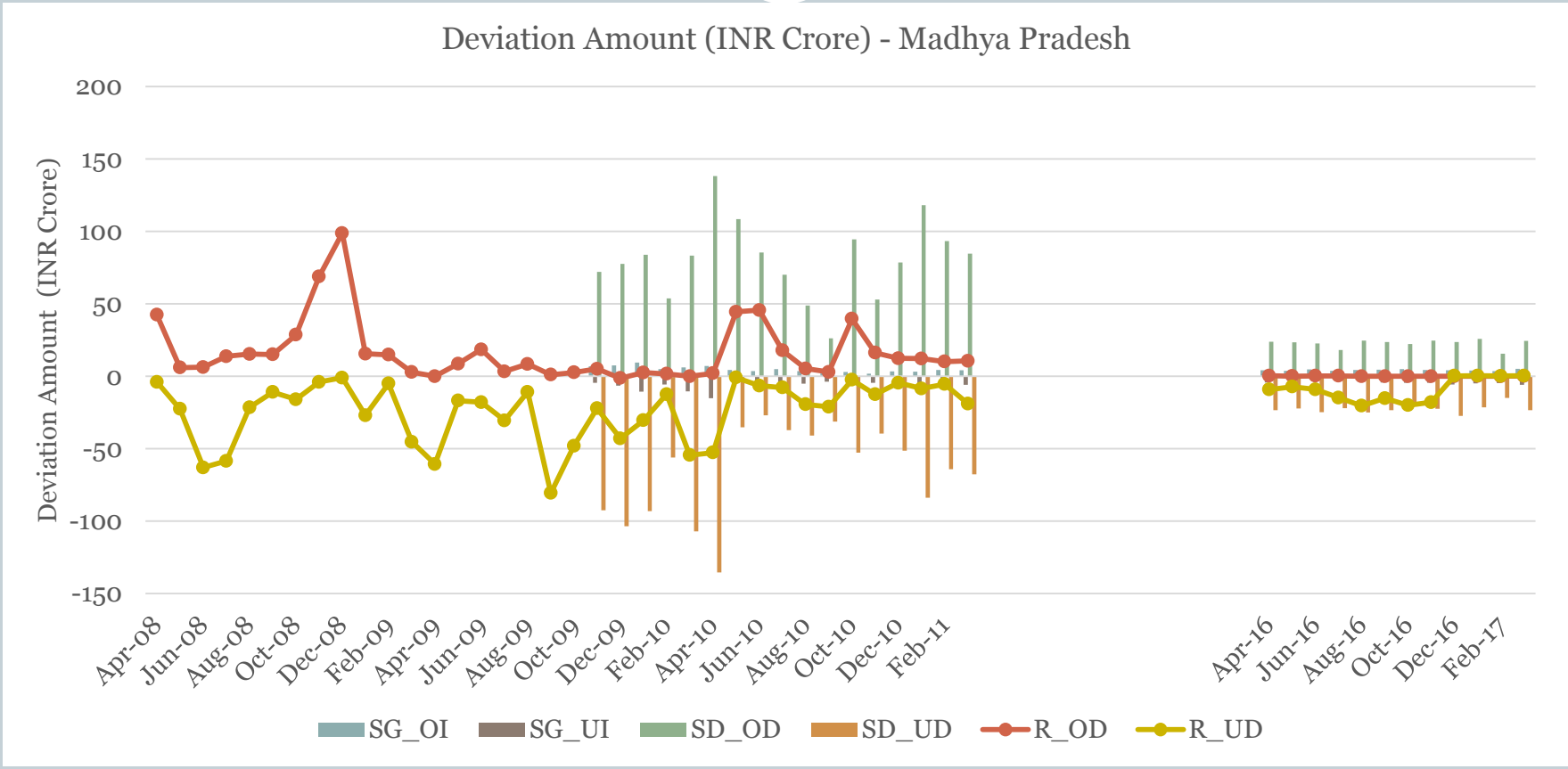





- Pre DSM and Post DSM (at state level) : significant improvement over the period (Monthly Deviation)
- Improvement in Balancing/Deviation management by Intra-state entities over the period
- Share of energy units handled at state periphery is ~ 35% of total energy units handled for intra-state entities

# Madhya Pradesh : Deviation Amount (INR Cr) FY09 to FY17






- Pre DSM and Post DSM (at state level) : Improvement in Regional UI (payable/receivables) management
- No significant cost implications for Intra-state entities.
- Causer pays principle well established.

# F&S Model Regulations – Key Highlights



- Applicability - All wind and solar generators connected to the State grid
  a. regardless of date of commissioning,
  b. including those connected via pooling stations
  c. selling power within or outside the state
- To provide day-ahead and week-ahead schedule
- Revisions can be made on 1.5 hours basis, up to a maximum of 16 revisions/day
- Payment as per actual generation
- Deviation charges are a function of the error % as calculated for every time-block:
- Error = 100 X (Actual Generation – Scheduled Generation) /Available Capacity
- Deviation Band & Charges:

**Existing Generators**

| Deviation/Error | Charges per unit |
|---|---|
| **Within +/- 15%** | No Penalty |
| **From 15% to 25%** | INR 0.50 |
| **From 25% to 35%** | INR 1.00 |
| **Greater than 35%** | INR 1.50 |

**New Generators**

| Deviation/Error | Charges per Unit |
|---|---|
| **Within +/- 10%** | No Penalty |
| **From 10% to 20%** | INR 0.50 |
| **From 20% to 30%** | INR 1.00 |
| **Greater than 30%** | INR 1.50 |

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# Comparison of F&S Regulations: selected Member States vis-à-vis FOR Model Regulations



| S. No. | Particulars | FOR Model F&S | APERC (final) | KERC (final) | RERC (final) | TNERC (draft) |
|---|---|---|---|---|---|---|
| 1 | Applicability | Wind and solar generators selling power within or outside the state | Wind and solar generators selling power to discoms/third party sale/captive consumption through OA within or outside the state | Wind generators combined capacity 10 MW and above. Solar generators capacity 5 MW and above within or outside the state | Wind and solar generators selling power to discoms/third party sale/captive consumption through OA: >5MW connected to state grid | Wind and solar generators (excluding Rooftop PV Solar Projects) selling power within the state |
| 2 | Forecasting Responsibility | Wind and solar generator or by QCA Or forecast by SLDC to be accepted | Wind and solar generator or by QCA Or forecast by SLDC accepted | Wind and solar generator or QCA or aggregator Alternatively through REMC | Wind and solar generator or by QCA Or forecast by SLDC accepted | Wind and solar generator or by QCA Or forecast by SLDC accepted |
| 3 | Scheduling Requirement | Weekly and day-ahead with maximum 16 revisions during a day | Weekly, day-ahead and intra-day with maximum 16 revisions during a day for wind and max. 9 revision for solar | Weekly, day-ahead and intra-day with maximum 16 revisions during a day | Weekly and day-ahead with maximum 16 revisions during a day | Weekly and day-ahead with maximum 16 revisions during a day |

# Comparison of F&S Regulations (contd…)



| S. No. | Particulars | FOR Model F&S | APERC (final) | KERC (final) | RERC (final) | TNERC (draft) |
|---|---|---|---|---|---|---|
| 4 | Computation of Error Formula | Available Capacity in denominator | Available Capacity in denominator | Available Capacity in denominator | Available Capacity in denominator | Available Capacity in denominator |
| 5 | Tolerance Band for DSM | 10% new wind and solar generator.<br>< = 15% existing wind and solar generator | ± 15% for wind and solar generators | ± 15% for wind and solar generators | ± 15% for wind and solar generators | ± 10% for wind & solar generators. |
| 6 | Charges | Existing Generators:<br>New Generators: | | | | |
| 7 | Reference point for DSM | Pooling station | Pooling station | Pooling station/ Aggregator Level | Pooling station | Pooling Station |

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# DSM Model Regulations – Key Highlights



- Applicability - Seller(s) and Buyer(s) involved in STOA/MTOA/LTA in intrastate transmission or distribution of electricity (including inter-state wheeling of power)
- Deviation (Each 15 minute):

| Seller | Buyer |
|---|---|
| Actual Injection - Scheduled generation | Actual Drawl - Scheduled Drawl |

- Charges payable (overdrawal/under-injection) and receivable (under-drawal/over-injection) for each time-block
- Deviation Charges:

| Deviation Charges for each 0.01 Hz Step | | |
|---|---|---|
| Frequency Range | 50.05 - 50.0 Hz | 50.0 - 49.8 Hz |
| Charges | 50 Paise/kWh | 27.50 Paise/kWh |

- Volume Cap: 150 MW or 12% of Schedule (Different caps for RE Rich States)
- No over-drawal/under-injection when Frequency below 49.7 Hz

# DSM Model Regulations – Key Highlights



- Change in sign of deviation once every 6 time blocks- violation attracts additional charges @10% of deviation charges
- Capping of Deviation Charges: Generating Stations ( using Coal, Lignite or Gas supplied under APM) regulated by SERC - Cap Rate of Paise 303.04/ unit
- Infirm Power Price:

| Source | Price/Unit (Paise) |
|---|---|
| Coal/Lignite/Hydro | 178 |
| APM Gas | 282 |
| Imported Coal | 303 |
| RLNG | 824 |

Allowed upto 6 months or as allowed by Commission

- State Deviation Pool Account to be operated by SLDC , review by SPC

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# Various options exist for intra-day transaction of power between States



## Various options for inter-State trade of power, as presented by Dr. Chatterjee*:

| S.No. | Options | Pros | Cons |
|---|---|---|---|
| 1 | Banking - Excess Power is banked with another State in regional grid and utilized back when required | - Voluntary;<br>- No price transaction;<br>- Easy to implement | - Still bilateral<br>- Opaque to cheaper options;<br>- True marginal cost of meeting demand not known;<br>- Elements of Cost and Value missing;<br>- No knowledge of gain or loss |
| 2 | Day Ahead Market Price on Power Exchange as reference | - Well accepted reference price;<br>- Dispute free | - Very remote chance of availability of generation sources with marginal cost equal to or less than DAM price;<br>- Liquidity will always be an issue |
| 3 | Pool based on variable cost as approved by the Regulator and on Payment of cost | - Visibility of all options for purchase decision;<br>- Dispute free as regulator approved VC;<br>- All resources get paid as per their cost or MC;<br>- Improvement over option 2, liquidity | - Still based on cost and not on value;<br>- VC difficult to ascertain;<br>- Merchant plants can't participate (tariffs not determined by regulator ) |
| 4 | Pool based on variable cost as approved by the Regulator and on payment of marginal cost | - Same as Option 3;<br>- Improvement over Option 3 – element of 'value' introduced because of marginal cost based payment | - VC difficult to ascertain;<br>- Merchant plants can't participate ;<br>- Payment based on marginal cost may lead to heart burn;<br>- Still administered |
| 5 | Pool based on auction (intra-day for the rest of the day) | - Market Discovered Price;<br>- Dispute free;<br>- Not administered;<br>- Akin to DAM but closer to real time | - Preparedness of RPC or PX;<br>- Discoms decision making process;<br>- OA registry, a pre-requisite |
| 6 | Pool based on auction (hourly) | - Market Discovered Price;<br>- Dispute free;<br>- Not administered;<br>- Akin to DAM but closer to real time | - Preparedness of RPC or PX;<br>- Discoms decision making process;<br>- OA registry, a pre-requisite |
| 7 | Pool based on auction (intra-hour i.e. 15 min. block) | - Market Discovered Price;<br>- Dispute free;<br>- Not administered;<br>- Akin to DAM but closer to real time | - Preparedness of RPC or PX;<br>- Discoms decision making process;<br>- OA registry, a pre-requisite |

**NRPC, WRPC & SRPC have recommended Option #5 as a starting point**

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* views were personal

# (8) Model Regulations for Intra-State Hydro Generating Stations: Key Highlights



- Model Regulations – Key Highlights:

| | |
|---|---|
| **Annual Fixed Charges (AFC) comprise of** | -Return on Equity<br>-Interest on Loan<br>-Interest on Working Capital<br>-Depreciation<br>-Operation & Maintenance Expense |
| **Return on Equity** | -15.5% for RoR (Run of River) Hydro Plants<br>-16.5% for Storage & Pumped Storage Type Plants<br>-Additional 0.5% for timely completion<br>1% deduction in case of commissioning without peaking/ FGMO /PSS /Communication /Blackstart /Synchronous Condenser facility wherever applicable |
| **Annual Fixed Cost recovery through Two-Part tariff** | -Capacity Charge (50% of AFC); PAF (Plant Availability Factor) to be more than or equal to NAPF (Normative Plant Availability Factor)<br>-Energy Charge (50% of AFC, Energy rate computed by using Design Energy) |
| **Submission of Undertaking prior to COD** | -Successful trial operation for 12 hours<br>-Black Start Capability<br>-Islanded Operation / House load operation<br>-Dead bus charging and line charging capability<br>-Auto synchronization<br>-Peaking Capability (110 %)<br>-Dynamic VAR support as per the capability curve<br>-Frequency Response (Primary & Secondary)<br>-Synchronous Condenser Mode of Operation wherever applicable<br>-Pumped Mode of Operation wherever applicable<br>-Part-load operation<br>-Ramp-up capability<br>-Ramp-down capability<br>-AVR and Power System Stabilizer wherever applicable |

# Key Highlights (contd…)



- Model Regulations – Key Highlights:

| | |
|---|---|
| **Scheduling** | -By 0600 Hrs, Submission from Station to SLDC for next day<br>-By 0800 hrs: Entitlement of beneficiaries as per allocations<br>-By 1000 hrs: Requisition in the Station by beneficiaries<br>-By 1200 hrs: Optimized Injection Schedule for the Station and the drawal schedule of the beneficiaries from the Station |
| **Synchronous Condenser Operation** | -Demonstration of Synchronous Condenser Mode of Operation (SCMO) at-least once in a calendar month as per SLDC instructions<br>-Active power drawn during SCMO to be socialized and included in pooled transmission loss by the SLDC during preparation of state energy accounts<br>-VARh exchange payable @ 25 p/kVArh subject to periodic review by the Commission |
| **Blackstart** | -Demonstration of Blackstart at least once every year<br>-Testing of Diesel Generator sets (BSDG) for black start on weekly basis<br>-Fuel stock (useable under black out conditions) to be maintained in sufficient quantity to operate at full for a minimum of 20 hours and/or at 50% of accredited capacity for 40 hours<br>-Reimbursement of O&M expenses incurred during Blackstart<br>-Lumpsum incentive of Rs. 0.5 Lakh for successful demonstration of Blackstart capability by the Station subject to certification by the SLDC |

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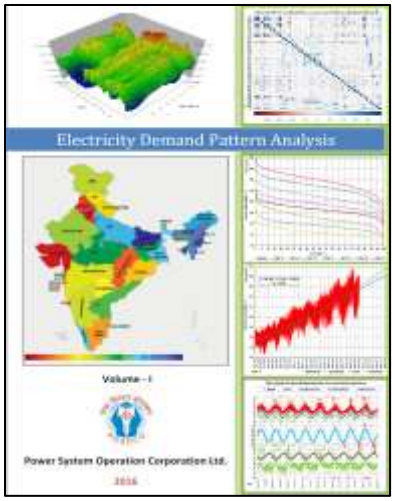
# Electricity Demand Pattern Analysis




https://posoco.in/reports/electricity-demand-pattern-analysis/

**Source of Data : Daily reports & Telemetry**
**Total no. of samples used : > 38 Million**
**Total type of different charts : 50**
**Total no. of Charts : 1065**

## *Big Data Analysis*

- **Data – Information – Knowledge – Wisdom**
- **Patterns Analysis for: Planning, Efficiency, Optimisation**
- **Tacit knowledge – Every graph conveys deep insights**
- **Correlates Social Behaviour and Lifestyle Changes**
- **Seasonal and Diurnal Patterns**
- **Renewables, sunrise, sunset and duration of the day**

***"A good forecaster is not smarter than everyone else, he merely has his ignorance better organised." - Anonymous***

# Big Data Analytics

- **“Study the past, if you would divine the future”**

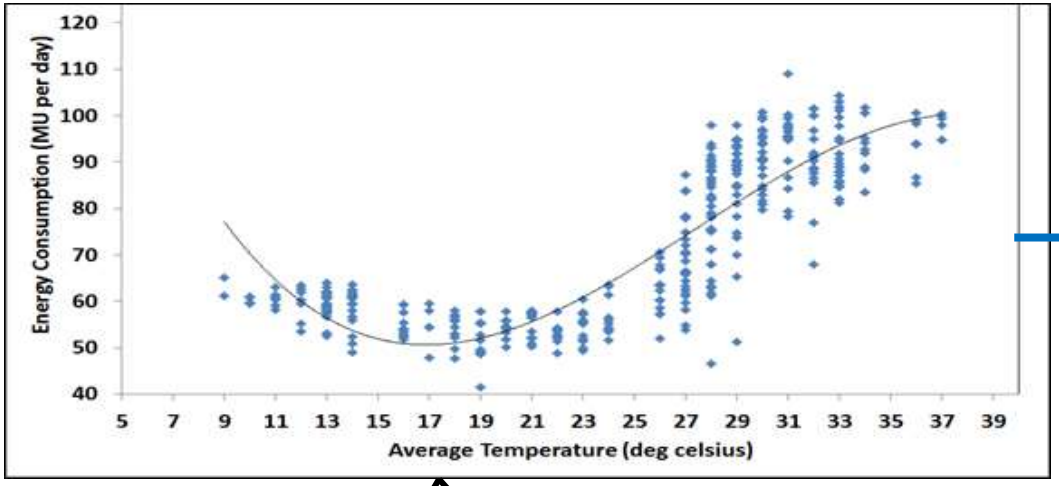
  *….Confucius*

- Multi-year, demand pattern analysis
  - Five minute data for eight (8) years considered
  - Diurnal, seasonal, monthly, yearly analysis
- What answers do we seek from analysing the past ?
  - Growth story and its likely trajectory (future investments)
  - Power procurement strategies to be adopted
    - Base load, peak power, seasonal effect
    - Flexibility and need for Demand Response
    - Banking opportunities, pumped storage
  - How can solar power complement in meeting the load?

***A good forecaster is not smarter than everyone else, he merely has his ignorance better organised. "--Anonymous***

# Factors Affecting Demand Met Pattern

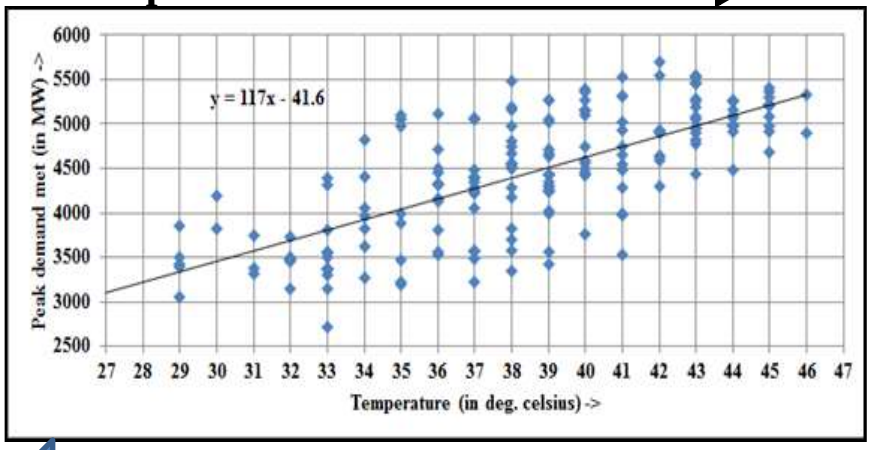
## *1. Weather Conditions-Temperature*




- √-shaped energy vs. temperature curve for Delhi

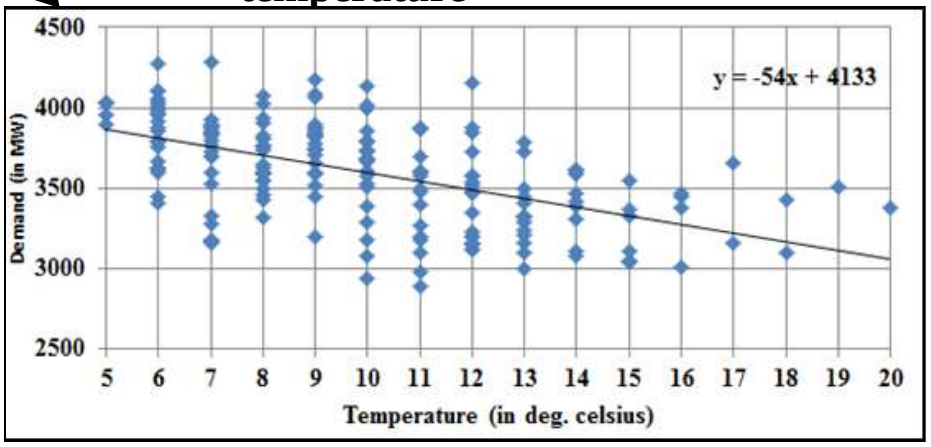
**Summer (April-June)**

- **Demand increases with increase in temperature.**




**Winter (December-February)**

- **Demand decreases with increase in temperature**

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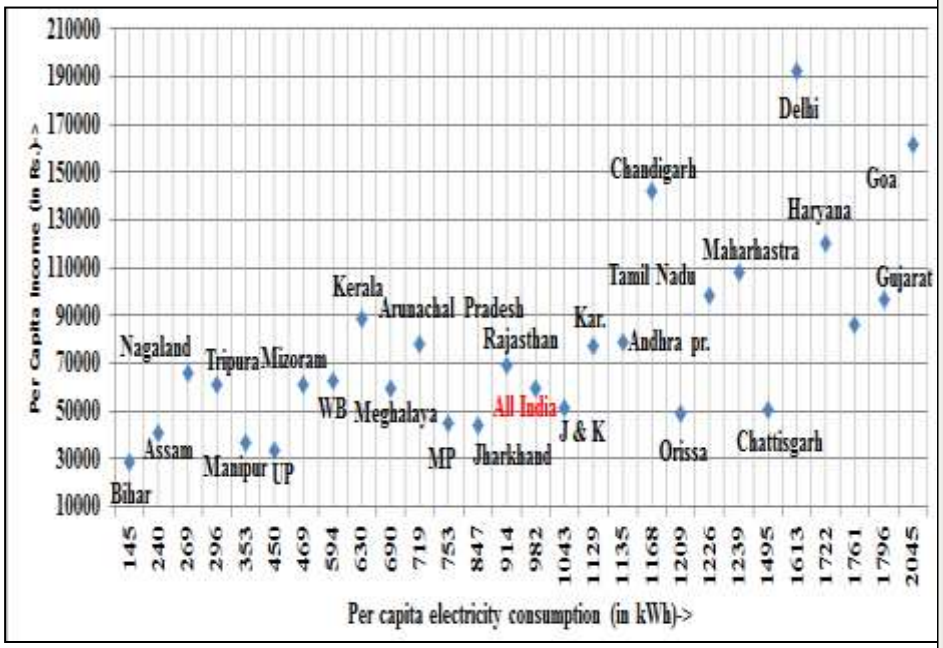
*To expect the unexpected shows a thoroughly modern intellect. "--Oscar Wilde*

# 2. Economic factor

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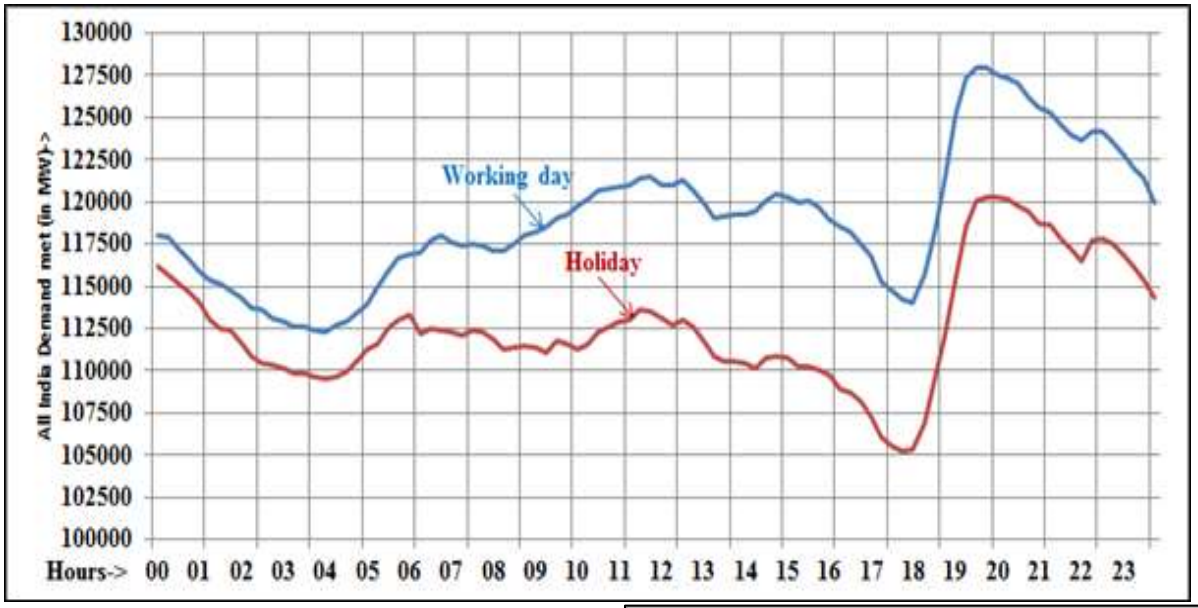
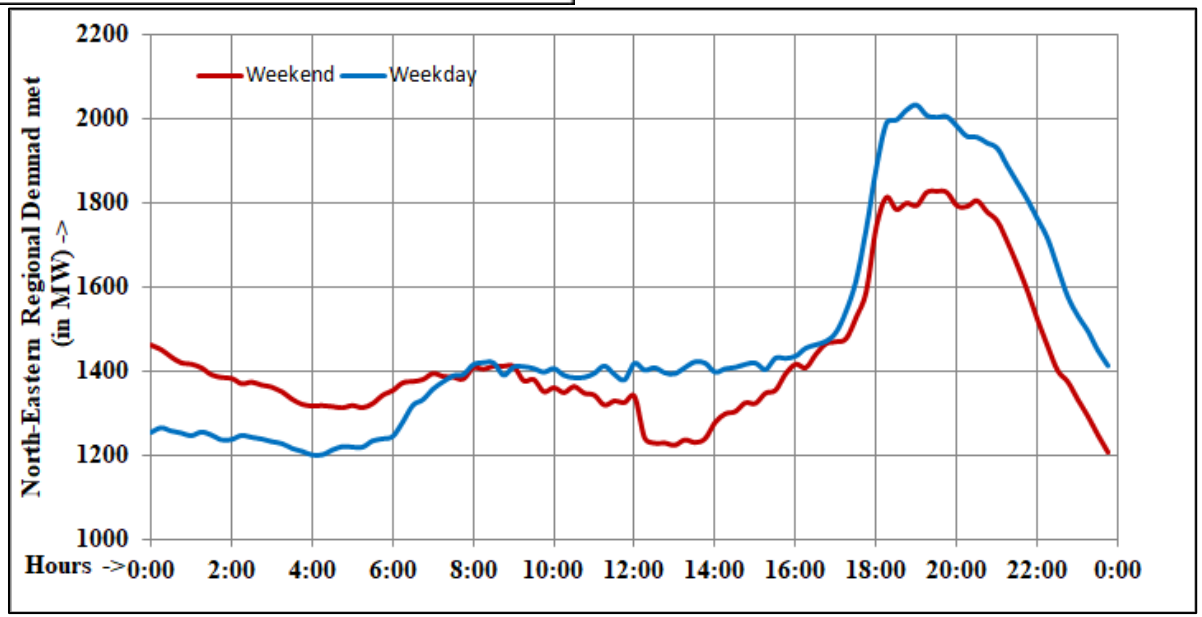
*"It is said that the present is pregnant with the future. " --Voltaire*

# 3. Holidays-Vs- Weekday




*If you have to forecast, forecast often. "--Edgar R. Fiedler*

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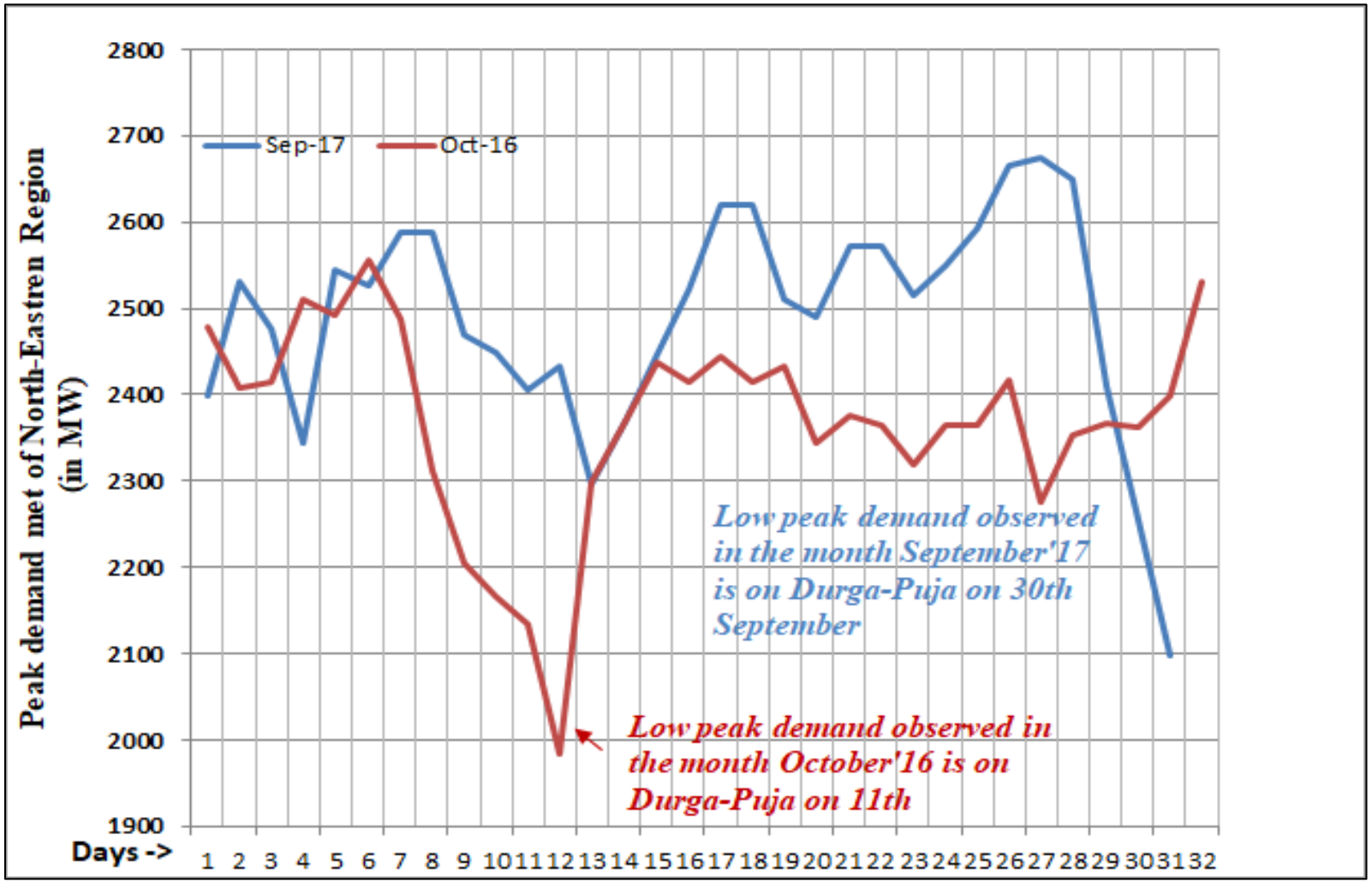
# 4. Festivals




**Durga Puja Festival**

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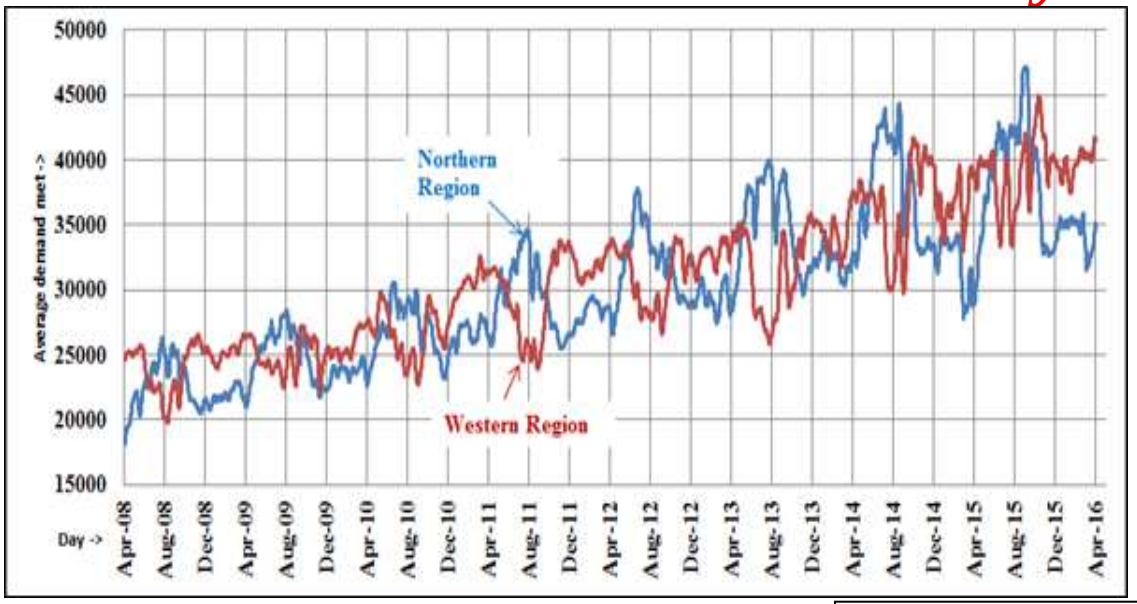
***It is far better to foresee even without certainty than not to foresee at all. "-Henri Poincare***

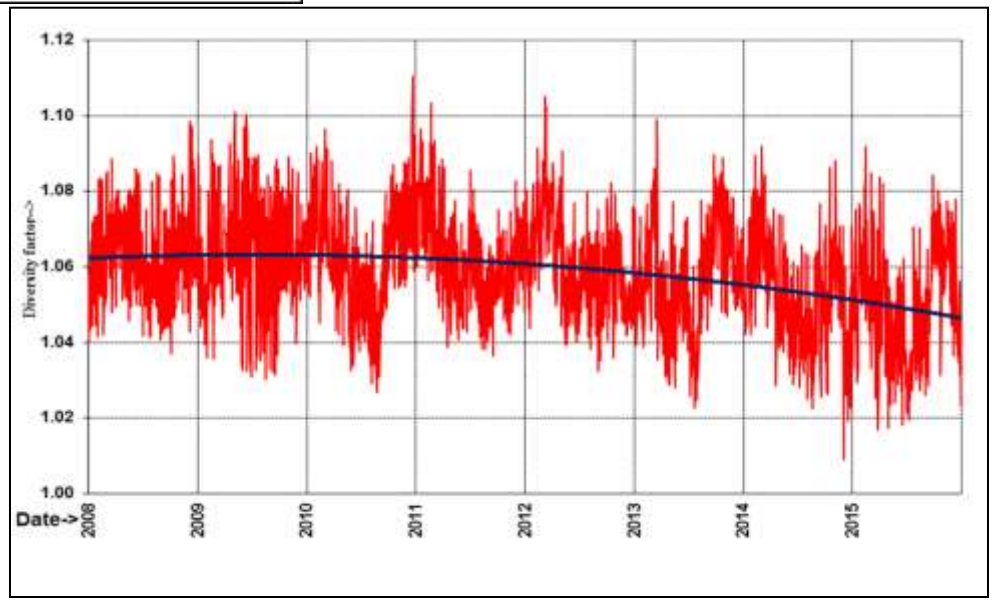
# 5. Diversity




- **Phase opposition of Northern region and Western region**

- **Diversity Factor**

**Diversity Factor = (Sum of Individual Max. Demand)**
**(Simultaneous Max. Demand)**

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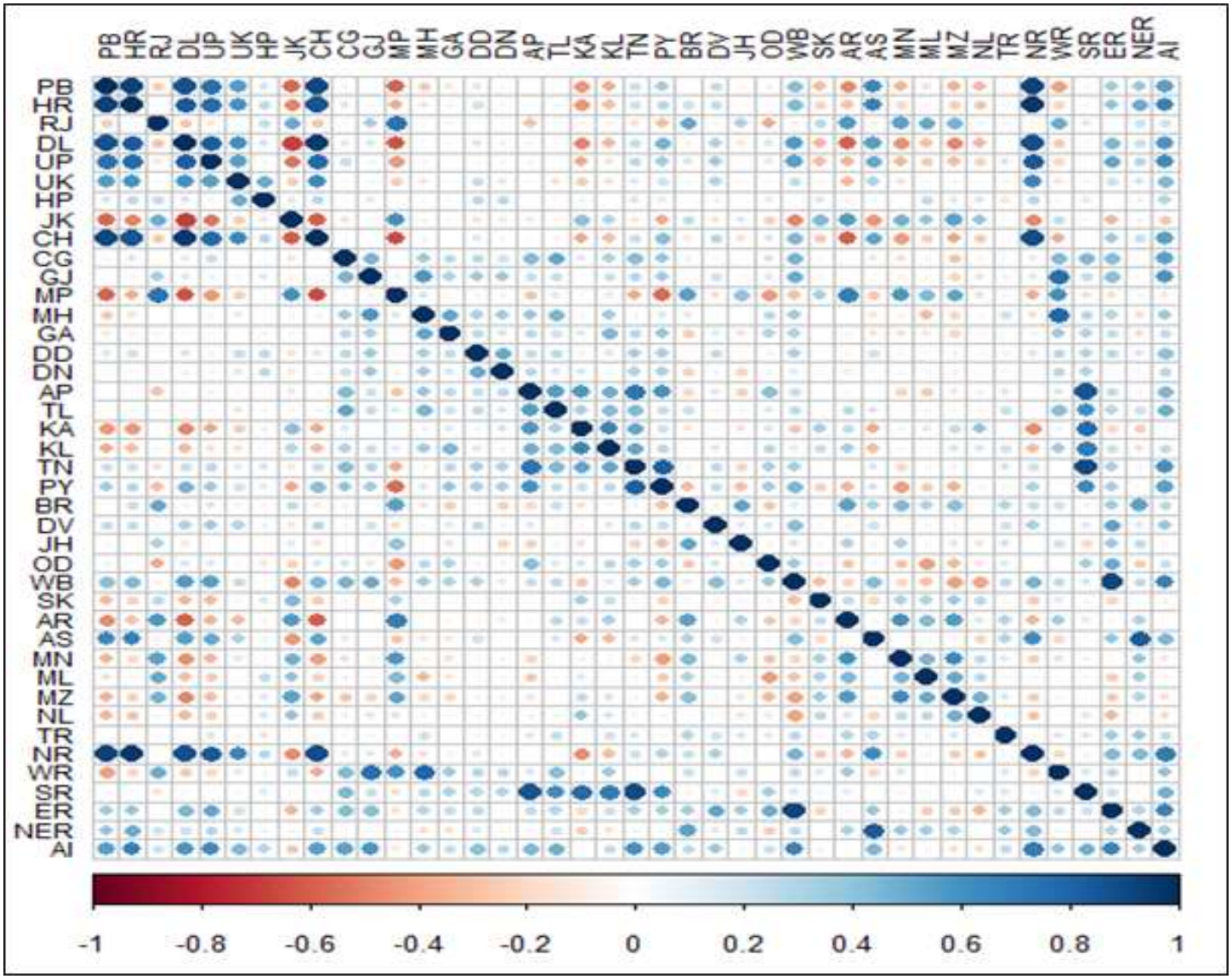
*"There are two kinds of forecasters: those who don't know, and those who don't know they don't know." — John Galbraith*

# Correlogram




- **The scale is from -1 (Dark Red) to +1 (Dark Blue)**
- **Negative correlation between two states shows that demand of one state is increasing while the other is decreasing.**

*The herd instinct among forecasters makes sheep look like independent thinkers. "--Edgar R. Fiedler*

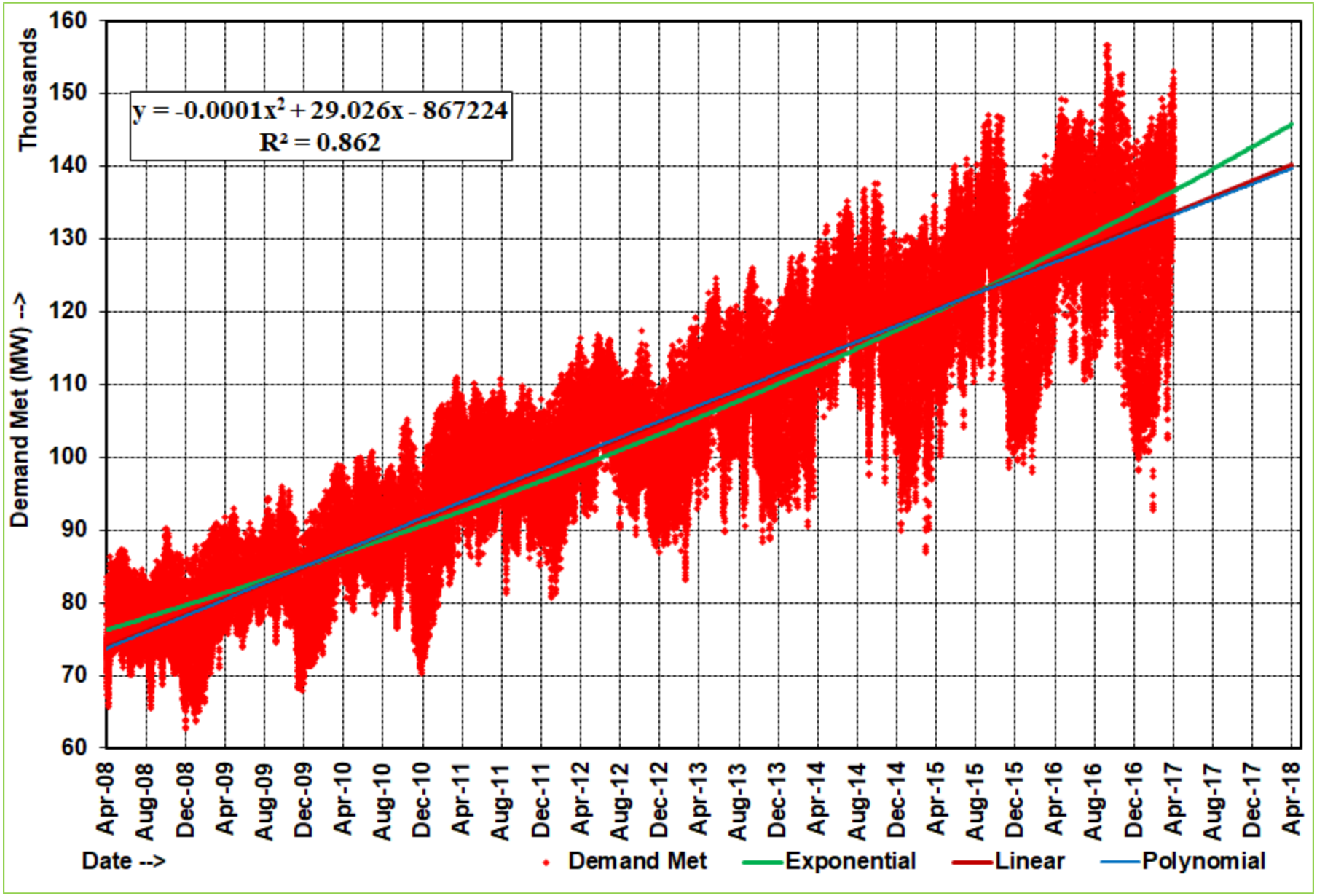
# Data Source and Assumptions

- **Analysis based on instantaneous 15 min and hourly demand met SCADA NLDC.**
- **Time period – 1st April'08 to 31st March'16.**
- **Maximum/Minimum/Average demand met during the day/months/years have been calculated by using 15 minutes instantaneous Demand data.**
- **Some discrepancies in data could also be present due to failure of communication at some point of time. In case of missing data following assumption have been made:**

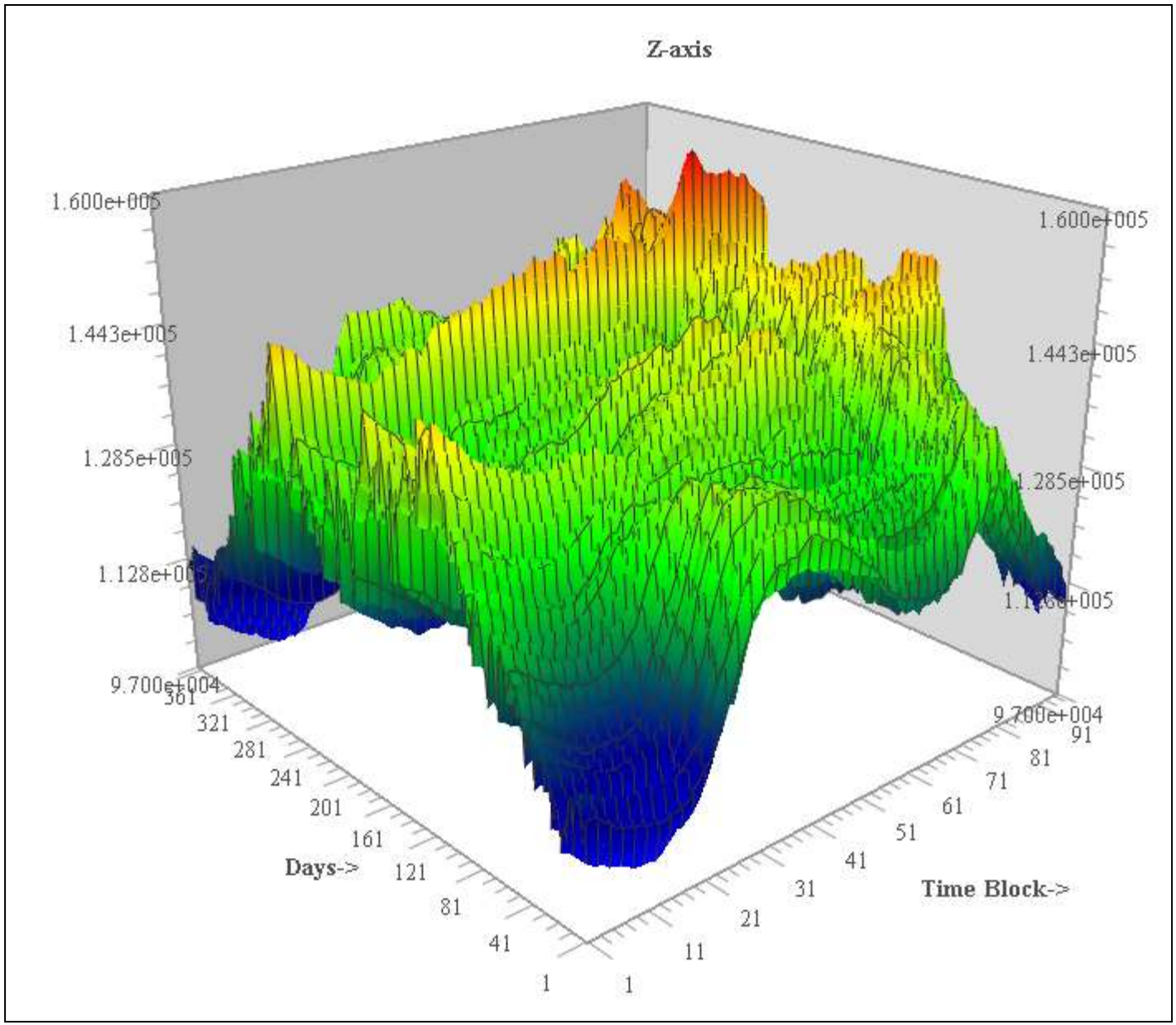
  1. Loss of data for small period of time: Last data considered.
  2. Loss of data for long period: Same time period data of previous day considered.
  3. Loss of data for entire day: Previous day data has been considered
- **SCADA data is not time synchronised data.**
- **State Demand Met Calculation**
  - **Summation of internal generation and total drawl from the grid.**
- **Drawl of any state is calculated at the periphery of the state.**

***Foreknowledge of the future makes it possible to manipulate both enemies and supporters. "--Raymond Aron***

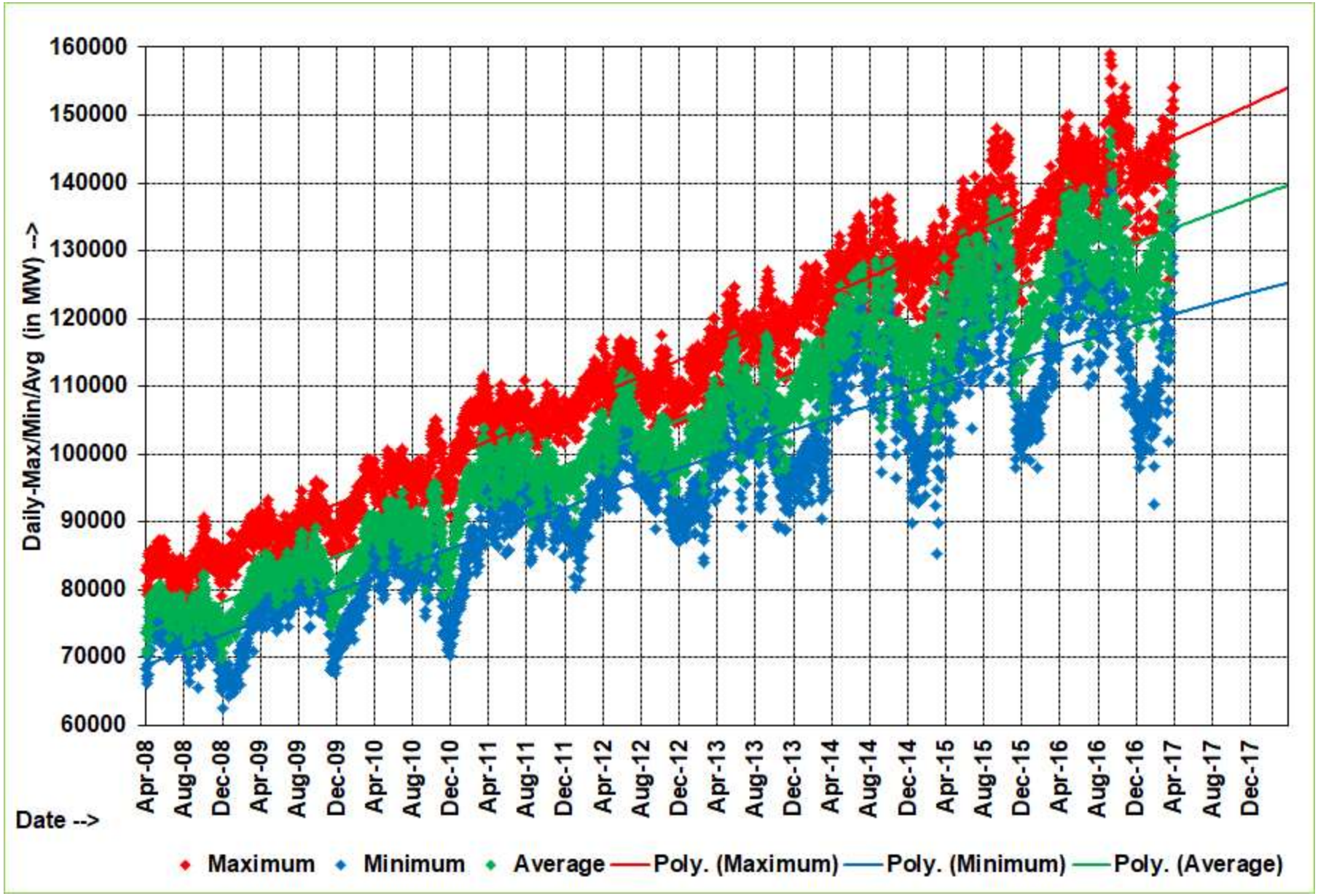
# All India Hourly Demand met pattern



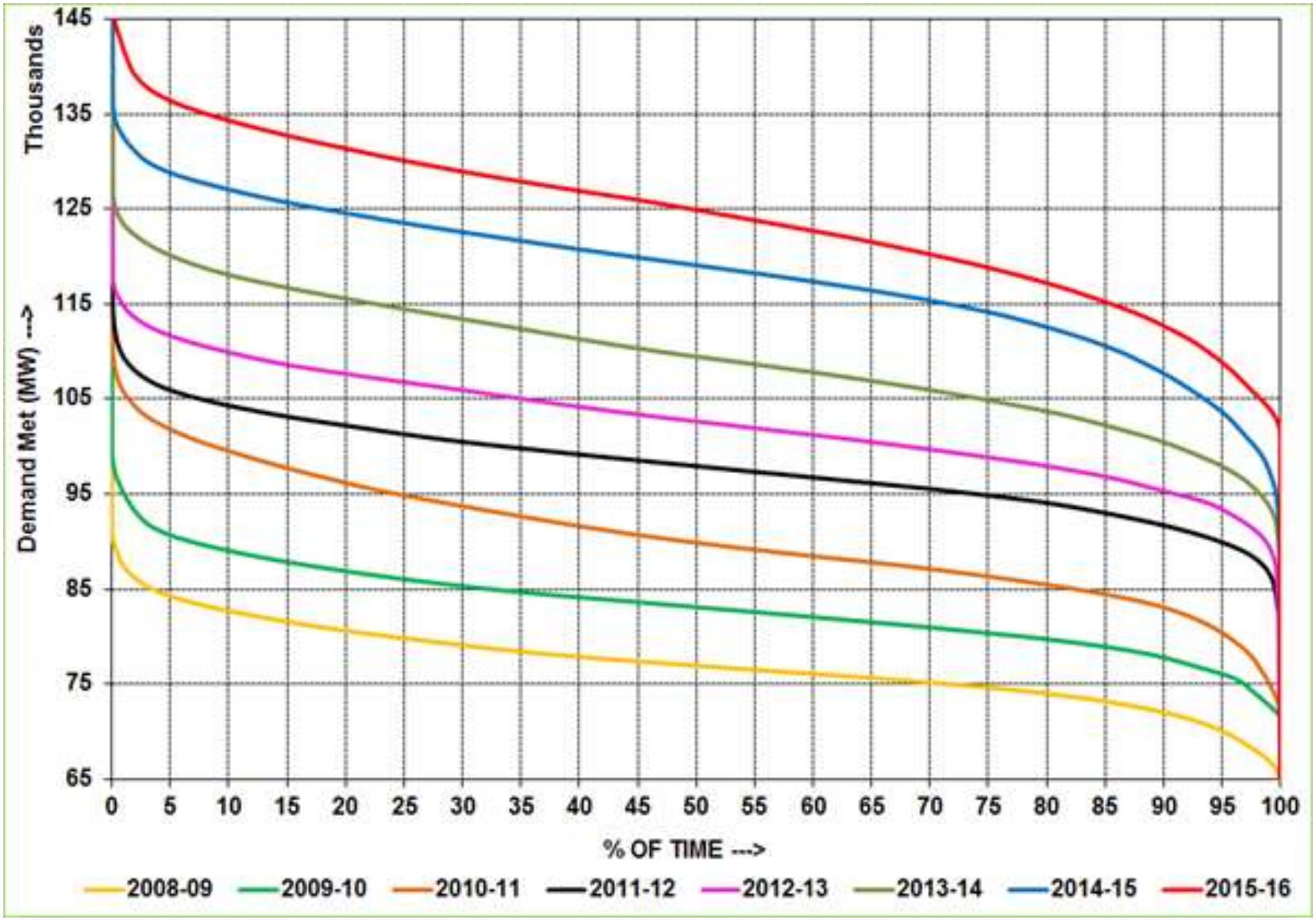
# All India 3-D plot of annual demand met



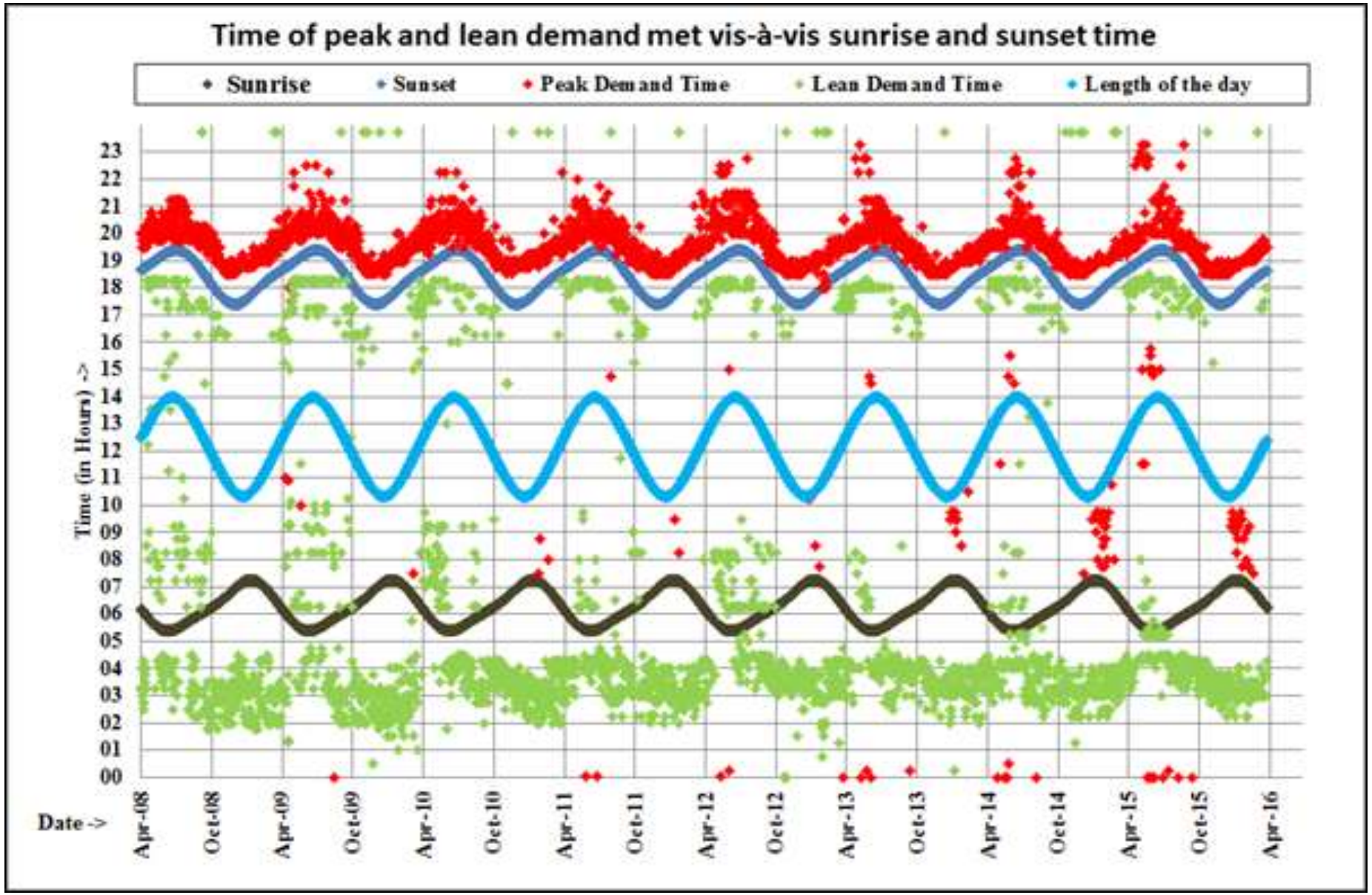
# All India Daily maximum, minimum and average demand met pattern



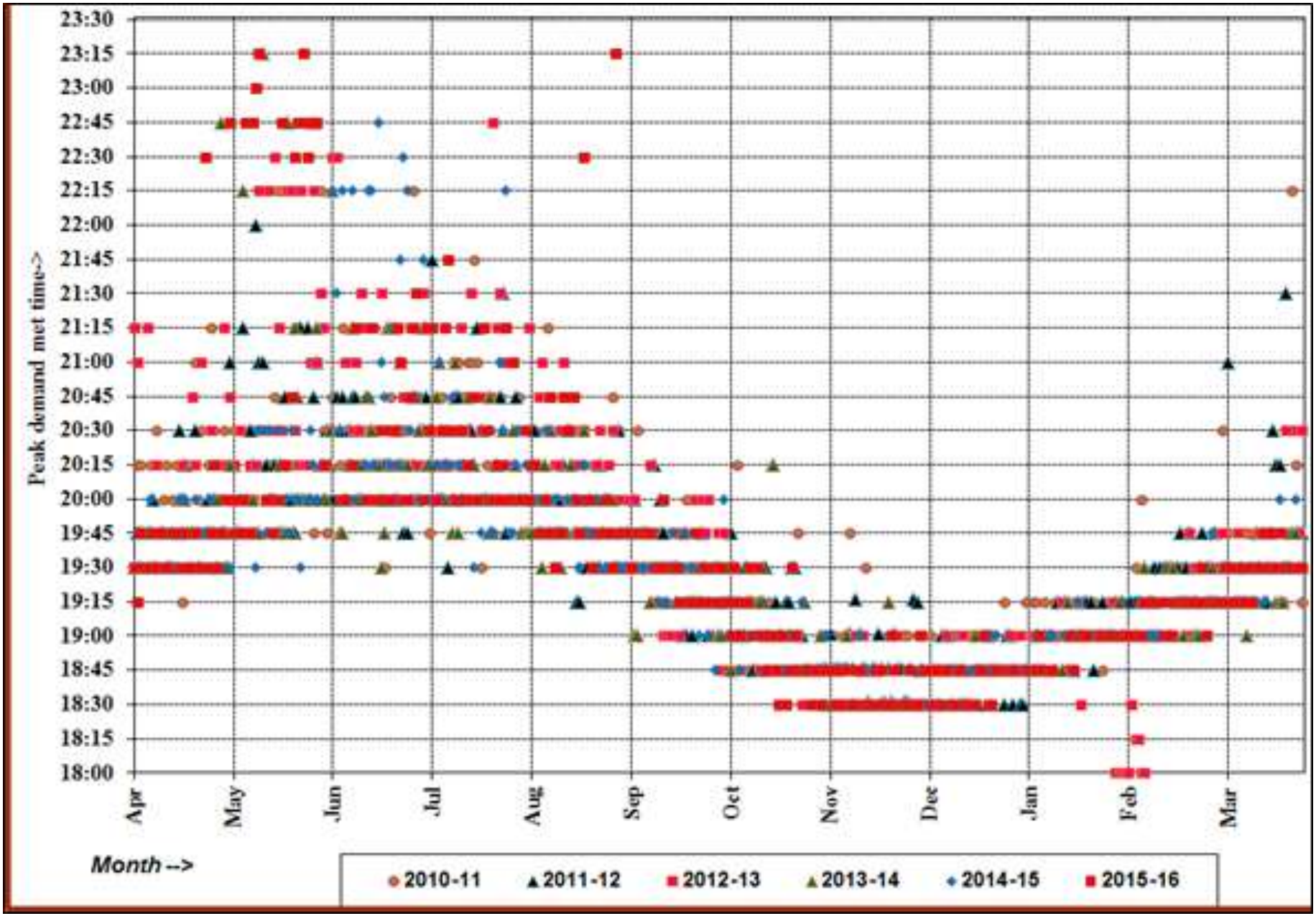
**All India Annual Demand Duration Curve ( considering block-wise samples):**



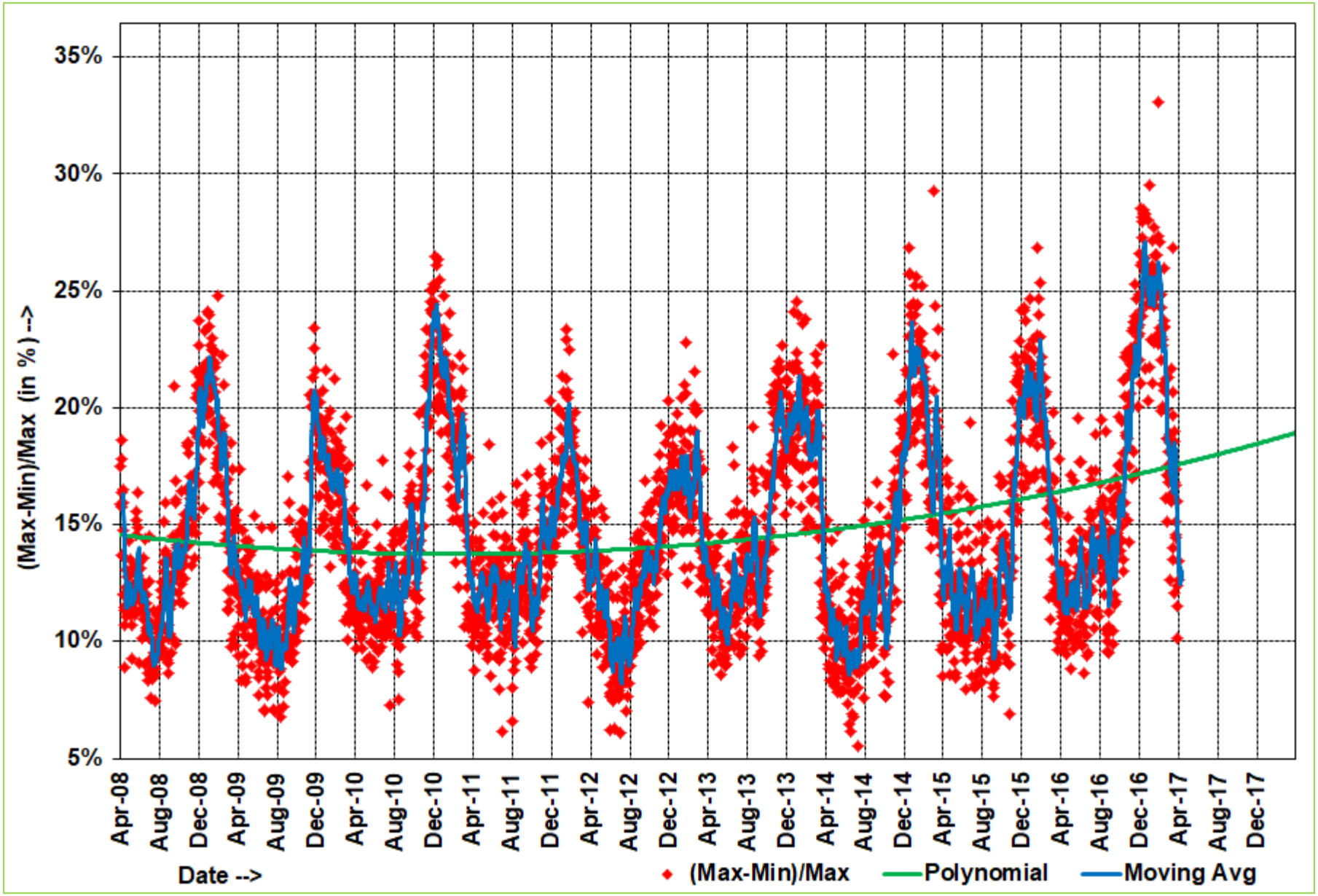
**All India :Time of daily sunset, sunrise with occurrences of peak and lean demand met**



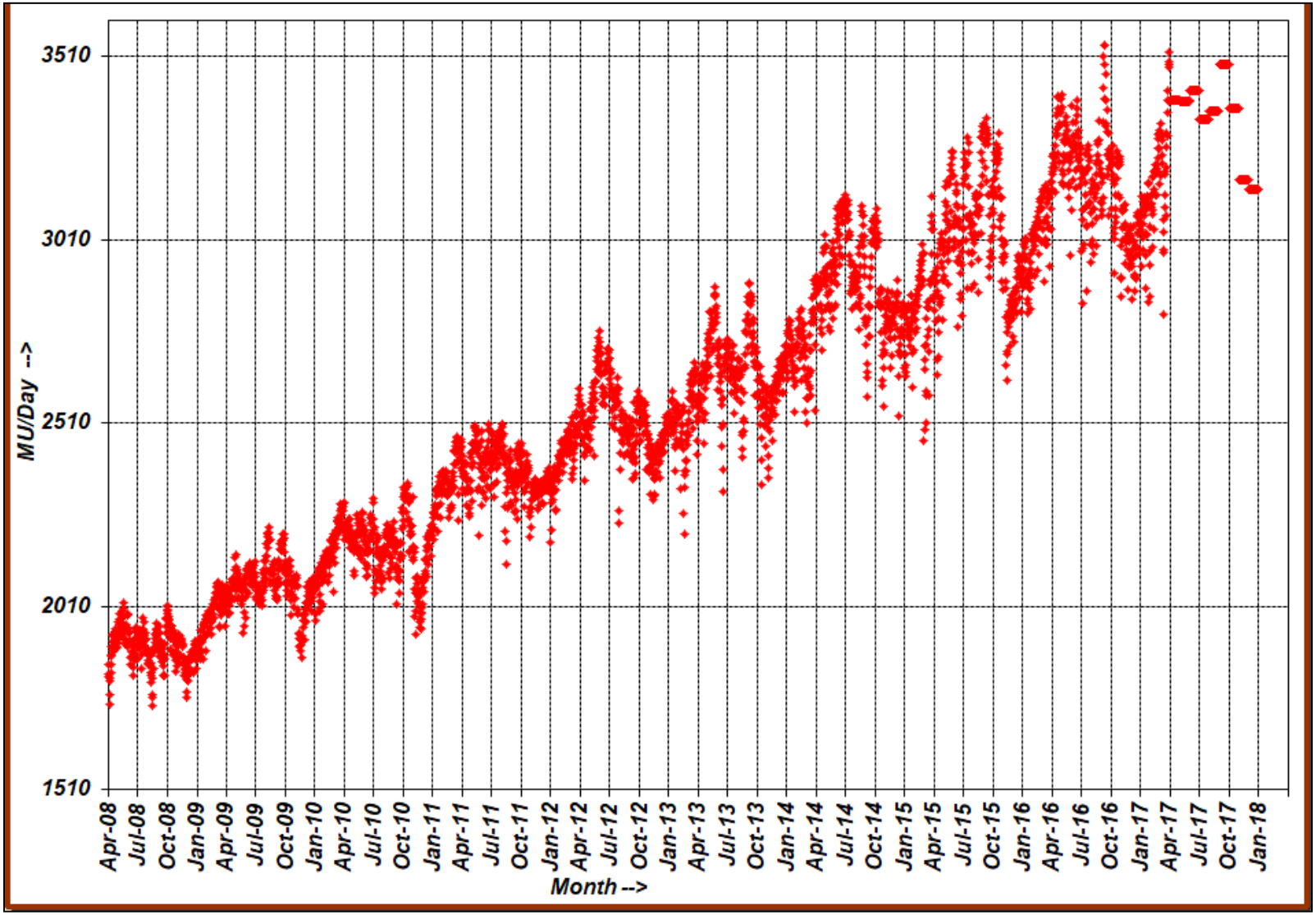
## All India Maximum daily Demand Met occurrences: Year-On-Year pattern



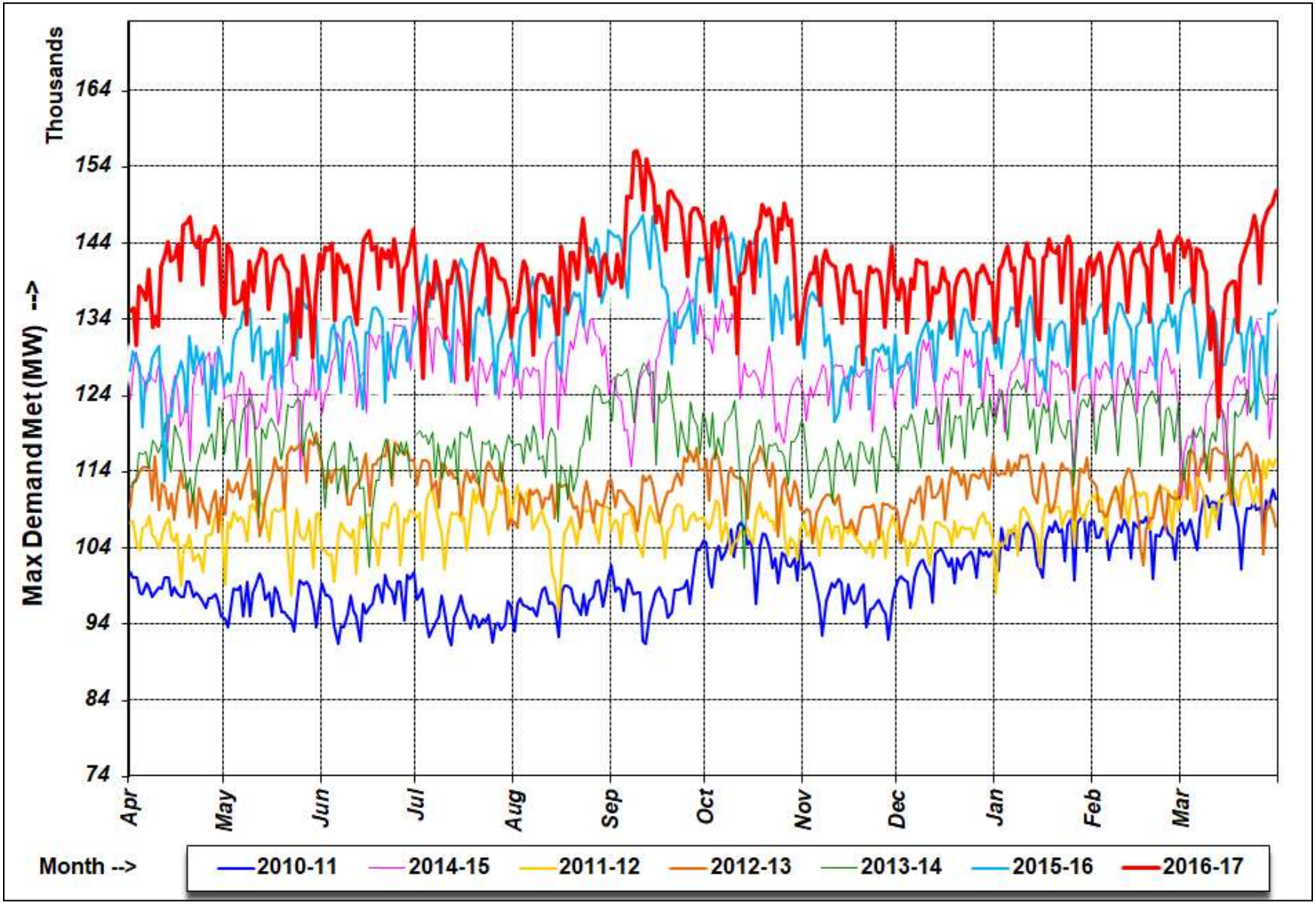
## All India Daily difference of Peak and Lean as a Percentage of Peak demand met Pattern:



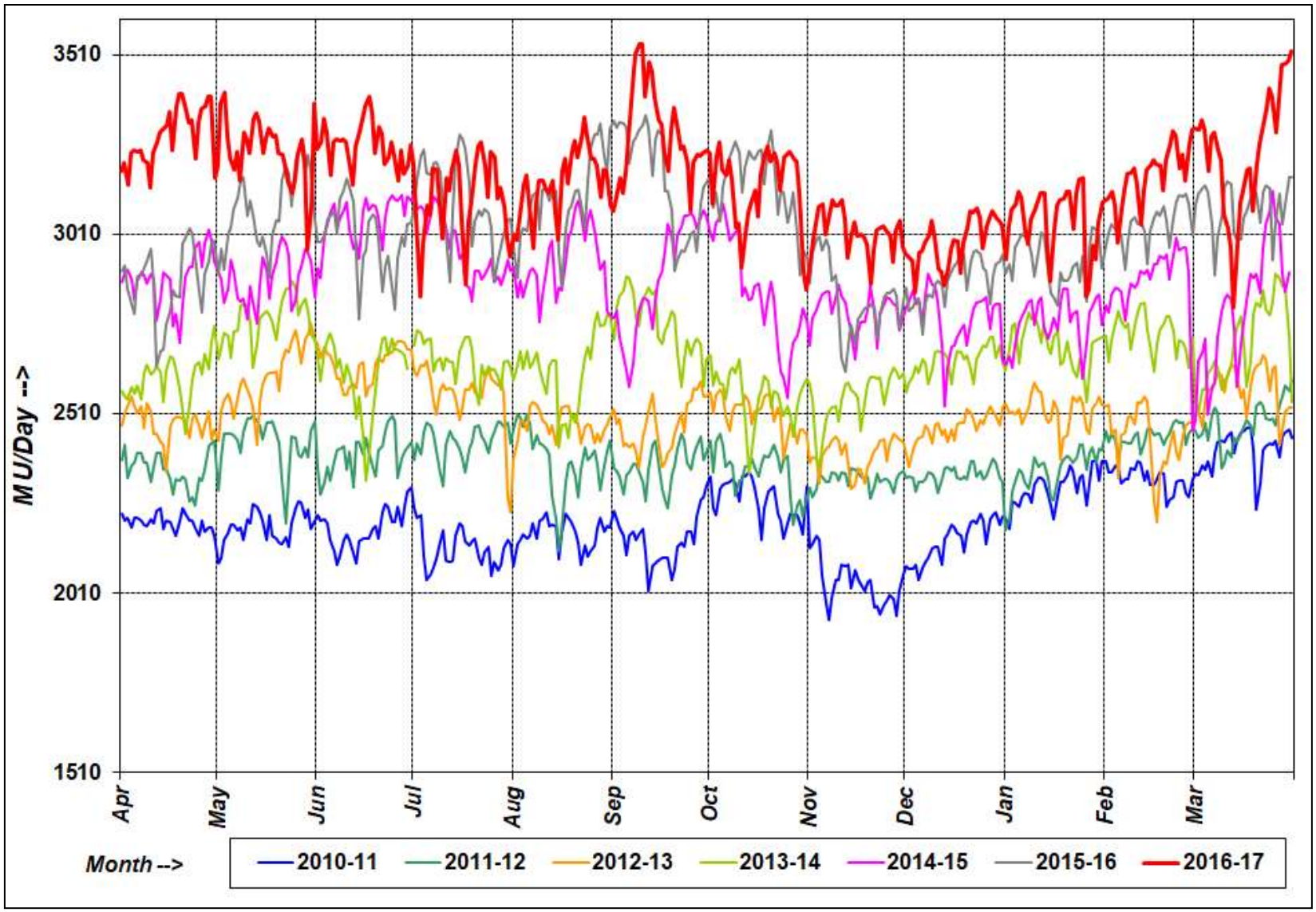
## All India Daily energy consumption pattern:



## All India Daily Peak Demand met pattern:

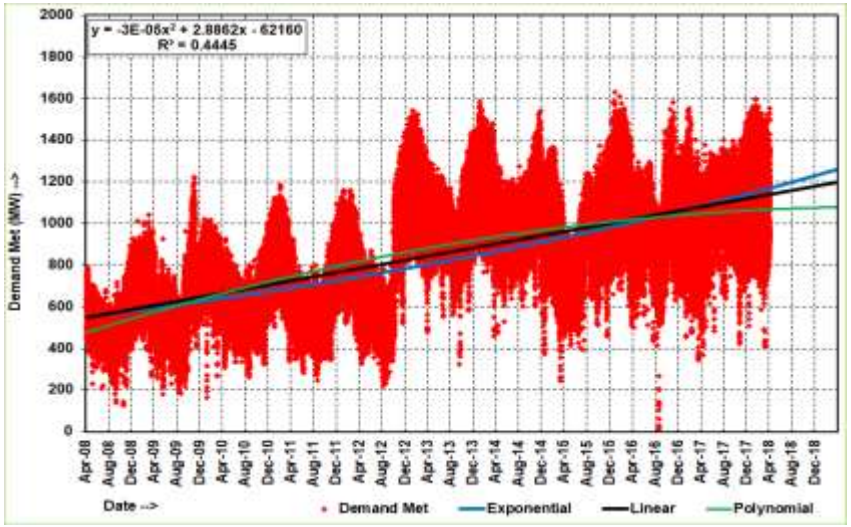


## All India Daily energy consumption pattern:

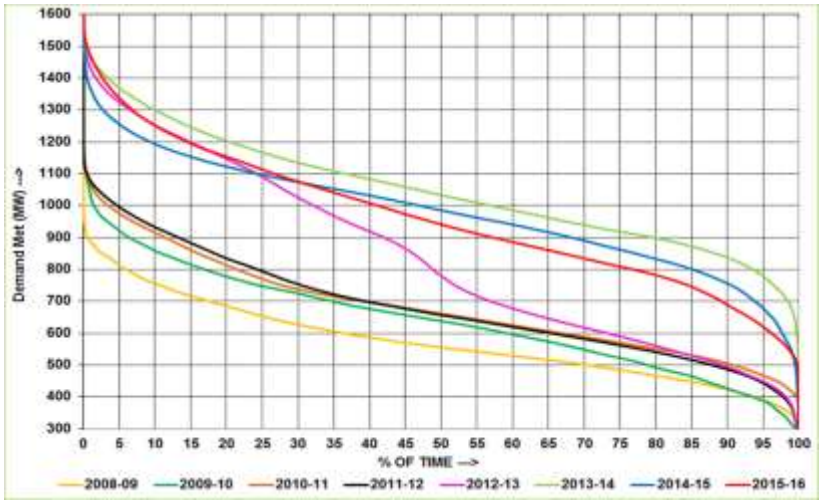


# Himachal Pradesh

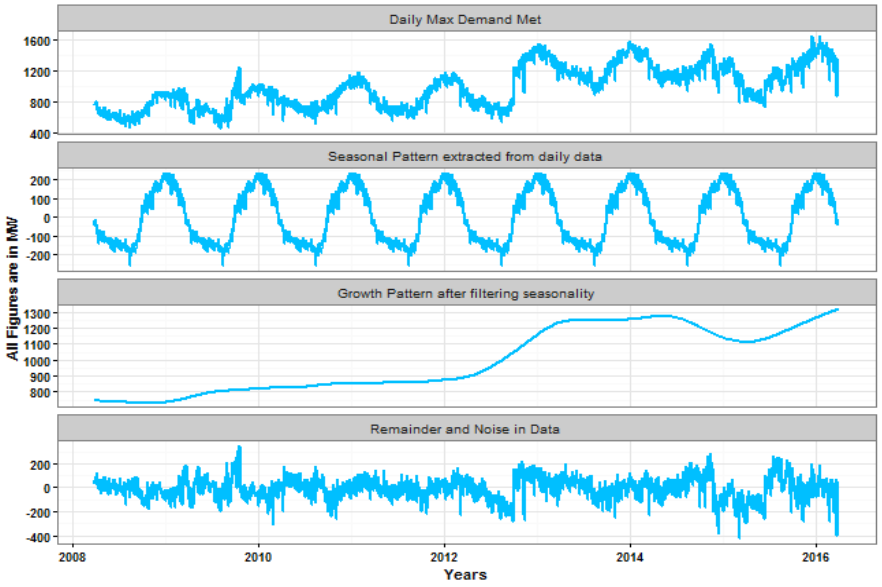
## Hourly Demand met pattern



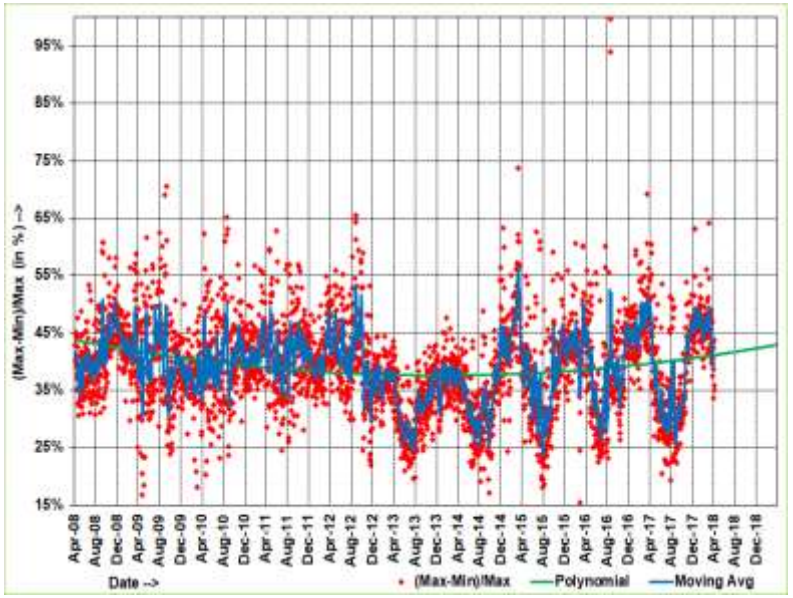

## Annual Demand Duration Curve ( considering block-wise samples):



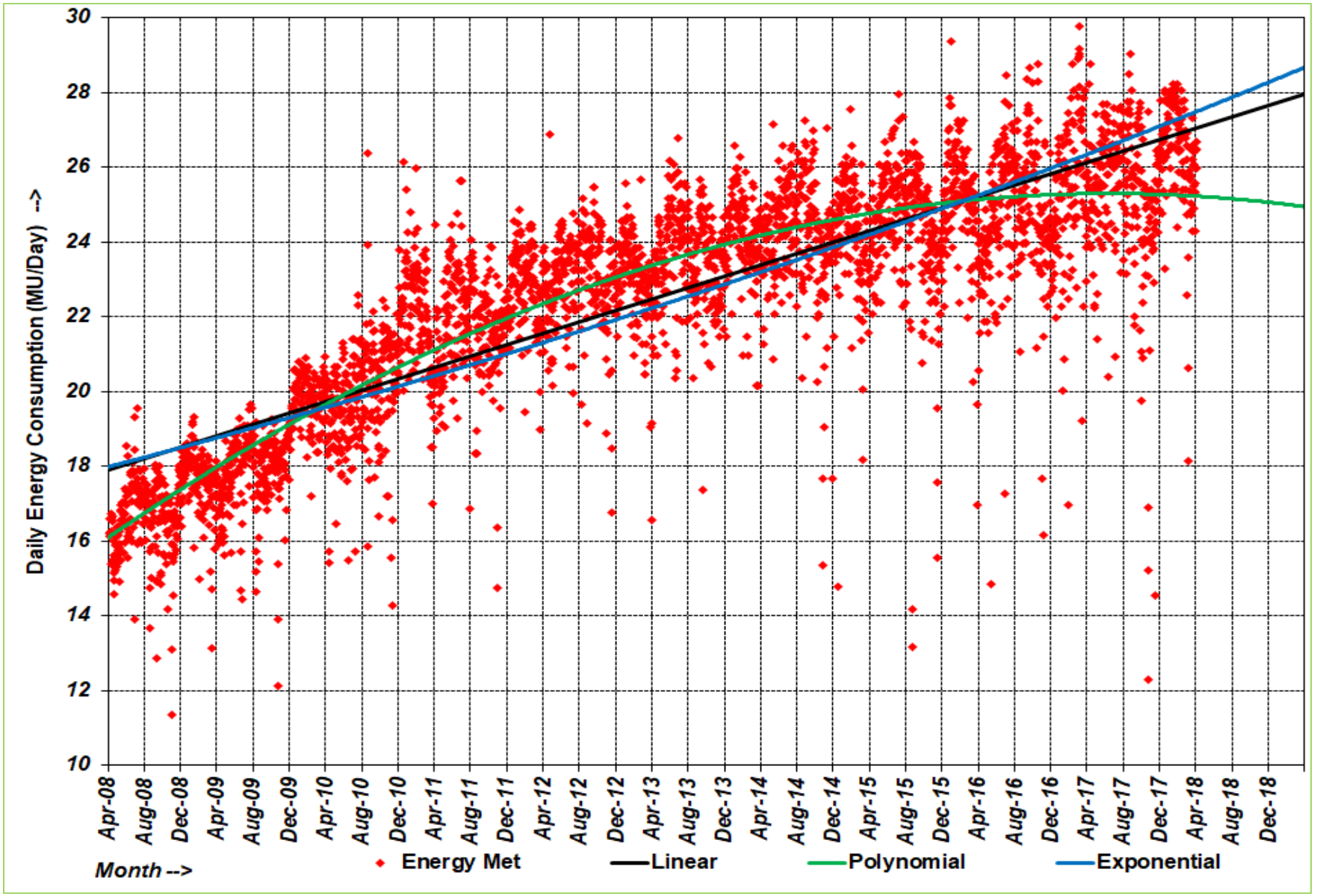

## Decomposition of Daily Maximum Demand Met:



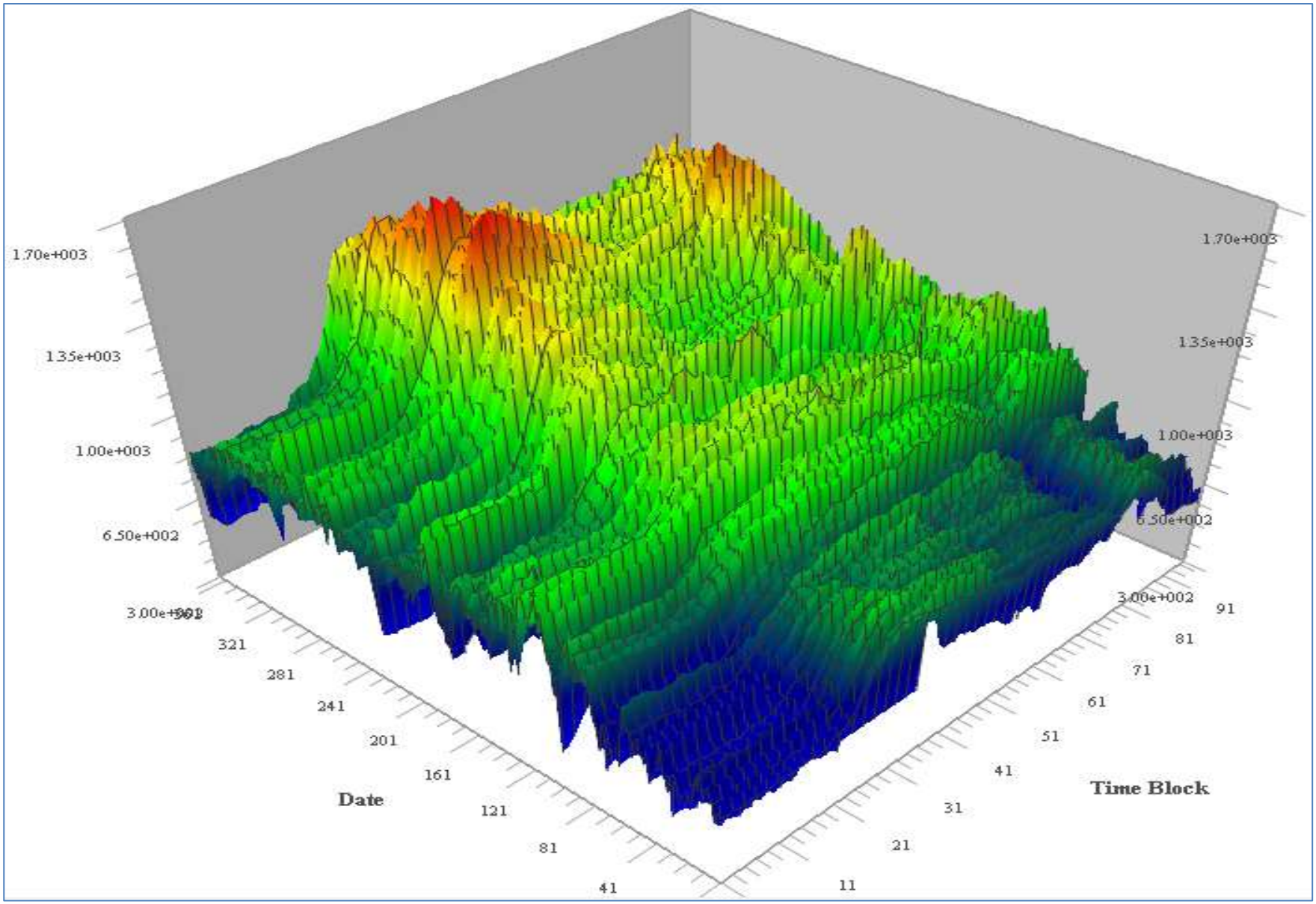

## Daily difference of Peak and Lean as a Percentage of Peak demand met Pattern:



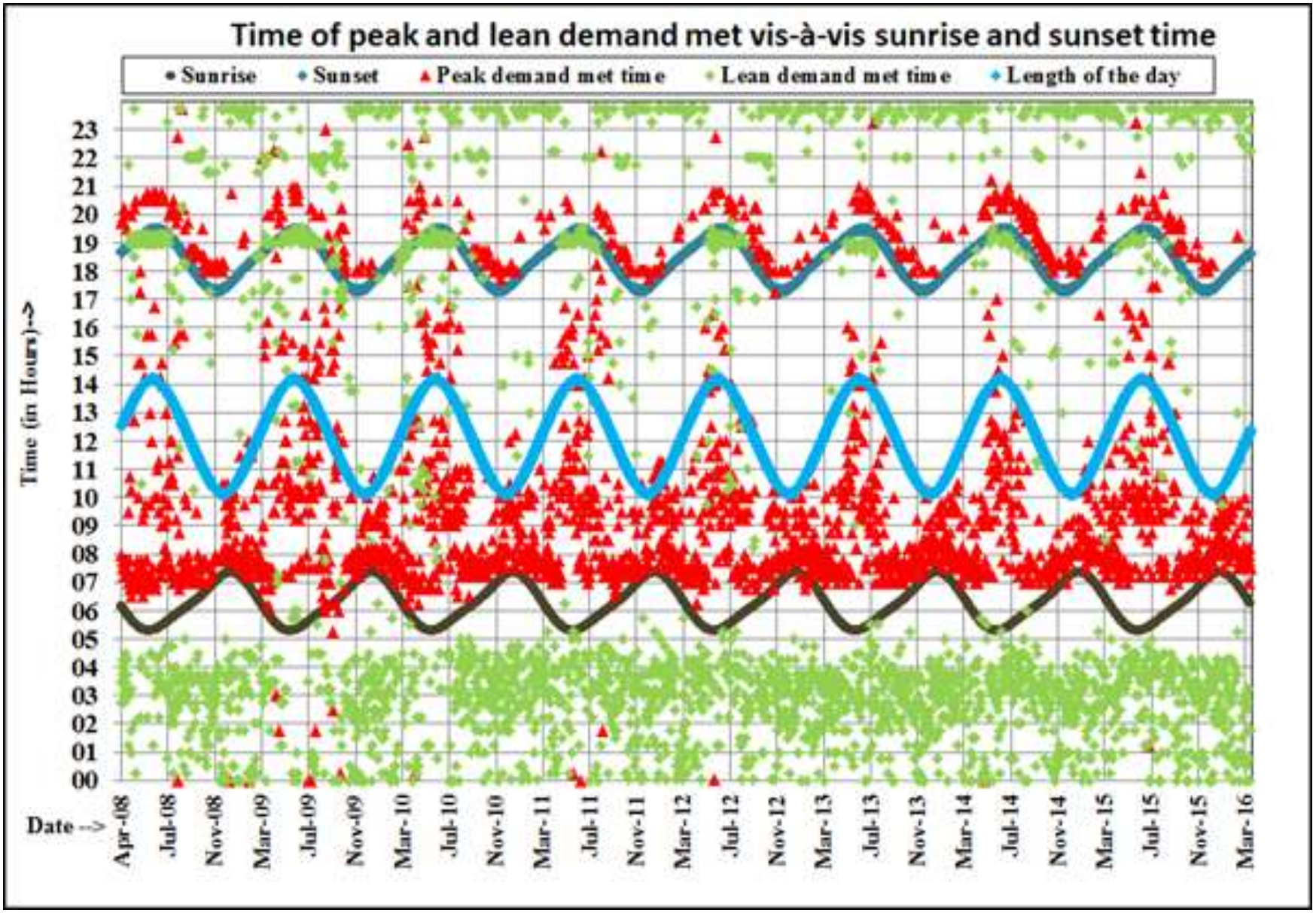
# Himachal Pradesh Daily Energy Consumption



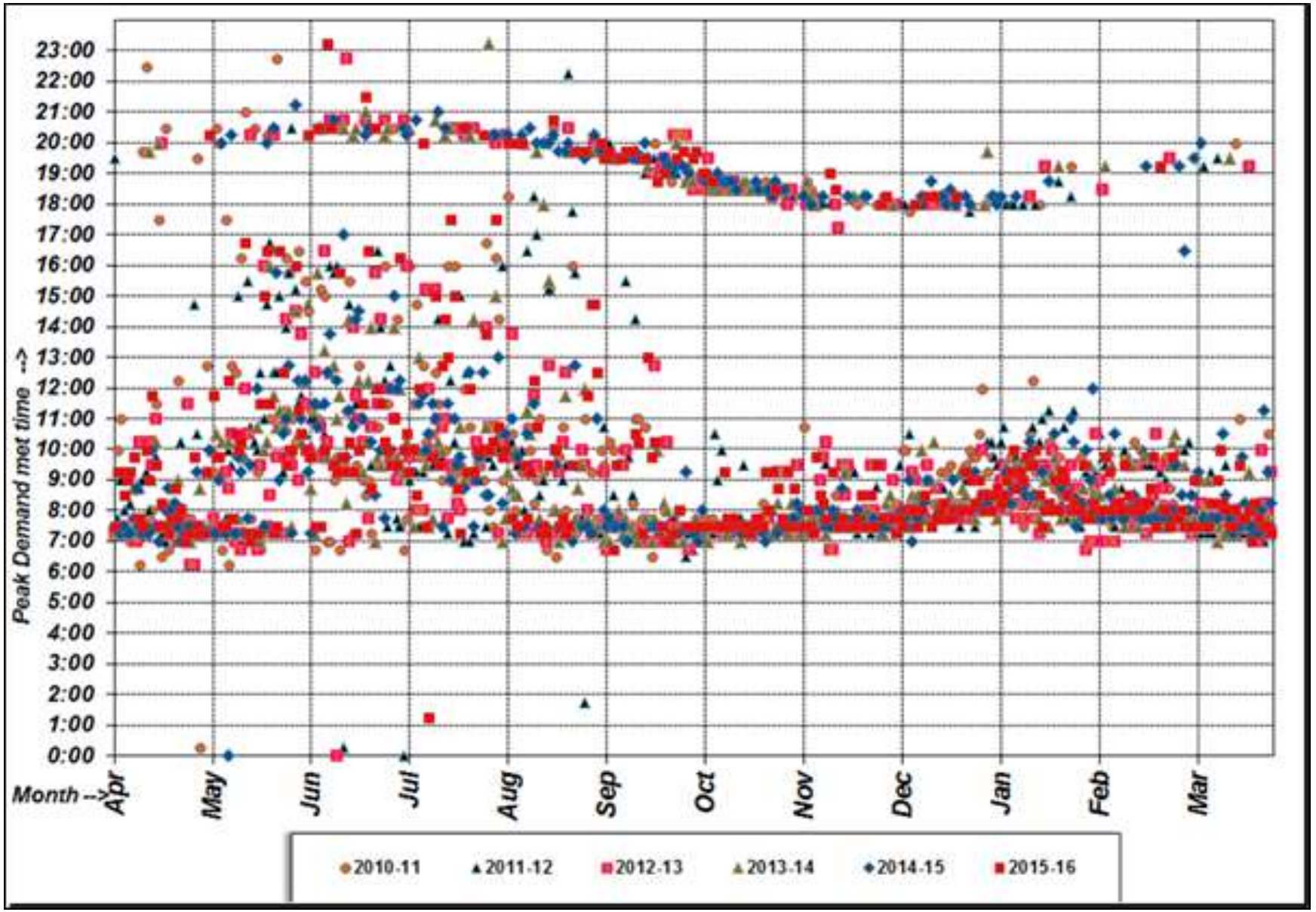
# Himachal Pradesh 3-D plot of annual demand met



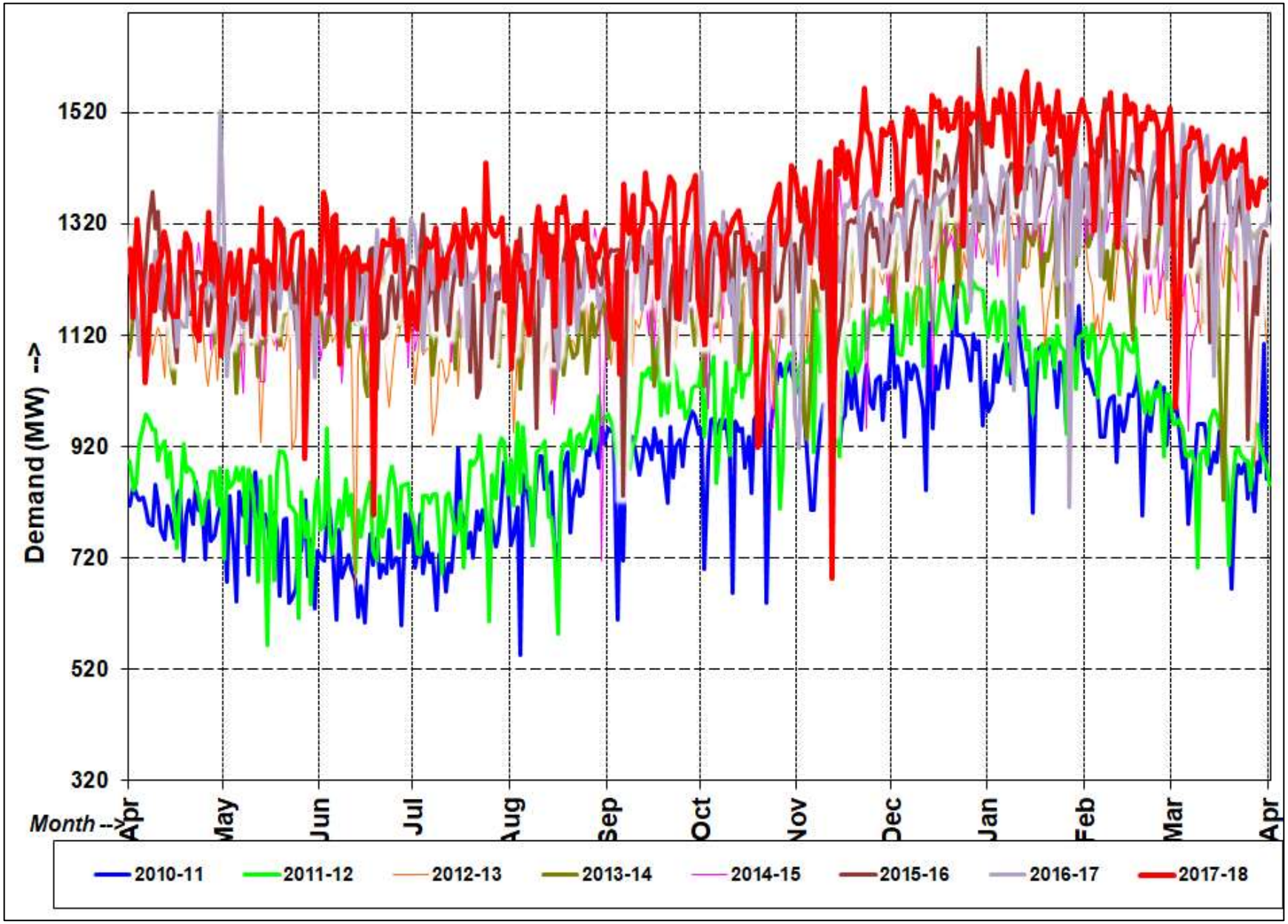
# Himachal Pradesh :Time of daily sunset, sunrise with occurrences of peak and lean demand met



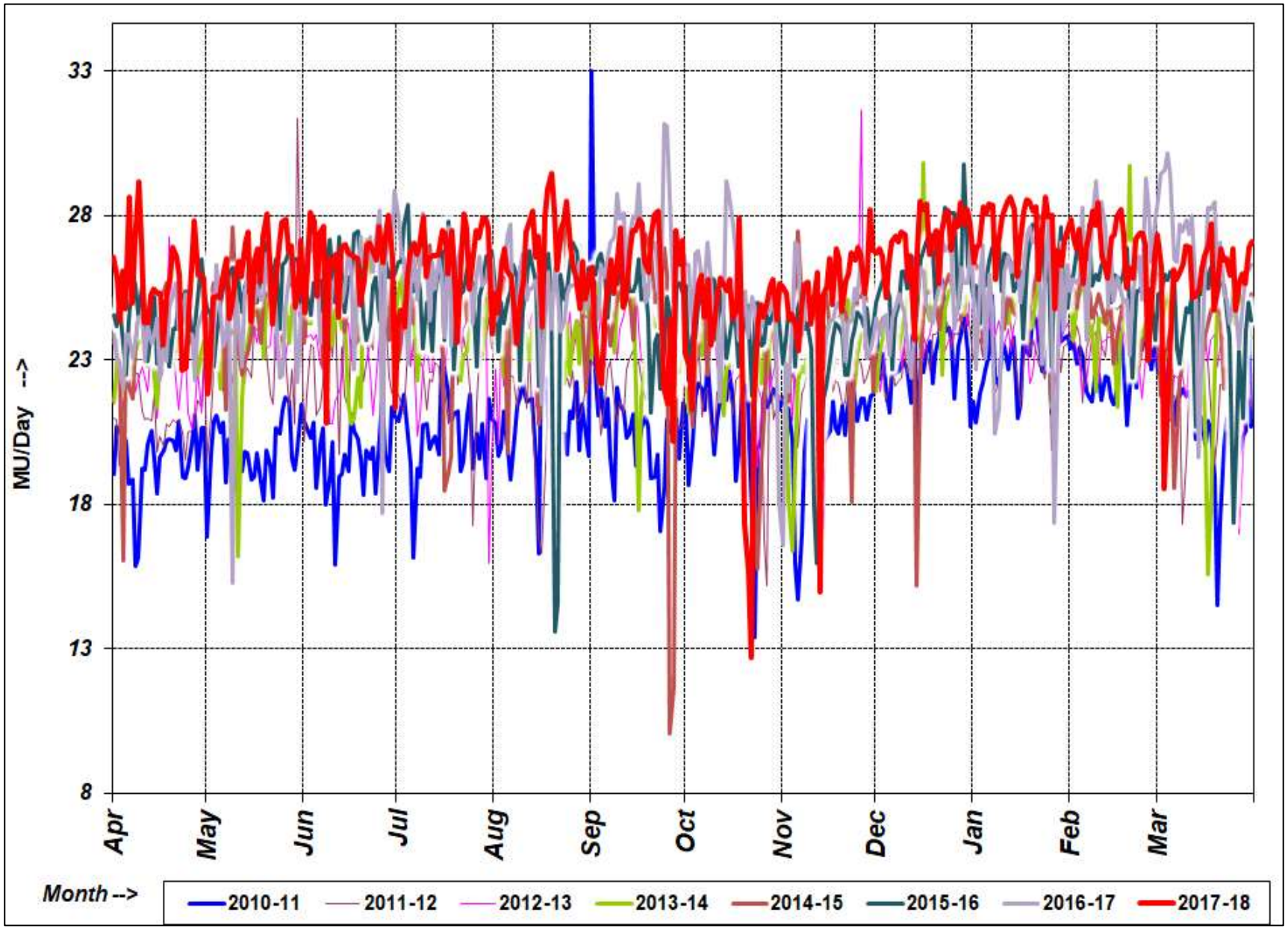
## Himachal Pradesh Maximum daily Demand Met occurrences: Year-On-Year pattern

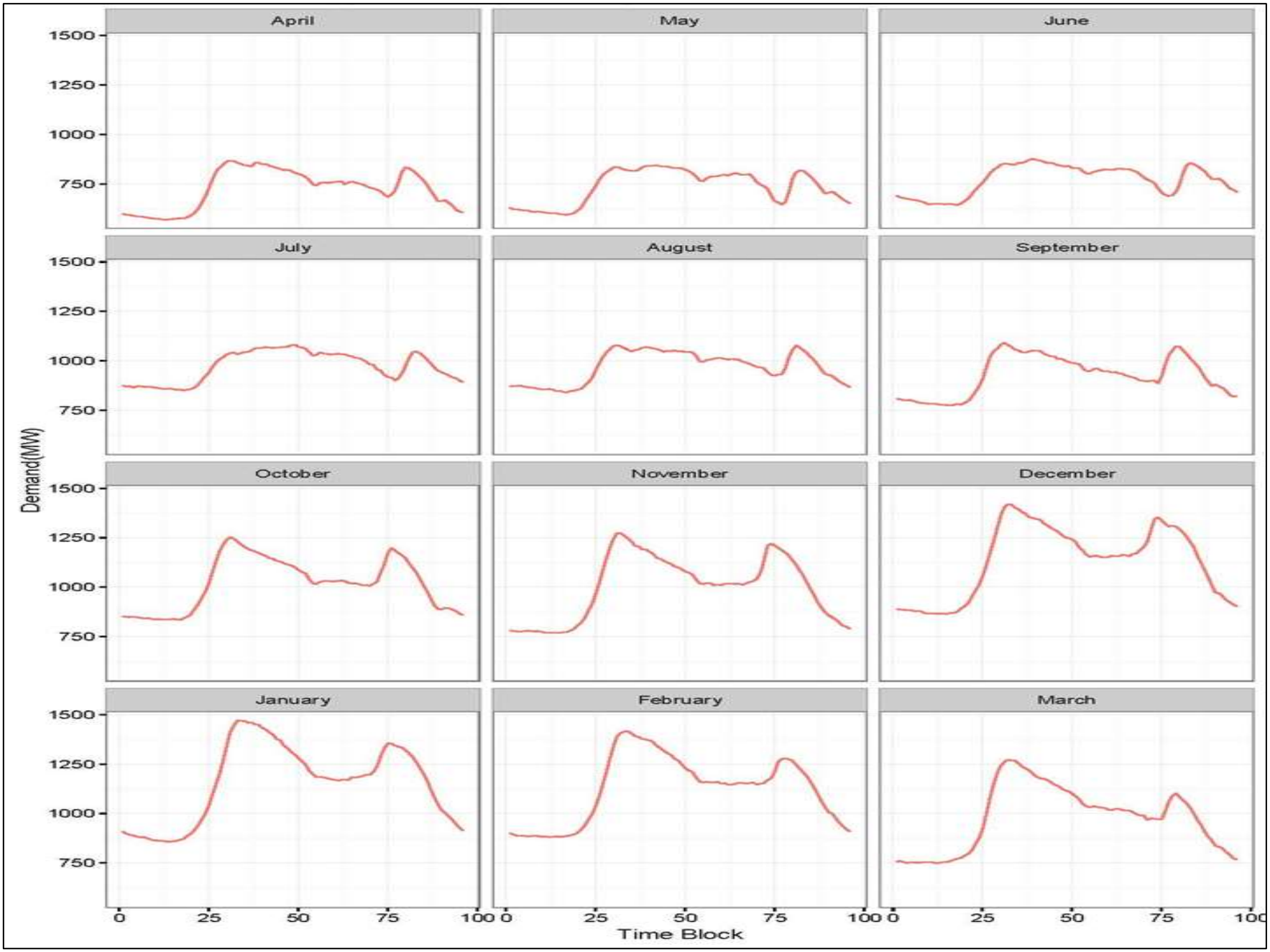


## Himachal Pradesh Daily Peak Demand met pattern:



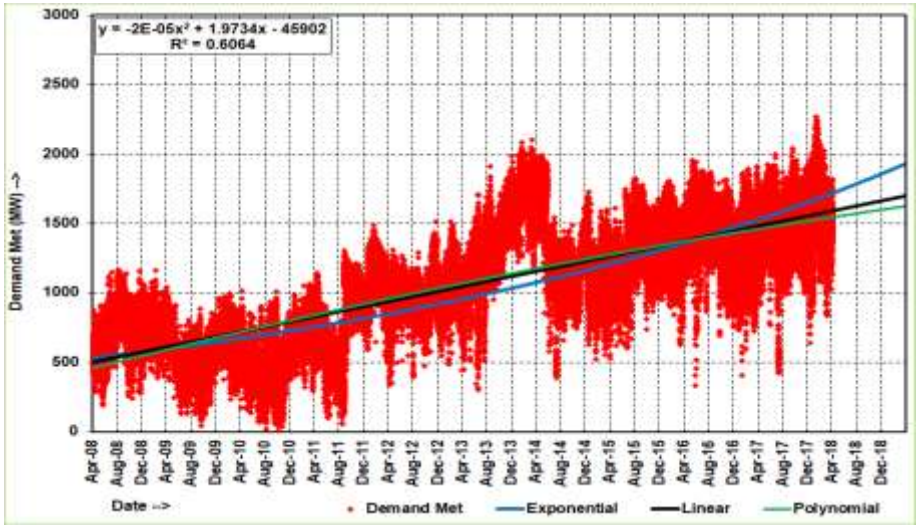
# Himachal Pradesh Daily energy consumption pattern:



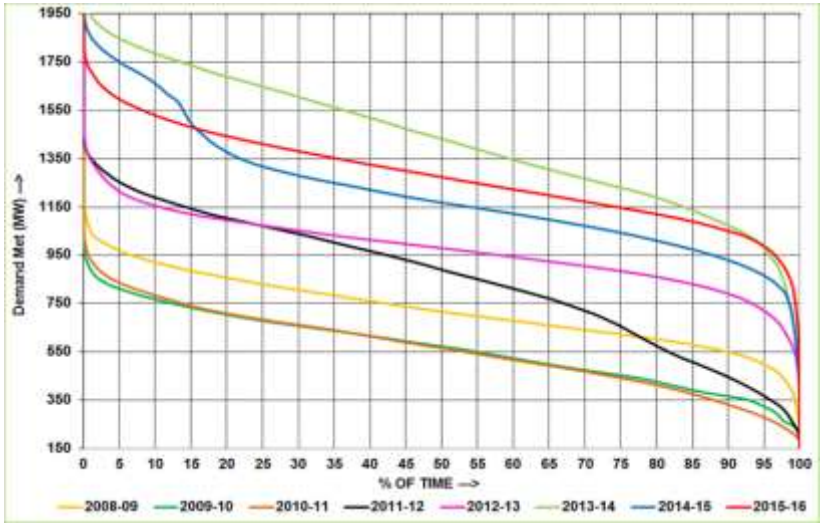

April
May
June
July
August
September
October
November
December
January
February
March
1500
1250
1000
750
0
25
50
75
100
Demand(MW)
Time Block

# Uttarakhand

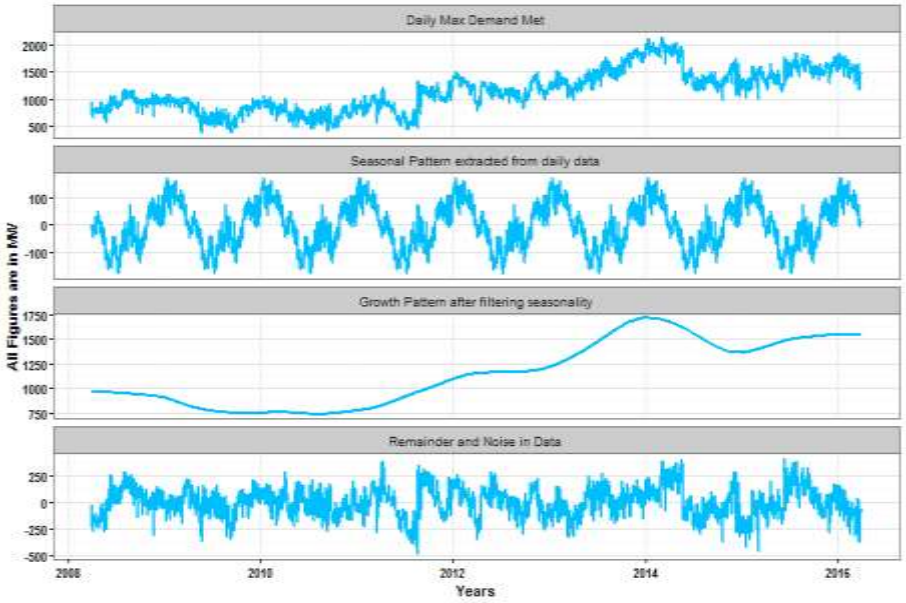
## Hourly Demand met pattern



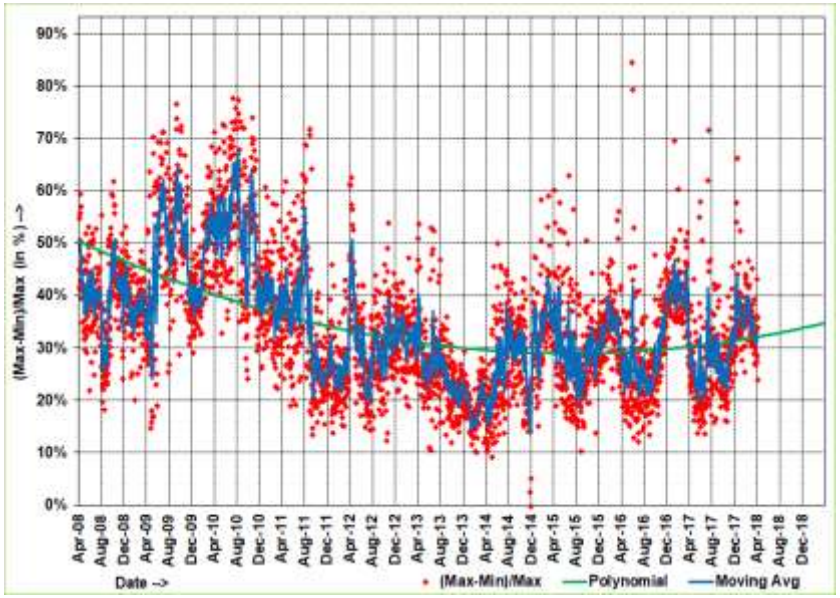

## Annual Demand Duration Curve ( considering block-wise samples):



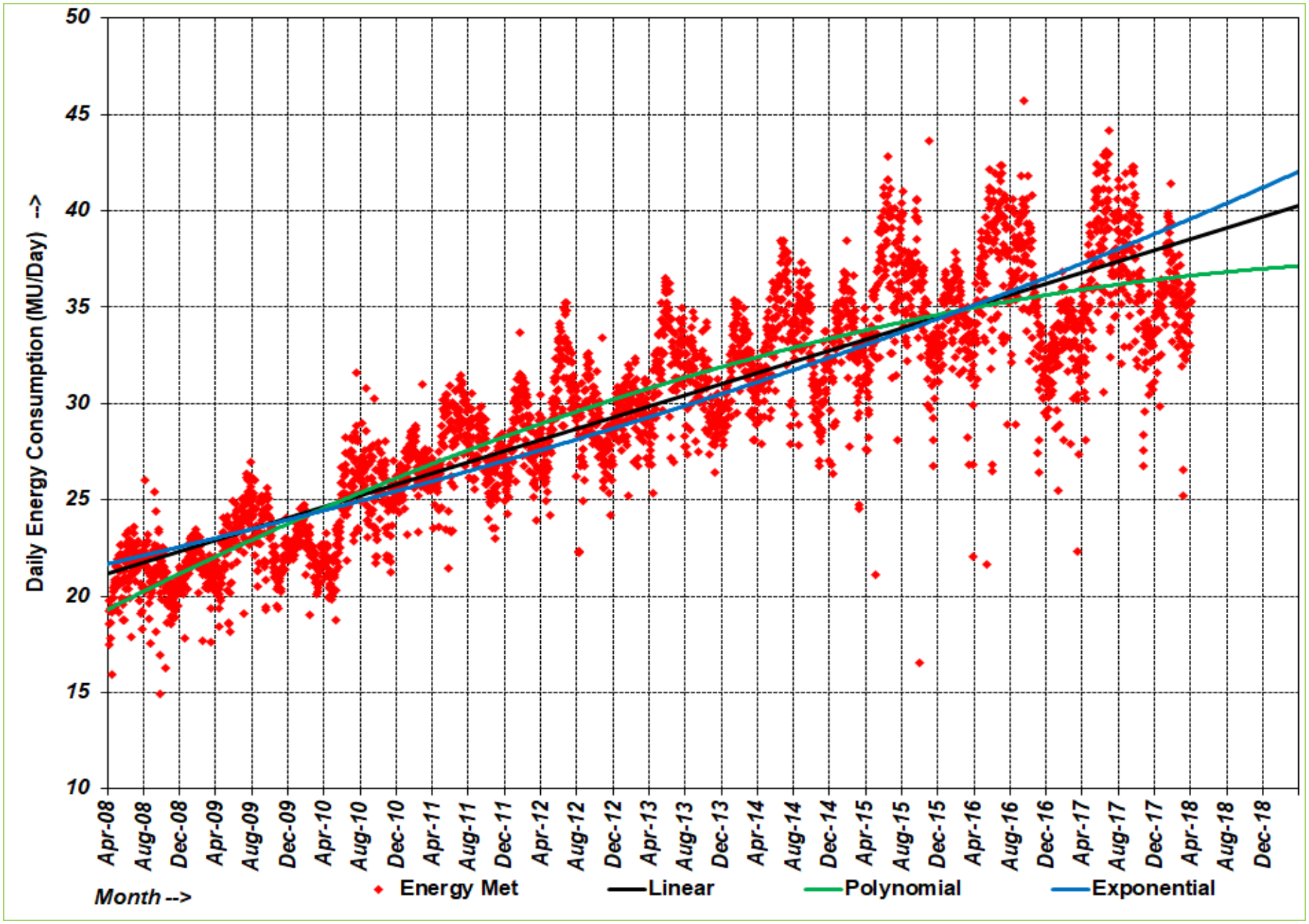

## Decomposition of Daily Maximum Demand Met:



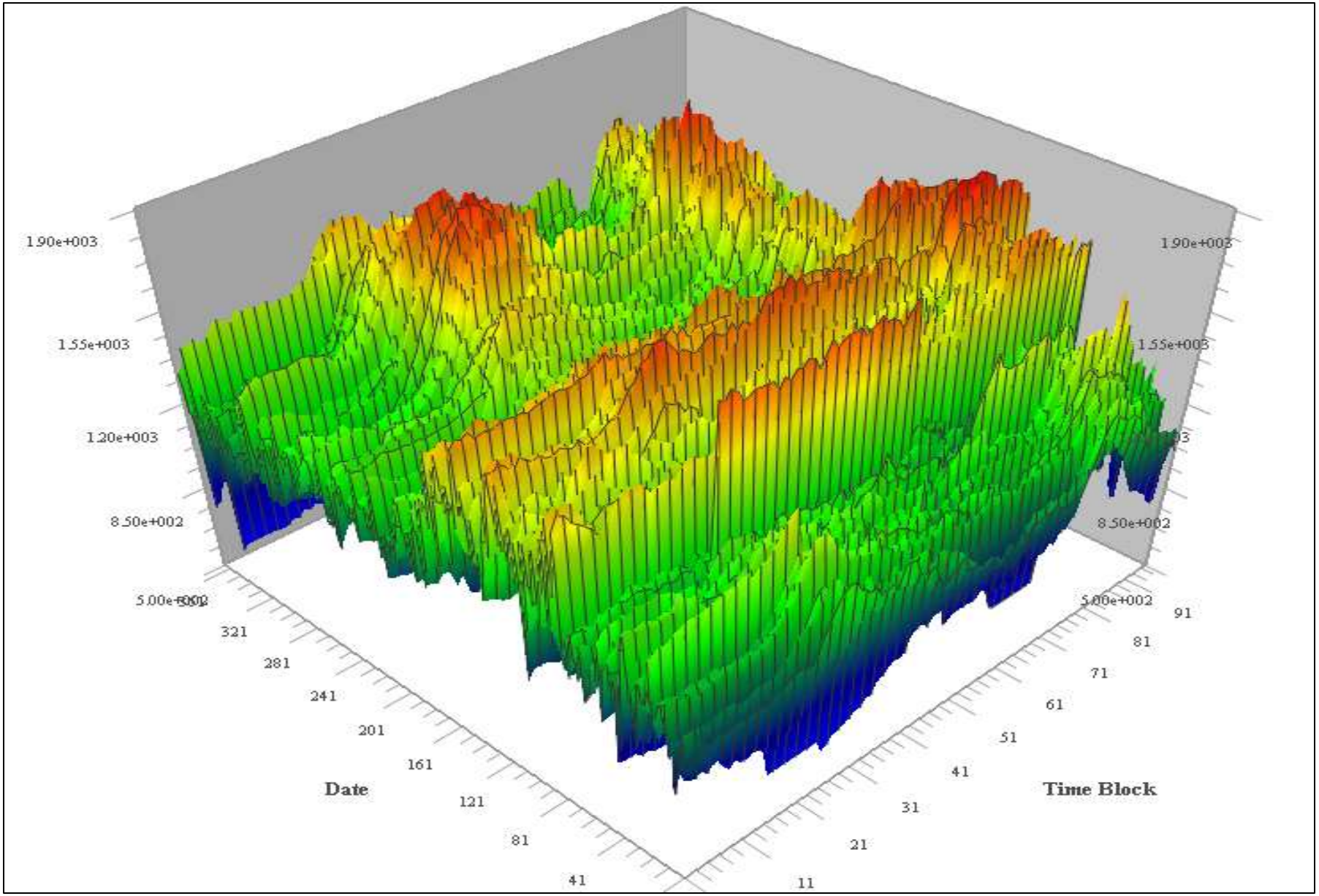

## Daily difference of Peak and Lean as a Percentage of Peak demand met Pattern:



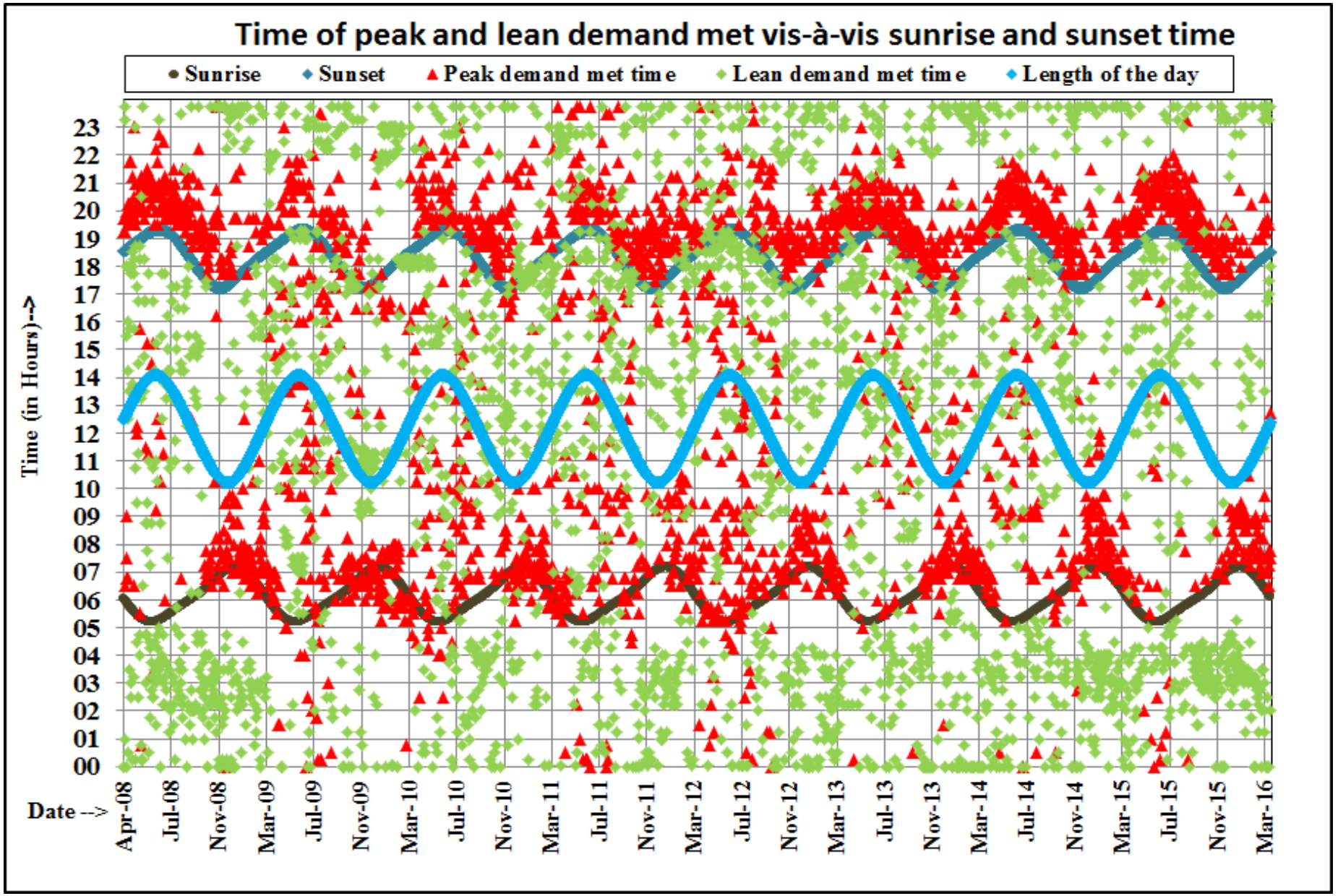
# Uttarakhand Daily Energy Consumption



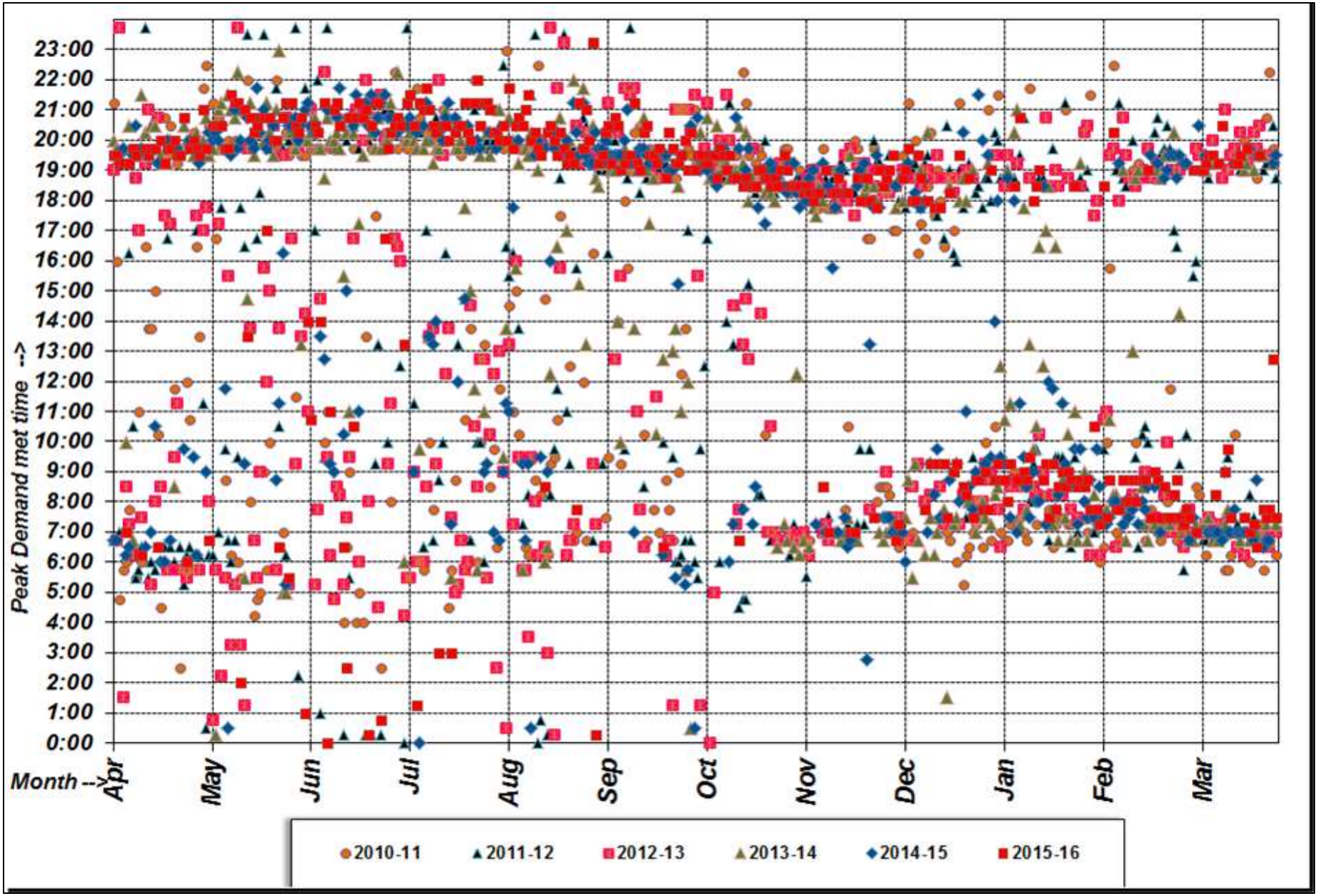
# Uttarakhand 3-D plot of annual demand met



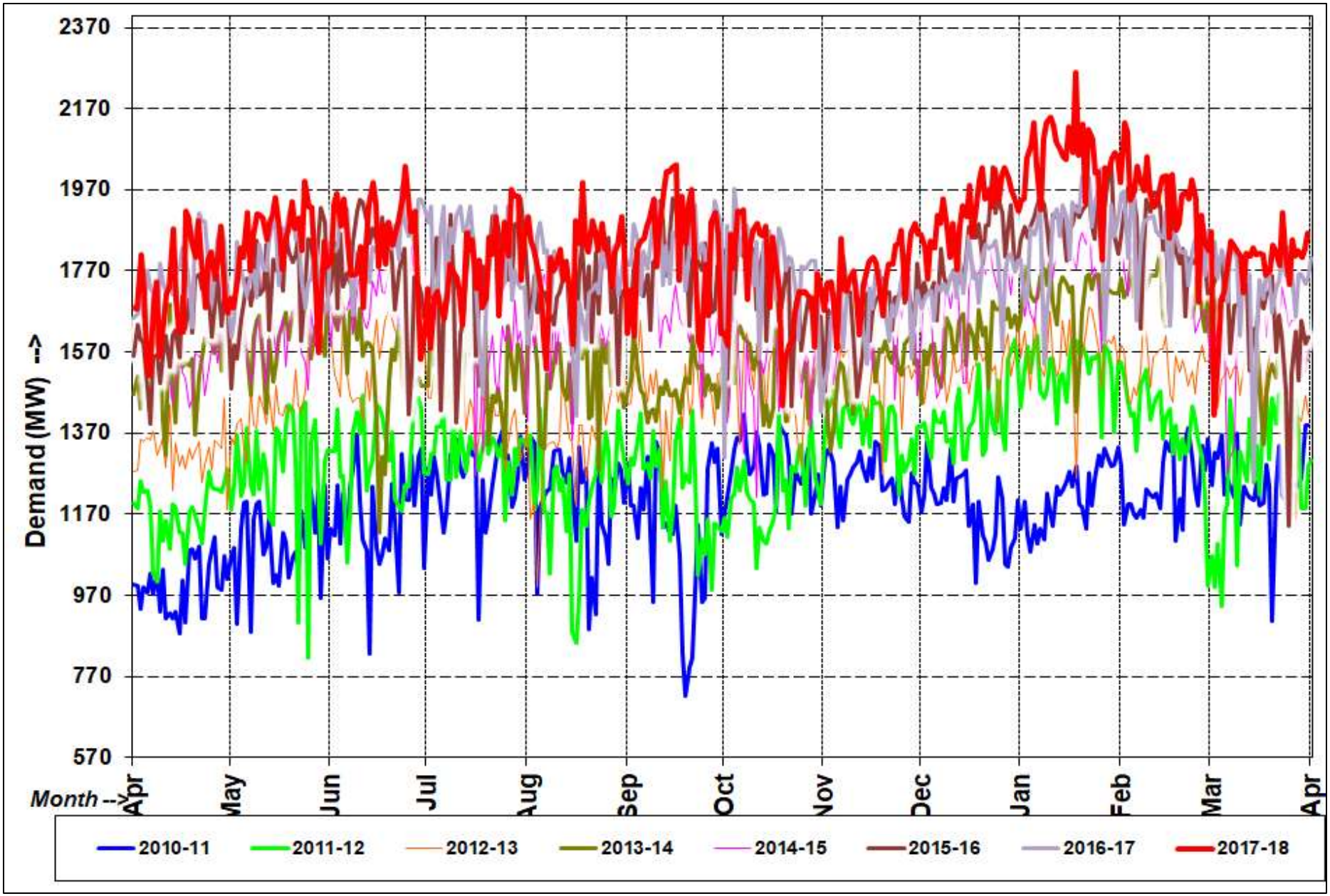
## Uttarakhand :Time of daily sunset, sunrise with occurrences of peak and lean demand met



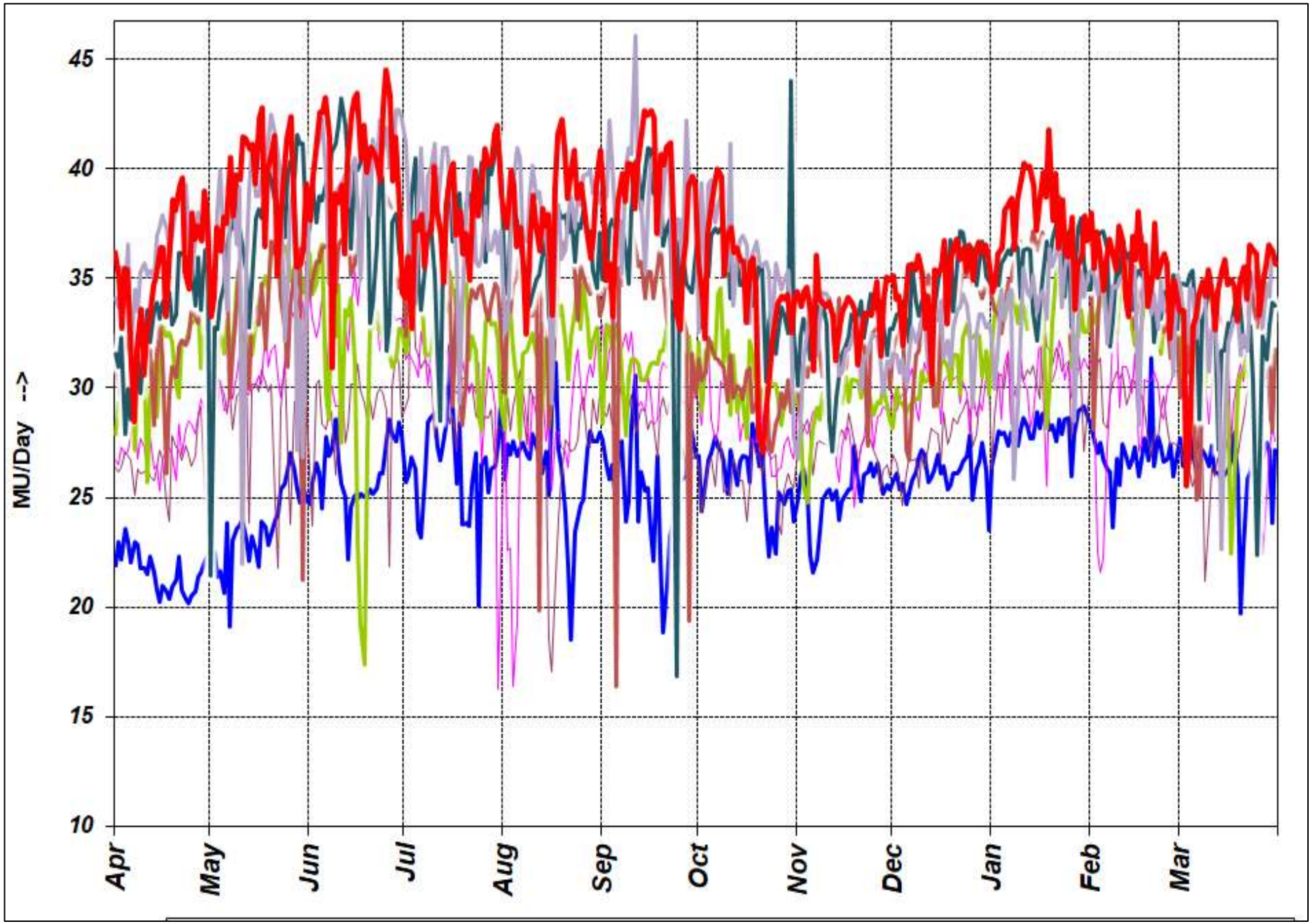
# Uttarakhand Maximum daily Demand Met occurrences: Year-On-Year pattern

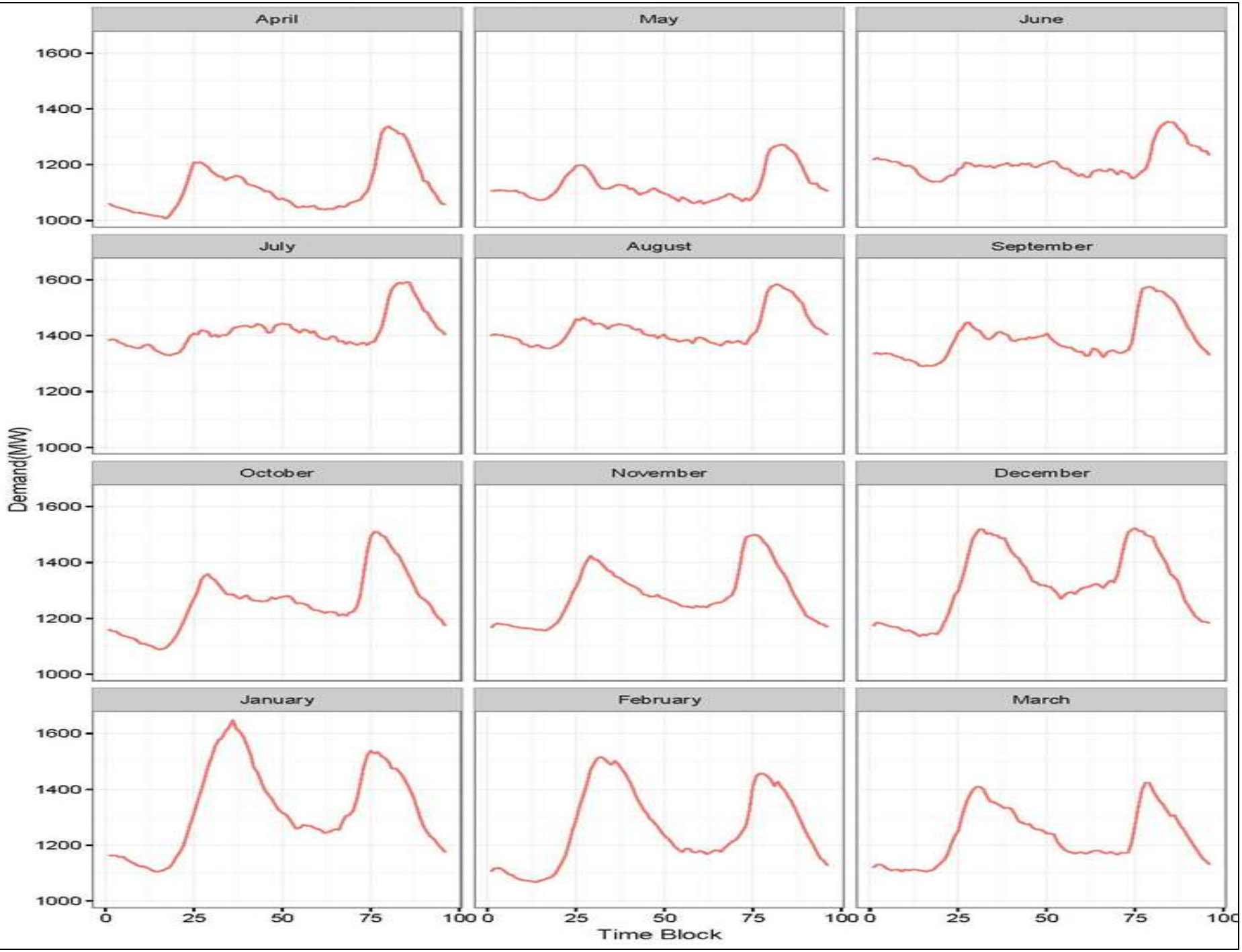


# Uttarakhand Daily Peak Demand met pattern:



## Uttarakhand Daily energy consumption pattern:

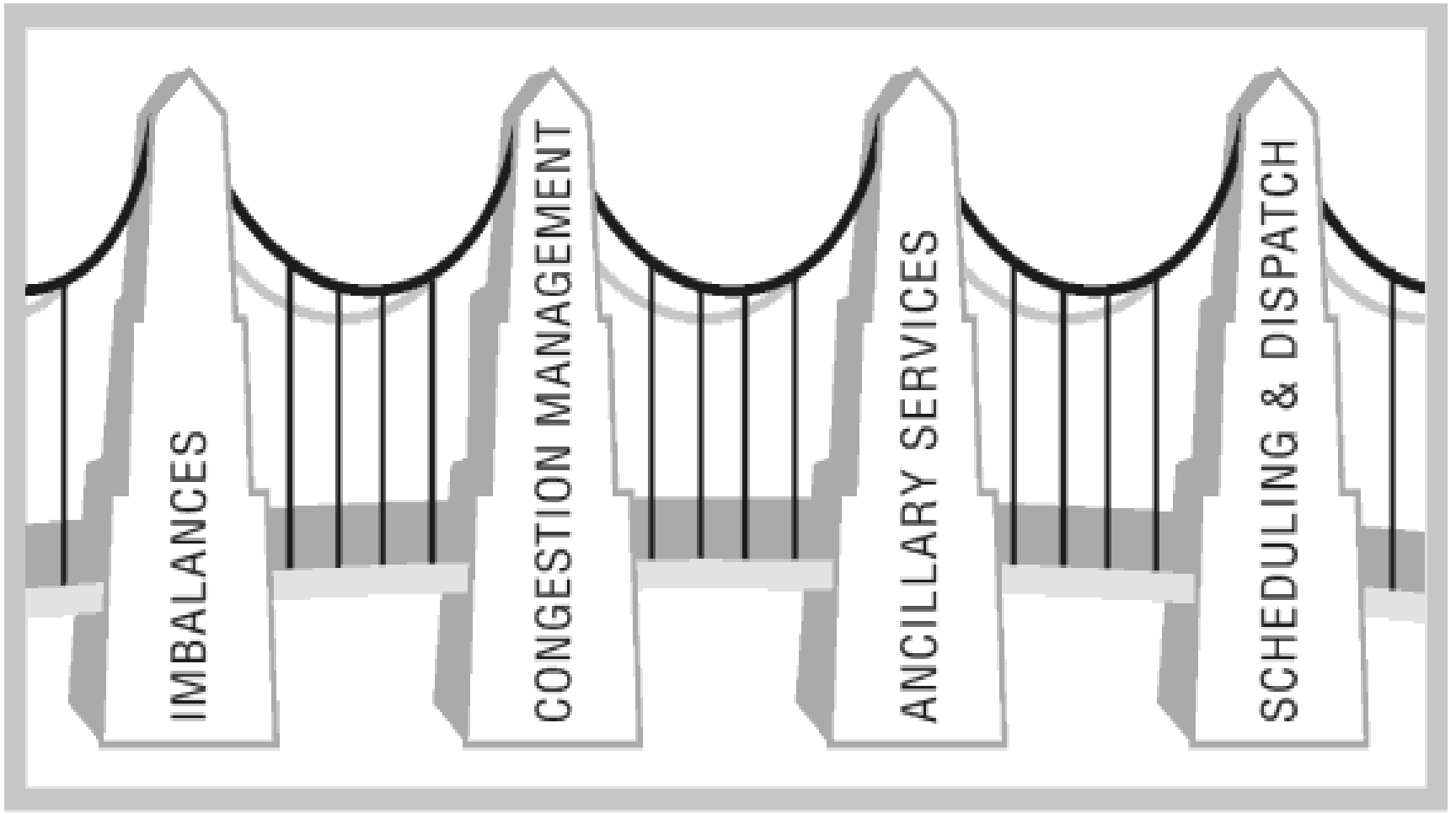



April
May
June
July
August
September
October
November
December
January
February
March
Demand(MW)
1600
1400
1200
1000
0
25
50
75
100
Time Block

# Thank You !

# Experience Sharing
# of
# Reserves Regulation Ancillary Services
# “RRAS”

# Pillars of Market Design




Sally Hunt – ‘ Making Competition Work in Electricity’

# What does Ancillary Services mean?

- The literal meaning of the word ancillary is providing support or help.

- **NERC defines Ancillary Services as**

*"An Interconnected operation services necessary to effect transfer of electricity between purchasing and selling entities, and which a transmission provider must include in an open access transmission tariff."*

- **As per IEGC, 2010**
  - *"Ancillary services in power system (or grid) operation means services necessary to support the power system (or grid) operation in maintaining power quality, reliability and security of the grid, e.g active power support for load following, reactive power support, black start etc"*

# Types of Ancillary Services

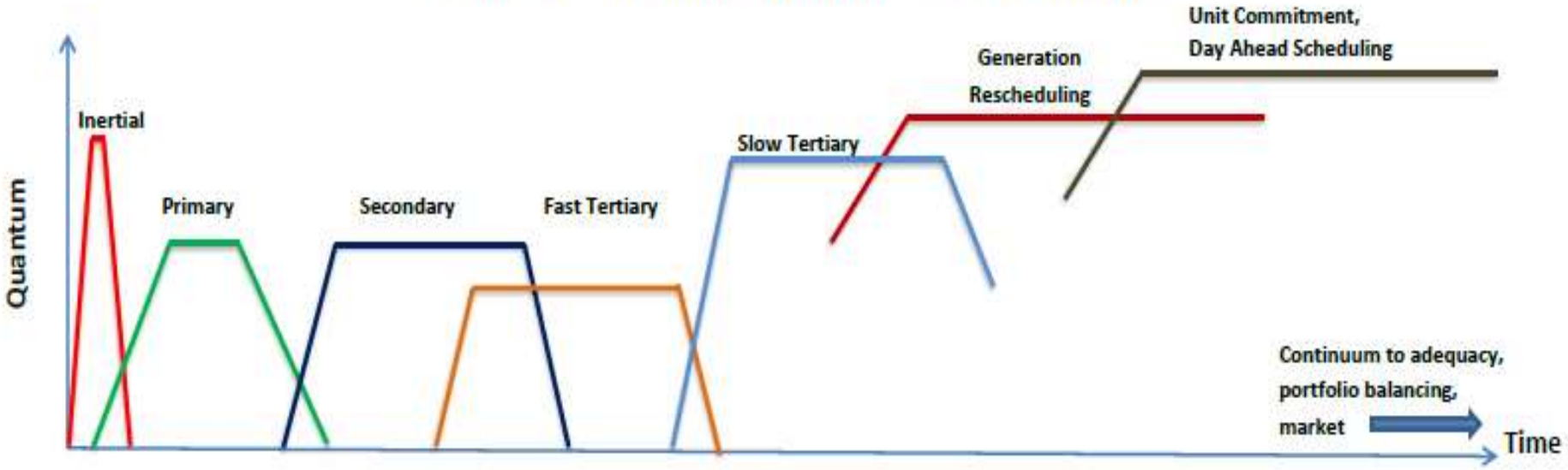
- Generally, the System Operator (SO) procures ancillary services for ensuring security, reliability, stability and quality of the power supply to the consumers.

- Ancillary services can be provided by generators, Load Serving Entities (LSEs) and transmission operators.

- Ancillary services are classified, procured and remunerated depending upon the operational practices of the Electricity Supply Industry (ESI).

- **Ancillary services consist of services required for**
  - Maintaining generation and load balance (frequency control)
  - Maintaining Voltage and reactive power support
  - Maintaining generation and transmission reserves
  - Emergency preparedness (system restart & stability control)

# System Balancing in India – A Schematic




| Response → Attribute ↓ | Inertial | Primary | Secondary | Fast Tertiary | Slow Tertiary | Generation Rescheduling | Unit Commitment |
|---|---|---|---|---|---|---|---|
| Time | First few secs | Few sec - 5 min | 30 s – 15 min | 5 - 30 min | > 15 – 60 min | > 60 min | Hours/ day-ahead |
| Quantum | ~ 10000 MW/Hz | ~ 4000 MW | ~ 4000 MW | ~ 1000 MW | ~ 8000-9000 MW | Load Generation Balance | Load Generation Balance |
| Local / LDC | Local | Local | NLDC / RLDC | NLDC | NLDC / SLDC | RLDC / SLDC | RLDC / SLDC |
| Manual / Automatic | Automatic | Automatic | Automatic | Manual | Manual | Manual | Manual |
| Centralized / Decentralized | Decentralized | Decentralized | Centralized | Centralized | Centralized/ Decentralized | Decentralized | Decentralized |
| Code / Order | IEGC / CEA Standard (?) | IEGC / CEA Standard | Roadmap on Reserves | Ancillary Regulations | Ancillary Regulations | IEGC | IEGC |
| Paid / Mandated | Mandated | Mandated | Paid | Paid | Paid | Paid | Paid |
| Regulated / Market | Regulated | Regulated | Regulated | Regulated | Regulated / Market | Regulated / Market | Regulated / Market |
| Implementation | Existing | Partly Existing | Yet to start | Yet to start | Existing | Existing | Existing |

# Frequency Control Ancillary Services

- A certain amount of active power, called *frequency control reserve*, is kept available to perform this task.
- Three levels of control are generally used to achieve FCAS:
  - Primary frequency control (a response period of 5 to10s),
  - Secondary frequency control (10s to 15min ) and
  - Tertiary frequency control (10 to 30min).

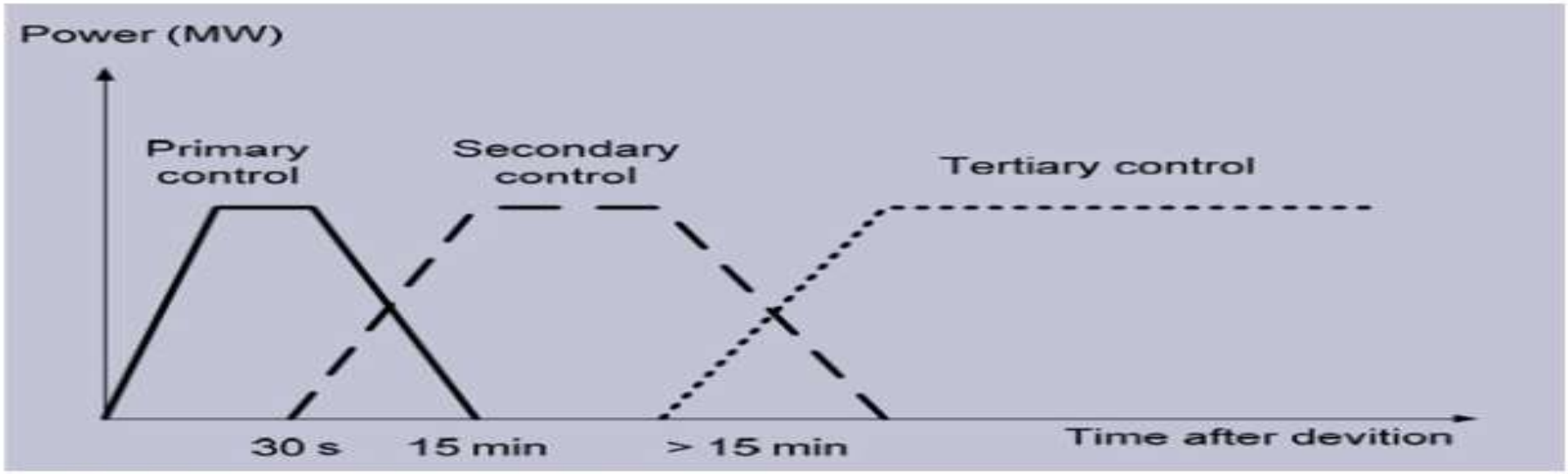



Figure 5: UCTE's classification of frequency reserves

# Roadmap for Reserves

## Primary

- **All India - 4000 MW**
  - Outage of Ultra Mega Power Plant (UMPP) or any similar event

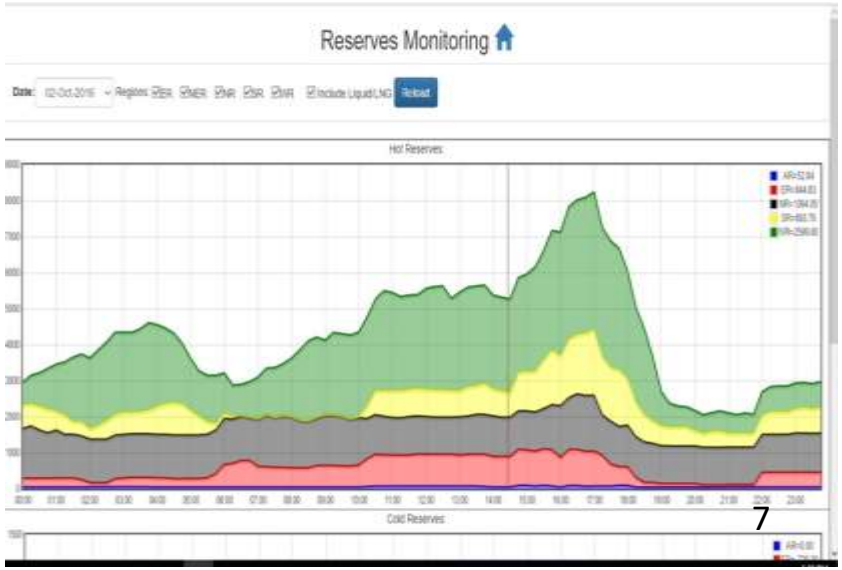
## Secondary

- **All India - 3623 MW**
  - NR – 800 MW
  - WR – 800 MW
  - SR – 1000 MW
  - ER – 660 MW
  - NER – 363 MW

## Tertiary

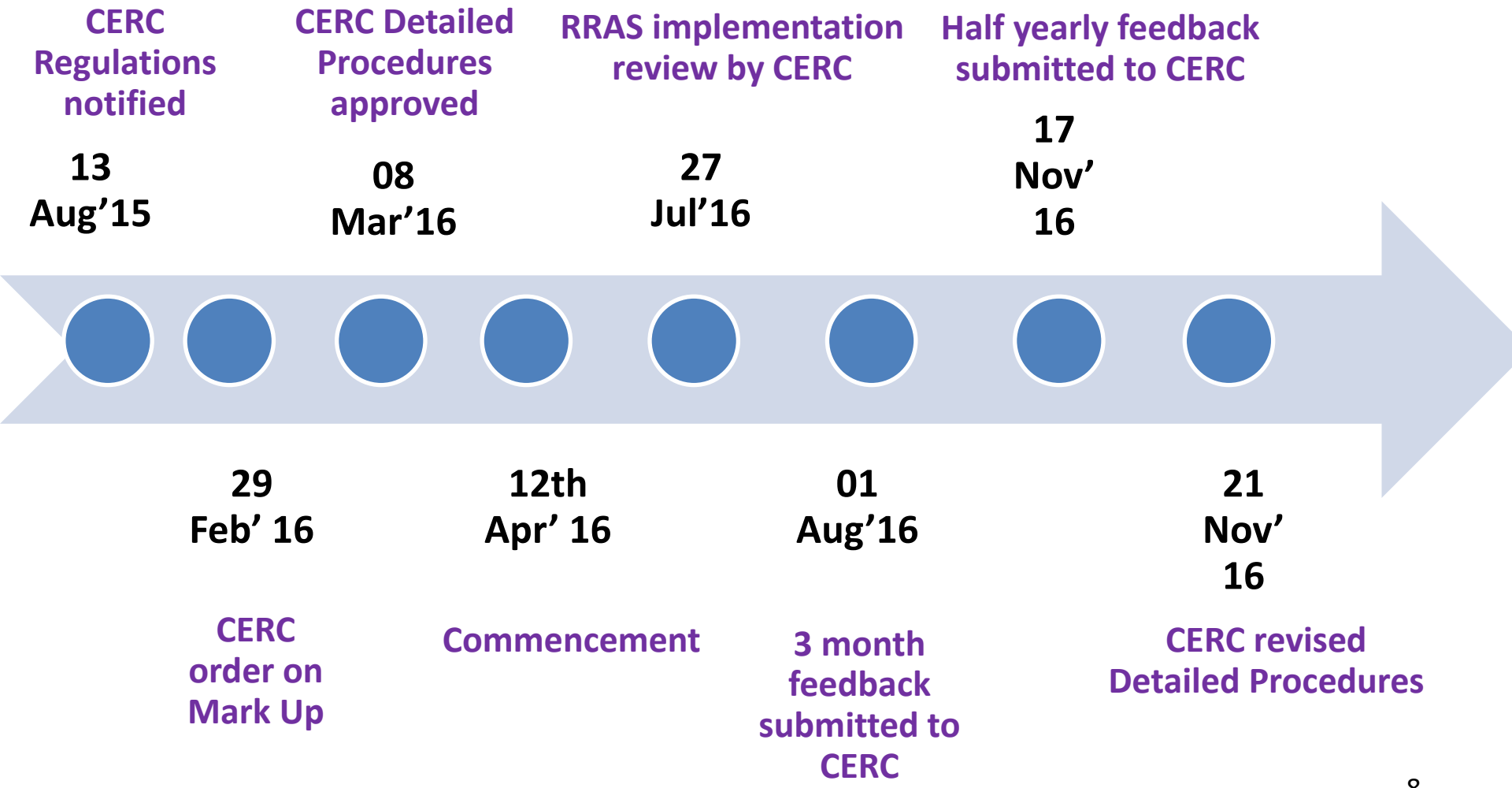
- **All India - 5218 MW**
  - NR – 1658 MW
  - WR – 1353 MW
  - SR – 1343 MW
  - ER – 857 MW
  - NER – 65 MW

- CERC Roadmap for Reserves
- Stakeholder Consultations
- Pilot project initiated– Sept.'16
  - Coal fired based station – NTPC Dadri
  - Plant level specifications - AGC signals
  - Control actions from NLDC
  - Petition filed by POSOCO with CERC on 3rd April 2017 on AGC Pilot
  - Heard by CERC on 18th June 2017
  - Order by CERC on 16th Dec, 2017
  - AGC operationalized on 04th Jan,2018



# Ancillary Services Operations

*Experience in Indian Context and way forward*



# Reserve Regulation Ancillary Services (RRAS)

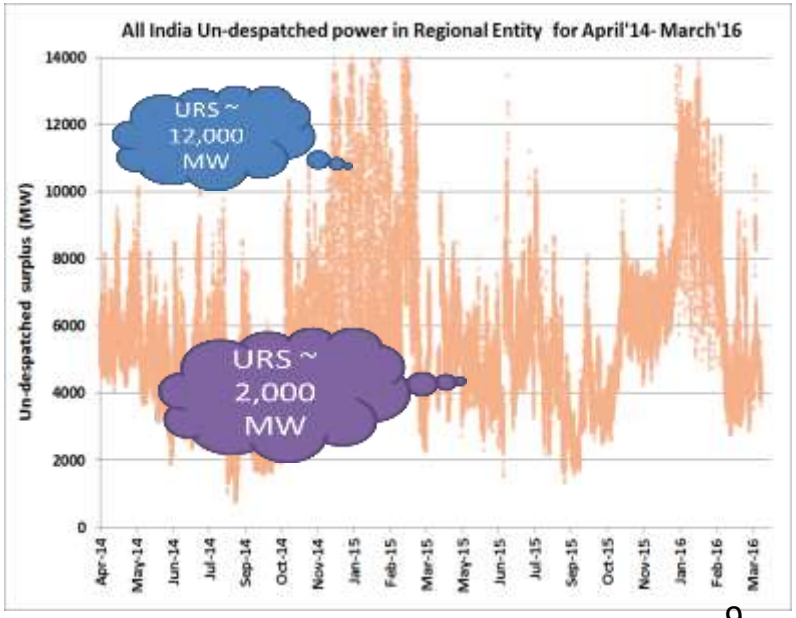
**Reserve Regulation Ancillary Services – 'Value Added Services'**

- Keeping frequency within specified limits
- Maintaining the voltage profile
- Load Following
- Ramp Management
- Reliability and Security of All India Grid
- Utilization of Un-despatched Surplus
- Congestion Management
- Optimization at Regional & National Level
- Grid Integration of Renewables

**Ancillary Services Definition…**

"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."
- Eric Hirst and Brendon Kirby

**Key to Ancillary Services - Undespatched Surplus in ISGS**



# Role of Nodal Agency

## Merit Order Stack

- Separate Stack
- **Regulation Up**
- **Regulation Down**
- URS capacities of ISGS
- Variable cost of generation
- Time-block wise
- Region-wise
- Factoring ramp up/down rate, response time, ttransmission constraints – both inter-regional and intra-regional

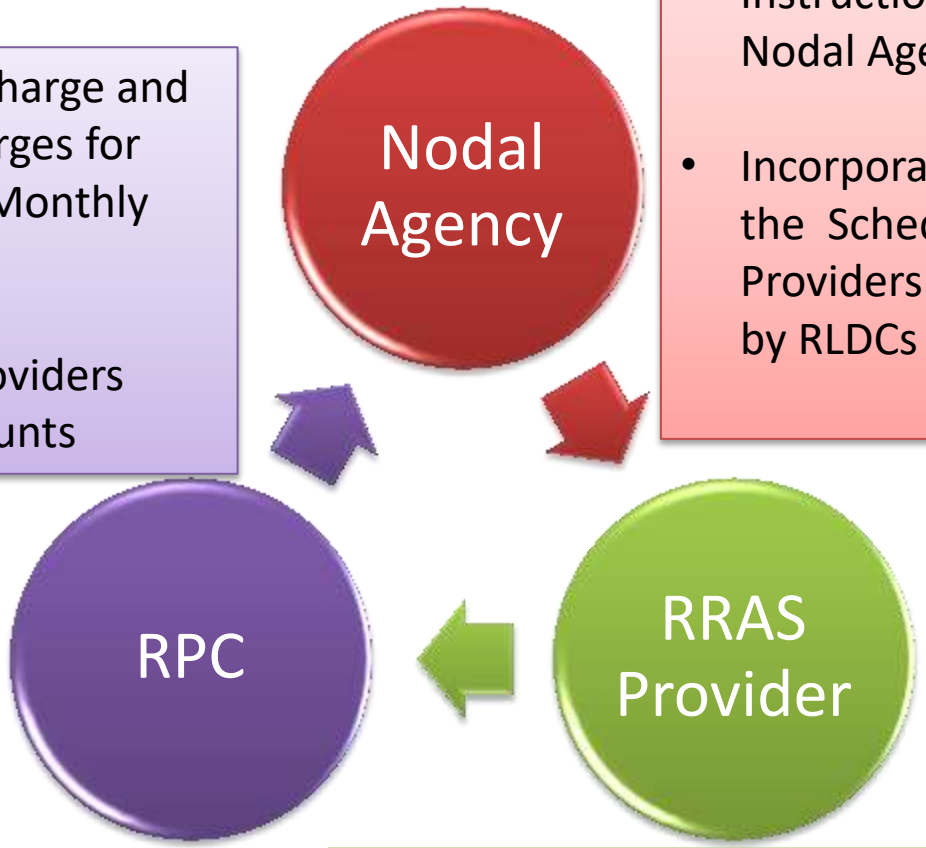
## Events

- Extreme weather forecasts and/or special day;
- Generating unit or transmission line outages;
- Trend of load met;
- Trends of frequency;
- Abnormal event such as outage of hydro generating; units due to silt, coal supply blockade etc.;
- Excessive loop flows leading to congestion; and
- Such other events

# Role of RRAS Provider and RPCs

- Despatch & Withdrawal Instructions through RLDCs by Nodal Agency
- Incorporation of instructions in the Schedules of RRAS Providers and respective VAE by RLDCs

- Fixed charge, Variable charge and any other statutory charges for merit order dispatch – Monthly basis
- Preparation of RRAS Providers Energy/ Deviation Accounts




Fixed charge, Variable charge and any other statutory charges

# RRAS Energy Accounting & Settlement

## RRAS Energy Accounting

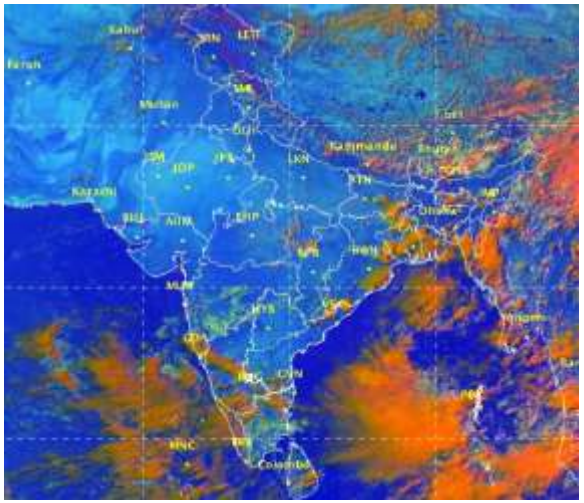
- Done by RPC on weekly basis along with DSM Account
- Based on interface meters data and schedule of RRAS Providers
- Separate statement maintained along with Regional Deviation Settlement Account for RRAS

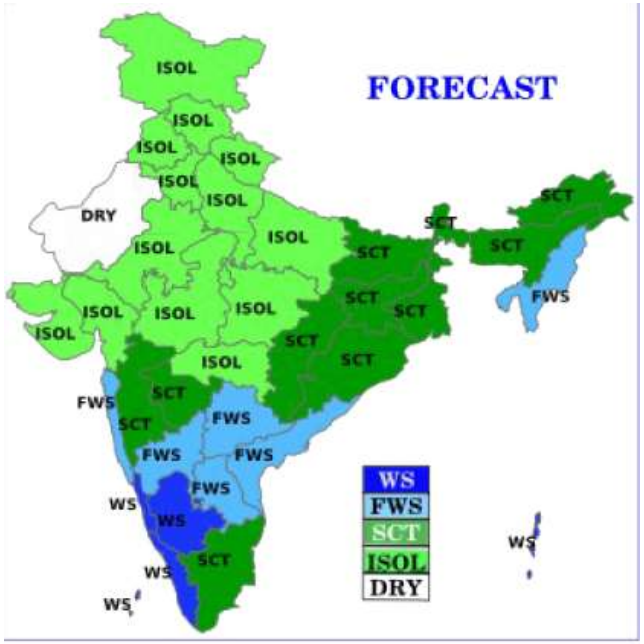
## RRAS Energy Settlement

- Under separate account head of RRAS from Regional DSM Pool Account
- **Regulation Up**
  - RRAS provider paid at their fixed & variable charges with markup
- **Regulation Down**
  - RRAS provider shall pay 75 % of variable charges to Pool Fund
- No retrospective settlement
- Any deviation settled as per CERC DSM Regulations, 2014
- Penalties for sustained failure to provide RRAS and violation of directions of RLDC

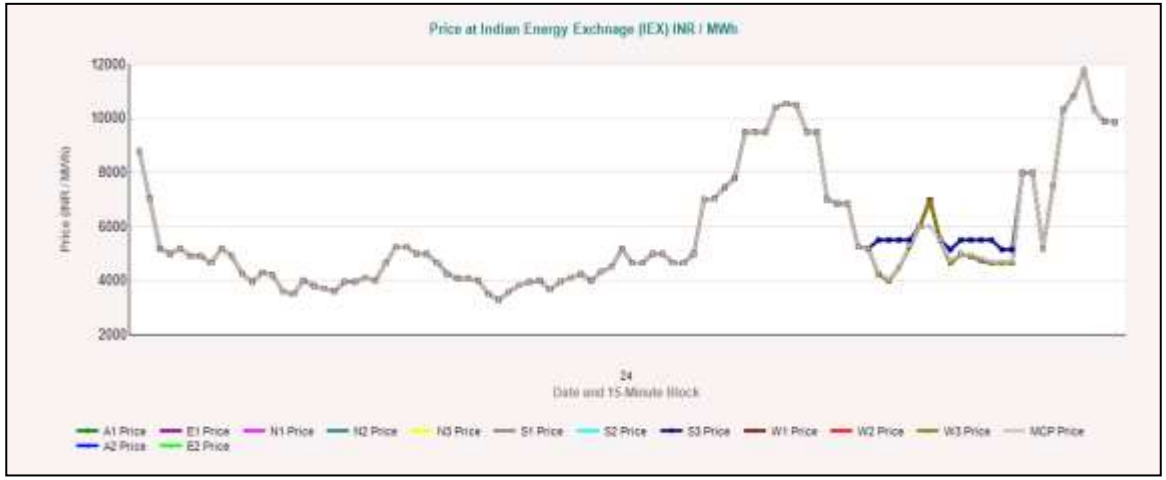
# Cues for System Operator…

## Weather Forecast (1)





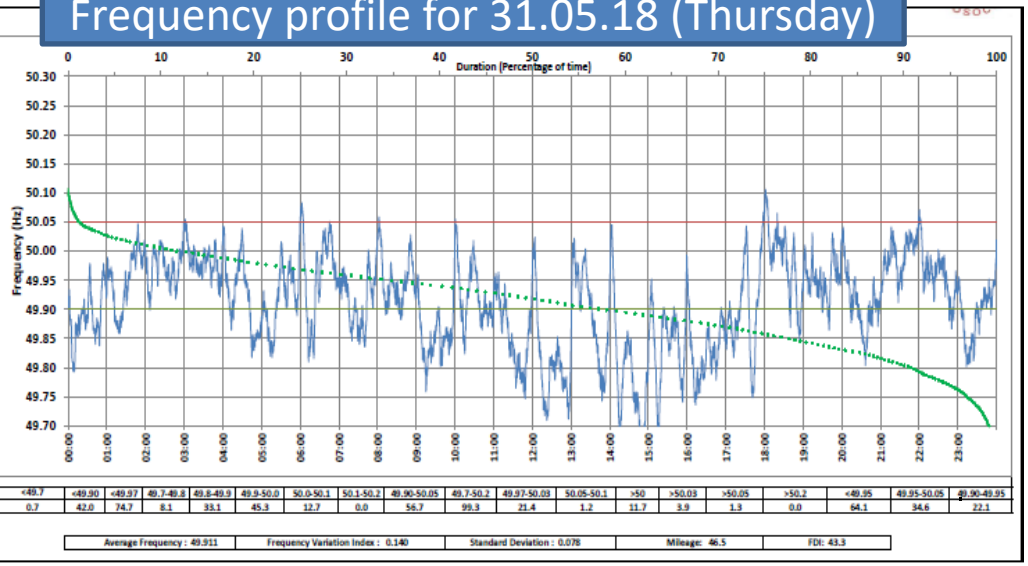

## Power Exchange Prices(2)




# Cues for System Operator…Frequency Profile (3)

## Frequency profile(3)

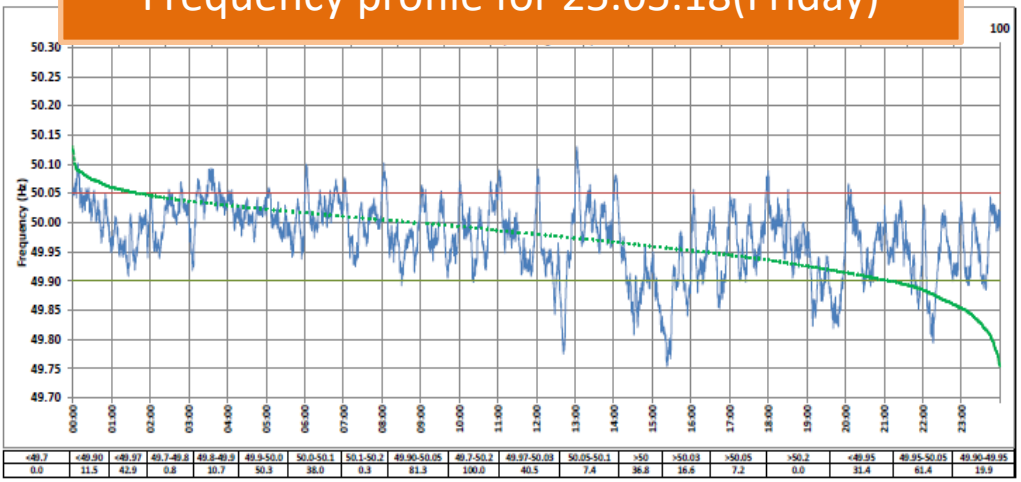
### Frequency profile for 31.05.18 (Thursday)




| <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 | <49.95 | 49.95-50.05 | 49.90-49.95 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.7 | 42.0 | 74.7 | 8.1 | 33.1 | 45.3 | 12.7 | 0.0 | 56.7 | 99.3 | 21.4 | 1.2 | 11.7 | 3.9 | 1.3 | 0.0 | 64.1 | 34.6 | 22.1 |

| Average Frequency : 49.911 | Frequency Variation Index : 0.140 | Standard Deviation : 0.078 | Mileage: 46.5 | FDI: 43.3 |
|---|---|---|---|---|

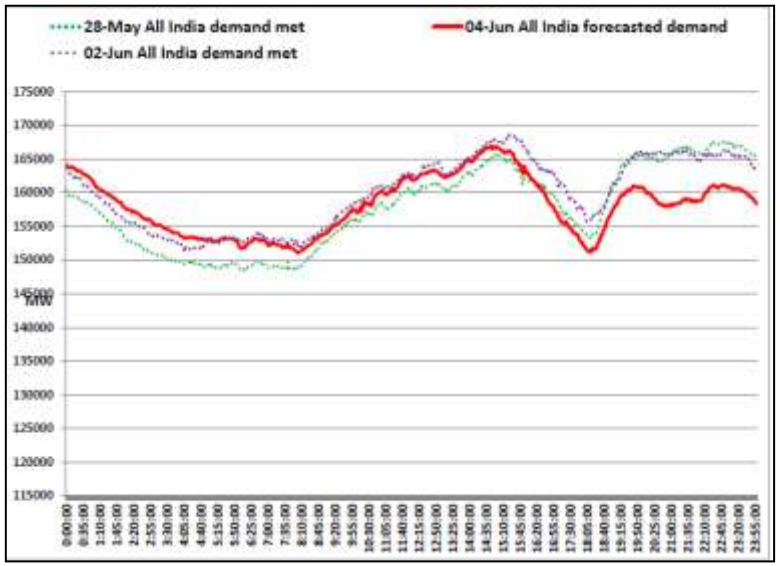
### Frequency profile for 25.05.18(Friday)

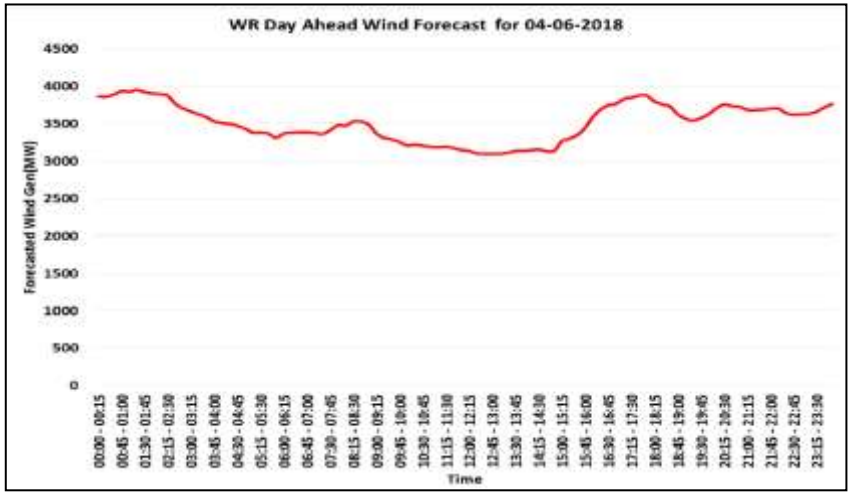



| <49.7 | <49.90 | <49.97 | 49.7-49.8 | 49.8-49.9 | 49.9-50.0 | 50.0-50.1 | 50.1-50.2 | 49.90-50.05 | 49.7-50.2 | 49.97-50.03 | 50.05-50.1 | >50 | >50.03 | >50.05 | >50.2 | <49.95 | 49.95-50.05 | 49.90-49.95 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 11.5 | 42.9 | 0.8 | 10.7 | 50.3 | 38.0 | 0.3 | 81.3 | 100.0 | 40.5 | 7.4 | 36.8 | 16.6 | 7.2 | 0.0 | 31.4 | 61.4 | 19.9 |

| Average Frequency : 49.973 | Frequency Variation Index : 0.043 | Standard Deviation : 0.060 | Mileage: 42.7 | FDI: 18.7 |
|---|---|---|---|---|

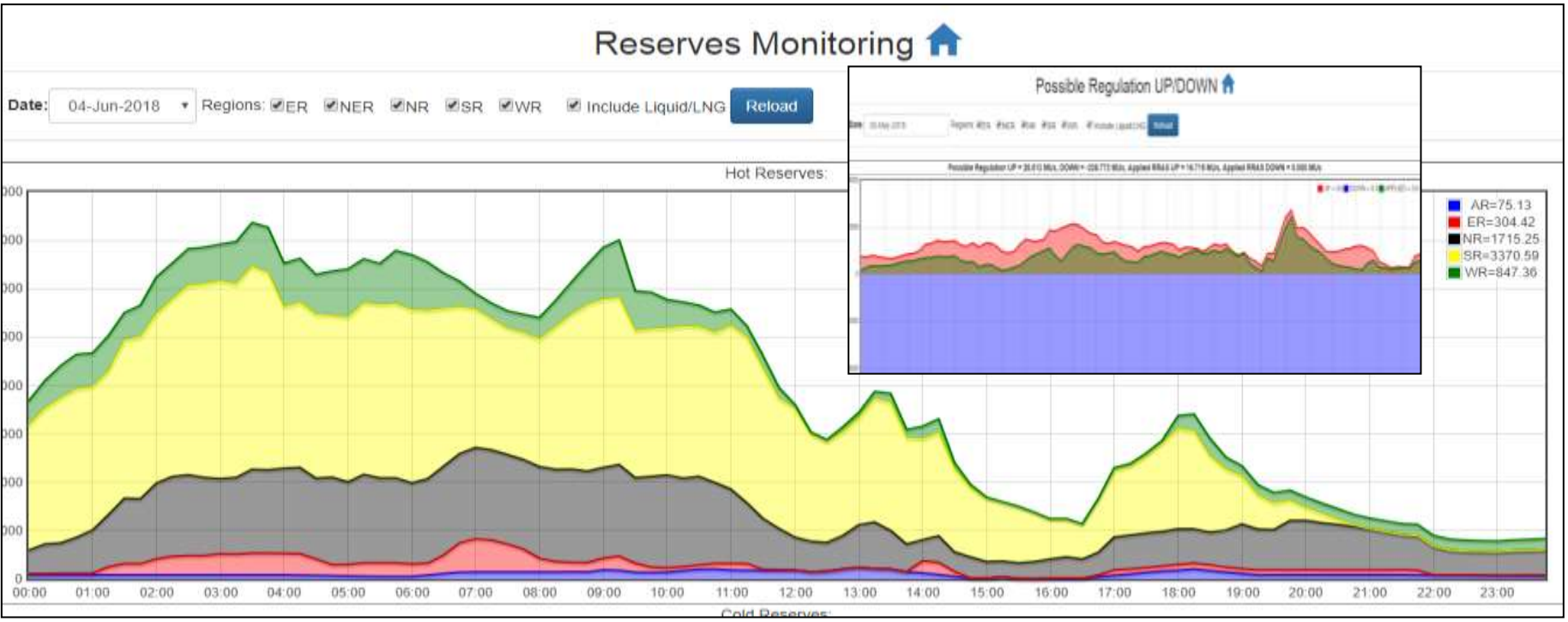
## Load Forecast (4)

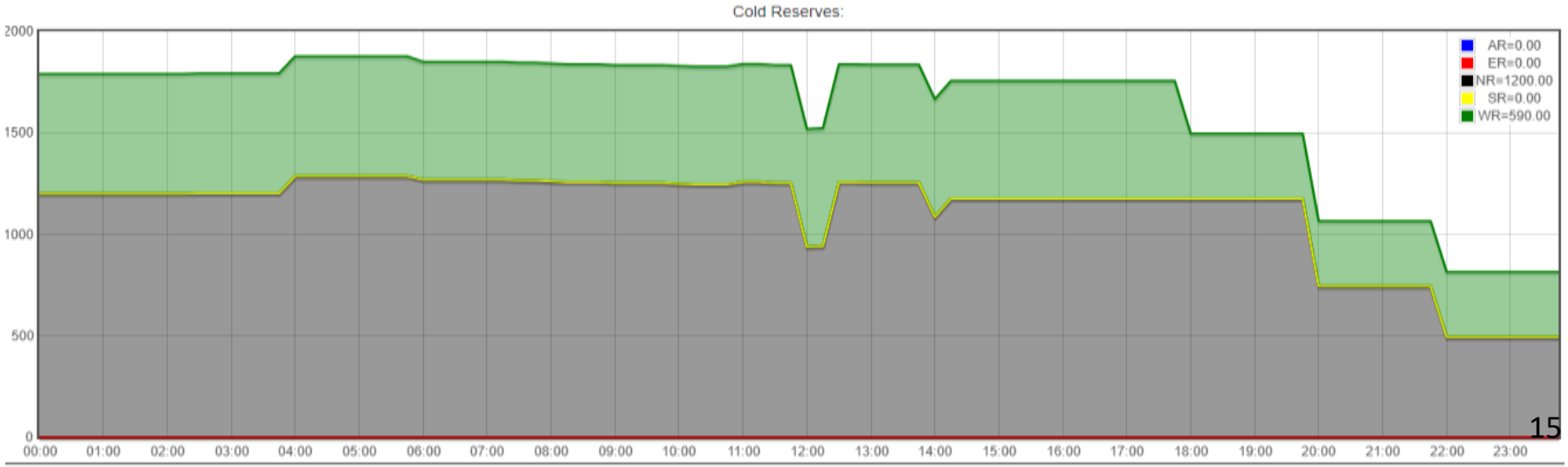


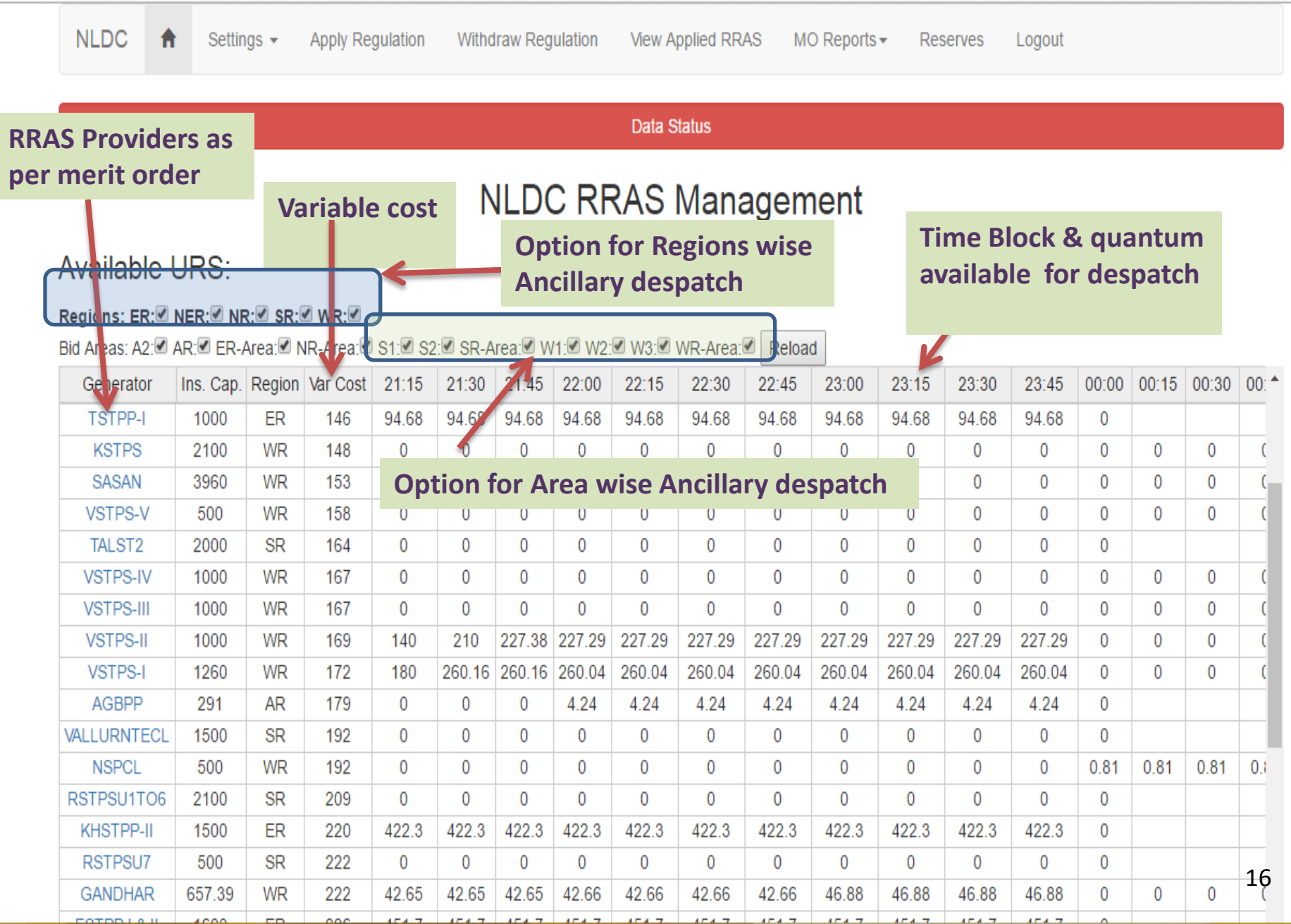
# Cues for System Operator……

## Reserves Monitoring (5)



# In-house developed Ancillary Services Software Application




| Generator | Ins. Cap. | Region | Var Cost | 21:15 | 21:30 | 21:45 | 22:00 | 22:15 | 22:30 | 22:45 | 23:00 | 23:15 | 23:30 | 23:45 | 00:00 | 00:15 | 00:30 | 00: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TSTPP-I | 1000 | ER | 146 | 94.68 | 94.68 | 94.68 | 94.68 | 94.68 | 94.68 | 94.68 | 94.68 | 94.68 | 94.68 | 94.68 | 0 | | | |
| KSTPS | 2100 | WR | 148 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SASAN | 3960 | WR | 153 | | | | | | | | | | 0 | 0 | 0 | 0 | 0 | 0 |
| VSTPS-V | 500 | WR | 158 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TALST2 | 2000 | SR | 164 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| VSTPS-IV | 1000 | WR | 167 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| VSTPS-III | 1000 | WR | 167 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| VSTPS-II | 1000 | WR | 169 | 140 | 210 | 227.38 | 227.29 | 227.29 | 227.29 | 227.29 | 227.29 | 227.29 | 227.29 | 227.29 | 0 | 0 | 0 | 0 |
| VSTPS-I | 1260 | WR | 172 | 180 | 260.16 | 260.16 | 260.04 | 260.04 | 260.04 | 260.04 | 260.04 | 260.04 | 260.04 | 260.04 | 0 | 0 | 0 | 0 |
| AGBPP | 291 | AR | 179 | 0 | 0 | 0 | 4.24 | 4.24 | 4.24 | 4.24 | 4.24 | 4.24 | 4.24 | 4.24 | 0 | | | |
| VALLURNTECL | 1500 | SR | 192 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| NSPCL | 500 | WR | 192 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.81 | 0.81 | 0.81 | 0.8 |
| RSTPSU1TO6 | 2100 | SR | 209 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| KHSTPP-II | 1500 | ER | 220 | 422.3 | 422.3 | 422.3 | 422.3 | 422.3 | 422.3 | 422.3 | 422.3 | 422.3 | 422.3 | 422.3 | 0 | | | |
| RSTPSU7 | 500 | SR | 222 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| GANDHAR | 657.39 | WR | 222 | 42.65 | 42.65 | 42.65 | 42.66 | 42.66 | 42.66 | 42.66 | 46.88 | 46.88 | 46.88 | 46.88 | 0 | 0 | 0 | 0 |

# Key Statistics of RRAS Implementation

## (April, 2016 – April, 2018)

RRAS Providers:
54 Nos.

Capacity under RRAS:
56 GW

Highest Variable Charge
~ Rs. 10.24 / Unit
(Auraiya LF– NR)

Lowest Variable Charge
~ Rs. 1.17 / Unit
(Singrauli – NR)

Maximum 'Up' Regulation :
3746 MW

Maximum 'Down' Regulation :
2366 MW

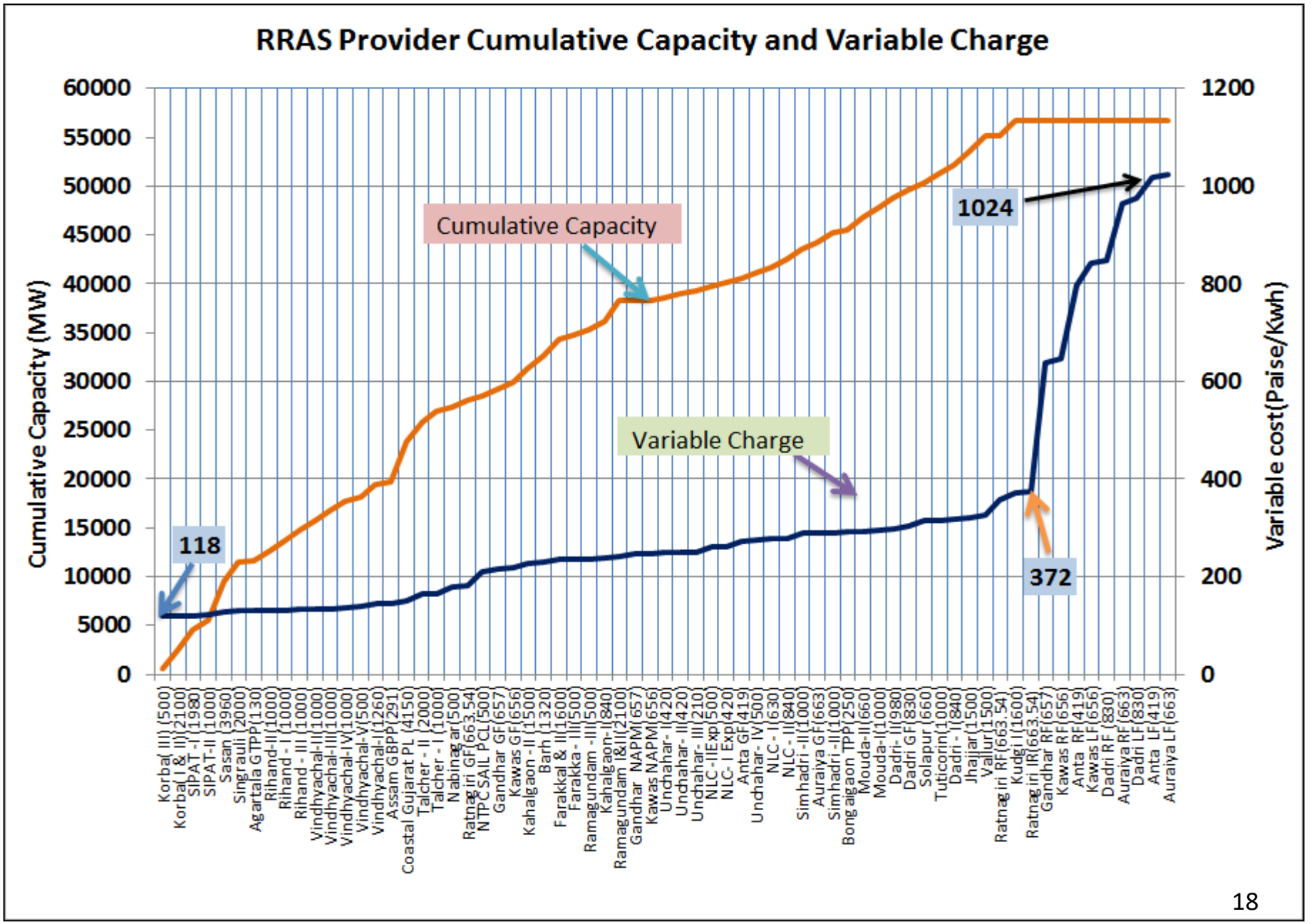
Avg. Daily Number of RRAS Instructions :
07 to 08 Nos.

| Item (Apr'16 – Apr'18) | Total | Average (₹ per unit) |
|---|---|---|
| Regulation Up | 5837 Nos | |
| Energy scheduled | 6813 MU | -- |
| Fixed charges paid | ₹ 844 Crores | ₹ 1.24 |
| Variable charges paid | ₹ 1991 Crores | ₹ 2.92 |
| Markup paid | ₹ 343 Crores | ₹ 0.50 |
| Total paid for RRAS Up | ₹ 3177 Crores | ₹ 4.66 |
| Regulation Down | 760 Nos | |
| Energy scheduled | 519 MU | -- |
| Variable charges retained by RRAS providers | ₹ 28 Crores | ₹ 0.55 |
| Variable Charges refunded to DSM Pool | ₹ 85 Crores | ₹ 1.63 |

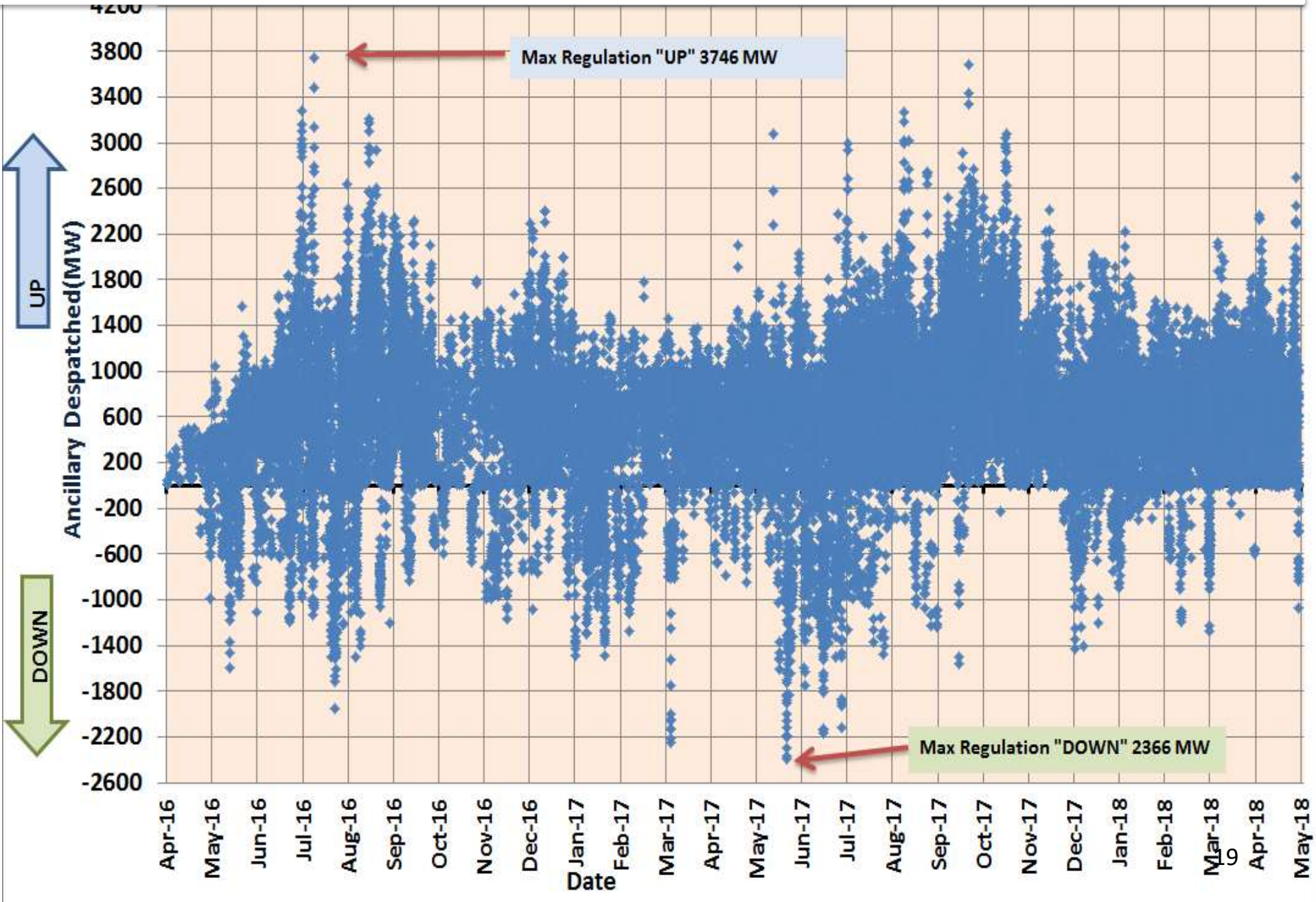
Avg Daily Energy Despatched:
Up – 9MU / day
(0.3% of Energy met)

Avg Daily Energy Despatched:
Down – 1 MU / day
(0.02% of Energy met)

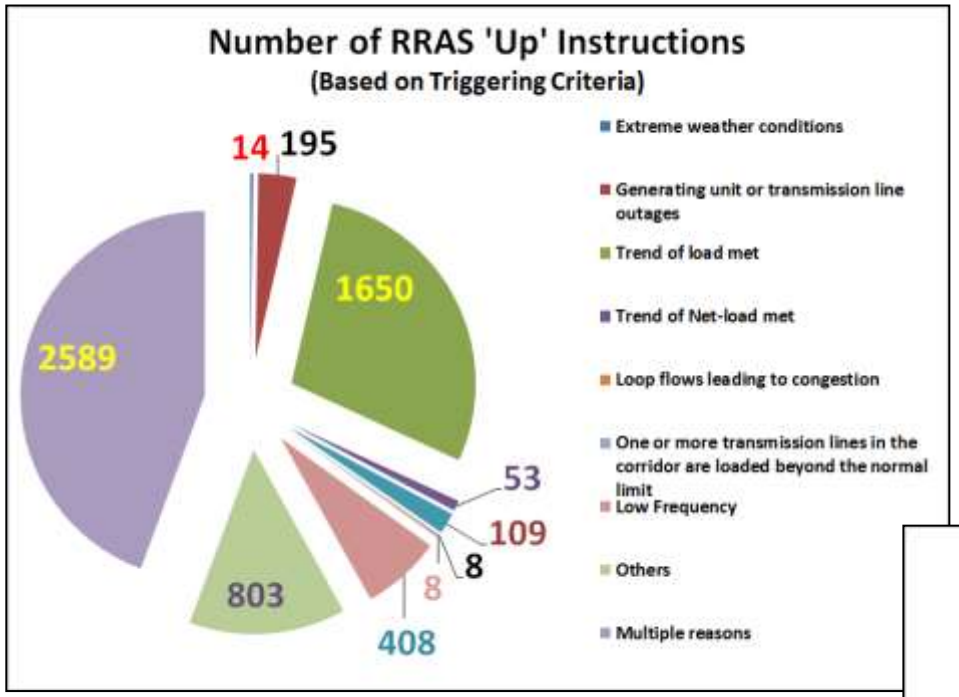
# Pattern of Variable Cost (16th May - 15th June'18)

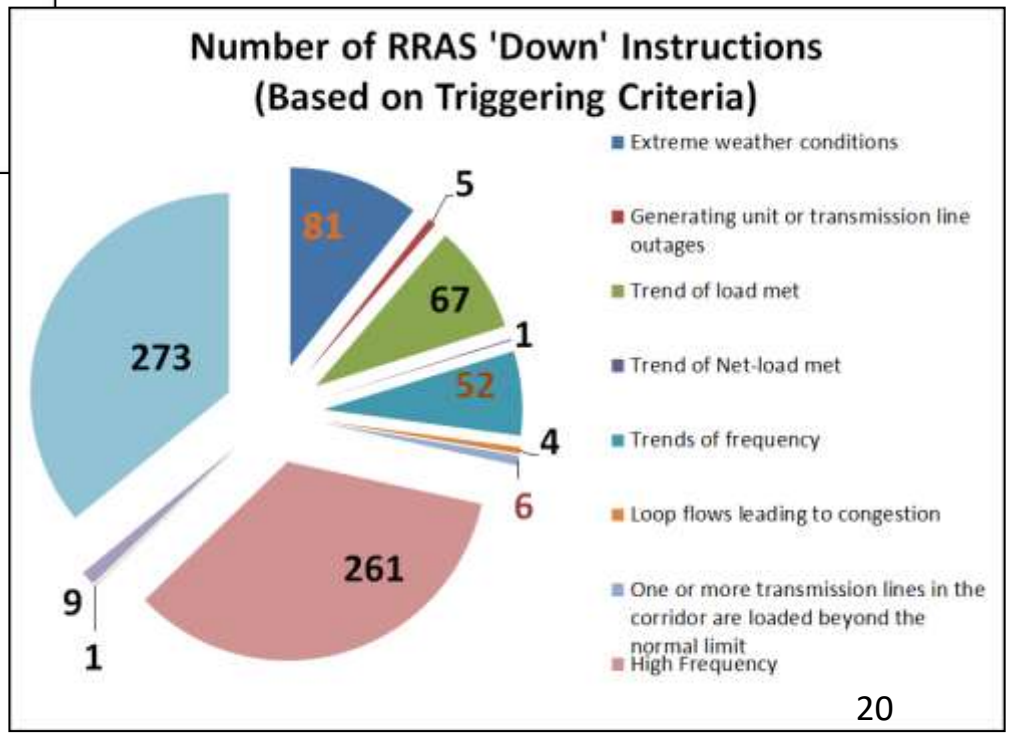


# RRAS Despatch(April-16 to April-18)

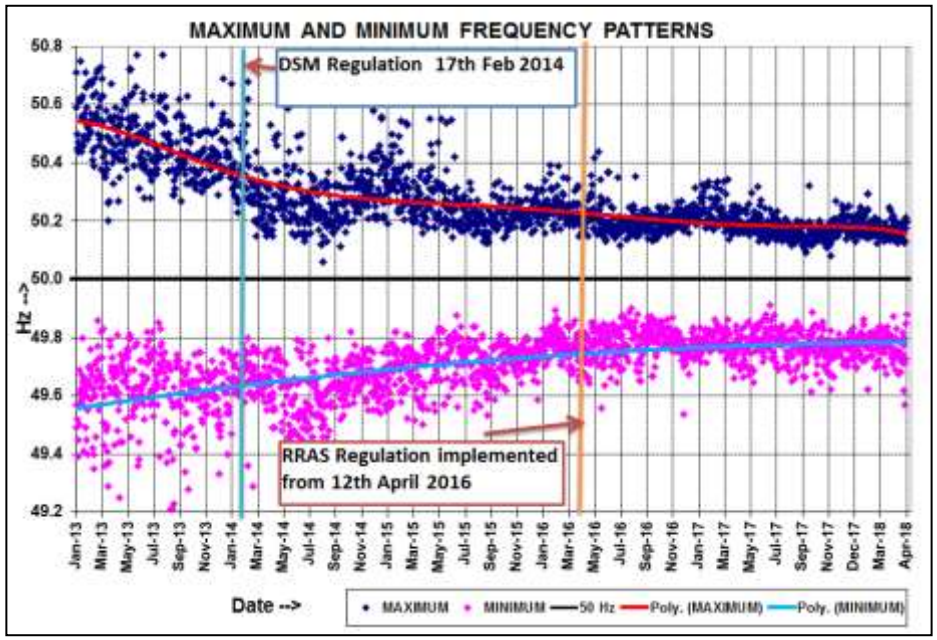


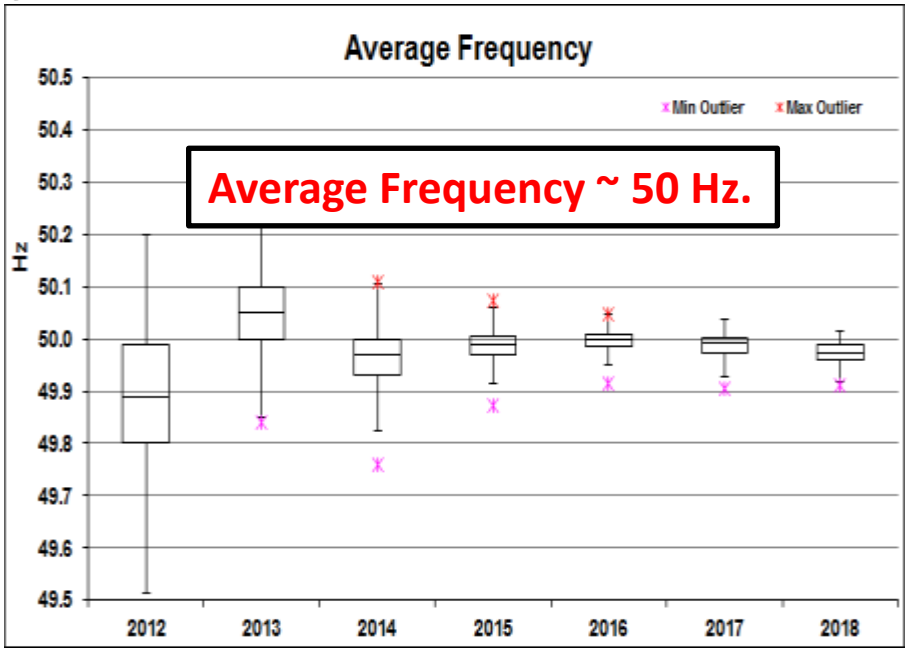
# RRAS Despatch (April, 2016 – April, 2018)

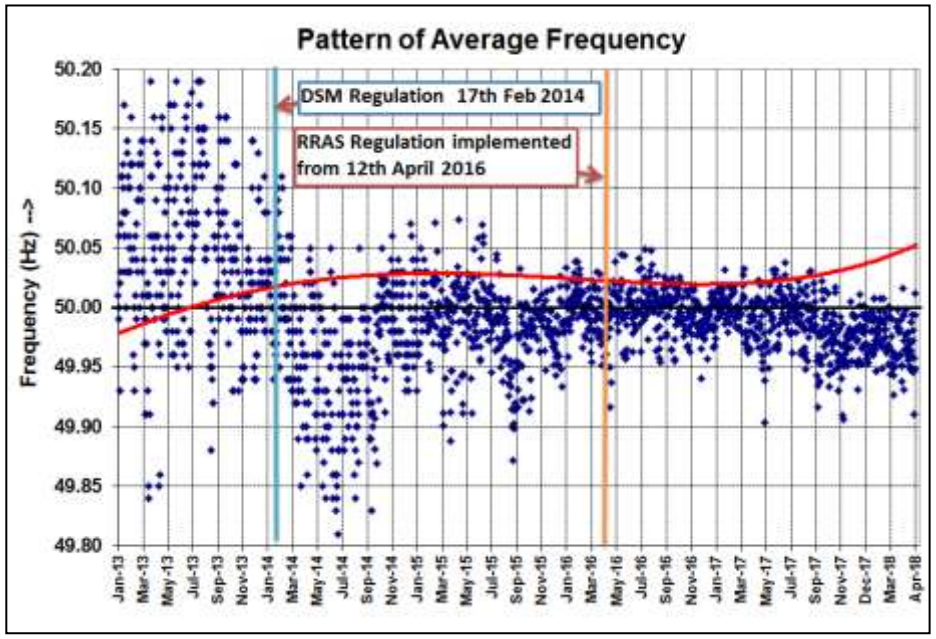


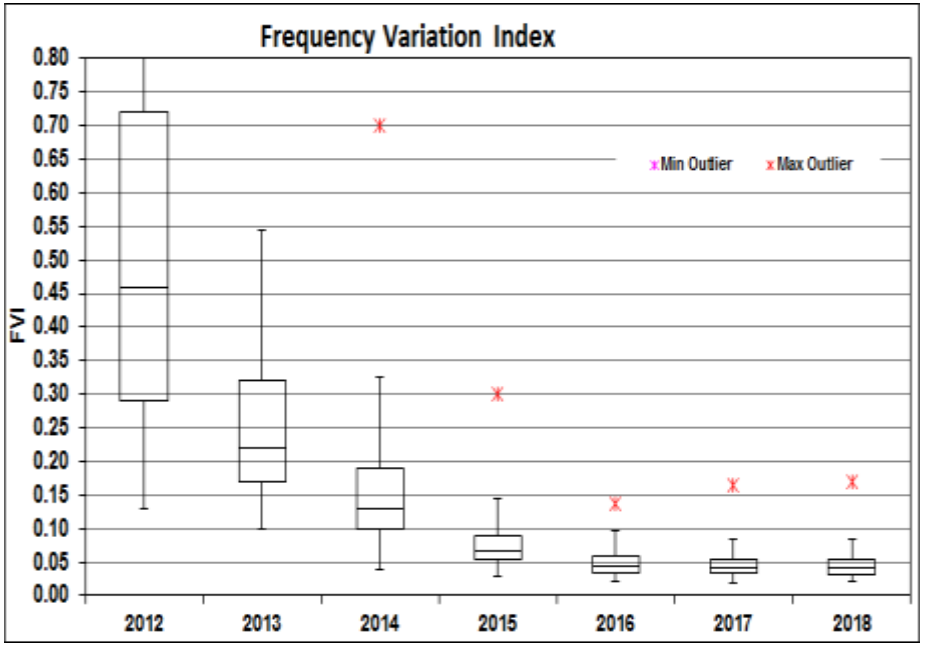



# Frequency Profile



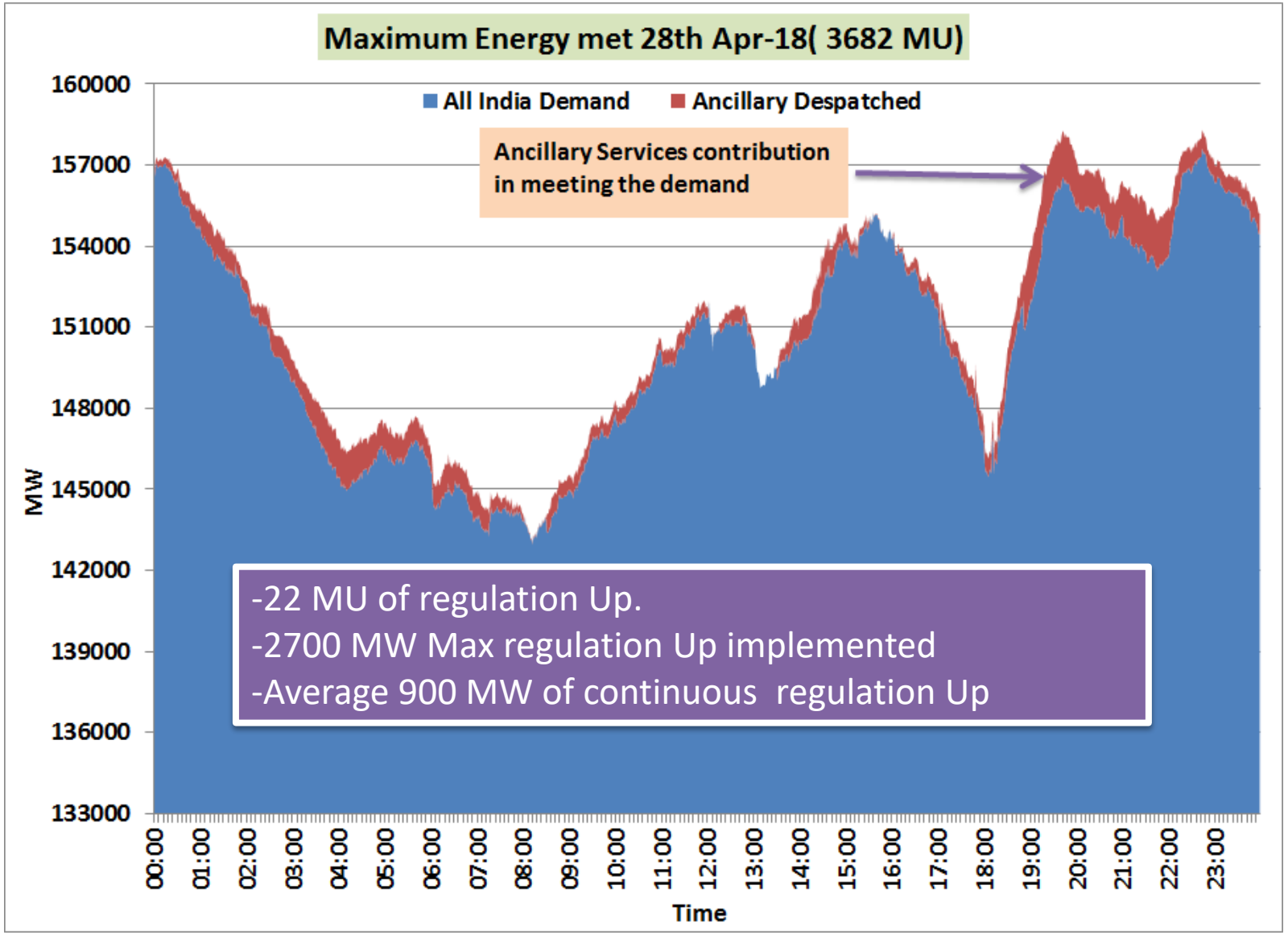



# Example: Triggering criteria of Ancillary Services

- Trend of Load Met

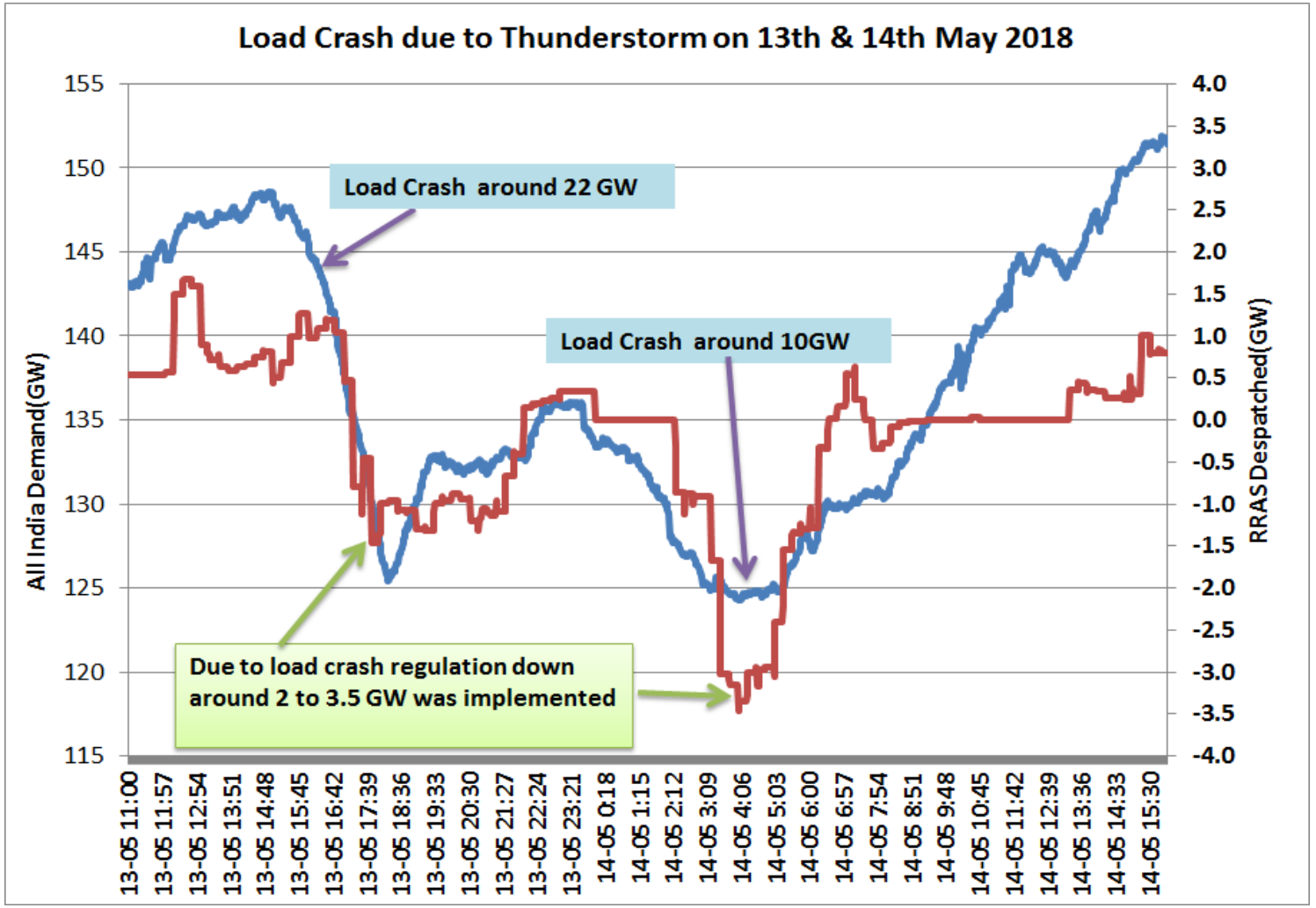


# Example: Triggering criteria of Ancillary Services

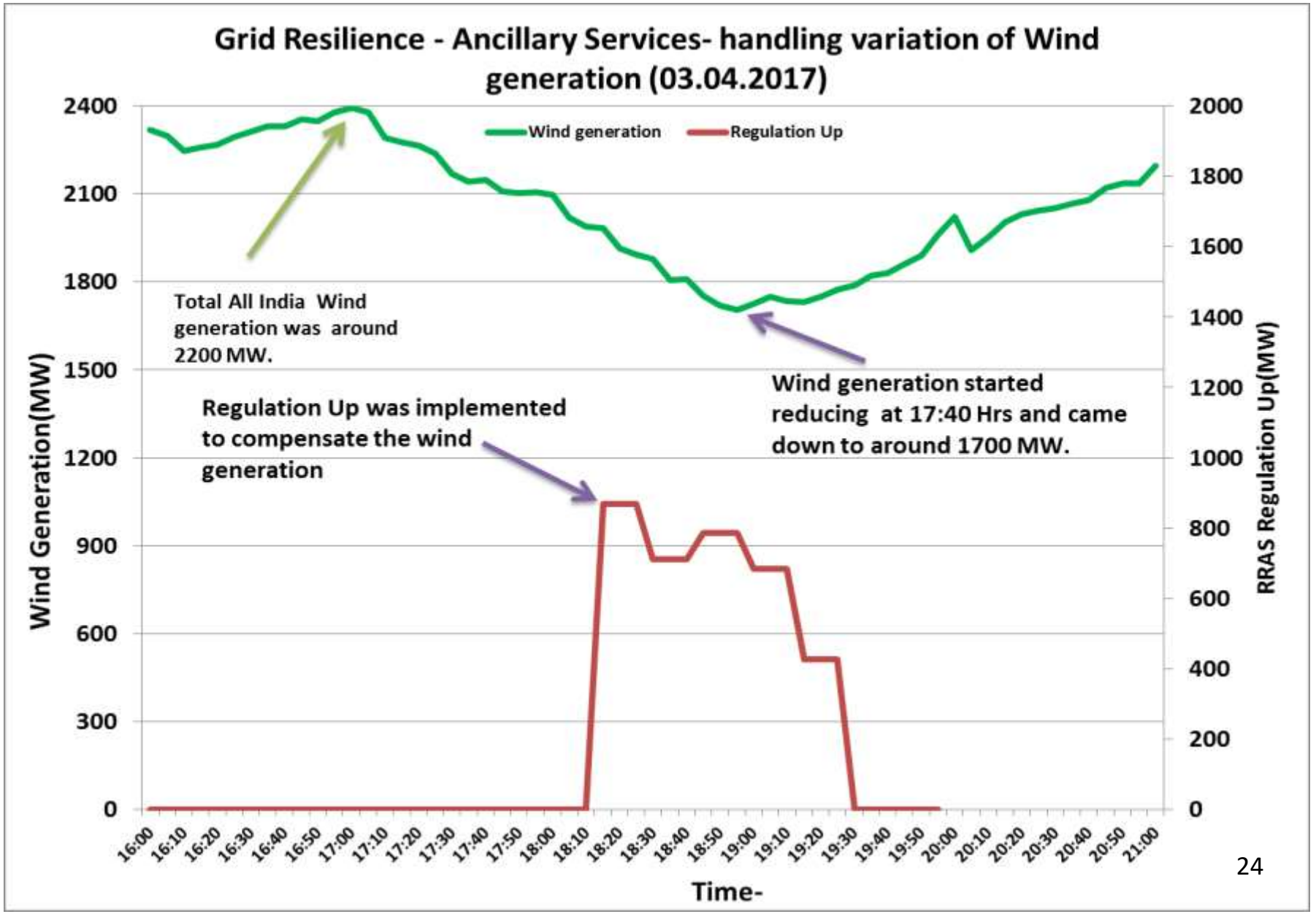
**Extreme Weather Conditions**

-13th May'18, 13:55 Hrs thunderstorm accompanied with gusty in NE & ER.

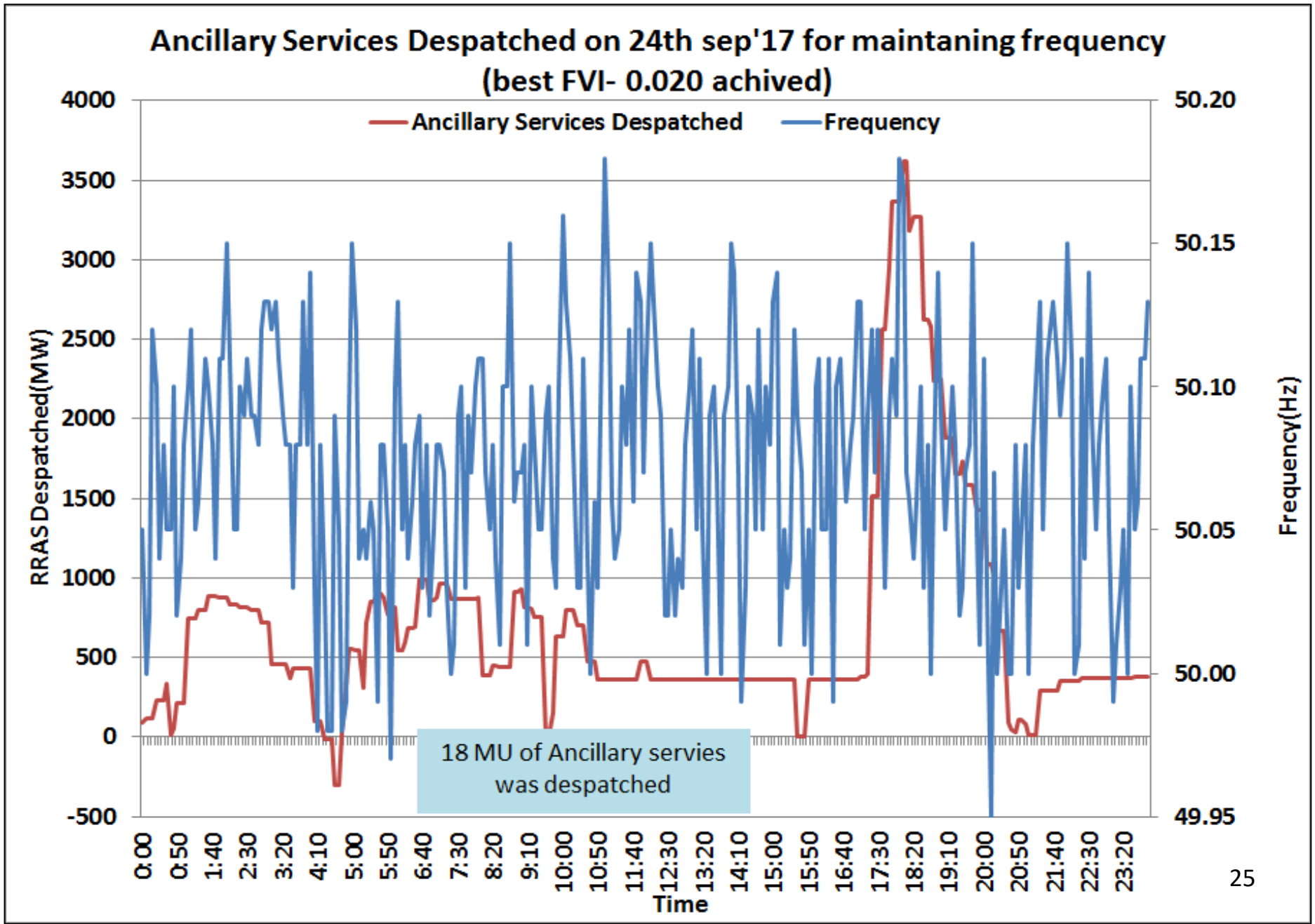
-Many 765kV and 400kV important lines tripped



# Example: Triggering criteria of Ancillary Services

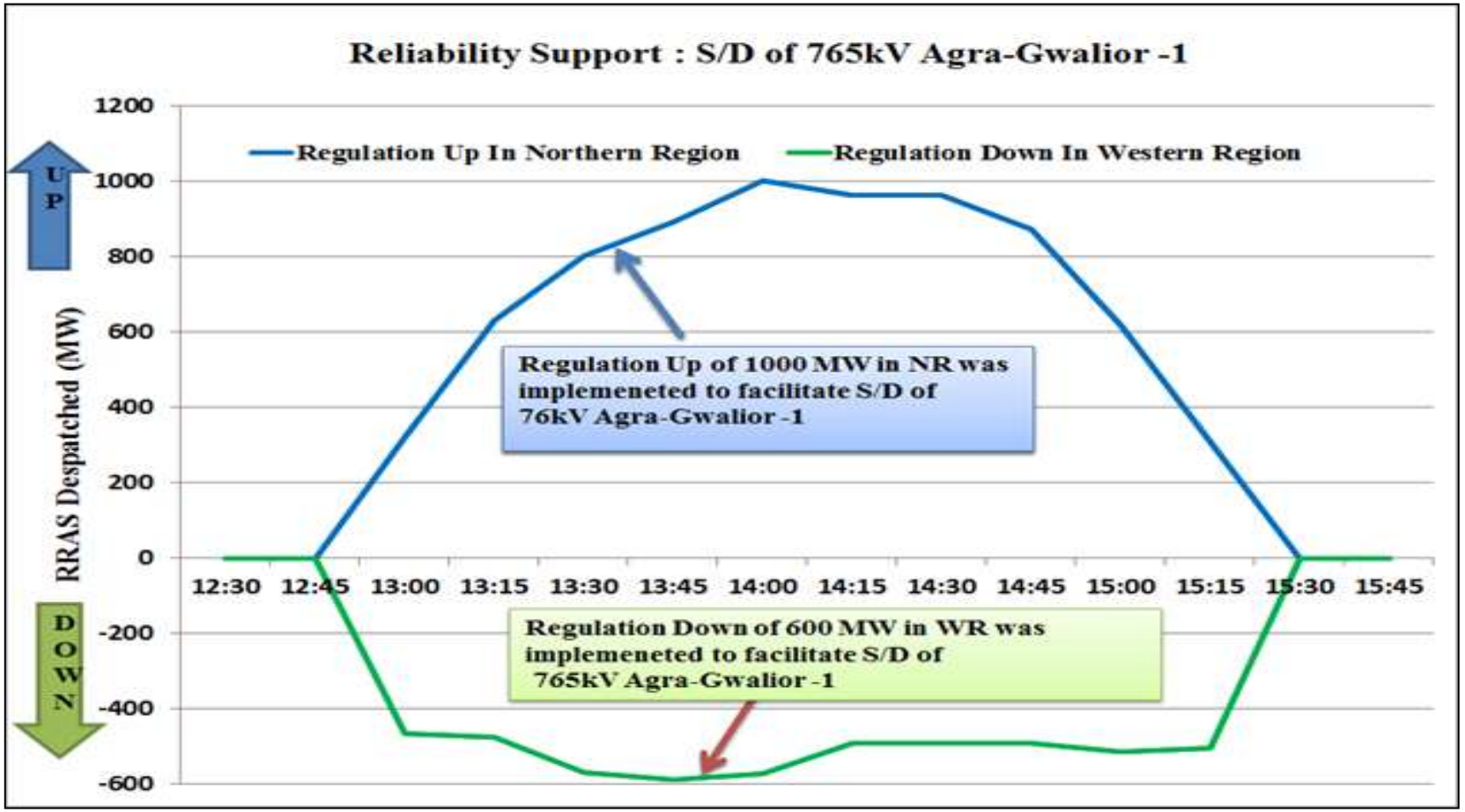


# Best frequency profile for 24th-Sept-17:FVI -0.020



# Example: Triggering criteria of Ancillary Services

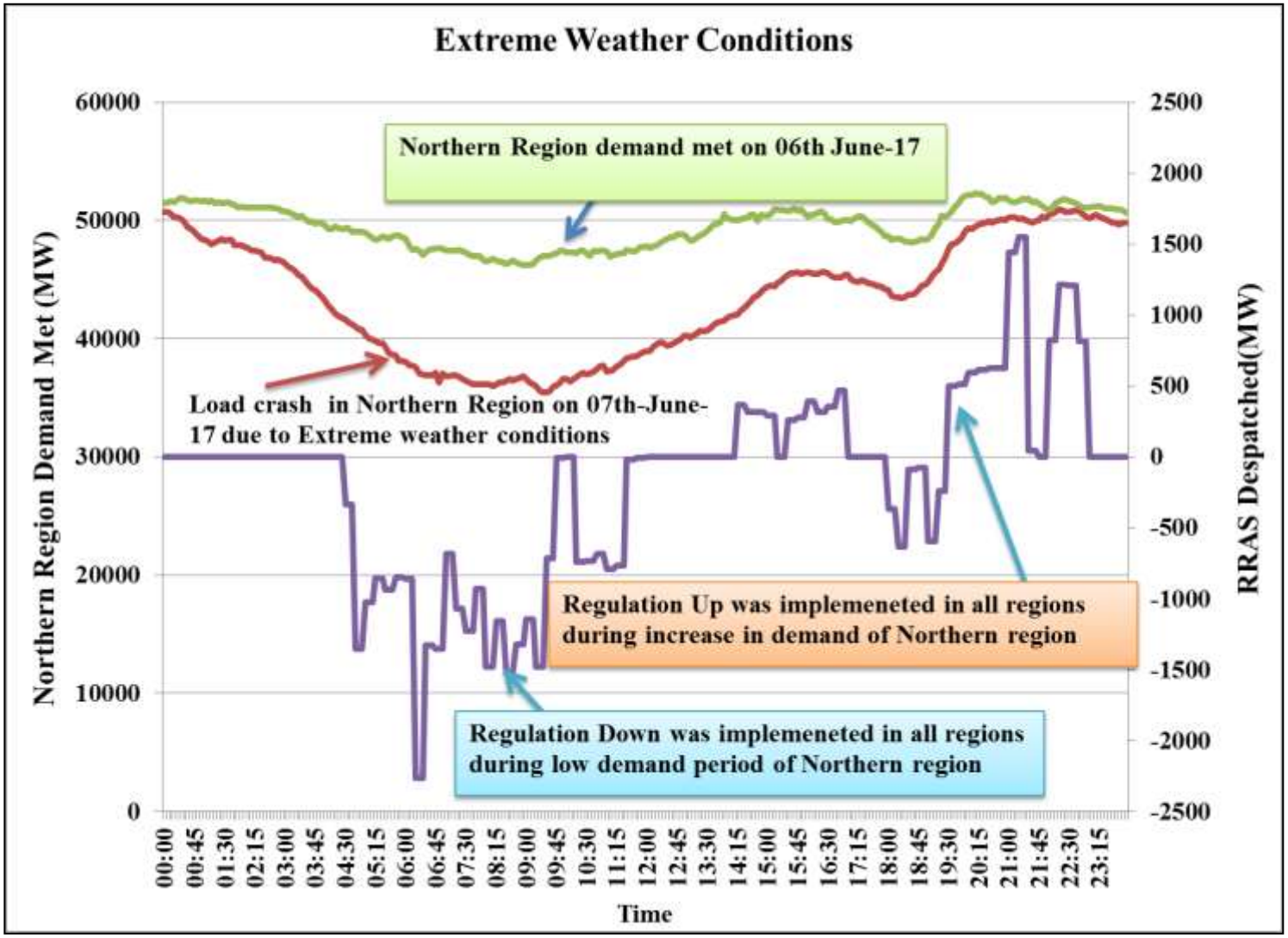
- Transmission Line Outage




**17th June-2017, 765 kV Agra-Gwalior -1 line was taken under E/S/D from 12:15 to 15:30 Hrs.**
**Import ATC of NR was reduced from 7400 to 6400MW**

# Example: Triggering criteria of Ancillary Services

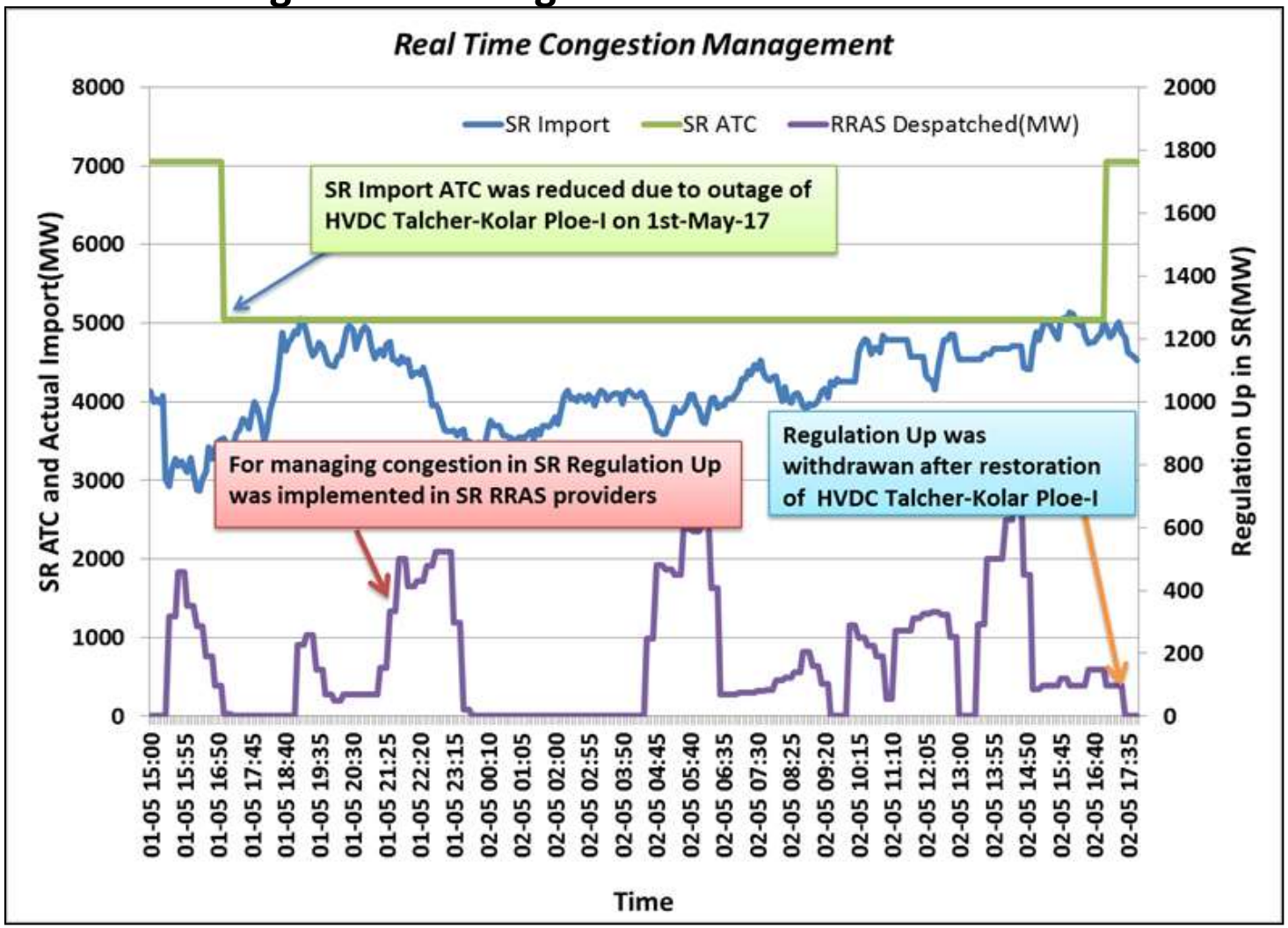
- **Extreme Weather Conditions**




**Load Crash in Northern Region on 06th-June-17**

# Example: Triggering criteria of Ancillary Services

- **Real Time Congestion Management**




**01st May-2017, HVDC Talcher –Kolar Pole-I tripped at 15:21 Hrs**

# Information Dissemination

- Information on Nodal Agency (NLDC) Website
- 1.RRAS Instruction summary- http://103.7.128.238:8080/ancl/viewregweb.php

2.Monthly report- https://posoco.in/reports/ancillary-services-reports/

3. RRAS Providers details- https://posoco.in/reports/as3-details

4.Half year Feedback report- https://posoco.in/reports/half-year-feed


- ERPC- http://erpc.gov.in/as-3-formats/
- NRPC- http://www.nrpc.gov.in/comm/ancillary
- NERPC- http://www.nerpc.nic.in/Ancillary%20S
- SRPC- http://www.srpc.kar.nic.in/html/all_uplc
- WRPC- http://www.wrpc.gov.in/Commercial_rras_dat.asp?In=


- RRAS Accounts uploaded by RPCs
  - ERPC- http://erpc.gov.in/ui-and-deviation-accts/
  - NRPC- http://www.nrpc.gov.in/comm/rras.html
  - NERPC- http://www.nerpc.nic.in/devreport.php
  - SRPC - http://www.srpc.kar.nic.in/html/all_uploa
  - WRPC- http://www.wrpc.gov.in/Commercial_rras

# Key Learnings from Indian Experience

- Layer of Centralized Ancillary Despatch over Decentralized Layer of Scheduling Process
- Improved Frequency Profile.
- Ramp Management - Evening Peak / Morning Peak
- Real Time Congestion Management
- Grid Resilience – Handling Low Probability High Impact Events
- Availability of Variable charges for first time in public domain
  - Better Despatch Decisions
  - Changing Merit Order month on month
- Handling impact of extreme weather conditions on the grid
- Reliability Support
- Information Dissemination
- Benefits to stakeholders – Generators & State Utilities
- Freedom and Choice available to states retained

# Future road map of Ancillary Services-

- Energy Limited Resource (Hydro)-FRAS
- Harnessing Pumped Storage Plants (PSP)
  - Tehri (Regional entity)
  - State embedded plant (Purulia, Ghatghar, Kadamparai, Srisailam)
- Participation of Merchant/IPP
- Reactive Power & Voltage Control Ancillary Services
- Black Start Ancillary Services (BSAS)
- National Pool Account Operationalization

# धन्यवाद

# FOR Standing Committee Meeting

# 07th – 08th June, 2018

# Tehri, Uttarakhand

## Agenda

# Fast Response Ancillary Services (FRAS)

POSOCO

# 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

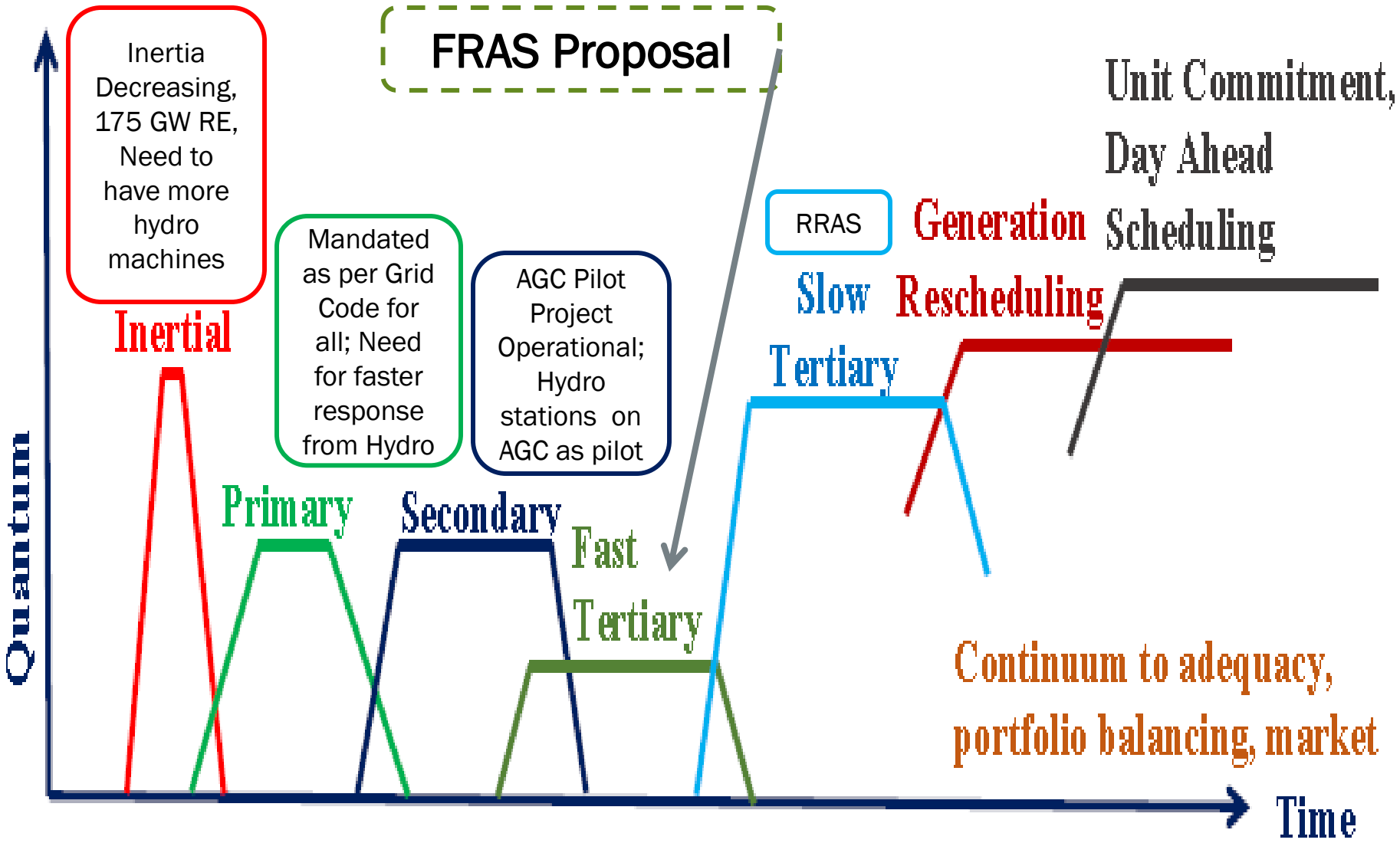
- **Hydro Power - a source of Flexibility & Reliability**
  - Overload capability
  - Peaking support
  - Fast ramping
  - Primary Response
  - Voltage Regulation
  - Black Start Capability
- **Need to Increase the Ambit of Ancillary Services**

**Recommendations and Mandate**

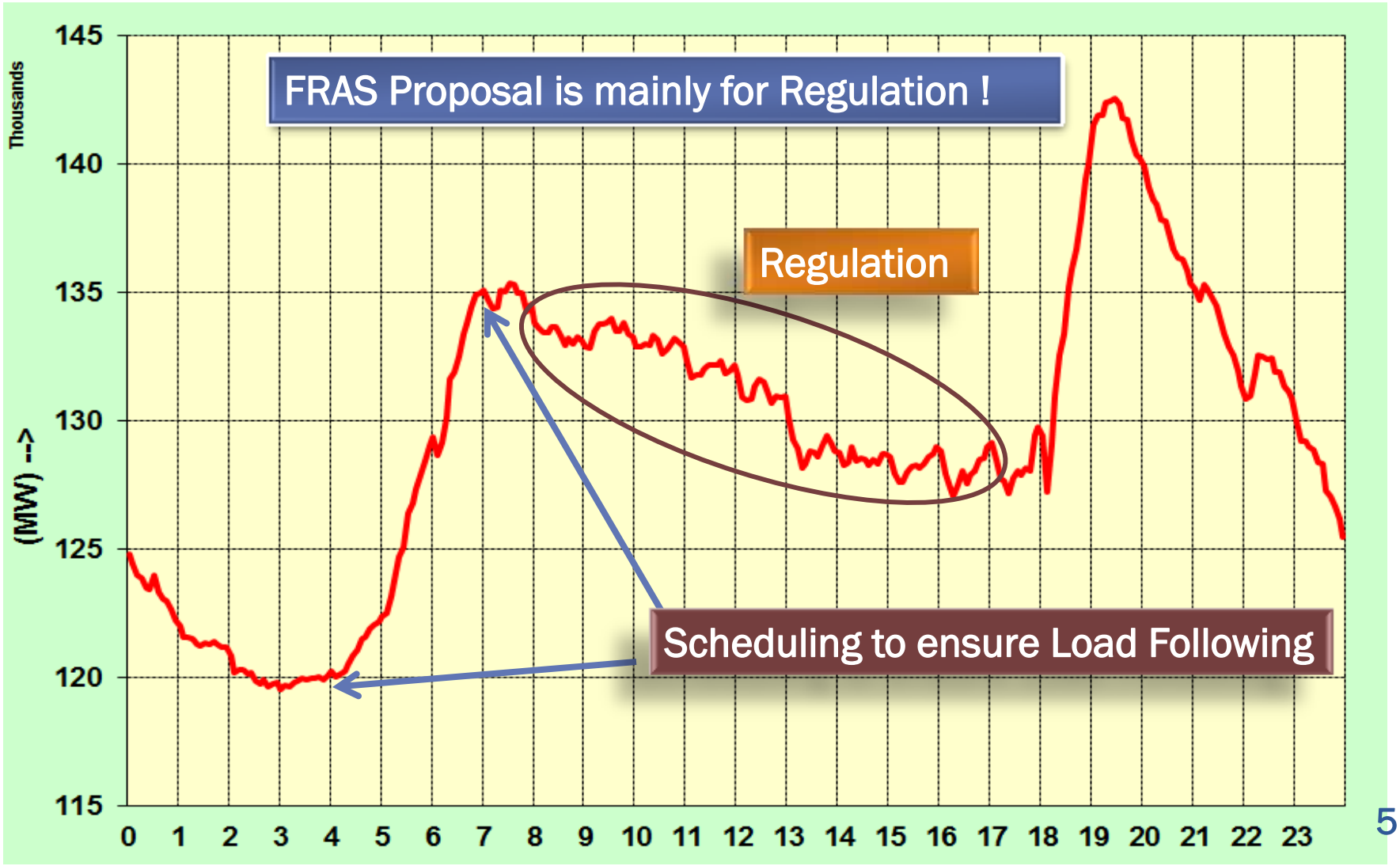
- Ministry of Power, GOI
  - Tariff Policy, 2016
  - Technical Committee on Renewable Integration, 2016
  - Sub-Committee on shifting Hydro power stations from Base Station to Peak Station, 2017
- CEA National Electricity Plan, 2016
- NITI Aayog - India's Renewable Electricity Roadmap, 2015

- FOLD-POSOCO Report on Operational Analysis for Optimization of Hydro Resources & facilitating Renewable Integration in India, 2017
  - **Scope for Optimization & Flexible operation - 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



# Load Following and Regulation



# International Survey

| | Spinning Reserves | Non-spinning Reserves | Regulation |
|---|---|---|---|
| **CAISO** | Spinning | Non-spinning | Regulation-up<br>Regulation-down<br>Regulation Mileage-up<br>Regulation Mileage-down |
| **ERCOT** | Responsive | Non-spinning | Regulation-up<br>Regulation-down |
| **ISO-NE** | Ten-minute Synchronized | Ten-minute Non-synchronized<br>Thirty-minute Operating | Regulation |
| **MISO** | Spinning | Supplemental | Regulation |
| **NYISO** | Ten-minute Spinning<br>Thirty-minute Spinning | Ten-minute Non-synchronized<br>Thirty-minute Non-synchronized | Regulation |
| **PJM** | Synchronized | Primary | Regulation |
| **SPP** | Spinning | Supplemental | Regulation-up<br>Regulation-down |

Table 1-1 Overview of the ancillary services offered by each ISO/RTO

Source: Survey of U.S. Ancillary Services Markets, Argonne National Laboratory Energy Systems Division [www.ipd.anl.gov/anlpubs/2016/01/124217.pdf](www.ipd.anl.gov/anlpubs/2016/01/124217.pdf)

# 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

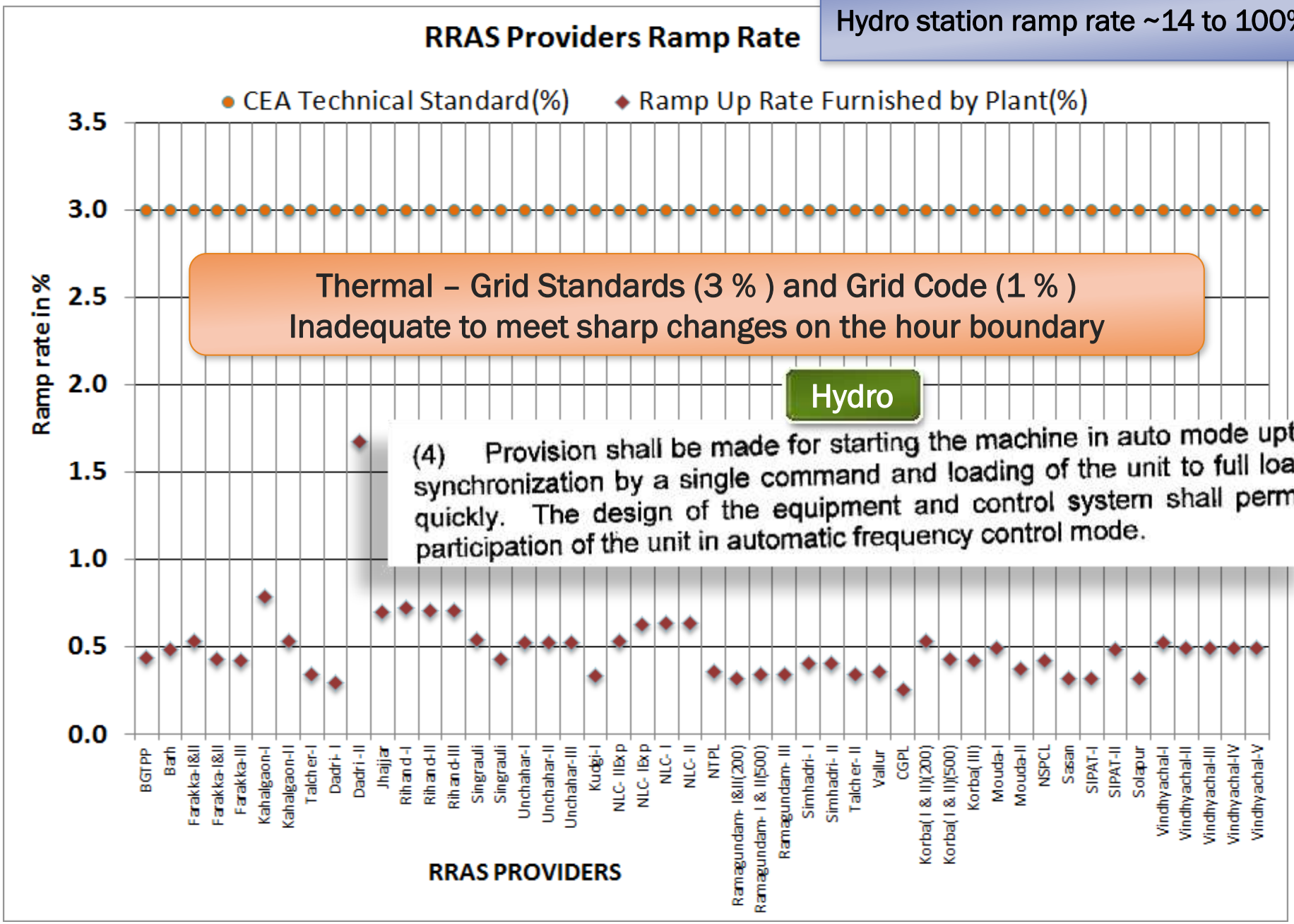
Thermal: Ramp limited Resource

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
  - Ensuring requisite response through maximum number of stations
- 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

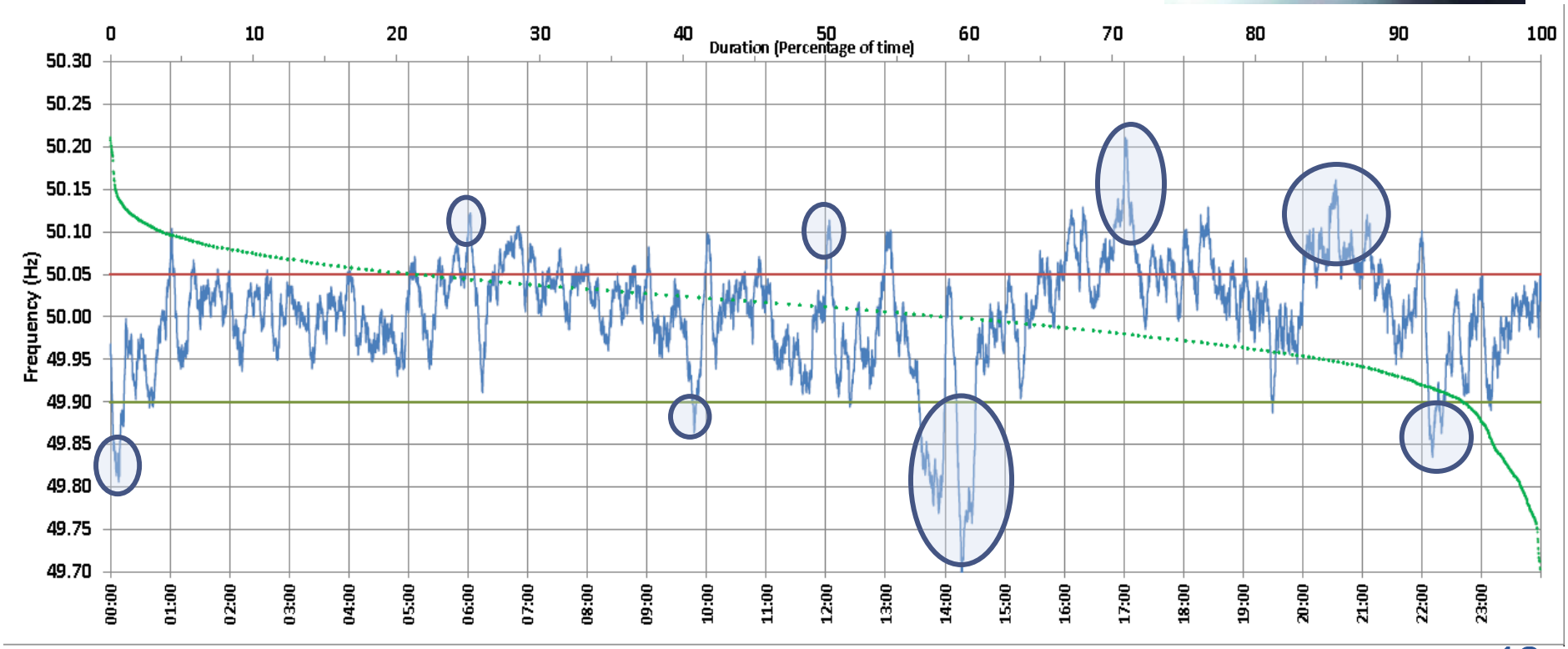
# Proposal - Fast Response Ancillary Service (2)

- 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

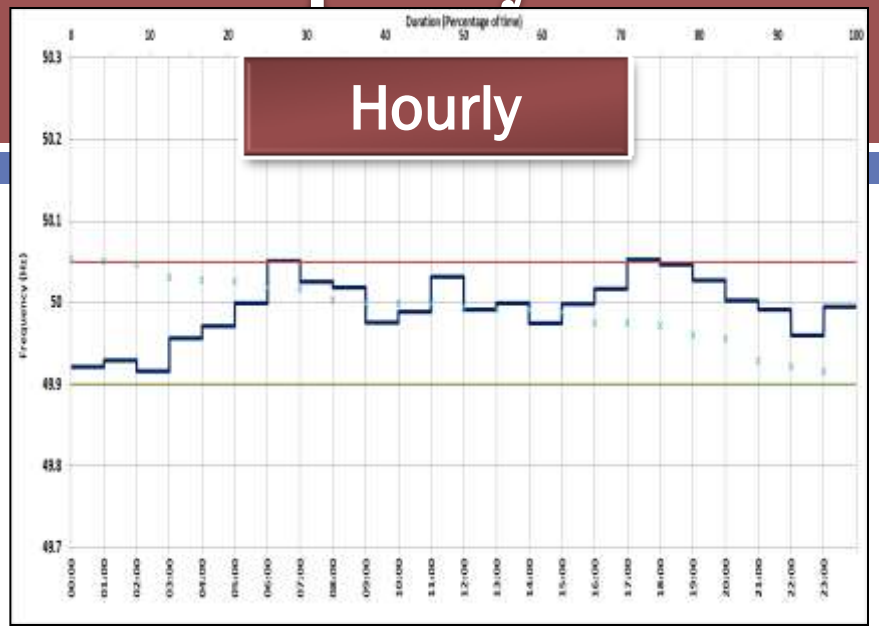
- Accounting and Settlement
  - No fixed charge or variable charges to be paid
  - Incentive on mileage basis
    - $E_m = \Sigma \mid E_{up} \mid + \Sigma \mid E_{down} \mid$
    - To be decided by the Commission

# Triggering Criteria

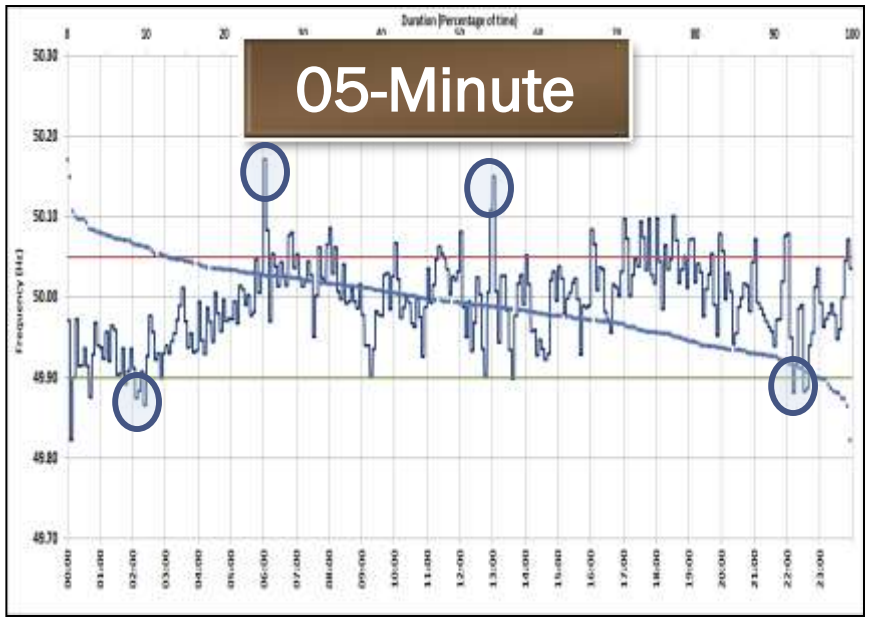
- Hour boundary frequency changes
- Sudden changes in demand
- Ramp management
- Grid contingency
- RE Variation

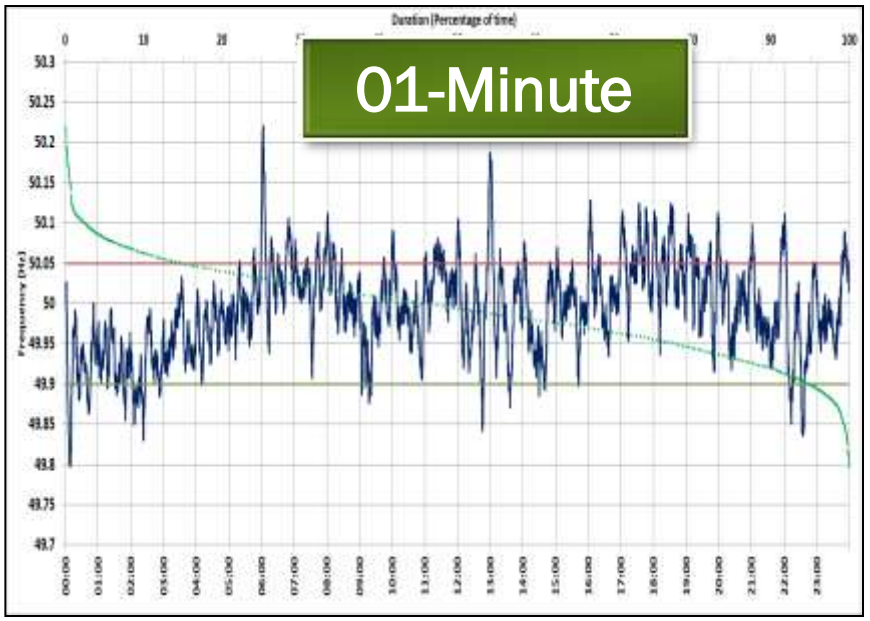


# Frequency Profile – Different Timescales







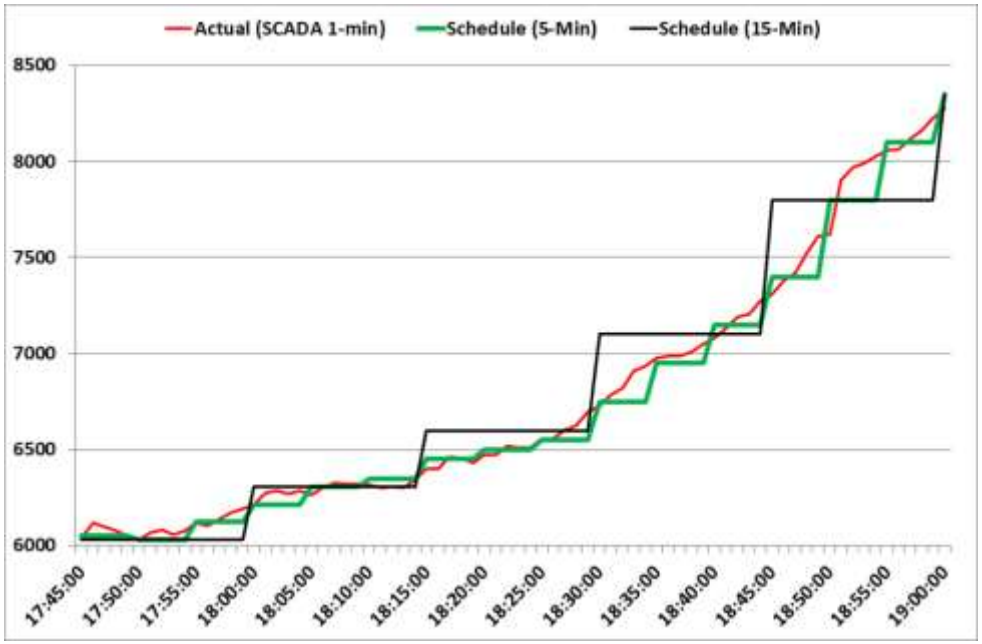



# Honouring Constraints

- 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.

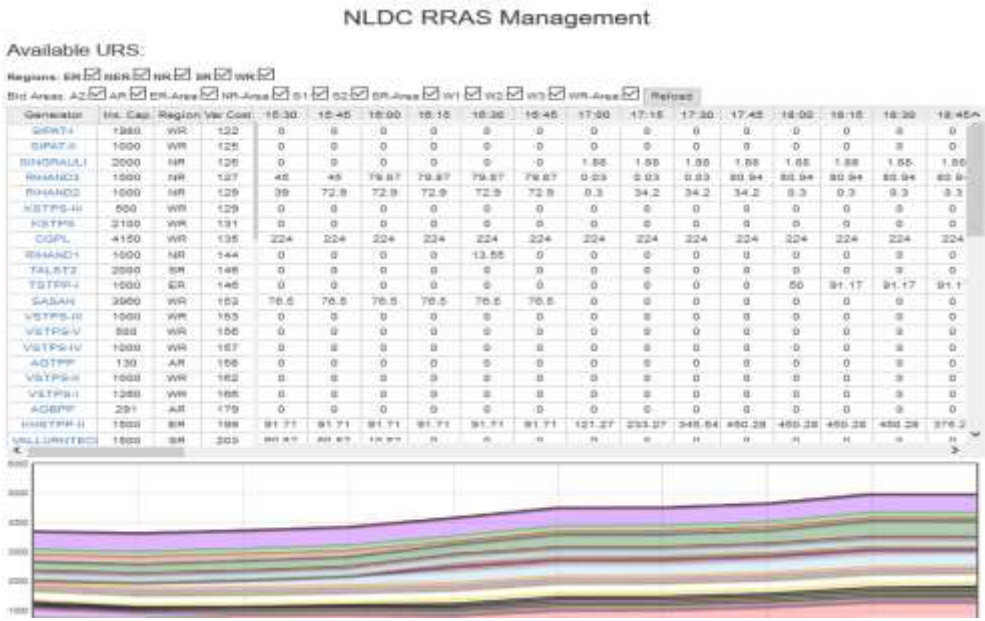
# Scheduling and Settlement

- 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



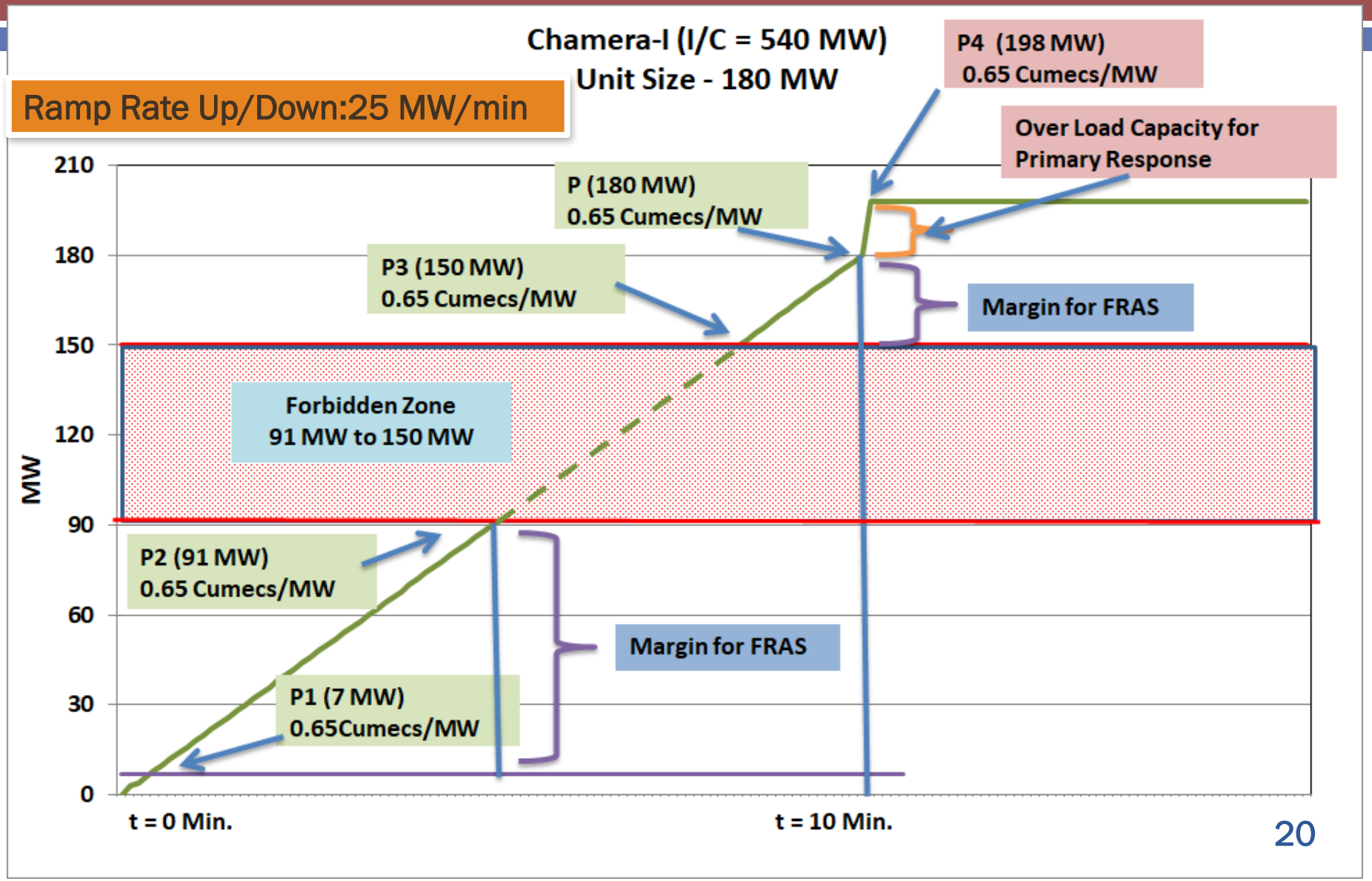

# Discussion with Central Sector Hydro Generators

- Meetings
  - 13th March, 2018 at CERC, Delhi
  - 09th March, 2018 at NLDC, Delhi
  - 23rd February, 2018 at CERC, Delhi
- Participants
  - CERC, CEA, NHPC, SJVN, BBMB, THDC, NEEPCO, NTPC & 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 & SJVN

# 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
  - Order by Central Commission for Pilot Project
  - 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 !

# FOR Standing Committee Meeting

# 07th – 08th June, 2018

# Tehri, Uttarakhand

## Agenda

# Cascading Impact of FRAS through Hydro on Downstream Projects

POSOCO

# Definitions

- **'in tandem'**
  - at the same time:
    - The heart and lungs will be transplanted in tandem.
  - If two pieces of equipment, people, etc. are working in tandem, they are working together, especially well or closely:
    - I want these two groups to work/operate in tandem on this project.

- **'Cascade'**
  - A process whereby something, typically information or knowledge, is successively passed on.
    - as modifier 'the greater the number of people who are well briefed, the wider the cascade effect'
  - A succession of devices or stages in a process, each of which triggers or initiates the next.

# Tandem and Cascade Hydro

| Characteristic | Tandem Hydro | Cascade Hydro |
|---|---|---|
| Operation | Synchronized | Independent |
| Controls | Common | Distinct |
| Time Gap | Bare minimum leeway | Some leeway |
| Storage | Bare minimum leeway | Some leeway |
| Scheduling and Despatch | Interdependent | Independent |
| Example | Nathpa-Jhakri/Rampur | Tehri/Koteshwar |

# Tandem Hydro

**Nathpa – Jhakri (NJHPS)** ⟷ **Rampur**

- 6 x 250 MW (Upstream)
- ROR with Limited Pondage for 1.5 Hrs. in one stretch

- 6 x 68.67 MW (Downstream)
- ROR, in Tandem with NJHPS, with limited pondage

## Dependency of NJHPS on Karcham Wangtoo (KWHEP)

- In low flow season, NJHPS depends exclusively on upstream KWHEP for water

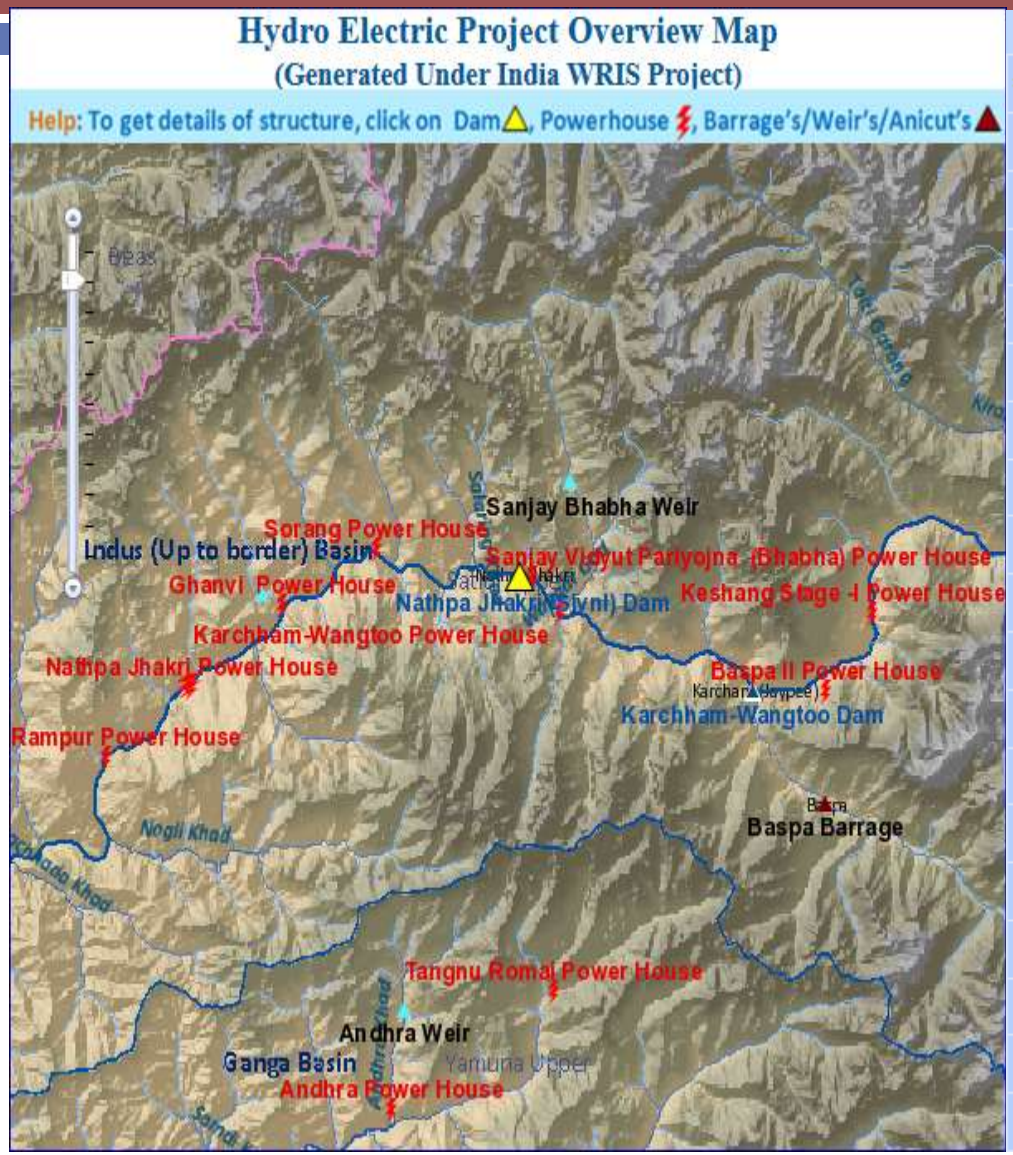
## Limited Pondage at Rampur

- Rampur HPS has to operate in tandem with NJHPS with an limited intermediate pondage capacity of 21830 Cum only.

## Scheduling Constraint for Synchronization

- Normally KWHEP is synchronized as almost same time of NJHPC & Rampur. But in case KWHEP machine synchronization is not matching the schedule of NJHPC & Rampur then KWHEP, through NRLDC, is requested to moderate their schedule.

# Nathpa-Jhakri & Rampur




**Salient Features**

| # | Attribute | Value |
|---|---|---|
| 1 | Hydroelectric Project Name | Nathpa Jhakri Hydroelectric Project |
| 2 | Hydroelectric Project Name Alias | |
| 3 | State | Himachal Pradesh |
| 4 | Districts | Shimla |
| 5 | River | Satluj |
| 6 | Basin | Indus up to International Border |
| 7 | Hydroelectric Region | Northern HE Region |
| 8 | Total Installed Capacity (MW) | 1500 |
| 9 | Type of Project | Major (> 25 MW) |
| 10 | Hydroelectric Project Status | Completed |
| 11 | Purpose | Hydroelectric |
| 12 | Owner | Central |
| 13 | Owner Name | SJVNL |
| 14 | Interbasin | No |
| 15 | Project Sharing | None |
| 16 | Interstate Aggrements | |
| 17 | Intercountry | None |
| 18 | Remarks | |

# Information Requirement of Hydro Units

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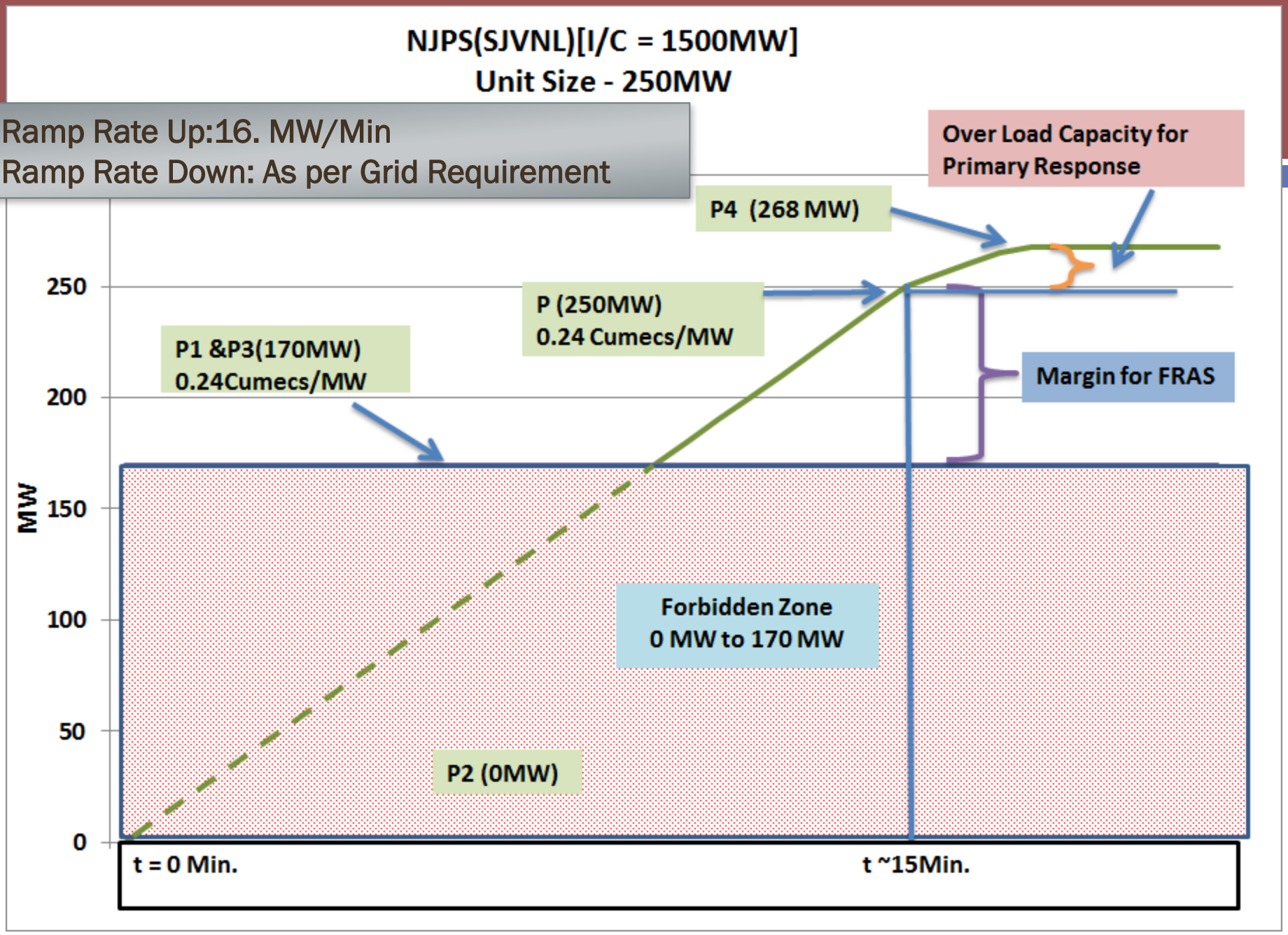
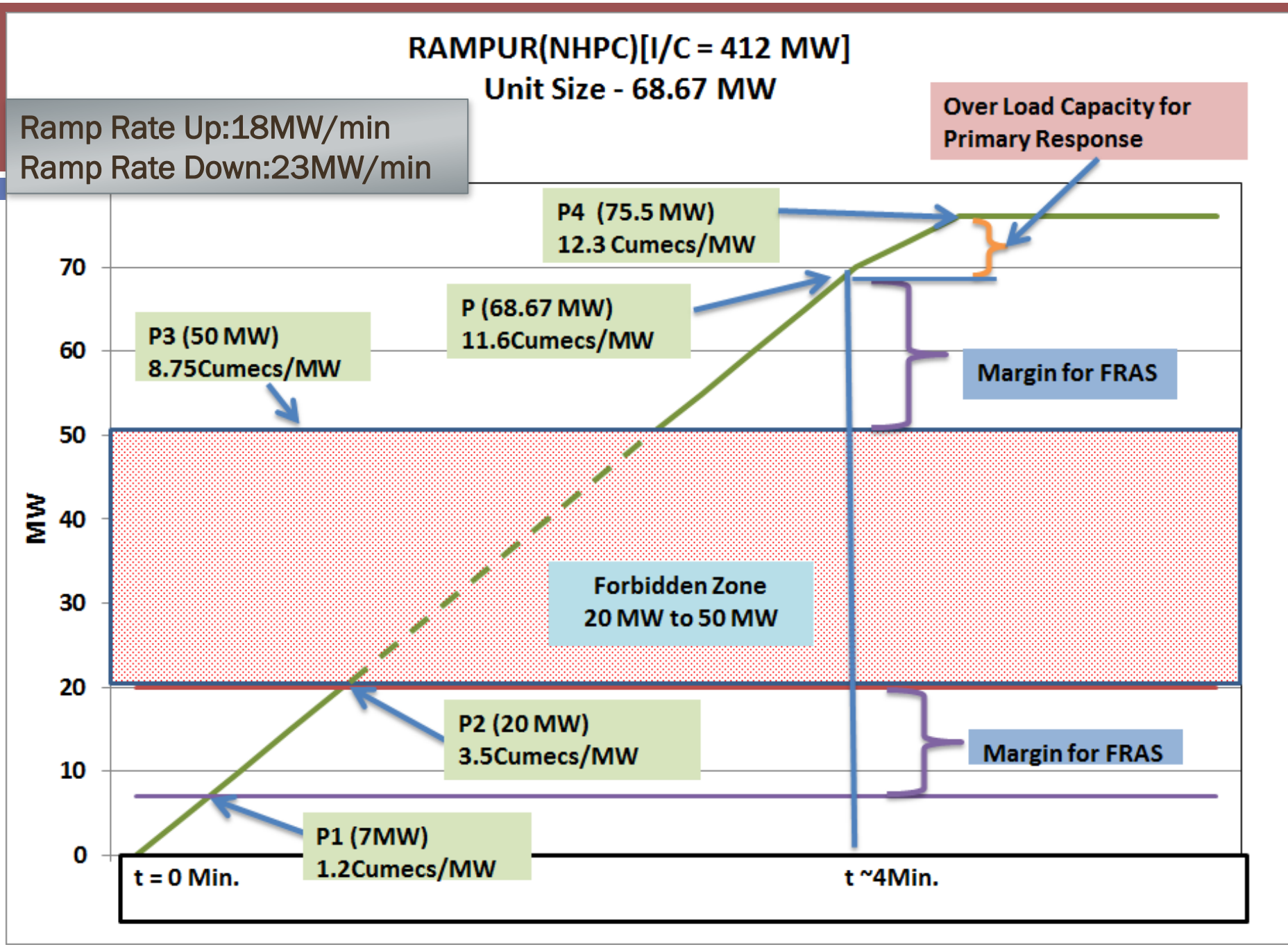
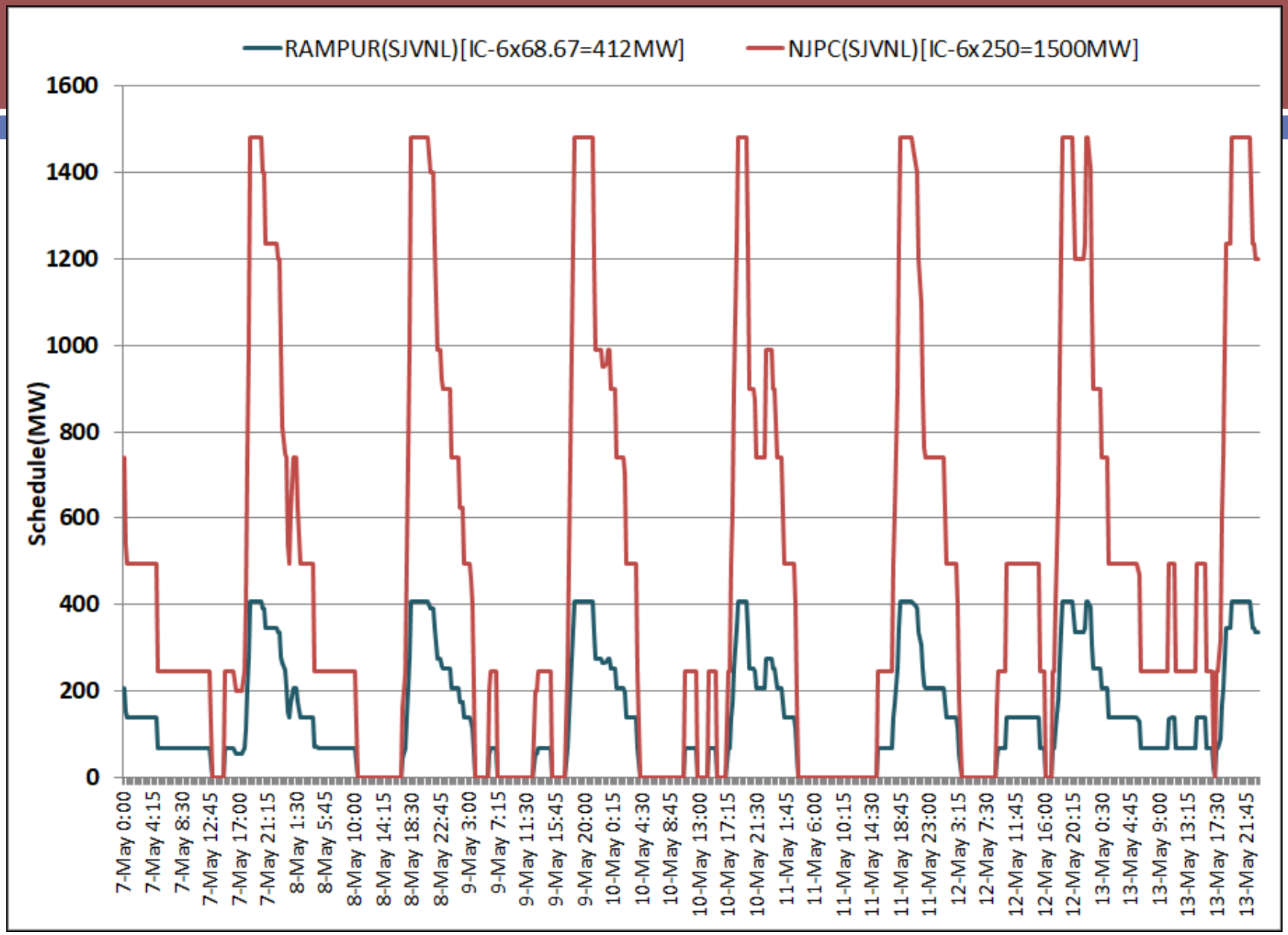
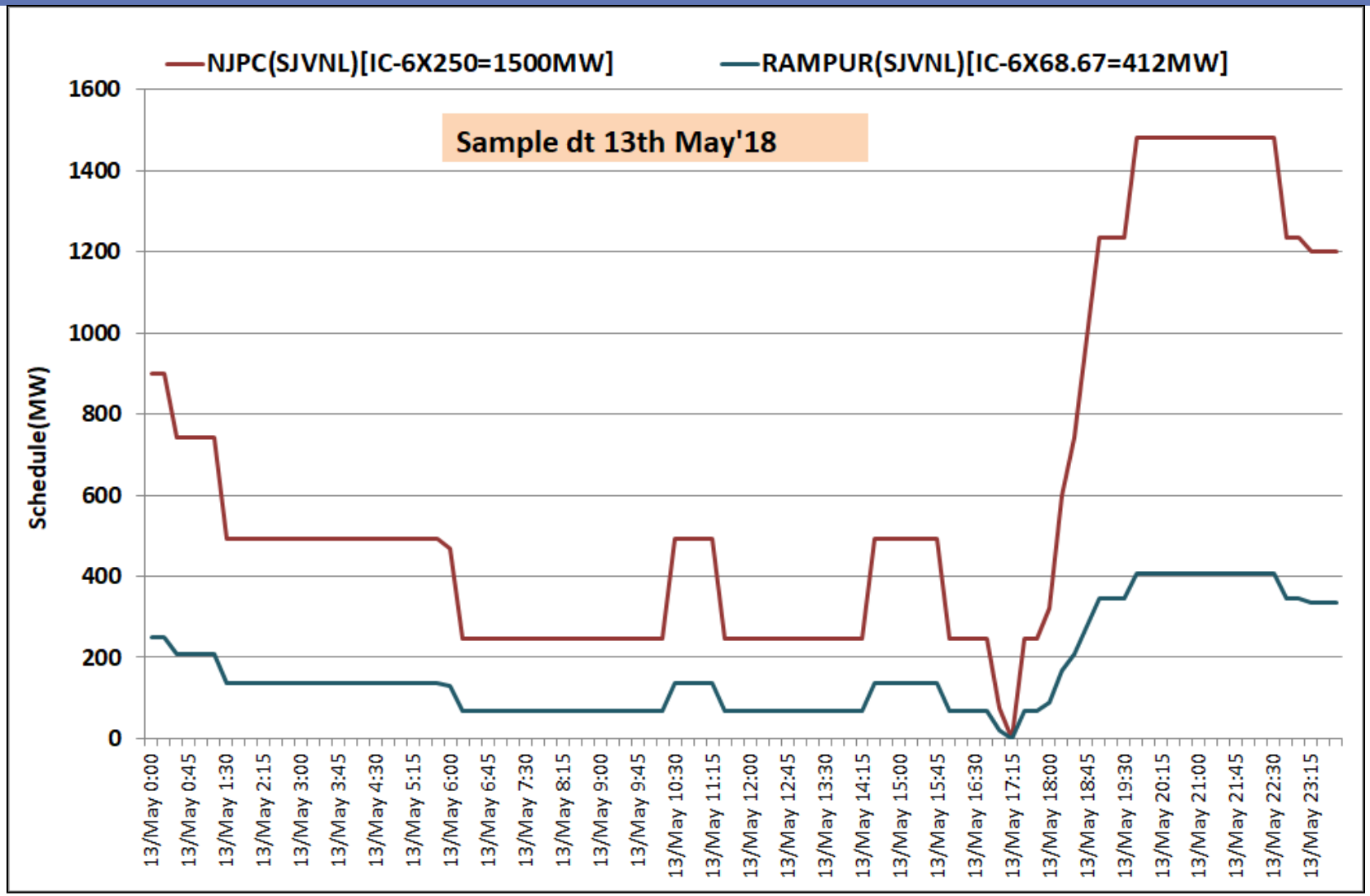

NJPS(SJVNL)[I/C = 1500MW]
Unit Size - 250MW
Ramp Rate Up:16. MW/Min
Ramp Rate Down: As per Grid Requirement
Over Load Capacity for Primary Response
P4 (268 MW)
P (250MW)
0.24 Cumecs/MW
P1 &P3(170MW)
0.24Cumecs/MW
Margin for FRAS
Forbidden Zone
0 MW to 170 MW
P2 (0MW)
MW
250
200
150
100
50
0
t = 0 Min.
t ~15Min.


RAMPUR(NHPC)[I/C = 412 MW]
Unit Size - 68.67 MW
Ramp Rate Up:18MW/min
Ramp Rate Down:23MW/min
Over Load Capacity for Primary Response
P4 (75.5 MW)
12.3 Cumecs/MW
P (68.67 MW)
11.6Cumecs/MW
P3 (50 MW)
8.75Cumecs/MW
Margin for FRAS
Forbidden Zone
20 MW to 50 MW
P2 (20 MW)
3.5Cumecs/MW
Margin for FRAS
P1 (7MW)
1.2Cumecs/MW
MW
0
10
20
30
40
50
60
70
t = 0 Min.
t ~4Min.

# SJVNL


RAMPUR(SJVNL)[IC-6x68.67=412MW]
NJPC(SJVNL)[IC-6x250=1500MW]
Schedule(MW)
1600
1400
1200
1000
800
600
400
200
0
7-May 0:00
7-May 4:15
7-May 8:30
7-May 12:45
7-May 17:00
7-May 21:15
8-May 1:30
8-May 5:45
8-May 10:00
8-May 14:15
8-May 18:30
8-May 22:45
9-May 3:00
9-May 7:15
9-May 11:30
9-May 15:45
9-May 20:00
10-May 0:15
10-May 4:30
10-May 8:45
10-May 13:00
10-May 17:15
10-May 21:30
11-May 1:45
11-May 6:00
11-May 10:15
11-May 14:30
11-May 18:45
11-May 23:00
12-May 3:15
12-May 7:30
12-May 11:45
12-May 16:00
12-May 20:15
13-May 0:30
13-May 4:45
13-May 9:00
13-May 13:15
13-May 17:30
13-May 21:45

# Tandem Operation – Sample Day



# Cascade Hydro (1)

**Chamera - III**

- 3 x 77 MW (Upstream)
- Pondage

**Chamera - II**

- 3 x 100 MW (Downstream)
- Pondage

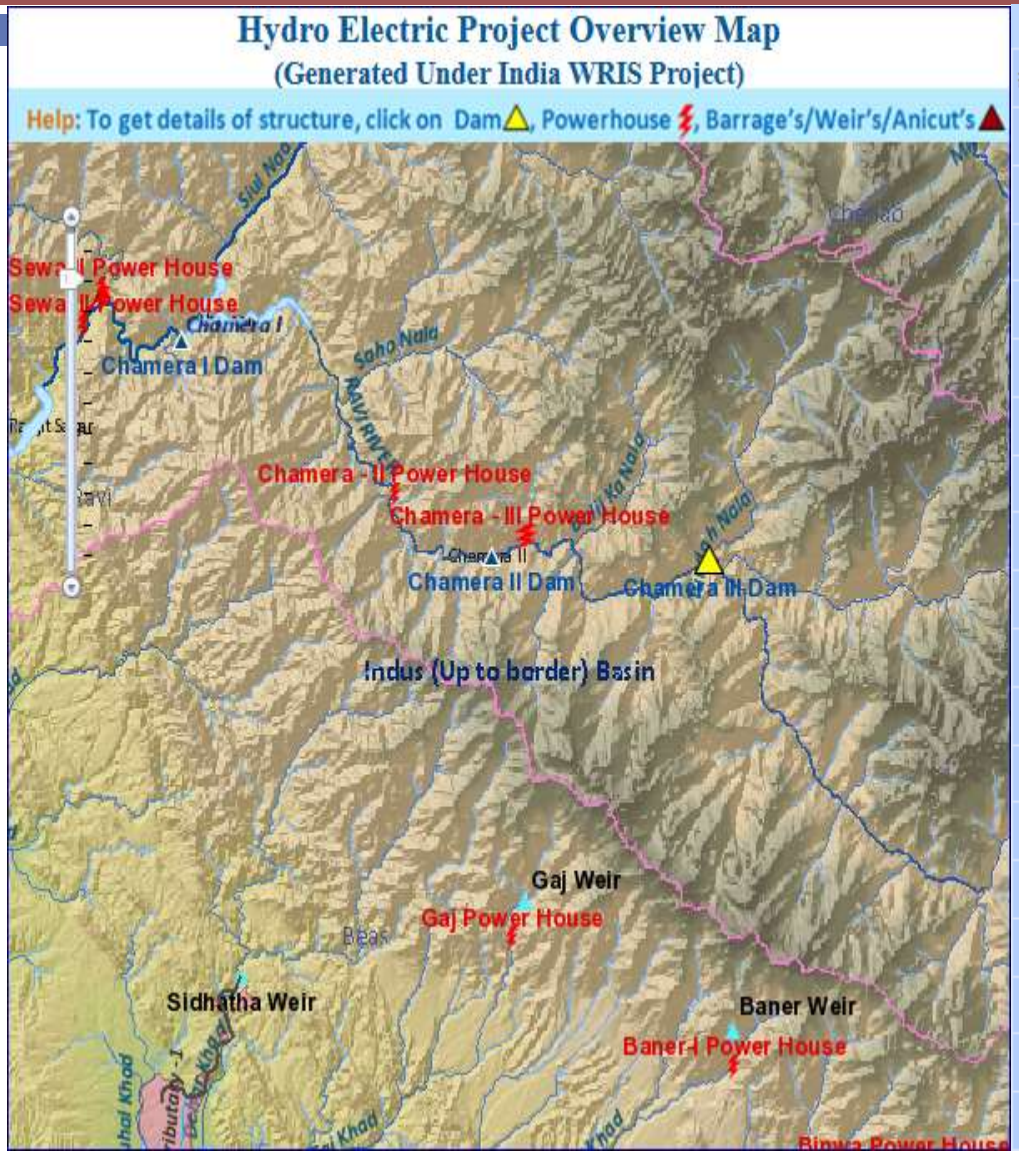
## Start-up of Units

- Chamera – III: Simultaneous start-up of all 3 units
- Chamera – II: Sequential start-up of units

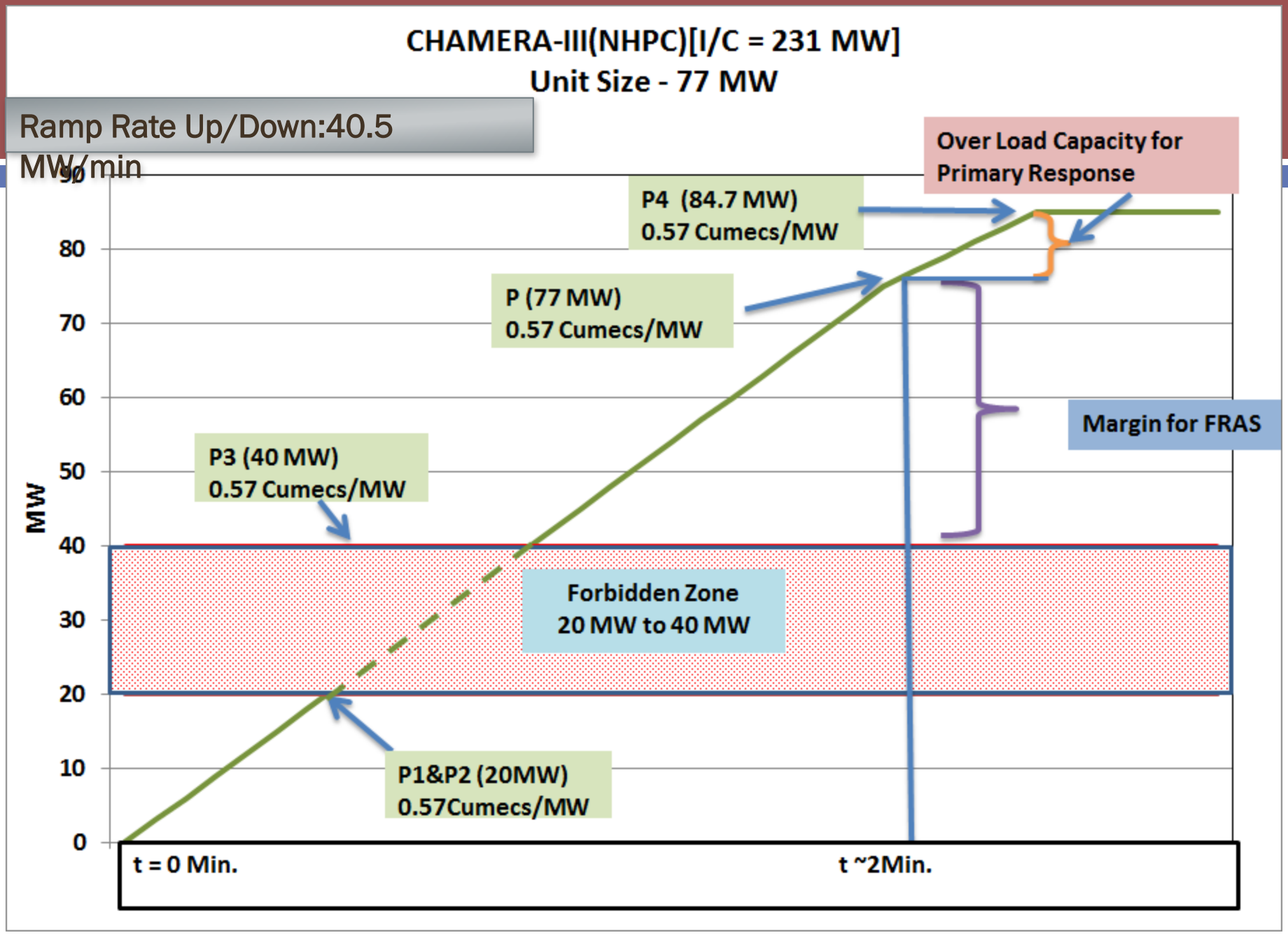
## Other Constraints

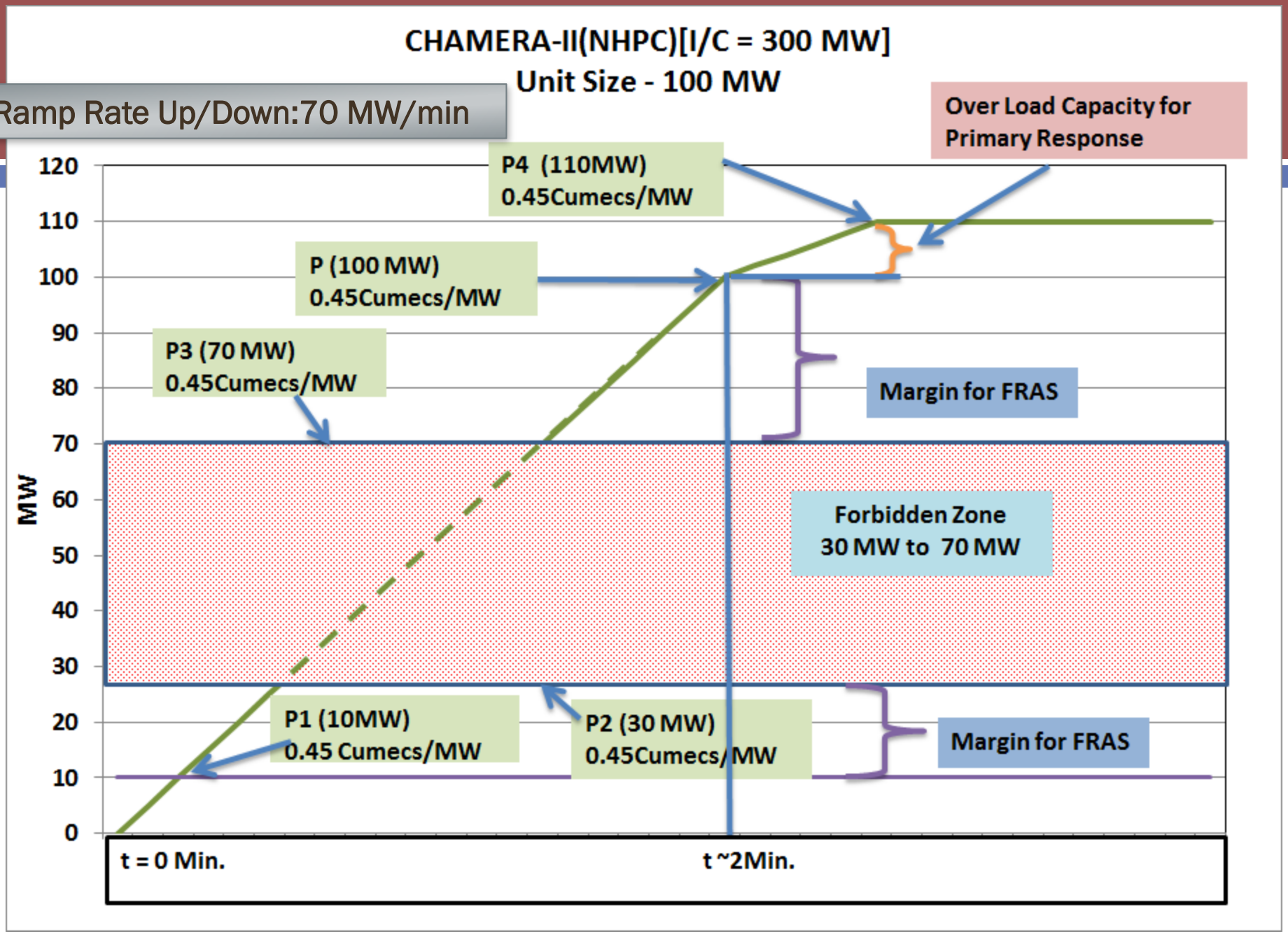
- Siren is to be blown 30 min before starting of each unit during lean season in both Chamera – III and Chamera – II.

# Chamera – III & Chamera - II

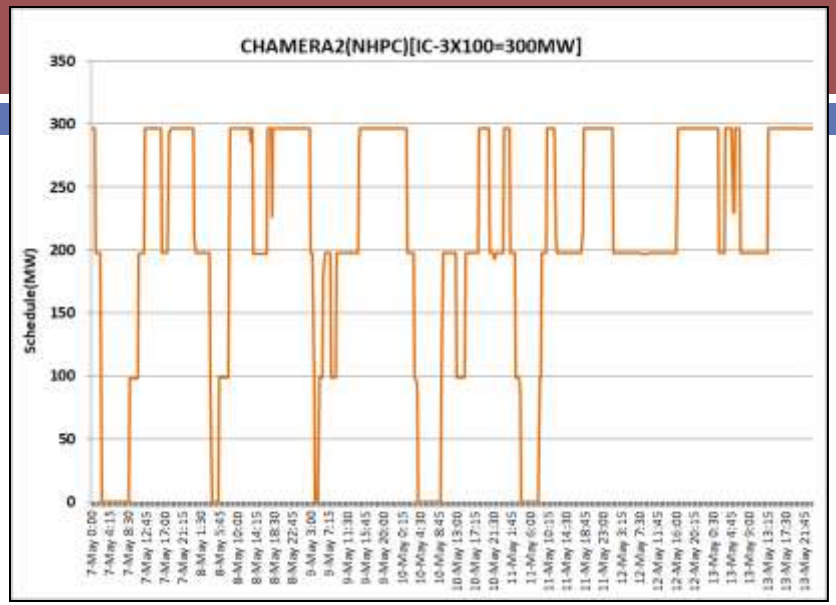


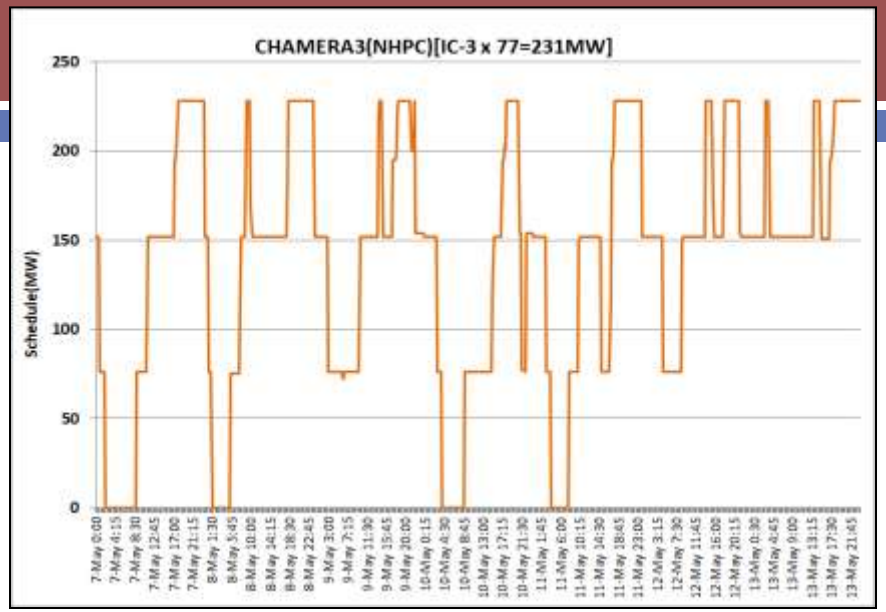

| Salient Features | | |
|---|---|---|
| # | Attribute | Value |
| 1 | Hydroelectric Project Name | Chamera - III Hydroelectric Project |
| 2 | Hydroelectric Project Name Alias | |
| 3 | State | Himachal Pradesh |
| 4 | Districts | |
| 5 | River | RAVI |
| 6 | Basin | Indus up to International Border |
| 7 | Hydroelectric Region | North HE Region |
| 8 | Total Installed Capacity (MW) | 231 |
| 9 | Type of Project | Major (> 25 MW) |
| 10 | Hydroelectric Project Status | Completed |
| 11 | Purpose | Hydroelectric |
| 12 | Owner | Central |
| 13 | Owner Name | NHPC |
| 14 | Interbasin | No |
| 15 | Project Sharing | None |
| 16 | Interstate Aggrements | |
| 17 | Intercountry | None |
| 18 | Remarks | |

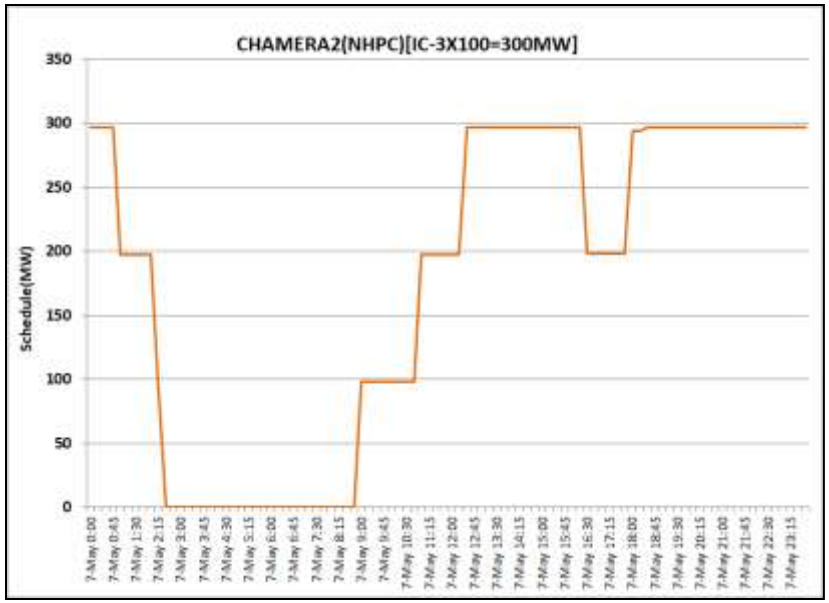

CHAMERA-III(NHPC)[I/C = 231 MW]
Unit Size - 77 MW
Ramp Rate Up/Down:40.5 MW/min
Over Load Capacity for Primary Response
P4 (84.7 MW)
0.57 Cumecs/MW
P (77 MW)
0.57 Cumecs/MW
Margin for FRAS
P3 (40 MW)
0.57 Cumecs/MW
Forbidden Zone
20 MW to 40 MW
P1&P2 (20MW)
0.57Cumecs/MW
MW
90
80
70
60
50
40
30
20
10
0
t = 0 Min.
t ~2Min.

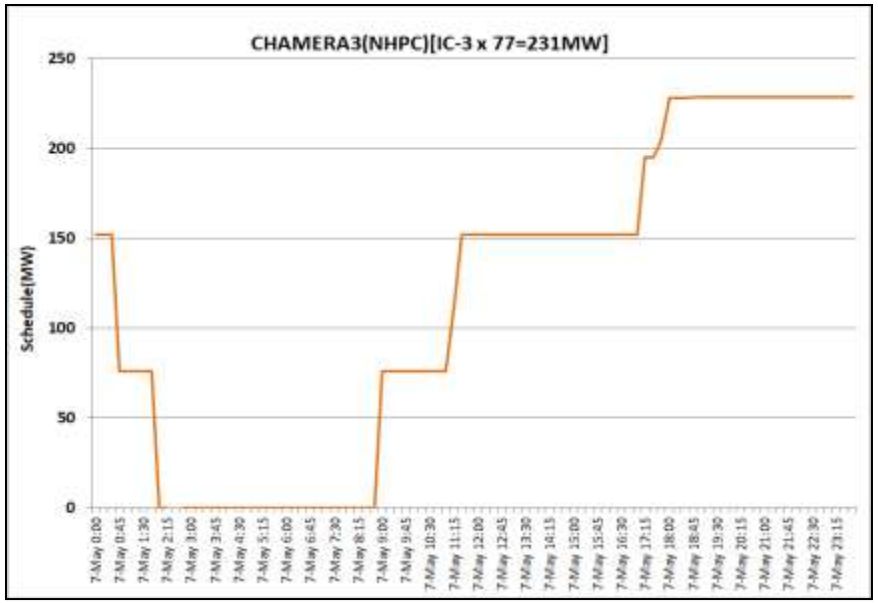

CHAMERA-II(NHPC)[I/C = 300 MW]
Unit Size - 100 MW
Ramp Rate Up/Down:70 MW/min
Over Load Capacity for Primary Response
P4 (110MW) 0.45Cumecs/MW
P (100 MW) 0.45Cumecs/MW
P3 (70 MW) 0.45Cumecs/MW
Margin for FRAS
Forbidden Zone 30 MW to 70 MW
P1 (10MW) 0.45 Cumecs/MW
P2 (30 MW) 0.45Cumecs/MW
Margin for FRAS
MW
120
110
100
90
80
70
60
50
40
30
20
10
0
t = 0 Min.
t ~2Min.

# Chamera – II and III Operation – Sample Week & Day



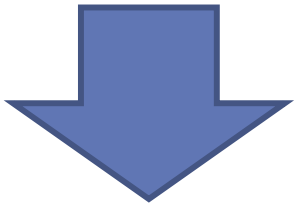



# Cascade Hydro (2)

**Tehri**

- 4 x 250 MW (Upstream)
- Reservoir



**Koteshwar**

- 4 x 100 MW (Downstream)
- ROR with Storage

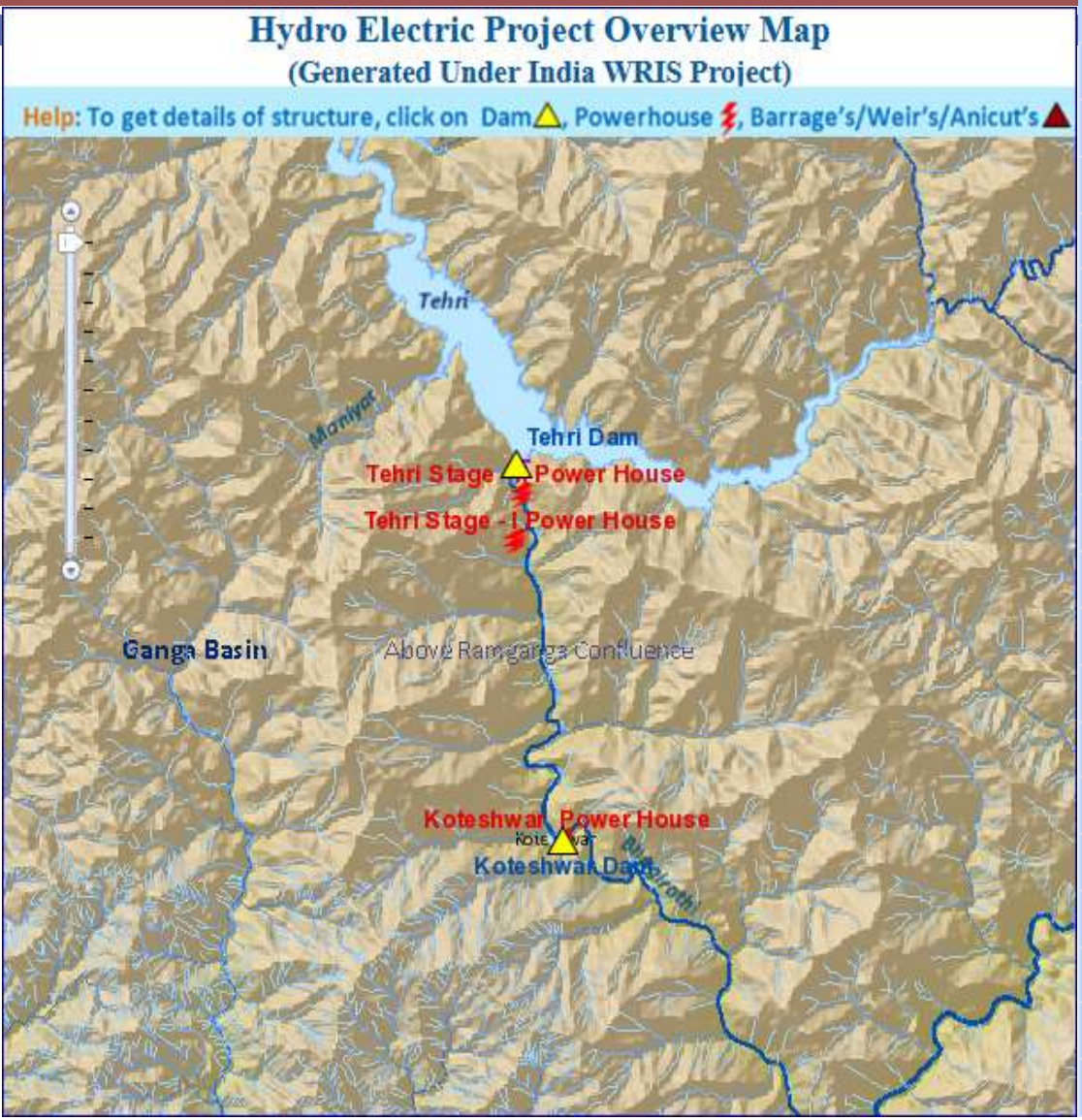
## Start-up of Units

- Tehri: Sequential start-up of units
- Koteshwar: Simultaneous start-up of all 4 units

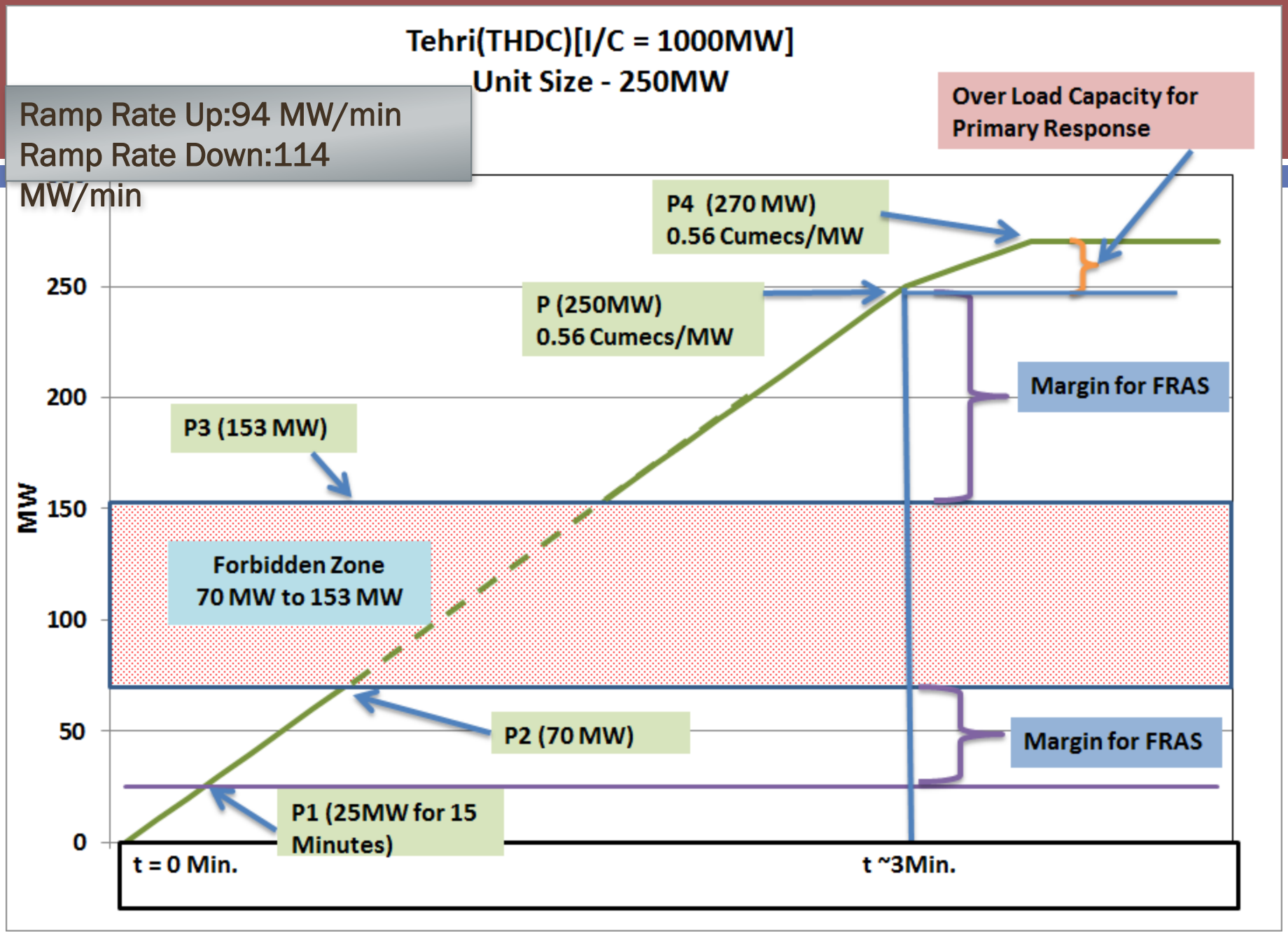
## Other Constraints

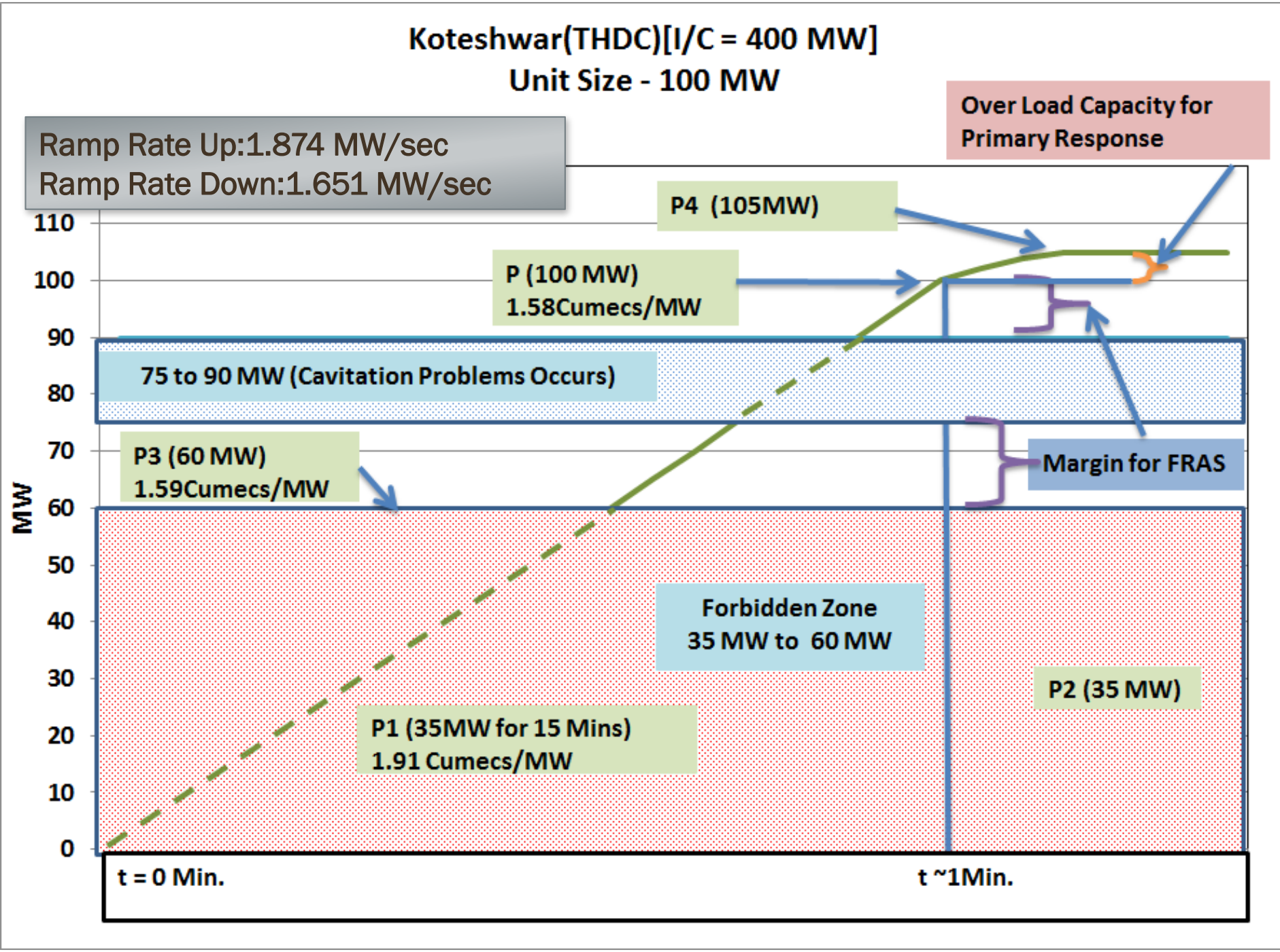
- Koteshwar HEP regulates water released from Tehri HPP for downstream irrigation and drinking water requirements.
- One unit of Koteshwar HEP is operated round the clock to ensure continuous supply of water in the downstream of Tehri Complex

# Tehri & Koteshwar

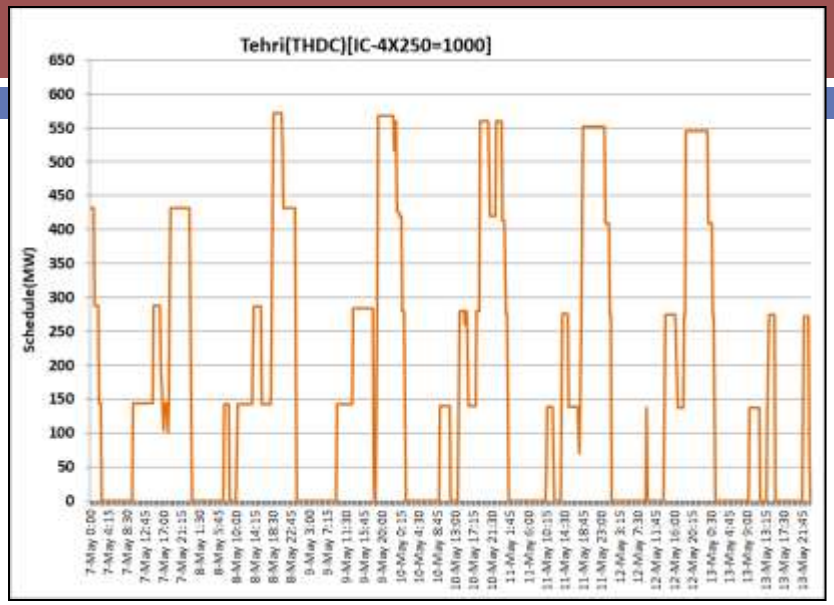


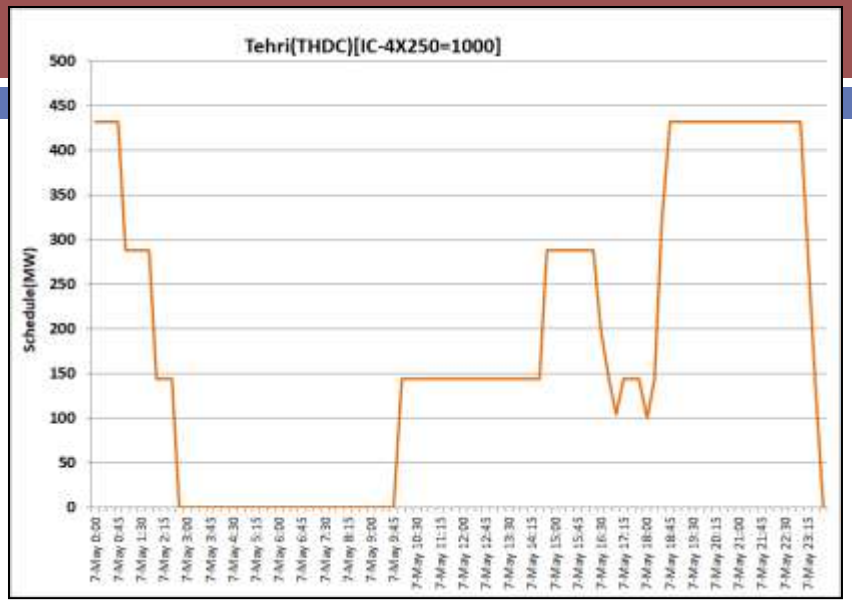

| Salient Features | | |
|---|---|---|
| # | Attribute | Value |
| 1 | Hydroelectric Project Name | Tehri Hydroelectric Project |
| 2 | Hydroelectric Project Name Alias | |
| 3 | State | Uttarakhand |
| 4 | Districts | |
| 5 | River | Bhagirathi |
| 6 | Basin | Ganga |
| 7 | Hydroelectric Region | Northern HE Region |
| 8 | Total Installed Capacity (MW) | 2000 |
| 9 | Type of Project | Major (> 25 MW) |
| 10 | Hydroelectric Project Status | Completed |
| 11 | Purpose | Hydroelectric |
| 12 | Owner | Central |
| 13 | Owner Name | THDC |
| 14 | Interbasin | No |
| 15 | Project Sharing | None |
| 16 | Interstate Aggrements | |
| 17 | Intercountry | None |
| 18 | Remarks | |

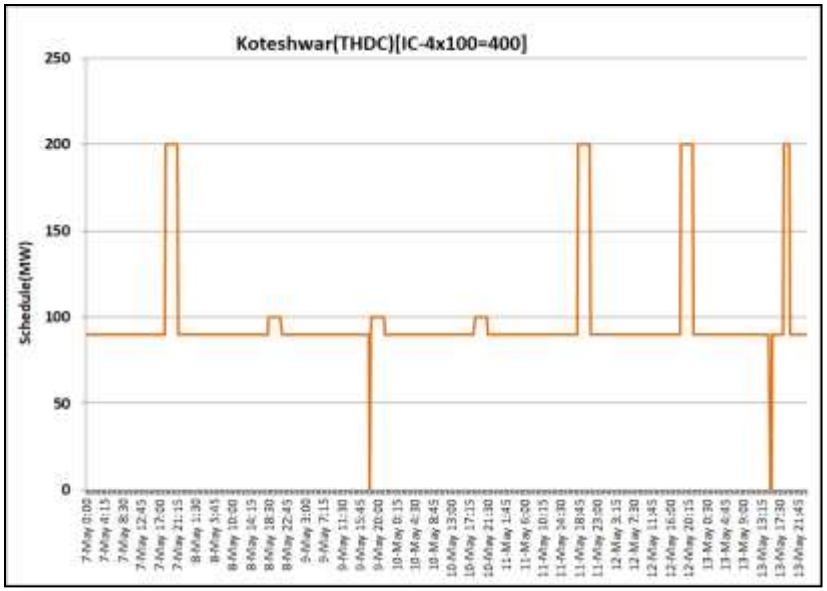

Tehri(THDC)[I/C = 1000MW]
Unit Size - 250MW
Ramp Rate Up:94 MW/min
Ramp Rate Down:114 MW/min
Over Load Capacity for Primary Response
P4 (270 MW)
0.56 Cumecs/MW
P (250MW)
0.56 Cumecs/MW
Margin for FRAS
P3 (153 MW)
Forbidden Zone
70 MW to 153 MW
P2 (70 MW)
Margin for FRAS
P1 (25MW for 15 Minutes)
MW
250
200
150
100
50
0
t = 0 Min.
t ~3Min.

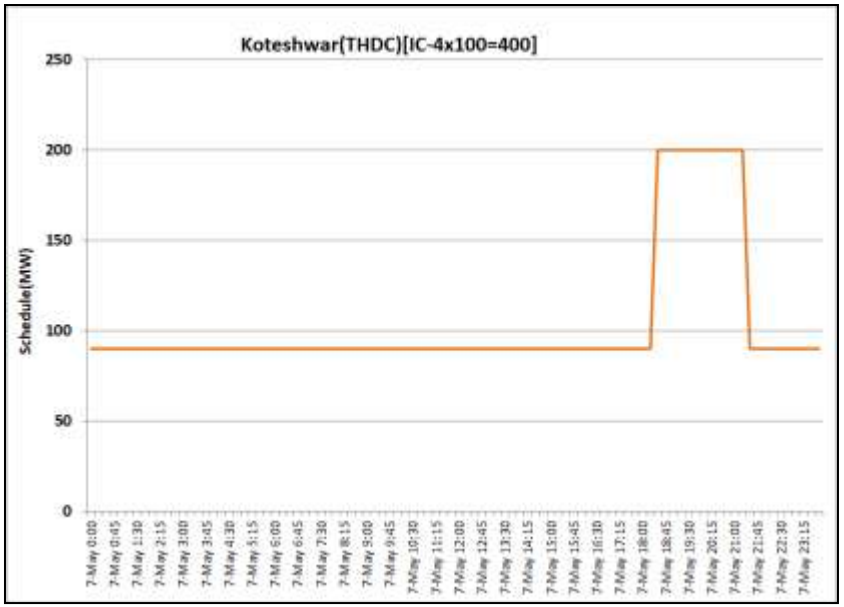

Koteshwar(THDC)[I/C = 400 MW]
Unit Size - 100 MW
Ramp Rate Up:1.874 MW/sec
Ramp Rate Down:1.651 MW/sec
Over Load Capacity for Primary Response
P4 (105MW)
P (100 MW)
1.58Cumecs/MW
75 to 90 MW (Cavitation Problems Occurs)
P3 (60 MW)
1.59Cumecs/MW
Margin for FRAS
Forbidden Zone
35 MW to 60 MW
P2 (35 MW)
P1 (35MW for 15 Mins)
1.91 Cumecs/MW
MW
110
100
90
80
70
60
50
40
30
20
10
0
t = 0 Min.
t ~1Min.

# Tehri and Koteshwar Operation – Sample Week & Day



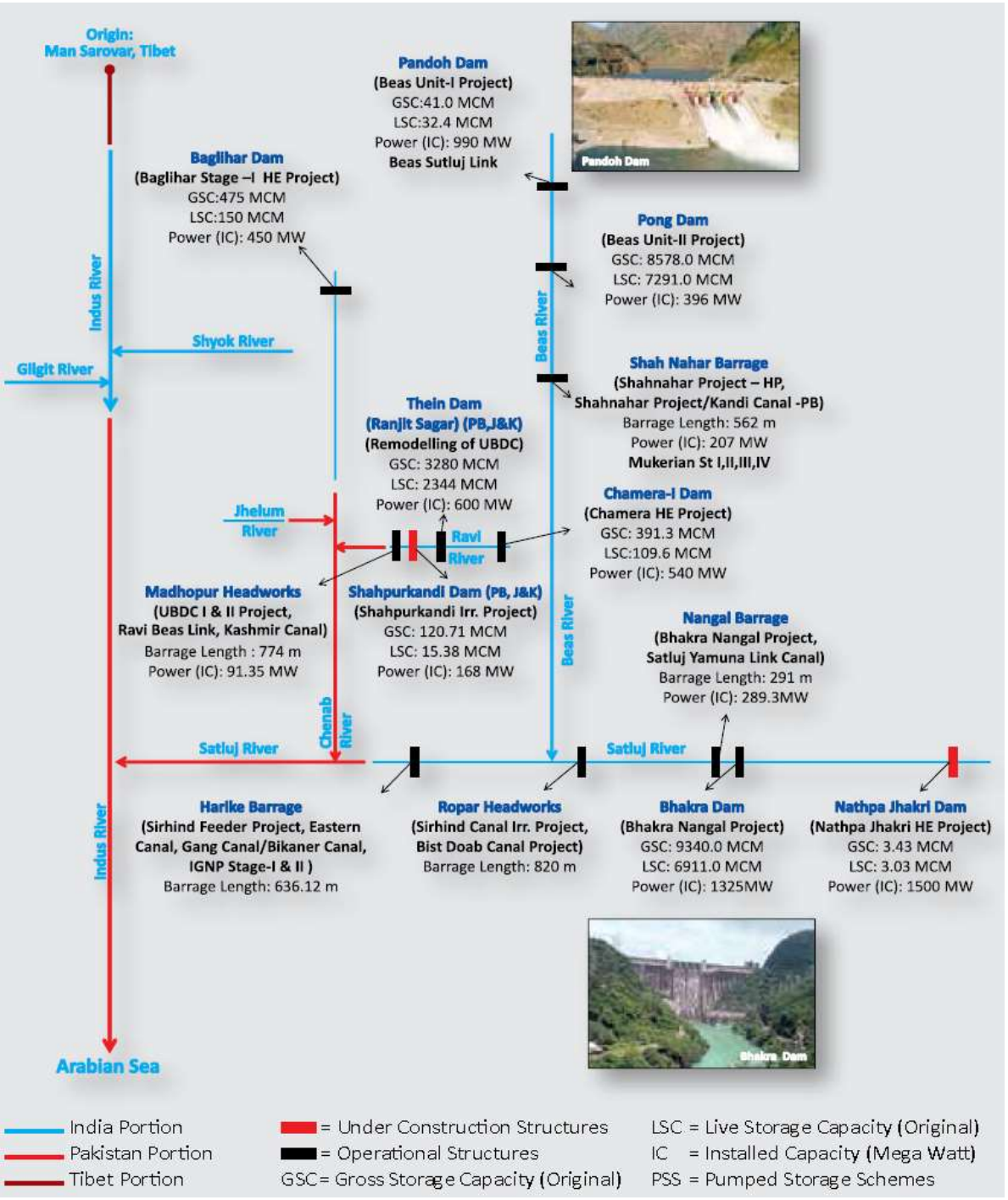



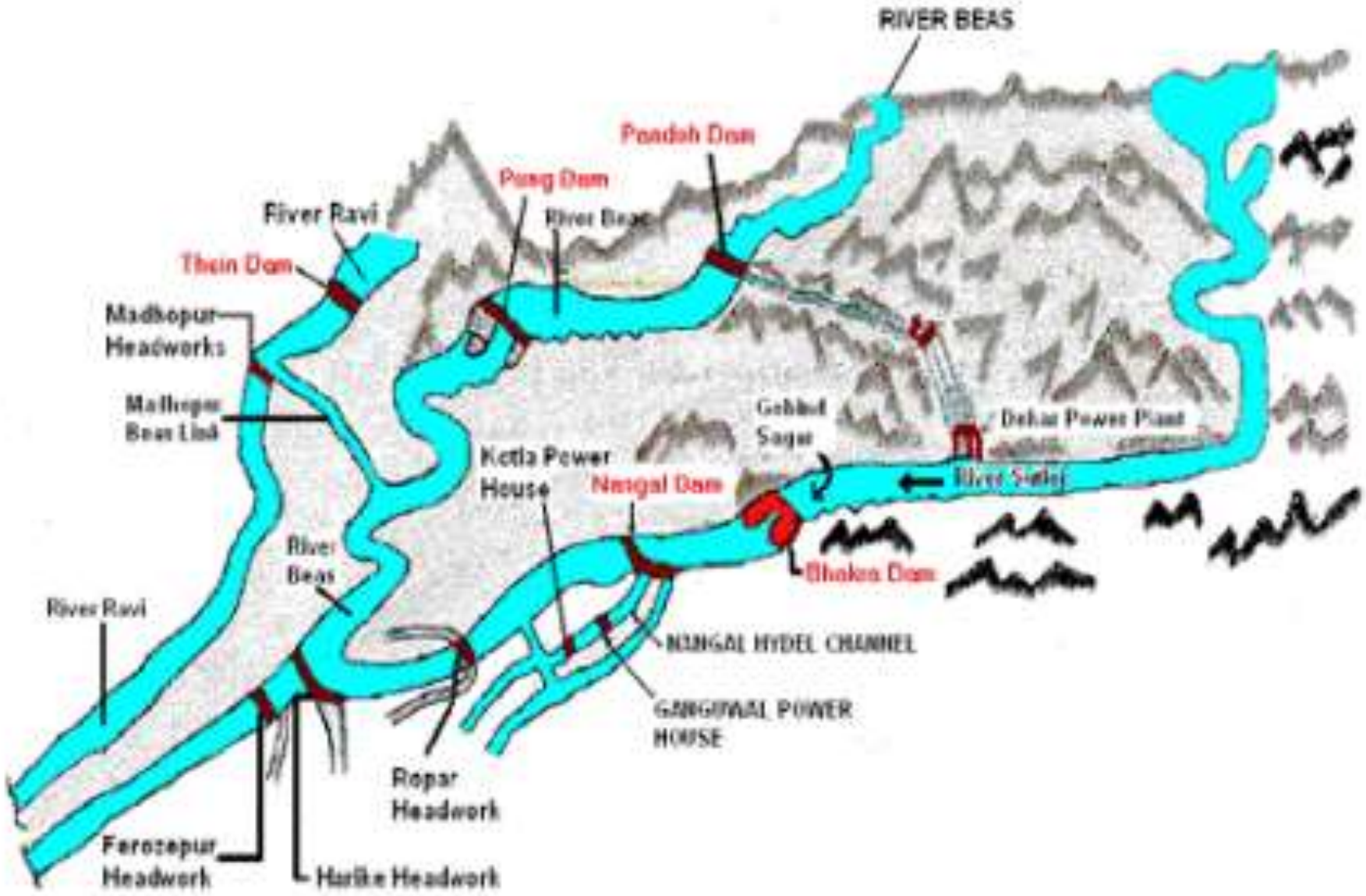
# Bhakra-Beas Projects

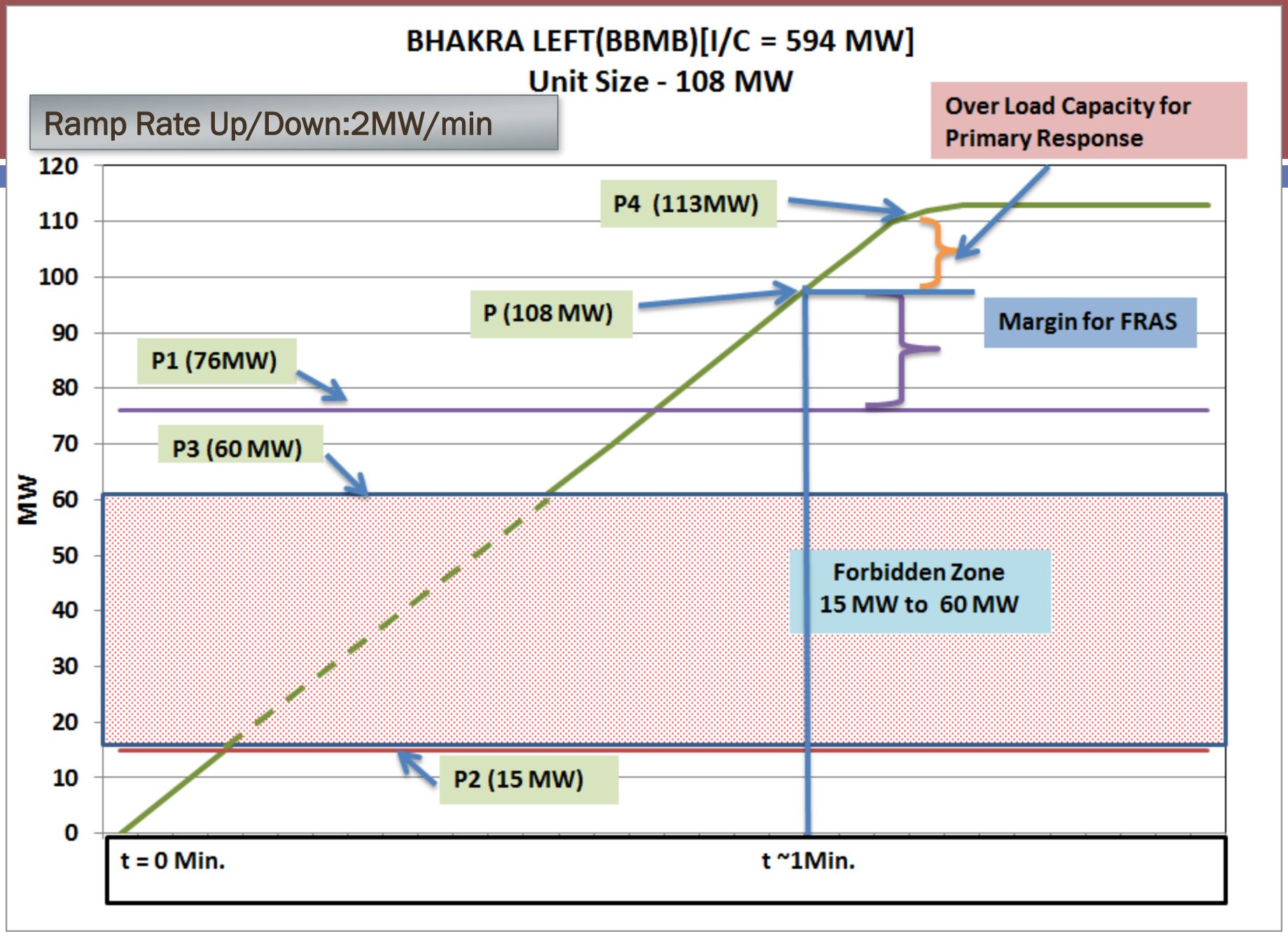
| S.No | Title/Parameters | Bhakra Left | Bhakra Right | Pong | Dehar |
|---|---|---|---|---|---|
| 1 | Generating Units | 2*108 MW+ 3*126 MW | 5*157 MW | 6*66 MW | 6*165 MW |
| 2 | Type of Plant | Reservoir | Reservoir | Reservoir | Pondage |
| 3 | How many units can be started simultaneously or is it sequential operation | All units can be started simultaneously. However started one by one | | | |
| 4 | Requirement of Tandem Operation of the Plant | No | | | |
| 5 | Any Other Information including the constraints | No | | | |

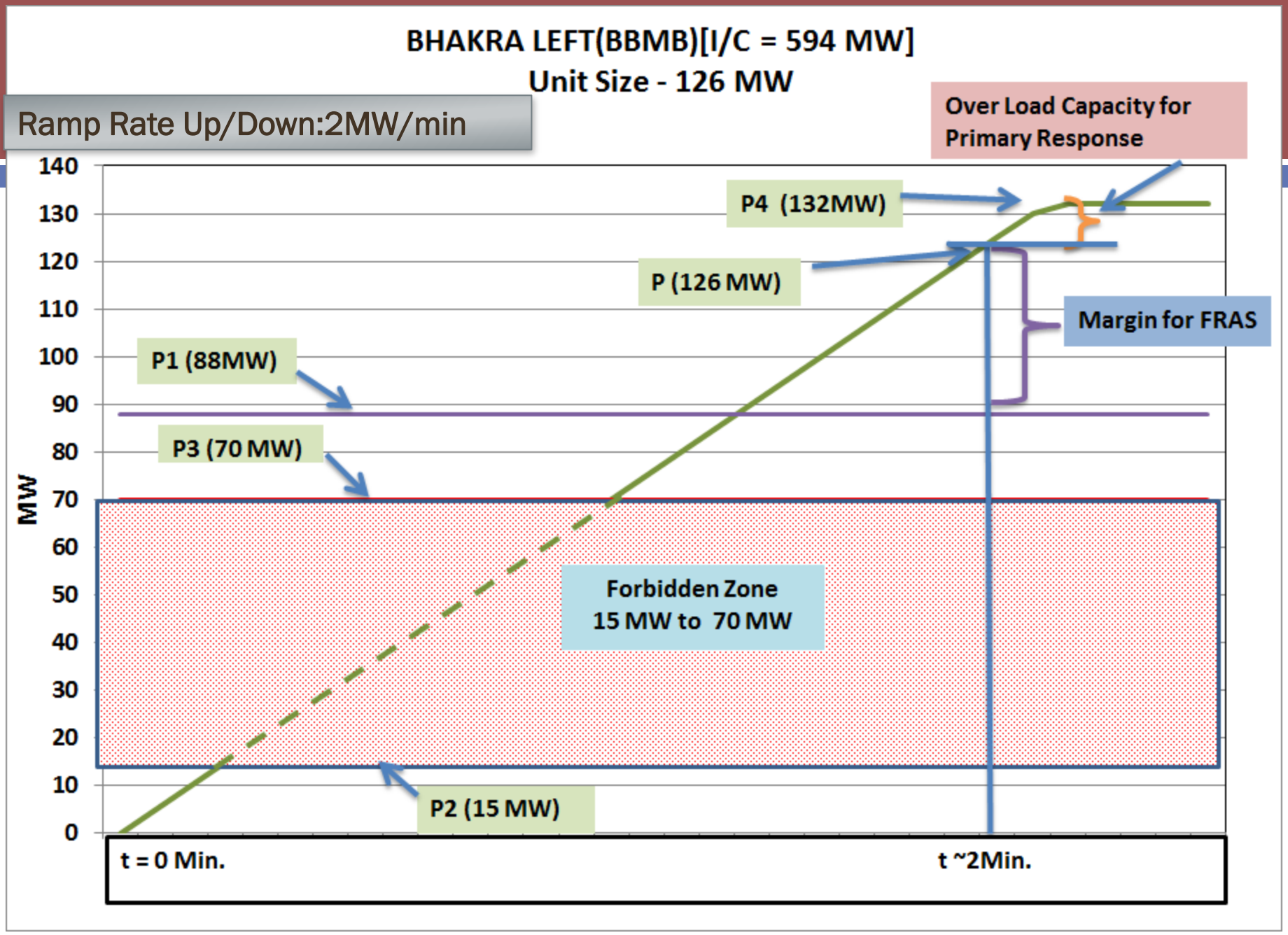
# Indus Basin

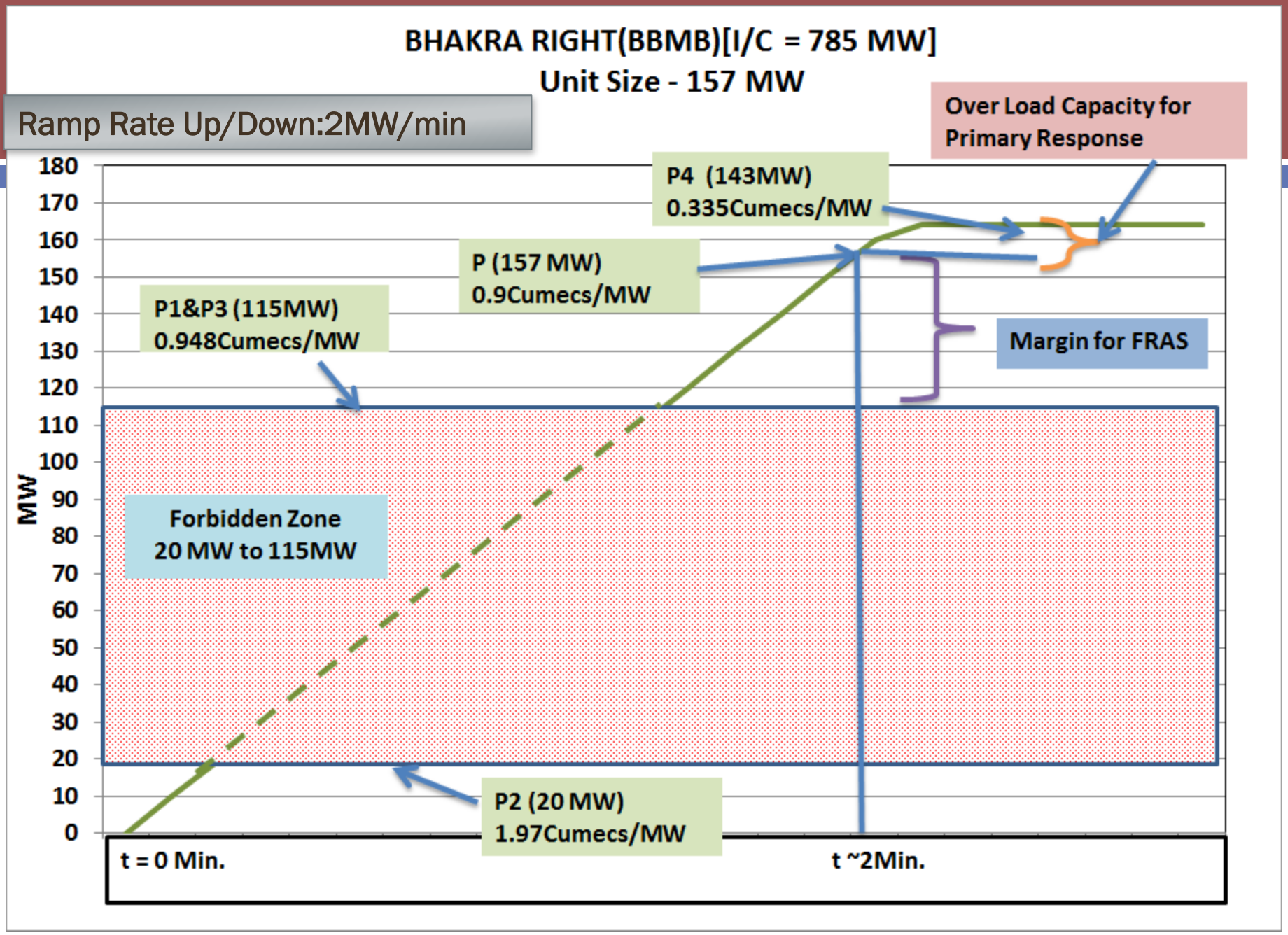

Origin:
Man Sarovar, Tibet
Pandoh Dam
(Beas Unit-I Project)
GSC:41.0 MCM
LSC:32.4 MCM
Power (IC): 990 MW
Beas Sutluj Link
Pandoh Dam
Baglihar Dam
(Baglihar Stage –I HE Project)
GSC:475 MCM
LSC:150 MCM
Power (IC): 450 MW
Indus River
Pong Dam
(Beas Unit-II Project)
GSC: 8578.0 MCM
LSC: 7291.0 MCM
Power (IC): 396 MW
Beas River
Shyok River
Gilgit River
Shah Nahar Barrage
(Shahnahar Project – HP,
Shahnahar Project/Kandi Canal -PB)
Barrage Length: 562 m
Power (IC): 207 MW
Mukerian St I,II,III,IV
Thein Dam
(Ranjit Sagar) (PB,J&K)
(Remodelling of UBDC)
GSC: 3280 MCM
LSC: 2344 MCM
Power (IC): 600 MW
Chamera-I Dam
(Chamera HE Project)
GSC: 391.3 MCM
LSC:109.6 MCM
Power (IC): 540 MW
Jhelum River
Ravi River
Madhopur Headworks
(UBDC I & II Project,
Ravi Beas Link, Kashmir Canal)
Barrage Length : 774 m
Power (IC): 91.35 MW
Shahpurkandi Dam (PB, J&K)
(Shahpurkandi Irr. Project)
GSC: 120.71 MCM
LSC: 15.38 MCM
Power (IC): 168 MW
Beas River
Nangal Barrage
(Bhakra Nangal Project,
Satluj Yamuna Link Canal)
Barrage Length: 291 m
Power (IC): 289.3MW
Chenab River
Satluj River
Satluj River
Harike Barrage
(Sirhind Feeder Project, Eastern
Canal, Gang Canal/Bikaner Canal,
IGNP Stage-I & II )
Barrage Length: 636.12 m
Ropar Headworks
(Sirhind Canal Irr. Project,
Bist Doab Canal Project)
Barrage Length: 820 m
Bhakra Dam
(Bhakra Nangal Project)
GSC: 9340.0 MCM
LSC: 6911.0 MCM
Power (IC): 1325MW
Nathpa Jhakri Dam
(Nathpa Jhakri HE Project)
GSC: 3.43 MCM
LSC: 3.03 MCM
Power (IC): 1500 MW
Indus River
Arabian Sea
Bhakra Dam
India Portion
Pakistan Portion
Tibet Portion
= Under Construction Structures
= Operational Structures
GSC= Gross Storage Capacity (Original)
LSC = Live Storage Capacity (Original)
IC = Installed Capacity (Mega Watt)
PSS = Pumped Storage Schemes

# Satluj Beas Ravi Development Master Plan

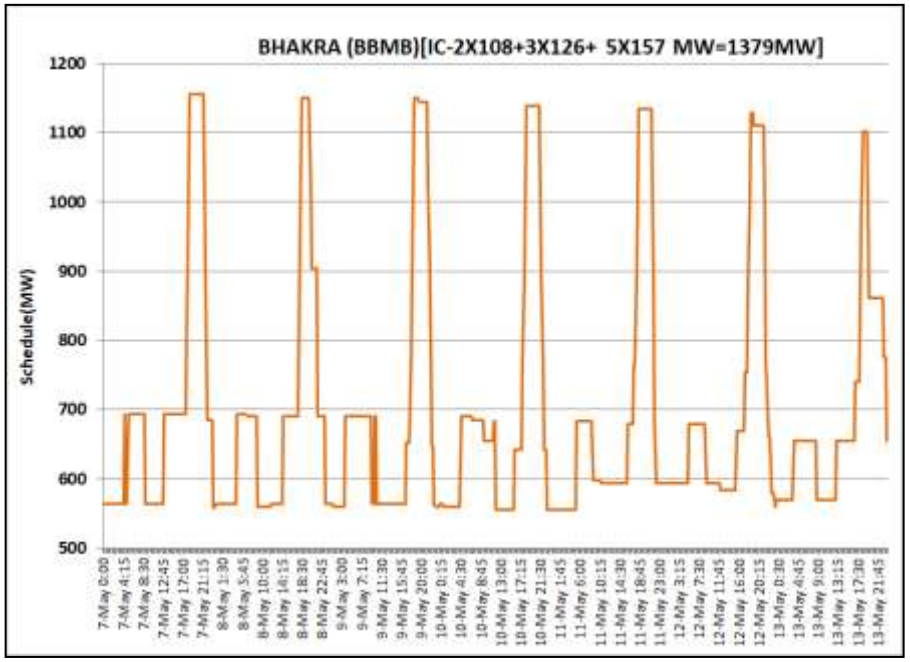


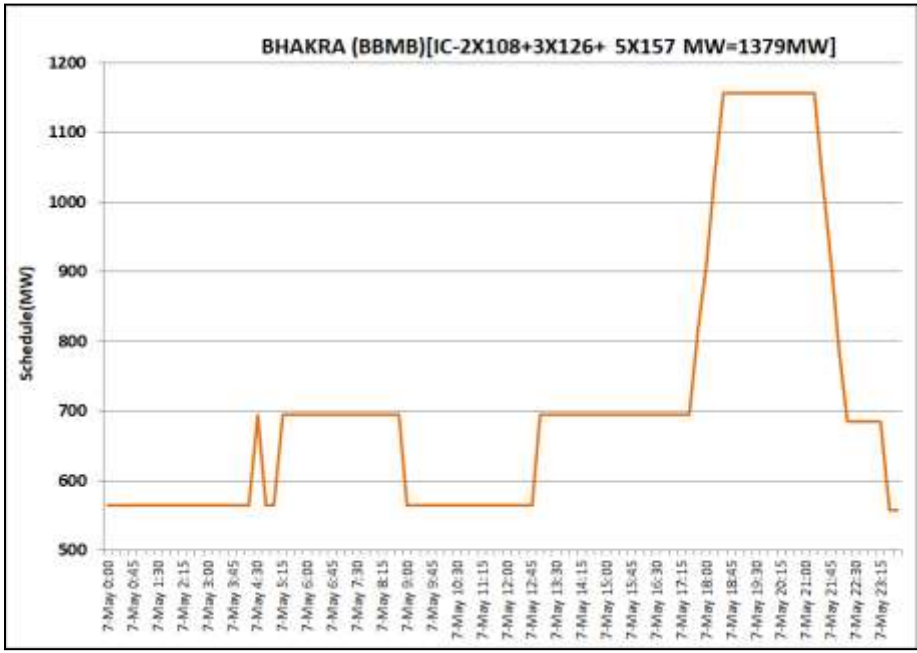

BHAKRA LEFT(BBMB)[I/C = 594 MW]
Unit Size - 108 MW
Ramp Rate Up/Down:2MW/min
Over Load Capacity for Primary Response
P4 (113MW)
P (108 MW)
Margin for FRAS
P1 (76MW)
P3 (60 MW)
Forbidden Zone
15 MW to 60 MW
P2 (15 MW)
MW
120
110
100
90
80
70
60
50
40
30
20
10
0
t = 0 Min.
t ~1Min.


BHAKRA LEFT(BBMB)[I/C = 594 MW]
Unit Size - 126 MW
Ramp Rate Up/Down:2MW/min
Over Load Capacity for Primary Response
P4 (132MW)
P (126 MW)
Margin for FRAS
P1 (88MW)
P3 (70 MW)
Forbidden Zone
15 MW to 70 MW
P2 (15 MW)
MW
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
t = 0 Min.
t ~2Min.


BHAKRA RIGHT(BBMB)[I/C = 785 MW]
Unit Size - 157 MW
Ramp Rate Up/Down:2MW/min
Over Load Capacity for Primary Response
P4 (143MW)
0.335Cumecs/MW
P (157 MW)
0.9Cumecs/MW
P1&P3 (115MW)
0.948Cumecs/MW
Margin for FRAS
Forbidden Zone
20 MW to 115MW
P2 (20 MW)
1.97Cumecs/MW
MW
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
t = 0 Min.
t ~2Min.

# BBMB….(1)


BHAKRA (BBMB)[IC-2X108+3X126+ 5X157 MW=1379MW]
Schedule(MW)
1200
1100
1000
900
800
700
600
500


BHAKRA (BBMB)[IC-2X108+3X126+ 5X157 MW=1379MW]
Schedule(MW)
1200
1100
1000
900
800
700
600
500

# Cascade Hydro (3)

**Khandong**

- 2 x 25 MW (Upstream)
- Reservoir

**Kopili Stage - II**

- 1 x 25 MW (Upstream)
- Reservoir

**Kopili**

- 4 x 50 MW (Downstream)
- Reservoir

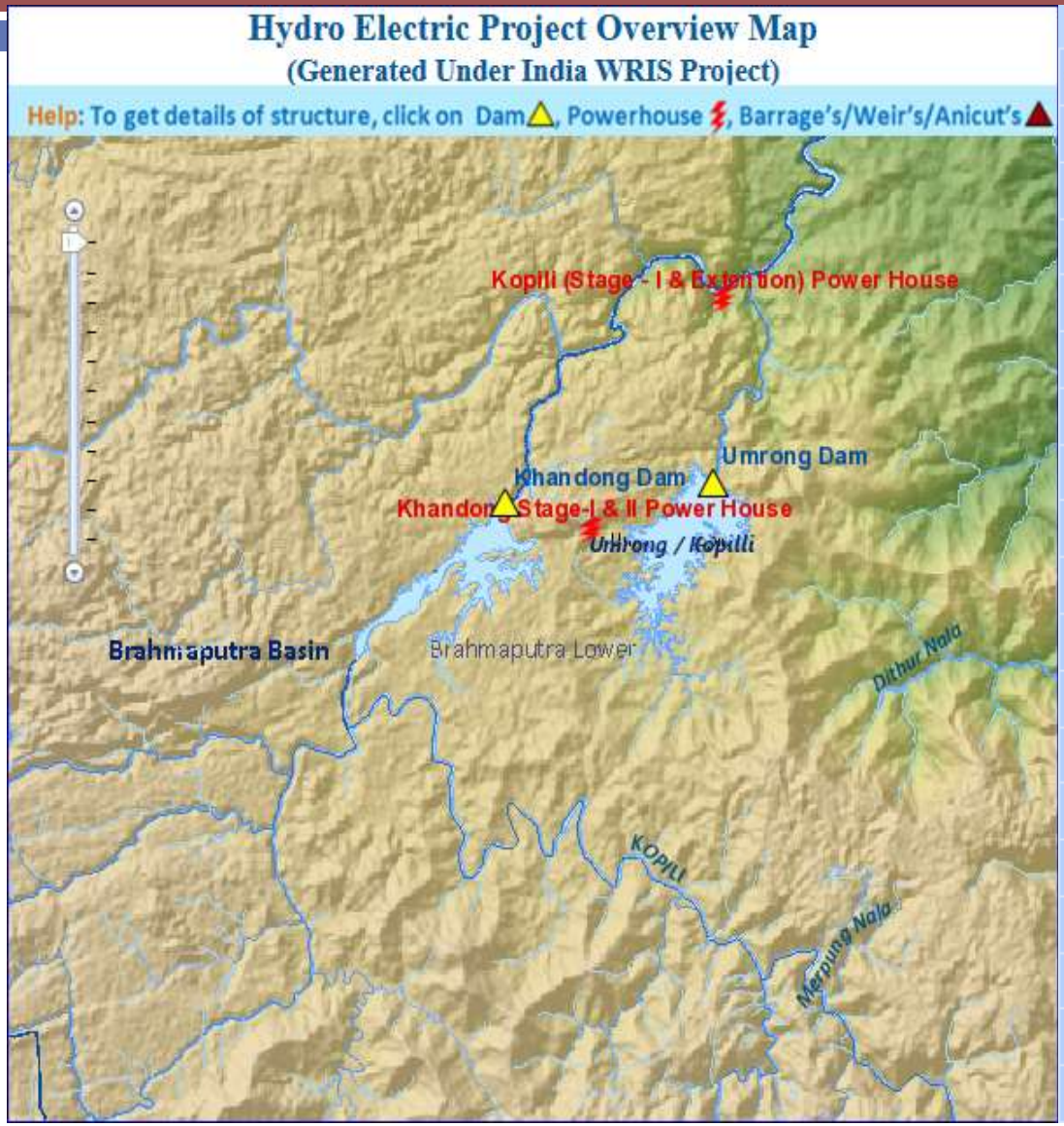
## Maximum Possible Ex-bus Injection

- **Khandong**
  - 49 MW (When Stage II Power House is not running)
  - 43 MW (When Stage II is running)
- **Kopili Stage – II**
  - 24 MW (When one unit of Khandong is not running
  - 19 MW (When all Khandong units are running)

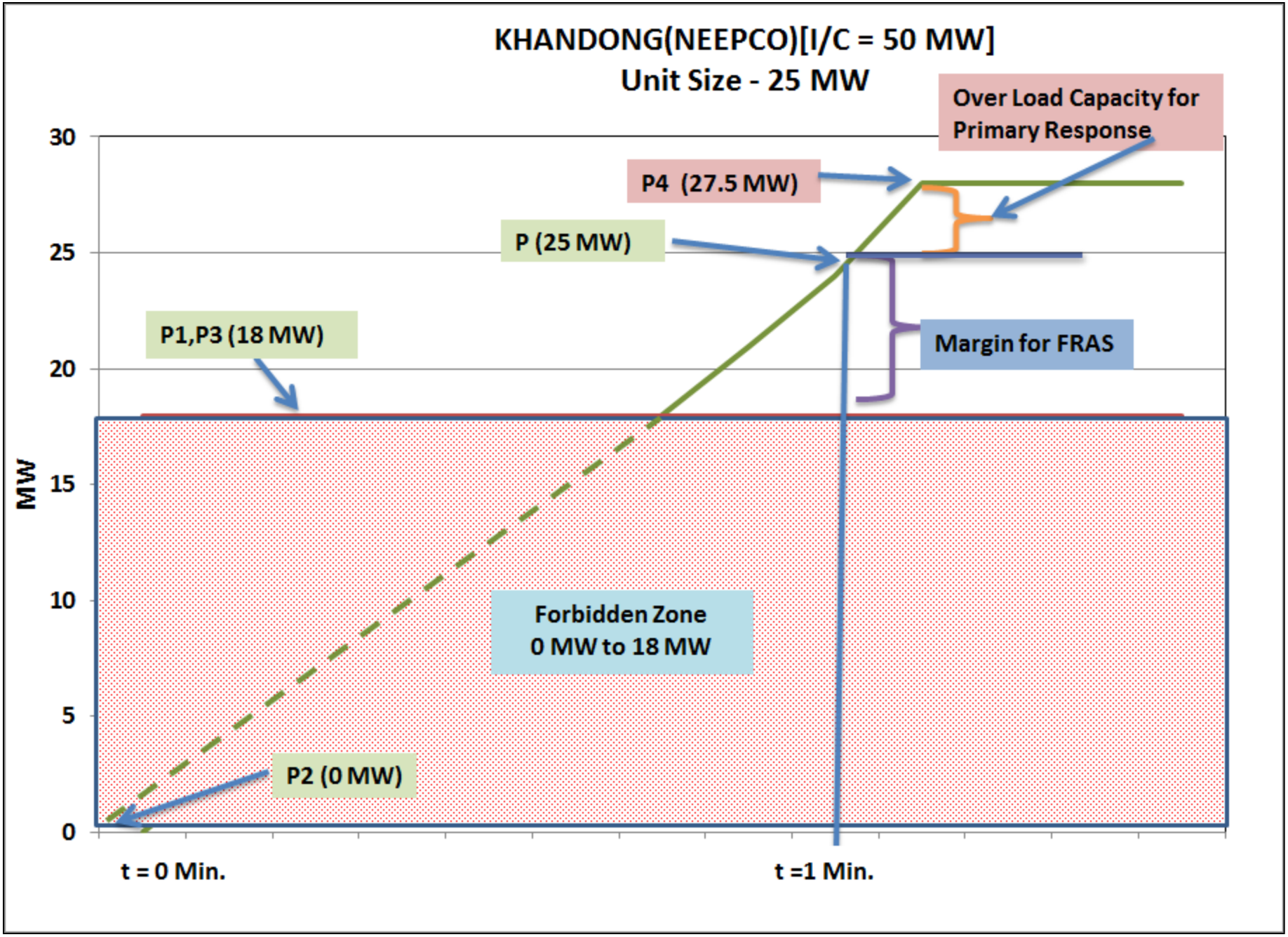
## Other Constraints

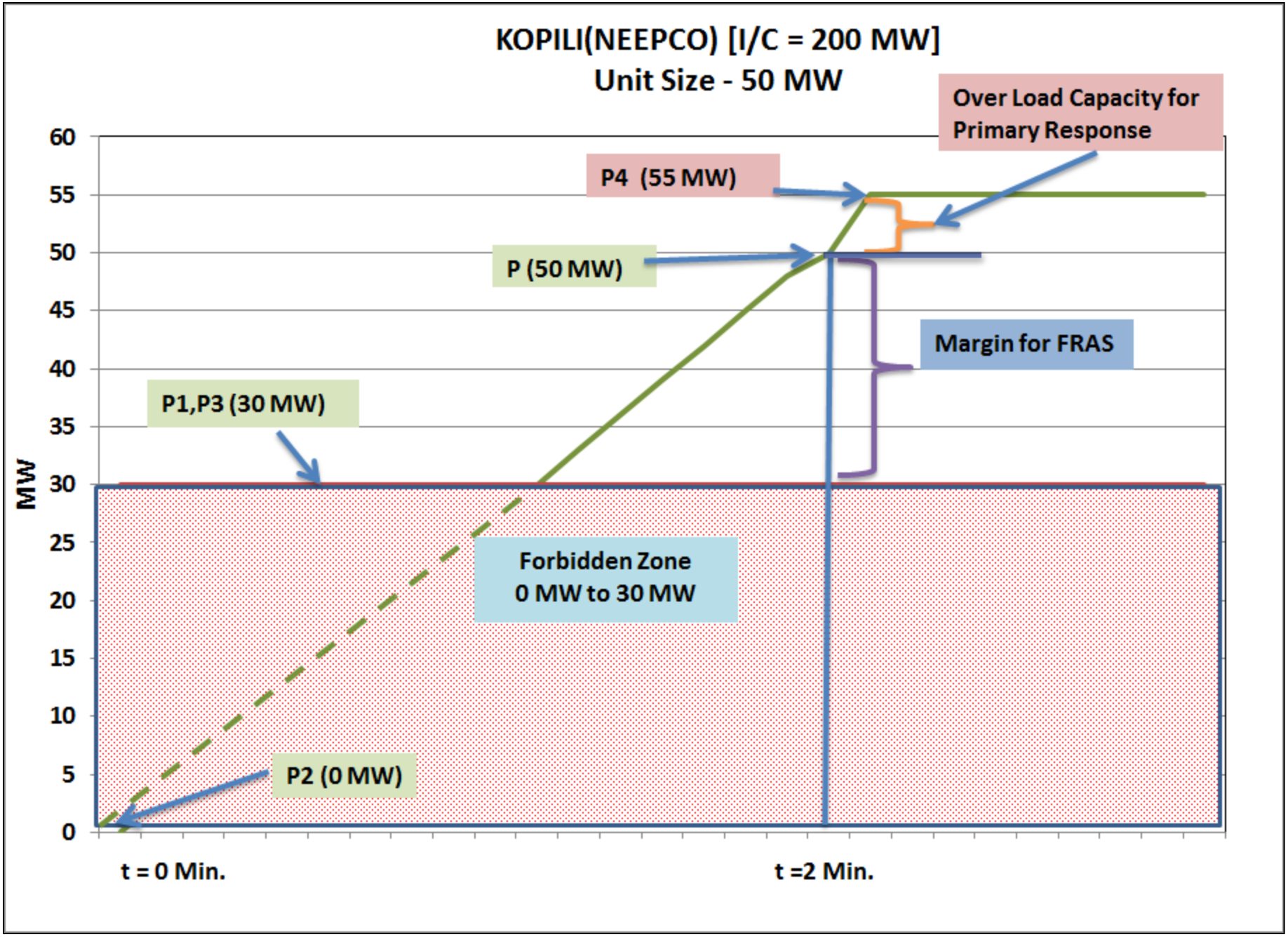
- Khandong is completing normative operative life in April 2019
- Since 2006, the plants are operating with highly acidic reservoir water (pH = 3.5) leading to corrosion of parts

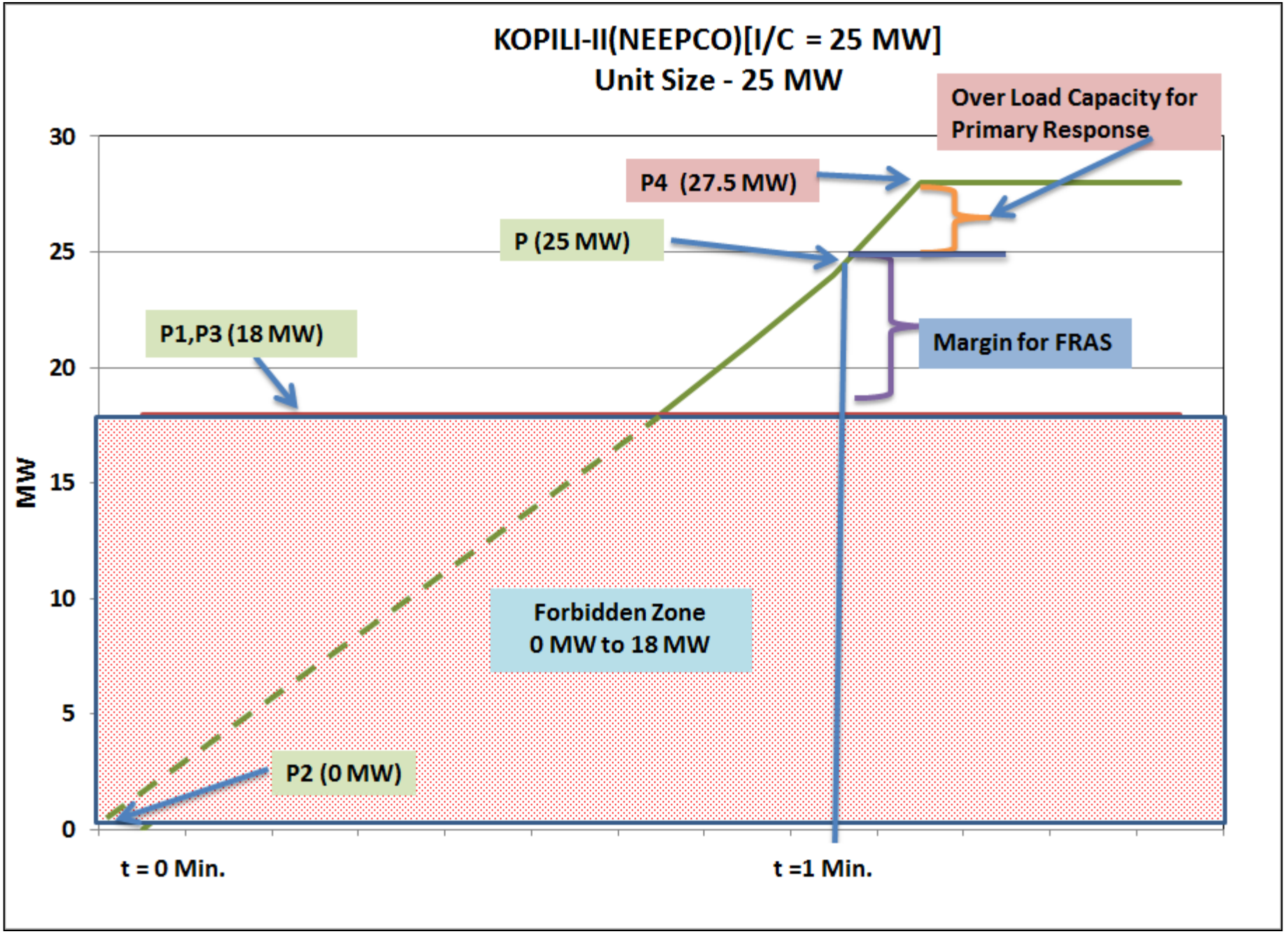
# Kopili, Kopili – II and Khandong



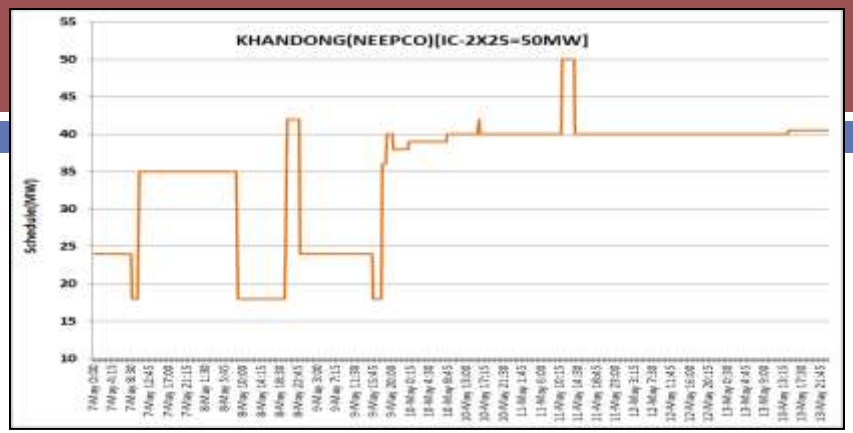

| Salient Features | | |
|---|---|---|
| # | Attribute | Value |
| 1 | Hydroelectric Project Name | Kopili Hydroelectric Project |
| 2 | Hydroelectric Project Name Alias | |
| 3 | State | Assam |
| 4 | Districts | Umrongso |
| 5 | River | Kopili |
| 6 | Basin | Brahmaputra |
| 7 | Hydroelectric Region | North Eastern HE Region |
| 8 | Total Installed Capacity (MW) | 275 |
| 9 | Type of Project | Major (> 25 MW) |
| 10 | Hydroelectric Project Status | Completed |
| 11 | Purpose | Hydroelectric |
| 12 | Owner | Central |
| 13 | Owner Name | NEEPCO |
| 14 | Interbasin | No |
| 15 | Project Sharing | None |
| 16 | Interstate Aggrements | |
| 17 | Intercountry | None |
| 18 | Remarks | |

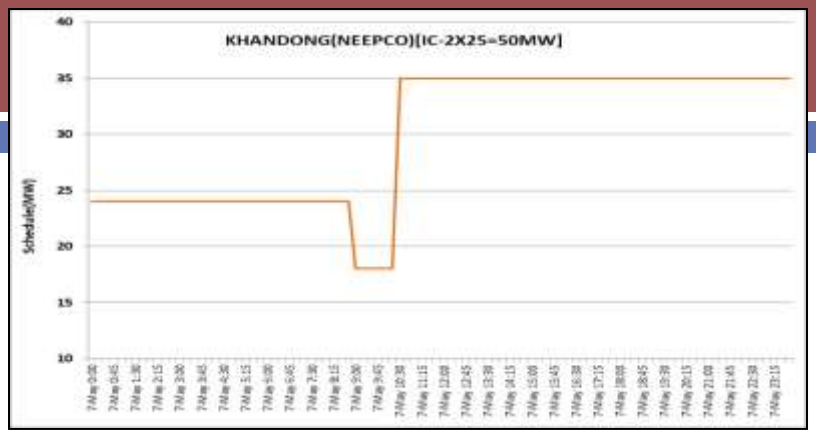

KHANDONG(NEEPCO)[I/C = 50 MW]
Unit Size - 25 MW
Over Load Capacity for Primary Response
P4 (27.5 MW)
P (25 MW)
P1,P3 (18 MW)
Margin for FRAS
Forbidden Zone
0 MW to 18 MW
P2 (0 MW)
MW
30
25
20
15
10
5
0
t = 0 Min.
t =1 Min.

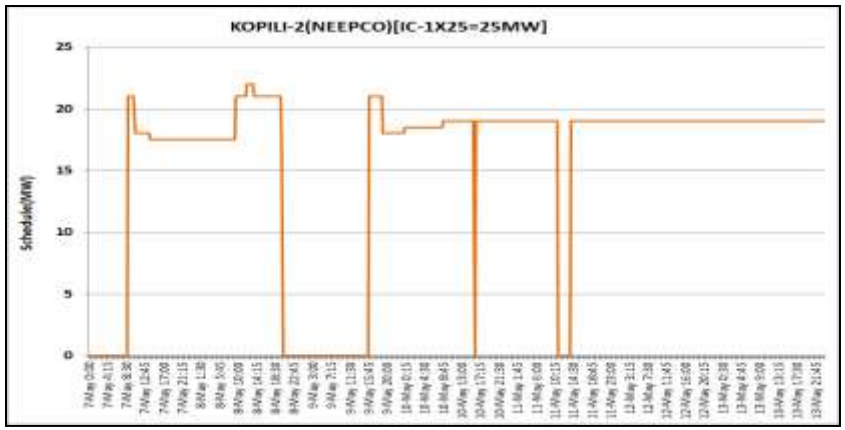

KOPILI(NEEPCO) [I/C = 200 MW]
Unit Size - 50 MW
Over Load Capacity for Primary Response
P4 (55 MW)
P (50 MW)
Margin for FRAS
P1,P3 (30 MW)
Forbidden Zone
0 MW to 30 MW
P2 (0 MW)
MW
60
55
50
45
40
35
30
25
20
15
10
5
0
t = 0 Min.
t =2 Min.

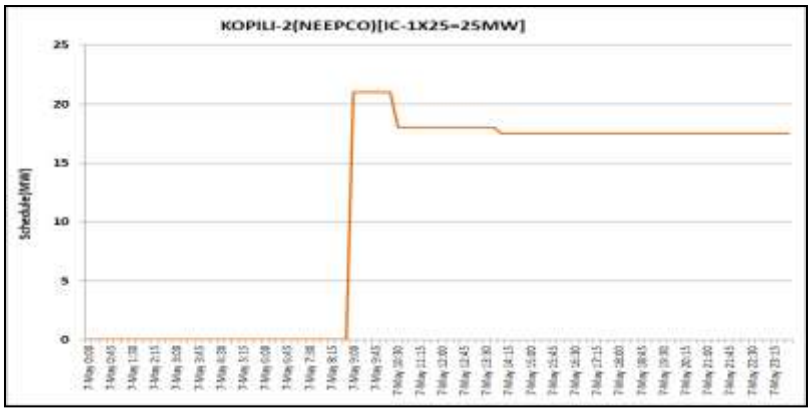

KOPILI-II(NEEPCO)[I/C = 25 MW]
Unit Size - 25 MW
Over Load Capacity for Primary Response
P4 (27.5 MW)
P (25 MW)
P1,P3 (18 MW)
Margin for FRAS
Forbidden Zone
0 MW to 18 MW
P2 (0 MW)
MW
30
25
20
15
10
5
0
t = 0 Min.
t =1 Min.

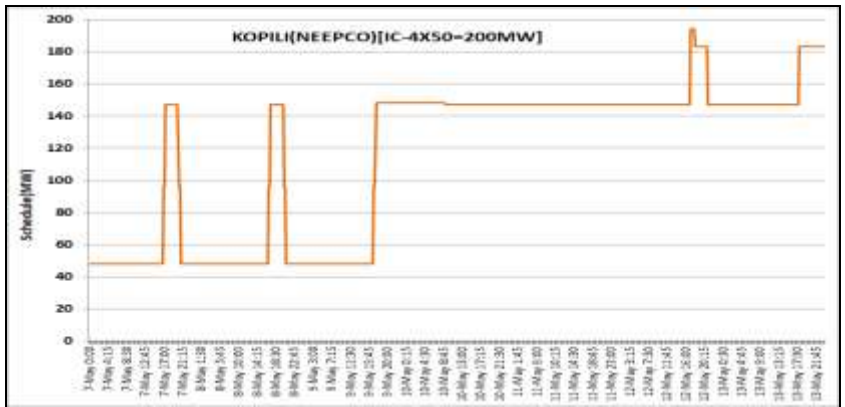
# Khandong, Kopili-II & Kopili Operation – Sample Week & Day

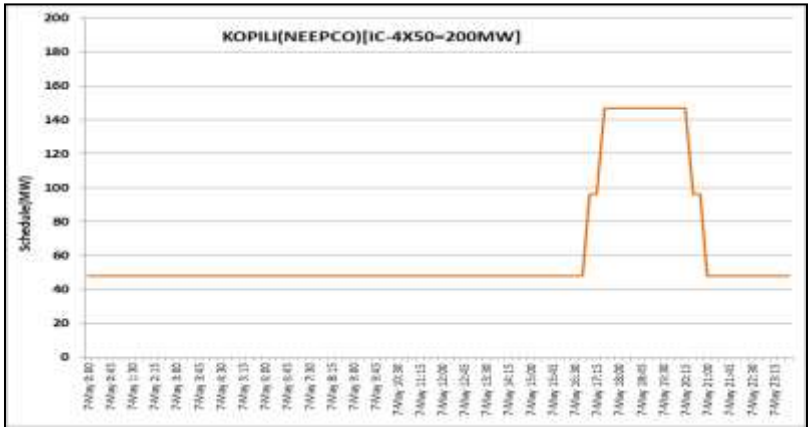


# Cascade Hydro (4)

**Ranganadi**

- 3 x 135 MW (Upstream)
- RoR with 3 hours pondage

**Pare***

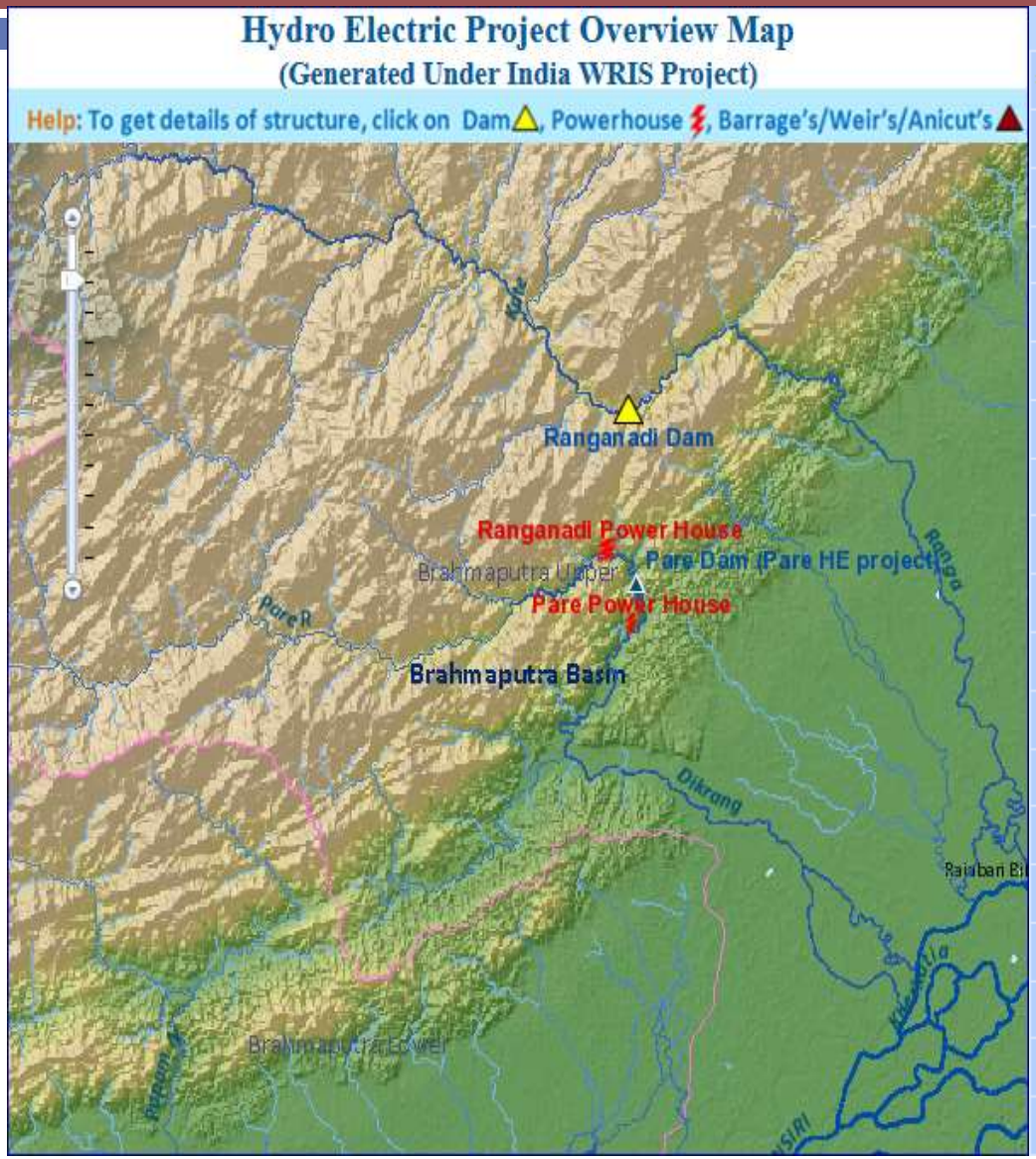
- 2 x 55 MW (Downstream)
- ROR with 8 hours pondage

**Data awaited from NEEPCO*

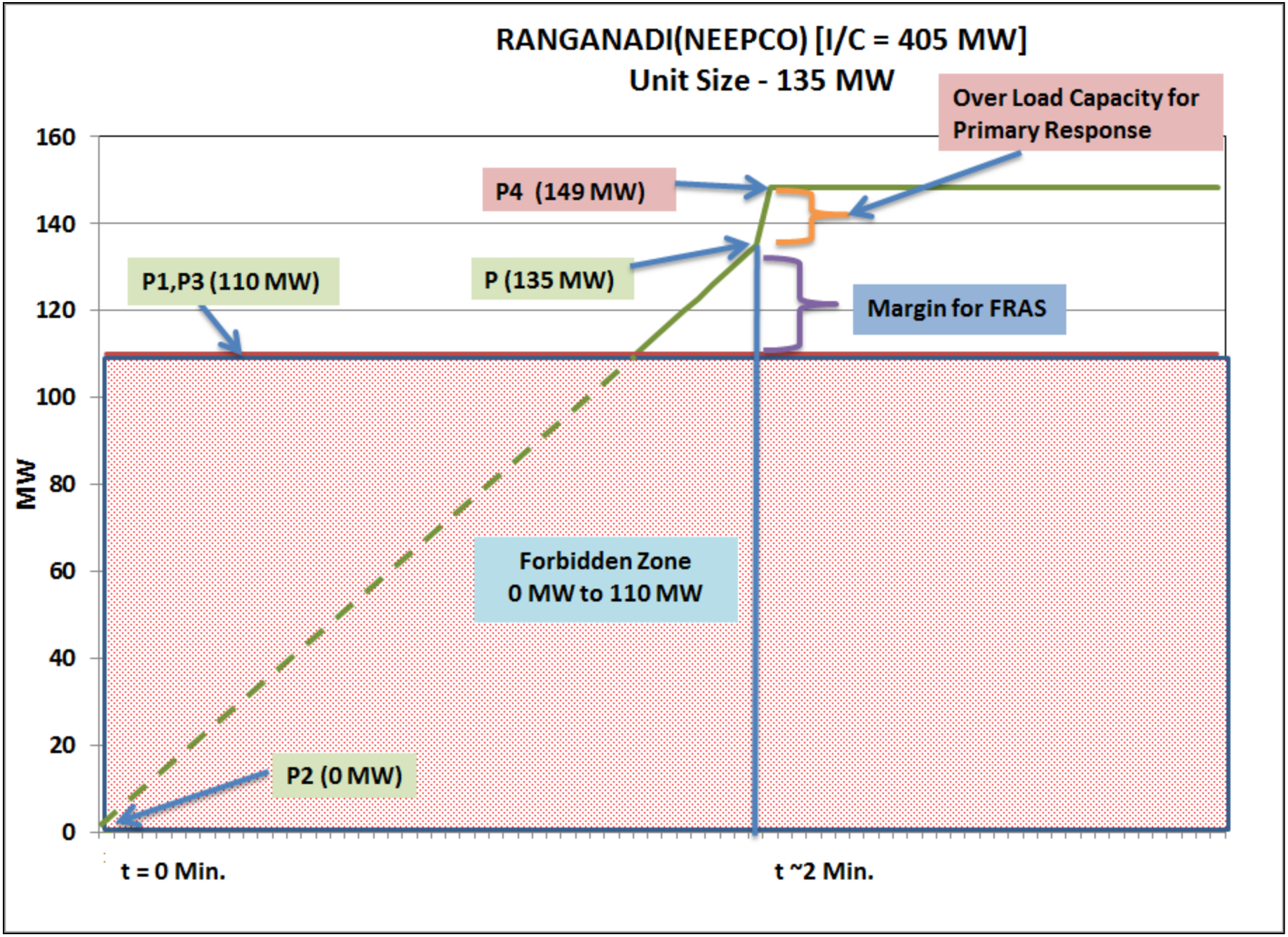
*Pare HEP*

- *Unit 2 – 21st May, 2018*
- *Unit 1 – 28th May, 2018*

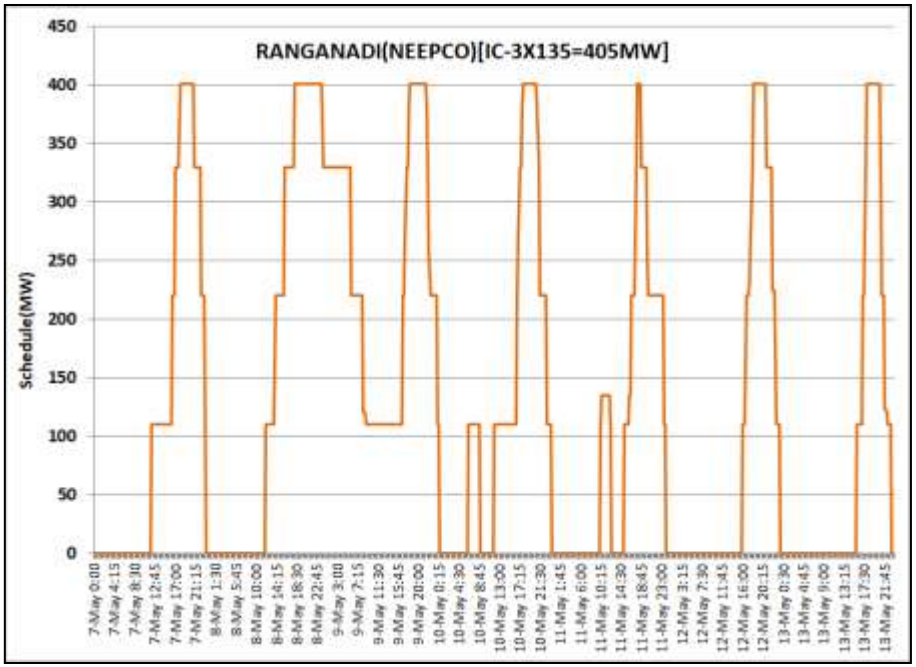
# Ranganadi

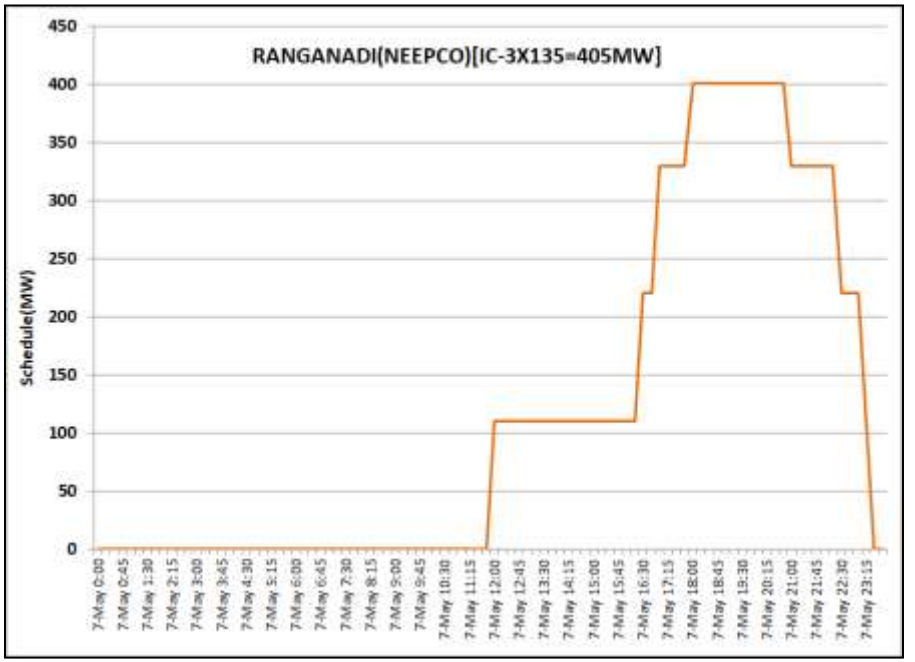



| Salient Features | | |
|---|---|---|
| # | Attribute | Value |
| 1 | Hydroelectric Project Name | Ranganadi Hydroelectric Project |
| 2 | Hydroelectric Project Name Alias | |
| 3 | State | Arunanchal Pradesh |
| 4 | Districts | |
| 5 | River | Ranganadi |
| 6 | Basin | Brahmaputra |
| 7 | Hydroelectric Region | North Eastern HE Region |
| 8 | Total Installed Capacity (MW) | 405 |
| 9 | Type of Project | Major (> 25 MW) |
| 10 | Hydroelectric Project Status | Completed |
| 11 | Purpose | Hydroelectric |
| 12 | Owner | Central |
| 13 | Owner Name | NEEPCO |
| 14 | Interbasin | No |
| 15 | Project Sharing | None |
| 16 | Interstate Aggrements | |
| 17 | Intercountry | None |
| 18 | Remarks | |


RANGANADI(NEEPCO) [I/C = 405 MW]
Unit Size - 135 MW
Over Load Capacity for Primary Response
P4 (149 MW)
P1,P3 (110 MW)
P (135 MW)
Margin for FRAS
Forbidden Zone
0 MW to 110 MW
P2 (0 MW)
MW
160
140
120
100
80
60
40
20
0
t = 0 Min.
t ~2 Min.

# NEEPCO…..(1)


RANGANADI(NEEPCO)[IC-3X135=405MW]
Schedule(MW)
450
400
350
300
250
200
150
100
50
0


RANGANADI(NEEPCO)[IC-3X135=405MW]
Schedule(MW)
450
400
350
300
250
200
150
100
50
0

# Pondage Based HEPs

- No Upstream/Downstream HEPs affected

| HEP | Remarks |
|---|---|
| NTPC Koldam (4 x 200 MW) | Reservoir Level be maintained between 637 - 642 m |
| NHPC Loktak (3 x 35 MW) | Siren is to be blown 30 min before starting of each unit during lean season |
| NHPC Rangit (3 x 20 MW) | |
| NHPC Teeta-V (3 x 170 MW) | |
| NHPC Bairasuil (3 x 60 MW) | |
| NHPC Chamera – 1 (3 x 180 MW) | |
| NHPC Dulhasti (3 x 130 MW) | |
| NHPC Dhauliganga (4 x 70 MW) | |
| NHPC Sewa – II (3 x 40 MW) | |
| NHPC Parbati – III (4 x 130 MW) | 1. Siren is to be blown 30 min before starting of each unit during lean season.<br>2. Full Inflow shall be available after commissioning of Parbati-II HEP |

# Summary

- There is minimal operational constraint regarding FRAS despatch from reservoir/pondage based stations.
- There is minimal impact on the state sector HEPs on account of FRAS despatch in the central sector plants.
- All those constraints shall be honoured during despatch of FRAS which, at present, are being considered while scheduling of hydro plants by respective RLDCs.

# A Small Step for Hydro

# A Giant Leap for Indian Power System

Thank You !