MINUTES OF EIGHTEENTH MEETING OF "TECHNICAL COMMITTEE FOR IMPLEMENTATION OF FRAMEWORK ON RENEWABLES AT THE STATE LEVEL"

Venue	:	Upper Ground Floor, CERC New Delhi
Date	:	23-02-2018
List of Participants	:	At **Annexure – 1(Enclosed)**

1. The Eighteenthmeeting of Technical Committee on Implementation of Framework for Renewables at the State level was held under the Chairmanship of Mr. A. S Bakshi, Member, CERC on 23rd February 2018.Mr.Bakshi welcomed all the participants and the special invitees. Chairman, CERC also attended the meeting . Shri Bakshi briefed Chairman, CERC about the background and scope of the Technical Committee and highlighted various activities which have been carried out by the Committee.

2. Dr. Sushanta.K.Chatterjee, Joint Chief (RA), CERC welcomed all the participants and special invitees including Mr. P.K Pujari, Chairman CERC and gave brief background of the Technical Committee. Further, he highlighted the agenda items scheduled for the meeting.

Discussions on the Agenda

1. Agenda Item No. 1: Status of implementation of SAMAST Report

- **Update by Consultant for Haryana & Punjab**
- **Update in respect of other States by respective Members**
- **Energy Accounting System in States/UTs other than those represented in the Committee (UTs of Andaman & Nicobar Islands, Puducherry, Daman & Diu etc.).**

a. The Consultant (Idam Infra) made a presentation**(Annexure-II)** on the status of implementation of SAMAST in Haryana and Punjab.

b. **Haryana:** The Consultant briefed the Committee that DPR for SAMAST implementation in Haryana has been approved by the management of HVPNL. HVPNL would submit DPR before Appraisal Committee at the earliest. The Consultant also presented the salient features of approved budgetary cost estimates of DPR for SAMAST implementation in Haryana. The total estimated cost is about Rs. 32.93 Cr which includes the Hardware – Metering

infrastructure, Software, Communication Components, Training & Capacity building.

c. **Punjab:**The Consultant highlighted that they have circulated the draft templates for budgetary cost estimate and sample DPR template to Punjab SLDC. During the Special Meeting on 19th Jan 2018 at Chandigarh, the salient features of DPR and budgetary cost estimates for SAMAST implementation in Punjab were presented. Punjab SLDC highlighted the issues/ challenges in finalization of draft DPR, which were discussed in detail. Based on inputs, Punjab SLDC is in process of revising DPR and shall put up for approval of management.

d. Further, the consultant apprised the Committee on the status of West Bengal. It was informed that the DPR for SAMAST has been submitted to Appraisal Committee in 22.12.2017 to avail grant/funding support through PSDF. The total estimated cost is about Rs. 26 Cr which includes the Hardware – Metering infrastructure, Software, Communication Components, Training & Capacity building.

e. Mrs. Neerja Mathur, Member, JERC, updated about the operationalization of SLDCs, RE and Open Access status for Andaman & Nicobar Islands, Puducherry, Daman& Diu. Further, she requested the Committee to provide support for SAMAST implementation in Union Territories. It was also discussed to link each UT to nearest RPC so as to provide them hand holding support and strengthen their respective Load Dispatch Centers.

f. Mr. P. Ramamohan, Member, APERC informed the Committee that a writ Petition has been filed before High Court by some developers challenging F&S Regulations of AP and similar petition has been filed before the Karnataka high court.

g. POSOCO highlighted the need of imparting training of specialized courses to the SLDCs staff to augment and strengthen the Load Dispatchers

Action points/ Decisions

i) The Consultant to assist JERC in implementing SAMAST framework in UTs.

ii) A Subgroup will be formed for Training and Capacity Building of SLDC Staff. The Sub Group will be chaired by Mr. S.K Soonee, Advisor - POSOCO and Mrs. Shilpa Aggarwal, Joint Chief (Engg.) – CERC, will be Member Secretary of the same. Initial Members of this Sub Group will be SLDCs of Member States of Technical Committee. Later, the Sub-group will be extended to other states also.

iii) To promote higher participation of SLDC Staff, it was proposed to incentivize those candidates who clear the exam/certification. LDC Funds can be utilized for the same, post approval from CERC.POSOCO also highlighted the difficulty in

getting adequate number of persons for LDC training because of the requirement of an undertaking that the officer would not be shifted out from SLDC for a specified period. It was agreed that Commission may be requested to have a relook at this requirement

iv) For Best Practices of DSM Implementation at State Level, POSOCO, at FOLD Platform, will be organizing meetings with different States to present on the same. The first meeting/presentation is scheduled for 26 March 2018 for the State of Gujarat.

v) Member, APERC to provide a copy of the Petition filed before AP High Court to analyze on what points the F&S Regulations of the State have been challenged.

2. Agenda Item No. 2: Status of implementation of Regulations on Forecasting, Scheduling and Deviation Settlement

a. The Consultant made a presentation (attached as Annexure-II) on the status of implementation of Regulations on Forecasting, Scheduling and Deviation Settlement in Tamil Nadu, Punjab, Haryana and Telangana.

b. **Tamil Nadu:** - TNERC had published draft F&S and DSM Regulations on 28th December 2017 for public comments up to 27thJanuary, 2018. TNERC is currently scrutinizing public comments received on draft F&S and DSM Regulations. TNERC, in consultation with the Consultant will finalize the Draft F&S and DSM Regulations.

c. **Punjab:** The Consultant briefed the Committee that they have shared draft F&S Regulations to PSERC and the Consultant attended various discussions at PSERC, Chandigarh. PSERC published the draft F&S Regulations for public consultation and invited comments till 22ndFebruary, 2018.

d. **Haryana:** The Consultant apprised the Committee that HERC has published draft F&S Regulations for public consultation and invited comments till 12thFeb, 2018. HERC is currently scrutinizing public comments received on draft F&S Regulations.

e. **Telangana:** The Consultant circulated draft F&S Regulations to TSERC on the lines of Model F&S Regulations and highlighted key points that would require further deliberations considering Telangana specific wind/solar power development. Further inputs were provided by TSERC and the revised F&S Regulations were circulated on 25th January 2018. TSERC is in process of finalizing and publishing draft F&S Regulations on their website for public comments

Action points/ Decisions

i) TNERC would finalize draft F&S Regulations and DSM Regulations after addressing public comments.

ii) TSERC, HERC and PSERC would finalize draft F&S Regulations after addressing public comments.

3. Agenda Item No. 3: Dr. S K Chatterjee, JC (RA), CERC on Load/Generation Management – Intra Day (Options for Handling Variation including in RE): Context - Regional Co-Operation For RE Integration

a. Dr. Chatterjee presented on the Load/Generation Management – Intra Day (Options for Handling Variation including in RE) (attached as **Annexure-III**). He gave the background on the matter relating to Regional Co-operation for RE Integration. He highlighted that during the 12thmeeting of the Technical Committee it was discussed that there is a need for cooperation among States for Optimum Utilization of Resources. Sub-Groups of RE rich regions (NR, WR & SR) headed by Member Secretaries of RPCs were formed to examine the feasibility and modality of cooperation for optimum utilization of generation resources with least cost options. The RPCs held various meetings in their regions to discuss this issue, which was followed by meeting of the Heads / Representatives of the Sub-Groups was convened under the Chairmanship of Mr.A.S.Bakshi. During that meeting it emerged that States have their own inhibitions on Co-operation with other States and have recognized the value of electricity vis-à-vis the cost of generation. Further, the Regions have their own reserves for co-operation.

b. Dr. Chatterjee highlighted that during the 14th Meeting of the Technical Committee, a presentation was made on the options for Intra Day transactions. Further, he elaborated on the 7 options (as listed below) for Intra Day/Hour Ahead transactions and the pros and cons of all these options were discussed.

- Option 1: Banking – Already taking place between states. When there is higher generation in one State, it banks its power with the other and gets the same quantum of energy when it has high demand.
- Option 2: Power Exchange (DAM price as reference) - The reference price in this case is taken as the Day Ahead price on the power exchange.
- Option 3: Pool based on Variable Cost (VC) as approved by the Regulator and on payment of variable cost.

- Option 4: Pool based on VC as approved by the Regulator and on payment of Marginal Cost

Options 5, 6 and 7 are based on the auction

- Option 5: Pool based on auction for intra-day for the rest of the day
- Option 6: Pool based on auction for intra-day on hourly basis
- Option 7: Pool based on auction for intra-day on intra-hour basis i.e for 15 min. block-wise

c. It was highlighted that 3 RPCs have provided their feedback (NRPC, WRPC and SRPC) and have recommended Option 5 to begin with. However, the concept of Gate Closure will still be mission in Option 5. Dr. Chatterjee, highlightedthat various international markets have the concept of Gate Closure which can be introduced with Option 6 if implemented. Sh. Sooneeand POSOCO also recommended to initiate the market with Option 6 as the concept of Gate Closure is a must for successful operation of a market.

d. Dr. Chatterjee underscored that to make such market a success, the DISCOMs decision making process needs to be enhanced. For Real Time Market, the man on the desk needs to be provided sufficient authority to make the decisions on behalf of the DISCOM. Further, the need for development of OA registry was also highlighted. Without OR registry being operational online, operationalization of Option6 would be difficult.

Decisions

i) The members of the Committee unanimously decided to go ahead with Option 6 i.e. Pool based on auction for intra-day on hourly basis. Post getting confidence in operating Option 6, operation of Option 7 can be explored. Recommendations should be made to CERC for necessary amendments in relevant regulation (IEGC, Power Markets, etc.,) to introduce this market. Further, the same will be referred to the Forum of Regulators.

ii) On OA Registry, POSOCO was advised to submit their inputs on the same in 2 weeks' time to CERC Sectt., so as to prepare a roadmap on the same. It was informed that Deloitte could assist in developing software for OA registry.

4. **Agenda Item No. 4: Presentation on Introduction of Fast Response Ancillary Services (FRAS) From Hydro Generating Stations, followed by Discussion with Central Hydro Generators on implementation of Hydro as FRAS**

Discussion

a. Mr.. S C Saxena, DGM, POSOCO presented on Introduction of Fast Response Ancillary Services (FRAS) from Hydro Generating Station (attached as Annexure IV). Background and status of Ancillary Services implementation was provided.

b. 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.

c. The schematic of System Balancing in India was discussed highlighting the need of niche product for Fast Tertiary. The key learnings and the challenges of Ancillary Services were also discussed. The issues pertaining to hydro scheduling like, Energy Limited Resource, Other Commitments, Zero Marginal Cost etc were also deliberated.

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

e. The proposal of utilizing Hydro as FRAS and the related issues were presented covering various important parameters like, Scheduling, Accounting and Settlement, Squaring off of Net Despatched Energy, Operational difficulties etc.

Decisions

i) The representatives from hydro generating stations sought some more time to understand the agenda and then provide their feedback on Hydro as FRAS. It was decided that special meeting of Hydro Generators along with POSOCO may be schedule to discuss this agenda. Further, it was decided that this meeting will be chaired by Chairperson, CERC.

5. Agenda Item No. 5:

(i)Presentation by GIZ on Analysis of Indian Electricity Distribution Systems for the Integration of High Shares of Rooftop PV

Discussion

a. Mr.Joerg Gaebler from GIZ and Mr..Eckehard Troester from Energynautics presented on the Analysis of Indian Electricity Distribution Systems for the Integration of High Shares of Rooftop PV (attached as **Annexure-V**)

b. They presented on the study which was carried out with the help of consulting support from Energynautics GmbH and piloted in the networks of two Discoms i.e. BSES Rajdhani Power Limited and Madhya Pradesh Madhya Kshetra Vidyut Vitaran Company Limited.

c. Results of software simulations for high penetration scenarios and analysis of impact on voltage and loading across network elements starting from LT to HT network were presented.

d. It was concluded that the PV systems with an aggregated capacity of up to 75% of the transformer rating can usually be connected without any further measures and in most cases 100% are actually possible.

Decisions

i) The Committee advised GIZ to widen the studies to all DISCOMs. It was also felt that feedback of DISCOMs is to be sought on the presentation and the presentation of GIZ is to be shared with all the SERCs/JERCs.

ii) It was informed that E&Y is also doing a similar study on Solar PV supported by World Bank as that of GIZ but more on Techno-commercial side. A separate meeting with some DISCOMs can be arranged along with the EY representatives.

iii) POSOCO was advised to study the impact of Roof top Solar PV on the national grid and loading of transformers

(ii) Presentation by KfW on Energy Portfolio in India and Financing prospects for Storage/Hydro with relevant stakeholders

a. Mr. Stefan from KfW presented on the KfW's Energy Portfolio in India and Financing prospects for Storage/Hydro with relevant stakeholders (attached as Annexure – VI). He gave the background of the KfW and the Germany-India partnership.

b. It was highlighted that the Government of Germany envisages to extend concessional loans to India in the range of EUR 1 billion (INR 7500 crore) until 2020 through KfW. Another milestone in the cooperation between India and Germany is the Green Energy Corridors Programme (GEC) where KfW on behalf of the German Government is financing more than EUR 1 billion for interstate and intrastate transmission infrastructure. KFW also has two ongoing financed projects in Hydro sector with capacity of 450 MW and 110 MW in the State of Himachal Pradesh and Arunachal Pradesh, respectively.

c. Further, it was underscored that German Government has already committed to fund for 120 Million Euro for Renewable Energy Power Plant/ Storage projects and 200 Million Euro for Hydro Power projects in Himalaya region. KfW could support an implementation of such applicable measures in the Indian generation, transmission and distribution grid, e.g. integration of renewable energy production, grid adaption measures including energy storage systems, etc. for other States/Regions also.

6. Agenda Item No. 6: Status Update On Sub-Group for Implementation of 5-Minute Scheduling, Metering, Accounting And Settlement

Discussion

a. Mr. S C Saxena, DGM, POSOCO presented the Sub-Group Report on Sub-Group for Implementation of 5-Minute Scheduling, Metering, Accounting And

Settlement(attached as **Annexure – VII**). Background of the Sub-Group and the activities carried out were also presented.

b. Mr. Saxena highlighted the CERC ABT Order dated 4th Jan 2000 under which the 15 Minutes time interval was introduced for the first time which was debated against 30 Minutes and 1 hour time interval.

c. Further, development in other sectors like Airlines, Banking, Railways etc were highlighted which have updated their time interval to shorter duration for sharing data/information.

d. Benefits of 5 minutes scheduling Vs 15 minutes scheduling were underscored. Various Policy/Regulatory mandates like, NITI Ayog Report - India's Renewable Electricity Roadmap 2030 (2015), SAMAST, FOR Model DSM Regulations, etc which highlights the importance of 5 minutes scheduling, metering and accounting were highlighted.

e. Case Study of Australia was presented which introduced 5 minutes despatch in 1998. However, the settlement was carried out for 30 minutes interval by averaging out prices of six (6) 5-minutes interval. Now they have aligned the settlement with the 5 minutes dispatch. Examples from USA markets which have 5-minutes time interval for dispatch were also highlighted.

f. Deliberations of the Sub-group meetings were also highlighted and the amendments in the CEA Metering Standards, which are envisaged as the very step for implementation were discussed. It was underscored that the Metering Standards have been long pending with CEA.

g. Sub-group held meeting at the Magarwada and Vadodara Sub-station with the representatives of NLDC, WRLDC, Powergrid, Gujarat SLDC and meter manufacturers (Honeywell, Elster, Secure and L&T). It was underscored that most of the new meters are compatible to switch to 5 minutes interval and require only a software update however, the old meters (older than 10 years) will be required to be replaced.

h. Further, POSOCO listed the regulations which will require amendments for implementing 5-minutes Scheduling, Metering, Accounting and Settlement. Recommendations of the report and the Action plan for implementing it was also provided.

i. Requirement of total number of interface meters and the associated cost at national level was also deliberated.

j. Timelines of activities from carrying out Pilot project in June 2018 to Going live by April 2020 was also highlighted.

Decisions

i) The Committee adopted the Report on 5 Minutes Scheduling, Metering, Accounting and Settlement and the timelines proposed in the report were reviewed. POSOCO to prepare a PERT chart for the timelines of all related activities alongwith details of which activities are dependent on which utilities

ii) For Technical Standards of RE, a letter to be written to Secretary- Power to expedite theRegulations on Technical standards from CEA.

iii) CERC to come out with a Suo Moto Order and on its basisPOSOCO to carry out atleast 1 Pilot on 5 Minutes Scheduling Metering, Accounting and Settlement in each region.

iv) POSOCO to prepare estimation of cost and quantum of meters required alongwith the basis to quantify the benefit of moving to 5 minutes from 15 Minutes.A Scheme is also required to be prepared to seekfunding for Statespost approval of FOR.

v) CERC should evolve Staff Paper/Draft Regulations for introduction of 5 Minutes Scheduling, Metering, Accounting and Settlement.

GENERAL:

1. It was decided that Chairperson, FOR would be requested to write to MOP for early release of funds for implementation of Samast report wherever schemes have been approved.

2. Other issues like Inertia in the system, QCA related issues, State Power Committees, need for a study on energy storage vs hydro vs thermal , Peak off peak tariff , need to encourage PSS etc would be taken up in the next meeting of the Technical Committee as these could not be taken up due to shortage of time.

3. CEA would be requested to expedite Technical standards (particulary those relating to LVRT, HVRT) for renewable power.

4. Meeting ended with thanks to the Chairperson, CERC for having spared his time for this meeting.

Annexure-1

LIST OF PARTICIPANTS AT THE EIGHTEENTHMEETING OF THE TECHNICAL COMMITTEE FOR "IMPLEMENTATION OF FRAMEWORK ON RENEWABLES AT THE STATE LEVEL" HELD ON 23.02.2018 AT CERC, NEW DELHI

1	Mr. P.K. Pujari, Chairperson	CERC, FOR
2	Mr. A. S. Bakshi, Member	CERC
3	Dr. M.K Iyer, Member	CERC
4	Mr. Ismail Ali Khan, Chairperson	TSERC
5	Mr. S. Akshaya Kumar, Chairperson	TNERC
6	Mr. Rabindra Nath Sen, Chairperson	WBERC
7	Mr. P. Rama Mohan, Member	APSERC
8	Mr.P.J. Thakkar, Member	GERC
9	Mr. R.P. Barwar, Member	RERC
10	Mrs.Neerja Mathur, Member	JERC
11	Mr. S.C. Srivastava, Chief Engg.	CERC
12	Mrs. Geetu Joshi, Chief Eco.	CERC
13	Dr. S.K. Chatterjee, JC(RA)	CERC
14	Ms. Shilpa Agarwal, JC (Engg.)	CERC
15	Mr. J S Bawa, Chief Engg.	CEA
16	Mr. S K Soonee, Advisor	POSOCO

17	Mr. K.V.S Baba, CMD	POSOCO
18	Mr. S.S Barpanda, GM	POSOCO-NLDC
19	Mr. P.K. Agarwal, Dir.	POSOCO
20	Mr. S.C Saxena, DGM	POSOCO-NLDC
21	Mrs. Rashmi Nair, DC(RA)	CERC
22	Mr.Rajasakher Devaguptapu, REO	FOR, CERC
23	Mr. Jogender Behera, Advisor Eco	CERC
24	Mr. Siddharth Arora, RO	CERC
25	Mr. KVN Pawan Kumar, Dy. Mgr.	POSOCO-NLDC
26	Mr. Ajit Pandit, Director	Consultant
27	Mr. Abhishak Dixit	Consultant
28	Mr. Shir Muhar Mani	THDCIL
29	Mrs. Anu Gautam	BBMB
30	Mrs. Pooja Gupta	BBMB
31	Mr. Janardan Choudhary	NHPC
32	Mrs. Manisha Shrivastava	NHPC
33	Mr. Abhishak	NHPC
34	Mr. Naresh Bansal	NHPC
35	Mr. S.P. Rathour	NHPC

36	Mr. Joerg Goebler	GIZ
37	Mr. Sandeep Goel	GIZ
38	Mr.EckehardTroester	Energynautics
39	Mr. Stefan	KFW
40	Nisteeth Shrivastava	KFW

Idam Infrastructure Advisory Pvt. Ltd.

Agenda Item-1 & 2

Status update on SAMAST implementation and draft F&S/draft DSM Regulations in Tamil Nadu, Haryana, Punjab, Telangana and West Bengal

18th Meeting of FOR Technical Committee

February 23, 2018

The engagement of Consultant for support to FOR and its Technical Committee is supported under USAID/GTG-RISE initiative through Deloitte.

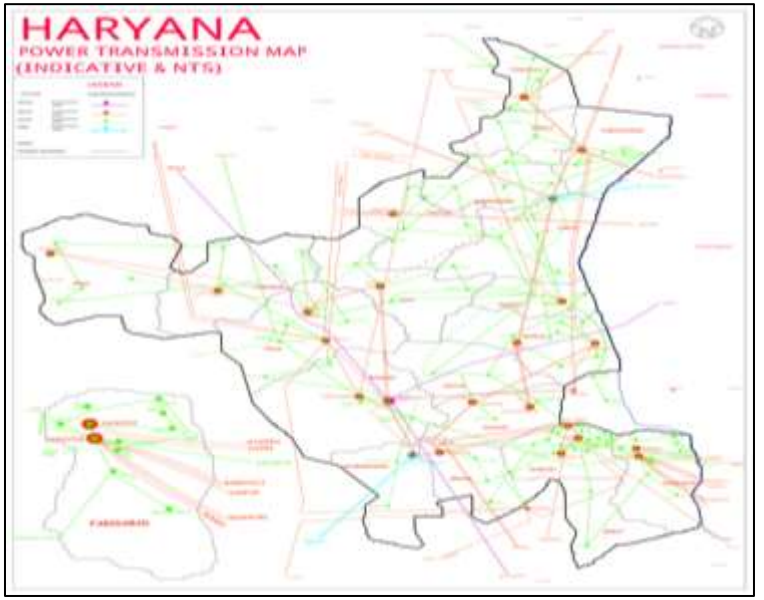
Overview of Activities for TA support for States

States	Activities
Haryana	- DPR for SAMAST implementation in Haryana - Draft F&S Regulations - Draft DSM Regulations - Draft Scheduling & Despatch Code for Haryana
Punjab	- DPR for SAMAST implementation in Punjab - Draft F&S Regulations
Tamil Nadu	- Draft F&S Regulations - Draft DSM Regulations
Telangana	- Draft F&S Regulations

Haryana

- During the meeting of **sub-group of Technical Committee on 19.1.2018**, the Draft DPR for SAMAST implementation prepared consultant was discussed in detail.
  - Metering requirement (T<>D) – Main/Check
  - Inclusion of DOA metering points and projections for Future Ready system
- Based on discussions, HVPN revised the Draft DPR. **The DPR is approved by the management of HVPN.**
- **HVPN is in a process of submitting the DPR to PSDF funding appraisal committee.**
- The Consultant circulated draft F&S Regulations, draft DSM Regulations and Draft Scheduling & Despatch Code for Haryana.
- HERC published the draft F&S Regulations, public comments were invited upto 12.2.2018.

Next Steps:
- Finalisation of F&S Regulations upon addressing stakeholder comment.



Summary of Key Cost Components (INR in Lakh)	
Hardware component-I	1494.35
Hardware component-II	233.00
Software component	544.00
Communication component	475.00
Infrastructure component	25.00
Training, Capacity Building & Annual Operating Cost	216.00
Contingency (est @ 3% on Metering and @5% on other cost)	119.48
Project Management and consultancy	186.41
GRAND TOTAL	**3293.24**

Cost-Estimate - Hardware-Metering infrastructure	1539.17
Cost-Estimate - Communication Component	498.75
Cost-Estimate - Software, Hardware-II, Infrastructure, Training & Capacity Building – SAMAST	1068.90
Project Management and consultancy	186.41
COST ESTIMATE GRAND TOTAL(INR in Lakh)	**3293.23**

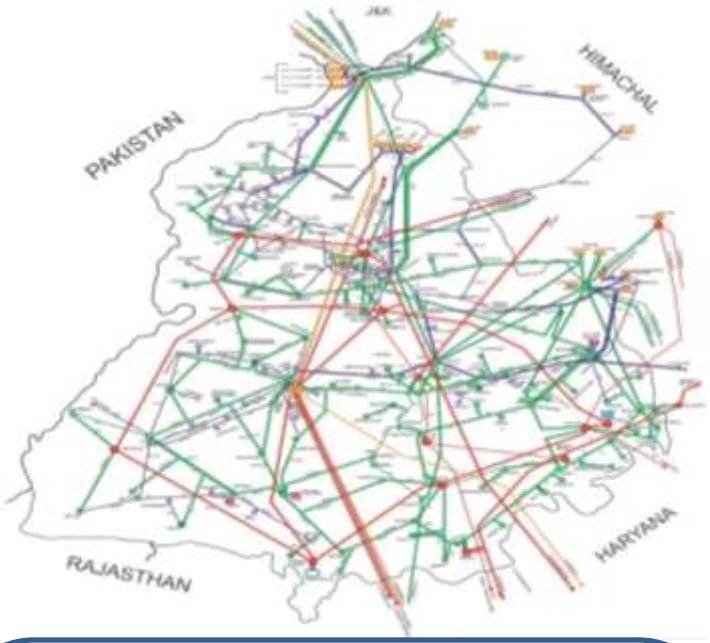
Regulatory Developments:
- Haryana falls under **Category 'B'** of SAMAST report (Deviation Settlement only for Open Access Consumers)
- Generators payment on actual basis
- MYT Tariff Regulations, 2012 specifies determination of Capacity Charge and Energy Charge of generators
- State Electricity Grid Code,2009 and its amendments
- HERC Open Access Regulations 2012, specifies treatment to the Deviation of OA generators/consumers

Punjab

- A meeting was organized in PSERC on 4-1-2018 with PSTCL, PSPCL and consultant to discuss implementation of SAMAST in the State
- Based on discussion during meeting Consultant prepared and circulated the Draft DPR for SAMAST implement in the State
- **During the meeting of sub-group of Technical Committee on 19.1.2018, the Draft DPR was discussed in detail.**
  - Interface point (T<>D) definition for EHV S/S
  - Projection of interface/metering requirement for future ready system.
- Based on discussions during the meeting Punjab SLDC is revising the DPR. The revised DPR will be submitted for management approval.
- The Consultant prepared draft F&S Regulations and DSM Regulations. Draft F&S Regulations was discussed with PSERC.
- PSERC, published the draft F&S Regulations for public comments (last date 22.2.2018)

Next Steps:

- PSERC is awaiting for public comments on draft F&S Regulations.
- DPR preparation by PSTCL/SLDC is currently underway.

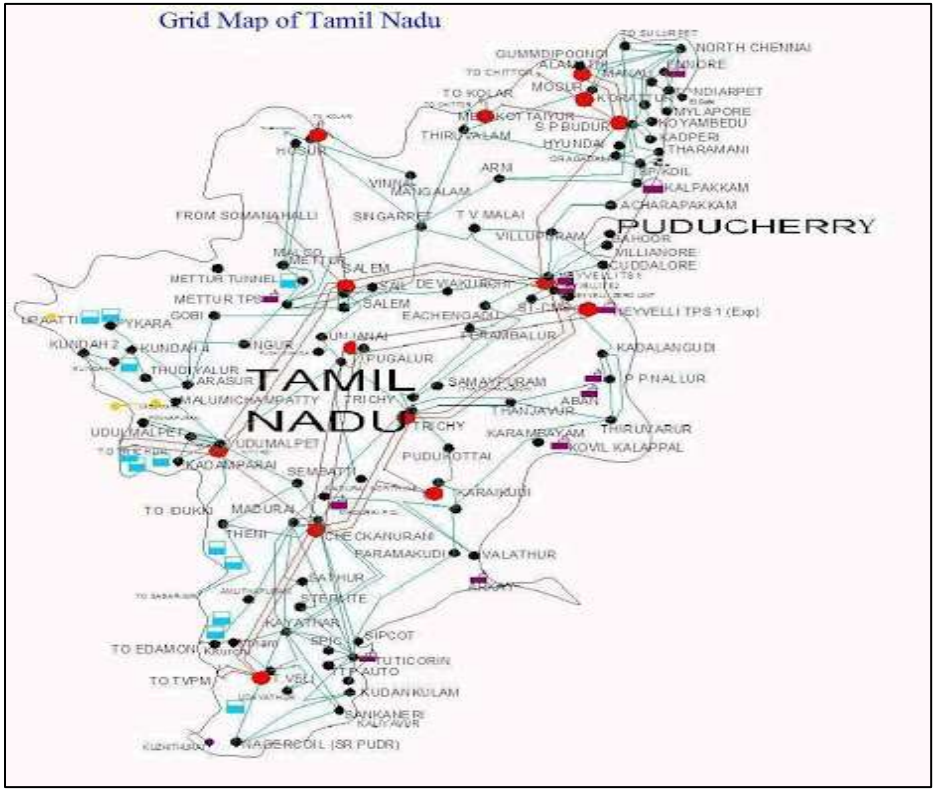


Regulatory Developments:

- Punjab falls under **Category 'B'** of SAMAST report
- Generators payment on actual basis
- MYT Regulations, 2014 specifies provision determination of Capacity Charge, Energy Charge and Deviation Charges of generators
- State Electricity Grid Code, 2013 specifies Scheduling and Despatch code
- Intra-State Open Access Regulations, 2011, specifies treatment to the Deviation of OA generators/consumers

Tamil Nadu

- The Consultant prepared the draft F&S and draft DSM Regulations and discussed with the Commission during couple of meetings.
- Various issues related to higher Wind and solar penetration and Open Access were discussed during the meetings.
- Based on the inputs of the Commission, the consultant revised the draft F&S and DSM Regulations.
- The Commission published the draft F&S and DSM Regulations on 28.12.2017 for public comments.
- Last date for receiving comments was 27.1.2018.
- Regulatory process for scrutiny of objections/suggestions is currently underway.



Next Step:

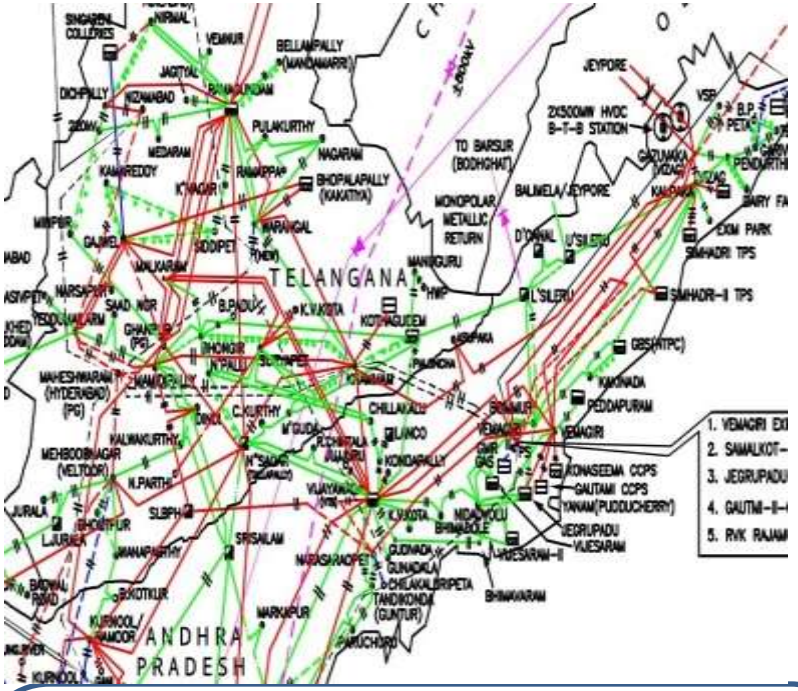
- Finalisation of F&S and DSM Regulations, upon addressing comments/suggestions of stakeholders

Regulatory Developments:

- Tamil Nadu falls under **Category 'C'** of SAMAST report
- MYT Tariff Regulations, 2005 and its amendments, TNERC MYT Regulation specifies provision determination of Capacity Charge and Energy Charge of generators
- State Electricity Grid Code, 2005 and its amendments
- Grid Connectivity and Intra-State OA Regulations, 2014, specifies treatment to the Deviation of OA generators/ consumers

Telangana

- The Consultant Prepared the draft F&S Regulations and discussed with the Commission during the meeting at TSERC, Hyderabad.
- Various issues were discussed during the meeting.
- Based on the inputs of the Commission, the consultant revised the draft F&S Regulations and circulated to the Commission
- The Commission revised the draft and referred to the consultant with comments.
- The Consultant addressed the comments and discussed with the Commission
- **The Commission finalized the draft F&S Regulations and published on 17.2.2018 for public comments.**
- Last date for receiving comments is **12.3.2018.**



Next Steps:

- Based on the Public comments TSERC will finalise the F&S Regulations

Regulatory Developments:

- Telangana falls under **Category 'B'** of SAMAST report
- Generators payment on actual basis
- Intra state DSM is yet to implemented in the State
- TSERC Grid code is in draft stage

Suggestions during Sub-Group Meeting (Punjab / Haryana) at Chandigarh (19th Jan 2018)

Training and Capacity Building of SLDC staff

- Sub-group may be created within the Technical Committee to look in to enhancing the infrastructural capabilities and man power capabilities of load despatch centres in India.

Best Practices of DSM Implementation at State level

- Sub-Group within Technical Committee may be formed to study/survey the best practices adopted by various states that have implemented (or under implementation) State level DSM framework. (viz. Gujarat, MP, Maharashra, etc).

Thank You

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Intra-Day Load/Generation Management
(Options for Handling Variation including in RE)

Presentation
before
FoR Standing Technical Committee
23.2.2018

Dr. Sushanta K. Chatterjee
Joint Chief (Regulatory Affairs)
Central Electricity Regulatory Commission

This Presentation contains …..

1. **Background**
2. **Constitution of RPC Sub-Committees**
3. **Views of RPC Sub-Committees**
4. **Options for “Intra-Day / Hour-Ahead” transactions**

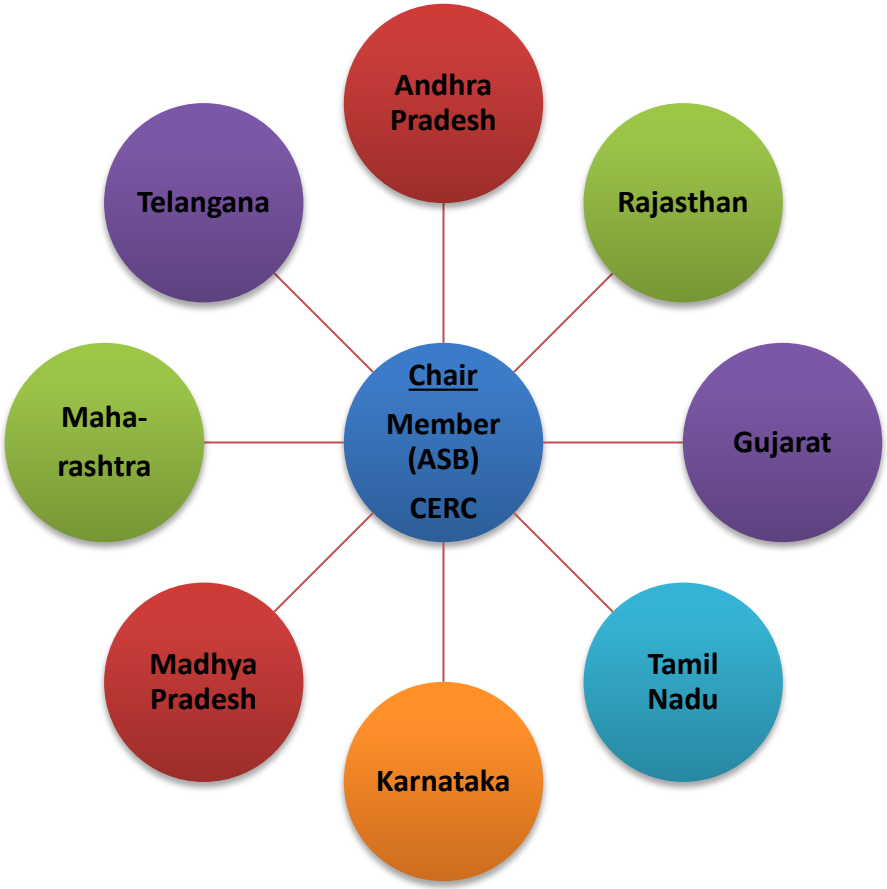
1. Background

FoR Standing Technical Committee

for Handholding States for roll out of framework at State level for effective Re integration

FoR Standing Technical Committee

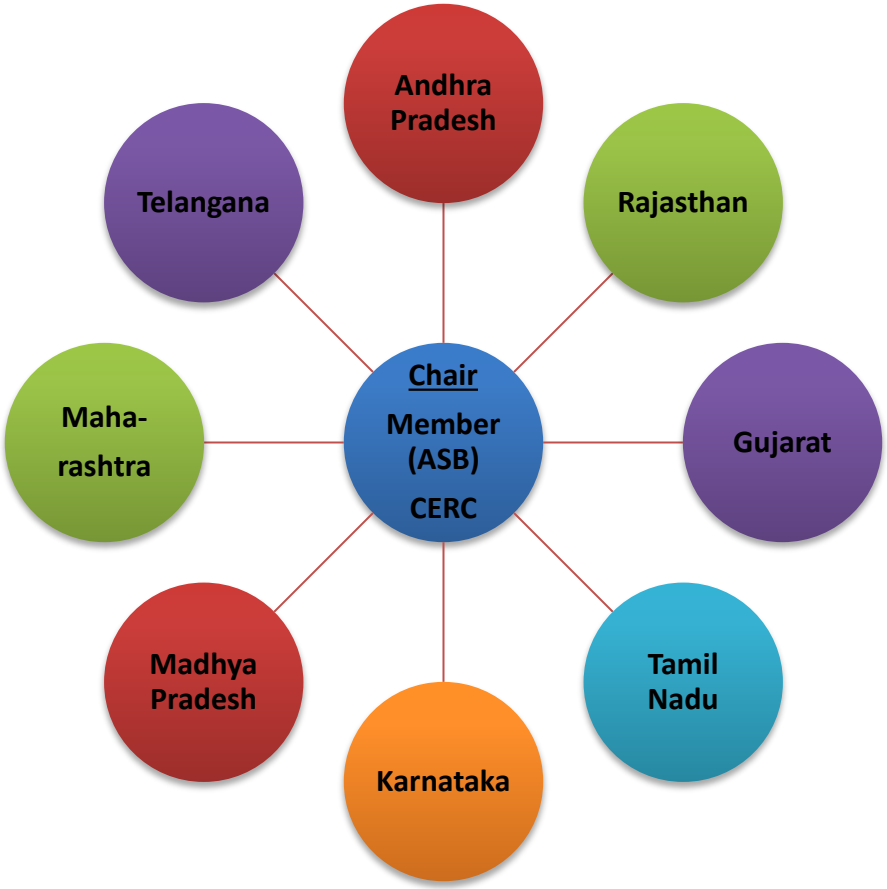
for Handholding States for roll out of framework at State level for effective Re integration



1. Background

FoR Standing Technical Committee

for Handholding States for roll out of framework at State level for effective Re integration



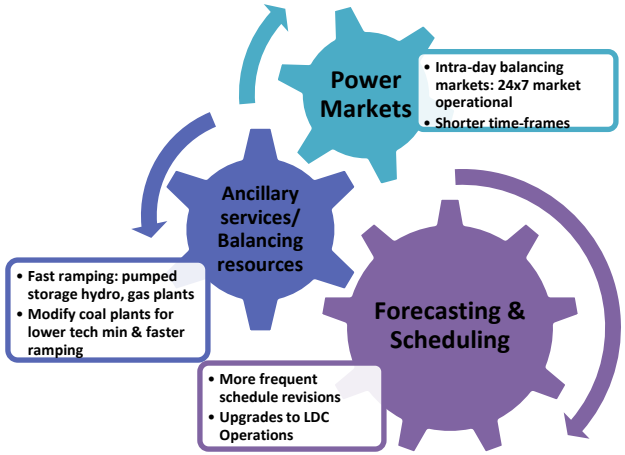
Mandate (expanded from time to time)

- **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**

So far held 17 Meetings

(apart from 2 additional Special Meetings)

1. Background



Renewable Energy Integration

Handholding States through FoR Technical Committee

– for roll out of similar framework at State level

- **Report on Scheduling, Accounting, Metering and Settlement of Transactions in Electricity (SAMAST)** **[5 States have submitted final DPRs, and 6 States are in the process of finalizing the DPR]**
- **Model Framework for Forecasting, Scheduling and Deviation Settlement for RE sources at the State level** **[7 States issued final Regulations, and 5 States issued draft Regulations]**
- **Model Deviation Settlement Mechanism (DSM) Regulations** **[2 States have issued final Regulations, and 2 States issued draft Regulations]**
- **Sub-group on Regional Co-operation for optimum utilization of Generation Resources**
- **Sub-group on Introduction of 5-minute Time Block**
- **Model Regulations on intra State Hydro Generation**
- **RPO Web-Tool**

2. Constitution of RPC Sub-Committees

FoR Standing Technical Committee, during its 12th Meeting,

- **Discussed the need for cooperation among States for Optimum Utilization of Generation Resources amongst other issues**
- **Sub-Groups of RE rich regions (NR, WR & SR) headed by Member Secretaries of RPCs**
- **Sub-Groups mandates to examine the feasibility and modality of cooperation for optimum utilization of generation resources with least cost options**

3. View of RPC Sub-Committees

FoR Standing Technical Committee, during its 12th Meeting,

- Discussed the need for cooperation among States for Optimum Utilization of Generation Resources amongst other issues
- Sub-Groups of RE rich regions (NR, WR & SR) headed by Member Secretaries of RPCs
- Sub-Groups mandates to examine the feasibility and modality of cooperation for optimum utilization of generation resources with least cost options

Sub-Committees

- Held region-wise meetings for initial brainstorming
- During their meeting with FoR Standing Technical Committee, it emerged that,
  - *The States have recognized the value of electricity vis-à-vis the cost of generation.*
  - *Some of the States are not willing to cooperate with other States in the Region on "cost" basis, for example, valuing pumped hydro resources.*
  - *Some of the Regions are predominantly "surplus" in power, leaving little scope for co-operation within the region. This necessitates a national level framework / product for optimum resource utilization.*
  - *Inter-state transactions need to be enabled closer to real-time, which will necessitate new intra-day market products at the national level.*

4. Options for “Intra Day / Hour Ahead” Transactions

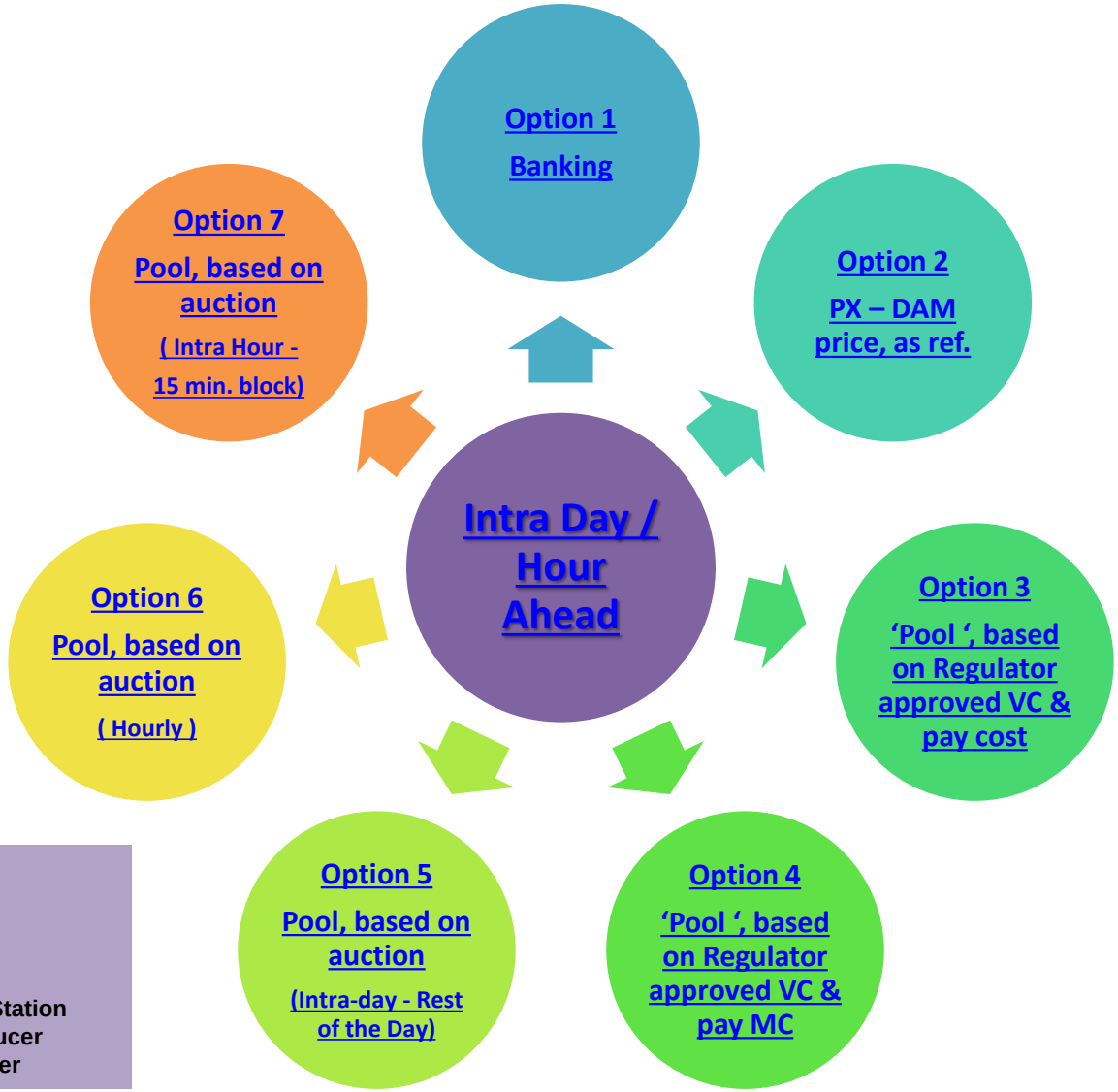
During the Meeting of FoR Standing Technical Committee with all Sub-Committees,

Joint Chief (RA) presented his personal views on options for enabling inter-State Trade of Power

4. Options for "Intra Day / Hour Ahead" Transactions

During the Meeting of FoR Standing Technical Committee with all Sub-Committees,

Joint Chief (RA) presented his personal views on options for enabling inter-State Trade of Power



PX – Power Exchange
DAM – Day Ahead Market
VC – Variable Cost
MC – Marginal Cost
OA – Open Access
ISGS – Inter-State Generating Station
IPP – Independent Power Producer
MPP – Merchant Power Producer

Thank you

4 (a) Option-1 for "Intra Day / Hour Ahead" Electricity Transactions

Option-1

Banking

Details

Pros

Voluntary;

No price transaction;

Easy to implement

Cons

Still bilateral;

Opaque to cheaper options;

True marginal cost of meeting demand not known;

Elements of Cost and Value missing;

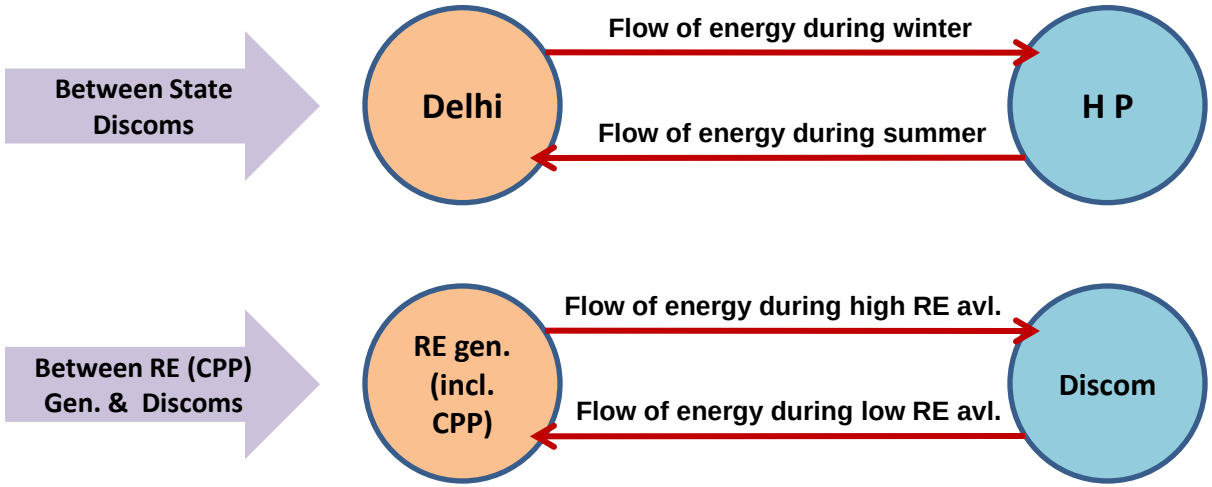
No knowledge of gain or loss

Main

PX – Power Exchange; DAM – Day Ahead Market; VC – Variable Cost; MC – Marginal Cost; OA – Open Access; ISGS – Inter-State Generating Station; IPP – Independent Power Producer; MPP – Merchant Power Producer

4 (a) Option-1 “Banking”

1. Arrangement between two parties to share generation resources without price considerations (reciprocal supply of equivalent quantum of energy without price consideration)
2. Banking is used by the contracting parties to hedge against the uncertainty of power availability and the vagaries of price fluctuations in situations of shortage. This may help manage the energy imbalances closer to real time for both the parties.



3. Participation is voluntary; Easy to implement; No formal contracts and no need for regulatory approval.
4. The contracting parties are unaware of the availability of cheaper options for meeting the same demand. Elements of cost as well as value of resources are missing completely; The parties have no knowledge of whether they are losing or gaining and to what extent.

Section Main

4 (b) Option-2 for “Intra Day / Hour Ahead” Electricity Transactions

Option-2

PX, DAM price as reference for settlement

Details

Pros

Well accepted reference price;

Dispute free

Cons

Very remote chance of availability of generation sources with marginal cost equal to or less than DAM price;

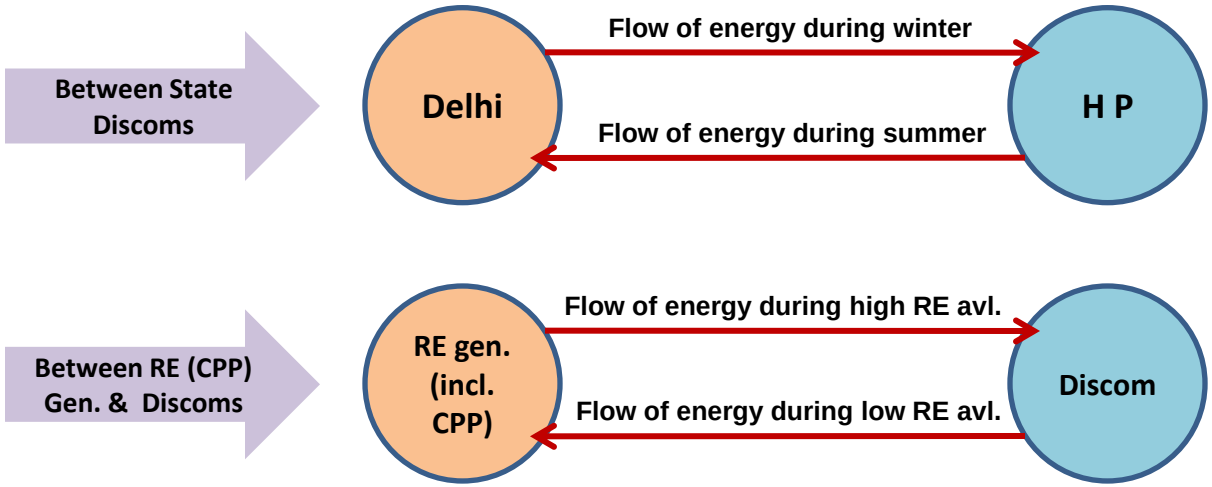
Liquidity will always be an issue

Main

PX – Power Exchange; DAM – Day Ahead Market; VC – Variable Cost; MC – Marginal Cost; OA – Open Access; ISGS – Inter-State Generating Station; IPP – Independent Power Producer; MPP – Merchant Power Producer

4 (b) Option-2 “PX, DAM price as reference for settlement”

1. Improved “Banking” arrangement with “Price Element” added to it
2. MCP of DAM in PXs stands as reference for settlement of transaction
3. MCP of DAM in PXs gained wider acceptability



4. Participation is voluntary; Easy to implement
5. There could be a problem of Liquidity, as available sources could be costlier than DAM Price.
6. URS could be used for Ancillary Services, rather than for Banking – as Ancillary Service may fetch more price (full cost + mark up of Rs. 0.50 p.u.)
7. May not be long term sustainable option for real-time energy market

Section Main

4 (c) Option-3 for "Intra Day / Hour Ahead" Electricity Transactions

Option-3

Pool based on regulator approved VC / and pay as per cost

Details

Pros

Visibility of all options for purchase decision;
Dispute free as regulator approved VC;
All resources get paid as per their cost or MC;
Improvement over option 2;
Liquidity

Cons

Still based on cost and not on value;
VC difficult to ascertain;
Merchant plants cannot participate as their tariffs are not determined by Regulator

Main

PX – Power Exchange; DAM – Day Ahead Market; VC – Variable Cost; MC – Marginal Cost; OA – Open Access; ISGS – Inter-State Generating Station; IPP – Independent Power Producer; MPP – Merchant Power Producer

4 (c) Option-3 "Pool based on regulator approved VC / and pay as per cost"

1. Transactions move from bilateral to multilateral
2. Pool of Generation sources (not cleared in DAM and available for real-time dispatch) stacked in VC based merit order
3. This is a viable option at regional level to be pooled by RLDC or RPC
4. Options for value of transaction include pay-as-you-bid-action / VC alone / VC + mark up / Total Cost

5. Limitations of bilateral transactions addressed

6. VC of state level gencos not available, hence difficult to draw merit order
7. MPPs / CPPs with surplus power remain excluded as their VC is not determined by Regulator
8. Pay-as-you-bid mechanism is inferior to uniform price auction mechanism

Section Main

4 (d) Option-4 for "Intra Day / Hour Ahead" Electricity Transactions

Option-4

Pool based on regulator approved VC / and pay as per marginal cost

Details

Pros

Same as Option 3;

Improvement over Option 3;

Element of 'value' introduced because of marginal cost based payment

Cons

VC difficult to ascertain;

Merchant plants cannot participate as their tariffs are not determined by Regulator;

Payment based on marginal cost may lead to heart burn;

Still administered

Main

PX – Power Exchange; DAM – Day Ahead Market; VC – Variable Cost; MC – Marginal Cost; OA – Open Access; ISGS – Inter-State Generating Station; IPP – Independent Power Producer; MPP – Merchant Power Producer

4 (d) Option-4 “Pool based on regulator approved VC / and pay as per MC”

1. Inclusion of uniform price auction mechanism
2. Payment based on “Regional Level System MC (@ highest VC of generation scheduled)”
3. Uniform payment is made
4. Real time excess RE generation could also be accommodated

5. VC of state level Gencos not available, hence difficult to draw merit order
6. MPPs / CPPs with surplus power remain excluded as their VC is not determined by Regulator

Section Main

4 (e) Option-5 for "Intra Day / Hour Ahead" Electricity Transactions

Option-5

Pool based on Auction (collective transaction)

Auction based

Double sided closed bidding

Bidding platform at RPC level/PX

Monitoring Committee at RPC level.

Details

Illustration & Participants

Pros

Market Discovered Price;

Dispute free;

Not administered;

Akin to DAM but closer to real time;

Cons

Preparedness of PX;

Discoms decision making process;

OA registry, a pre-requisite

Main

PX – Power Exchange; DAM – Day Ahead Market; VC – Variable Cost; MC – Marginal Cost; OA – Open Access; ISGS – Inter-State Generating Station; IPP – Independent Power Producer; MPP – Merchant Power Producer

4 (e) Option-5 "Pool based on Auction (collective transaction)"

1. Introduction of Uniform Price Auction for real time price discovery
2. Facilitates participation of regulated as well as non-regulated generators
3. Price discovery based on demand and supply – truly reflects value
4. DAM framework on PXs can be adopted for the intra-day segments
5. Double sided closed auction recommended as facility to adjust the quotes till the point of inflection may attract adversarial audit scrutiny

6. Facilitates resource optimization across regions subject to transmission constraints

7. Collective transaction in "Intra-Day" segment might not work due to low liquidity. However, increasing awareness may lead to growth in liquidity
8. Delegation of decision making authority in Discoms
9. Automation of the Process is pre-requisite
10. Absence of "Gate Closure" option

Section Main

4 (e) Option-5 for "Intra Day / Hour Ahead" Electricity Transactions

Option-5

Pool based on Auction (collective transaction)

Auction based
Double sided closed bidding
Bidding platform at RPC level/PX
Monitoring Committee at RPC level.

Illustration

- ✓ **7.30 – 8.00 – for ---rest of the day, and so on**
- ✓ **Until 7.30 am discoms can self – schedule for rest of the day, if they so desire.**
- ✓ **7.30 am onwards, no right for self scheduling for rest of the day**

(This will need change in existing re-call facility of one hour)

This is not going to adversely affect discoms' right to recall as they will have several reference price points every hour to take a call on self scheduling.

Participants

- **State Gencos inclining RE, on their own , or**
- **Discoms on their behalf**
- **Discoms as buyers and sellers**
- **ISGS / IPPs / MPP**

Section Main

PX – Power Exchange; DAM – Day Ahead Market; VC – Variable Cost; MC – Marginal Cost; OA – Open Access; ISGS – Inter-State Generating Station; IPP – Independent Power Producer; MPP – Merchant Power Producer

4 (f) Option-6 for "Intra Day / Hour Ahead" Electricity Transactions

Option-6

Pool based on Auction (collective transaction)

Auction based

Double sided closed bidding

Bidding platform at RPC level/PX

Monitoring Committee at RPC level.

Details

Illustration & Participants

Pros

Market Discovered Price;

Dispute free;

Not administered;

Akin to DAM but closer to real time;

Cons

Preparedness of PX;

Discoms decision making process;

OA registry, a pre-requisite

Main

PX – Power Exchange; DAM – Day Ahead Market; VC – Variable Cost; MC – Marginal Cost; OA – Open Access; ISGS – Inter-State Generating Station; IPP – Independent Power Producer; MPP – Merchant Power Producer

4 (f) Option-6 “Pool based on Auction (collective transaction)”

1. **Introduction of National Uniform Price Auction based on Hourly Bids**
2. **Introduction of “Gate Closure”,**
   - **Window of “7.30 – 8.00” will be open for transactions of “9.00 – 10.00”**
   - **Window of “8.30 – 9.00” will be open for transactions of “10.00 – 11.00”**
   - **And so on.**

3. **Facilitates desired firmness and seriousness in real-time trade and effective integration of RE**

4. **Delegation of decision making authority in Discoms**
5. **Automation of the Process is pre-requisite**

Section Main

4 (f) Option-6 for "Intra Day / Hour Ahead" Electricity Transactions

Pool based on Auction (collective transaction)

Auction based
Double sided closed bidding
Bidding platform at RPC level/PX
Monitoring Committee at RPC level.

Option-6

Illustration

- ✓ **7.30 – 8.00 – for ---9.00 to 10.00 and so on**
- ✓ **Until 7.30 am discoms can self – schedule for, 9.00 to 10.00 if they so desire.**
- ✓ **7.30 am onwards, no right for self scheduling for 9.00 to 10.00**

(This will need change in existing re-call facility of one hour)

This is not going to adversely affect discoms' right to recall as they will have several reference price points every hour to take a call on self scheduling, say for 9.00 to 10.00 and so on

Participants

- **State Gencos inclining RE, on their own , or**
- **Discoms on their behalf**
- **Discoms as buyers and sellers**
- **ISGS / IPPs / MPP**

Section Main

PX – Power Exchange; DAM – Day Ahead Market; VC – Variable Cost; MC – Marginal Cost; OA – Open Access; ISGS – Inter-State Generating Station; IPP – Independent Power Producer; MPP – Merchant Power Producer

4 (g) Option-7 for "Intra Day / Hour Ahead" Electricity Transactions

Option-7

Pool based on Auction (collective transaction)

Auction based

Double sided closed bidding

Bidding platform at RPC level/PX

Monitoring Committee at RPC level.

Details

Illustration & Participants

Pros

Market Discovered Price;

Dispute free;

Not administered;

Akin to DAM but closer to real time;

Cons

Preparedness of PX;

Discoms decision making process;

OA registry, a pre-requisite

Main

PX – Power Exchange; DAM – Day Ahead Market; VC – Variable Cost; MC – Marginal Cost; OA – Open Access; ISGS – Inter-State Generating Station; IPP – Independent Power Producer; MPP – Merchant Power Producer

4 (g) Option-7 “Pool based on Auction (collective transaction)”

1. **Introduction of National Uniform Price Auction based on Intra-Hour Bids**
2. **Availability of “Gate Closure”,**

3. **Addresses variations due to change in RE output at a very short time interval**
4. **Real time market design facilitating effective integration of large scale RE**

Section Main

4 (g) Option-7 for "Intra Day / Hour Ahead" Electricity Transactions

Pool based on Auction (collective transaction)

Auction based
Double sided closed bidding
Bidding platform at RPC level/PX
Monitoring Committee at RPC level.

Option-7

Illustration

- ✓ **7.30 – 8.00 – for ---9.00 to 9.15 and so on**
- ✓ **Until 7.30 am discoms can self – schedule for 9.00 to 9.15 time block, if they so desire.**
- ✓ **7.30 am onwards, no light for self scheduling for 9.00 – 9.15 block**

(This will need change in existing re-call facility of one hour)

This is not going to adversely affect discoms' right to recall as they will have several reference price points every hour to take a call on self scheduling, say for 9.00 – 9.15 and so on

Participants

- **State Gencos inclining RE, on their own , or**
- **Discoms on their behalf**
- **Discoms as buyers and sellers**
- **ISGS / IPPs / MPP**

Section Main

PX – Power Exchange; DAM – Day Ahead Market; VC – Variable Cost; MC – Marginal Cost; OA – Open Access; ISGS – Inter-State Generating Station; IPP – Independent Power Producer; MPP – Merchant Power Producer

4. Process Flow of Options for “Intra Day / Hour Ahead” Transactions

Illustration

- **Auction: 7.30 Hrs. – 8.00 Hrs. window, transaction for**

4. Process Flow of Options for "Intra Day / Hour Ahead" Transactions

Illustration

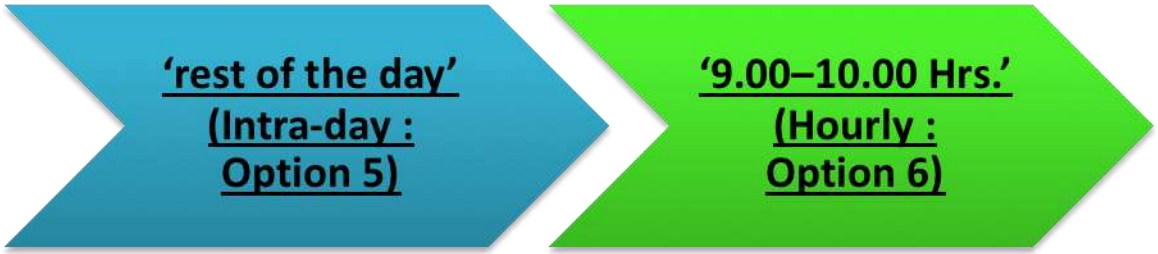
- **Auction: 7.30 Hrs. – 8.00 Hrs. window, transaction for**

'rest of the day' (Intra-day : Option 5)

4. Process Flow of Options for "Intra Day / Hour Ahead" Transactions

Illustration

- **Auction: 7.30 Hrs. – 8.00 Hrs. window, transaction for**



4. Process Flow of Options for "Intra Day / Hour Ahead" Transactions

Illustration

- **Auction: 7.30 Hrs. – 8.00 Hrs. window, transaction for**

4. Process Flow of Options for "Intra Day / Hour Ahead" Transactions

Illustration

- **Auction: 7.30 Hrs. – 8.00 Hrs. window, transaction for**

- **Generators can participate for sale of surplus power (over and above already scheduled on day-ahead basis)**
- **Sellers (other than generators) and buyers can participate for surplus / deficit vis-à-vis their schedule on day-ahead basis**
- **After the trade materializes under Option 5, 6 or 7 as the case may be, net schedule for the buyers and sellers shall be prepared, which will serve as reference point for Deviation Settlement Mechanism (DSM) / Unscheduled Interchange (UI)**
- **However, payment for 'Day-ahead' transaction and 'Intra-day' (Option 5) / 'Hourly' (Option 6) / 'Intra-hour' (Option 7) transactions shall be settled separately based on the schedules for the respective segments**
- **Open Access Registry and delegation of decision making authority to operating level at Discom are pre-conditions to success of this framework**

Main

KfW Development Bank

Energy Transition (Energiewende) - Challenges and Prospects for Germany and India

FOR Technical Committee, Delhi, 23.February 2018

Quelle: KfW Bankengruppe
Foto: Anne Schönharting, Agentur OSTKREUZ

german cooperation
DEUTSCHE ZUSAMMENARBEIT

KFW

More than 70 years of KfW

Financing with a public mission

- Promotional bank of the Federal Republic of Germany
- Established in 1948 as Kreditanstalt für Wiederaufbau
- Shareholders: 80% Federal Republic, 20% federal states
- Headquarters: Frankfurt am Main
- Representative offices: about 80 offices and representations worldwide
- Balance sheet total 2016: EUR 507.0 billion
- Financing volume 2016: EUR 81.0 billion
- 5,944 employees (2016) [1]
- Best long-term rating: Aaa/AAA/AAA

[1)] The average number of employees including temporary staff but without members of the Executive Board and trainees

KfW Development Bank as part of the KfW Group
(2017, EUR)

KFW

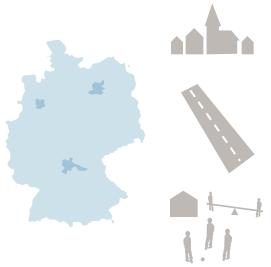
Domestic promotion

We promote Germany

SMEs

Private clients

Municipalities



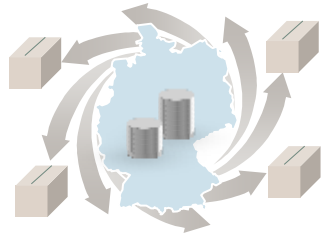
KFW

Financing volume (FV): 51.8 billion

International financing

We support internationalisation

Export & project finance

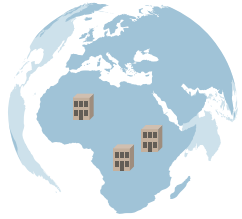


KFW IPEX-Bank

FV: 13.8 billion

We promote development

Developing countries & emerging economies



KFW

KFW DEG

FV: 8.2 billion and 1.6 billion

Support for climate and environmental protection

german cooperation

Goals of the German Energy Transition

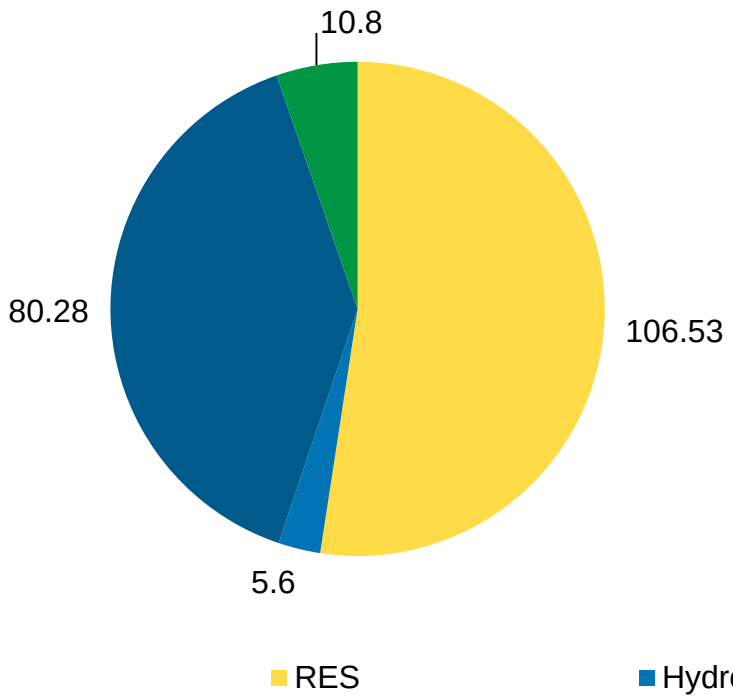
Achieving a secure, environmentally friendly, and economical energy supply

1	**Nuclear phase out**		▪ Exit until 2022
2	**Renewable energies**		Share of RE of gross electricity consumption ▪ 35% till 2020 ▪ 80% till 2050
3	**Energy efficiency**		Reduction of primary energy consumption ▪ 20% till 2020 ▪ 50% till 2050
4	Reduction of **greenhouse gas emissions**		▪ - 40% till 2020 ▪ - 80-95% till 2050 (vs. 1990 base year)

German Energy Mix

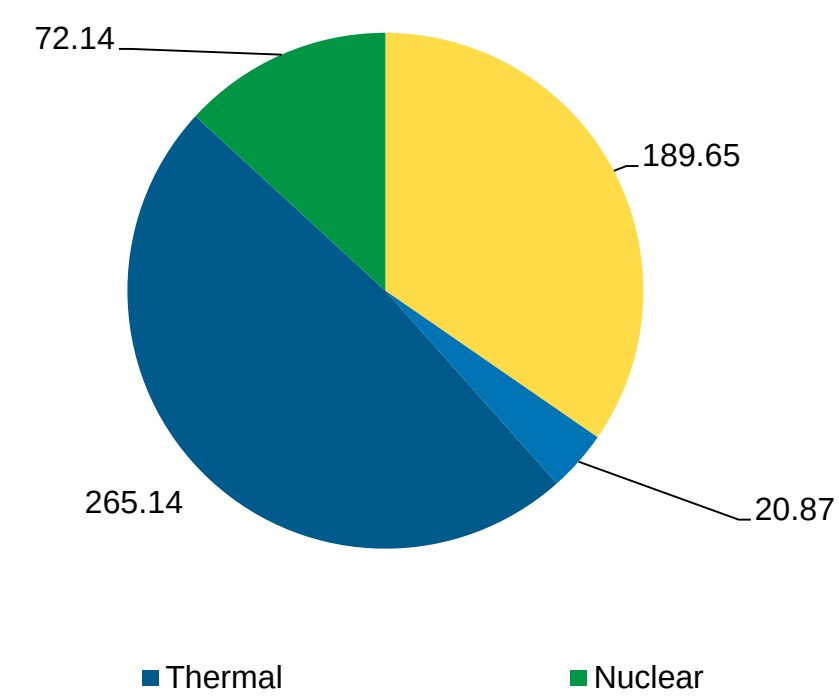
38% of electrical energy generated by renewables

Installed capacity (in GW)



Source: www.energy-charts.de, 2017

Net electricity generation (in TWh)



Source: www.energy-charts.de, 2017

Impact on grid infrastructure

Generation, grid and consumption cannot any more be considered in isolation

Three major challenges…

More uneven power generation

Multidirectional power transmission

Increased electricity trading in the EU

… require a comprehensive solution

New power lines
- Energy Grid Expansion Act
- Grid Expansion Acceleration Act

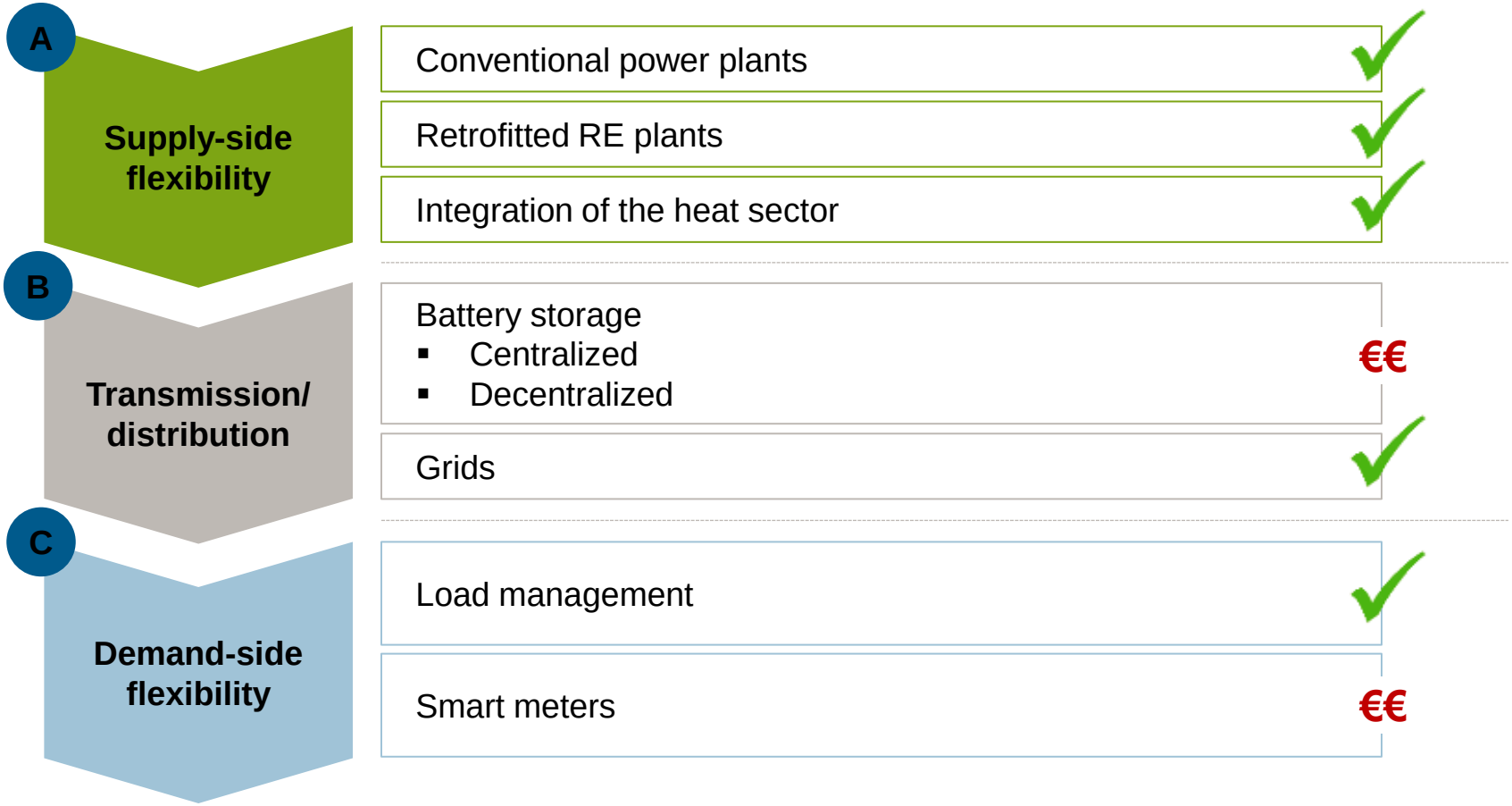
New technologies
- Underground cables
- High voltage DC transmission

European coordination
- EU-wide consultations on common electricity & gas infrastructure projects

Smart grids
- Smart linkage between power generation system and load

Flexibility and system balance

Technical potential of the flexibility options exceeds the actual need

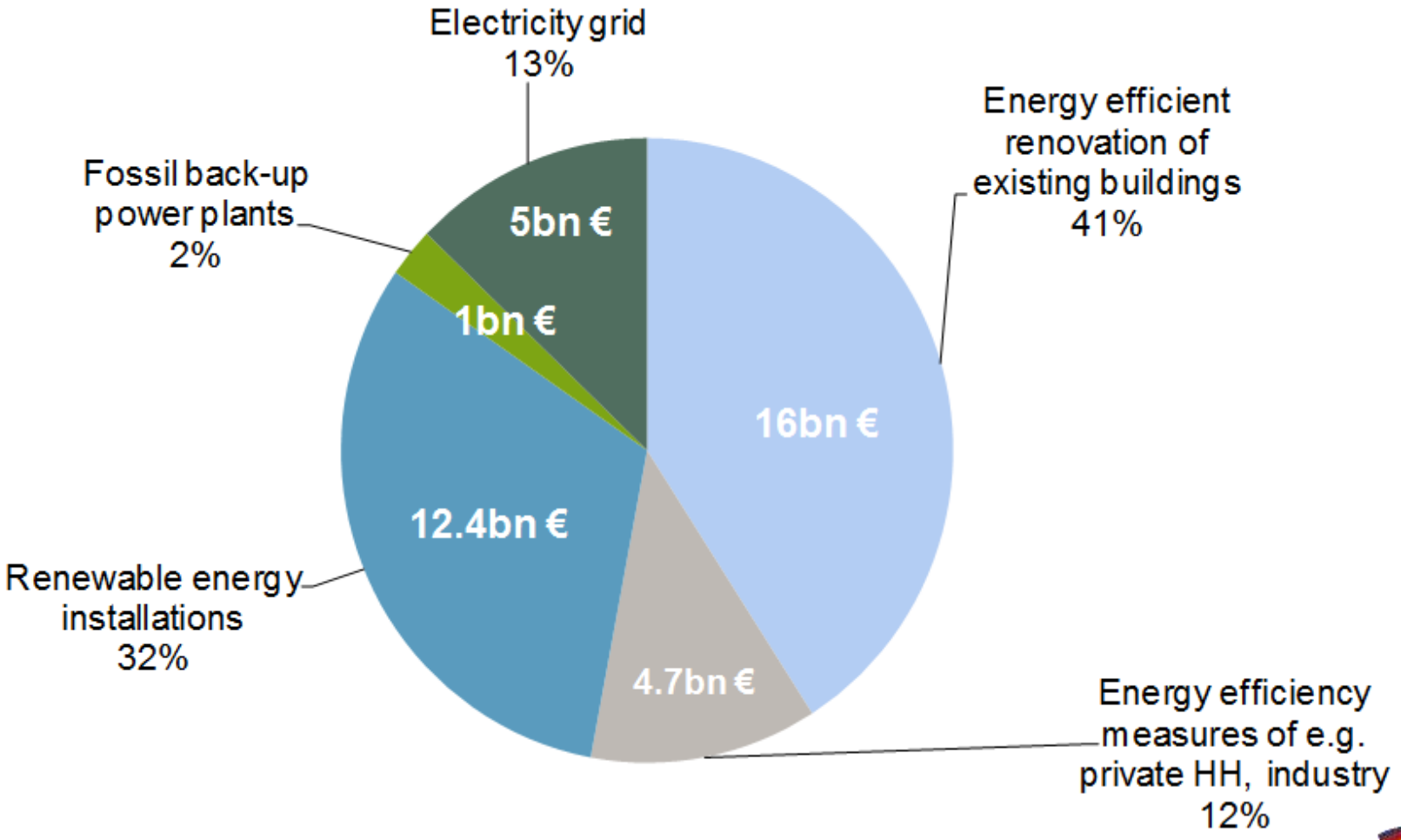


The challenge is not about technology and control, but rather about incentives.

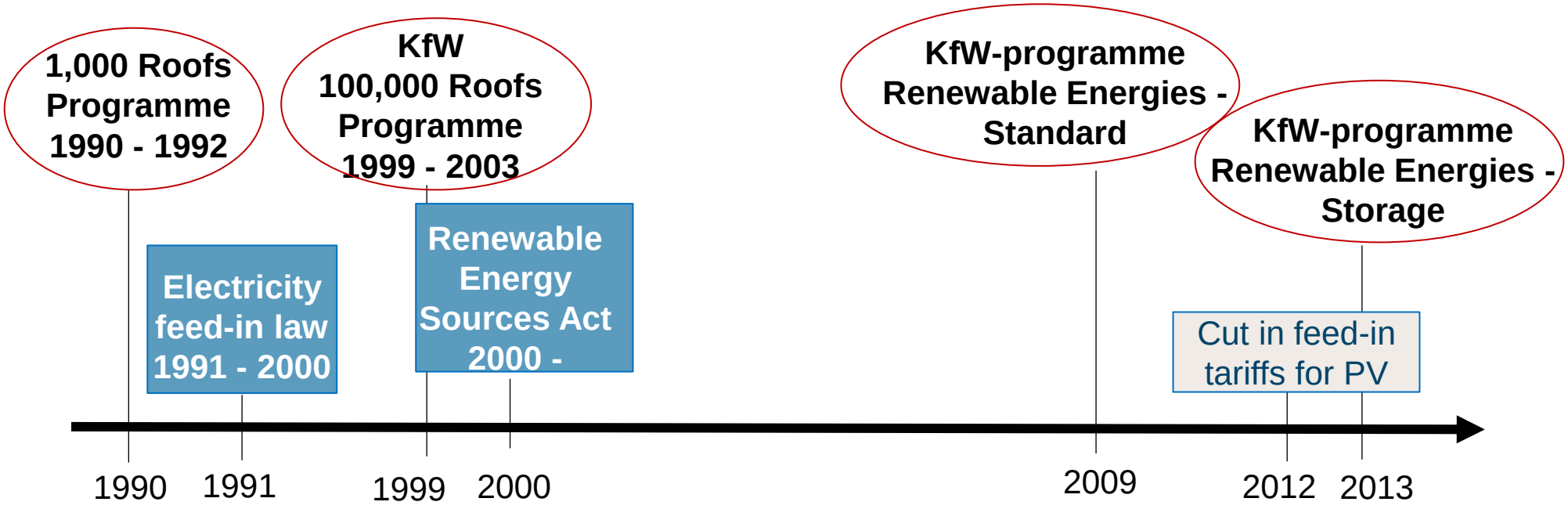
Flexibility and system balance

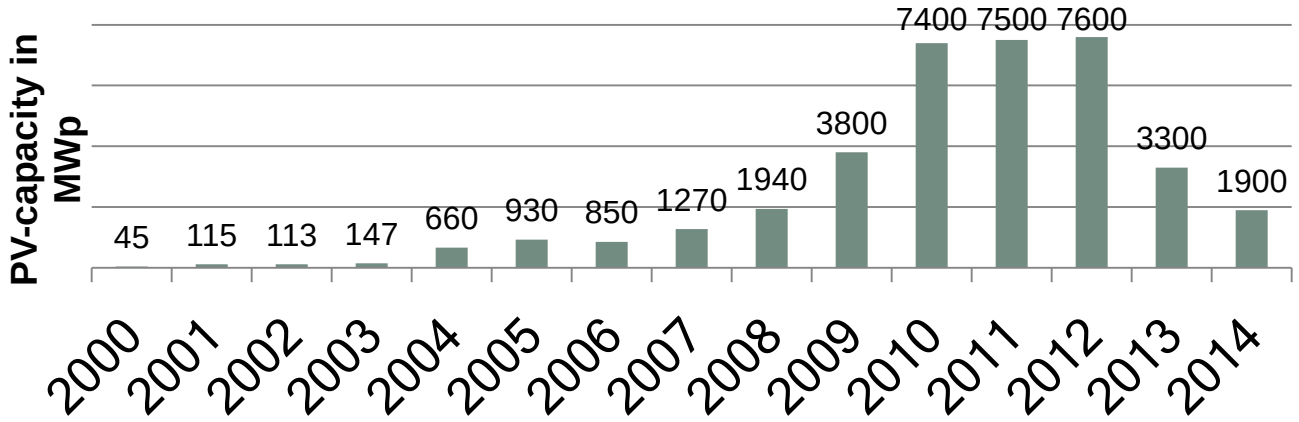
Large Investment needs until 2020: Annually at least 39 bn. EUR on average

Source: KfW Economic Research.



››› KfW promotion for the Energy Transition – a brief history





KFW

german cooperation

KfW Promotion for the Energy Turnaround – Action Plan Energy Transition

› KfW is a important financier of the German Energy Transition. In 2012-2016 KfW committed **103 bn EUR**.

›KfW‘s promotional activities address both pillars of the German energy transition:

- › Energy efficiency in private, commercial, public buildings, industrial production & processes, urban quarters:

  80 bn EUR

- › Renewable energies for heat and electricity generation:

  23 bn EUR

Renewable Energies

- › KfW Renewable Energies Programme
- › KfW Offshore Wind Energy Programme
- › KfW Energy Turnaround Financing Intiative

Energy Efficiency

- › KfW Energy Efficiency Programme
- › KfW Programme Energy-efficient Construction and Rehabilitation

Indo-German Financial Cooperation in the Energy Sector

A long lasting and growing partnership

Overall objective

Contributing to an **inclusive**, technically and economically **efficient**, socially and ecologically **sustainable** energy supply and use.

RE generation		▪ Solar Power Plants ▪ Hydro Power Plants ▪ Lines of Credit (IREDA, REC) ▪ **Solar Energy Partnership**	Ongoing: EUR 620 m Pipeline: EUR 1bn
Transmission & Distribution		▪ Support transmission infrastructure for the evacuation of RE power - **Green Energy Corridors** ▪ Support distribution infrastructure for loss reduction measures	Ongoing: EUR 1bn Pipeline: EUR 600m
Energy efficiency		▪ EE in appliances and lighting (EESL) ▪ EE in MSME (SIDBI) ▪ EE in water pumps for farmers	Ongoing: EUR 420m Pipeline: EUR 160m
Access to energy		▪ Establish successful business model for rural electrification (LoC)	Ongoing: EUR 25m

Energy Transition in Germany and India

A natural partnership arising from different challenges yet similar goals

A mutual goal to…

- Significantly **increase the share of renewables** in their energy generation portfolio, focusing on solar (rooftop) and wind
- Improve **energy efficiency**
- Reduce **climate gas emissions**

… all while ensuring a **sustainable energy supply** which does not undermine **economic growth** or **international competitiveness**

India is moving towards its own Energiewende
– and Germany is a crucial partner on this way

Green Energy Corridors

Indo-German cooperation fosters grid integration of renewables in India

The agreement, signed on 11th April 2013, foresees

- the financing of power transmission infrastructure on both intra- and inter-state levels
- investment support for grid substations, power line systems and control infrastructure (i.e. SCADA etc.)

KFW Concessional loans up to **EUR 1 bn**

giz **Technical assistance** e.g. for forecasting and market design

Progress so far

- **8 loan agreements** totaling EUR 1 bn have been signed (PowerGrid, and the states TN, AP, RJ, HP, GJ, MP and MH
- Construction of an envisaged **5,800 kilometers of new power lines** and **installation and renewal of 165 switchgear substations** has started
- **7 state-level, 3 regional-level and one central-level REMCs**

A look at the Indian grid

Both technological and market capabilities require development

Ability to back down coal plants' operations

Ability of hydro and gas-fired thermal power for balancing

Variability of RE supply

Load schedule accuracy

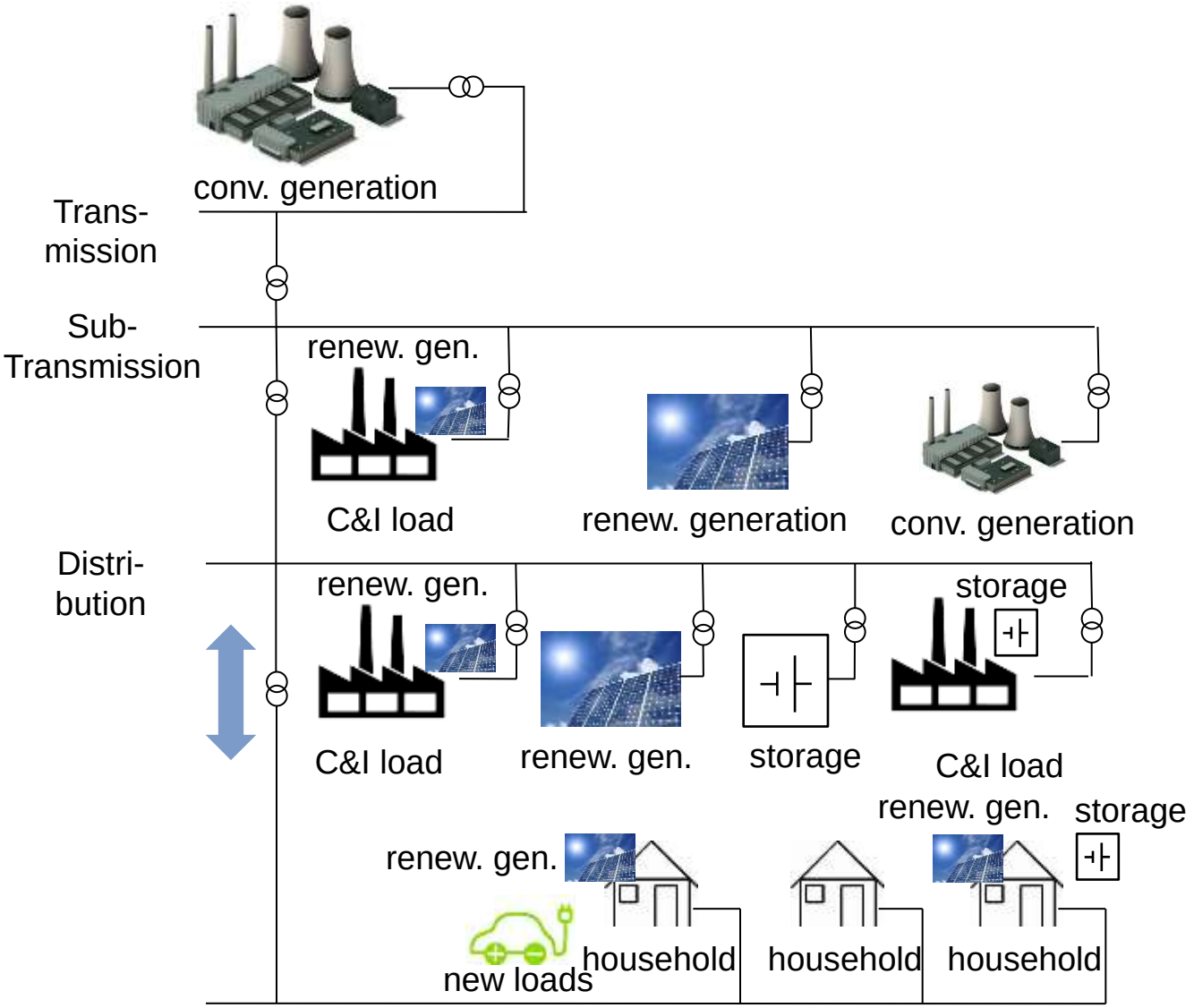
Regional balancing

To meet India‘s renewable target, investment will be needed for transmission and grid management technology.

KFW

german cooperation

Infrastructure investments for energy transition



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Bank aus Verantwortung

18th FOR Technical Committee Meeting
Delhi
23 February 2018

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

Discussion with Central Hydro Generators on Implementation of Hydro as FRAS

Key Statistics of RRAS Implementation

(April, 2016 – January, 2018)

RRAS Providers: 54 Nos.

Capacity under RRAS: 55 GW

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

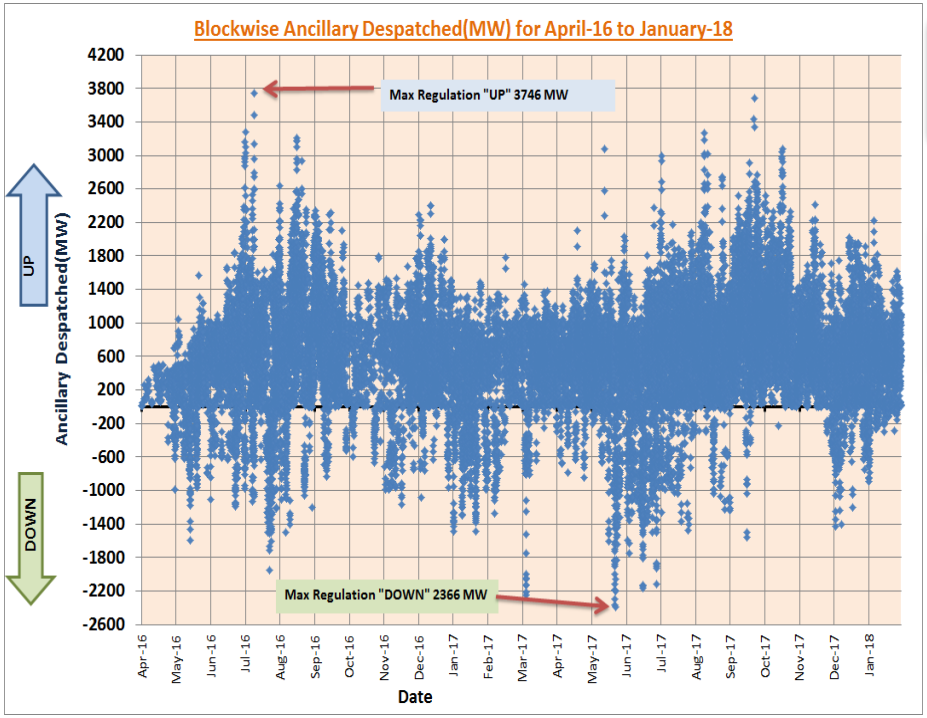
Lowest Variable Charge ~ Rs. 1.06 / Unit (Sipat-I – WR)

Maximum 'Up' Regulation : 3746 MW

Maximum 'Down' Regulation : 2366 MW

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

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



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

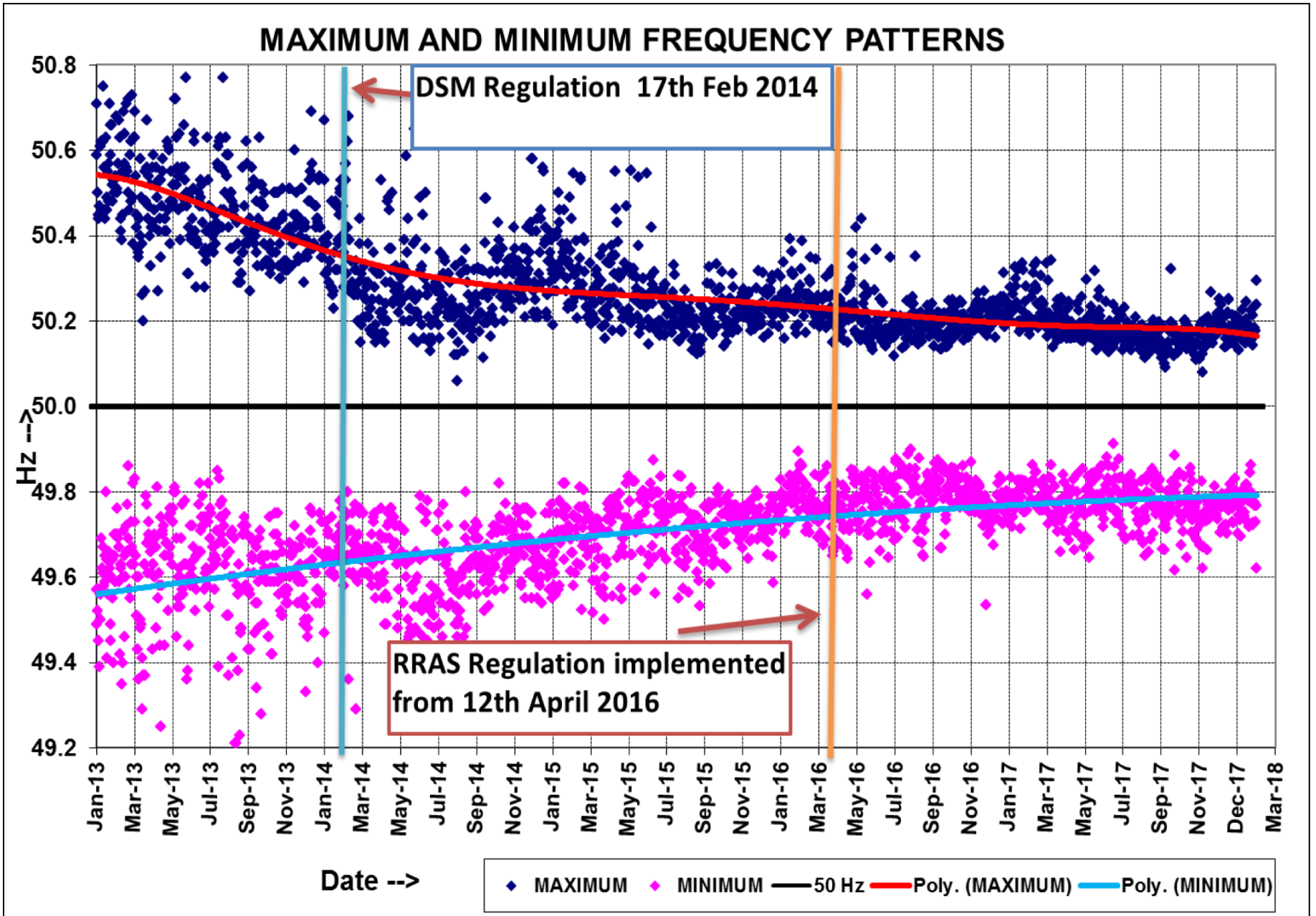
Average Cost for Regulation Up Despatch: **₹ 4.63/ Unit**

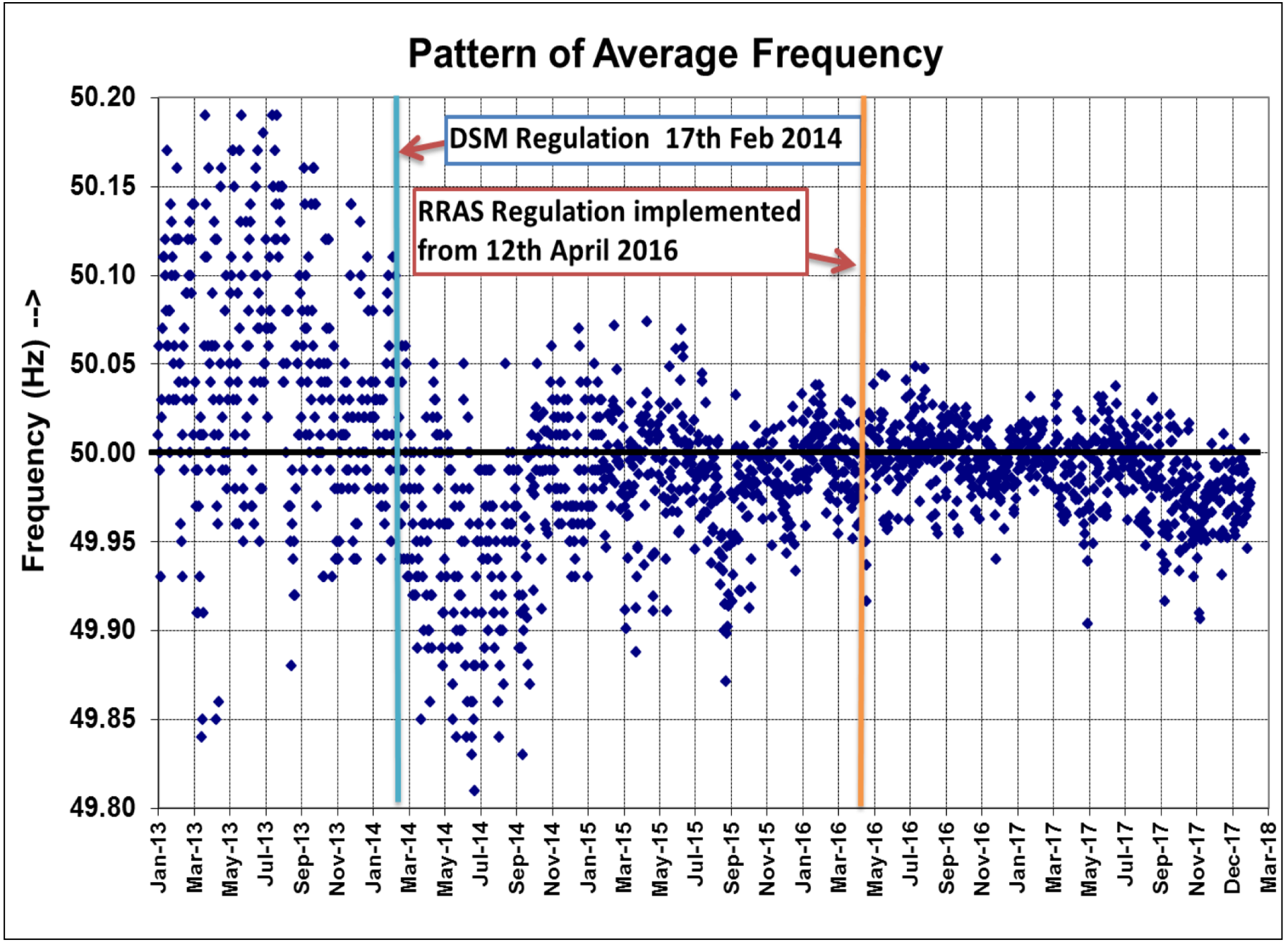
Mark Up paid to RRAS provider- 50 Paise/Unit

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

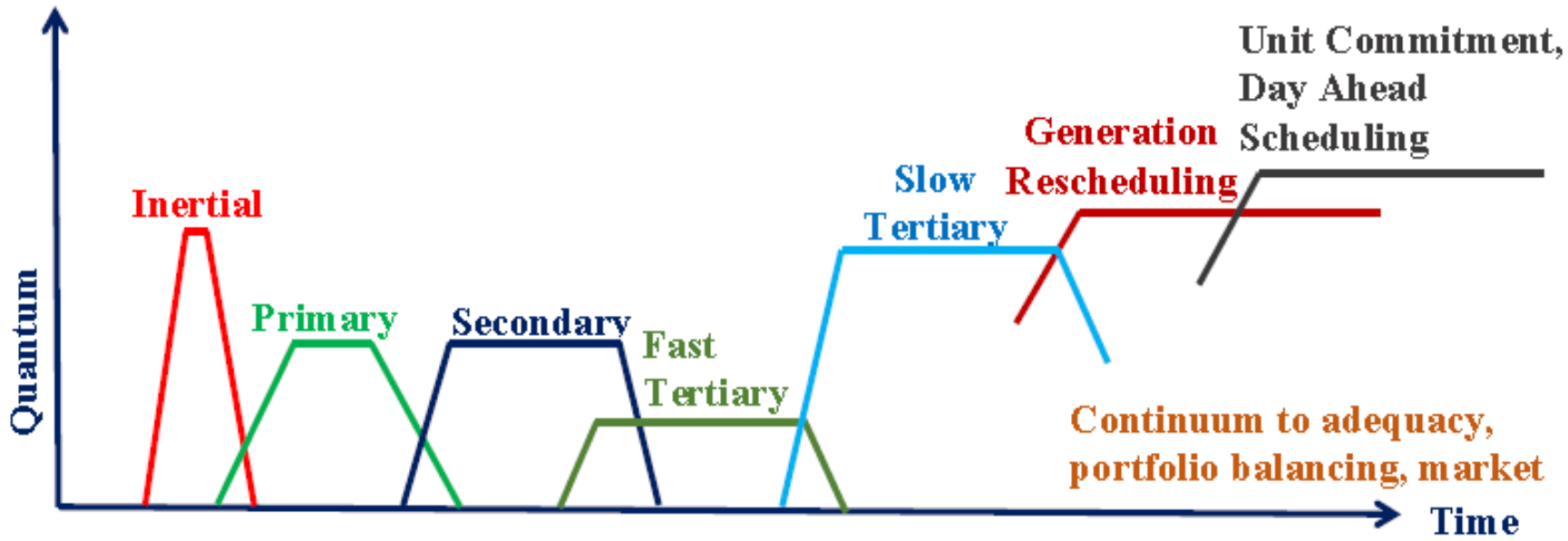
Average Variable charges retained by RRAS providers- 54 Paise/Unit

Improvement in Frequency Profile




Pattern of Average Frequency
DSM Regulation 17th Feb 2014
RRAS Regulation implemented from 12th April 2016
Frequency (Hz) -->
50.20
50.15
50.10
50.05
50.00
49.95
49.90
49.85
49.80
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jul-14
Sep-14
Nov-14
Jan-15
Mar-15
May-15
Jul-15
Sep-15
Nov-15
Jan-16
Mar-16
May-16
Jul-16
Sep-16
Nov-16
Jan-17
Mar-17
May-17
Jul-17
Sep-17
Nov-17
Dec-17
Mar-18

System Balancing in India – A schematic



Response → Attribute ↓	Inertial	Primary	Secondary	Fast Tertiary	Slow Tertiary	Generation Rescheduling/ Market	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	Pilot	Yet to start	Existing	Existing	Existing

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

Present Issues in Hydro Scheduling under RRAS

Need for fast regulation service and ramping support

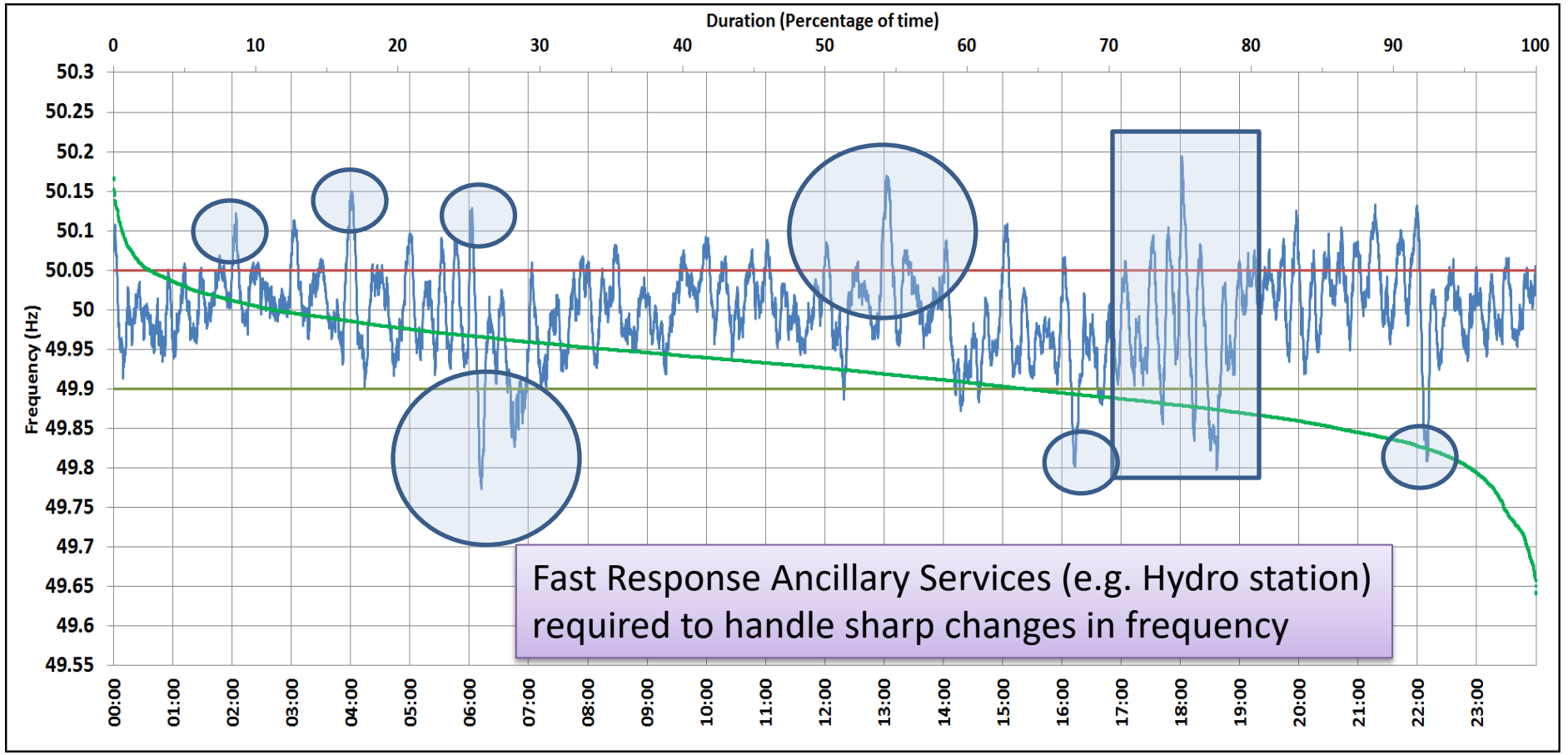
Hydro : Energy Limited Resource

Thermal: Ramp Limited Resource

Other than power generation commitments

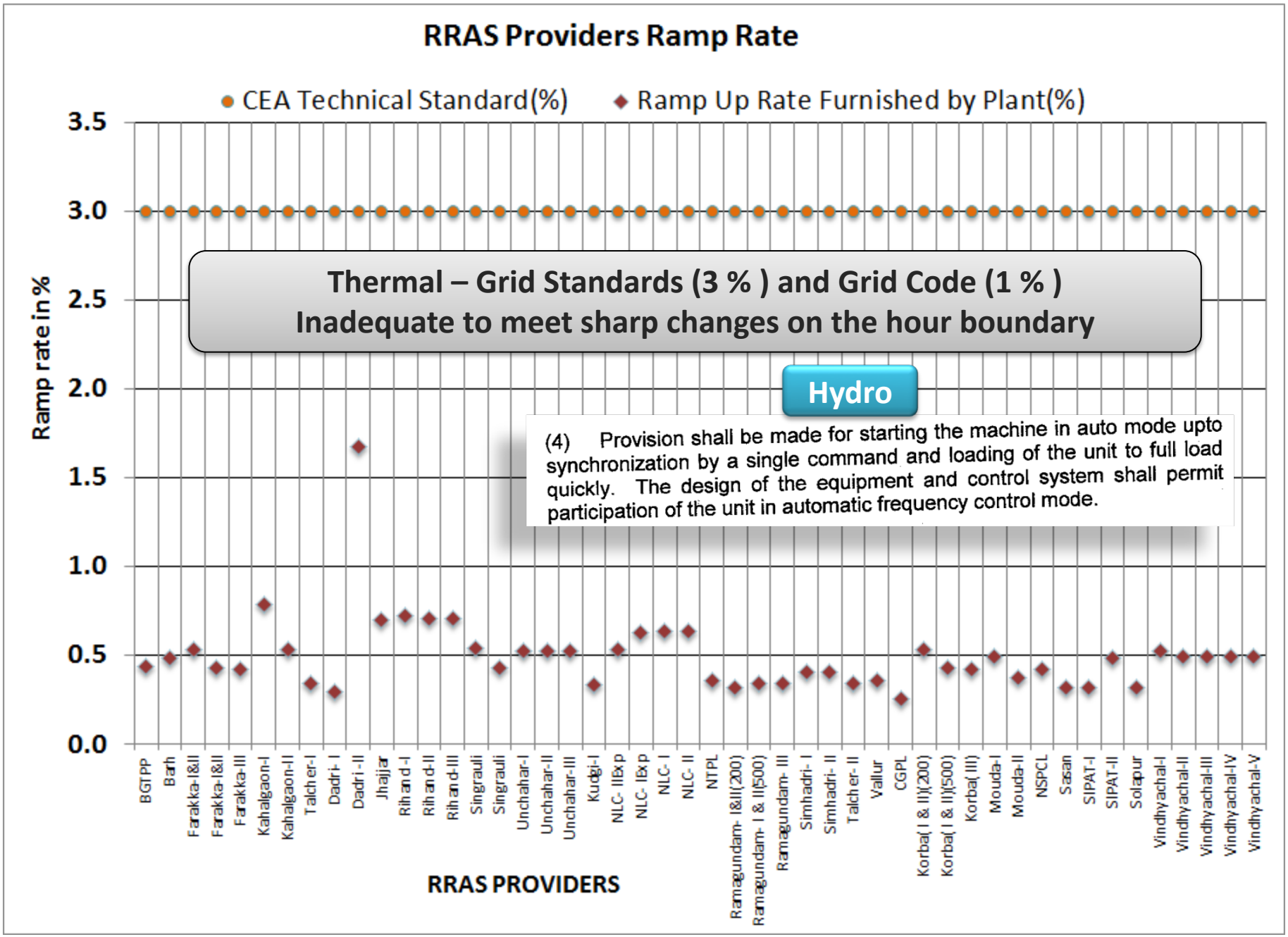
Marginal Cost is zero

Need for Fast Responding Ancillary Service (1)



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

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


RRAS Providers Ramp Rate
CEA Technical Standard(%)
Ramp Up Rate Furnished by Plant(%)
Ramp rate in %
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Thermal – Grid Standards (3 %) and Grid Code (1 %)
Inadequate to meet sharp changes on the hour boundary
Hydro
(4) Provision shall be made for starting the machine in auto mode upto synchronization by a single command and loading of the unit to full load quickly. The design of the equipment and control system shall permit participation of the unit in automatic frequency control mode.
BGTPP
Barh
Farakka-I&II
Farakka-I&II
Farakka-III
Kahalgaon-I
Kahalgaon-II
Talcher-I
Dadri- I
Dadri -II
Jhajjar
Rihand -I
Rihand-II
Rihand-III
Singrauli
Singrauli
Unchahar-I
Unchahar-II
Unchahar-III
Kudgi-I
NLC- IIExp
NLC- IExp
NLC- I
NLC- II
NTPL
Ramagundam- I&II(200)
Ramagundam- I & II(500)
Ramagundam- III
Simhadri- I
Simhadri- II
Talcher- II
Vallur
CGPL
Korba(I & II)(200)
Korba(I & II)(500)
Korba(III)
Mouda-I
Mouda-II
NSPCL
Sasan
SIPAT-I
SIPAT-II
Solapur
Vindhyachal-I
Vindhyachal-II
Vindhyachal-III
Vindhyachal-IV
Vindhyachal-V
RRAS PROVIDERS

Sl No	Name	Organization	Region	Storage (S) /RoR with Pondage (P) / RoR (R)	I/C (MW)	Fixed cost (Paisa/kWh)	Variable cost (Paisa/kWh)
1	Teesta-V	NHPC	ER	R	510	116	116
2	Rangit			R	60	183	183
3	Bairasiul		NR	P	180	96	96
4	Chamera-II			P	300	99	99
5	Chamera-I			P	540	111	111
6	Uri Stage – I			R	480	81	127
7	Salal			R	690	58	170
8	Dhauliganga			P	280	151	151
9	Tanakpur			R	94.2	157	157
10	Chamera-III			P	231	212	212
11	Parbati III			P	520	274	274
12	Sewa-II			P	120	216	236
13	Dulhasti			P	390	279	328
14	Uri Stage – II			R	240	241	328
15	Naptha Jhakri	SJVN		P	1500	119.1	119.1
16	Rampur			P	412	161.3	161.3
17	Tehri	THDC		S	1000	299.8	299.8
18	Koteshwar			S	400	195.5	195.5
19	Koldam	NTPC		P	1000	217.1	217.1
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	1515		
			Total		**12633**		

Proposal - Fast Response Ancillary Service (1)

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

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

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

- Only for short durations
  - Hour boundary frequency changes, Sudden changes in demand, Ramp management, Grid contingency and RE variation

- 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
    - $E_m = \Sigma \mid E_{up} \mid + \Sigma \mid E_{down} \mid$ (@ say 10 paise per kWh)

Primary Frequency Response - Hydro

- IEGC mandate (Clause 5.2 (f))
  - All hydro units of 25 MW and above capacity
  - Margin for primary frequency response at the time of scheduling of generators by RLDCs
  - Droop Settings – 3 to 6 %

- Droop settings
  - CEA Technical Standards for Connectivity to the Grid Regulations (Part 2 (1)4) : 0 to 10 %
  - May be kept on lower side for faster response

Discussion…Issues…Next Steps

- Triggering
  - Conditions, Timeframe for Despatch
- Scheduling
  - 5-Minute schedules, Accounting 15-Minute
- Communication of despatch instructions
- FRAS Net Despatched Energy – squared off over a day
- Governor Droop Setting for faster response
- Operational difficulties
  - Incorporation of 5-Minute despatch instructions
- Constraints (if any to be tabulated)
  - Station-wise, unit-wise, type-wise
- Incentive
  - Factors, Calculation and Quantum

Discussion

Roof Top PV in Indian Distribution Networks – A Grid Integration Study for select regions of New Delhi and Bhopal

Delhi, 23 February 2018

Dr.-Ing. Eckehard Tröster, Energynautics, Germany

On behalf of:

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

of the Federal Republic of Germany

In partnership with:

Government of India
Ministry of New and Renewable Energy

Consulting support:

energynautics
solutions for sustainable development

GSES global sustainable energy solutions India

Partner Distribution licensees:

BSES Rajdhani Power Limited

प्रकाश एवं विकास

energynautics
solutions for sustainable development

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

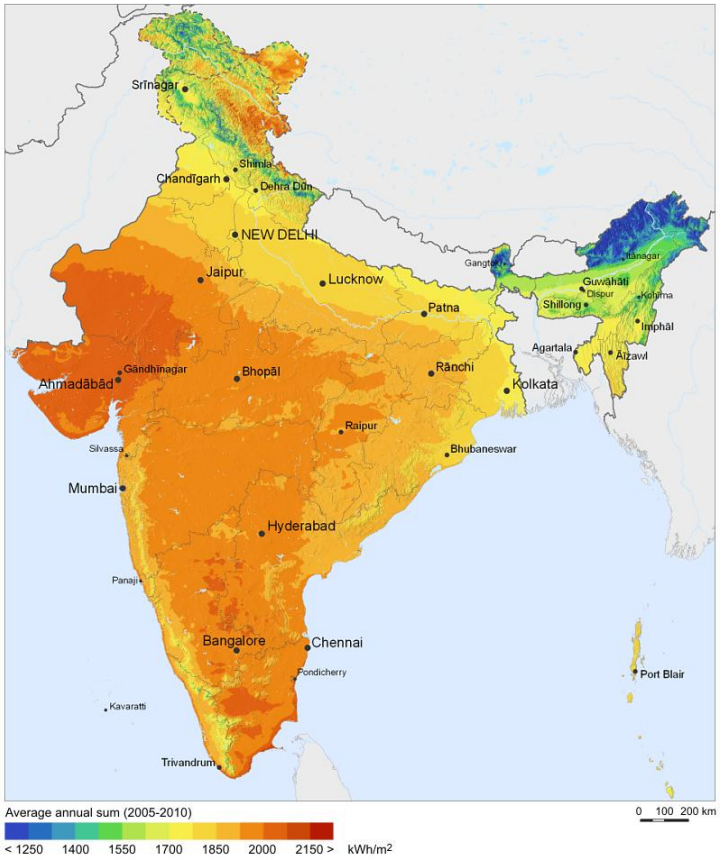
CONTENT

- Introduction
- Modelling and Scenarios
- Technology Options
- Simulations and Results
- Unbalance Simulation Results Delhi
- Conclusions and Recommendations

1. INTRODUCTION

OBJECTIVES AND BACKGROUND

- India plans to increase its PV capacity to 100 GW by 2022, 40 GW of which will be rooftop installations.
- Rooftop PV (and distributed generation in general) is new for most Indian distribution companies.
- Within this study, four distribution grids in Delhi and Bhopal were selected and modelled in DIgSILENT PowerFactory based on data provided by the distribution companies.
- These simulation models were used to analyze the impact of rising shares of rooftop PV on these grids.

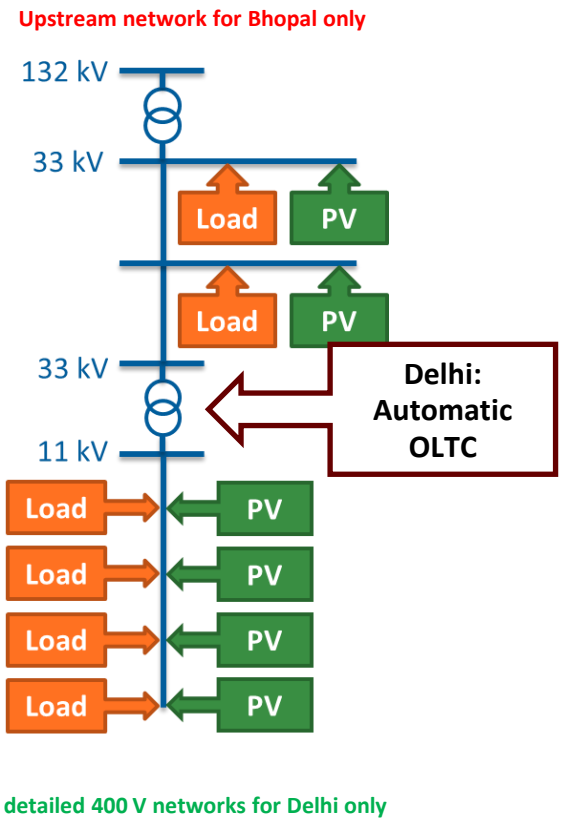


MODEL GRIDS

	Delhi urban	Delhi rural 1	Delhi rural 2	Bhopal urban	Bhopal rural
Supplied from	33 kV	66 kV	66 kV	132/33 kV	33 kV
Dominant cable/line type	300XLPE cable, 5.7 MVA	Dog ACSR OHL, 5.7 MVA	Dog ACSR OHL, 5.7 MVA	Rabbit ACSR OHL, 2.9 MVA	Raccoon ACSR OHL, 3.8 MVA
Length OHL	-	19.8 km	16.7 km	2.7 km	11.0 km
Length UG cables	3.1 km	10.9 km	2.6 km	-	-
Total length	3.1 km	30.7 km	19.3 km	2.7 km	11.0 km
Installed DT capacity	5.4 MVA	5.2 MVA	4.6 MVA	2.2 MVA	3.7 MVA
Peak load	2.5 MW	3.4 MW	3.0 MW	1.1 MW	1.6 MW

2. MODELLING AND SCENARIOS

DIFFERENCES DELHI VS. BHOPAL



Delhi uses 66 or 33 kV for primary distribution, while Bhopal uses 33 kV exclusively.

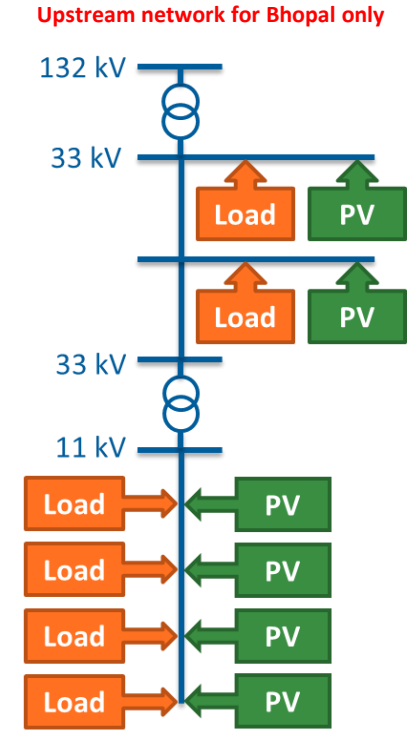
Main difference: In Bhopal, the **132/33 kV** on-load tap changing transformer is the **last instance of voltage control.** Voltage and loading in the 33 kV grid thus directly impact 11 and 0.4 kV levels and must thus be considered in the simulations.

Delhi is currently retrofitting all **66/11 kV** and **33/11 kV** OLTC transformers with **automatic voltage control**. 11 kV is thus decoupled from the **upstream network**, which **need not be modelled**.

For one feeder in Delhi, data was available to **model the low voltage level** (400 V) in detail. All other models used aggregated models for 400 V.

SCENARIOS – PV DISTRIBUTION ALONG THE FEEDER

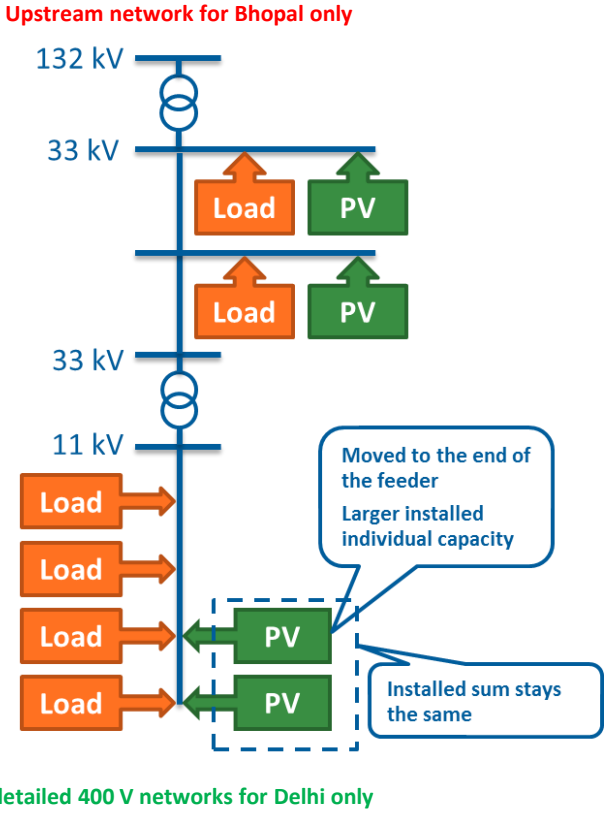
PV equal distribution



PV development may not always be homogeneous.

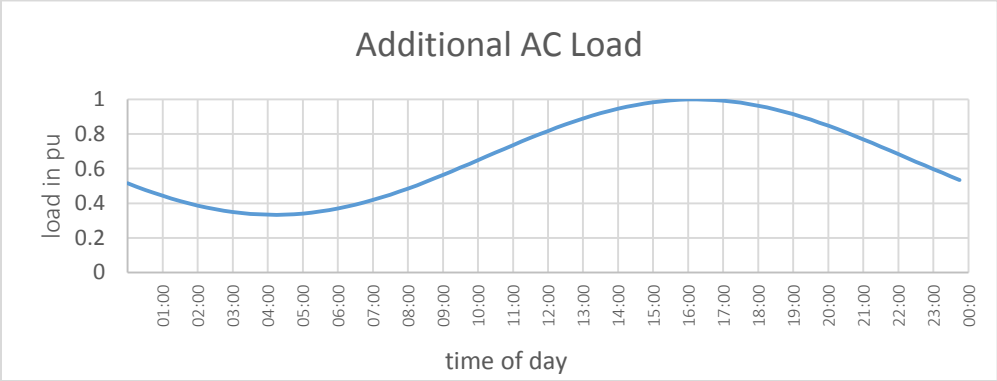
A concentration of PV capacity at the end of a feeder has a higher impact on voltage than homogeneous distribution.

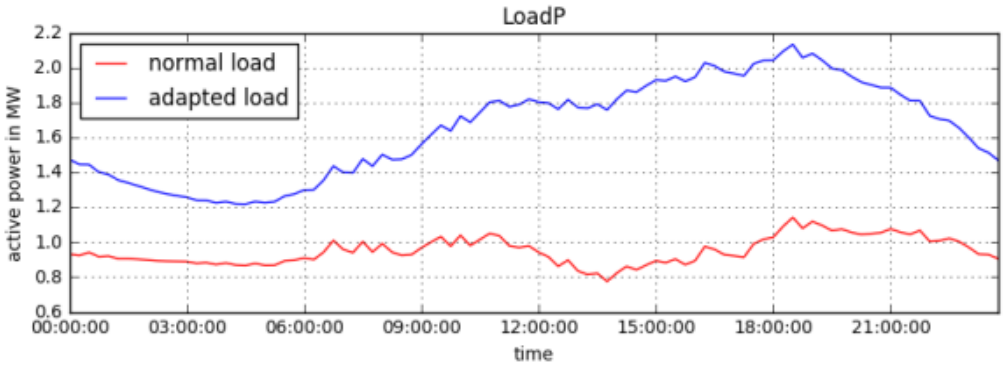
PV end of feeder



SCENARIOS – ADAPTED LOAD

Additional Load is added with the assumption that there would be a **25% energy consumption (kWh)** increase in the load (5% per year for 5 years, 2016 to 2022), typically with regard to Air-Conditioning, where a high evening peak is considered





3. TECHNOLOGY OPTIONS

TECHNOLOGY OPTIONS (OVERVIEW)

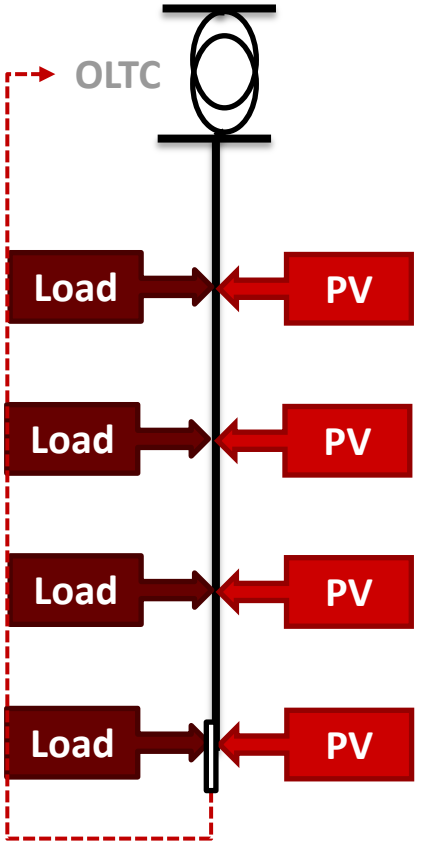
Measure	Abbreviation
No Solution/ Base case	base
OLTC with automatic voltage regulation at MV level	mvoltc
Wide area control	wide area control
Shunt compensators for voltage control	shuntvcontrol
PV inverters with fixed non-unity power factor	fixed PF
Active voltage control by PV inverters (Q(U) characteristic)	qvchar
On-load tap changing DT	oltc
PV cap at certain percentage of installed panel capacity	cap pv
Reinforcements of lines, cables transformers	grid reinforcement
PV storage battery deployment - own consumption	storage ownConsumption
PV storage battery deployment - peak shaving	storage peakShaving
Demand side management	dsm

- If the PV induced reversed flow on a feeder becomes too high, voltage limits may be violated.
- High reversed flows can also overload assets in the grid, lines and transformers.
- The conventional way of dealing with such issues is network reinforcement.
- Grid operators in countries and areas with high penetration levels of distributed integration have developed and introduced a number of measures that can increase the hosting capacity of a grid without grid reinforcements.
- Grid reinforcements may be an inefficient way of dealing with issues that only appear during peak PV feed-in and thus relatively rarely.

TECHNOLOGY OPTION: WIDE AREA CONTROL

Measure	Abbreviation
No Solution/ Base case	base
OLTC with automatic voltage regulation at MV level	mvoltc
Wide area control	wide area control
Shunt compensators for voltage control	shuntvcontrol
PV inverters with fixed non-unity power factor	fixed PF
Active voltage control by PV inverters (Q(V) characteristic)	qvchar
On-load tap changing DT	oltc
PV cap at certain percentage of installed panel capacity	cap pv
Reinforcements of lines, cables transformers	grid reinforcement
PV storage battery deployment - own consumption	storage ownConsumption
PV storage battery deployment - peak shaving	storage peakShaving
Demand side management	dsm

66/33 kV to 11 kV transformer is controlled with discrete on load tap changers which control voltage at different points of the feeder. These can be at 11 kV or 400 V level



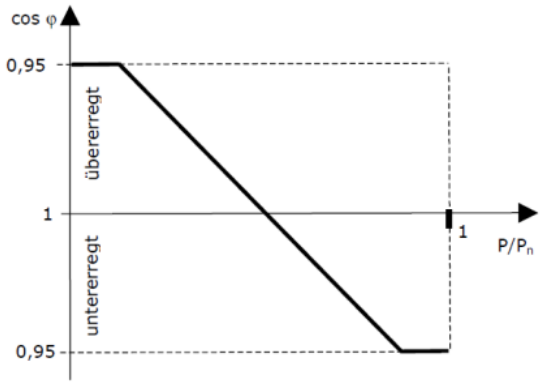
TECHNOLOGY OPTION: REACTIVE POWER

Measure	Abbreviation
No Solution/ Base case	base
OLTC with automatic voltage regulation at MV level	mvoltc
Wide area control	wide area control
Shunt compensators for voltage control	shuntvcontrol
PV inverters with fixed non-unity power factor	fixed PF
Active voltage control by PV inverters (Q(V) characteristic)	qvchar
On-load tap changing DT	oltc
PV inverter cap	cap pv
Reinforcements of lines, cables transformers	grid reinforcement
PV storage battery deployment - own consumption	storage ownConsumption
PV storage battery deployment - peak shaving	storage peakShaving
Demand side management	dsm

Reactive power from PV inverters can be used to mitigate voltage problems.

PV inverters can either be operated at a fixed power factor, or with a Q(V) or Q(P) characteristic.

Technology is available and widely used.

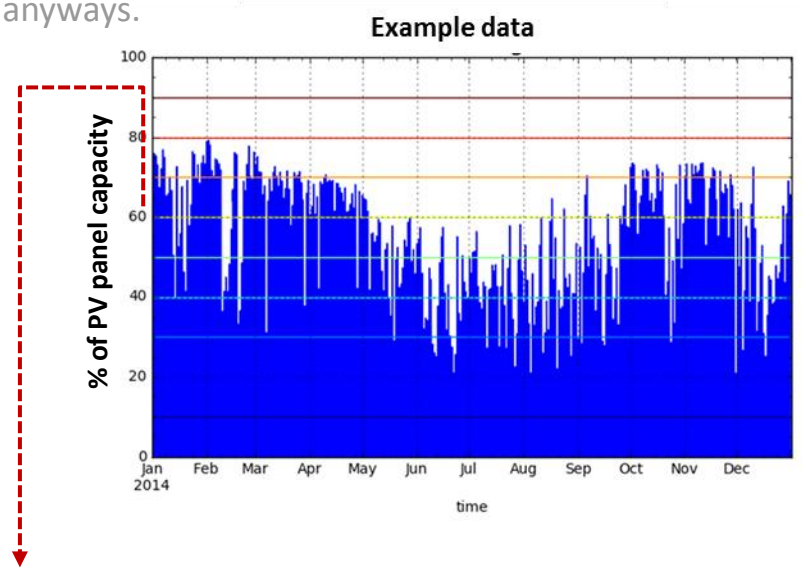


TECHNOLOGY OPTION: INVERTER CAP

Measure	Abbreviation
No Solution/ Base case	base
OLTC with automatic voltage regulation at MV level	mvoltc
Wide area control	wide area control
Shunt compensators for voltage control	shuntvcontrol
PV inverters with fixed non-unity power factor	fixed PF
Active voltage control by PV inverters (Q(V) characteristic)	qvchar
On-load tap changing DT	oltc
PV cap at certain percentage of installed panel capacity	cap pv
Reinforcements of lines, cables transformers	grid reinforcement
PV storage battery deployment - own consumption	storage ownConsumption
PV storage battery deployment - peak shaving	storage peakShaving
Demand side management	dsm

PV panels usually do not reach their full peak output due to heat and dust.

Independently of that, peak power situations are rare anyways.



Capping the inverter somewhere here would reduce peak feed-in while losing only a small amount of yearly energy.

Bhopal: Cap at 75 % of peak power (53 % of panel capacity)
Delhi: Cap at 70 % of peak power (50 % of panel capacity)

→ less than 3 % of energy lost annually

4. SIMULATIONS AND RESULTS

SIMULATIONS

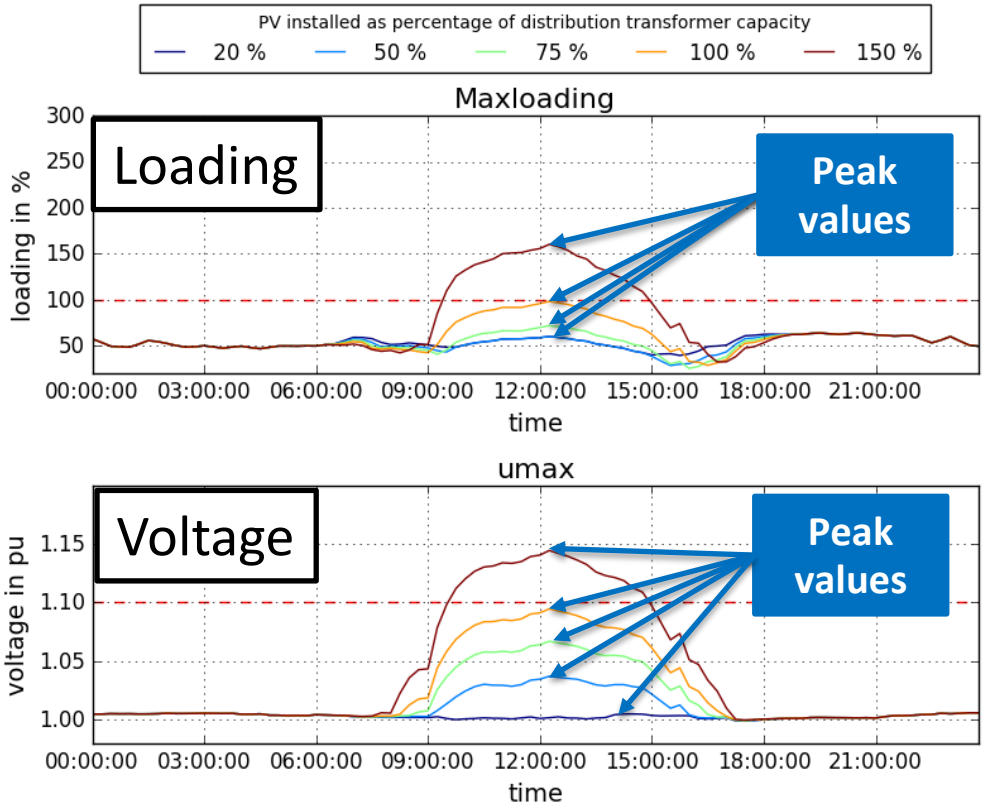
Stepwise increase of installed PV generation

Delhi urban		Delhi rural		Bhopal urban		Bhopal rural	
% of DT	MW	% of DT	MW	% of DT	MW	% of DT	MW
20%	1.1	15%	1.5	30%	3.9	30%	10.9
50%	2.7	40%	3.9	50%	6.5	50%	18.2
75%	4.1	75%	7.4	75%	9.8	75%	27.2
100%	5.4	100%	9.8	100%	13.0	100%	36.3
150%	8.1	150%	14.7	150%	19.5	150%	54.5

Both rural feeders combined

Bhopal: Including upstream PV and parallel feeders

SIMULATIONS



Simulation of a full day with

- **Maximum PV infeed profile**
- **Minimum load**

Evaluation of

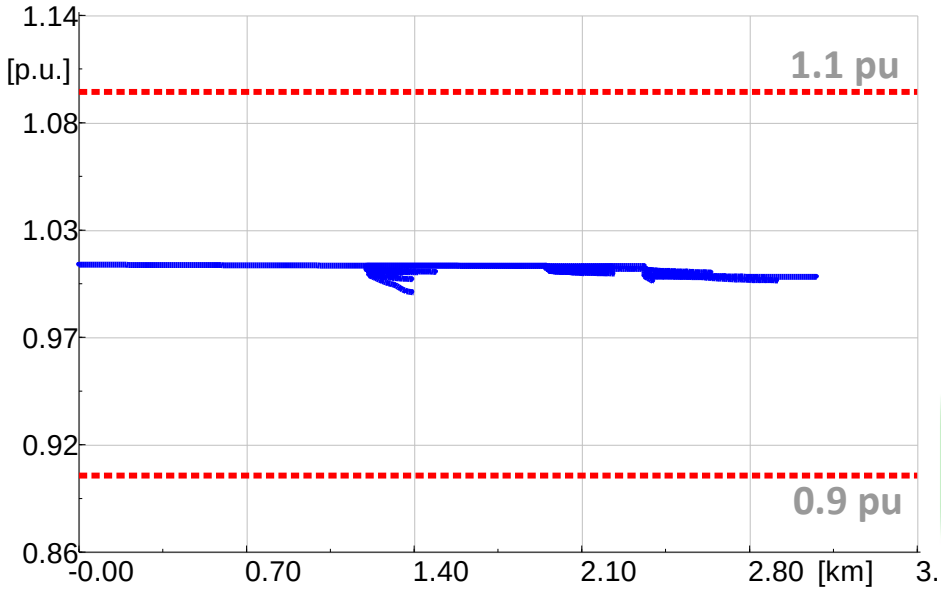
- **Highest voltage**
- **Highest loading at every time step regardless of position in the grid**

Peak loading and peak voltage get stored for each variation of installed PV

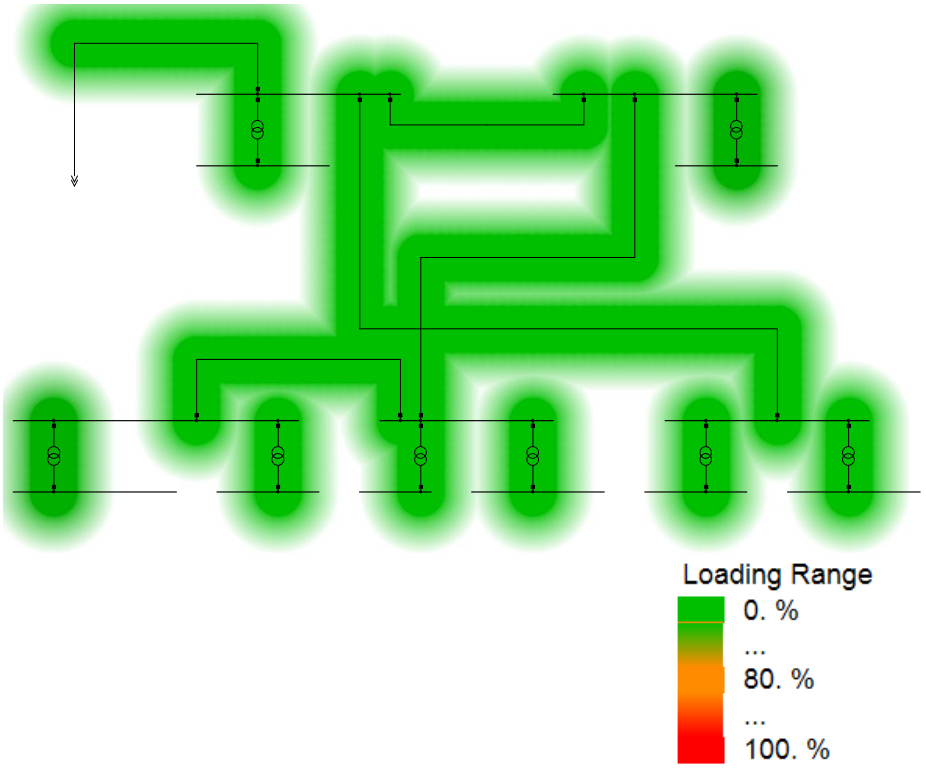
RESULTS ON INCREASING PV PENETRATION

PV Penetration:
20 % of DTs

Voltage



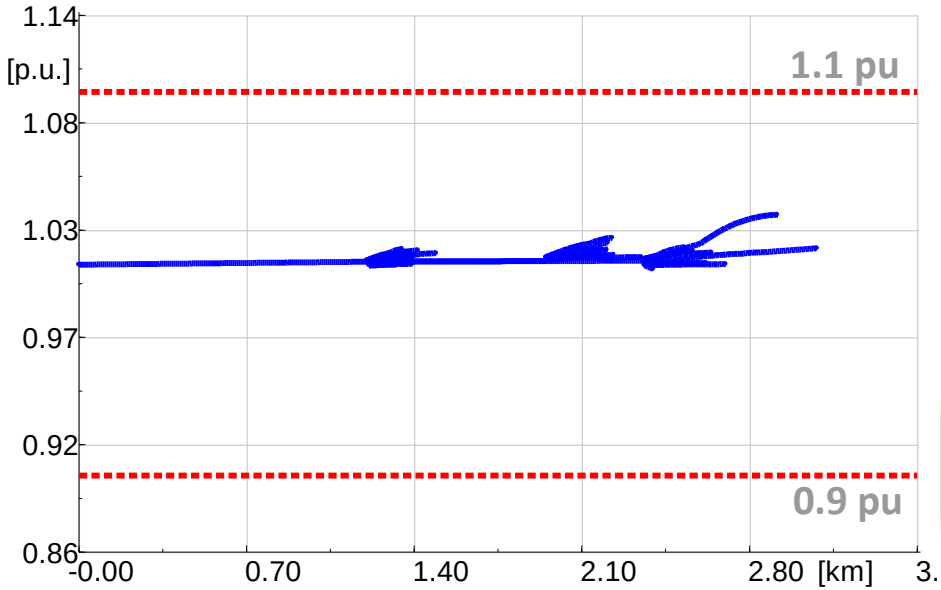
Loading



RESULTS DELHI URBAN (1)

PV Penetration:
50 % of DTs

Voltage



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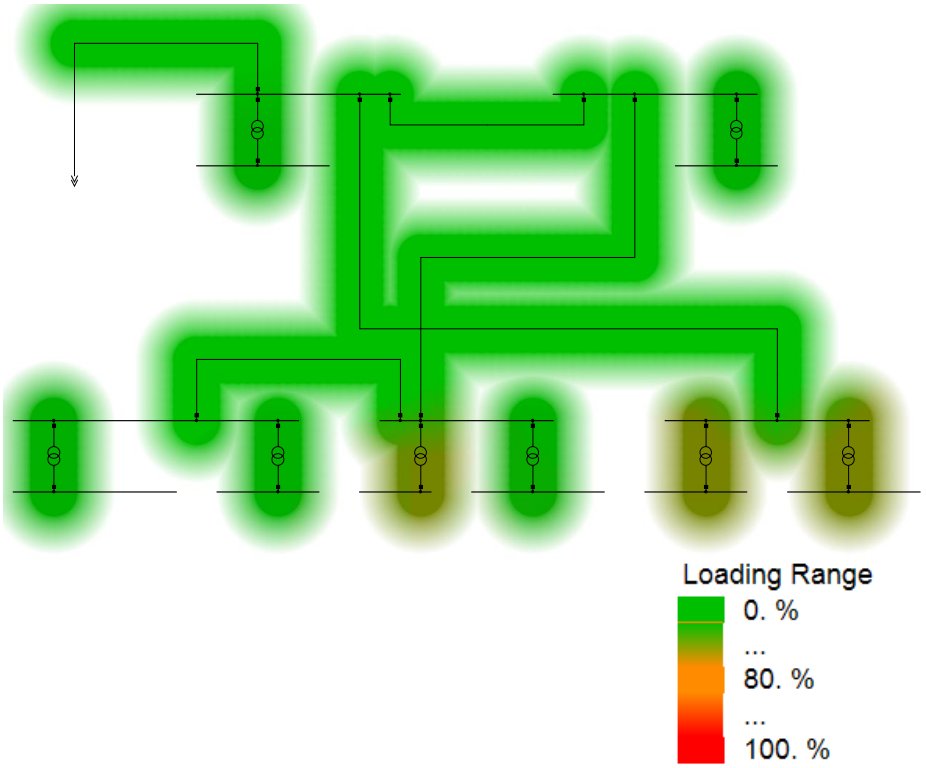
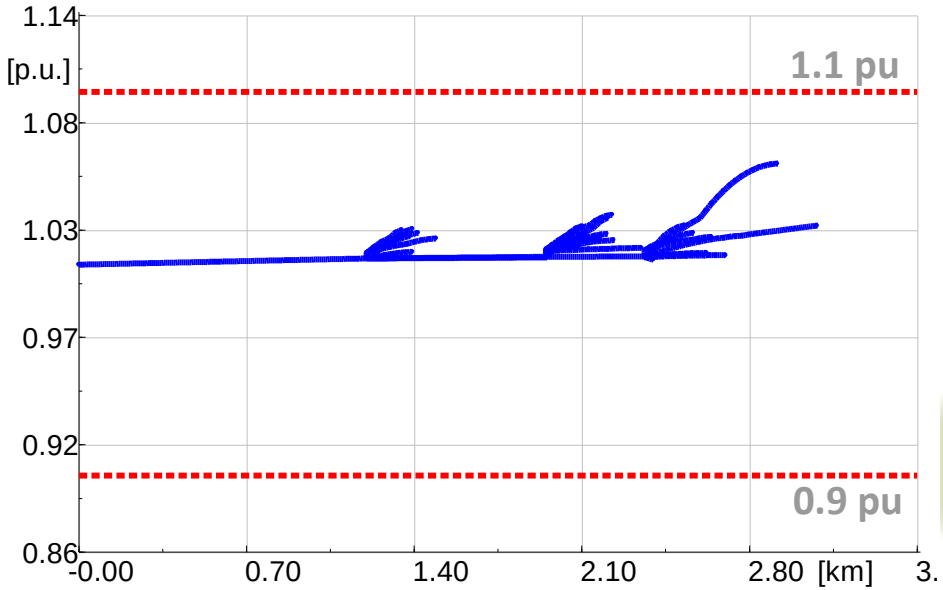


RESULTS DELHI URBAN (2)

PV Penetration:
75 % of DTs

Voltage



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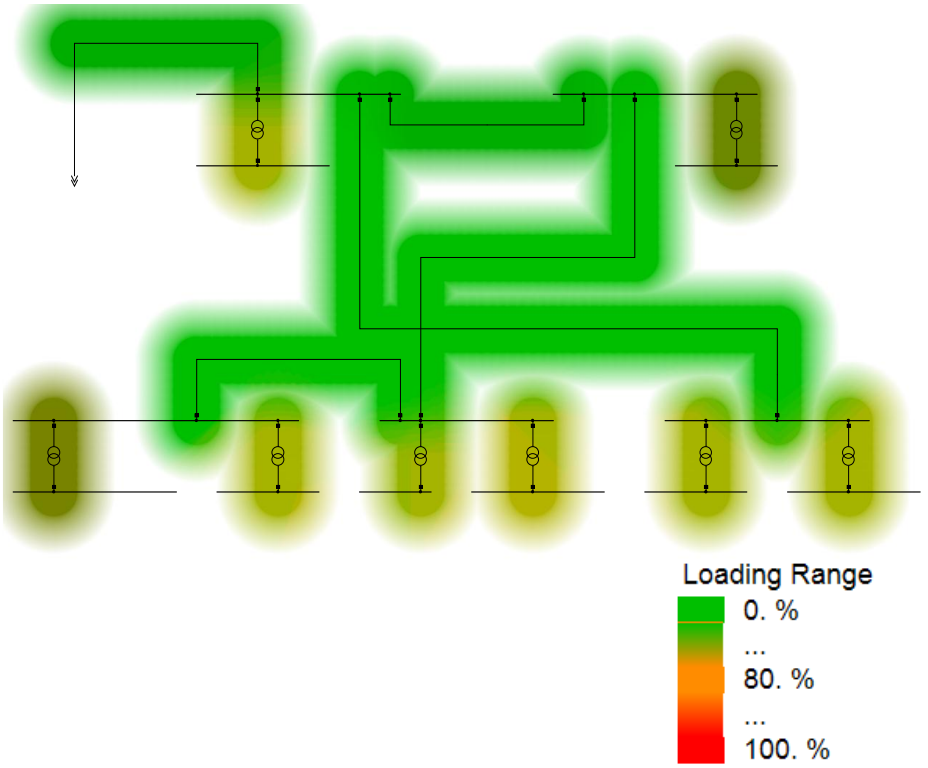
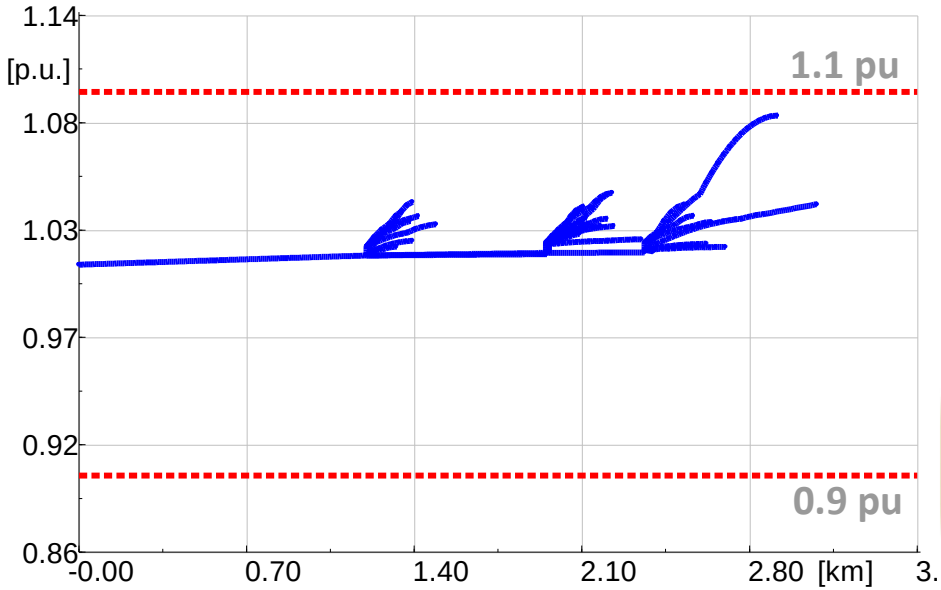


RESULTS DELHI URBAN (3)

PV Penetration:
100 % of DTs

Voltage



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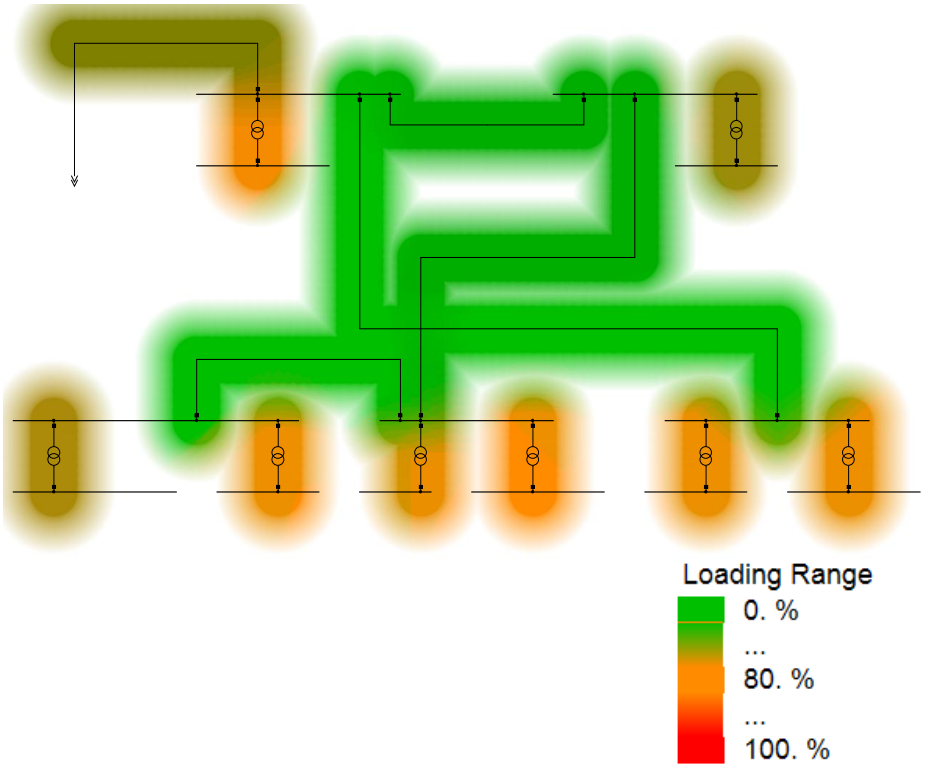
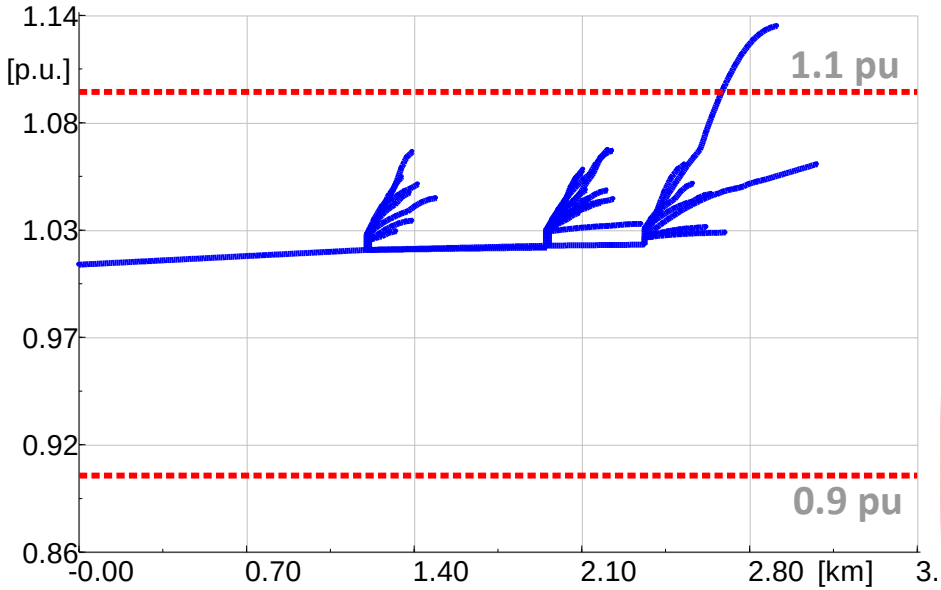


RESULTS DELHI URBAN (4)

PV Penetration:
150 % of DTs

Voltage



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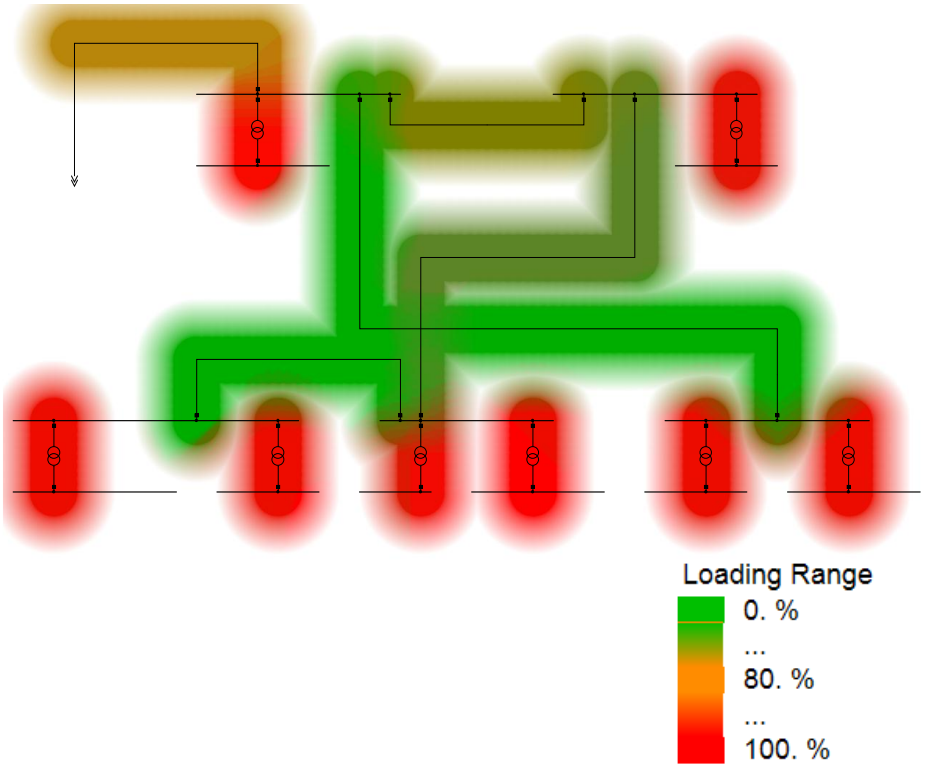
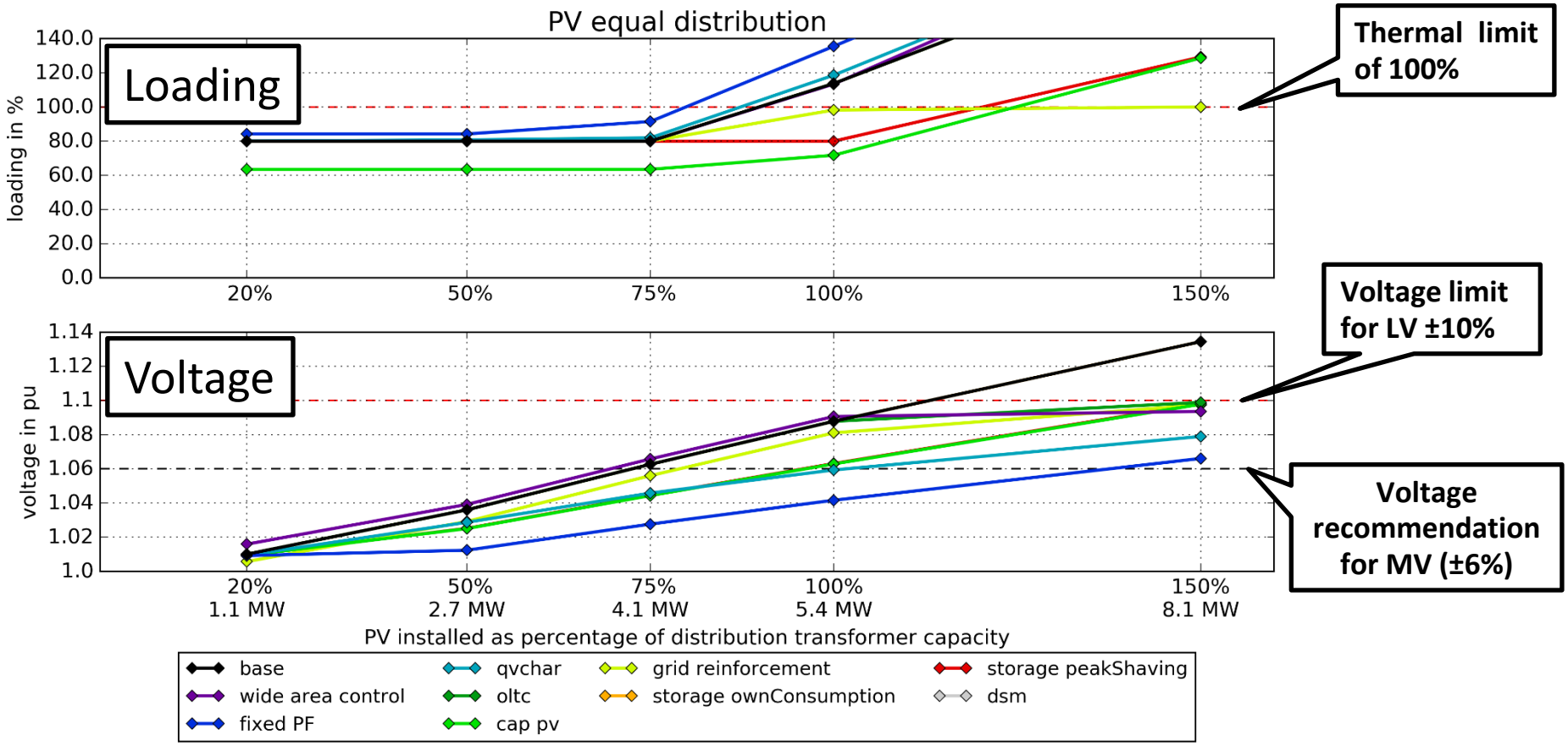
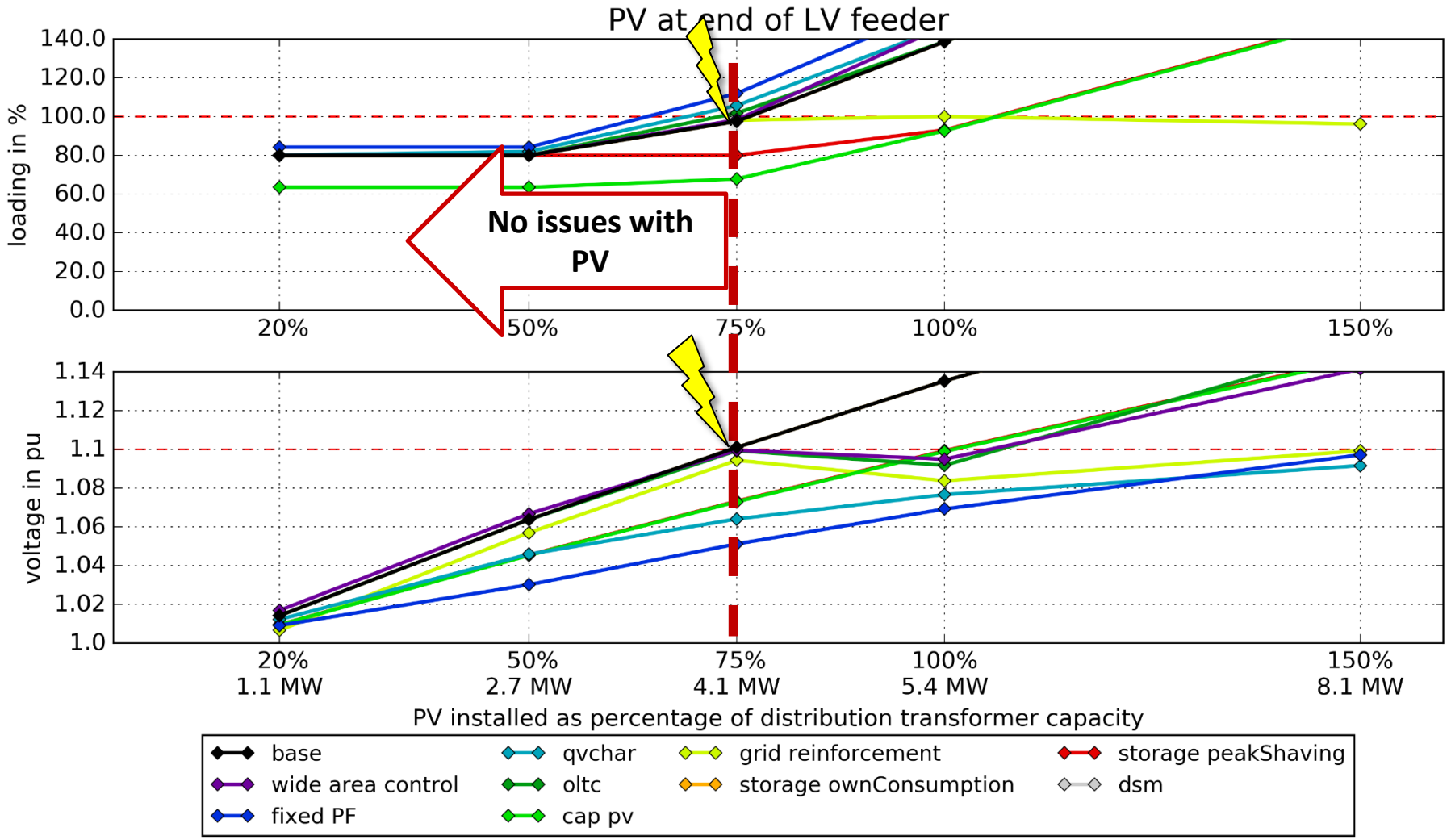


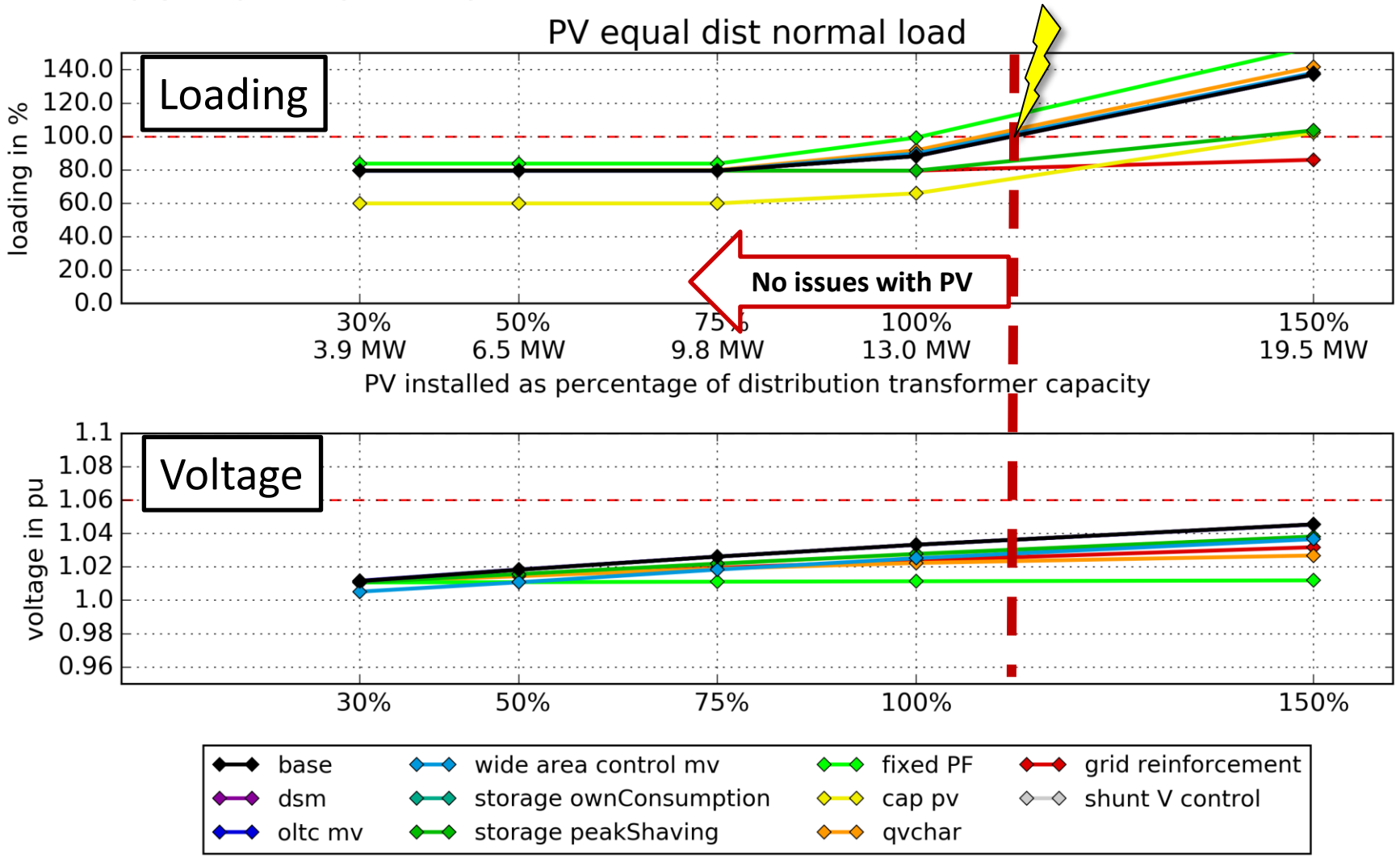
RESULTS DELHI URBAN (5)



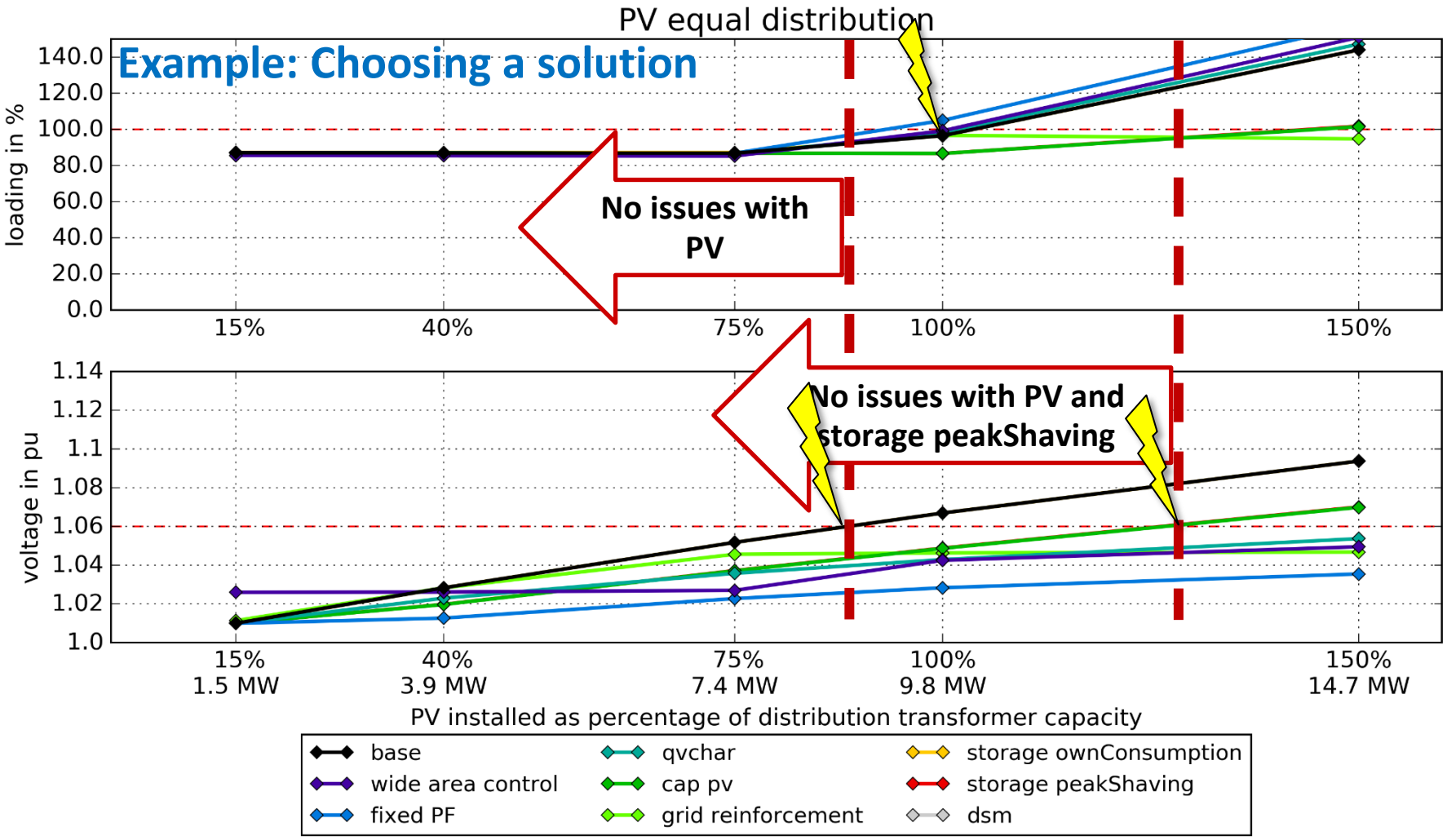
RESULTS DELHI URBAN (6)



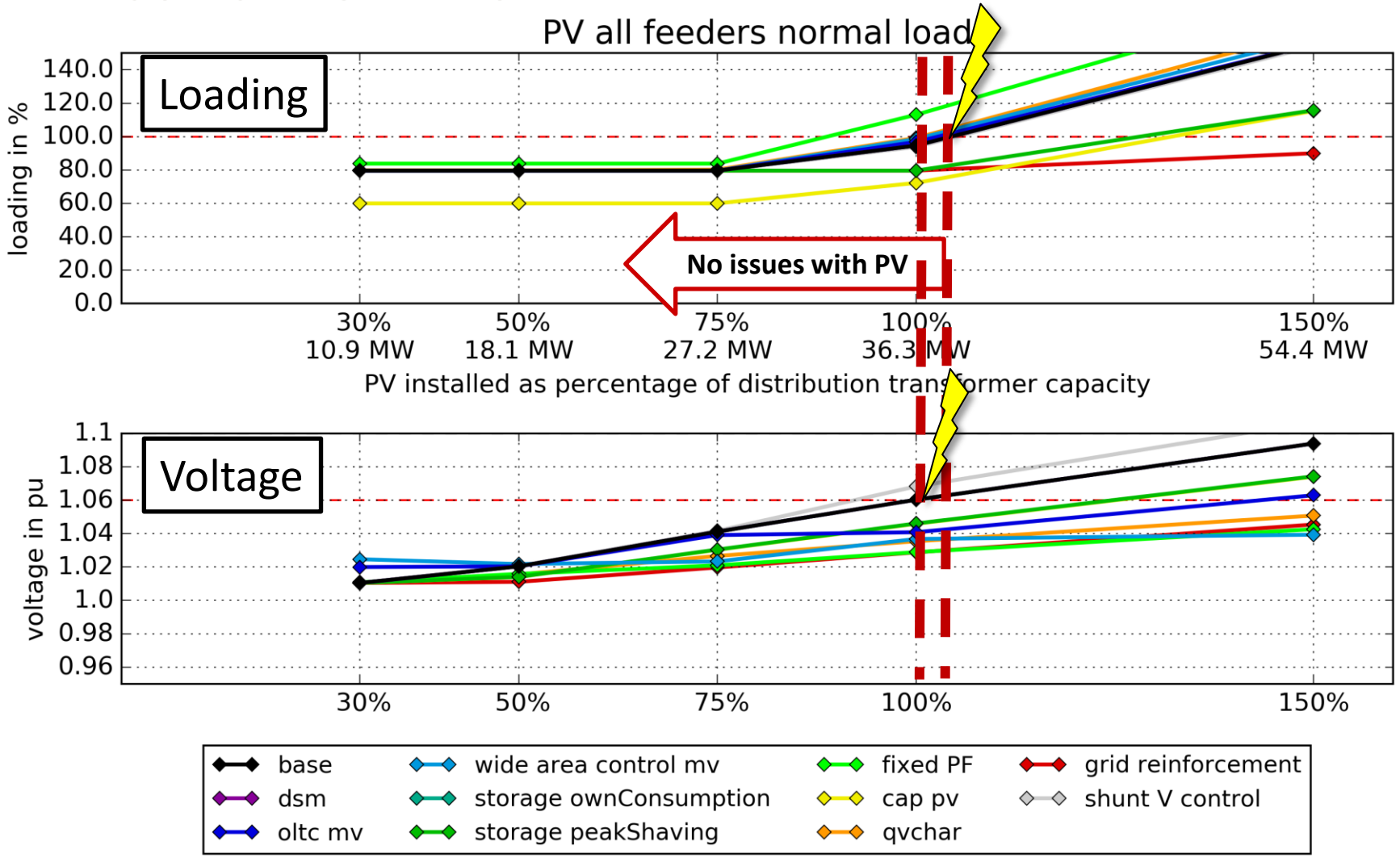
RESULTS BHOPAL URBAN



RESULTS DELHI RURAL (1)



RESULTS BHOPAL RURAL



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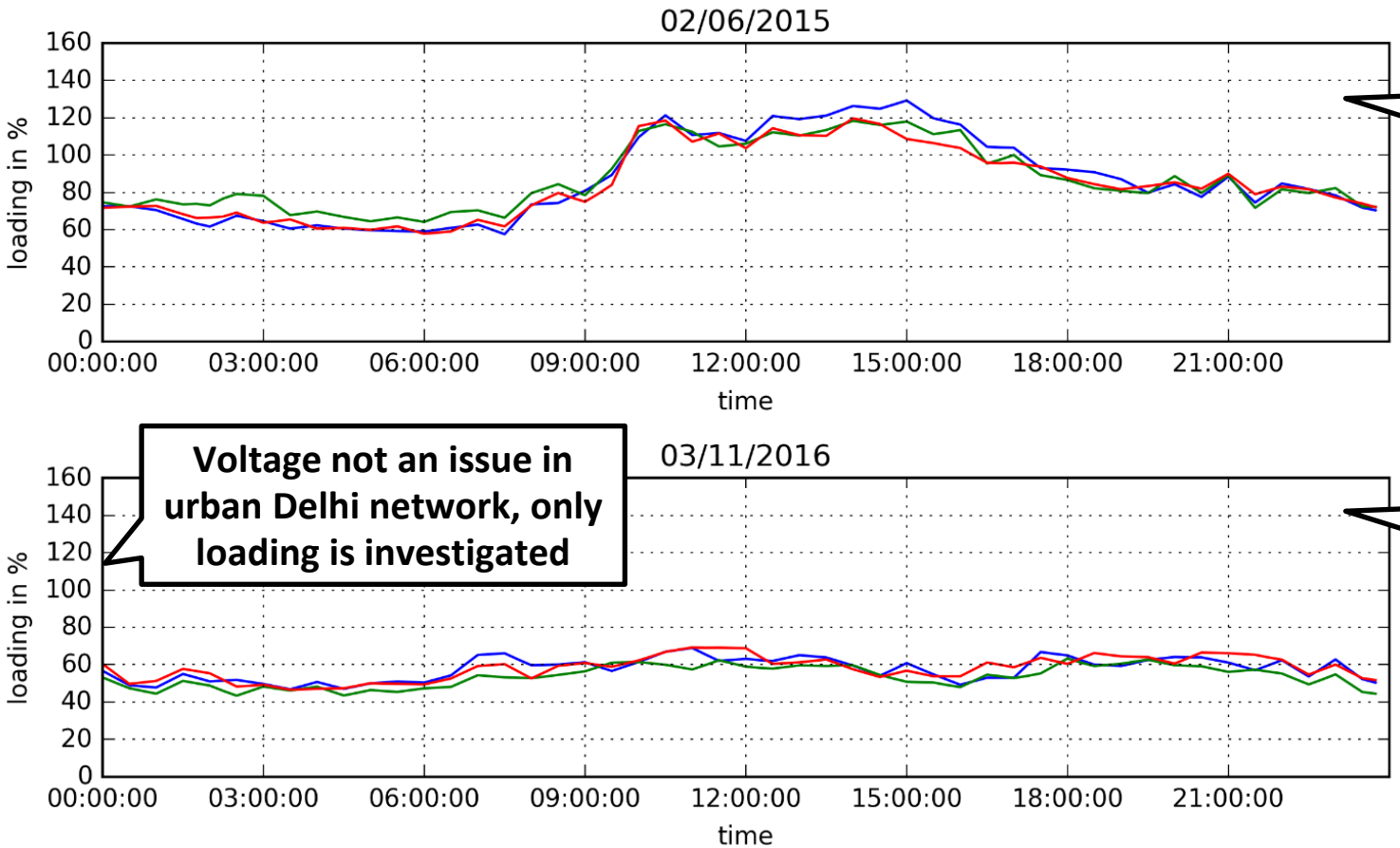
RESULTS COMPARISON

Measure	Delhi urban, PV equal distribution		Bhopal urban, PV equal distribution		Delhi rural, PV equal distribution		Bhopal rural, PV equal distribution	
base	90%		110 %		90%		100 %	
oltc	90%	o	110%	o	Already in base case		105%	↑↑
wide area control	90%	o	110%	o	105%	↑↑	100%	o
fixed PF	80%	↓	100%	↓	95%	↑	90%	↓
qvchar	90%	o	110%	o	105%	↑↑	100%	o
cap pv	150%	↑↑	145%	↑↑	150%	↑↑	125%	↑↑
storage peakShaving	120%	↑↑	140%	↑↑	125%	↑↑	125%	↑↑

UNBALANCE SIMULATION RESULTS DELHI

STATUS QUO
UNBALANCE DUE TO LOAD



03/11/2016 – LOW LOAD
INTRODUCING DIFFERENT PV LEVELS

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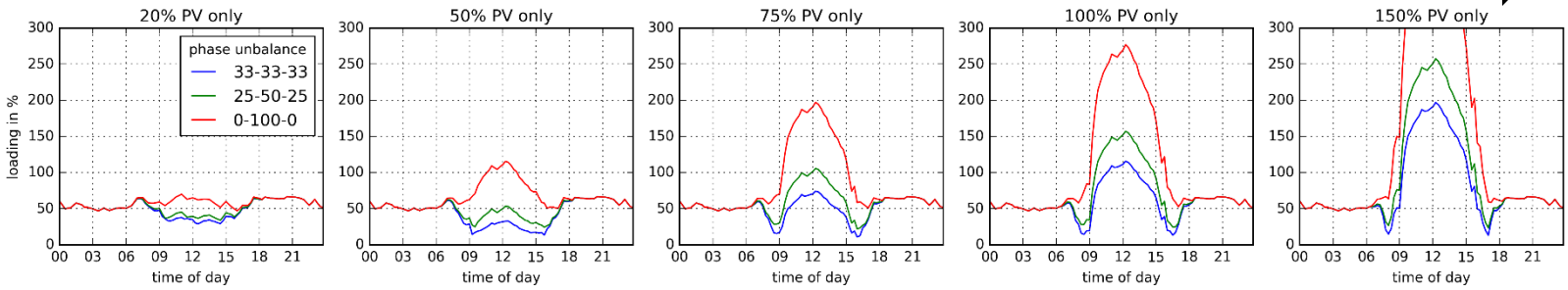
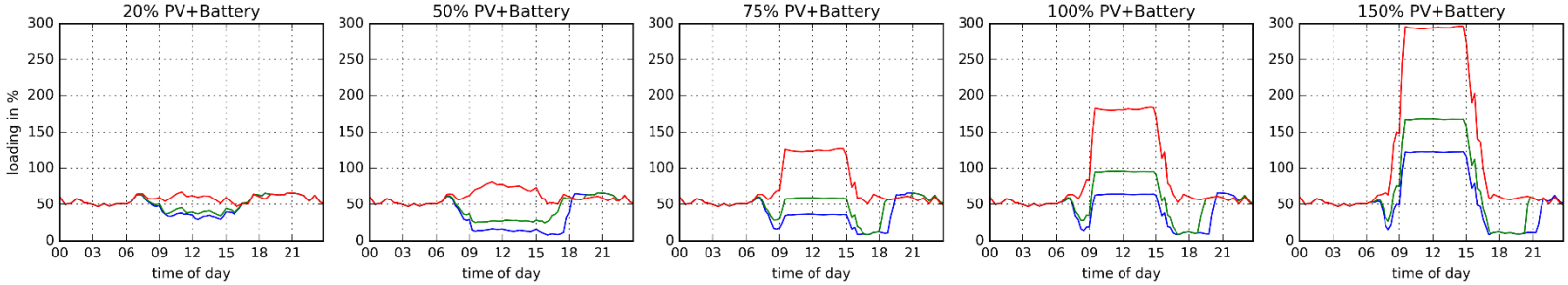
Increase of PV installed as percentage of distribution transformer capacity

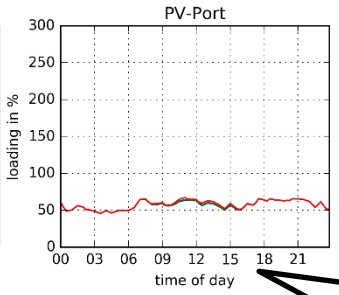
PV only



PV+ Battery



PV Port



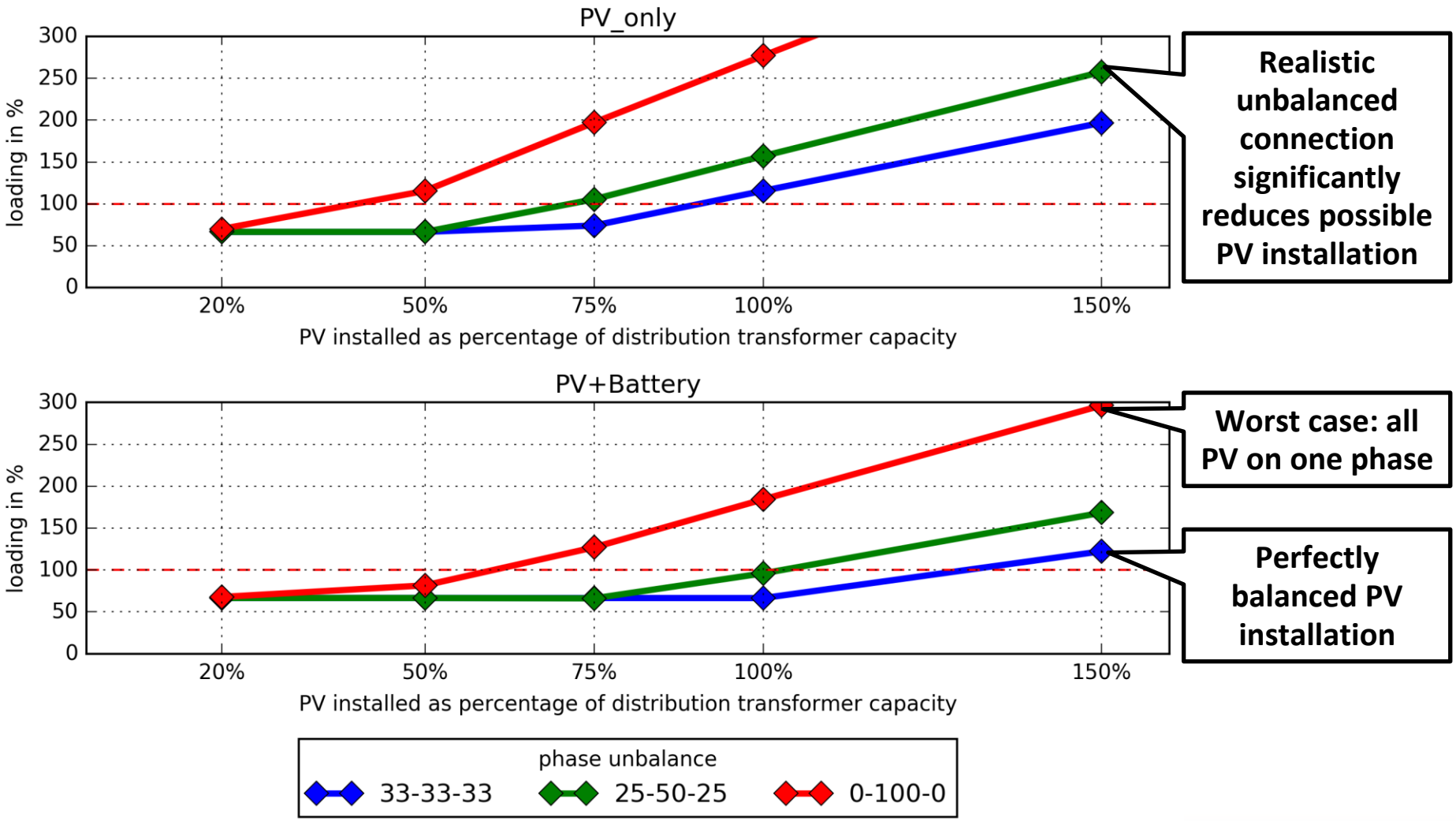
Three different unbalanced PV installation scenarios investigated:

1. 33-33-33: Equal PV distribution per phase
2. 25-50-25: One phase has twice the PV capacity installed
3. 0-100-0: One phase has all the PV capacity installed

Highest loading of the feeder is investigated (cable of feeder)

18 nodes = 36kW = 6% of installed DT capacity

03/11/2016 – LOW LOAD RESULTS

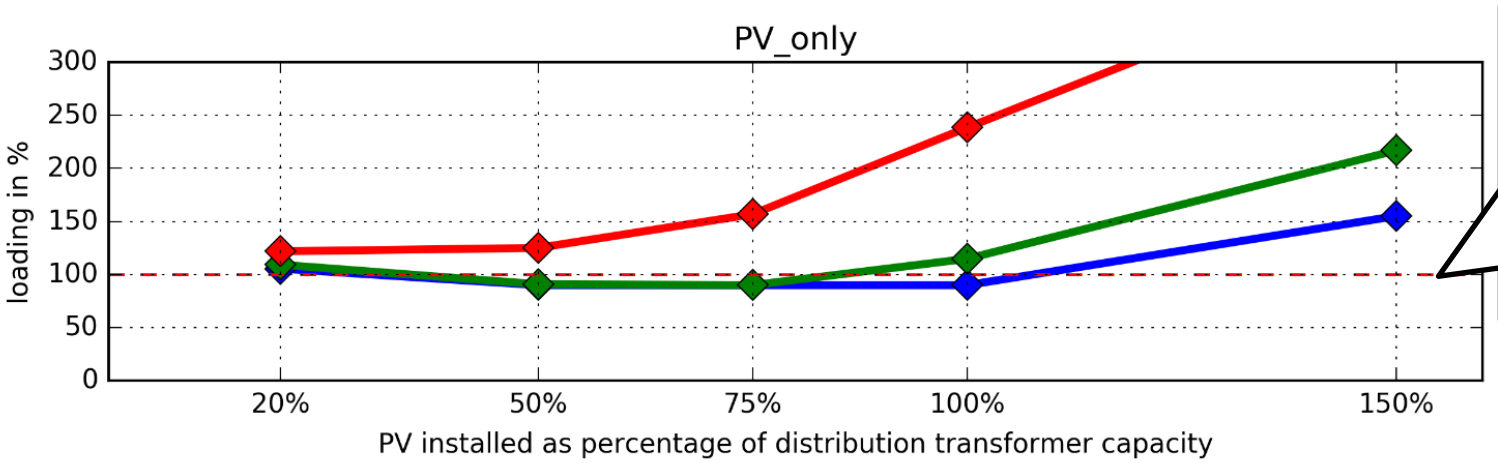


Realistic unbalanced connection significantly reduces possible PV installation

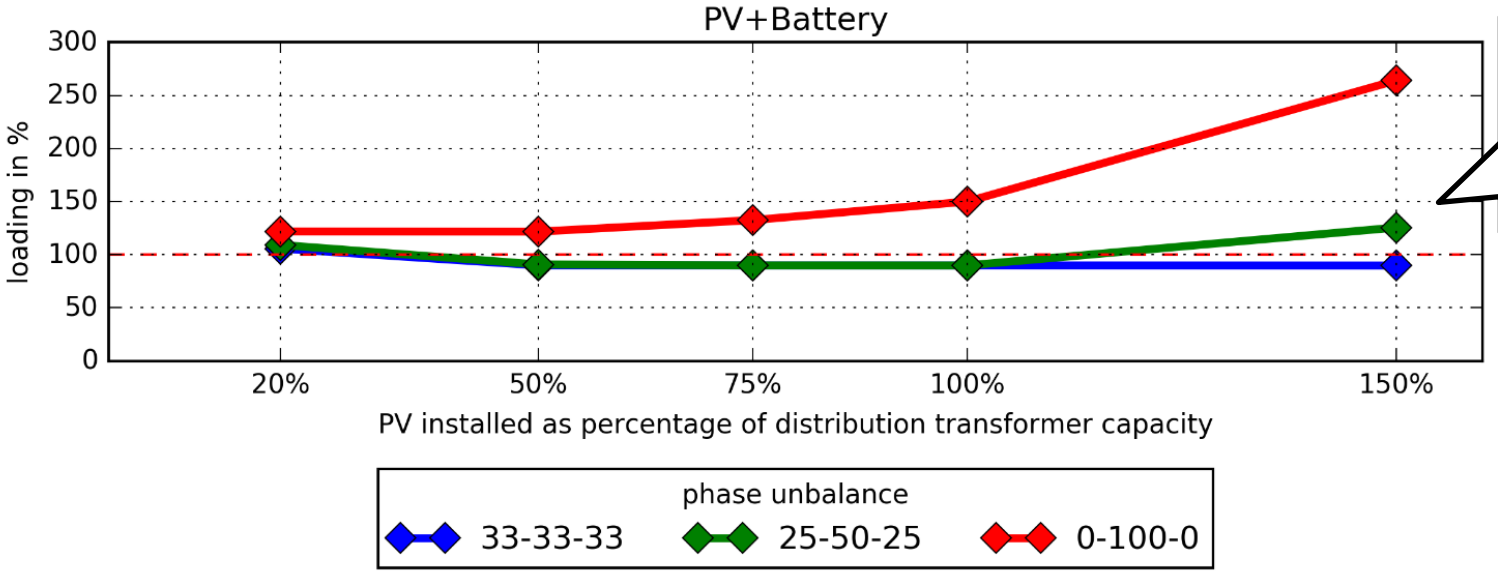
Worst case: all PV on one phase

Perfectly balanced PV installation

02/06/2015 – HIGH UNBALANCE RESULTS

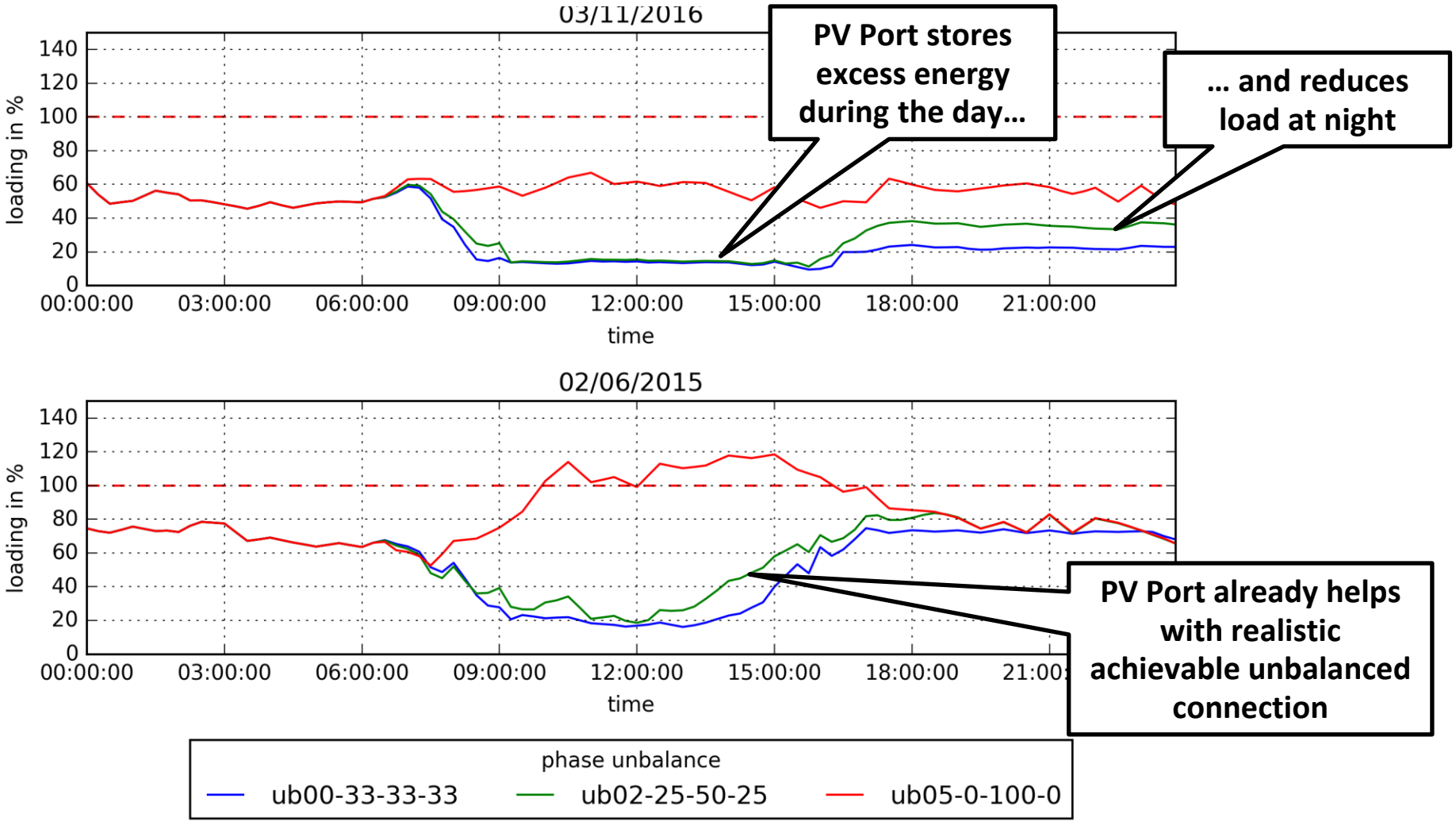


PV reduces load during midday and mitigates overloading – if connected symmetrical!



Storage allows for a smooth balance during midday

PV PORT – 150% PV AS PERCENTAGE OF DT CAPACITY
RESULTS



RESULT OVERVIEW

unbalance	03/11/2016 low load			02/06/2015 high unbalance		
	PV only	PV+ Battery	PV Port	PV only	PV+ Battery	PV Port
33-33-33	90%	130%	unlimited	110%	150%	unlimited
25-50-25	75%	105%	unlimited	85%	115%	unlimited
0-100-0	40%	60%	unlimited	~50%	~50%	unlimited

Conclusions:

- **A worst case distribution of 100% PV on one phase will considerably reduce the max PV penetration level.**
- **However, with realistic unbalances and realistic PV distribution the 75% value holds.**
- **For PV-Port there is no limitation of installed PV capacity due to non-existent power export!**

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

- **Grids in India are not very different from other grids in the world.**
- **PV systems with an aggregated capacity of up to 75% of the transformer rating can usually be connected without any further measures. In most cases 100% are actually possible.**
- **Above 75% the rural networks suffers predominately from over-voltage issues.**
  - Voltage issues can be solved with wide area control of the 66/11kV transformer and reactive power provision by the PV systems
- **Above 75% in the urban network, mostly loading problems occur.**
  - As the lines are short there is less voltage drop across them.
  - Above 75% line loading issues and above 100% distribution transformer overloading have to be considered critical
  - Besides conventional network reinforcement, implementing peak-shaving battery systems is a possible solutions

RECOMMENDATIONS: TECHNOLOGY OPTIONS

- **Automatic voltage control at 132/33, 220/66 or 220/33 kV should be implemented**
- **Automatic voltage control at 66/11 or 33/11 kV is very beneficial, but not strictly required**
- **Under- and overvoltage can be efficiently eliminated using wide area control**
- **Require voltage control capability by rooftop PV inverters through reactive power**
- **Active power controllability should be required from all PV units**
  - Large centralized PV power plants should be remotely controllable
  - Rooftop PV units should either be capped at 70 to 75 % of their maximum expected output, or be remotely controllable, or be equipped with a peak shaving storage (requires incentive)

Batteries can have additional value: UPS, capping nightpeak, …

RECOMMENDATIONS: LEGAL AND REGULATORY FRAMEWORK

- **Remote control of PV units**
  - Requires legal framework of operation (When, who and how to use)
  - Require voltage control capability from PV inverters, controlled by grid operator
  - Active power curtailment requires agreed remuneration of lost energy
  - Recommended to align the voltage control requirements with the German low voltage grid code, most PV systems already comply
- **Capping of PV at 70 or 75 % would have to be specified in grid code and net metering scheme, and checked for legal complications**
- **PV batteries require incentives for installation and running them in peak shaving mode**
- **Grid code requirements should be developed in coordination transmission system operators**
  - Example: frequency response of PV units

NEXT STEPS

Discom Energy Scenarios 2022 / 2027

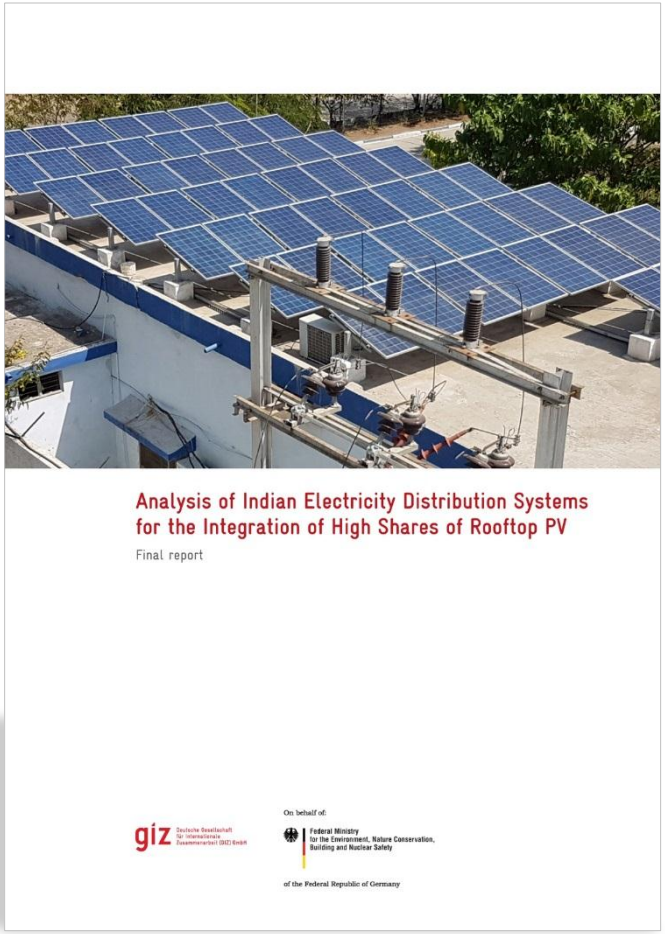
- Replication of the Grid Integration study with modified scope in network of distribution licensees in states where more rooftop PV is expected with a vision of 2022 and 2027.
- Development of a simple online tool to estimate impacts of increased penetration in distribution feeders to be publicly available for the use of distribution licensees
- Establishment of business models for standard, small rooftop PV systems with or without storage (PV-ports) for the residential sector
- Development of new prototypes of (PV-Ports) and testing of business models for distribution licensees
- Implementation and scale-up with support through Regulators and Distribution Companies in States.

→ Support, inputs and involvement from the FOR Technical Committee is requested

THANK YOU FOR YOUR ATTENTION!

Report can be downloaded at

http://www.comsolar.in/what-we-do/capacity-development/grid-integration-study/



18th FOR Technical Committee Meeting
Delhi
23 February 2018

Sub-Group Report

on

"Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement"

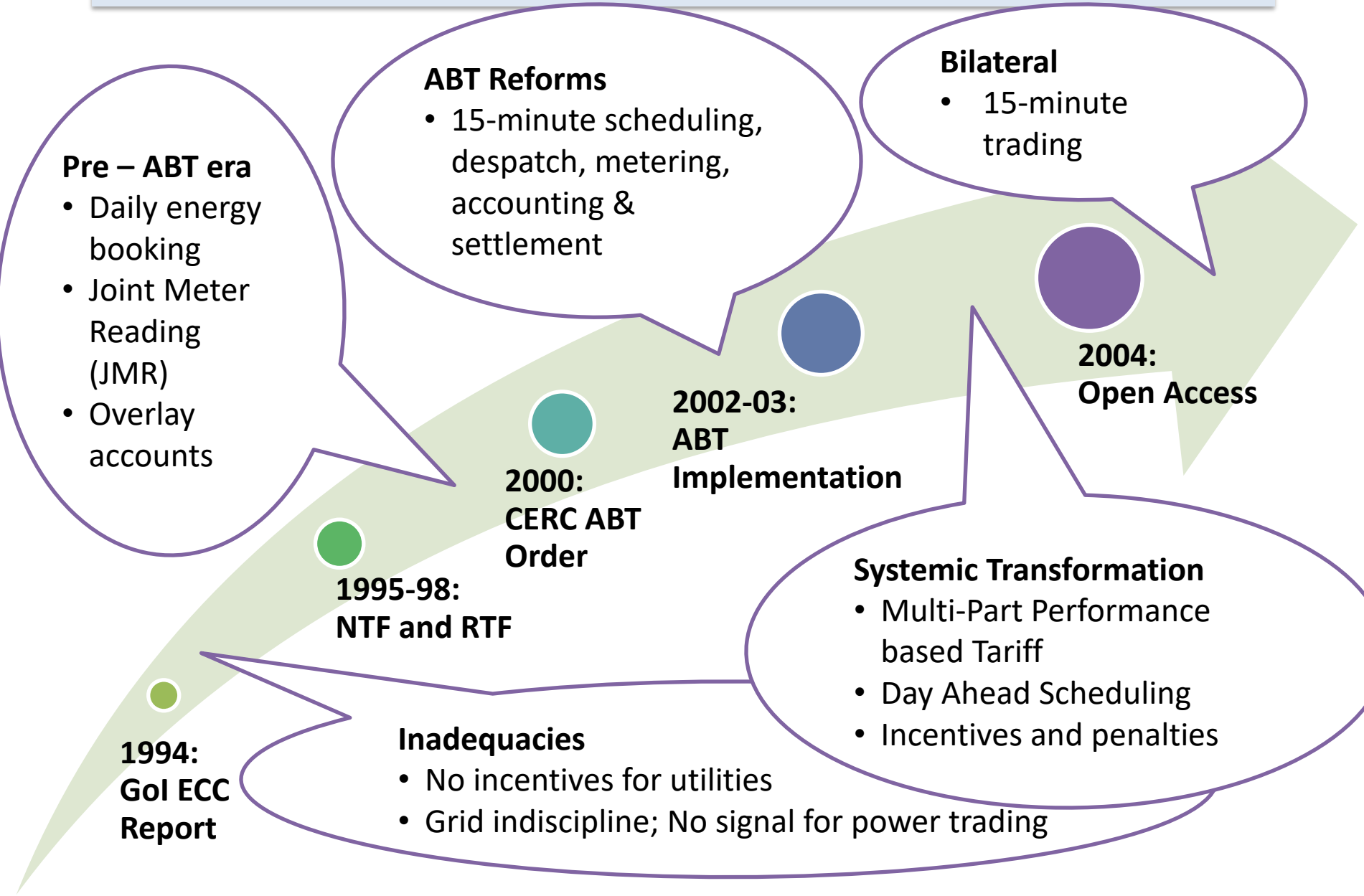
Status Update

- Placed before the FOR Technical Committee on 23rd Feb., 2018
- Draft Report circulated to Sub-group members on 24th Jan., 2018
- Progress apprised to FOR Technical Committee on regular basis
  - (12th and 16th Meetings)
- Three Meetings of the Sub-Group
- 5-Minute Meter Demonstration and Testing
  - With three meter manufacturers

Structure of the Report

- Chapter 1 - Introduction
- Chapter 2 - Imperatives for Fast Markets
- Chapter 3 - Policy and Regulatory Mandate
- Chapter 4 - International Experience
- Chapter 5 - Deliberations and Stakeholder consultations
- Chapter 6 - Meter Capability Demonstration and Testing
- Chapter 7 - Regulatory Provisions to Handle Transition
- Chapter 8 - Action Plan
- Chapter 9 - Metering Infrastructure and Cost Estimates
- Chapter 10 - Handling Transition and Timelines
- Chapter 11 - Recommendations and Way Forward
- Chapter 12 - References

Looking Back to Look Forward



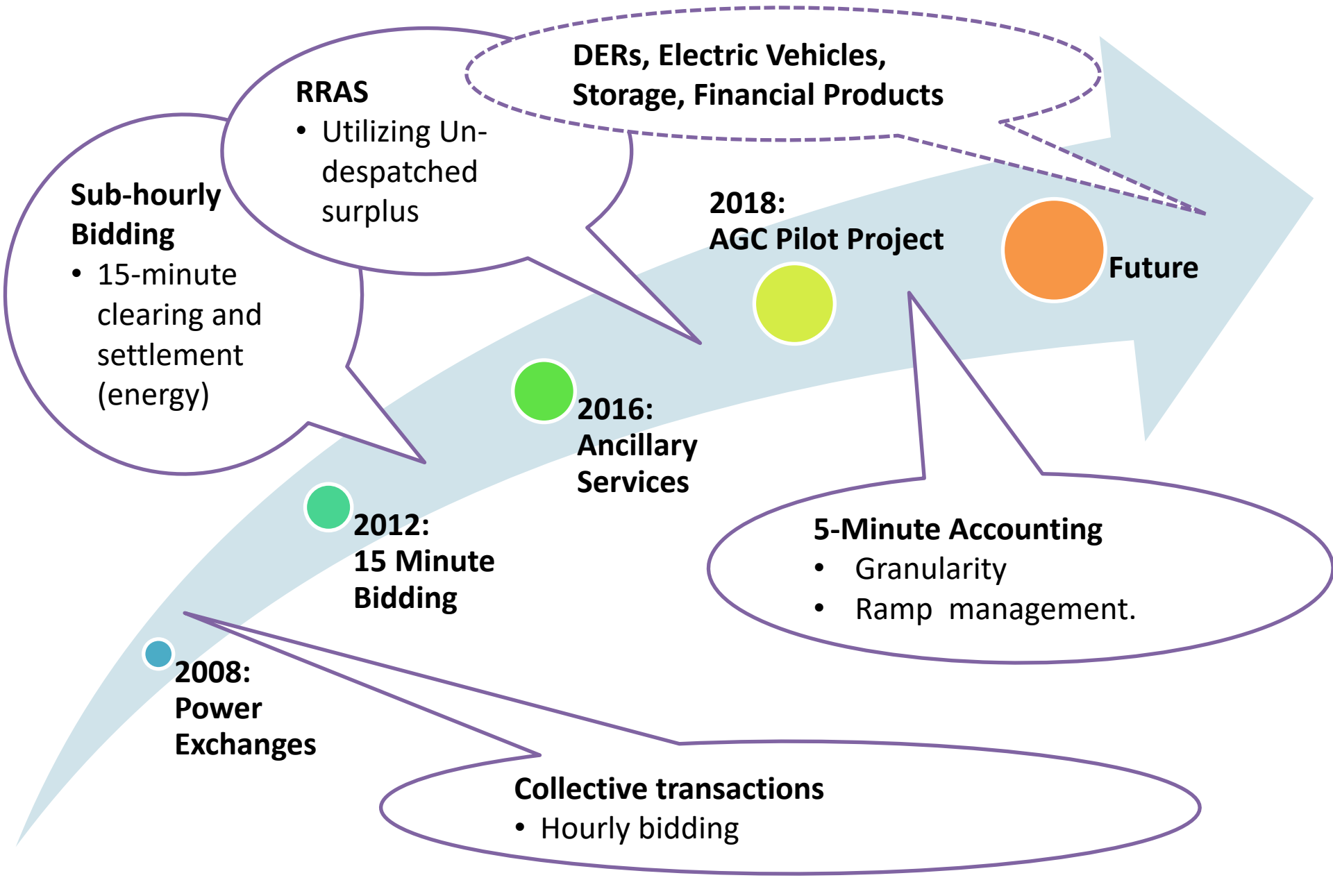
CERC ABT Order dated 04th Jan 2000

5.9.12 We have also considered the views of some of the beneficiaries to change the time block of 15 minutes.

We are convinced that a short time block of 15 minutes can be expected to ensure alertness on the part of the dispatcher to take quick corrective action for maintaining desirable system parameters.

If the interval is larger, there may be a tendency to defer the action with possibilities of steep frequency excursions thereby inviting damages to the system.

Looking Forward to Leap Ahead



Developments in Other Sectors…

Airlines

Banking

भारतीय रिज़र्व बैंक
RESERVE BANK OF INDIA
www.rbi.org.in

May 08, 2017

National Electronic Funds Transfer (NEFT) system – Settlement at half-hourly intervals

Petroleum

Railways

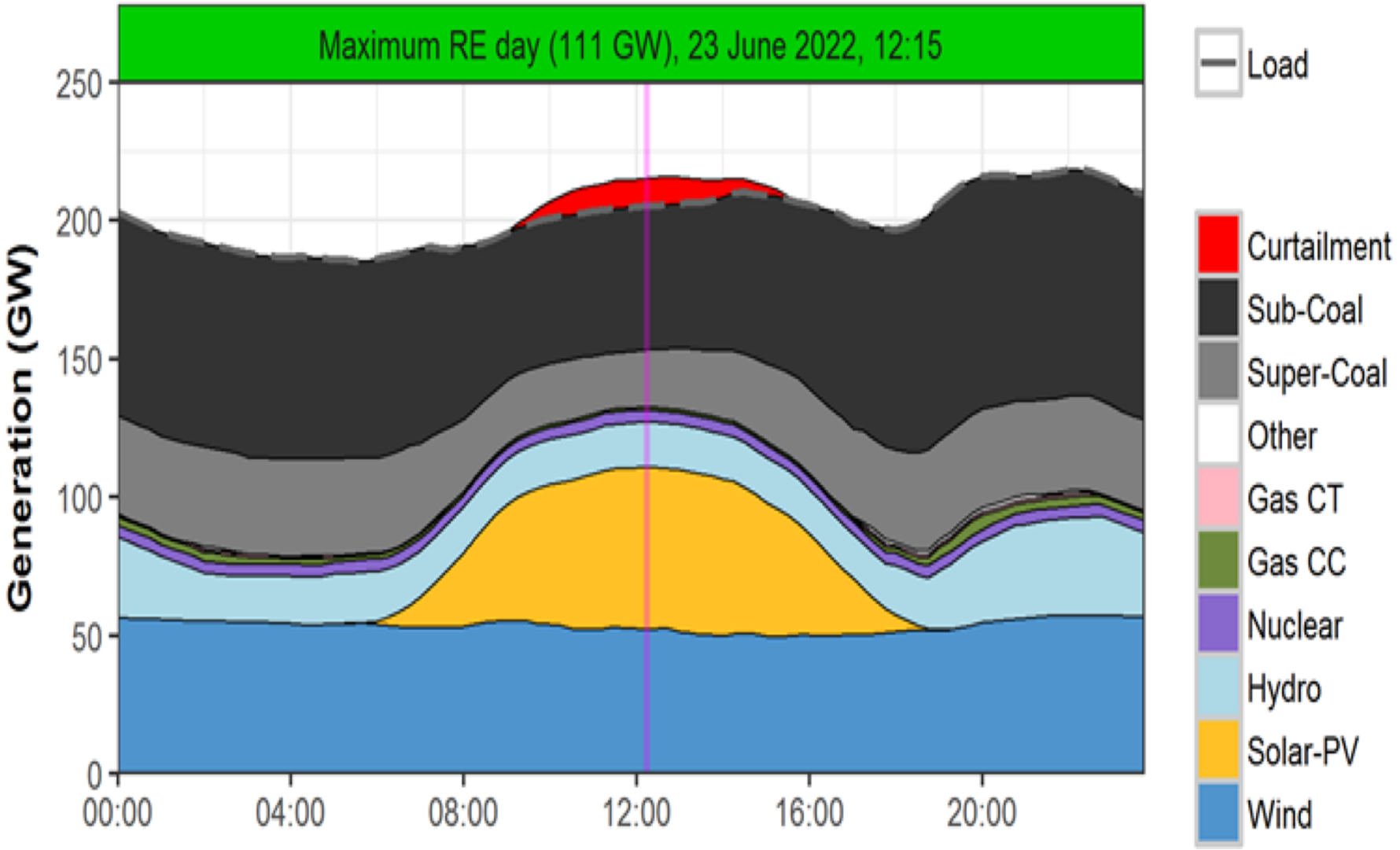
12392*	Shramjeevi SF Expres...*	SF	ECR	6	S M T W T F S	NDLS	13:10
19023	Mumbai Firozpur Jant...	Exp	WR	1	S M T W T F S	NDLS	13:15
12716	Sachkhand Express	SF	SCR	4	S M T W T F S	NDLS	13:20
12483	Kochuveli - Amritsar...	SF	NR	2	F	NDLS	13:25
19566	Uttranchal Express	Exp	WR	--	S	NDLS	13:25
12217	Kerala Sampark Krant...	SKr	NR	3	M W	NDLS	13:25
09566	Haridwar Okha Uttran...	Exp	WR	--	S	NDLS	13:25
19024	Firozpur - Mumbai Ce...	Exp	WR	7	S M T W T F S	NDLS	13:30
12485	Hazur Sahib Nanded -...	SF	NWR	3	M T F	NDLS	13:30

Stock Exchanges

Data Time-Interval	Annual Cost*
1 Minute	Rs. 13,20,000
2 Minutes	Rs. 7,50,000
5 minutes	Rs. 2,75,000
15 Minutes	Rs. 60,000

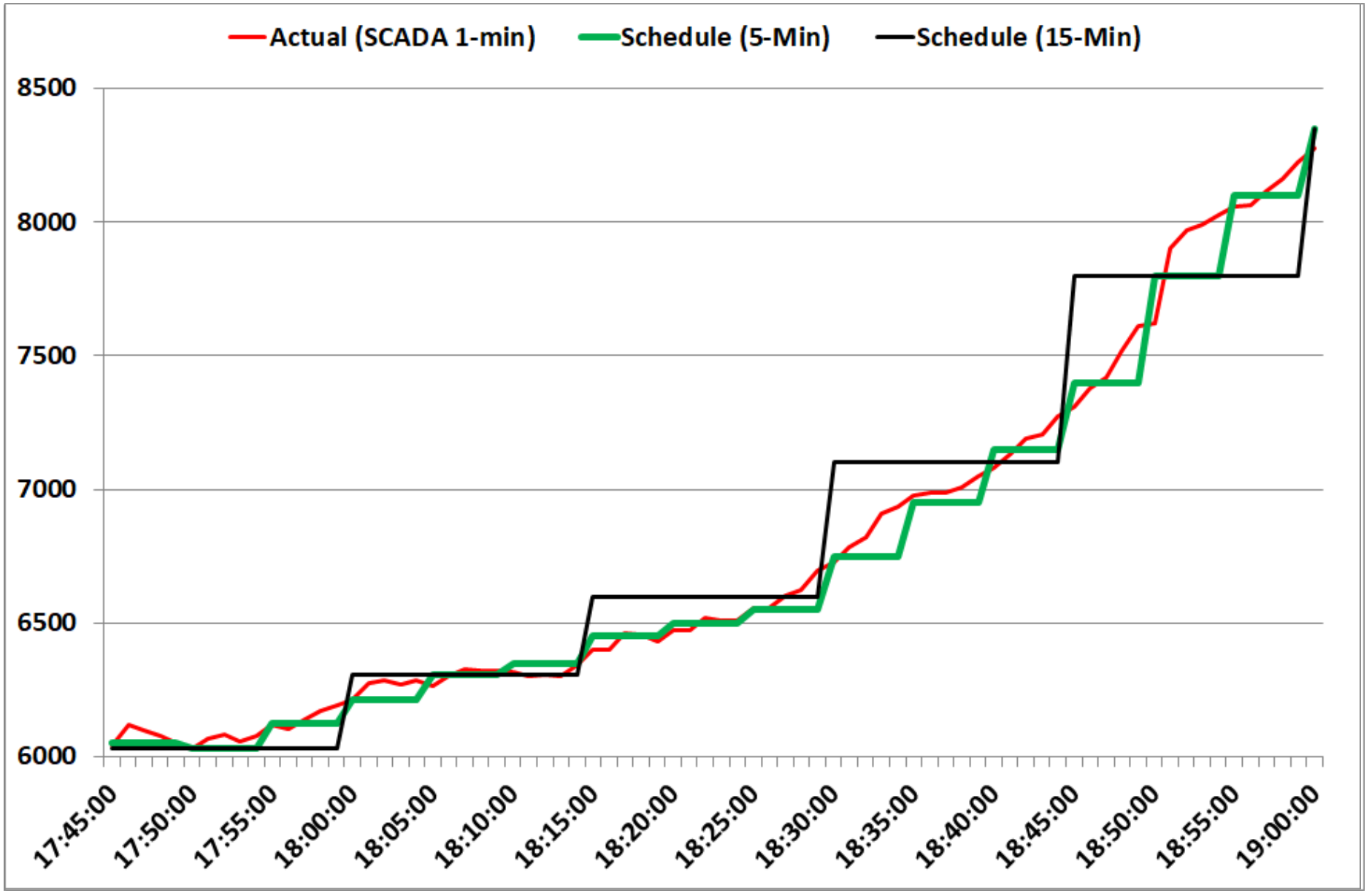
*NSE Annual Data Charges, Capital Market Segment

Increasing Renewable Energy Penetration

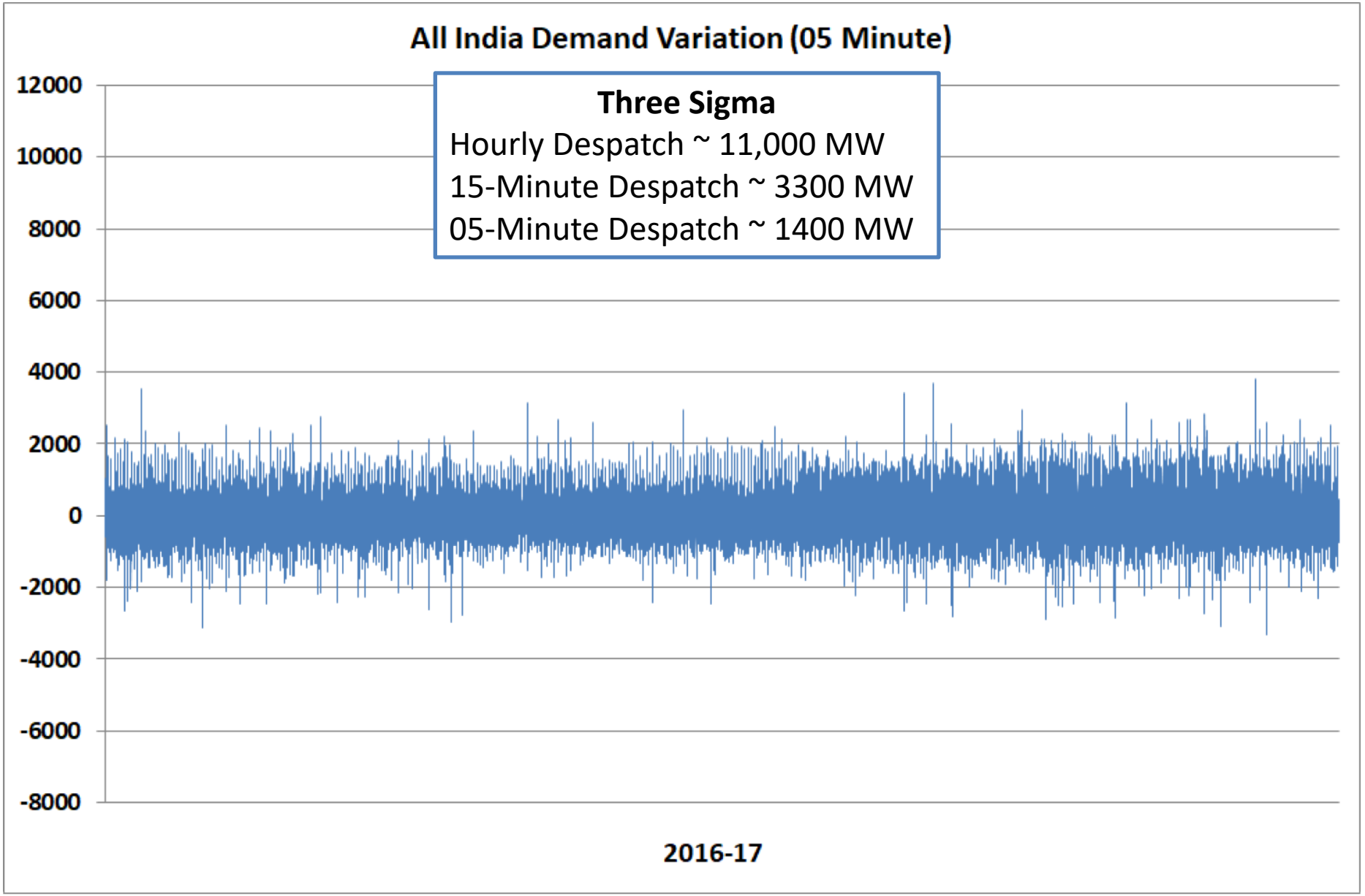


Sample Day in 2022 (Source: GtG Study Report)

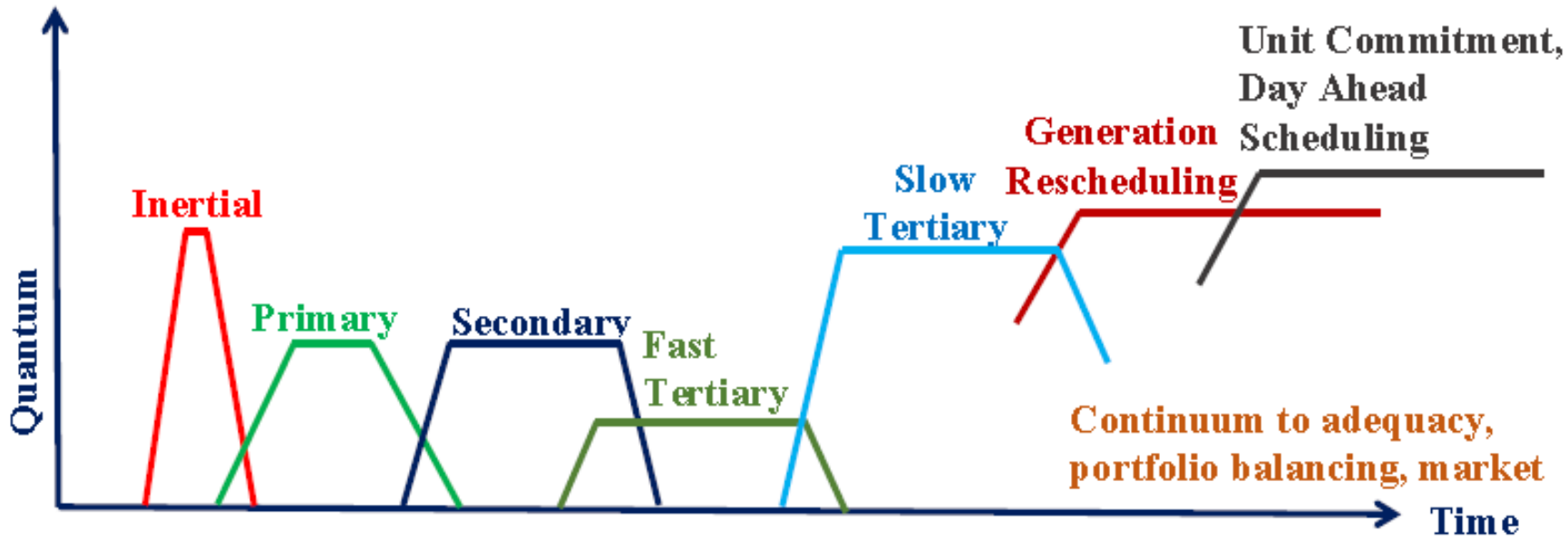
Ramp Management



Reduced Variability and Reserve Requirement

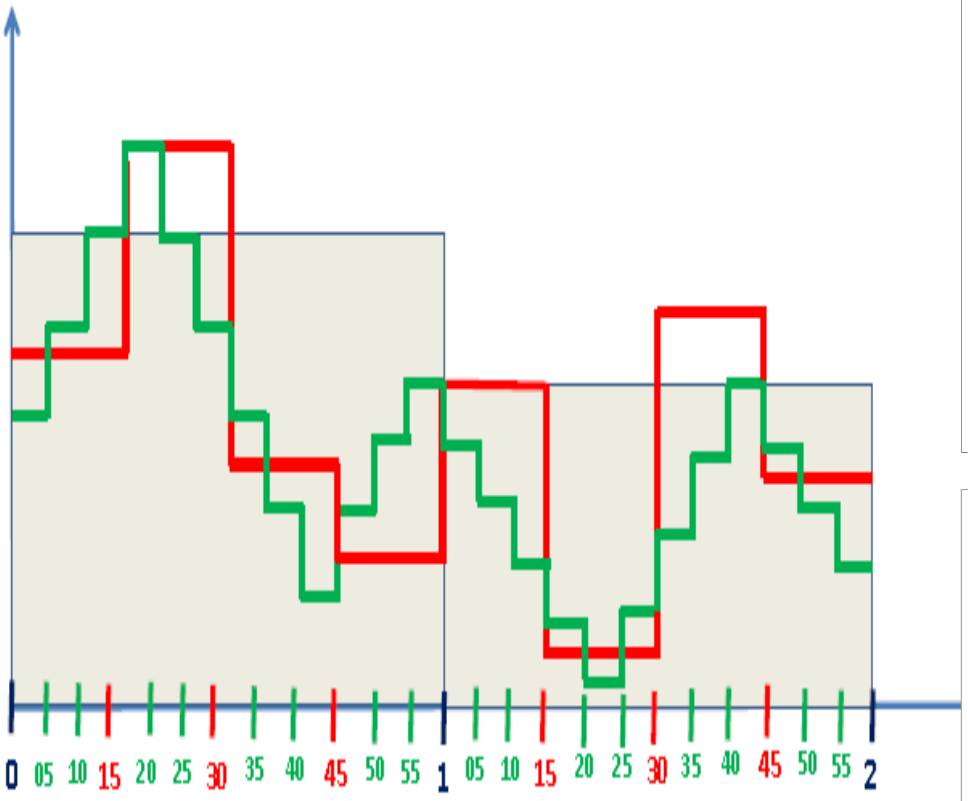


System Balancing in India – A schematic

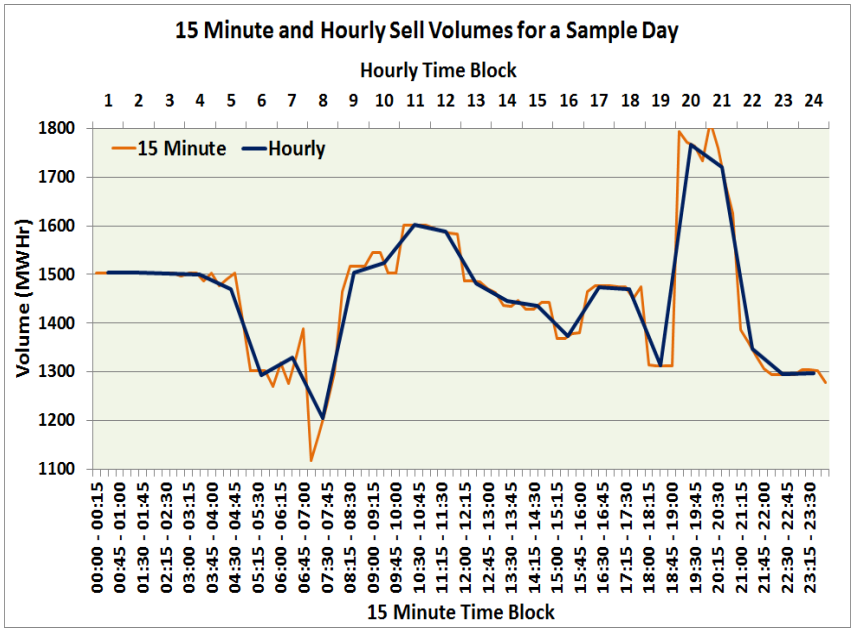


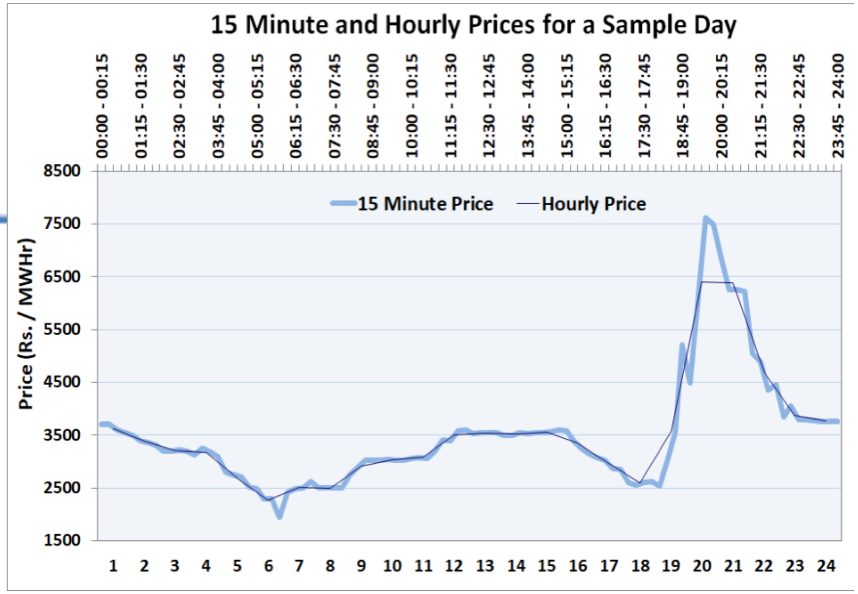
Response → Attribute ↓	Inertial	Primary	Secondary	Fast Tertiary	Slow Tertiary	Generation Rescheduling/ Market	Unit Commitment
Time	First few secs	Few sec - 5 min	30 s – 15 min	5 - 30 min	> 15 – 60 min	> 60 min	Hours/ day-ahead
Quantum	~ 10000 MW/Hz	~ 4000 MW	~ 4000 MW	~ 1000 MW	~ 8000-9000 MW	Load Generation 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	Pilot	Yet to start	Existing	Existing	Existing

Scheduling and Bidding in PX



5 Minute, 15 Minute and Hourly Schedules

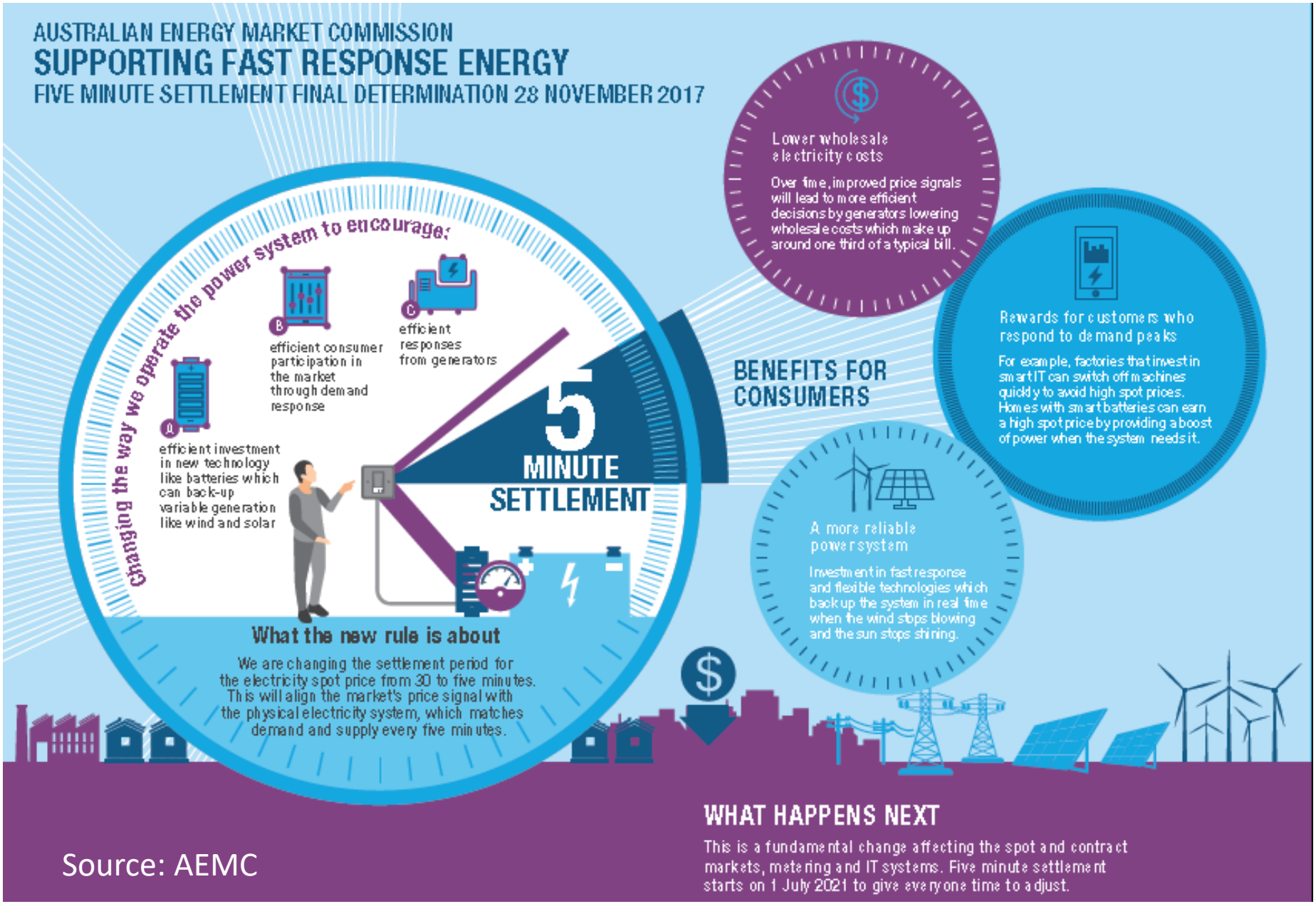




Policy / Regulatory Mandate

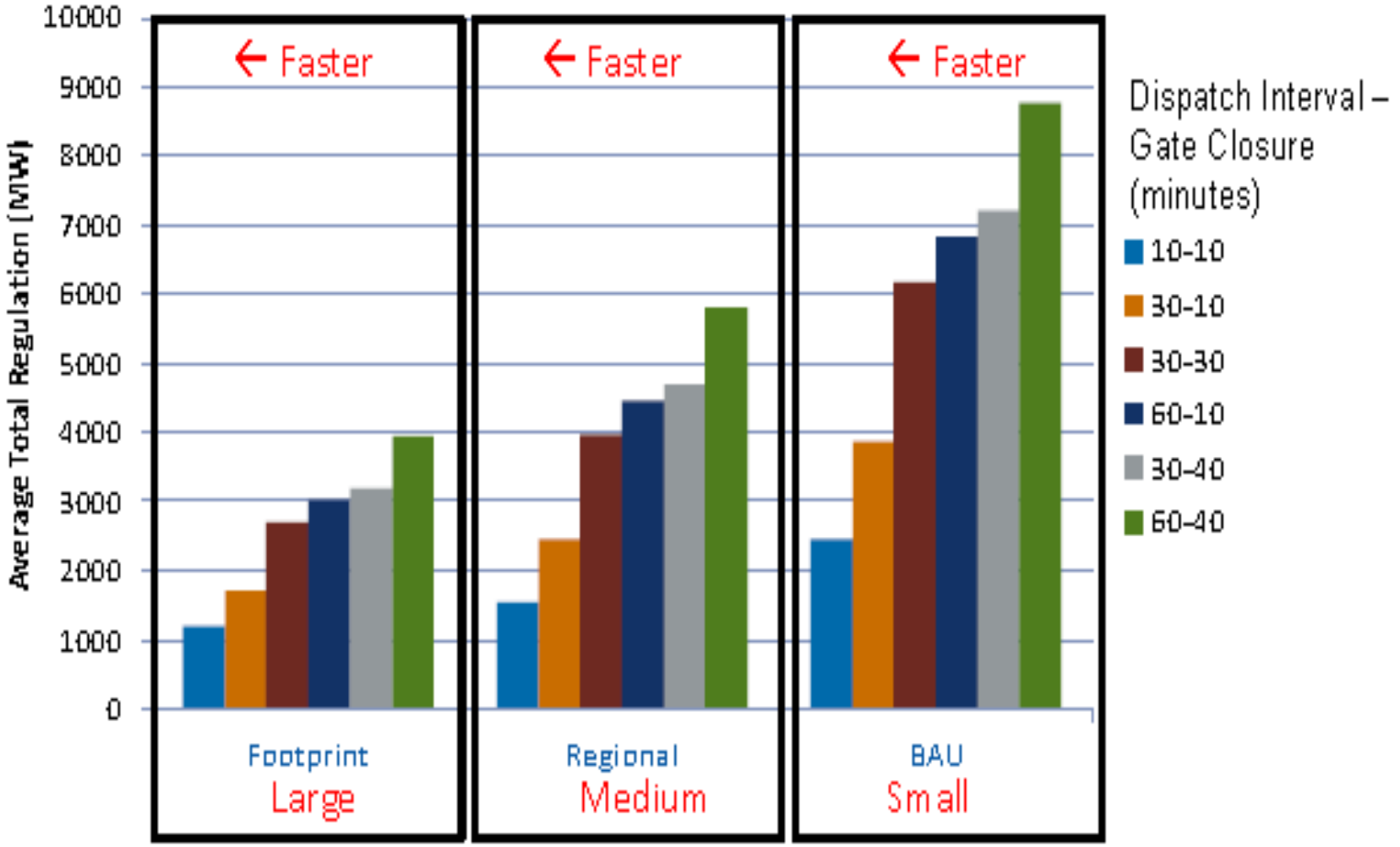
- CERC Consultations/Orders/Regulations
  - Consultation Paper on Modifications in Power Market Design: Evening Market, 15 minute Bidding time block and Ancillary market on PX (2010)
  - Order on Automatic Generation Control (AGC) Pilot Project (2017)
- NITI Ayog Report - India's Renewable Electricity Roadmap 2030 (2015)
  - Shorter Despatch Interval of 5-mintues
- Ministry of Power Technical Committee Report (2016)
  - Frequent market opportunities
- Forum of Regulators (FOR) - SAMAST Report (2
  - 5-minute scheduling, metering & accounting
- FOR Model Deviation settlement Regulations (
  - Provision for 5-minute scheduling, metering & accountin
- NITI Aayog - Draft National Energy Policy (201
  - Shorter despatch interval of 5-minutes

International Experience - Australia



Source: AEMC

Despatch Interval and Regulation



Milligan, Kirby, King, Beuning (2011), The Impact of Alternative Dispatch Intervals on Operating Reserve Requirements for Variable Generation. Presented at 10th International Workshop on Large-Scale Integration of Wind (and Solar) Power into Power Systems, Aarhus, Denmark. October

International Experience - USA

Table i. ISO's intraday timeline summary[4]

ISO	Procedure	Frequency	Look-ahead	Commitment	Dispatc	Prices[5]
CAISO	Residual unit commitment (RUC)	Daily	24-168 h	Long start units		Availability[6]
	Short-term unit commitment (STUC)	1 h	4 h	Medium/short		
	Real-time unit commitment and FMM	15 min	60-105 min	Fast start units	✓	✓
	Real-time economic dispatch	5 min	Up to 60 min		✓	✓
ISO-NE	Resource Adequacy Analysis (RAA)	Daily	Oper. day	Non-fast start		
	Additional RAAs	As needed	Oper. day	✓		
	Unit dispatch software	5 min	60 min		✓	Ex-post
MISO	Reliability Assessment Commitment	Daily	Oper. day	✓		
	Intraday RAC	As needed	Oper. day	✓		
	Look-ahead commitment (LAC)	15 min	3 h	✓		
	Real-time SCED	5 min	N/A		✓	Ex-post
NYISO	Supplemental resource evaluation	As needed	Oper. day	✓		
	Real-time commitment (RTC)	15 min	150 min	✓		
	Real-time dispatch (RTD)	5 min	60 min		✓	✓
PJM	Reliability Assessment Commitment	Daily	Oper. day	✓		
	Combustion Turbine Optimizer (CTO)	As needed	Oper. day	✓		
	Ancillary Service Optimizer (ASO)	1 h	60 min	✓		
	Intermediate-term SCED	15 min	60-120 min	✓		
	Real-time SCED	5 min	15 min		✓	✓
ERCOT	Day-ahead Reliability Unit	Daily	Oper. day	✓		
	Hourly RUC	1 h	Oper. day	✓		
	SCED	5 min	N/A		✓	✓

USA ISOs Intraday Timeline Summary (Source: MIT Energy Initiative)

Deliberations in Meetings (1)

- Need to move to “fast” markets
- 5-minute scheduling & settlement and earmarking of the reserves are interwoven processes.
- 5-minute bidding in OTC/PX markets will lead to price discovery for 5-minute intevals.

- 5-minute DSM prices would be a vital indicator for imbalance handling caused especially by renewable generation.
- Provisions for 5-minute may be made mandatory for future procurement of meters.
- Requirement of amendments in the CEA Metering Standards
- 5-minute scheduling & settlement entail regulatory interventions

Deliberations in Meetings (2)

- Handling Transition
  - To begin with, 5-minute metering will be in parallel with 15 minute metering. A changeover date would be applicable
  - “Scheduling and Despatch” has to be aligned with “Settlement” process in 5-min too.
  - To begin with, accounts for both 5-minute and 15-minute accounting may be kept in parallel.
- Capacity building for 5-Minute granular forecasting at state level
- SAMAST implementation would enable states to leapfrog
- Stakeholder Consultations
  - RPC Forum
  - Discoms – Gujarat, Delhi, Tamil Nadu and West Bengal

Meter Demonstration – M/s Secure

Main meter: NP-8607 A (Elster)
Model- Alpha M++

Check meter: Y0356046 (Secure)
Model- Apex 150

Meter Demonstration – M/s Elster Honeywell

Main meter: NP-8627 A
Model- Alpha A1640

Check meter: NR-3102 A
Model- Alpha M++

Meter Demonstration – M/s L & T

Main Meter – NP 2985A (Secure)
Model E2M021

Check Meter - H 170903 (L&T)
Model ER300P

Meter Testing Witnessed Jointly by Representatives of NLDC, WRLDC, POWERGRID, Gujarat SLDC and Meter Manufacturers

Demonstration of 5-Minute Metering at POWERGRID 400/220 kV GIS Magarwada Station, Daman, 13th Sep 2017

1. List of participants attached
2. Objective:
   a. Demon… ing at 15-minute interval) for record…
   b. Validate… g 15-minute meters
3. Participating M…
   a. M/s Se…
   b. M/s Ho…
   c. M/s L&… the 25th September as the re-configu…
4. Site Description … wing elements:
   a. 400 kV …
   b. 400 kV …
   c. 400 kV …
   d. 400 kV Magarwada Boisar s/c
   e. 315 MVA 40…
   f. 315 MVA 40…
5. Existing Meter Placem…
   a. In 400 kV lines, the main meters are placed at both ends
   b. On the ICTs, main meter on HV side and standby meter on LV side
   c. Drawl of Daman & Diu computed from the HV side meters of the ICTs
   d. All the meters at Magarwada end are of Elster make Model 'Alpha M++'

Magarwada S/s

Meter No.	CT Ratio	PT Ratio	Element Detail
NP-8627-A	1000/1	400/100	400KV Navsari Magarwada - I
NP-8589-A	1000/1	400/110	400KV Navsari Magarwada - II
NP-8598-A	1000/1	400/110	400kv Boisar Magarwada(PG)
NP-8607-A	1000/1	400/110	400KV Kala Magarwada GIS(PG)
NP-8626-A (HV)	600/1	420/110	315 MVA 400/220 kV ICT I
NP-8597-A (LV)	1000/1	245/110	315 MVA 400/220 kV ICT I
NP-8604-A (HV)	600/1	420/110	315 MVA 400/220 kV ICT II
NP-8624-A (LV)	1000/1	245/110	315 MVA 400/220 kV ICT II

WRLDC NLDC SLDC-GJ POWERGRID ELSTER SECURE

Demonstration of 5-Minute Metering at POWERGRID 765/400/220kV GIS Vadodara Station, Gujarat, 10th Oct 2017

1. List of participants attached in annexure-1
2. Objective:
   a. Dem… ling at 15 min…
   b. Vali… isting 15-min…
3. Site descrip… following elements
   a. 400…
   b. 400…
   c. 400…
   d. 400…
   e. 765…
   f. 765…
   g. 765…
   h. 400…
4. Existing Me…
   a. Spec… ICTs are stand… main meters.
   b. SEMs at Vadod… scription of meters is as below.

Vadodara S/s

S. No	Meter ID	Make	Model No.	Description
1	NP-2979-A	SML	E2M021	765KV Indore(PG) line at Vadodara(PG)
2	NP-2977-A	SML	E2M021	765KV Dhule(BDTCL) line at Vadodara(PG)
3	NP-2981-A	SML	E2M021	400KV Pirana(PG) line-1 at Vadodara(PG)
4	NP-2983-A	SML	E2M021	400KV Pirana(PG) line-2 at Vadodara(PG)
5	NP-2985-A	SML	E2M021	400KV Asoj line-1 at Vadodara(PG)
6	NP-2986-A	SML	E2M021	400KV Asoj line-2 at Vadodara(PG)
7	NP-2978-A	SML	E2M021	765KV side ICT-1 at Vadodara(PG)
8	NP-2982-A	SML	E2M021	400KV side ICT-1 at Vadodara(PG)
9	NP-2980-A	SML	E2M021	765KV side ICT-2 at Vadodara(PG)
10	NP-2984-A	SML	E2M021	400KV side ICT-2 at Vadodara(PG)
11	NP-5446-A	ELSTER	Alpha M++	400KV side of ICT-1 at Vadodara(PG)
12	NP-5448-A	ELSTER	Alpha M++	220KV side of ICT-1 at Vadodara(PG)
13	NP-5447-A	ELSTER	Alpha M++	400KV side of ICT-2 at Vadodara(PG)
14	NP-5449-A	ELSTER	Alpha M++	220KV side of ICT-2 at Vadodara(PG)

SLDC Gujarat WRLDC NLDC POWERGRID LBT LBT-Baroda

Meter Demonstration & Testing Results - Summary

Title	Elster	Secure	L & T
Reconfiguration of existing 15-min meter to 5-min	Possible in Existing meters, Simple, on-site	Not possible in existing meters, possible in new models only, on-site	Not possible in existing meters, new models only, off-site
Reconfiguration Time	Fast	Fast	At factory
Retention of old data	Old data erased	Block wise data erased cumulative data retained	No retention
Conversion software for NPC File	The software for conversion to .npc file is available	Software for converting to NPC format needs upgrade	The software for conversion to .npc file is not available
Wh recording	Acceptable	Acceptable	Acceptable
VARh recording	Variations observed due to integration time difference		Data not available
Storage	Could not be ascertained		Storage upgraded in factory

Required Regulatory Interventions

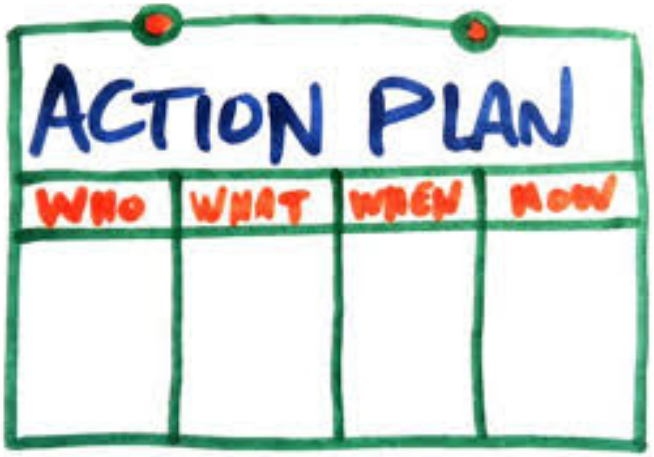
- **CERC Regulations**
  - Terms and Conditions of Tariff
  - Indian Electricity Grid Code
  - Deviation Settlement Mechanism
  - Open Access in inter-State Transmission
  - Ancillary Services Operations
  - Measures to relieve congestion in real time
- **Need for Expert Group:**
  - Technical Specifications for Interface Energy Meters
  - File Interchange Formats
  - Automated Meter Reading System
  - Communication Infrastructure
  - Application software at Central Location
  - Metering System Administration
  - Recovery of CAPEX and O & M charges

Modifications in CEA Metering Standards

- Record frequency data at 0.01 Hz resolution
- Net VARh and voltage to be recorded for each time block.
- Auxiliary Supply - SEM may normally be capable of operating with power drawn from the VT secondary circuits.
- Provision to operate on control power supply to the SEM from 110V DC / 220V DC.
- Built-in calendar and clock
- Secured software based solution for meter time correction and synchronization with GPS
- DLMS compliant for SEM communication protocol – Indian COSEM standard
- Data security ensured as per IEC-62056-51 standard
- Automated Meter Reading (AMR)
- Uniform protocol for communication for meters of different vendors.
- Optical coupling cable should be compatible with all types of meters.
- Replacement of defective meters within a stipulated time frame

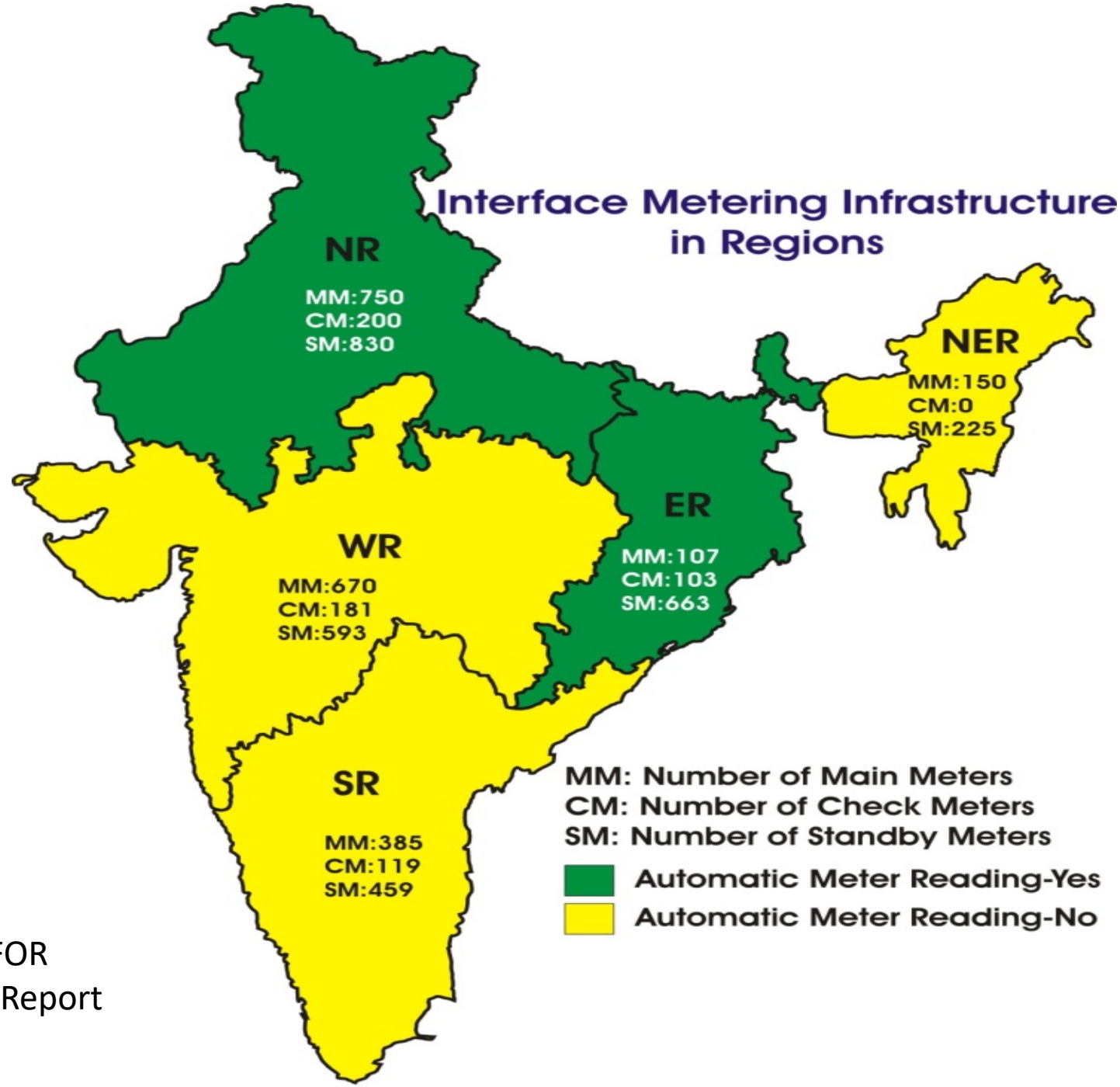
Action Plan

- Forecasting
- Scheduling & Despatch
- Power Exchanges – 5 minute price discovery
- Administration and Treatment of DSM
- Metering and Settlement
- Regulatory Amendments
- Gate closure provisions
- CEA Metering Standards Amendments
- Upgradation/Replacement of meters
- Cost Recovery model (for meters)
- Software upgrade at the RPC/RLDC/SLDC
- Implementation of SAMAST Recommendations
- Stakeholder Capacity Building
- Centre for Power Sector Information Technology Services



Regional Entities

Region	Regional Entities		
	Generator	Drawee	Total
North	44	12	56
East	43	10	53
West	21	7	28
South	22	8	30
North-East	10	8	18
All India	**158**	**55**	**213**
Bhutan	4	1	5
Bangladesh	-	1	1
Nepal	-	1	1
Myanmar	-	1	1
Total	**162**	**59**	**221**
Future	**~ 250**	**~ 100**	**~ 350**



Source: FOR SAMAST Report

All India Metering Locations and Numbers

Region	Metering Locations	Number of Meters
North	274	1666
East	146	828
West	164	1490
South	157	887
North-East	75	375
All India	816	5246
Bhutan	3	18
Bangladesh	2	8
Nepal	4	8
Myanmar	1	2
Total	826	5282
Future	**~ 1000**	**~ 10,000**

Timeline of Activities

Required Action	Action By	Timeline
Pilot Projects implementation	CTU/RPCs/POSOCO	June 2018
Draft Regulatory Framework	CERC	June 2018
Amendments in Standards	CEA	June 2018
Technical specifications	CTU/RPCs/ POSOCO	July 2018
Software upgradation	CTU/RPCs/ POSOCO	July 2018
Final Regulatory Framework	CERC	Sept. 2018
Procurement	CTU/RPCs/ POSOCO	Sept. 2018
5-minute bidding	CERC/PX/POSOCO	April, 2019
Trial Run (Transition)	All	Apr'2019 – Mar'2020
Go Live	**All**	**01st Apr'2020**

Recommendations

- Development of Forecasting as a Core Area in System Operation
- Implementation of Five minute Scheduling and Despatch
- Implementation of 5-minute bidding in OTC/PX
- Five-minute Energy Accounting and Settlement System
- Administration and Treatment of the Five-minute Deviation Price
- Pan-India Pilot Project on 5-minute metering
- Change in data exchange file structures and other technical issues
- Regulatory Interventions
- Amendments in CEA Metering Standards
- Upgradation/Replacement of Metering Infrastructure
- Stakeholder Capacity Building
- Implementation of SAMAST Recommendations

References (1)

[1] CERC ABT Order in Petition No. 2/99 dated 04th January, 2000 http://www.cercind.gov.in/orders/2-1999GOIABT040100.pdf

[2] CERC Order on AGC Pilot Project in Petition No. 79/RC/2017 dtd. 06th Dec., 2017 http://www.cercind.gov.in/2017/orders/79_rc.pdf

[3] FOR Report on Scheduling, Accounting, Metering and Settlement of Transactions in Electricity (SAMAST report) http://www.forumofregulators.gov.in/Data/WhatsNew/SAMAST.pdf

[4] CERC (Ancillary Services Operations) Regulations, 2015.

http://www.cercind.gov.in/2015/regulation/Noti13.pdf

[5] CERC (Indian Electricity Grid Code) (Fifth Amendment) Regulations, 2017

http://www.cercind.gov.in/2017/regulation/130.pdf

[6] CERC Roadmap to Operationalise Reserves in the Country dtd. 13th October, 2015

http://www.cercind.gov.in/2015/orders/SO_11.pdf

[7] RBI NEFT system – Settlement at half-hourly intervals

https://rbi.org.in/scripts/NotificationUser.aspx?Id=10958&Mode=0

[8] DGCA circular - Procedure to be followed to mitigate flight delays

http://dgca.nic.in/circular/ATC/ATC05_2017.pdf

[9] MOP-USAID RE Integration National Study Report under Greening the Grid Program

https://posoco.in/reports/india-renewable-integration-study-report/

[10] NREL Report on Market Characteristics for Efficient Integration of Variable Generation in the Western Interconnection - Michael Milligan and Brendan Kirby https://www.nrel.gov/docs/fy10osti/48192.pdf

[11] POSOCO report on Electricity Demand Pattern Analysis

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

[12] Agora Energiewende - Refining Short-Term Electricity Markets to Enhance Flexibility

https://www.strommarkttreffen.org/2016-05-13-Pescia-Flexibility-Short-Term-Market-Design.pdf

References (2)

[13] Energy Innovation Report on Grid Flexibility: Methods for Modernizing The Power Grid

http://energyinnovation.org/wp-content/uploads/2016/05/Grid-Flexibility-report.pdf

[14] Draft National Electricity Plan - Central Electricity Authority (Dec., 2016)

www.cea.nic.in/reports/committee/nep/nep_dec.pdf

[15] Recent Trends in Variable Generation Forecasting and Its Value to the Power System IEEE TRANSACTIONS ON SUSTAINABLE ENERGY, VOL. 6, NO. 3, JULY 2015 https://www.nrel.gov/docs/fy15osti/63007.pdf

[16] NREL report on Flexibility Reserve Reductions from an Energy Imbalance Market with High Levels of Wind Energy in the Western Interconnection

https://www.nrel.gov/docs/fy12osti/52330.pdf

[17] AEMC Frequency control frameworks review

http://www.aemc.gov.au/Markets-Reviews-Advice/Frequency-control-frameworks-review#

[18] The Future of Wholesale Electricity Market Design, Brattle Group, http://www.brattle.com/system/publications/pdfs/000/005/359/original/The_Future_of_Wholesale_Electricity_Market_Design.pdf?1475081019

[19] AEMC Five Minute Settlement – Final Rule determination

http://www.aemc.gov.au/Rule-Changes/Five-Minute-Settlement#

[20] CERC Consultation Paper on Modifications in Power Market Design: Evening Market, 15 minute Bidding time block and Ancillary market on Power Exchange (2010)

http://www.cercind.gov.in/2010/Whats-New/ConsultationPaper__market_design_ver1.pdf

[21] Report of the Expert Group on 175 GW RE by 2022 - NITI Aayog

http://niti.gov.in/writereaddata/files/writereaddata/files/document_publication/report-175-GW-RE.pdf

[22] MoP Technical Committee Report on Large Scale Integration of Renewables http://powermin.nic.in/sites/default/files/uploads/Final_Consolidated_Report_RE_Technical_Committee.pdf

References (3)

[23] FOR Model DSM Regulations at State Level (2017)

http://forumofregulators.gov.in/Data/Working_Groups/DSMR.pdf

[24] Draft National Energy Policy - NITI Aayog

http://niti.gov.in/writereaddata/files/new_initiatives/NEP-ID_27.06.2017.pdf

[25] CERC (Communication System for Inter-State Transmission of Electricity) Regulations

www.cercind.gov.in

[26] IEA report on `Re-powering Markets Market design and regulation during the transition to low-carbon power systems'

https://www.iea.org/publications/freepublications/publication/REPOWERINGMARKETS.PDF

[27] FERC Final Rule on “Settlement Intervals and Shortage Pricing in Markets Operated by Regional Transmission Organizations and Independent System Operators”, 16th June 2016

https://www.ferc.gov/whats-new/comm-meet/2016/061616/E-2.pdf

[28] Enhancing Intraday Price Signals in U.S. ISO Markets for a Better Integration of Variable Energy Resources - An MIT Energy Initiative Working Paper (May 2016)

https://energy.mit.edu/wp-content/uploads/2016/06/MITEI-WP-2016-05.pdf

Thank You !