Third Meeting of Technical Committee CEA

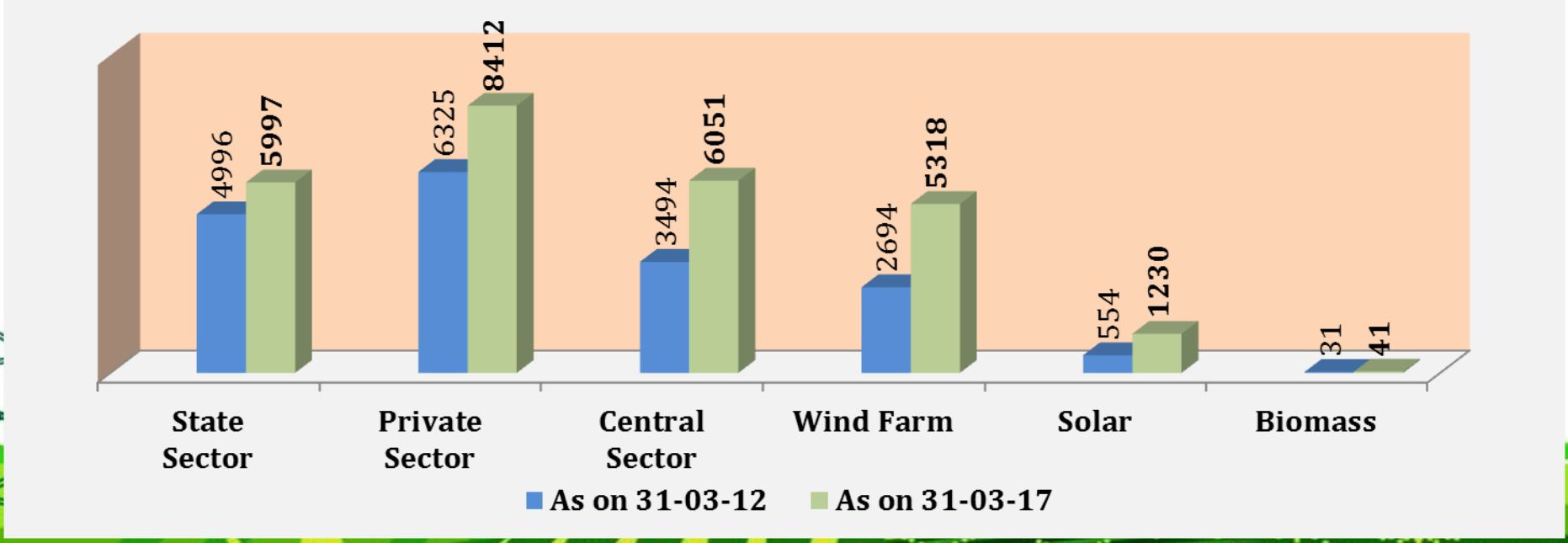
Study of optimal location of various types of balancing energy sources/ energy storage device : Western Region Gujarat

B. B. Mehta,
Chief Engineer,
SLDC, Gujarat

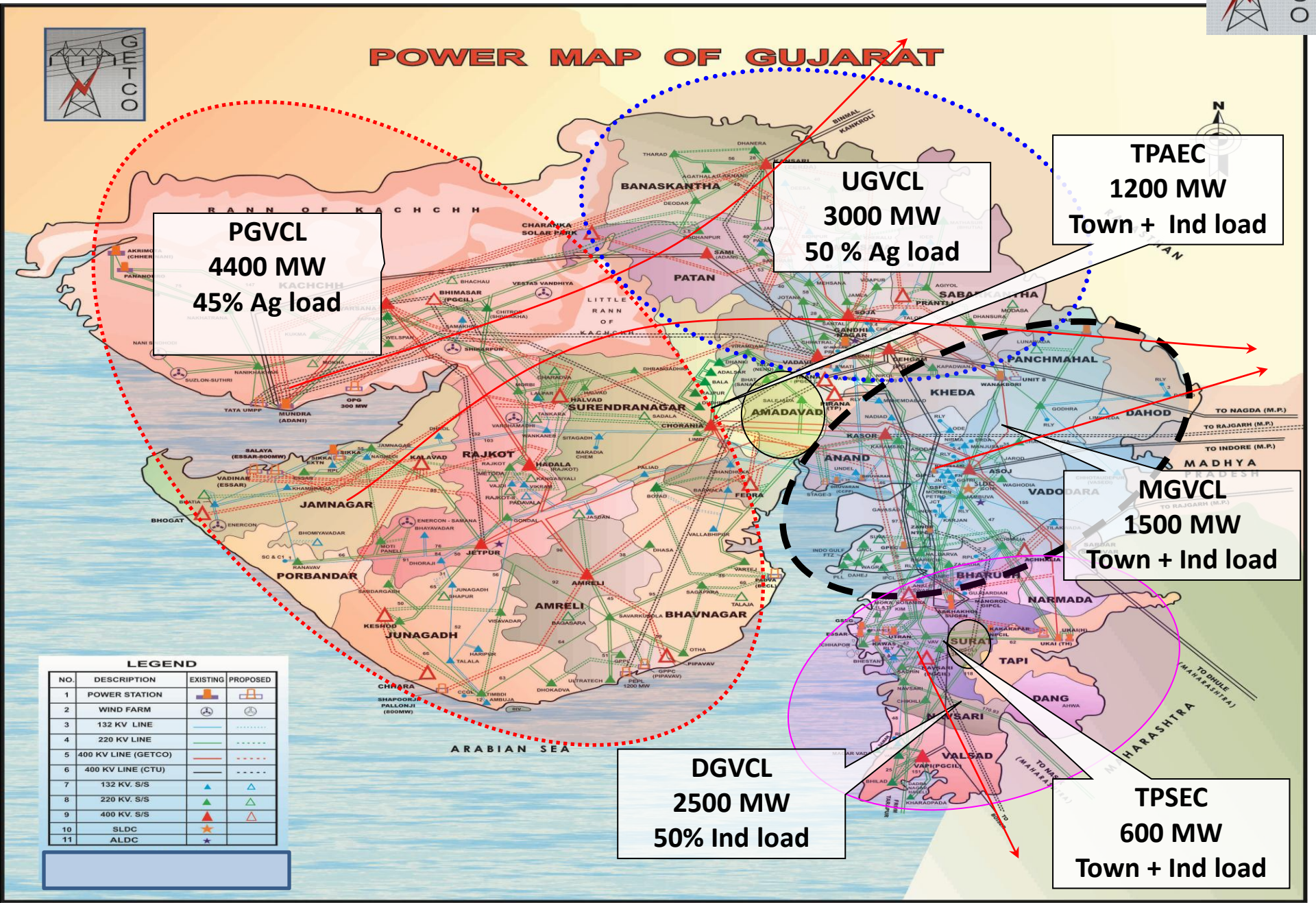
Adverse effect of variability of Wind & Solar generation

Gujarat Installed Capacity Overview

Installed Capacity (MW)	State Sector	Private Sector	Central Sector	Wind Farm	Solar	Biomass	Mini Hydro	Total
As on 31-03-12	4996	6325	3494	2694	554	31	0	18094
As on 31-03-13	4996	7018	5571	3087	857	31	6	21567
As on 31-03-14	5496	7423	5811	3352	861	31	9	22982
As on 31-03-15	5496	8126	5811	3542	974	41	9	23997
As on 31-03-16	5996	8026	5905	3933	1016	41	9	24924
As on 31-03-17	**5997**	**8412**	**6051**	**5318**	**1230**	**41**	**9**	**27058**



Load Diversity in Gujarat



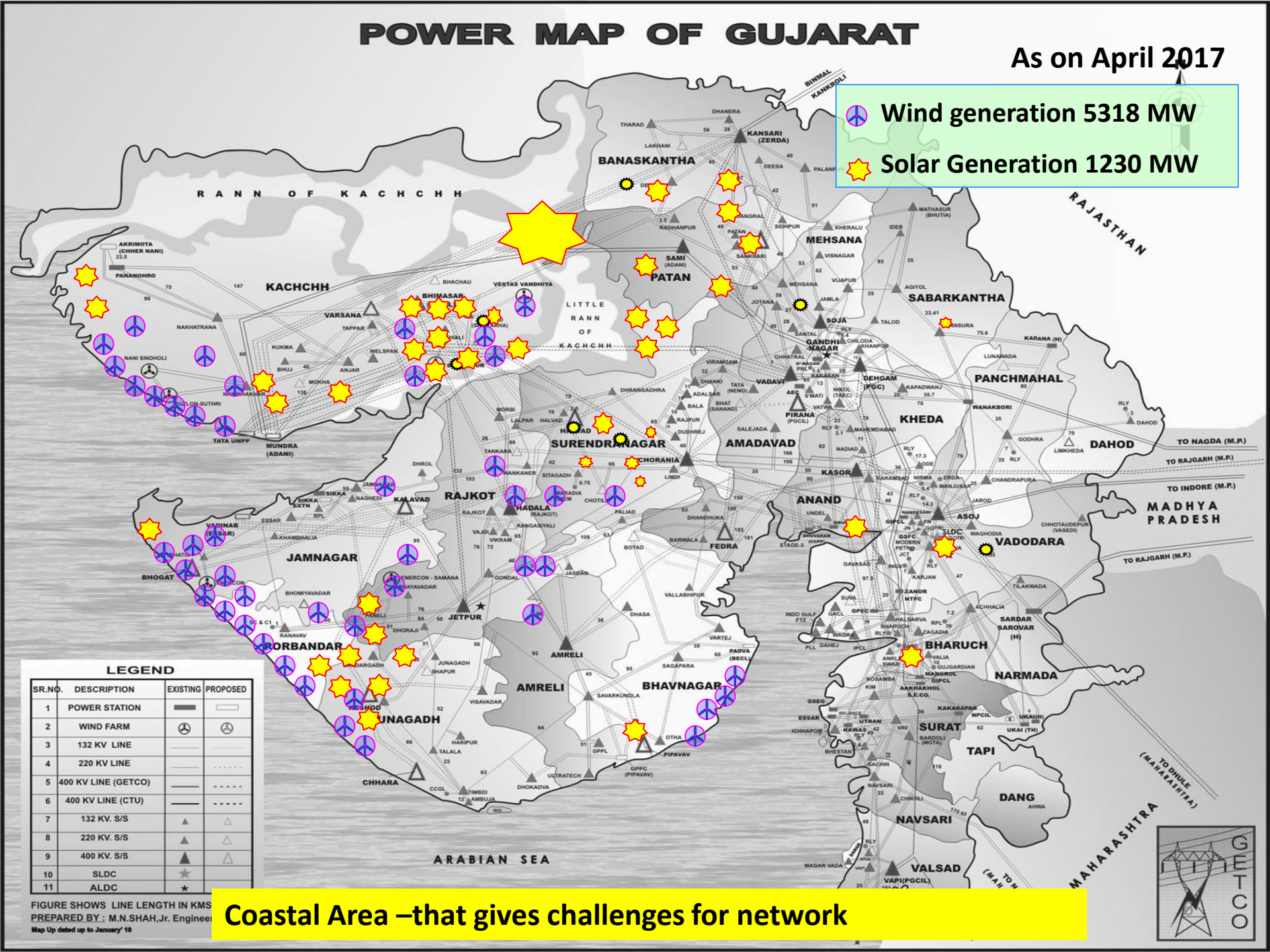
RE Contribution in Catered System

Energy supplied in MUs					
Year	Total MUs	Wind energy in MUs	in %	Solar energy in MUs	in %
2011-12	***78651***	***3961***	***5.04***	***167***	***0.21***
2012-13	87723	5436	6.20	1145	1.30
2013-14	86221	5289	6.13	1369	1.59
2014-15	96636	5660	5.86	1475	1.53
2015-16	103133	6447	6.25	1645	1.60
2016-17	***104285***	***7720***	***7.40***	***1738***	***1.67***

POWER MAP OF GUJARAT

As on April 2017

- Wind generation 5318 MW
- Solar Generation 1230 MW



LEGEND

SR.NO.	DESCRIPTION	EXISTING	PROPOSED
1	POWER STATION	▬	▭
2	WIND FARM	✇	✇
3	132 KV LINE	———	·····
4	220 KV LINE	———	·····
5	400 KV LINE (GETCO)	———	- - - - -
6	400 KV LINE (CTU)	———	- - - - -
7	132 KV. S/S	▲	△
8	220 KV. S/S	▲	△
9	400 KV. S/S	▲	△
10	SLDC	★	
11	ALDC	★	

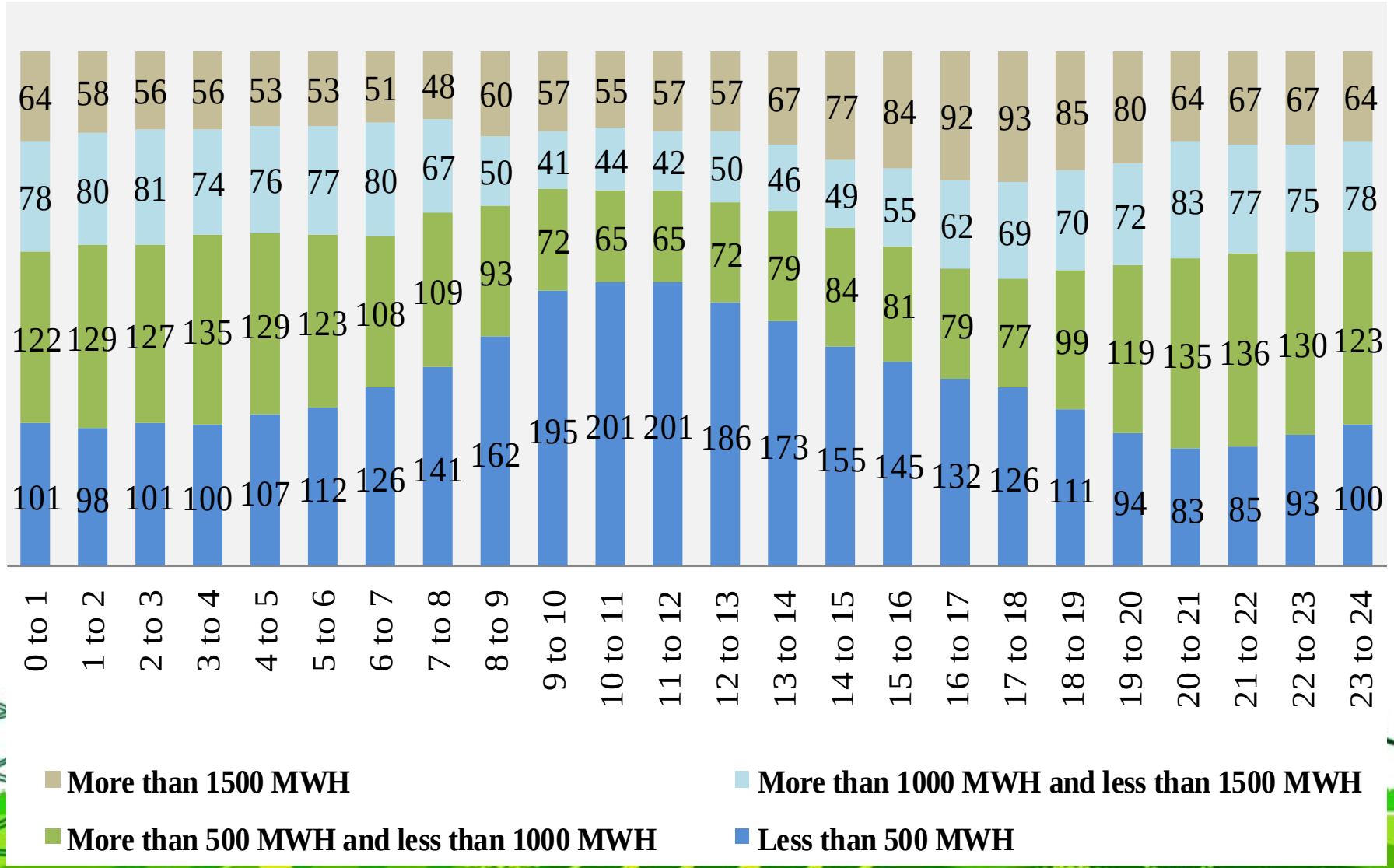
FIGURE SHOWS LINE LENGTH IN KMS

PREPARED BY : M.N.SHAH,Jr. Engineer

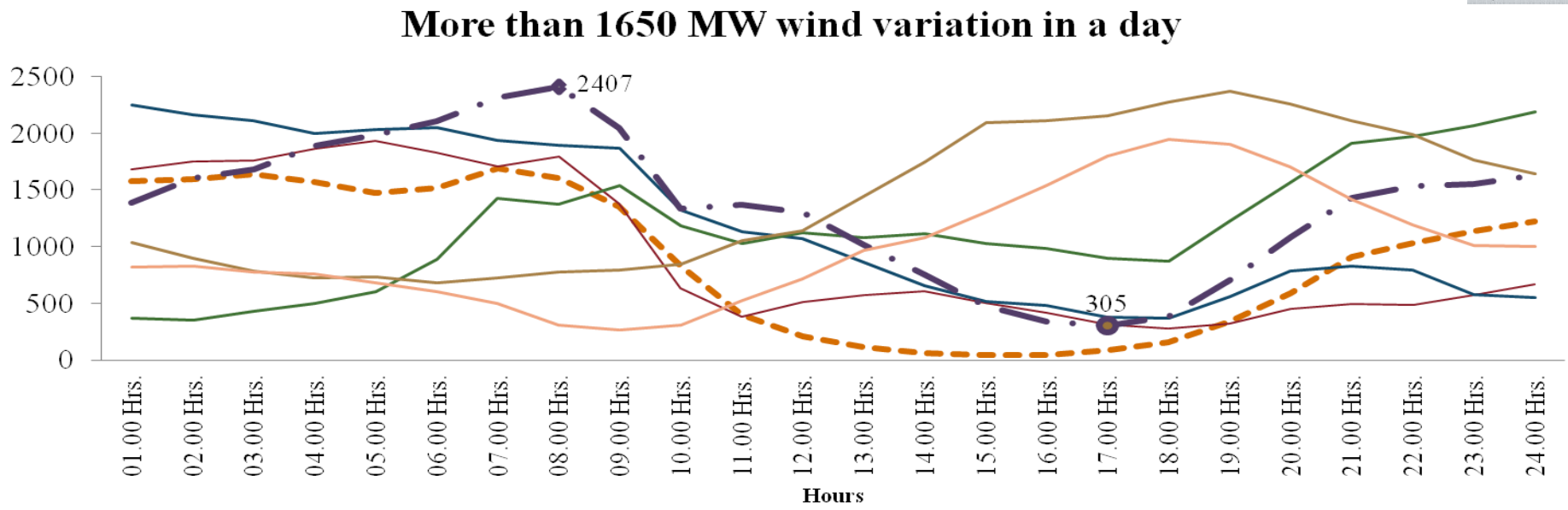
Map Up dated up to January' 10

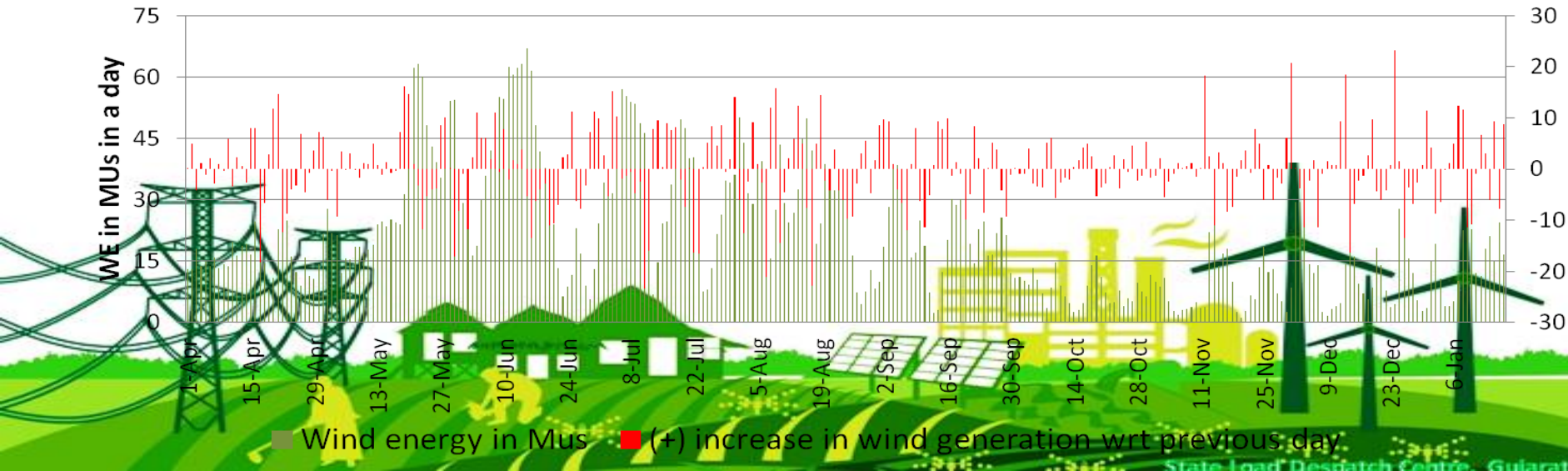
Coastal Area –that gives challenges for network

Hourly Wind Generation Pattern during the year 2016-17

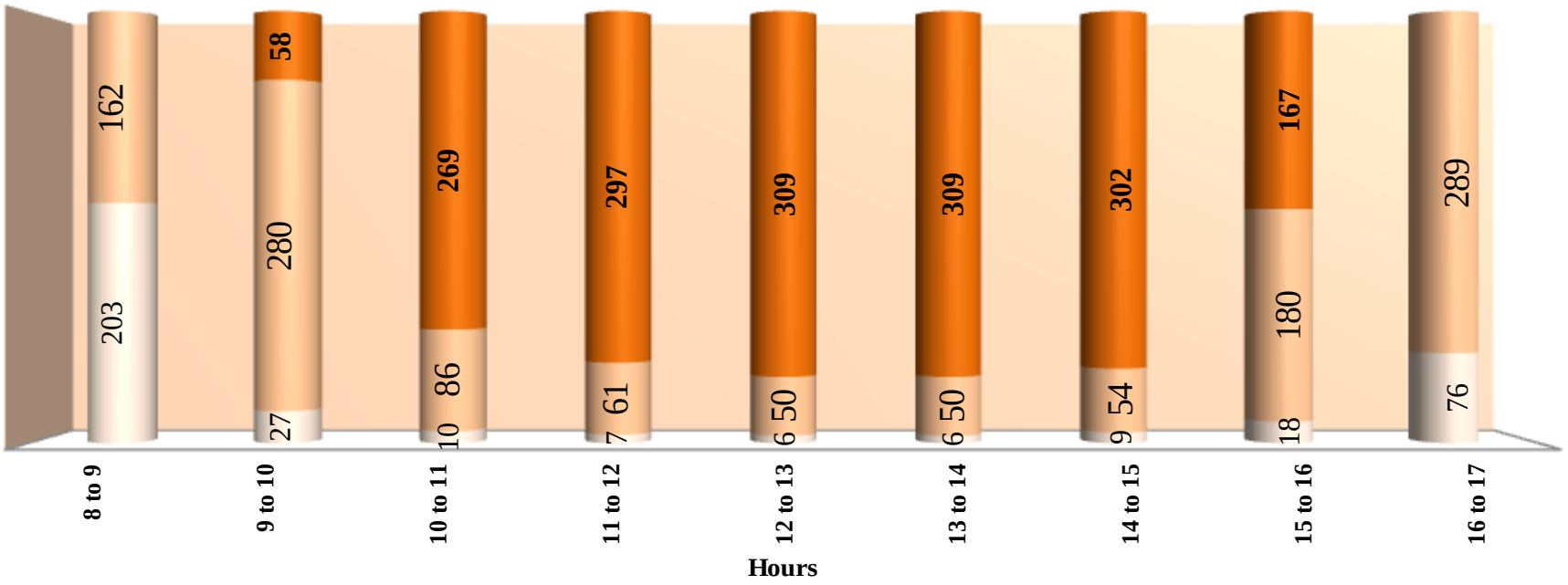


Typical Wind Generation Pattern

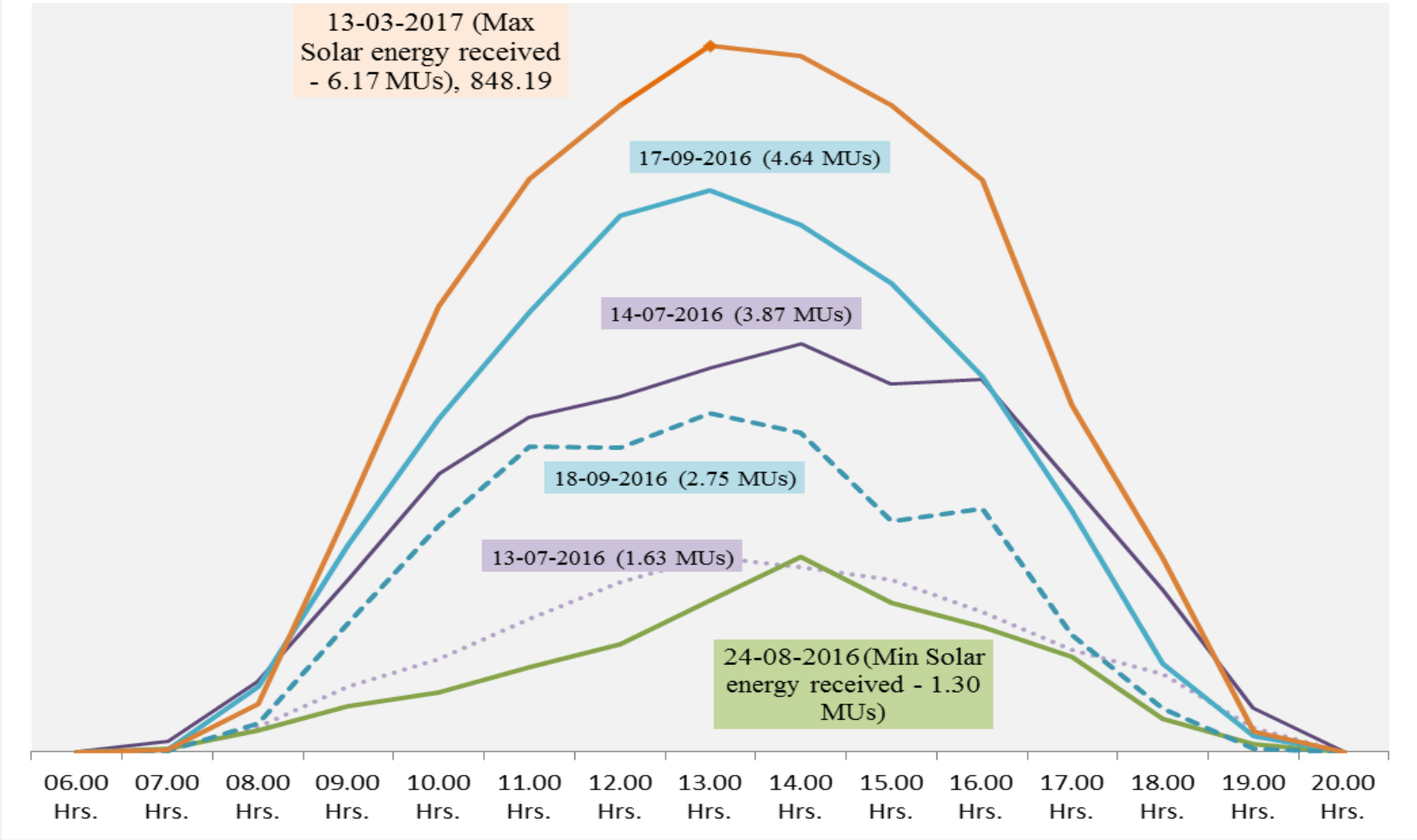




Hourly Solar Generation Pattern during the FY 2016-17



Typical Solar Generation Pattern



Loss of generation due to backing down of cheapest sources of conventional generation
and
losses due to Deviation Settlement Mechanism

Experience in running the grid due to "Operation Philosophy"

- **"Must Run" Status**
- **Scheduling of costlier generation when the system demand is high and wind generation is on lower side.**
- **Backing down of cheaper generation, particularly in night hours when system demand remains low and wind generation is on higher side.**

- **Difficult to manage Over Drawl and Under Drawl**
- **Within limit of ± 250 MW as per Hon'ble CERC, Deviation Settlement Mechanism (DSM) regulation.**

- **Non submission of proper RE forecasting by most of RE Developers**
- ***Huge capacity addition in wind generation leads system operation issues.***

Net Impact - RE Grid integration issues

- **System Operation constraints – case study:**
  - **Back-down of Cheapest Conventional generation due to high wind generation:**
  - **Reserve Shut Down of cheapest Generation**

Date	Maximum Wind in MW	Minimum Wind in MW	Total Wind Gen in	Cheapest Conventional Generation Back-Down		Reserve Shut Down (RSD) of
	Gen / Time	Gen / Time	MUS	When Max. Wind Generation	When Min. Wind Generation	Cheapest Generation
04.07.16	1530 / 20.00	1064 / 10.00	31.583	ALL P/UP	STPS 3-4 (2.31 RS)	APL (1.85 RS)
05.07.16	2639 / 19.00	1183 / 06.00	46.810	SLPP 2 (1.83 RS)	ALL P/UP	APL (1.85 RS)
06.07.16	2931 / 17.00	1693 / 08.00	57.055	VSTPS 4 (1.75 RS)	SLPP 2 (1.83 RS)	APL (1.85 RS)
07.07.16	2806 / 15.00	1791 / 05.00	55.260	EPGL (1.97 RS)	KHSTPS (2.28 RS)	APL (1.85 RS)
08.07.16	2698 / 15.00	1693 / 03.00	53.863	APL 1 (1.85 RS)	GTPS 5 (3.43 RS)	APL (1.85 RS)
09.07.16	2789 / 19.00	1475 / 08.00	53.346	KHSTPS (2.28 RS)	ALL P/UP	APL (1.85 RS)
10.07.16	2614 / 15.00	1324 / 03.00	48.690	APL 1 (1.85 RS)	EPGL (1.97 RS)	APL (1.85 RS)
11.07.16	2567 / 19.00	1297 / 07.00	46.246	SLPP 1 (1.84 RS)	ALL P/UP	APL (1.85 RS)

Net Impact - RE Grid integration issues

- **System Operation constraints – case study:**
  - **Back-down of conventional generation due to high wind generation:**

Date	Maximum Wind Generation (MW)	Minimum Wind Generation (MW)	Average Conventional Generation backed-down (MW)	Lowest rate of baking down (Rs./ Unit)
01.07.15	2282	1553	963	1.55
02.07.15	2107	823	1573	1.55
03.07.15	2435	1513	844	1.55
04.07.15	2643	1850	1102	1.38
05.07.15	2726	2162	1276	1.38

Net Impact - RE Grid integration issues

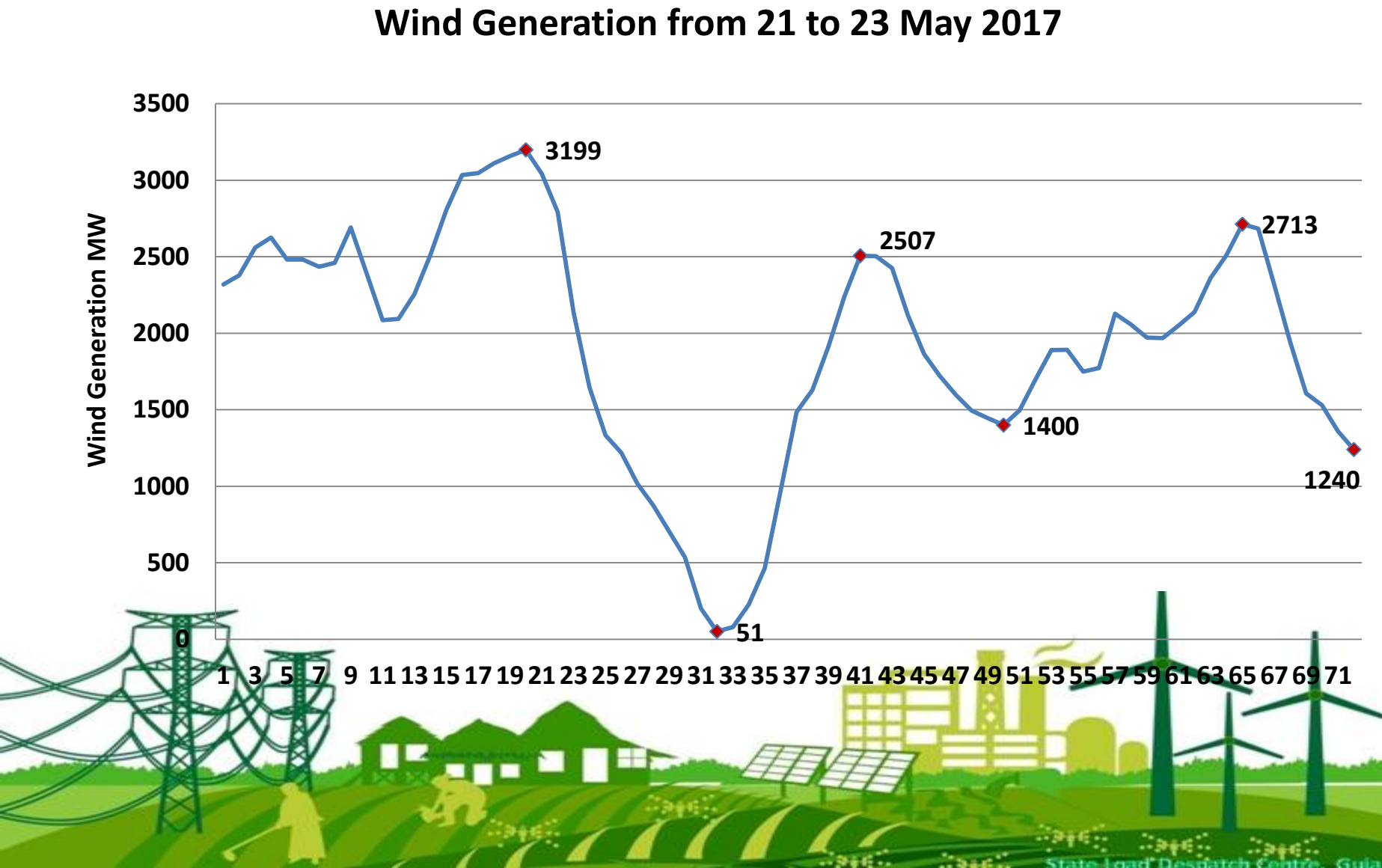
- **System Operation constraints – case study:**

➢ **Back-down of conventional generation due to high wind generation scenario:**

Date	Maximum Wind Gen (MW)	Minimum Wind Gen (MW)	Average Conventional Gen backed- down (MW)	Lowest rate of baking down of Gen (Rs./ Unit)
14-May-17	2200 / 18:00	849 / 8:00	1311	1.50 (VSTPS 4)
15-May-17	2519 / 18:00	1010 / 8:00	1289	1.49 (CGPL)
16-May-17	2312 / 18:00	1311 / 8:00	1149	1.51 (VSTPS 3)
17-May-17	2437 / 19:00	1104 / 6:00	408	1.85 (EPGL)
18-May-17	3079 / 18:00	1456 / 2:00	974	1.51 (VSTPS 3)
19-May-17	3099 / 18:00	1712 / 8:00	803	1.80 (SLPP)
20-May-17	3138 / 19:00	1854 / 6:00	812	1.53 (VSTPS 5)
21-May-17	**3199 / 20:00**	**1646 / 24:00**	1627	1.37 (SIPAT 1)
22-May-17	**2507 / 17:00**	**51 / 8:00**	938	1.52 (VSTPS 5)
23-May-17	**2713 / 17:00**	**1240 / 24:00**	824	1.85 (EPGL)

➢**Sudden rise / fall wind generation scenario**

Net Impact - RE Grid integration issues



Net Impact - RE Grid integration issues

- **System Operation constraints – case study:**

➢ **Back-down of Conventional generation Decreases with wind generation:**

Date	Maximum Wind Gen (MW)	Minimum Wind Gen (MW)	Wind Generation (MUs)	Conventional Generation (MUs)
22-Apr-17	2745	1370	47.63	**30.310**
23-Apr-17	2151	1165	40.92	**25.710**
24-Apr-17	1688	958	35.16	**19.570**
25-Apr-17	1823	358	26.70	**14.100**

Impact of variation in wind generation on Deviation Settlement Mechanism

- **Sudden rise in wind energy injection leads under drawl at State-regional periphery.**

- **SGS/ISGS cannot be backed down at such a faster rate w.r.t rate of rise in wind energy injection. Hence, State will under draw with respect to schedule. Under drawl in a time block in 250 MW (which ever is lower) shall be zero. And if frequency is more than 51.10 Hz then State has to pay penalty @ 1.78 Rs./unit for such violation.**

- **In other words, wind generators are being paid @ preferential tariff (in case of sale to DISCOM) or gets benefit of wheeling as the case may be whereas State has to pay penalty or gets nothing for under drawl (in excess of 250 MW which ever is lower)**

- **Similarly, as per DSM, every entity has to make sign change (sustained OD/UD) al least after every 12 block. High wind energy injection/variation particularly in low demand period makes difficult to comply this DSM condition.**

Experience in integration of RE with DSM

Sign change

- **Change of sign after 12 time blocks.**
- **During low demand and high wind injection scenario, it is not feasible to back down conventional generators beyond technical minimum level.**
- **In the State of Gujarat, there is no load to resume.**
- **Typical scenario in which demand drop drastically due to heavy rain. All on bar generators were back down up to technical minimum.**
- **Nos. of conventional plants in Gujarat grid: minor deviation in MW by scheduled conventional plants together leads wide variation at boundary, hence impact the DSM by +/- 250 limit and sign change also.**

Experience in integration of RE with DSM band +/- 250 MW

- **UI cap V/s Wind energy injection**
- **Direct impact of wind energy injection on State UI**

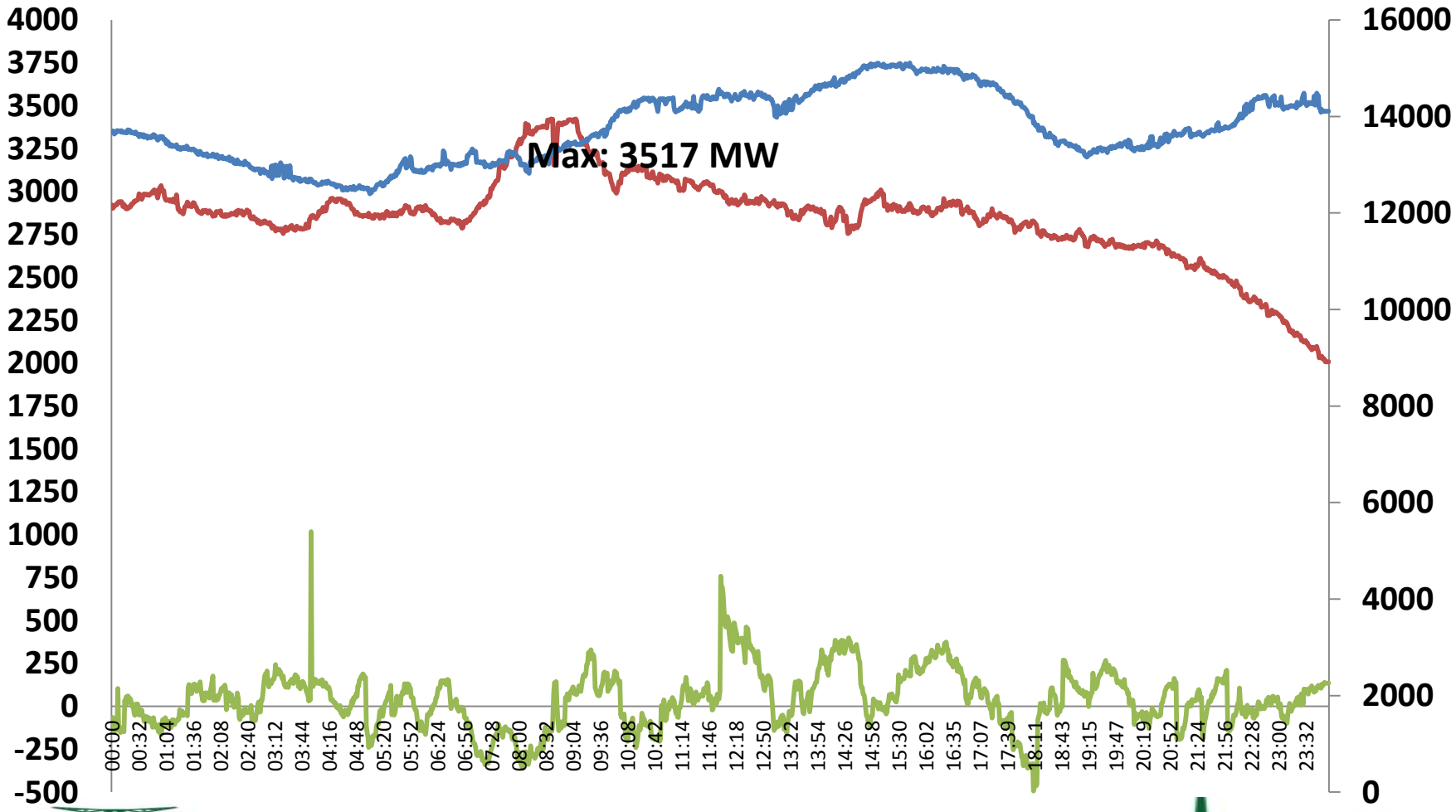
DATE	CAP UI RS_LAKH	Wind Energy injection (Mus)	Remarks
13/Jul/16	5.10	6.90	Wind injection increased & UI Cap increased
14/Jul/16	7.12	14.81	
13/Jul/15	2.46	24.17	Wind Injection Decreased & UI Cap Decreased
14/Jul/15	0.00	7.60	

Experience in integration of RE with DSM band +/- 250 MW

- **UI cap V/s Wind energy injection**
- **Direct impact of wind energy injection on State UI**

DATE	CAP UI RS_LAKH	Wind Energy injection (Mus)	Remarks
11/mar/17	16.16	29.71	Wind injection Decreased & UI Cap Decreased
12/mar/17	1.76	12.88	
08/may/17	4.87	26.20	Wind Injection increased & UI Cap increased
09/may/17	13.89	40.28	

Maximum Wind Generation (72 MUS)
1 minute data scenario of 29th May 17



Constraints on transmission or distribution (T & D) system faced
and
Necessary augmentation of T & D infrastructure which need to be under taken

Experience in running the grid due to "Dispatch Ability"

- **Location at remote places**
- **Adequate grid infrastructure is required.**

- **Long distance**
- **Causes over voltage & voltage fluctuations.**

- **Seasonal availability**
- **Transmission network remains unutilized during low wind generation scenario.**

Experience in running the grid due to "Grid Operational parameter"

- **High voltage scenario during less RE injection**
- **Under utilization of EHV network**

- **Reactive power management**
- **Consumption of Reactive Power**
- **Increases system losses and low voltage at tail end**
- **Voltage stability of the grid affected due to frequent start up operation during a day.**

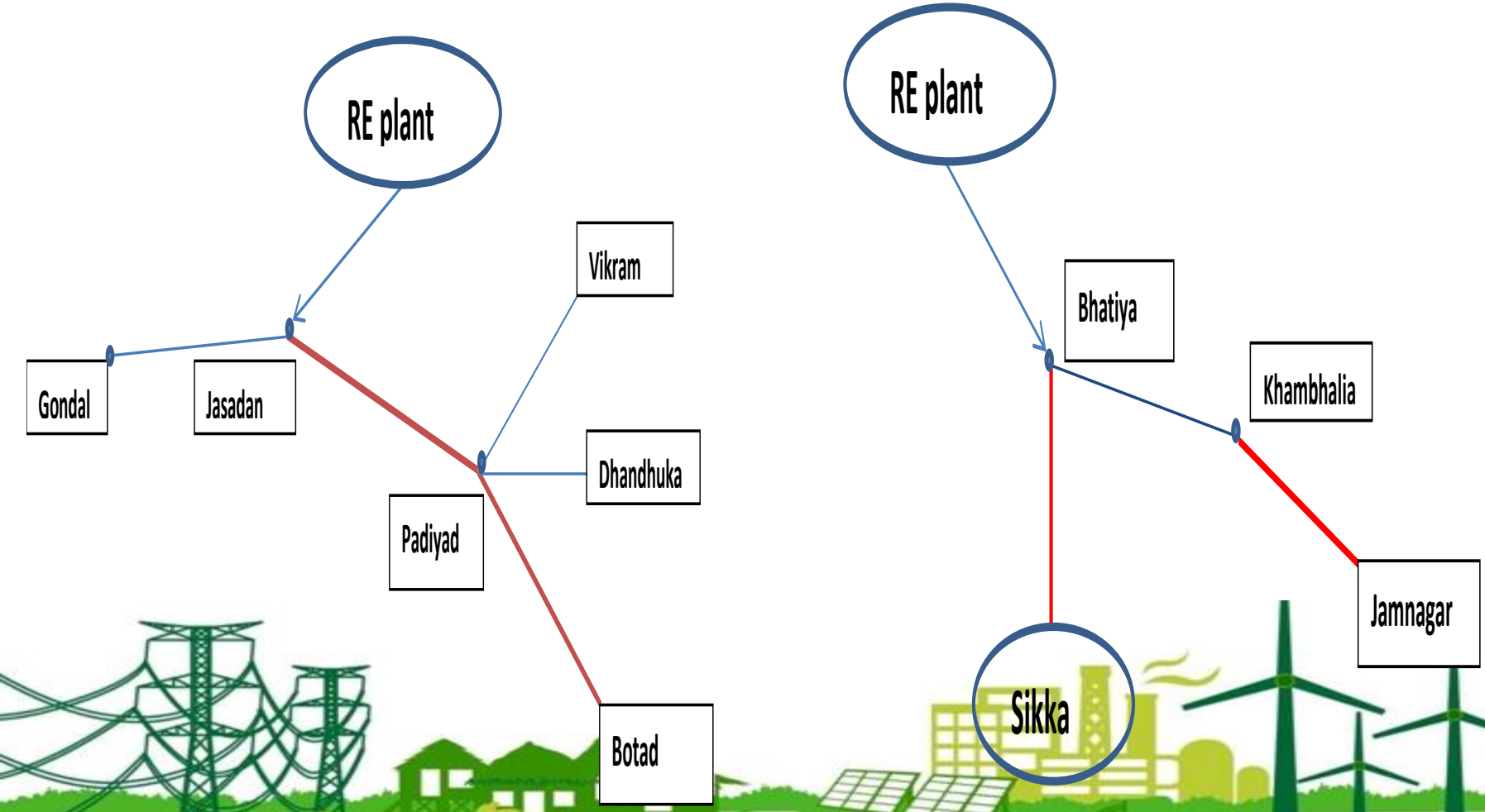
- **Critical loading of system elements.**
- **Very high or low RE generation resulting in over / under loading in associated transmission elements.**

- ***Huge capacity addition in wind generation leads towards instability of grid.***

Constraints on transmission or distribution (T & D) system faced

- **Case study: Transmission Constrain due to high and low wind generation**
- **During high wind injections, the loading on following elements observed on higher side:**
  - **400 KV D/C APL – Dehgam line**
  - **400 KV S/C Chorania – Kasor line**
  - **220 KV S/C Deodar – Charanka line**
  - **220 KV S/C Chorania – Salejada line**
  - **132 KV S/C Khambhalia – Jamnagar line**
  - **132 KV S/C Sikka – Bhatia line**
  - **2 x 400/220 KV 315 MVA ICTs at APL**
  - **220 KV S/C Vadavi –Chattral line**
- **During less wind injection & high demand in PGVCL, the loading on following elements observed on higher side:**
  - **220 KV D/C Amreli – Savarkundla line**
  - **220 KV S/C Jetpur – Gondal line**
  - **220 KV S/C Jetpur – Shapur line**

Necessary augmentation of T & D infrastructure which need to be under taken



Utilization of State’s own balancing plants

Experience in running the grid due to "Operation phenomenon"

- **System Operation Challenges**
- **Thermal capacity is the backbone of balancing RE as it is available in large quantities.**
- **Technical Minimum / Coal Minimum Issues:**
  - **Old Machine: Not flexible for fast pick up / back down**
  - **Design of machine**
  - **Oil Support after certain minimum level**
  - **Seasonal efficiency constrain: Thermal – summer & Gas - winter**
- **Current Problem: Are power plant again on bar on time after shut down??? (How long RE generation prevail???)**
- **Hot Start Issue**
- **Cold Start Issue**

Experience in running the grid due to "Conventional Plant"

- **Impact on Conventional Plants**
- **Limited ability to back-down generation**
- **Low Flexibility of Thermal Power Plant**
- **Gas plant may ramp up / down quickly. But; to keep costly gas base generation on bar to handle wind variation leads merit order violation.**
- **Low availability of hydro power for balancing to RE variation**
- **Rate of change of power contribution from RE**
- **Lack of regional Balancing**

- **Frequent Pick up and Back-down of Conventional Generation**
- **inefficient / Uneconomical operation**
- **increased capital and maintenance costs**
- **Backing down of cheaper generation**

Utilization of State's own balancing plants

- Collection & maintain Energy data and Static Data details of RE.
- Developed forecasting mechanism of RE.
- Demand forecasting received from Discom.
- Day Ahead Forecasting data of RE is being utilized to plan the RSD of conventional generator & schedule available conventional generation.
- Same Day (Intra-day) forecasting of RE is being utilized to pick up and Back down of conventional generation (Tech & Coal Minimum):
  - planning gas based generation, mainly in peak,
  - schedule of hydro generation,
  - revise schedule for central sector generation
- Accordingly to manage the system demand of Gujarat State.
- Summarize & Analysis of forecast and actual data

Utilization of State's own balancing plants

- The reserve / balance conventional generation is being identified through scheduling software.
- Monitoring balance / reserve conventional generation of on bar machines through SCADA system.
- Accordingly pick up and back down of conventional generation w.r.t variation of forecasted and actual RE generation.

Assessment of the quantum of electric storage system for balancing, which could be place near the RE generation sources

Assessment of the quantum of electric storage system for balancing

- **At initial stage, we can have focus on balancing mechanism available, instead of storage system which is costlier and also No policy frame work:**

- The available gas / hydro station to be deployed as balancing. MoP should arrange cheaper gas for balancing.

- The operation of balancing plant for other State, policy to be finalized and RLDC should encourage without any additional charges up to transmission capacity.

- New specially built / commenced balancing project to be drafted as multi State.

Assessment of the quantum of electric storage system for balancing

- All inoperative pump mode hydro to be operative on highest priority with plant wise follow up and monitoring at highest level of MoP, CEA and Utility.

- A research work may be entrusted to IIT like institute for converting conventional hydro in to pump mode by change in turbine, additional tail race etc. which shall be mandatory in future with 160 GW RE by 2020 - 22.

- Special focus on large size balancing with multi State beneficiary either of existing / inoperative / under construction project is MUST.

Assessment of the quantum of electric storage system for balancing

- The energy banking between two State without any financial transaction is seems to be very viable solution. Only RLDC need to be flexible encourage such transaction.

- Preferable location of Balancing Plants - Nearest to Wind Farm / Solar Plants is having Installed Capacity of 100 MW & above

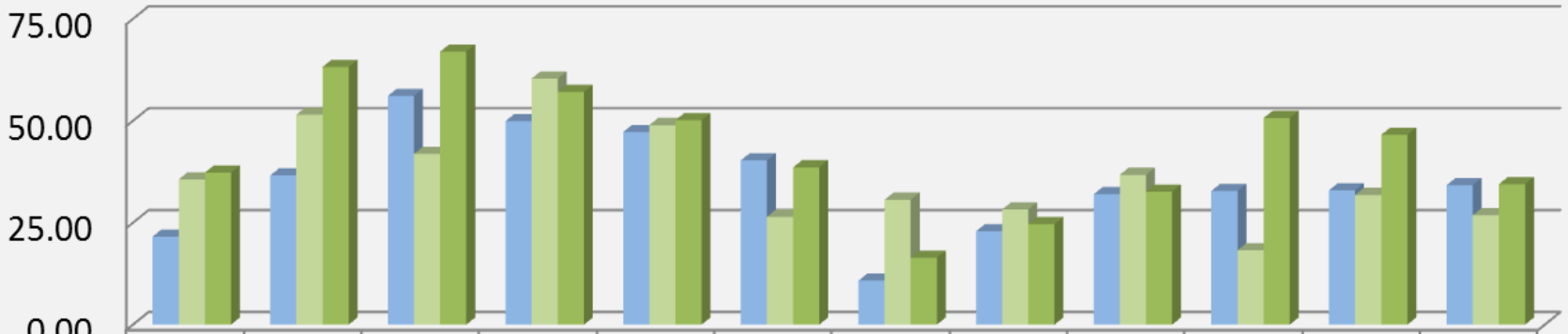
Details of issues in the Grid Integration of RE in WR and possible solution

Details of issues in the Grid Integration of RE (Wind) in WR: Gujarat

- Analysis:

- High Wind Scenario: Mid May to Mid August
- Low Winds Scenario: Mid August to December
- Average Wind Scenario: January to Mid May

Month wise Maximum wind energy in a day in MUs



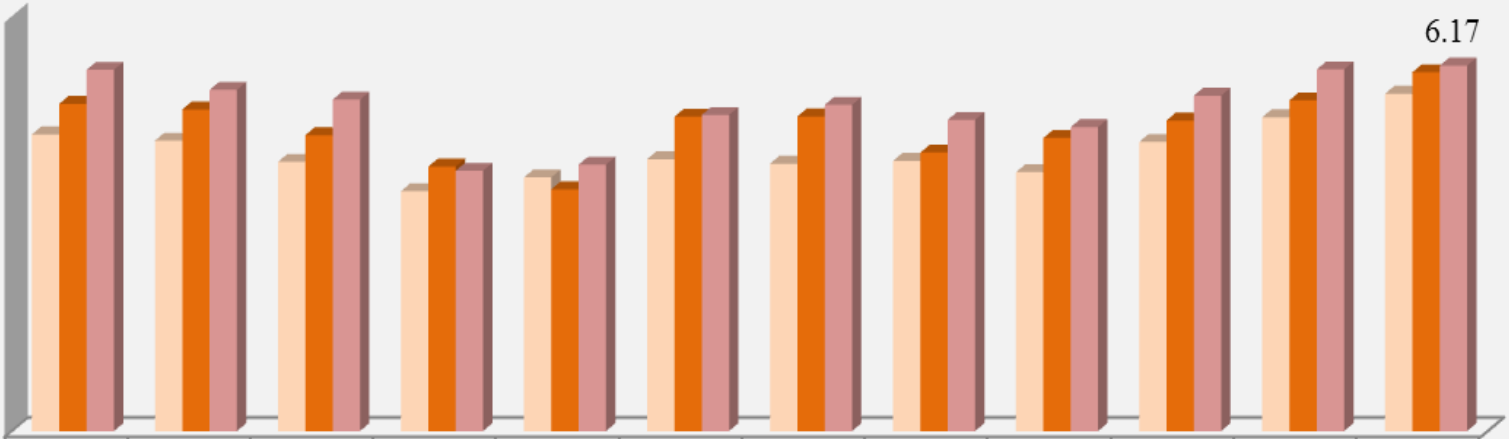
	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
2014-15	21.59	36.58	56.09	49.92	47.23	40.28	10.77	22.91	31.99	32.79	32.95	34.21
2015-16	35.62	51.51	41.85	60.35	48.94	26.45	30.62	28.26	36.74	18.24	31.80	26.83
2016-17	37.29	63.19	66.96	57.06	50.14	38.56	16.41	24.63	32.61	50.68	46.55	34.46

Details of issues in the Grid Integration o RE (Solar) in WR: Gujarat

- Analysis:

- High Solar Scenario: Mid February to May
- Low Solar Scenario: June to Mid September
- Average Solar Scenario: Mid September to Mid February

Month wise Maximum Solar Energy Generation in a day in MUs



	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
2014-15	5.01	4.91	4.55	4.05	4.29	4.59	4.52	4.56	4.37	4.88	5.30	5.70
2015-16	5.53	5.43	5.00	4.47	4.08	5.31	5.31	4.70	4.95	5.25	5.59	6.06
2016-17	6.10	5.76	5.60	4.40	4.50	5.34	5.51	5.26	5.13	5.67	6.11	6.17

Possible Solution in WR: View of Gujarat

- The transmission constrain right from pooling station to EHV sub station to be examine case by case and necessary augmentation of sub station and strengthening of lines / upward transmission system to be decided by using relevant real time data and system study. Time band work execution to be framed as per system study result.

- All RE approvals, now onwards, to be granted only after system study and network development / strengthening to be carried out in parallel with RE project development.

Possible Solution in WR: View of Gujarat

- To overcome, under draw / over draw at State periphery due to RE, the available variable sources like. hydro, gas based to be deployed and CEA / MoP should facilitated State with cheaper fuel for meaningful use as balancing.

- CERC may enhance O/D, U/D limit as per RE variation.

- Centralized accurate forecasting (SLDC /RLDC / NLDC & by Developer)

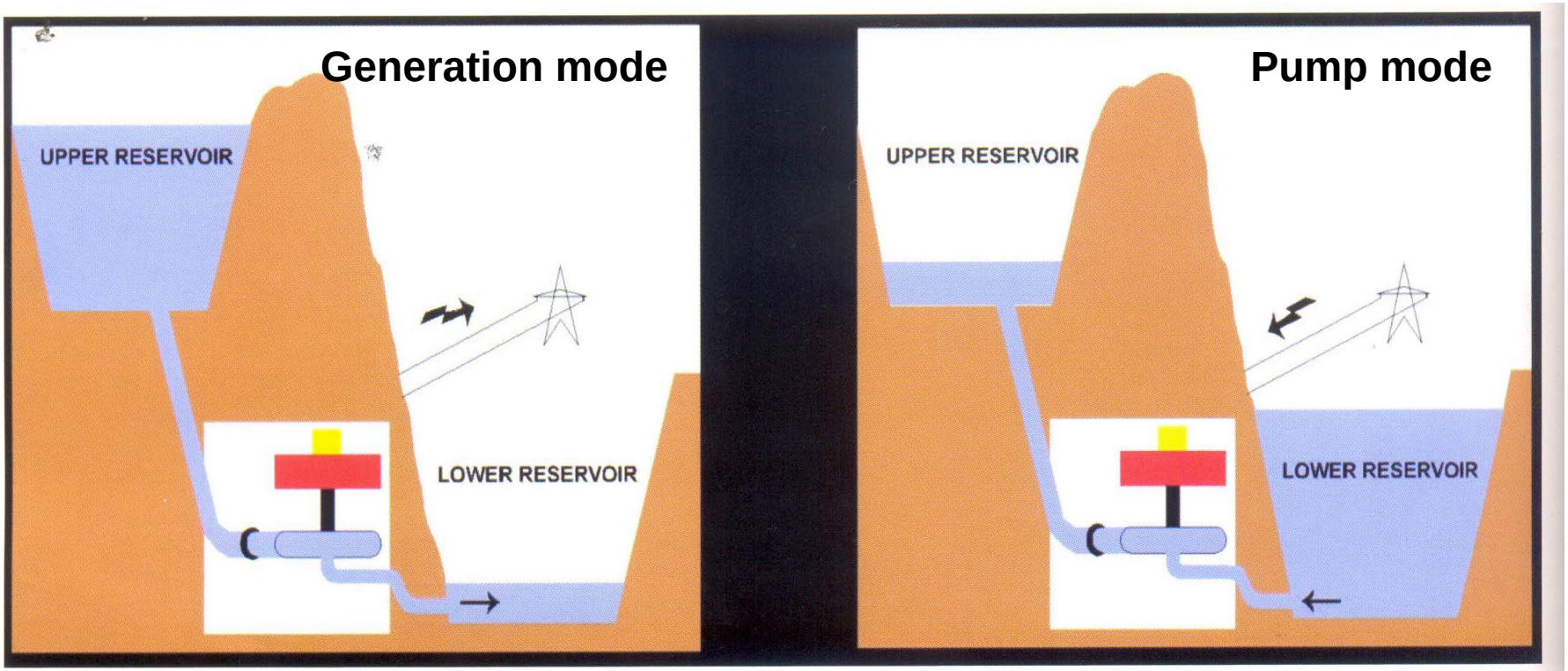
- Regulation on RE grid management (Harmonics, Reactive power etc.) by RE developers.

Possible Solution in WR: View of Gujarat

- AGC control, flexible generation by thermal plant- design parameter to be updated.
- RPO fulfil obligation to be compulsory - with penalty provision
- Increase the REC market

Pumped storage hydro power plant is a type of hydroelectric generation plant that stores energy in the form of water, pumped from a lower elevation reservoir to a higher elevation reservoir. It pumps water from lower reservoir to upper reservoir during off-peak period and generates electricity during peak periods. This is currently one of the most effective means of storing large amount of electrical energy. It helps in power generation load levelling.

Possible & Reliable Solution: View of Gujarat



Possible Solution: Pump mode

- **Balancing through coal plants is not a good solution. Instead focus on pump storage.**

- Potential of pump storage in Gujarat

  State owned Kadana Hydro Station- 60*4 MW has design capability and tail race reservoir already established.

  Problem: Vibration is to be resolved (OEM, BHEL)

  SSP 200*6 MW RBPH unit has technical capability of pump mode operation. Tail race reservoir work has been awarded. **Problem:** Being multi State project, consent of each beneficiary is required and all policy level issues to be resolved. (NCA is a Nodal Agency)

  Regulatory framework for pump mode operation will be required from Hon'ble commission.

Possible Solution: Pump mode

It is an effective tool to handle RE variation.

- Storage of energy in off peak hours and utilizing it in peak hours will help to optimize the cost of electricity:
  - Not need to peak up / procure costly generation in peak hours.
  - No need to run gas based plant in open cycle for few hours.

- Regulatory compliance:
  - In night hours (off peak hours), frequency remains >50.05 Hz. Under injection at 50.10 Hz & above is penalized at 1.78 Rs / unit.
  - There is no charge receivable for Under injection more than 250 MW at any frequency.

- During off peak hours, additional load (Pump mode operation) will help to maintain system voltage

Remedial Measures required to be taken

Solution to manage the gap between forecast and actual RE generation is Pump Hydro:

Status of Pumping mode operation	Installed Capacity	Nos. of Plant	State-wise Installed Capacity in MW
Existing	**4785.60**	**9**	**GJ, MH,** AP, TN, WB, DVC
Working	**2600**	**5**	TN (400), **MH (400)**, AP (900), WB (900)
Non Working	**2185.6**	**4**	**GJ (1440),** AP (750), DVC(40)
Under Construction	**1080**	**2**	UTK (1000), MH (80)
Under Planning	**2600**	**4**	TN (500), **MH (1100)**, WB (1000)

Source: Large Scale Grid Integration of Renewable Energy - CEA

Thought may be given to expert as a special R & D project to convert existing hydro station into pump mode operation.

Remedial Measures required to be taken:

State	Name of Project	Unit	Installed Capacity	Pumping mode operation
Gujarat	**Kadana St. I&II**	**4 X 60**	**240**	**Not Working**
	Sardar Sarovar	**6x200**	**1200**	**Not working**
Andhra Pradesh	Nagarjuna Sagar	7 X 100.80	705.60	Not Working
	Srisailam LBPH	6x150	900	Working
Tamil Nadu	Kadamparai	4x100	400	Working
DVC	Panchet Hill	1x40	40	Not working
Maharashtra	**Bhira**	**1x150**	**150**	**Working**
	Ghatgar	**2x125**	**250**	**Working**
West Bengal	Purlia PSS	4x225	900	Working

Status of communication system for RE generators to SLDC

Solar data Integration

- Radio Link between Solar Power Station and GETCO EHV Sub-Station, where RTU is installed.

Type of communication	Radio Modem	GSM/GPRS
Total Nos.	76	3

- Radio Modem is also provide for point to point speech communication between Solar Plant and RTU end of GETCO.
- The Radio Modem frequency band is 2.412 to 2.464 GHz which is Unlicensed Band.
- The total Equipment cost of 1 set is around Rs. 3.5 Lacs for Solar data acquisition system.
- Developers readily agreed to bear cost including maintenance.

Wind data Integration

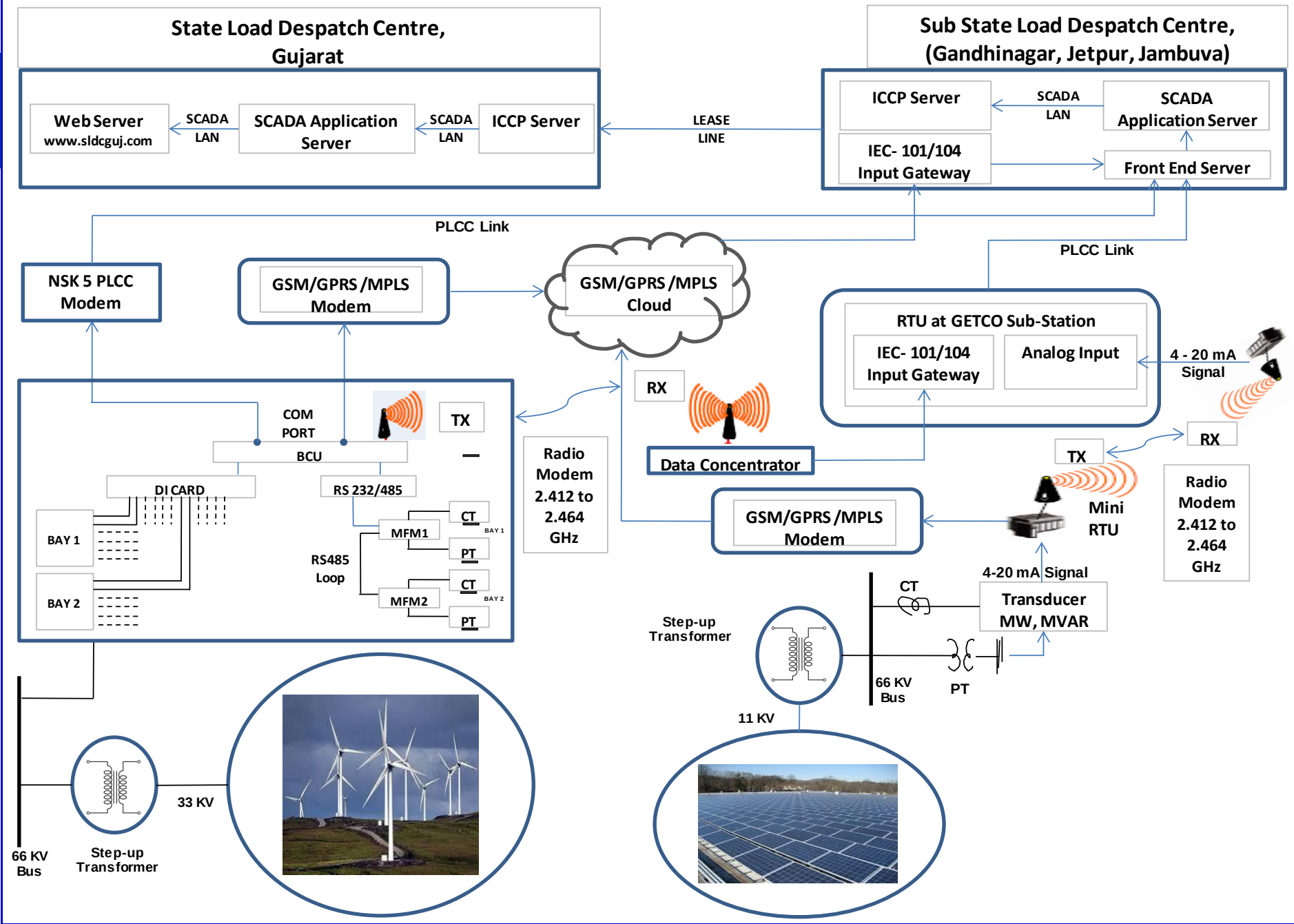
- Data connectivity is established between Wind Power Station and GETCO End Sub-Station for RTU with mix of available Technologies.

Type of communication	Radio Modem	GSM/GPRS	Lease Line	PLCC
Total Nos.	36	24	1	9

- The total cost of 1 set is around Rs. 6 Lacs for Wind data acquisition system including RTU and communication equipment.

- Developers readily agreed to bear cost including maintenance.

Real time Data Capturing of RE (Wind & Solar) at SLDC, Gujarat



Status of establishment of REMC in the State and its linking to SLDC

Status of establishment of RE data communication to SLDC

Extent of SCADA terminal to REMC Desk

- Presently, available SCADA system are competent to fetch the data of RE by using various communication system.
- SCADA system is being upgraded the by SLDC (from GE to Alstom). Further, installing and maintaining Data acquisition Communication System through RTU, lease line, radio link etc. is being carried out.
- SCADA system is having various server for data storage and communication.

Status of REMC features / functions at SLDC, Gujarat

RE Forecasting Tool

Service of Forecasting Service Provider (FSP) is available for wind generation forecasting. SLDC has also develop methodology of WGF.

RE Scheduling Tool

Scheduling software is available and RE power is being scheduled according to the forecast received from RE.

REMC SCADA Monitoring Tool

Real time data of RE pooling stations/solar plants are being captured at SLDC. Further, real time generation data of RE is also displayed on SLDC website.

Geo-Spatial Visualization of RE Generation

At present, real time data of MW & MVAR of RE pooling stations/solar plants are being monitored through SCADA.

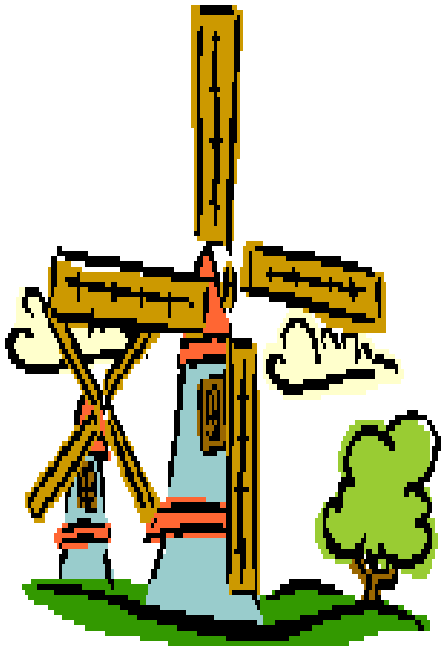
Status of REMC features / functions at SLDC, Gujarat

REMC WAMS

At present, PMU has been installed at 25 locations and WAMS is operationalized in Gujarat. Further, RE dominating locations will be covered during next phase of WAMS.

RE Control Reserve/Balancing Monitoring Tool

At present, reserve / balance power of conventional generation is identified through scheduling software and it is also monitored through SCADA system in real time.



Thanking you !!!

MAHATRANSCO
Maharashtra State Electricity Transmission Co. Ltd.

CEA-Technical Committee for Study of Balancing requirement to facilitate large scale RE integration and associated issues

Third Meeting

Presentation by

State Load Despatch Centre, Maharashtra

5th June 2017, Vadodara

RE integration – State specific issues:

1) Energy outlook – Installed capacity 40403 MW
   State is surplus in terms of Demand & Energy

2) Maharashtra has overall RE potential of 114 GW (Wind + Solar + Bagasse)

3) State RE policy is to increase RE by 14500 MW (by Year 2020) (Solar- 7500, wind-5000, Bagasse and other 2000 MW)

4) Evacuation infrastructure for RE is in place & planned under State STU plan.

5) NITI AYOG Studies for Maharashtra estimated balancing requirement for the year 2022 as around 4000 MW in place of existing 1500 MW.

Maharashtra State Review

MAHARASHTRA TRANSCO State Electricity Transmission Co. Ltd.

MAHARASHTRA STATE INSTALLED CAPACITY (as on 31-03-2017)

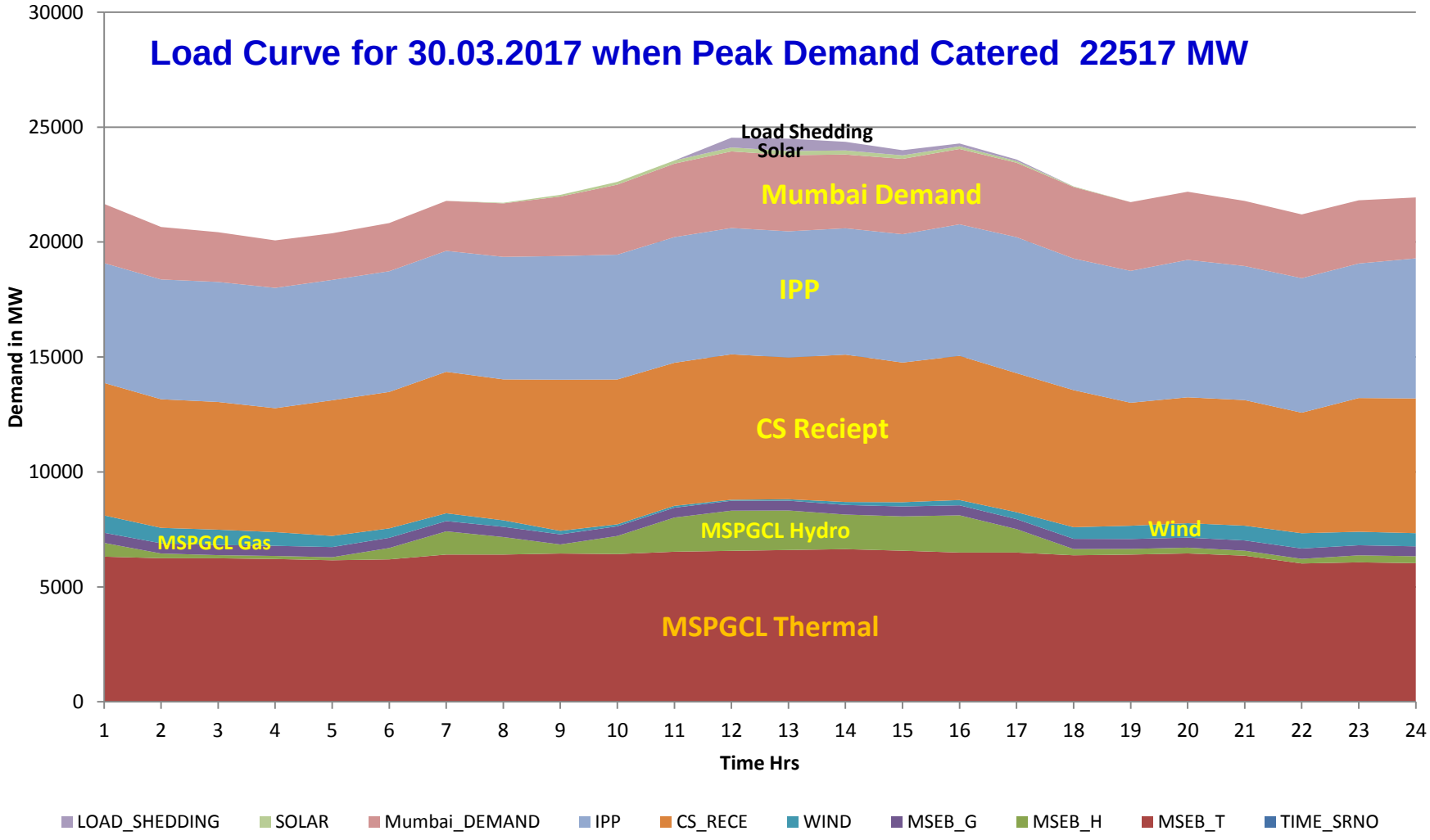
Maharashtra System Peak Installed Derated Capacity along with its CS Share

Particulars	Hydro	Thermal	Gas	Nuclear	NCE	Total
MSPGCL	2450	10580	672	0	0	13702
TPCL	447	1250	180	0	0	1877
REL	0	500	0	0	0	500
IPP / CPP	44	9125	388	0	7547	17104
CS(MS)	445	4702	1903	756	0	7807
Total	**3386**	**26158**	**3143**	**756**	**7547**	**40990**

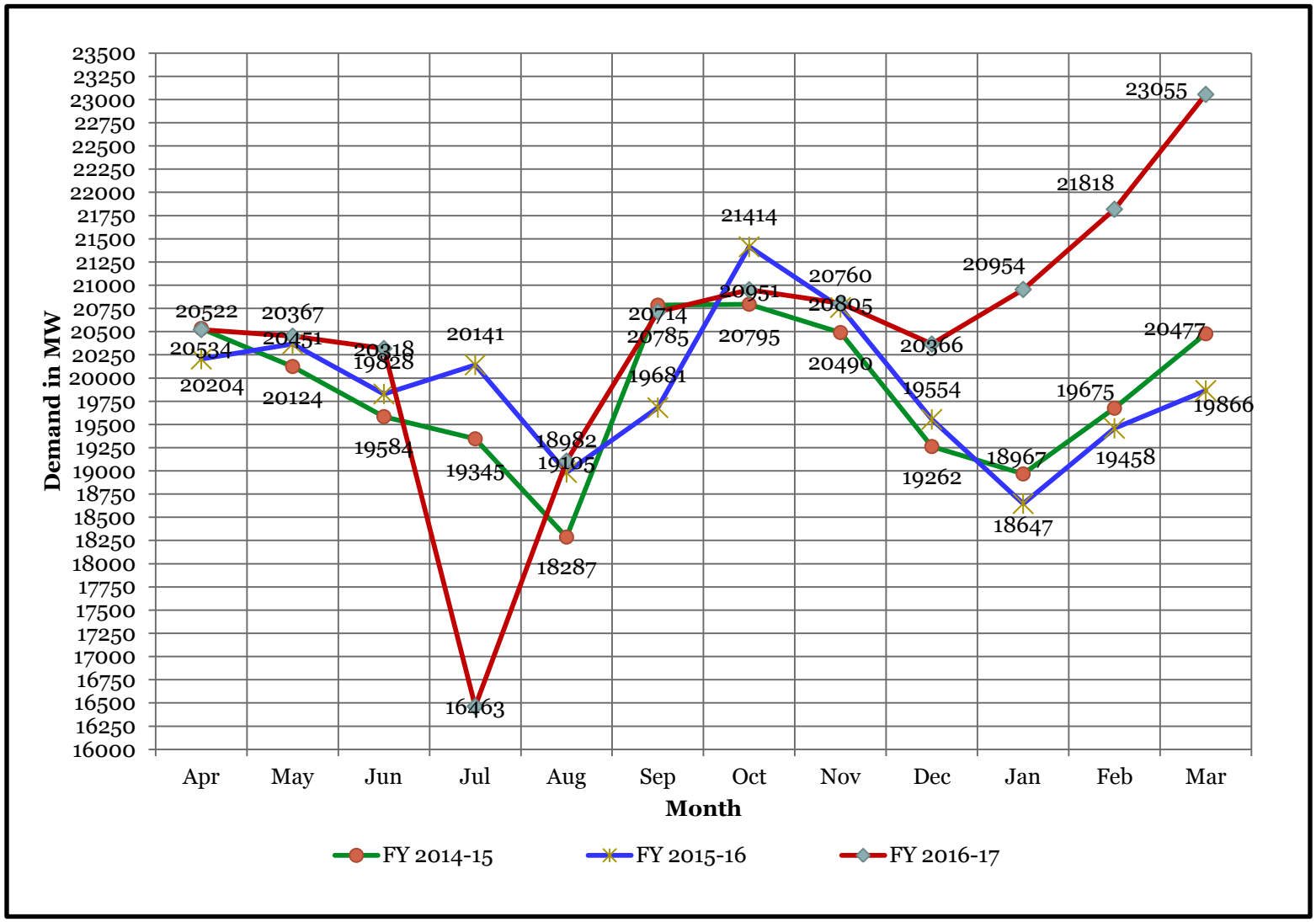
NON CONVENTIONAL ENERGY (NCE)SOURCES		
Source:- MEDA NOTE AS ON 31.03.2017	Wind	4769
	Small Hydro	300
	Bio-Mass	215
	Bagasse Co-Gen	1849
	Urban Waste	3
	Solar Power	376
	Industrial Waste	35
	Total NCE	7547

- State has catered 22517MW with out any constraints on 30.03.2017 at 12:00Hrs.
- Wind Power maximum injection was 2662 MW on 29.03.2017 at 18:00 Hrs without any constraints.
- Solar Power maximum injection was 297 MW on 21.03.2017 at 13:00hrs

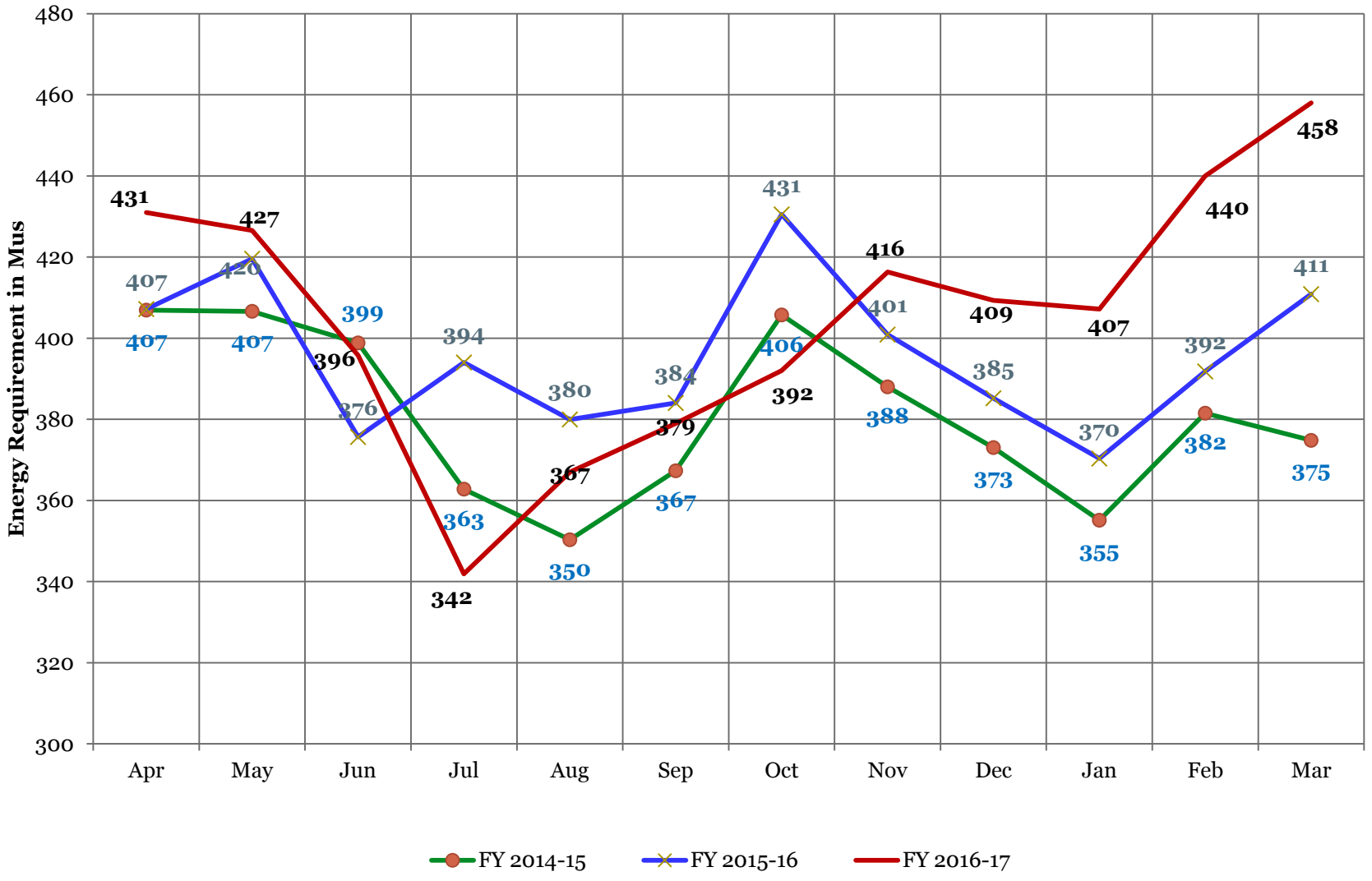
Maharashtra State Load Curve for 30.03.2017 with peak demand (Unrestricted) of 23055 MW



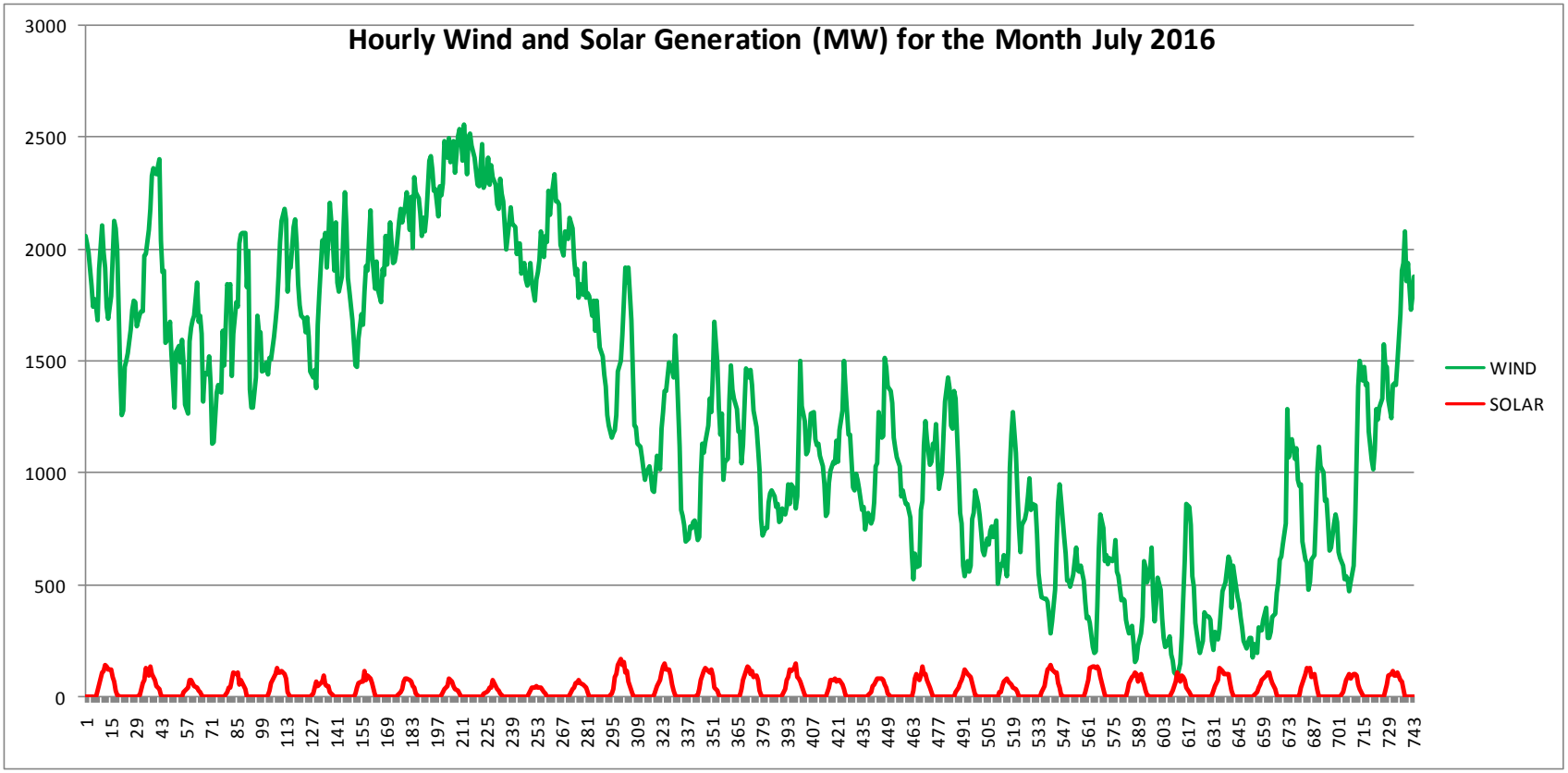
2.3 Monthly Maharashtra State Max Demand For the Period Apr-2014 to March-2017



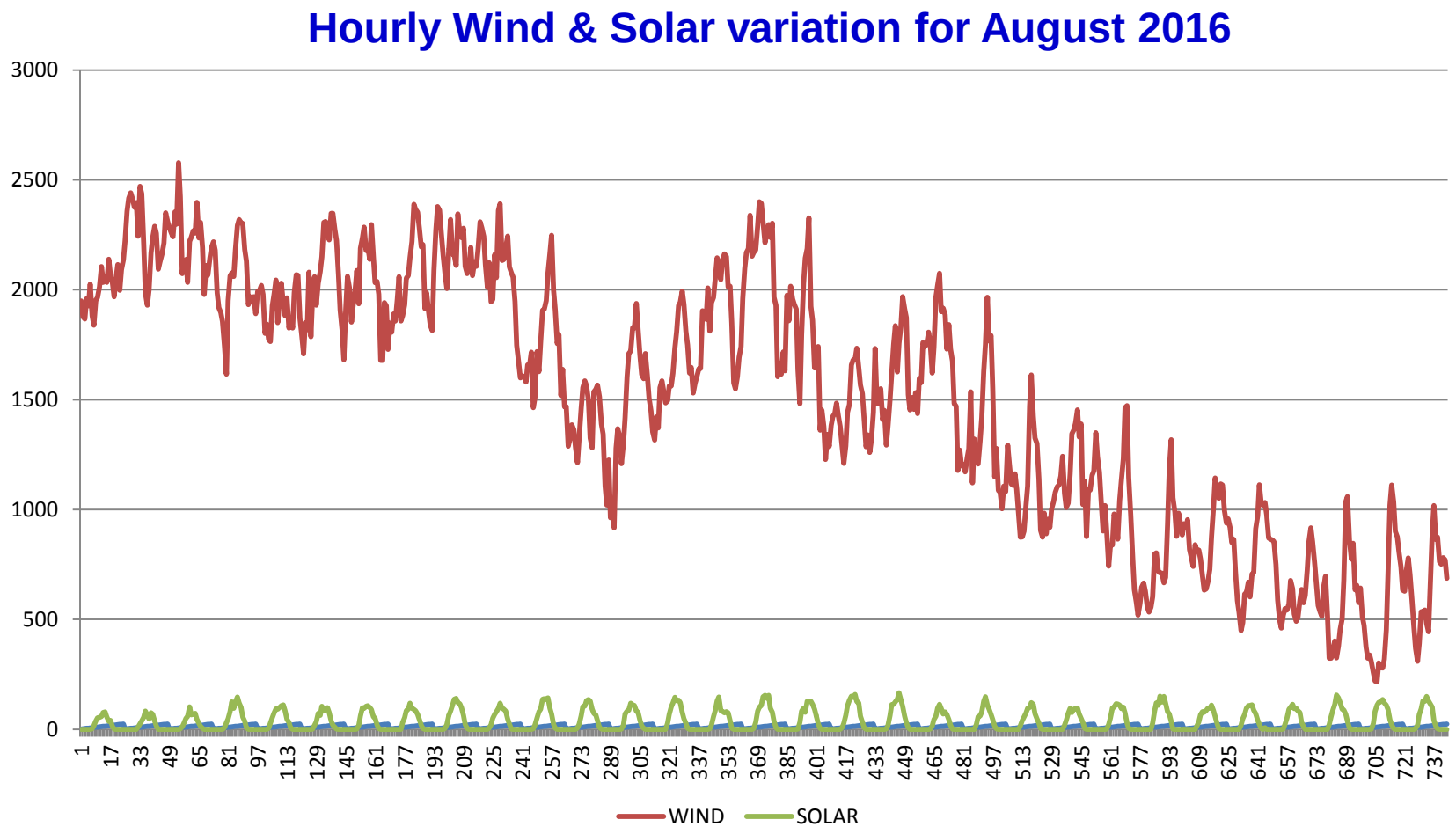
Monthly Maharashtra State Average Energy Req. For the Period Apr-14 to Mar-17



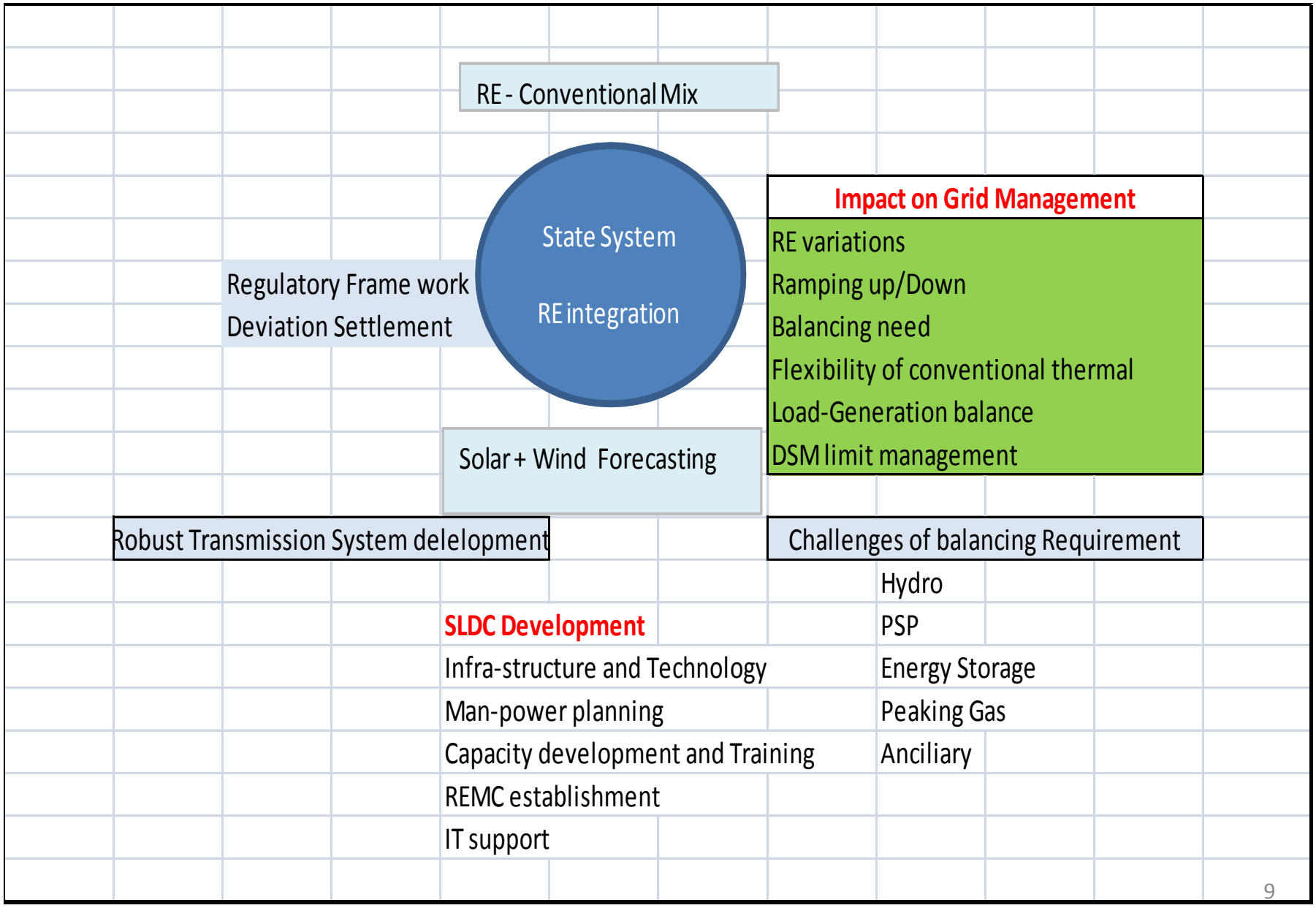
Maharashtra State Hourly Wind and Solar injection for the month of July 2016



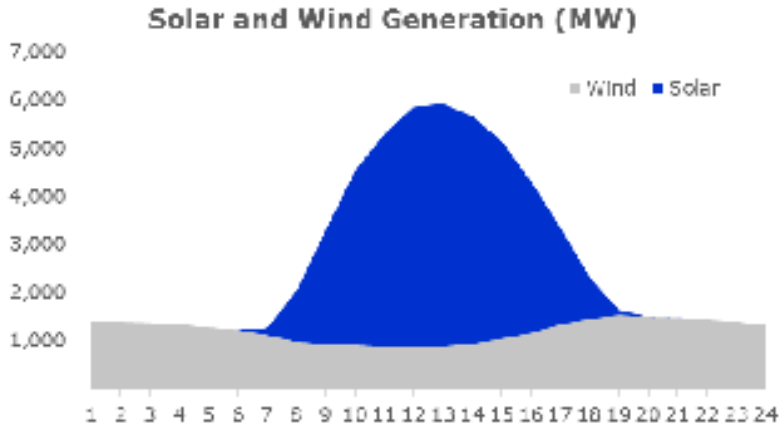
Maharashtra State Hourly Wind and Solar injection for the month of August 2016

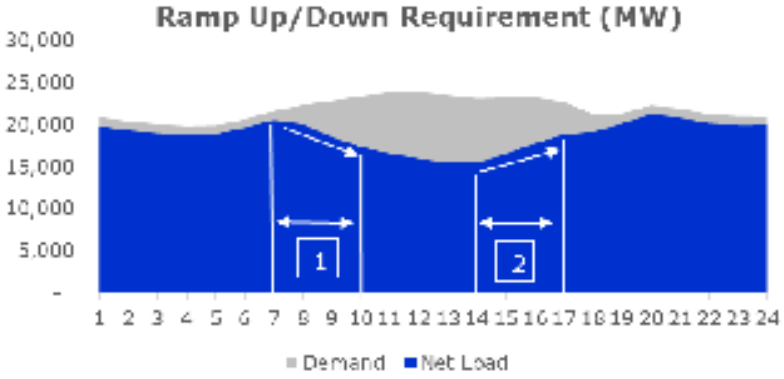


Large Scale RE integration: State specific issues



Ramp-up/Down Requirement of Maharashtra with RE Integration – Year 2022





Ramp Up/Down Requirement for FY 2022			
Type	Time	Quantum	Ramp/Minute
Down	7 AM-10 PM	**3.19 GW**	**(17.76)**
Up	14 PM-17 PM	**3.33 GW**	**18.54**

Available balancing Reserve including planned (MW)*

Source	Technology	Installed Capacity	Available Capacity	Availability Factor	Ramp Rate (%/Min)
Coal	Sub-Critical	NA	NA	NA	1%
Coal	Super Critical	5,940	1,188	20%	3%
Gas	Open Cycle	NA	NA	50%	25%
Hydro	Storage	5/4	2/3	50%	50%
Total		**6,487**	**1,462**		

- *Maharashtra need **3.33 GW** of balancing capacity within **four hour** of time block to manage RE in **2022***
- *State has **balancing capacity of 1,462 MW** to manage this variable generation*

Methodology adopted is as per PGCIL – RE Integration (Transmission an Enabler)

Maharashtra State - Key issues for RE balancing requirement.

S. No	Key issues	Observations
1	**Develop a Wind-Solar Hybrid policy to encourage investment in Hybrid Projects** • Identify potential sites for hybrid projects and develop pilot projects • MERC should bring regulatory clarity on hybrid tariff, energy metering accounting and settlement of RPO from hybrid projects	•There are many windy locations in the state where solar wind projects can be installed or solar projects can be integrated into existing wind power projects. •Hybrid projects will reduce infrastructure cost and increase its utilization. There is provision for encouraging solar wind hybrid power project in GoM policy dated 20th July 2015. •There is also provision in policy of deciding project specific tariff for Wind Solar Hybrid projects.
2	**Adoption of Sustainable/Innovation Business Models for Agriculture consumers** • Present business models are primarily subsidy driven • Net metering based solar pumps with attractive FIT for export could be a better option instead of subsidy based models	•State has taken decision to implement solar based agriculture feeder in the state to reduce subsidy burden on state Discoms. State has no policy for net metering based solar pumps.

Maharashtra State - Key issues for RE balancing requirement.

S. No	Key issues	Observations
3	**Encouraging development of SS based Solar Projects or Solar rooftop to minimise infrastructure investment and losses** • In Maharashtra, around 4 GW of solar generation can be easily absorbed through existing transmission lines if connected at 33 kV	•It is planned to install solar agriculture feeder based projects near existing substations to reduce infrastructure costs. Open land / government lands will be identified near substations for installations of solar projects. •The impact of Solar Roof top Net metering on common consumers tariff is high. Feed – in tariff metering should be recommended by Advisory Group.
4	**Focus on development of Solar Park in partnership with private players** • Through signing of MOU, forming JVs with private players, like Rajasthan, MP, AP etc.	•Solar Parks are planned as per GoM Policy. After implementation of Green Energy corridor transmission margin of 3500 MW will be created. Export power capability to the tune of 14000 MW is available. •Corridor development in STU planning will be taken up after identification of location for Solar Park.

Maharashtra State - Key issues for RE balancing requirement.

S. No	Key issues	Observations
5	**Explore retrofitting of the existing thermal plants to develop the balancing market** • To increase the balancing capacity. This will require developing market mechanism through regulatory intervention.	To enhance flexibility of Thermal units by way of operating at 55 % technical minimum level, the costs towards retrofitting and possibility of increased oil consumption will impact variable cost of generators and will impact on tariff. Ancillary services and other balancing power requirements needs to be addressed through regulatory intervention. CAPEX involved in retrofitting of Thermal Units needs to be compensated.
6	**Incentivise existing conventional plants for running at lower PLF** • To accommodate RE, Conventional projects are running at low PLF (MAHAGENCO average PLF for FY15~ 55%) • MNMRE/MOP should provide suitable compensation for loss of generation and revenue on account of low PLF	The incentive proposed for RE is creating burden on Distribution Licensee and in turn to common consumers. Incentive if any to be given should come through budget without effecting consumers. To accommodate RE, backing down of cheaper thermal, under utilization of network etc be considered while assessing impact of RE on Distribution Licensees. Suitable compensation for increased Heat rate for operating at low PLF operation needs to be provided.

Maharashtra State - Key issues for RE balancing requirement.

S. No	Key issues	Observations
7	**Maharashtra should adopt better forecasting and scheduling methodologies in view of large RE capacity addition by FY 2022** • In Tamil Nadu, NIWE is providing forecast with an accuracy of above 90% • Industry associations are financing this initiative, Rajasthan and Gujarat has also started this exercise	Renewable Energy Management Centre (REMC) is being established by PGCIL as implementing Agency at SLDC under Green Energy Corridor. Forecasting and scheduling module is envisaged in REMC Agreement for REMC is executed with PGCIL.
8	**MERC should come out with Scheduling and Forecasting Regulation for Renewable energy** • Proper Deviation and settlement mechanism should be in place for managing RE variability in view of large RE generation • FOR has issued model regulation for intrastate scheduling and forecasting mechanism. • States including Andhra Pradesh, Jharkhand, Madhya Pradesh, Odisha, Rajasthan and Tamil Nadu have already issued draft F&S regulations	MERC is in Process Development of Deviation and settlement mechanism for managing RE. MERC is in Process regulation for Forecasting Scheduling of RE.

Maharashtra State - Key issues for RE balancing requirement.

S. No	Key issues	Observations
9	**Real time monitoring of generation from RE** • Enable connectivity of pooling substations with REMC and setting up of communication channel at polling station should be mandatory • Grant from NCEF can be used to establish RTU/DC, ABT meters & Communication channel at polling station across • Need of common platform wherein REMCs can coordinate with RE developers for real time data communication & visibility of RE	There are 60nos. RE pooling stations in the state, out of which 10 nos. are reporting to SCADA. Real time visibility for major 20 nos. locations will be provided by STU shortly. For balance 30 nos. locations, PSDF approval is sanctioned. The coordination with RE developer will be establish at state level through proposed RE regulation.
10	**To develop capacity building of SLDC including domain knowledge, competence and decision making capability to handle large scale RE in the State.** • Knowledge exchange programs with RE rich countries needs to be organised to build the capacity of State Load dispatch centre • MNRE/MOP needs to facilitate/organise such programs	State will actively participate in the capacity building program for SLDC organized by MNRE/MOP.

Maharashtra State - Key issues for RE balancing requirement.

Other issues:

a) Source and location for balancing capacity requirement need to be work out for the state.

b) Impact on Demand due to adding large scale RE over and above RPO Targets need to be analyzed. RE capacity addition should be linked with electricity demand and projections.

c) Impact on consumer's tariff due RE capacity addition and additional need of balancing capacity, transmission infrastructure and backing down of cheaper generation should be studied.

d) Demand side management to minimise impact of RE variability is necessary

Impact of Large scale RE variability on grid management

A. State Underdrawal
B. Backing down of cheaper thermal generation
C. High ramp up and down requirement
D. Violation of DSM limits due to large & frequent variations
E. UI Penalty charges

Wind injection is maximum during monsoon season from June to September – However, its contribution to under drawl and backing down can not be established or quantified as it is not separately accounted for

The assessment of loss is as below:

•For the year 2015-16, during above period, when Wind injection was more than 1000 MW it is estimated that there was under drawl of 214 Mus (above DSM limit) and resulted into additional penalty of Rs. 4284 Lakhs approximately.

•Similarly for the year 2016-17 it is estimated that there was under drawl of 454 MU's and related penalty worked out as Rs 2530 Lakhs approximately.

•The backing down quantum during above four months of 2015-16 on account of high wind injection is worked out as 890 Mus approximately in the year 2015-16 while it is approximately 745 Mus for the monsoon period in the year 2016-17.

Any constraint faced for RE injection

a. **On 20.05.2017, Maharashtra has absorbed 2662 MW and 50.50 MUs without any constraint.**

b. **Under Green Energy corridor transmission system development is already taken up by Maharashtra STU which will create margin of 3500 MW RE absorption.**

c. **Corridor development under STU plan for up coming Solar/Wind farm will be taken up after identification of locations.**

Utilization of state's own balancing plant.

Maharashtra has storage Hydro plant capacity :

I. **Koyna (Stage 1&2-600 MW, Stage-III-320MW & Stage IV-1000 MW)**
II. **Ghatghar PSP (250 MW Generation, 300 MW Pumping)**
III. **Tata Hydro (Bhira-300 MW, Bhivapuri, 85, Khopoli-72 MW)**

Maharashtra is having about 2600 MW Hydro capacity as balancing power. However, with large scale RE the balancing need of the state shall be around 4500 MW.

Assessment of quantum of electric storage

a. **Considering large scale RE (Wind+Solar) integration future requirement of storage may be around 3000 MW**

b. **Ramping down/up capability of conventional Thermal plants need to be enhanced by operation at lower technical minimum level.**

c. **Demand side management of AG supply needs to be correlated with availability of solar power.**

d. **More pumped storage capacity needs to be developed to the tune of 1500 MW.**

Status of communication system to SLDC.

In Maharashtra existing 60 Nos RE injection STU pooling stations are covered under real time visibility as under:

a. **10 Nos. pooling station reporting to SLDC SCADA.**
b. **For 20 Nos. pooling station data, tendering is in its final stage.**
c. **For balance 30 Nos. pooling station data, PSDF approval is obtained.**

Ministry of Power, GoI has appointed PGCIL as implementation agency for setting up of Renewable Energy Monitoring Centers (REMCs) and Control Infrastructure.

Tender for western region states is under finalization by PGCIL, Maharashtra has participated in all the stages of processing for establishment of REMC.

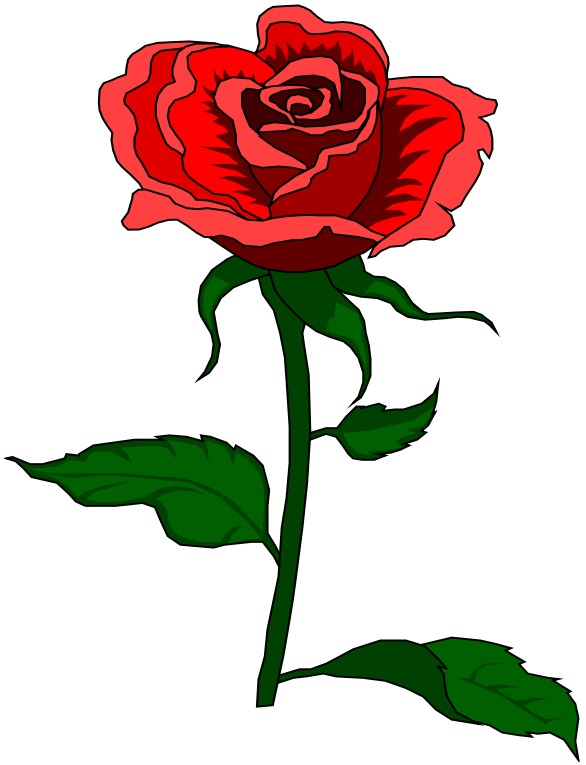
Agreement with PGCIL and SLDC is executed.

Way forward – State perspective

By considering above feedback on the blue print roadmap prepared for the state RE capacity addition need to be taken up further at micro level to convert into detail action plan on following points.

1) Infrastructure development plan – REMC, IT & Technology.
2) Balancing capacity requirement plan - Sources and Locations
3) Transmission system development plan - Solar + Wind evacuation as per location
4) Institutional & capacity development – SLDC and MEDA
5) Regulatory framework development - MERC

Balancing need and enhancement of flexibility and ramping up/ down capability has multiple dimension as mentioned above. Hence focused action plan should be developed to overcome related difficulties and meet the RE target in a seamless manner.



Thank You.

MAHATRANSCO
Maharashtra State Electricity Transmission Co. Ltd.

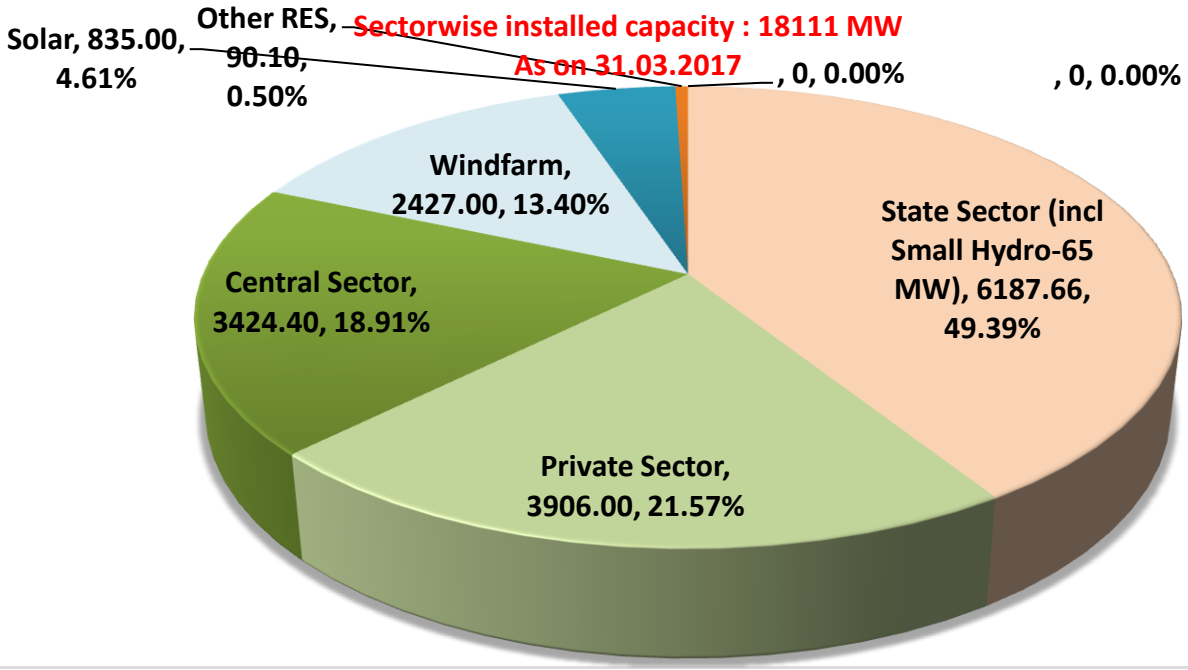
CEA-Technical Committee for Study of Balancing requirement to facilitate large scale RE integration and associated issues

Third Meeting

05.06.2017

Presentation by -

STATE LOAD DESPATCH CENTRE
MPPTCL, JABALPUR

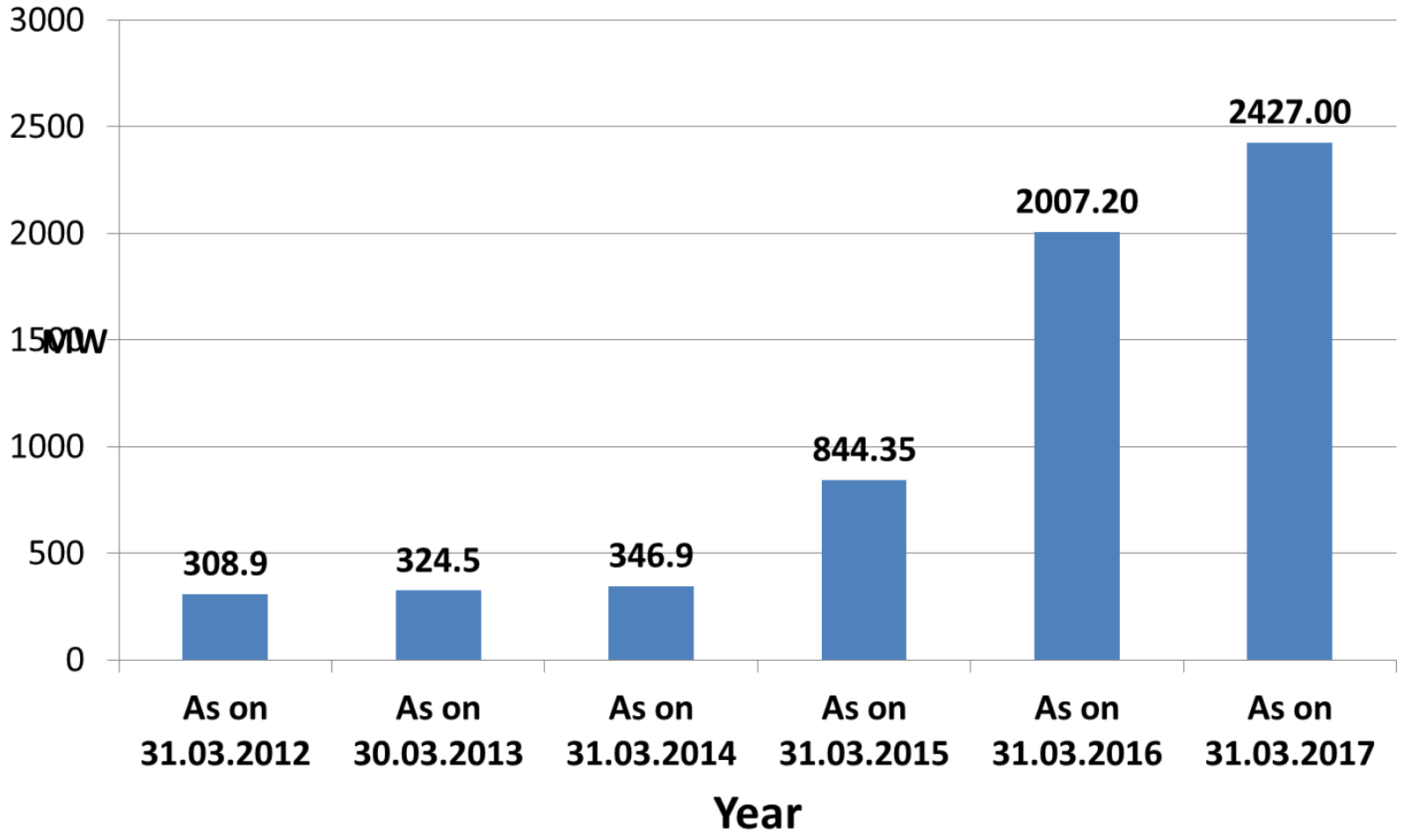


GROWTH IN INSTALLED CAPACITY OF MP (MP SHARE)

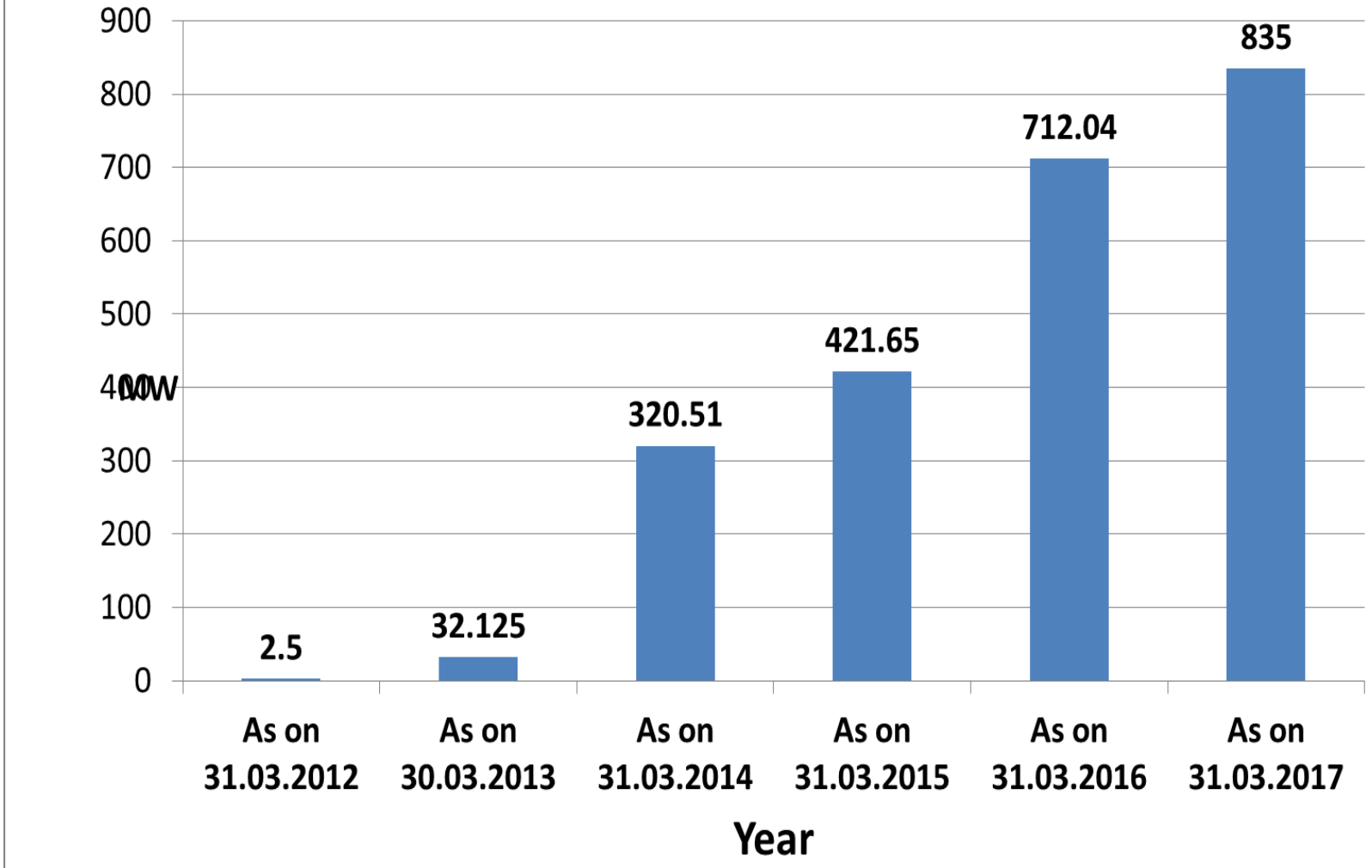
Year	State Sector	Private	Central Sector	Wind	Solar	Other RE	Total	% Increase
As on 31.30.2012	6156.66	500.00	2565.05	308.90	2.50	28.35	9561.46	
As on 31.03.2013	6081.66	1090.75	3026.76	324.50	32.13	29.55	10585.34	10.71
As on 31.03.2014	7069.16	1790.75	3227.20	346.90	322.91	49.10	12806.02	20.98
As on 31.03.2015	7429.16	3275.75	3280.64	844.35	421.65	47.60	15299.14	19.47
As on 31.03.2016	7429.16	3485.75	3424.42	2007.20	715.00	78.60	17140.12	12.03
As on 31.03.2017	7429.30	3905.75	3424.20	2427.00	835.00	90.10	18111.35	5.67
Capacity increased wrt to 31.03.2012								**89.42**

[Power Map of MP with RE Capacity]

INSTALLED CAPACITY OF WIND IN MP



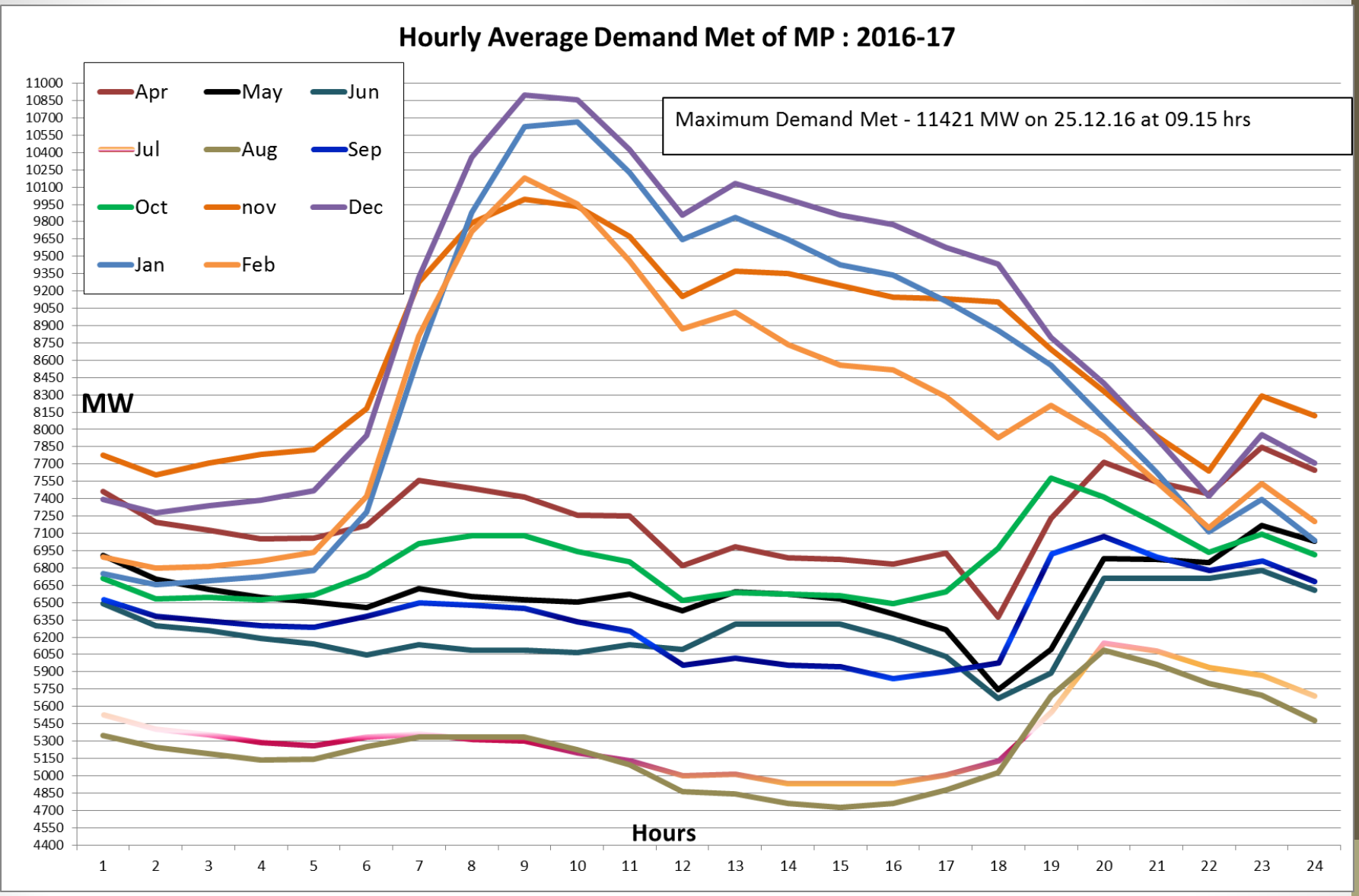
INSTALLED CAPACITY OF SOLAR IN MP



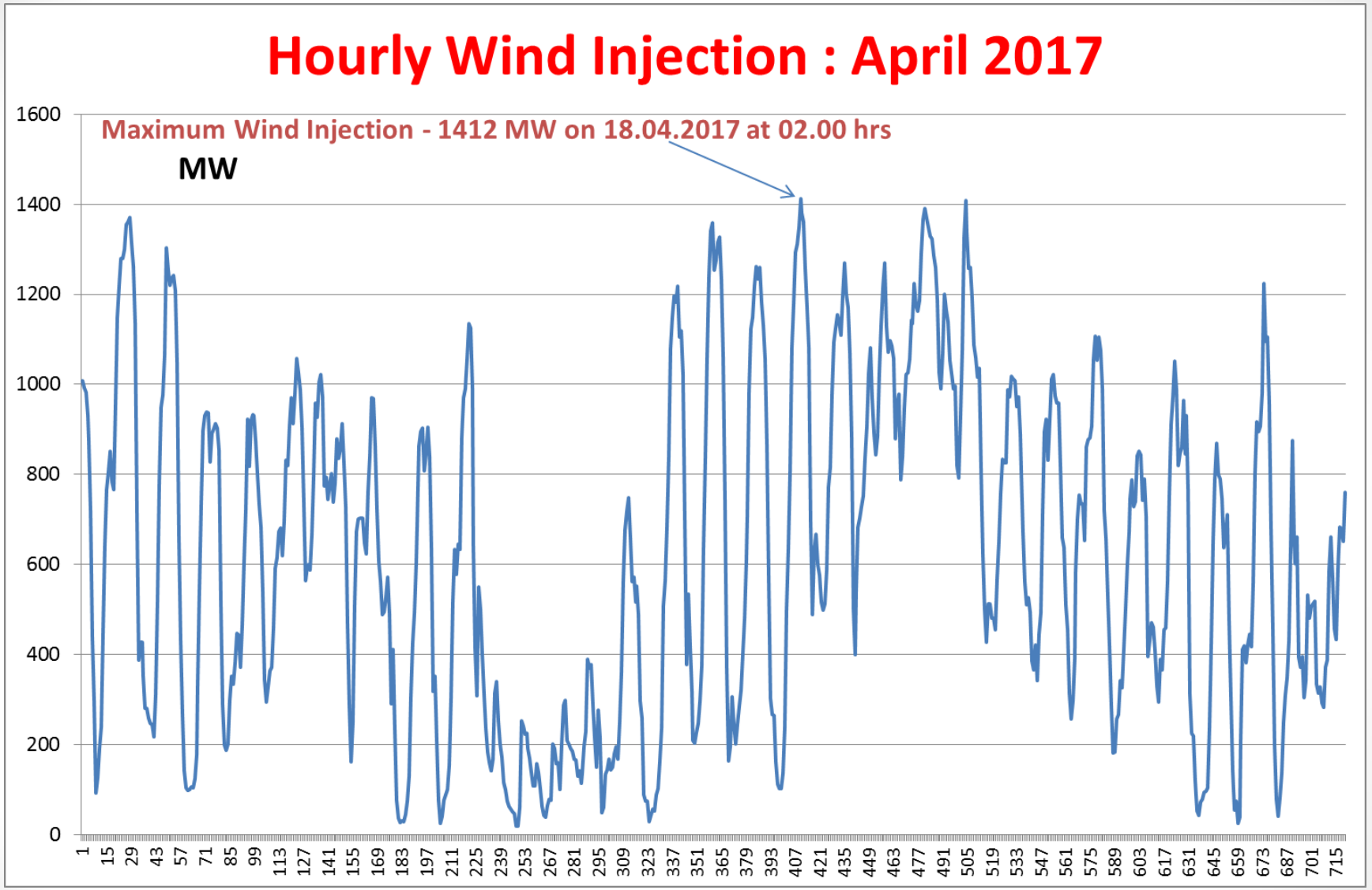
Contribution of Wind and Solar in Energy Supply of MP

Year	Energy Supply (MU)	Wind Injection	% of Wind	Solar Energy	% of Solar
2012-13	47858.32	570.99	1.19	11.75	0.02
2013-14	51952.48	515.63	0.99	242.86	0.47
2014-15	57406.79	632.37	1.10	610.71	1.06
2015-16	64148.49	1538.96	2.40	1118.81	1.74
2016-17	64373.74	3521.24	5.47	1368.15	2.13

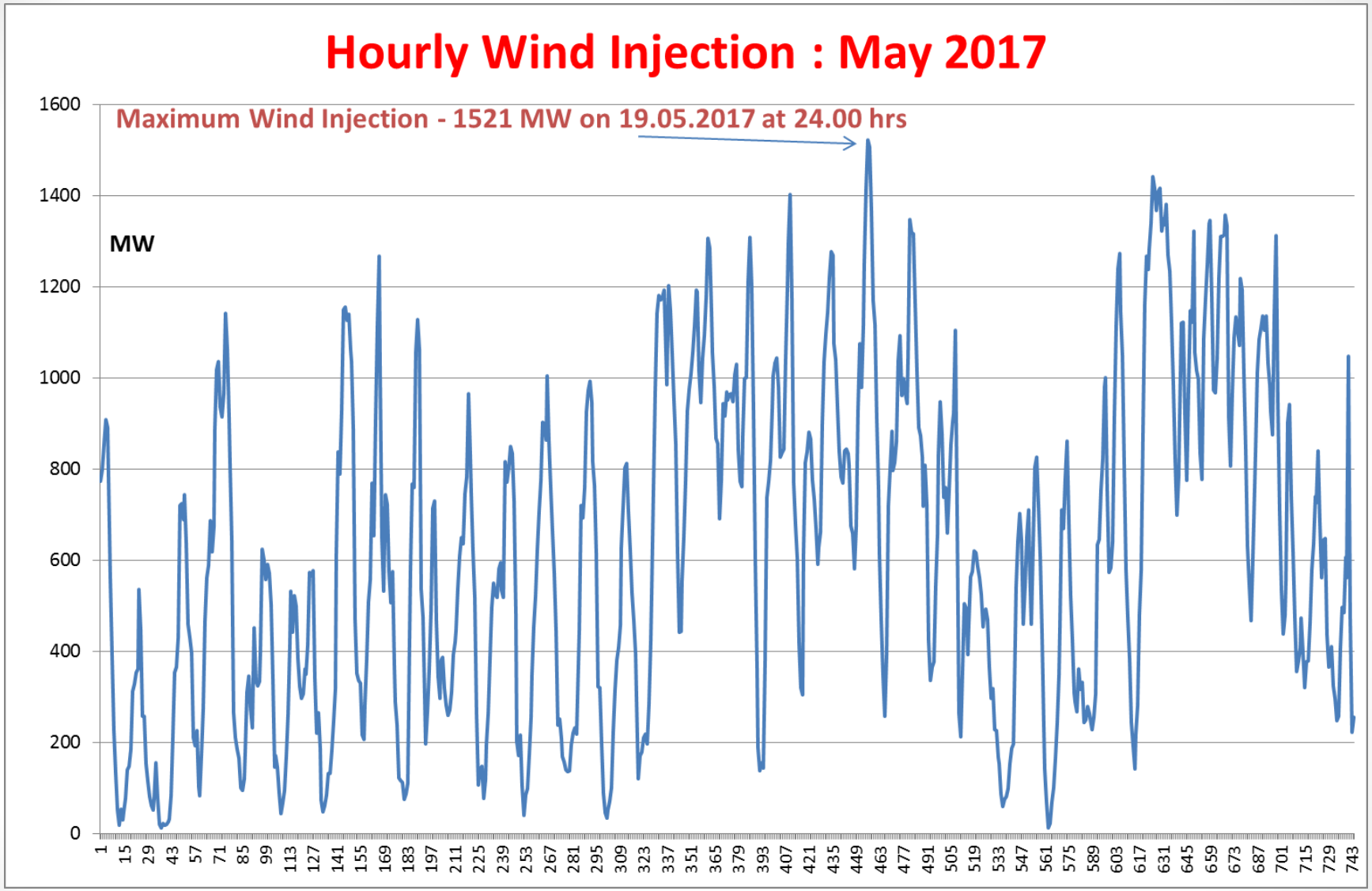
Hourly Average Demand Met of MP : 2016-17

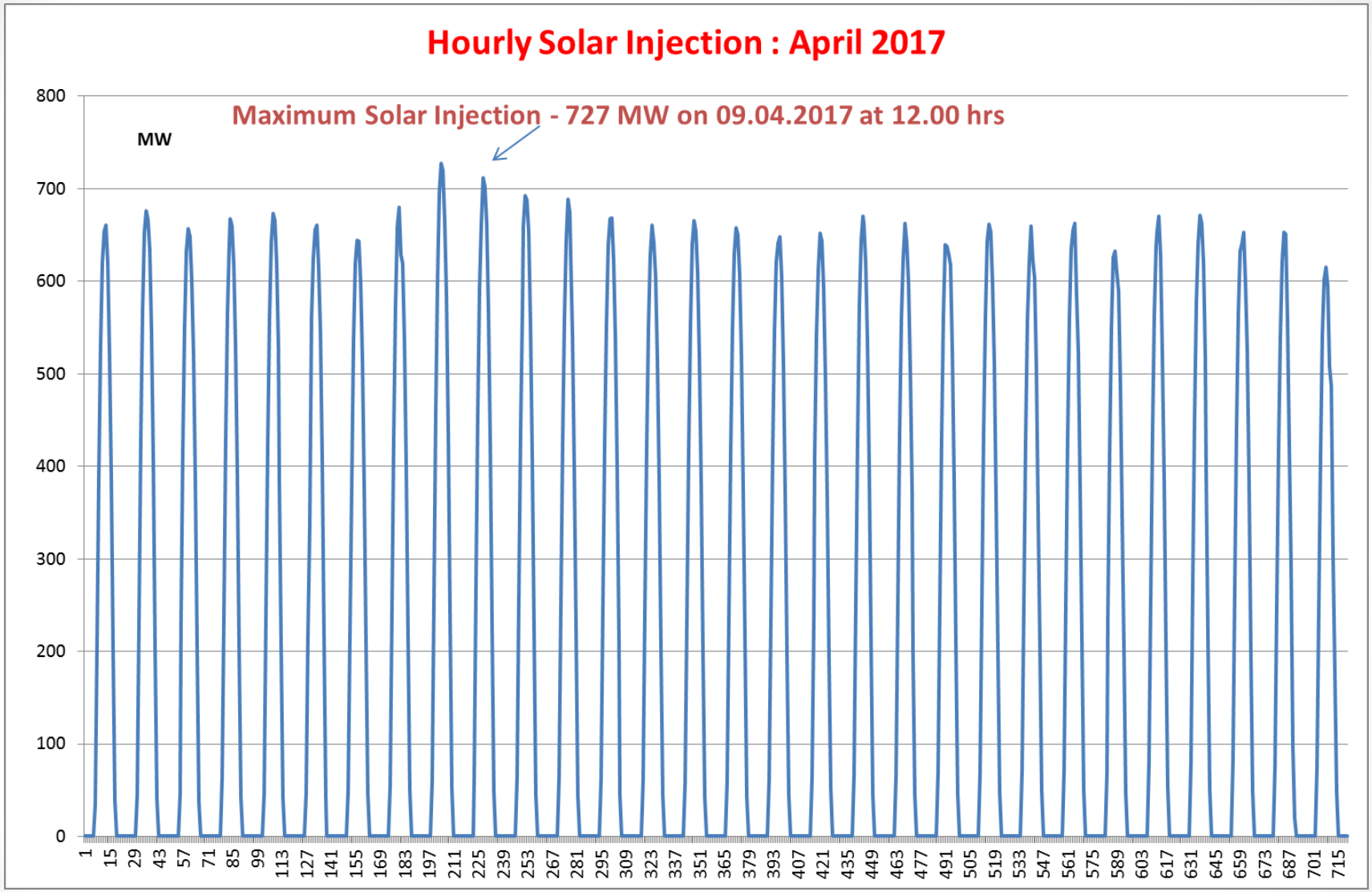


Hourly Wind Injection : April 2017

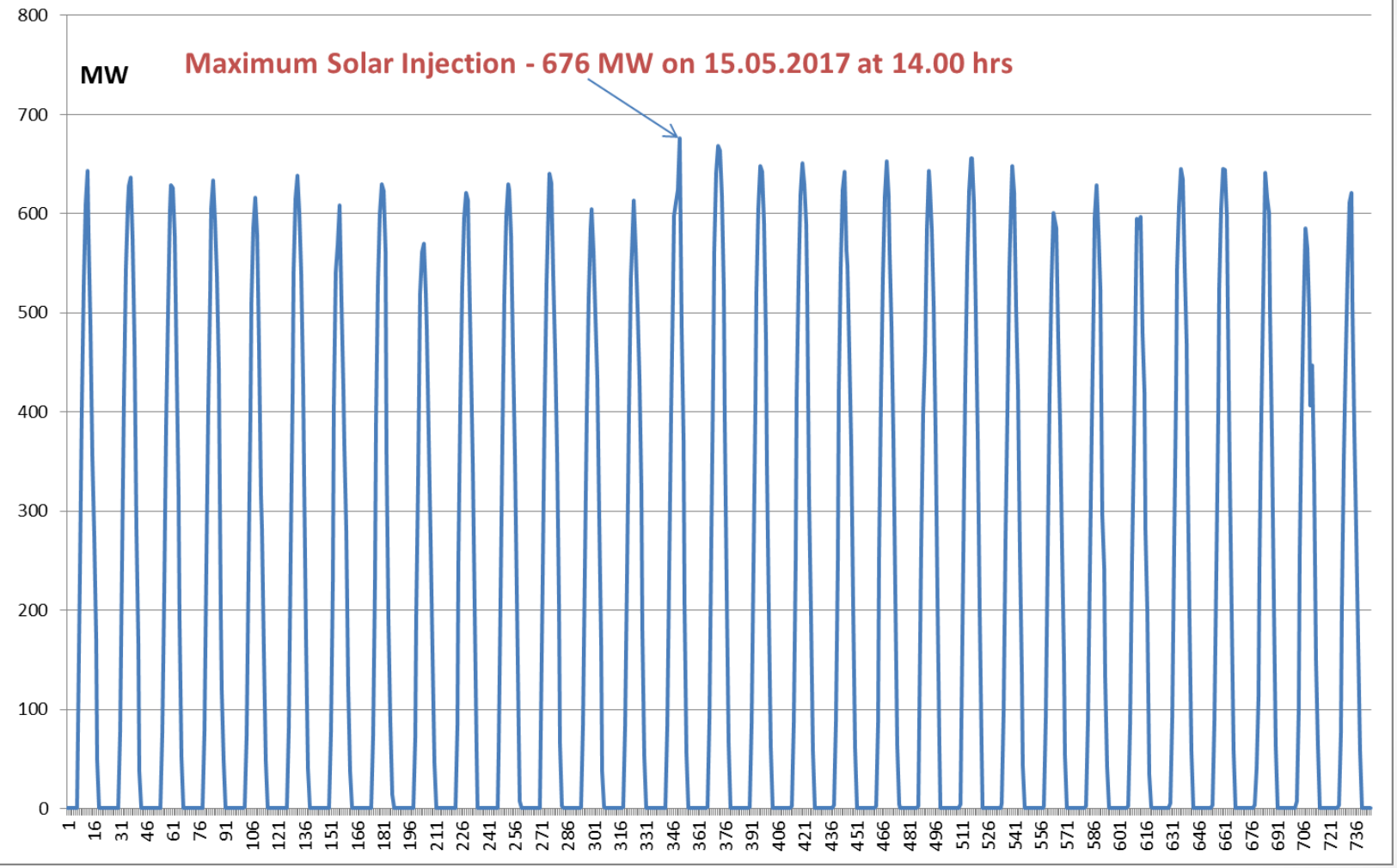


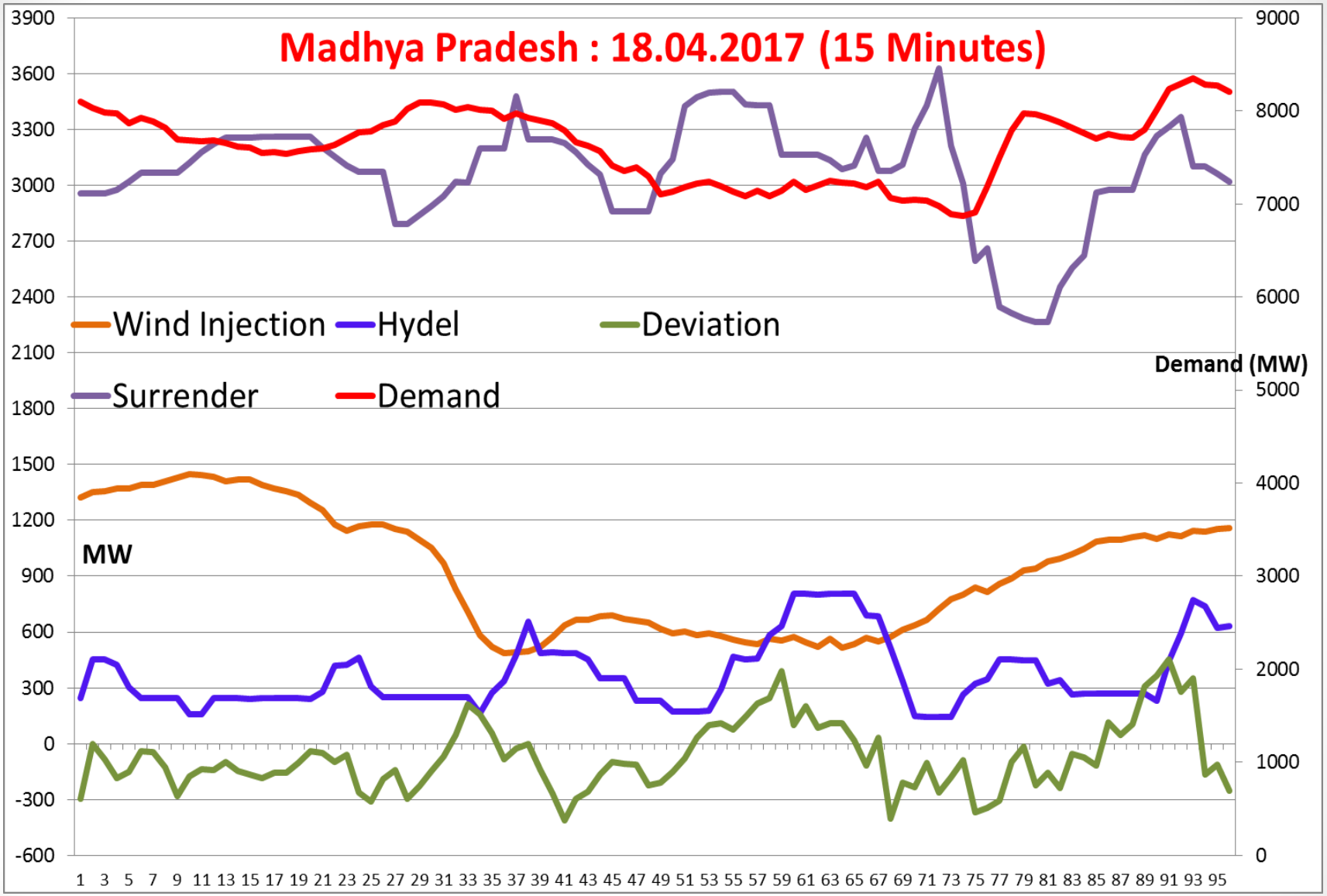
Hourly Wind Injection : May 2017

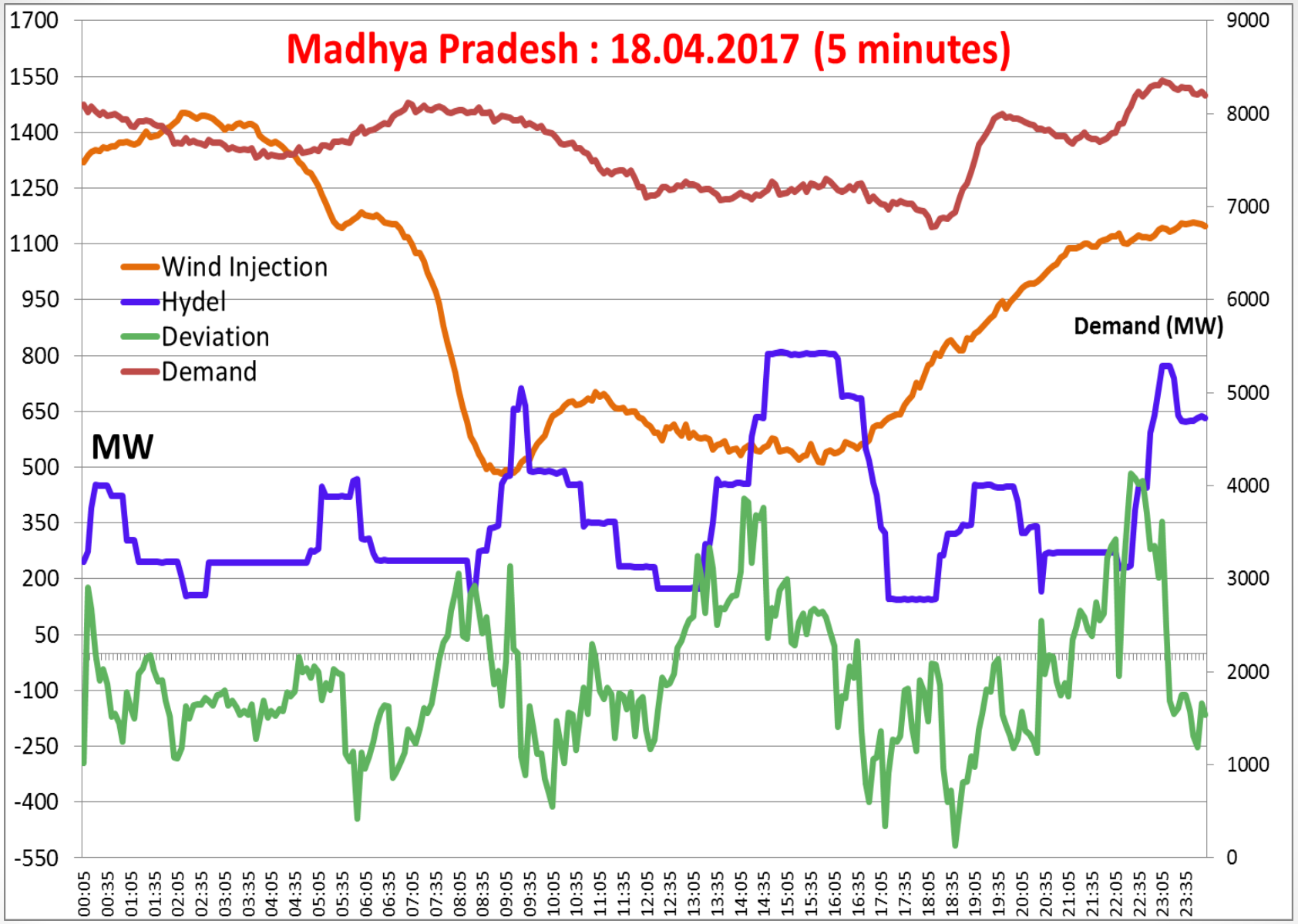



Hourly Solar Injection : April 2017
Maximum Solar Injection - 727 MW on 09.04.2017 at 12.00 hrs
MW
800
700
600
500
400
300
200
100
0
1
15
29
43
57
71
85
99
113
127
141
155
169
183
197
211
225
239
253
267
281
295
309
323
337
351
365
379
393
407
421
435
449
463
477
491
505
519
533
547
561
575
589
603
617
631
645
659
673
687
701
715

Hourly Solar Injection : May 2017




Madhya Pradesh : 18.04.2017 (15 Minutes)
Wind Injection
Hydel
Deviation
Surrender
Demand
MW
Demand (MW)
3900
3600
3300
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
-300
-600
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95


Madhya Pradesh : 18.04.2017 (5 minutes)
Wind Injection
Hydel
Deviation
Demand
MW
Demand (MW)
1700
1550
1400
1250
1100
950
800
650
500
350
200
50
-100
-250
-400
-550
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
00:05
00:35
01:05
01:35
02:05
02:35
03:05
03:35
04:05
04:35
05:05
05:35
06:05
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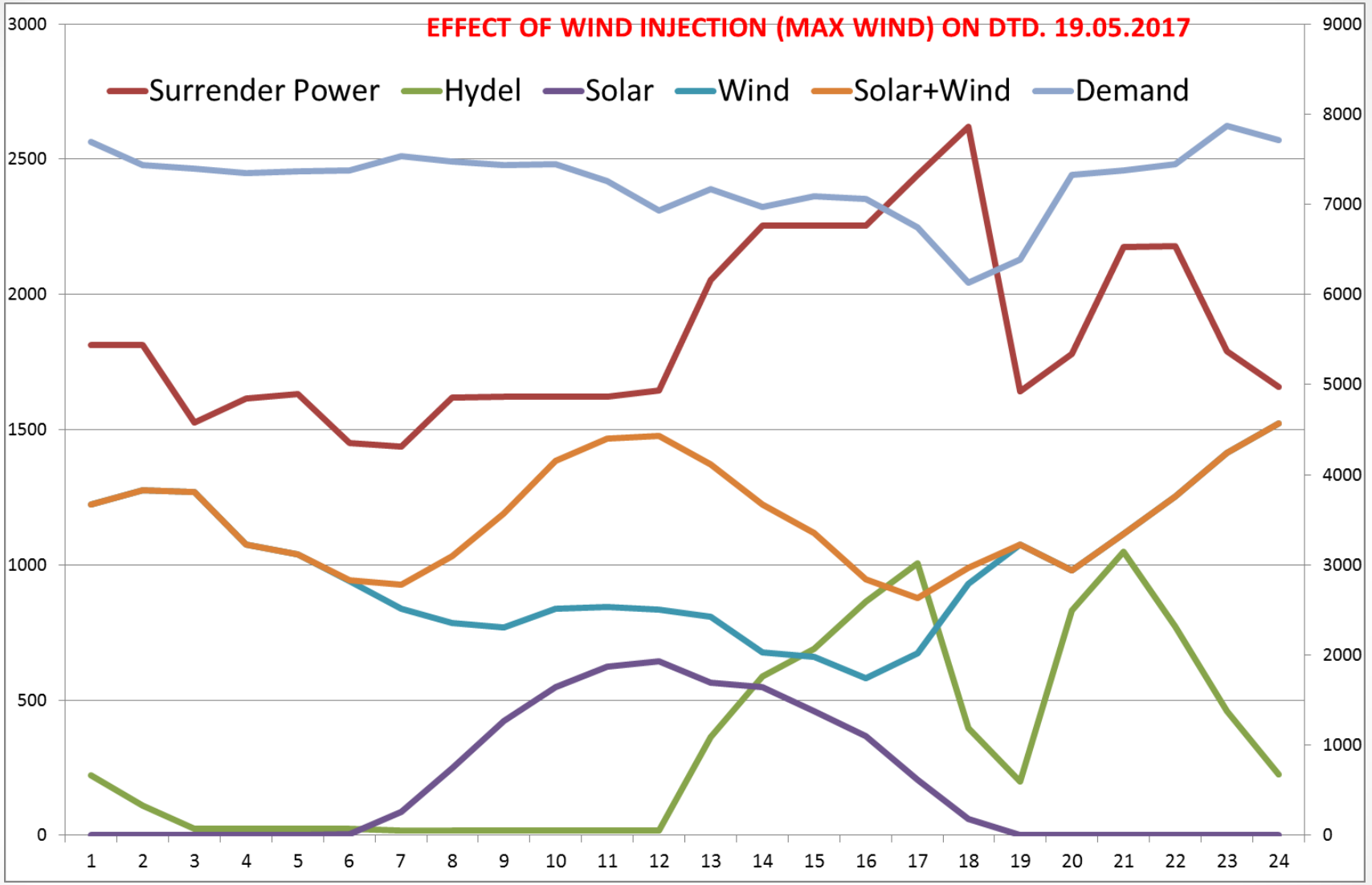
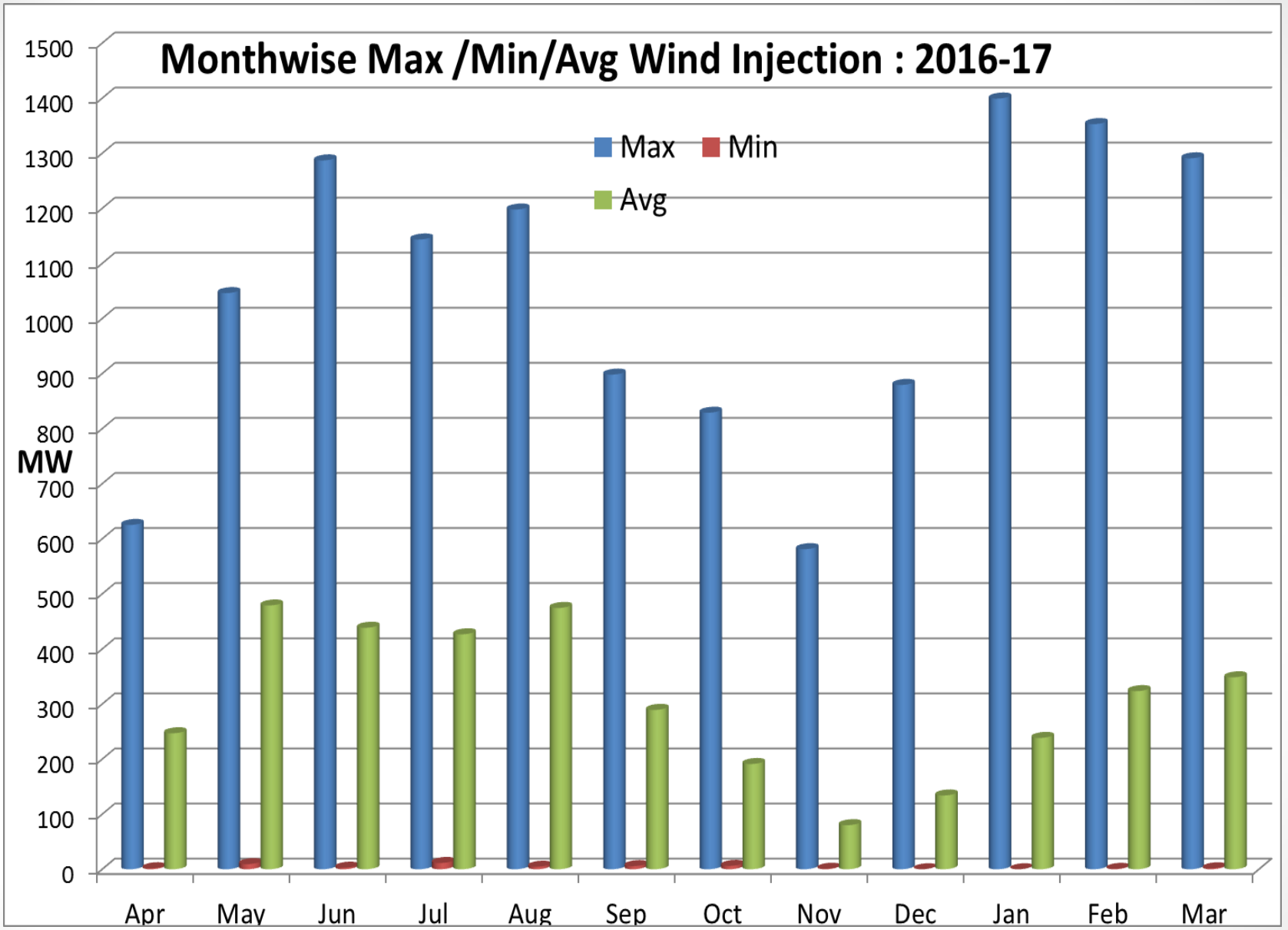
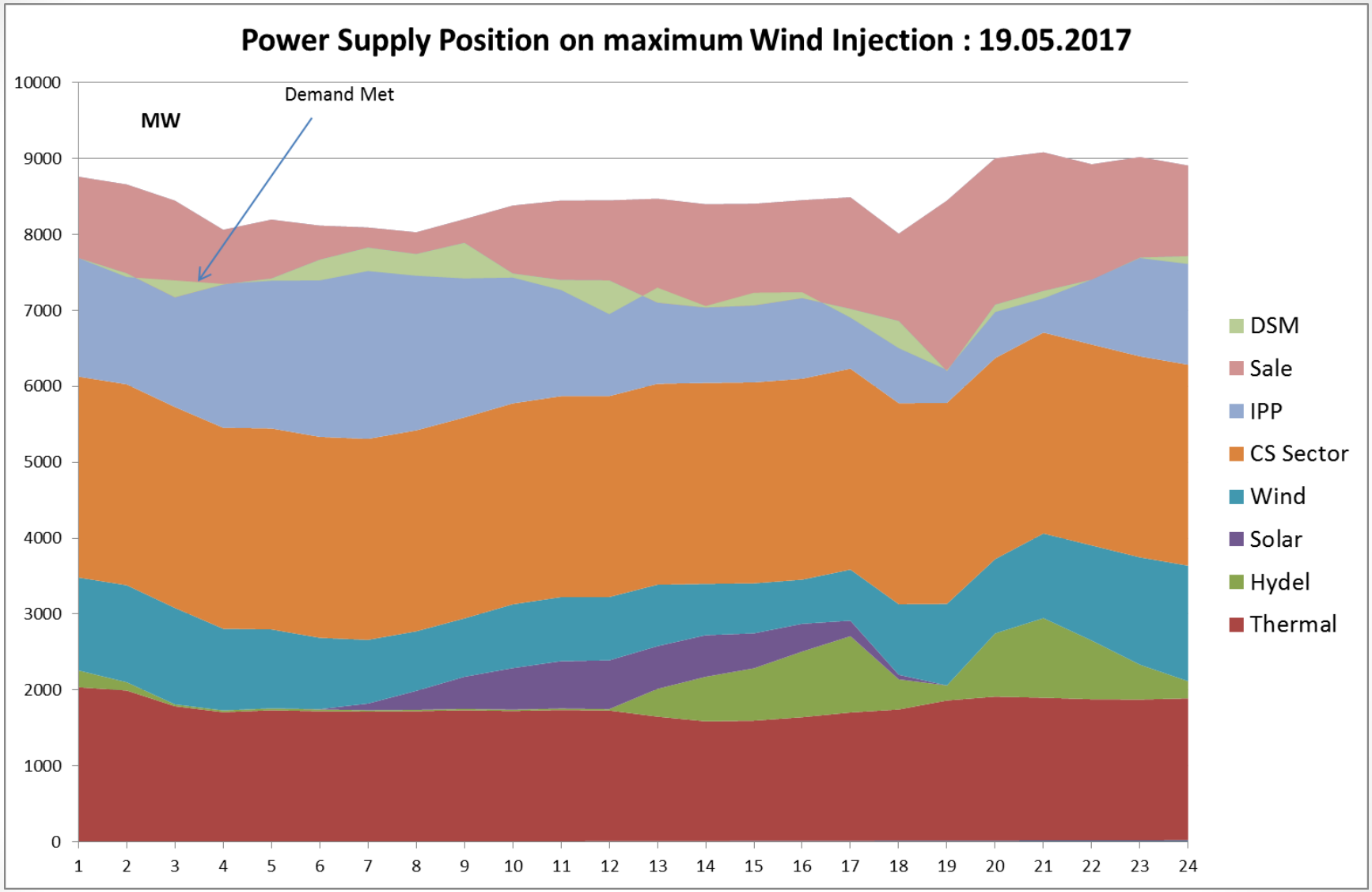
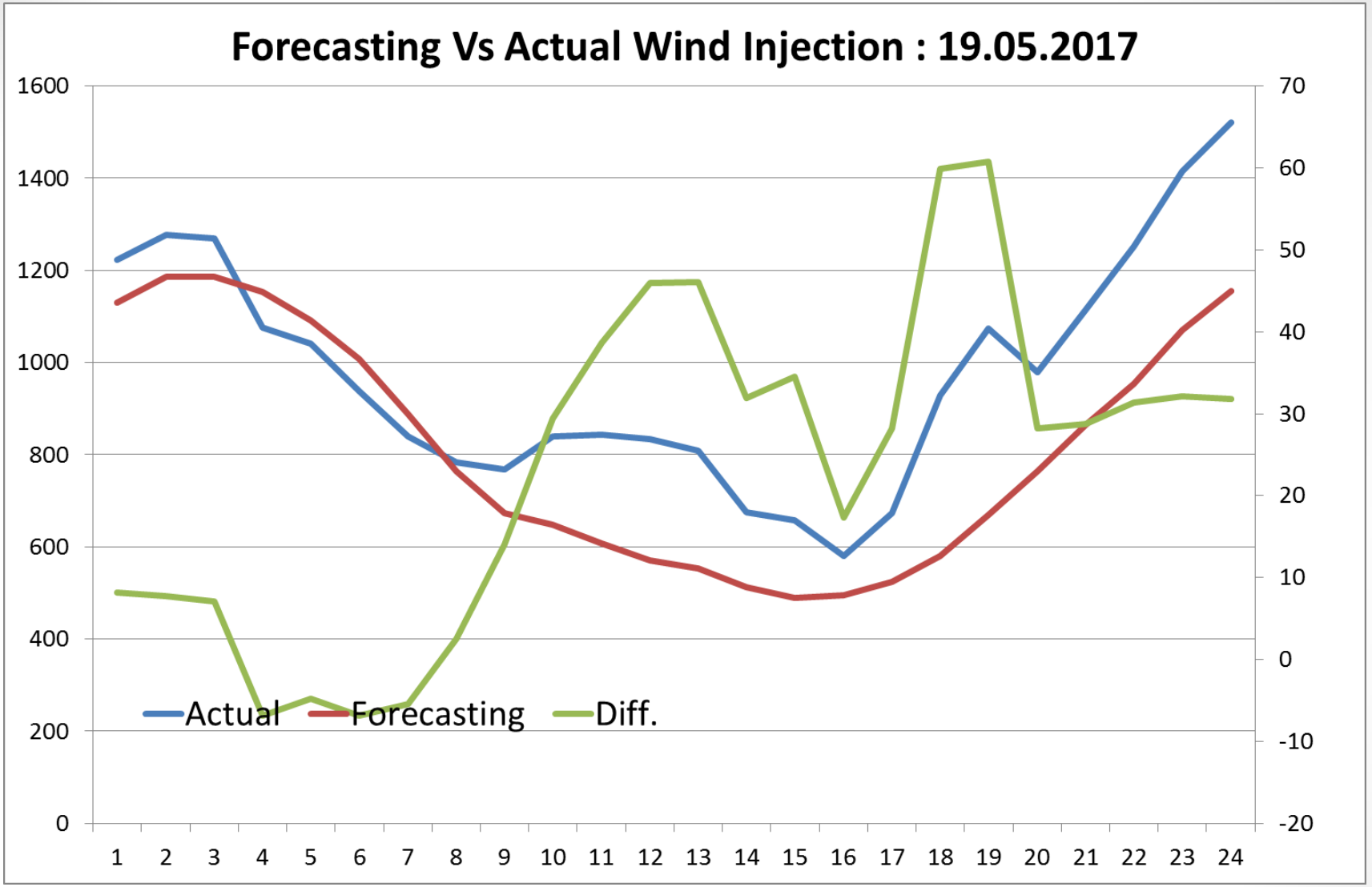
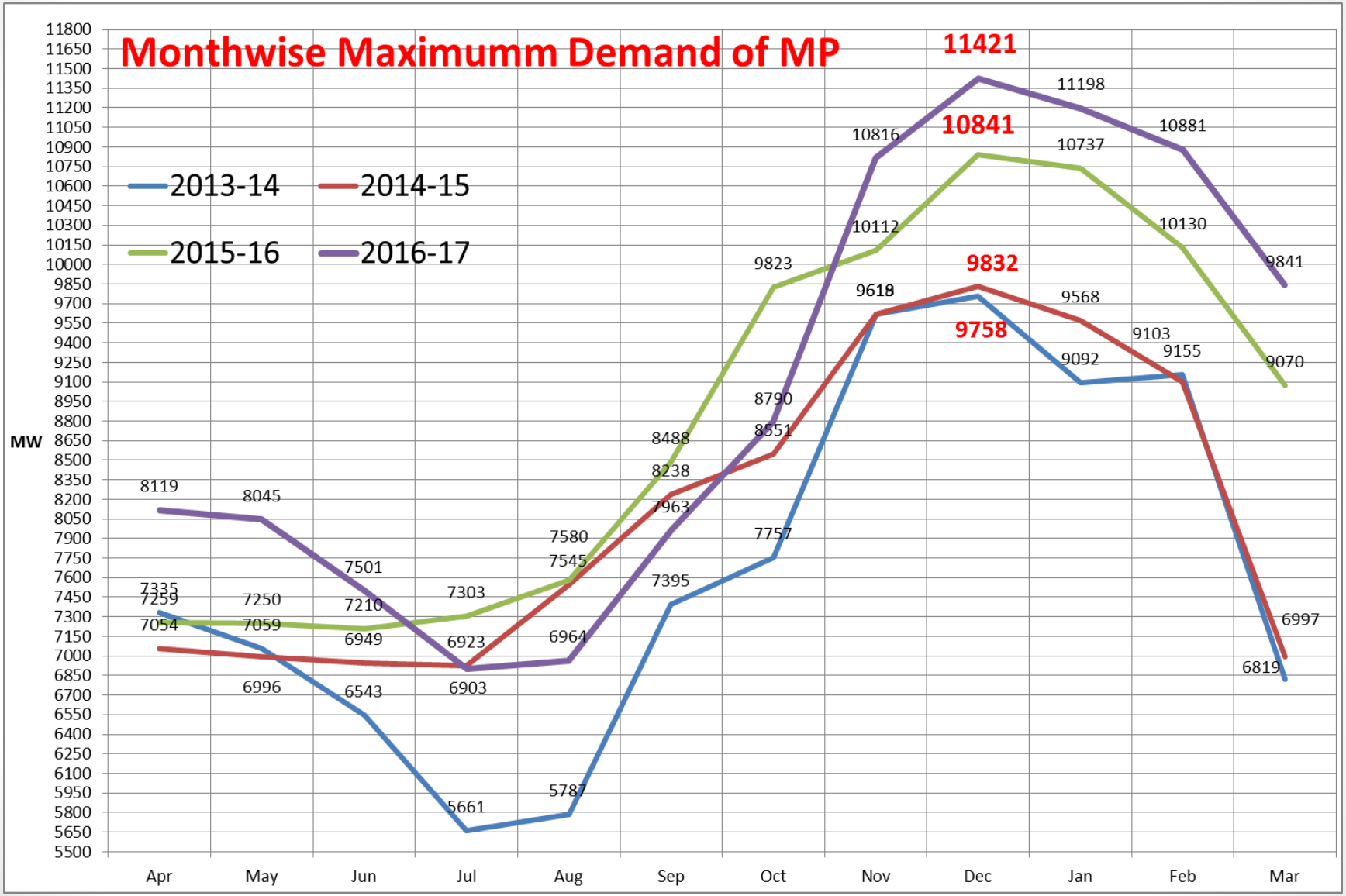
23:35


EFFECT OF WIND INJECTION (MAX WIND) ON DTD. 19.05.2017
Surrender Power
Hydel
Solar
Wind
Solar+Wind
Demand
3000
2500
2000
1500
1000
500
0
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

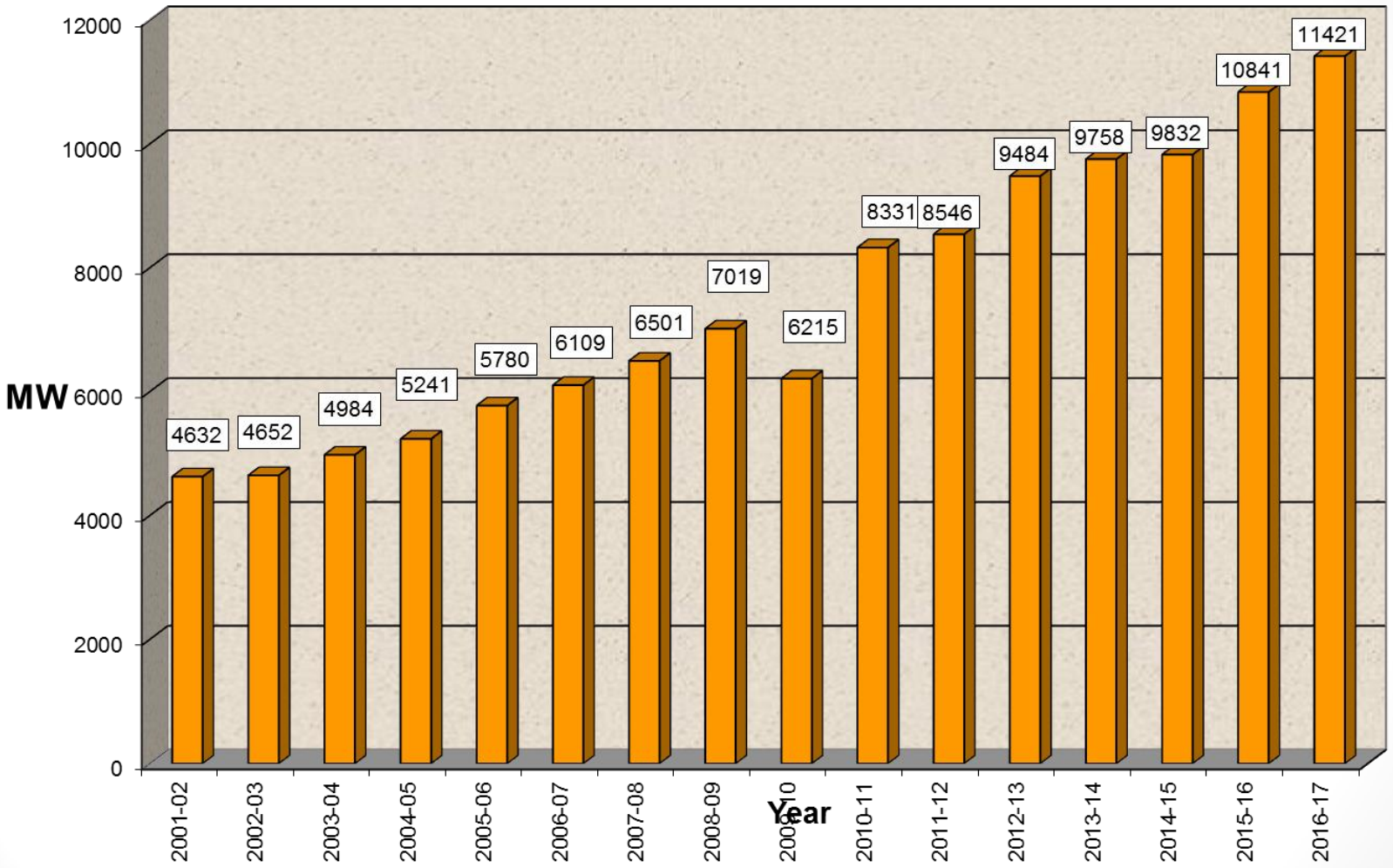

Monthwise Max /Min/Avg Wind Injection : 2016-17
Max
Min
Avg
MW
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar

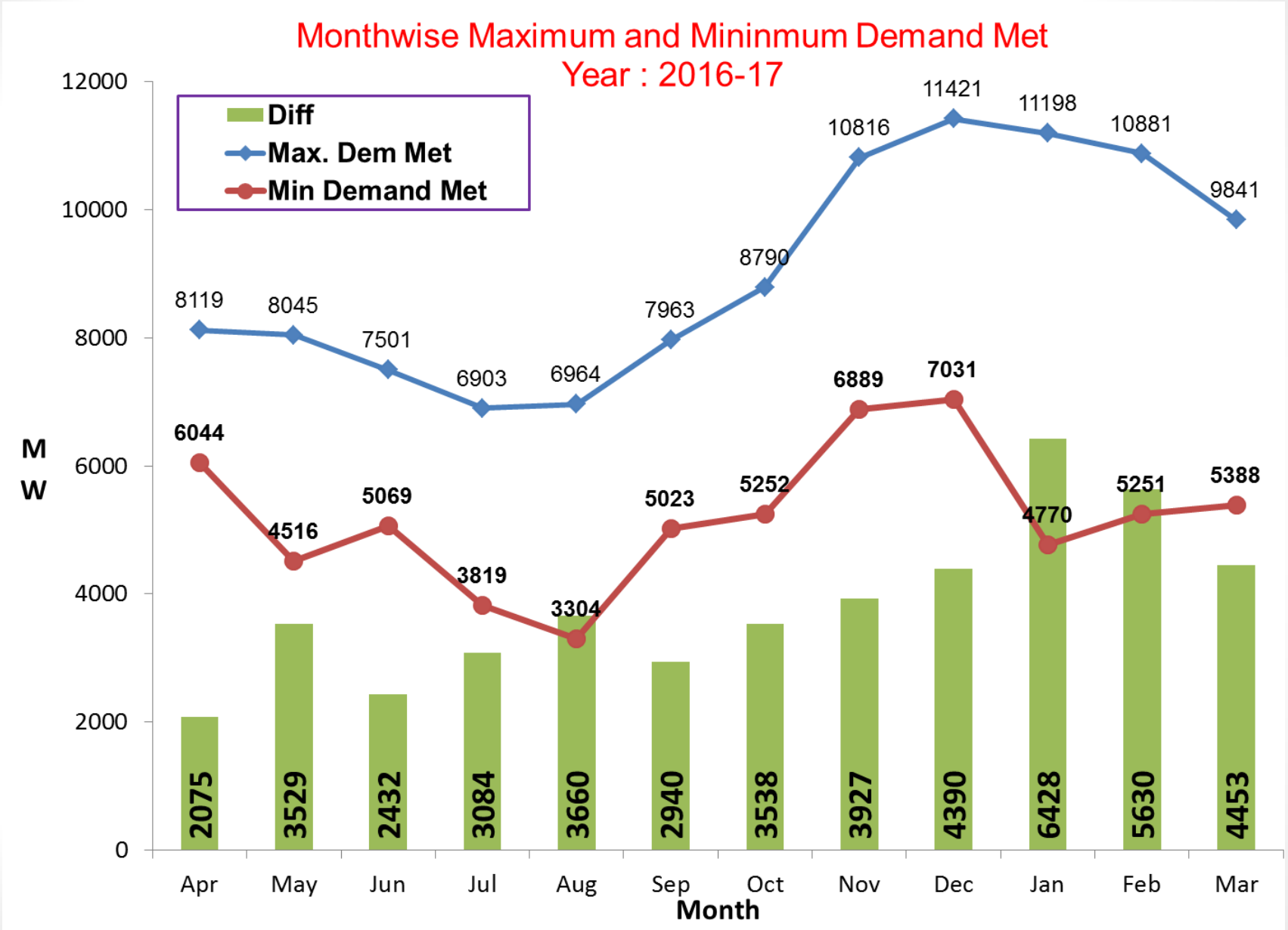

Power Supply Position on maximum Wind Injection : 19.05.2017
MW
Demand Met
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
DSM
Sale
IPP
CS Sector
Wind
Solar
Hydel
Thermal


Forecasting Vs Actual Wind Injection : 19.05.2017
1600
1400
1200
1000
800
600
400
200
0
70
60
50
40
30
20
10
0
-10
-20
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Actual
Forecasting
Diff.


Monthwise Maximumm Demand of MP
2013-14
2014-15
2015-16
2016-17
MW
11800
11650
11500
11350
11200
11050
10900
10750
10600
10450
10300
10150
10000
9850
9700
9550
9400
9250
9100
8950
8800
8650
8500
8350
8200
8050
7900
7750
7600
7450
7300
7150
7000
6850
6700
6550
6400
6250
6100
5950
5800
5650
5500
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
11421
10841
9832
9758
8119
8045
7501
7210
6949
6923
6903
7303
7580
7545
7963
8238
8488
8790
8551
7757
7395
6964
6543
5661
5787
7335
7259
7250
7059
7054
6996
10816
11198
10881
10737
10130
10112
9823
9841
9618
9568
9103
9155
9092
9070
6997
6819

GROWTH OF MAXIMUM DEMAND MET




Monthwise Maximum and Mininmum Demand Met
Year : 2016-17
Diff
Max. Dem Met
Min Demand Met
MW
12000
10000
8000
6000
4000
2000
0
8119
8045
7501
6903
6964
7963
8790
10816
11421
11198
10881
9841
6044
4516
5069
3819
3304
5023
5252
6889
7031
4770
5251
5388
2075
3529
2432
3084
3660
2940
3538
3927
4390
6428
5630
4453
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Month

Status of Green Energy Corridor Project (Phase-I) Madhya Pradesh
RENEWABLE ENERGY POWER EVACUATION WORKS

- Govt. of India is encouraging establishment of Renewable Energy Projects under Clean Energy Development mechanism.
- Madhya Pradesh State has also formulated various policies for development of these projects in the State Sector
- To evacuate power from anticipated RE capacity addition of about 5847MW in next five years, MPPTCL has conducted system studies & identified required transmission system strengthening and interconnection works for upcoming RE projects.
- **Estimated Cost of works proposed for RE Projects in MP**

(A)	Transmission System Strengthening Works	:**Rs.3575 Crore**
	(Phase I: Rs 2100 Crore + Phase II: Rs 1475 Crore)	
(B)	Interconnection works	:**Rs.1125 Crore**
	Total Estimated Cost (A+B)	**:Rs.4700 Crore**

- Phase-I Transmission System Strengthening Works amounting to Rs. 2100 Crore are proposed to be completed within 3 year.

GREEN ENERGY CORRIDOR SCHEME (PHASE-I)

(ANTICIPATED COMPLETION YEAR 2018-2019)

- Loan No. : **201366483**
- Total Project Cost : **Rs. 2100 Crore (Revised 2027 Crore)**
- Grant from NCEF (40%) : **Rs. 840 Crore**
- KFW Loan Component (40%) : **Rs. 840 Crore (i.e. EUR 124.0 million)**
- GoMP Share (20%) : **Rs. 420 Crore**

Sl.No.	Particulars	Nos./ Ckt. Km
1	400kV New Substations (Mandsaur, Sagar, Ujjain)	3 Nos.
2	400kV Line	690 Ckt. Km
3	400kV Reactors	3 Nos.
4	220kV New Substations (Sendhwa,Jaora,Gudgaon,Kanwan,Ratangarh, Susner,Sailana) (220kV S/s Suwasara excluded)	7 Nos.
5	220kV Line	1164 Ckt. Km
6	132kV Line	1128 Ckt. Km
7	132/33kV Addl. Transformer (Nalkheda, Vijaypur)	2 Nos.

Renewable Energy Integration Difficulties

- Wind & Solar generation both experience intermittency, a combination of non-controllable variability & partial unpredictability and depend on resources that are location-dependent.

- **Adequate grid infrastructure is required to transmit the wind energy to the load cente**
- Madhya Pradesh State is having maximum potential of Wind as well as Solar Generation in North-West and Western part of the State whereas South-West and Southern part the State has maximum Biomass Generation Potential

Balancing Potential

- Balancing Potential is different at any moment, it depends upon:-
  - Conventional Plant Availability and technical capabilities (Plants on bar, Technical Minimum, start up and down time)
  - Availability of other flexibility in the system
  - Reservoir Level of Hydel Power Stations and dispatchability
  - Thermal Generation is available in large quantity and therefore the backbone of balancing RE
  - MP have total 3261 MW capacity of hydro for balancing of RE during real time operation

Difficulties in Connectivity of RE Projects

i. Large Scale Wind/Solar integration may introduce new patterns in the flow of power during different time of the day which may cause congestions in transmission & distribution networks in case of a conservative planning.

ii. Wind/Solar Plants have low gestation period (3 to 6 months) as compared to time required for transmission strengthening (18 to 30 months). Therefore, constraints may arise on account of mismatch in completion of power project and adequate evacuation facilities.

iv. Most of the RE developer are applying for connectivity without valid PPA (Power Purchase Agreement) with the purchaser.

v. At the time of grant of connectivity, allocation of the capacity by MPNRED to the developer is not available.

vi. Due to non-availability of valid PPA and capacity allocation, the system strengthening required for the project can not be ascertain.

vii. Most of the RE developers are executing PPA just before the commissioning of their project which may cause constraint in transmission system as the system strengthening requires substantial time

- Only 100 MW capacity of NTPC under RUMS against 250 MW could be commissioned due to non availability of required infrastructure for power evacuation.

vii. Distribution Companies are allowing connectivity on 33kV without assessing the transformation capacity of the substation which is causing overloading of Transformer.

- Presently 5 Nos Substation of MPPTCL i.e. Agar, Susner, Daloda, Delchi and Barod are facing overloading problem of transformer (reverse flow) and resulting frequent tripping of these transformer due to large scale of RE commissioned at these sub stations.

Viii. Large number of RE projects coming up in same area may cause congestion in communication path as each project has to send data on round the clock basis to SLDC or sub-LDC for scheduling and monitoring.

Difficulty in Grid Operation

- Must Run Status

- Wind being variable & intermittent may cause severe stresses on the system and calls for suitable reserves/spinning capacities.

- With the lack of sufficient flexible support available from other conventional resources (Hydro Projects), it may become very difficult to operate the system with large amounts of wind power

- Induction machines and inverters are main constituent in Wind & Solar generation technology. These machines and inverters absorb heavy reactive power during start up as well as some reactive power in normal operating conditions.

Difficulty in Grid Operation

❑ *Difficulties in Real Time Operation*

- **RE Generators are not submitting proper forecasting and not revising the forecast during real time of operation due to absence of state regulation on forecasting, Scheduling and Deviation settlement.**
- **Difficulty to manage DSM Within limit of ± 250 MW as per Hon'ble CERC, Deviation Settlement Mechanism (DSM) regulation.**
- **Surrendering of cheaper power from SSGS/Central Generating Stations during sudden increase in Wind Injection --- based on MOD.**
- **Scheduling of costlier power during sudden withdrawal of wind generation.**
- **generation to technical minimum**
- **On bar / Off bar issue- inefficient / Uneconomical operation , increased capital and maintenance costs**

Difficulty in Grid Operation

❑ *Difficulties in Real Time Opearation*

- **Under utilization of EHV network during less RE Injection**
- **High voltage scenario during less RE injection**
- **Very high or low RE generation resulting in over / under loading in associated transmission elements.**

Telemetry and Forecasting Status

Type	Installed capacity MW	No.s of Pooling Stations	TELEMETERED		Visibility / Observability at SLDC		Forecasting available
			RE END	S/s END	RE END	S/s END	
WIND	2430	73	59	56	21	55	53
SOLAR	855	38	34	37	32	38	30
SUM	3285	111	93	93	53	93	83
%			**83.78**	**83.78**	**47.75**	**83.78**	**74.77**

LVRT Protection for Wind and Solar

- In compliance to CERC order dtd 05.01.2016 in petition no. 420/MP/2014, SLDC has requested wind and solar generators connected at 132 KV level and above to submit the LVRT capabilities status.
- In response 11 Wind Power Projects and 1 Solar Power Project have submitted the LVRT capabilities status.

REMC

- Renewable Energy Management Centre (REMC) is being established by PGCIL as implementing Agency at SLDC under Green Energy Corridor.
- Forecasting and scheduling module is envisaged in REMC
- Agreement for REMC is executed with PGCIL.
- About 80% static information has been submitted to PGCIL.
- Updated list of RE generators with pooling station details submitted to PGCIL.

WAY FORWARD

- **State Regulatory Framework :-** MPERC has notified draft Regulation on “Forecasting, Scheduling and Deviation Settlement of Wind and Solar Generators in the State level”. The public hearing has already been completed and Regulations are yet to be notified by the MPERC.
- Transmission system development :- The Connectivity to the RE generators should be provided by STU and MP Discoms only after ascertaining loading of network involved for power evacuation of RE generation.
- **Telemetry : -** SLDC issues the injection code to RE generators only after compliance of regulatory requirement (Telemetry, Metering etc.). The RE Generators provides the telemetry facility at the time of commissioning of RE generators, however problem in maintenance is faced as RE generators do not response. SLDC proposes to impose the penalty on RE generators in case of outage of telemetry.

Thank You !

एनटीपीसी NTPC
A Maharatna Company

Adverse Effects of variability of Renewable Power

A K Sinha
AGM,NTPC Ltd

Contents

- Renewable Integration Plan and its Impact
- Impact on coal and gas based Plants (Flexible Operation and Damage Mitigation)
- Impact of Variable Renewable Integration on Grid
- Policy Advocacy
- Conclusion

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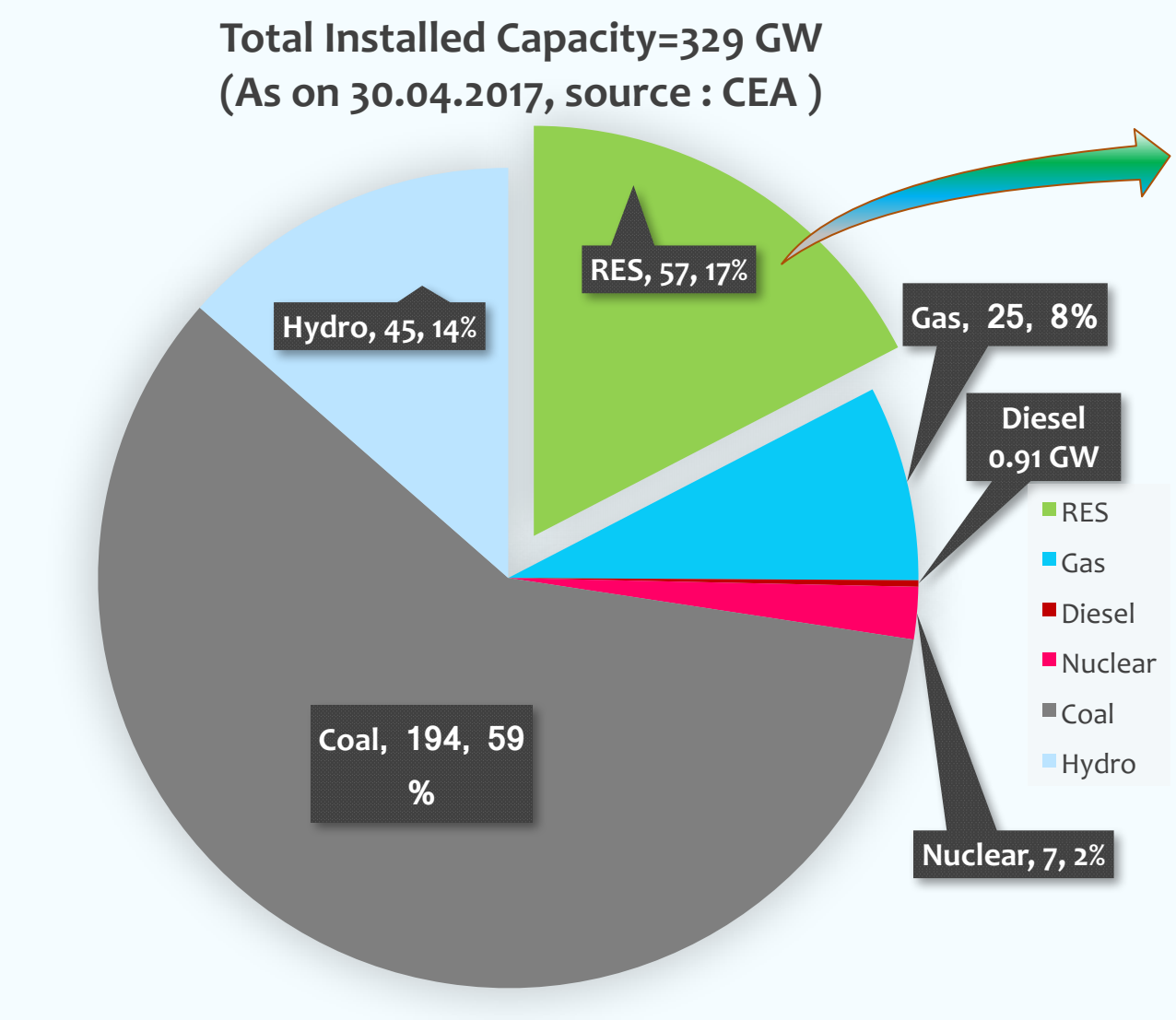
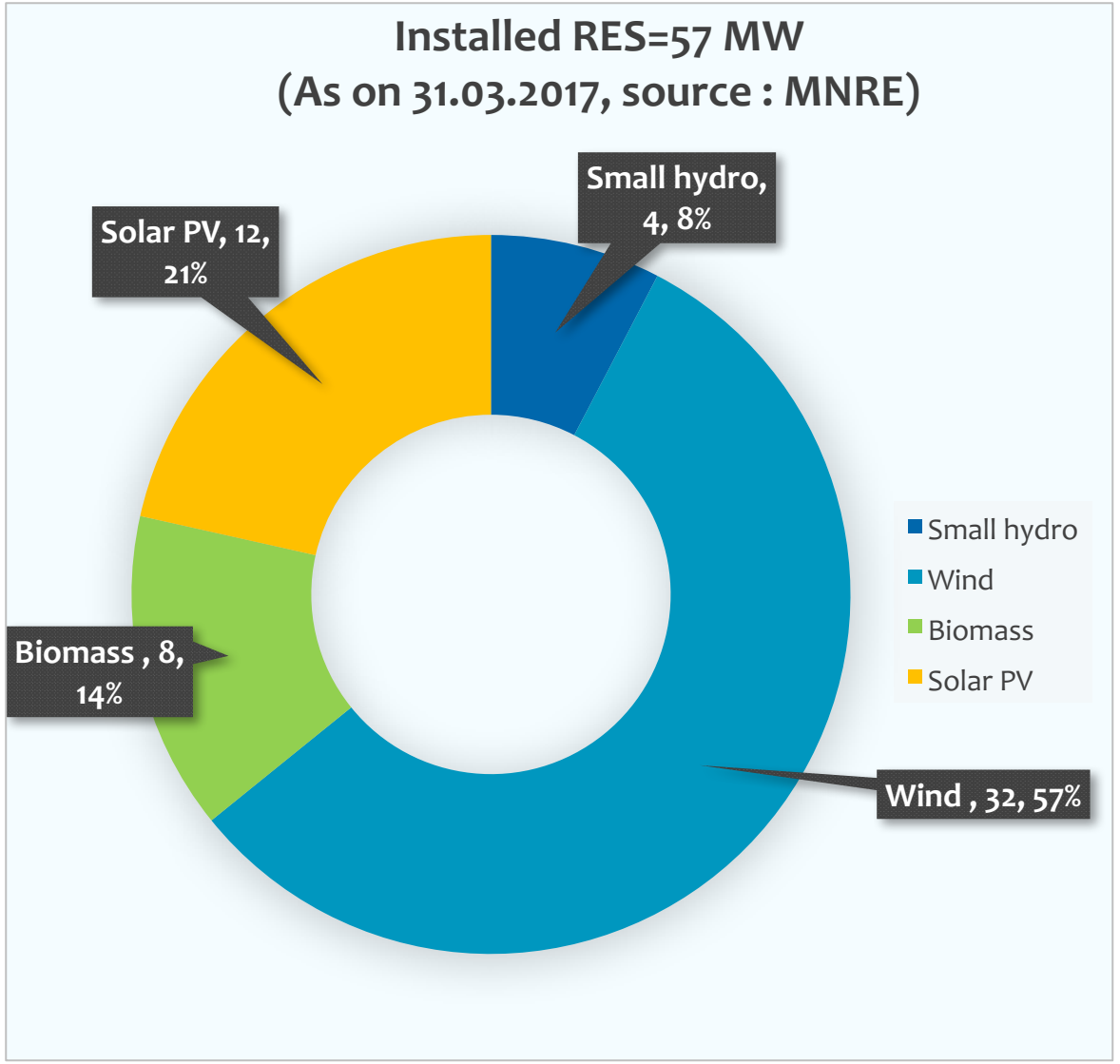
Renewable Integration Plan and its Impact

Present Installed Renewable Capacity





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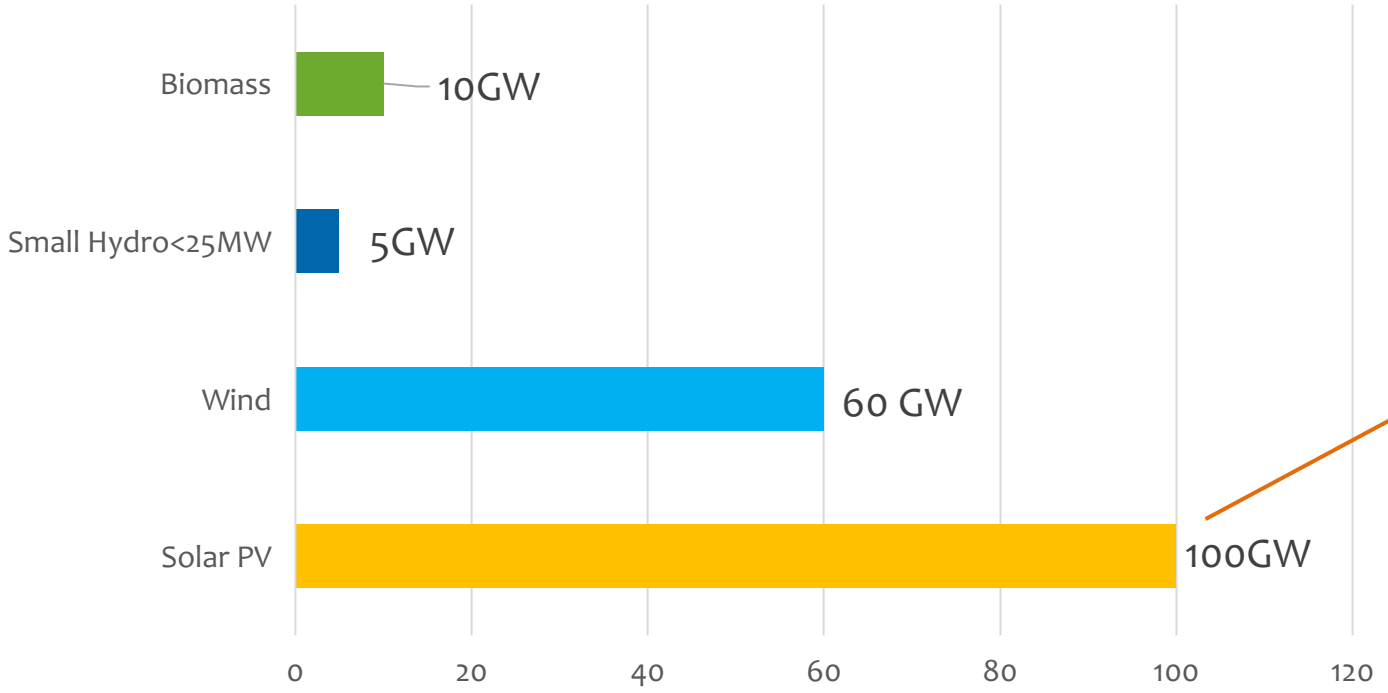
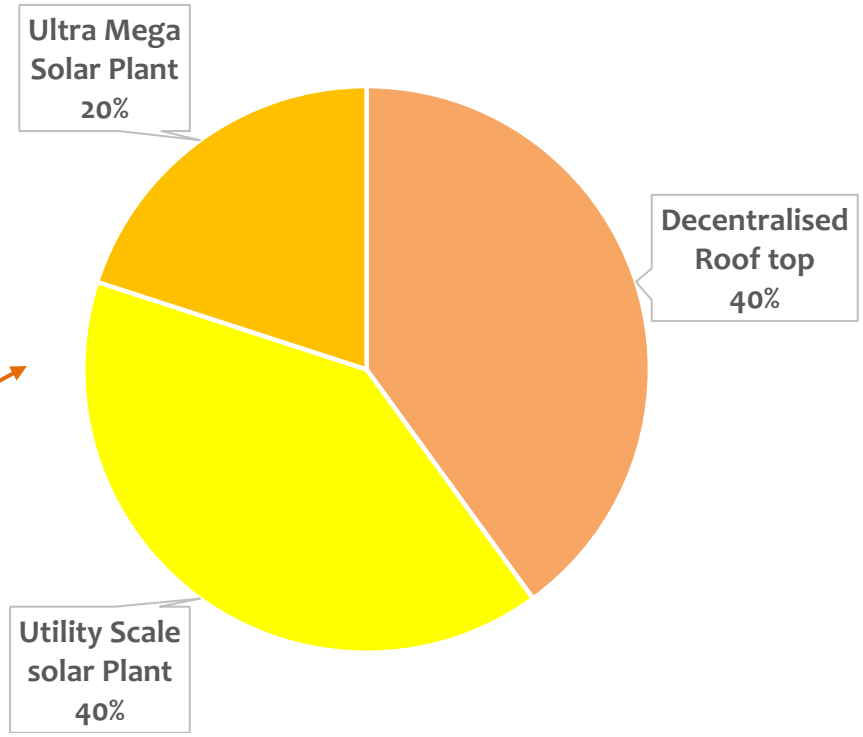
Future Renewable Integration Plan

India's Intended Nationally Determined Contribution (INDC) aims to base **40% of the total installed power generation capacity on non-fossil fuel resources by 2030** with international support on technology transfer and financing. This includes Government of India's ambitious target of achieving 175GW of RE by the year 2022.

175 GW Renewable Integration Plan by 2022



100 GW solar PV Integration plan



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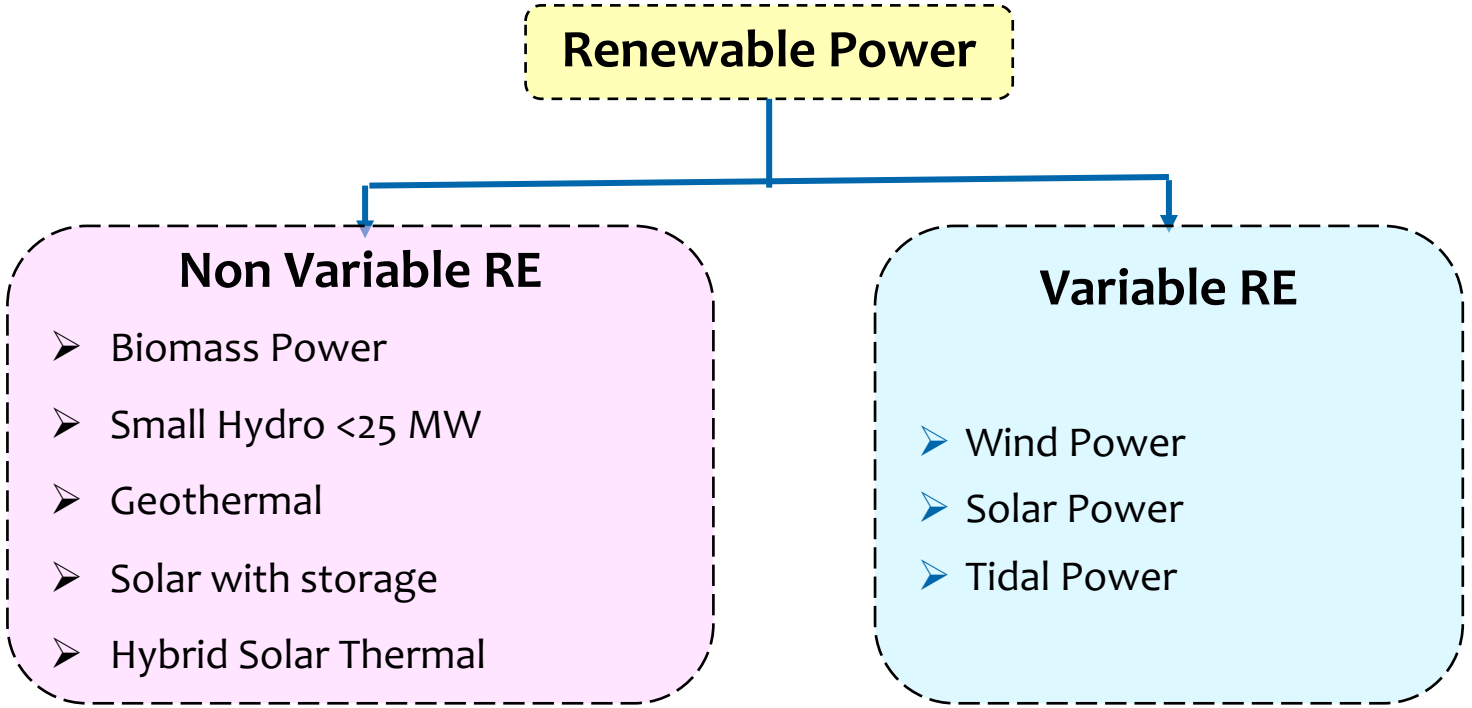
Variability of Renewable Power

Non variable renewable energy generation refers to sources of electricity that can be generated at the request of power grid operators or of the plant owner. Since wind power and solar power cannot be controlled by operators, so these are termed as Variable Renewable Energy (VRE) sources.



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Peculiarities of Variable Renewable power

- Variability
- Uncertainty
- Geographically Confined
- Low inertia

Impact on System

- Difficulty in load frequency control
- Difficulty in scheduling of tertiary reserves
- Requirement of enhanced transmission network and its under utilisation
- Increase in requirement of ancillary services and hence increased system operation cost
- Increase in transmission cost due to all above factors

Impact on existing Plant

- Lower PLF due to ducking of load curve
- High ramping requirement
- Two shifting and cycling of plants
- Increased forced outage and O&M cost
- Equipments life time reduction
- Poor heat rate and high Aux. Power

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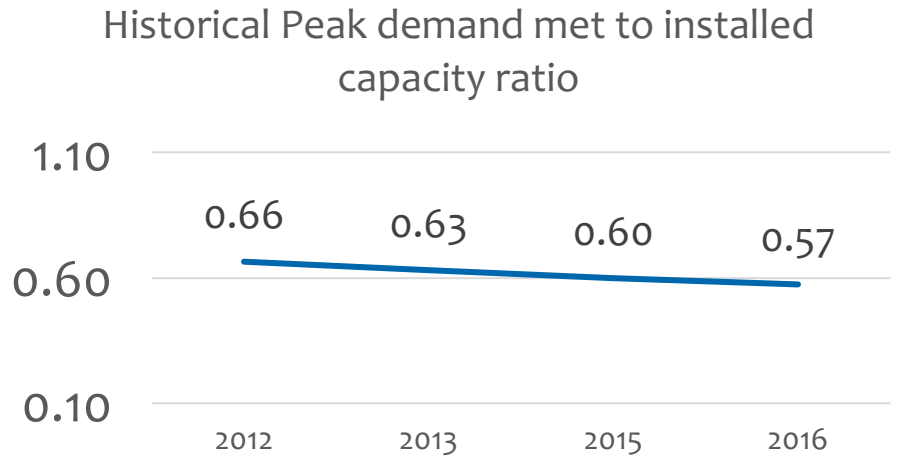
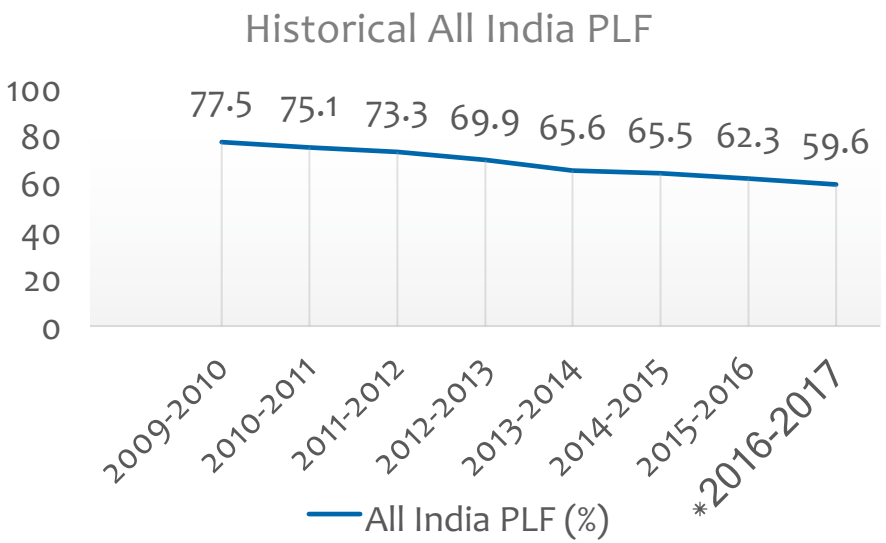
Today's Scenario: Cycling without Renewable Integration





- In last five years, conventional capacity was added rapidly but in same proportion electricity demand did not rise, which caused lower PLF and lower peak to installed capacity ratio.
- It is likely to fall further due to rapid addition of RE.

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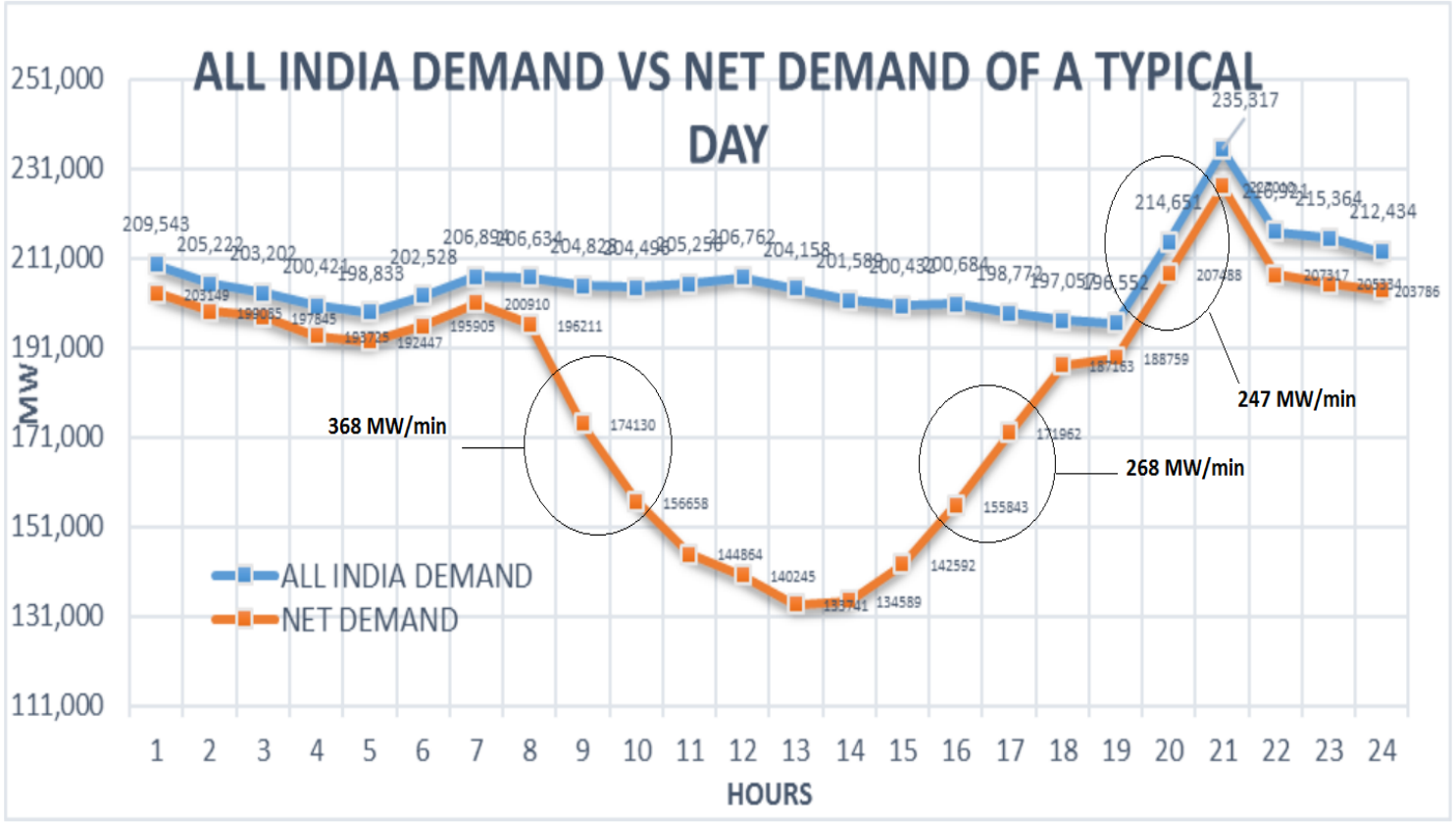
Future Net Demand Curve (2021-2022)

Source: CEA



- Installed capacity ~ 523 GW *
- Peak hour ramp rate is 247 MW/min.
- Ramping down rate with sun rise is highest i.e. 368 MW/ min.
- Duck belly demand to peak demand ratio is 61% which will lead to partial loading and two shifting i.e. cycling of fossil based power plants and hence low PLF.

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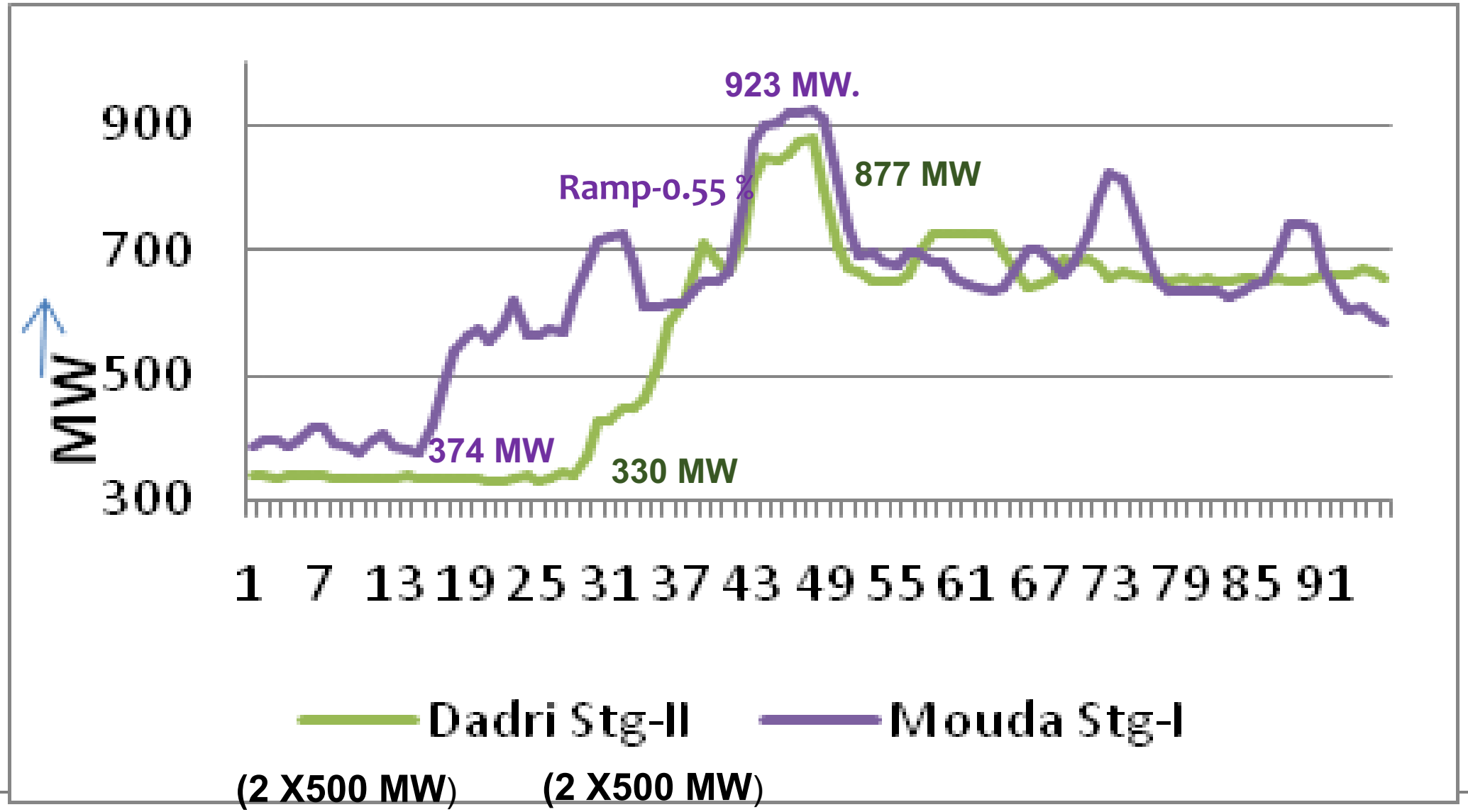
* Based on Draft NEP projections for 2021-22

NTPC's present level of Flexible operation



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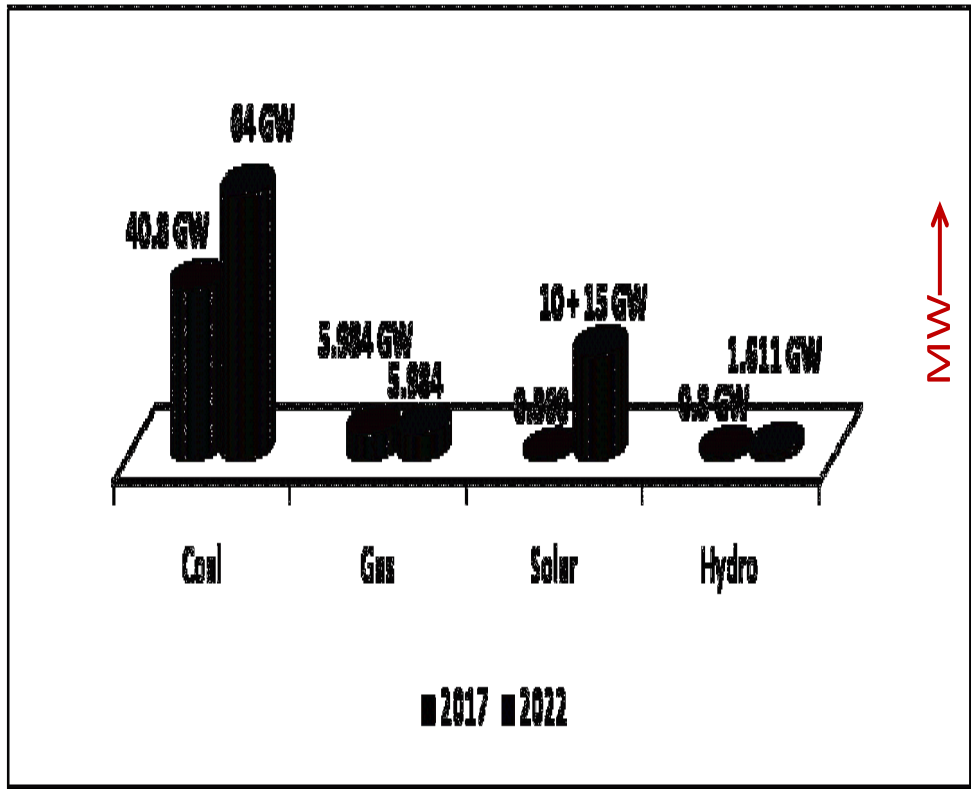
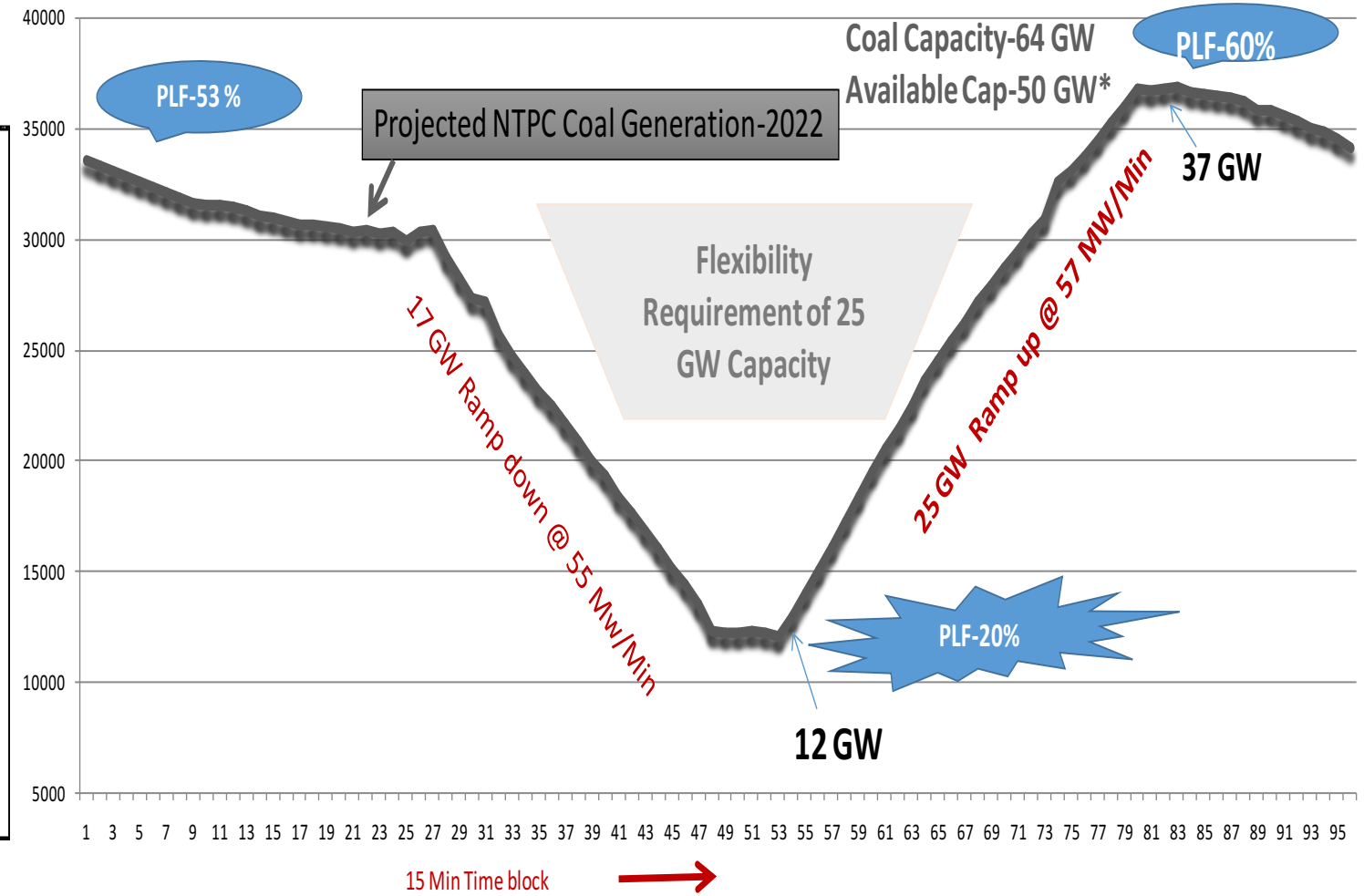
Emerging Scenario for NTPC Group in 2022



Capacity Growth



* Capacity <25 years old

Predicted Generation

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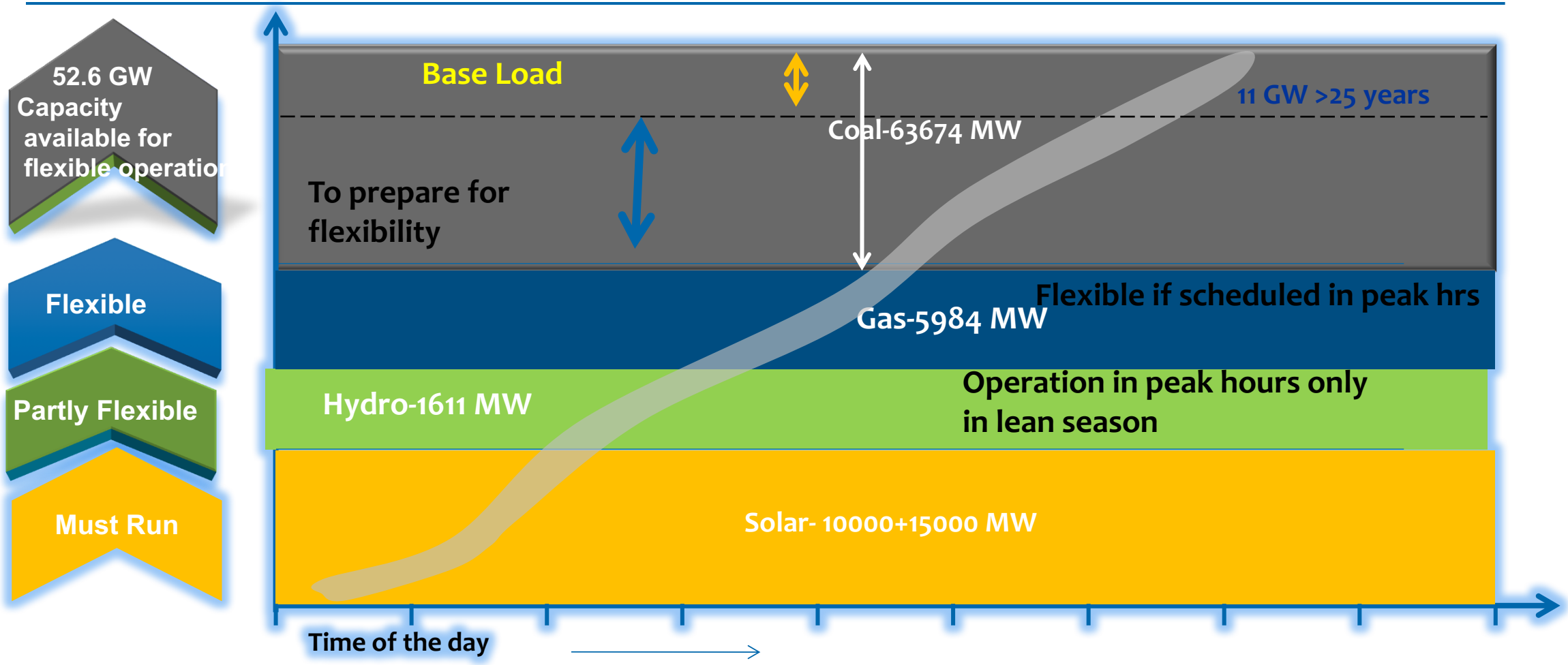
Group NTPC's Approach towards Flexibility

OPTION-1



Maximum flexibility band available-Coal-25 GW(with minimum operation 55% PLF

Gas-5.5 GW

Hydro-1.6 GW

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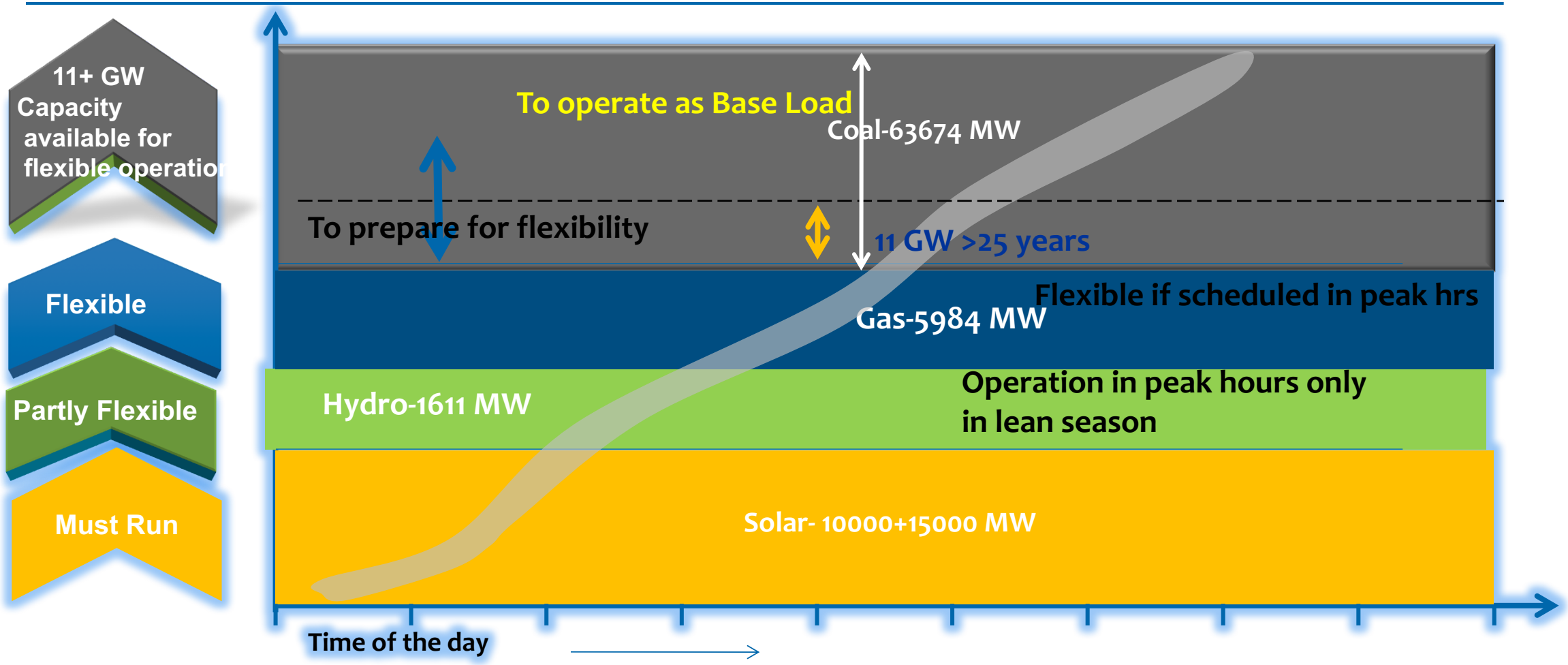
Group NTPC's Approach towards Flexibility

OPTION-2



Maximum flexibility band available-Coal-25 GW(with minimum operation 55% PLF
+ Gas-5.5 GW, Hydro-1.6 GW

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Requirement for NTPC (2021-2022)

- With participation of all the Units of NTPC the ramp down @ 0.2-0.3 % and peak ramp up @ 0.15 % will be required
- At ramp rate of 1%, 21 % of the units will be required to participate during ramp down and 15 % units will be required during peak ramp up
- But some units will be required to ramp up/down at higher rates as per the merit order.
- Duck belly demand to peak demand ratio is 61% (difference of 20 GW) which will lead to partial loading and frequent start stops
- Even if all the units operate at technical minimum the gap of 20 GW will not be met i.e there will be frequent start/stop of some of the units

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Cost of cycling to Generating Companies

- Modification cost required for making units cyclic ready
- Loss of useful life
- Increased O&M expenses
- Start up fuel cost
- Loss of availability due to forced outage
- Poorer heat rate
- Increased Aux. Power Consumption

Proper mechanism to recover these costs is necessary to maintain the financial sustainability of the Generating Companies.

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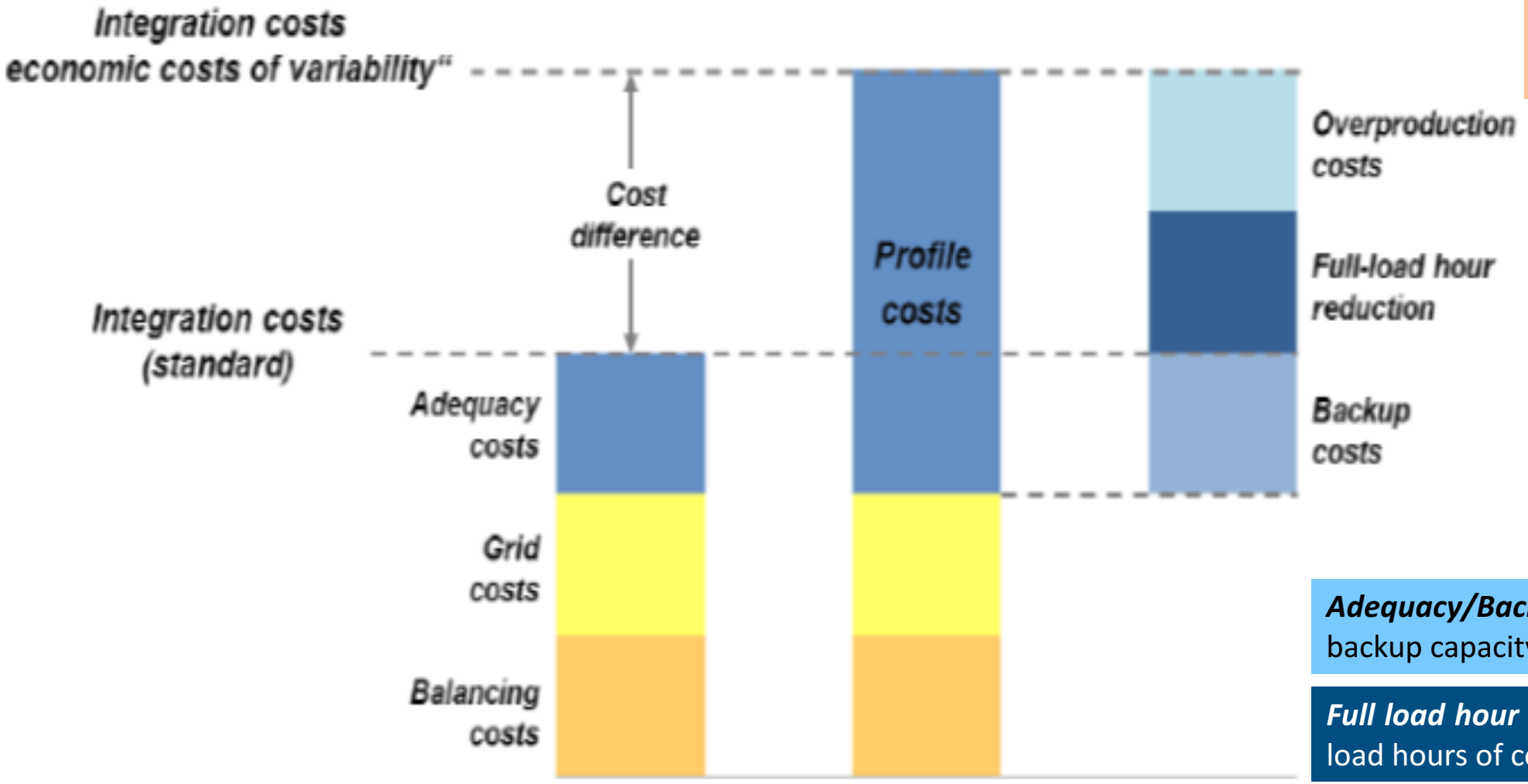
Integration Costs : German Experience



Balancing costs – Intraday adjustments against variations of RE

Grid costs –

- VRE source is located far from load centers investments in transmission might be necessary.
- Grid constraints are enhanced by VRE the costs for congestion management of power plants increase.

Adequacy/Backup costs – Due to need for backup capacity against low credible VRE

Full load hour reduction - **R**educes the full-load hours of conventional power plants

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Source: Falko Ueckedt et al ; System LCOE : What are the costs of variable renewables ?

Design and Incentivize cost effective power system based on economic evaluation

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Cost Drivers

- Profile costs – because of variability
  - There is a requirement of back-up capacity
  - Decrease in full –load hours of capital intensive dispatchable power plants
  - Frequent Ramp up/down
  - VRE supply may exceed demand and thus over produce
- Balancing Costs- because of uncertainity.
  - Day ahead forecast errors cause unplanned intra day adjustments of dispatchable power plants and require operating reserves to respond within minutes to seconds
- Grid related costs
  - VRE located far off from load centres- requiring investments in transmission
  - Cost of congestion management

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System Levellised Cost of Electricity: German Experience

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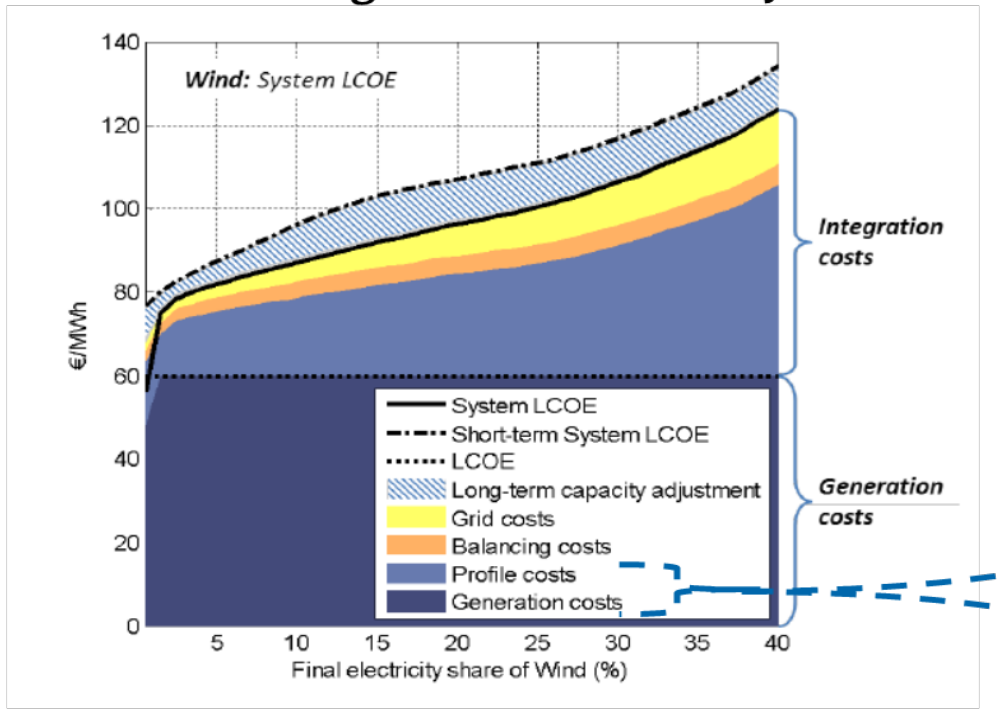
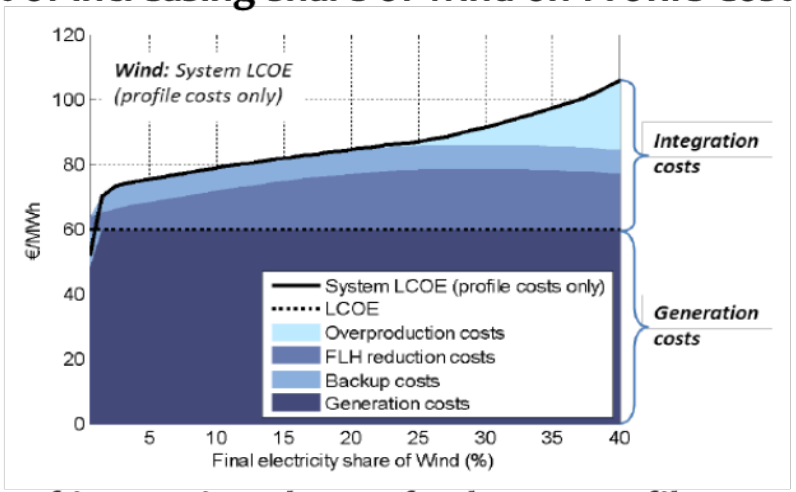
Effect of increasing share of wind on System LCOE



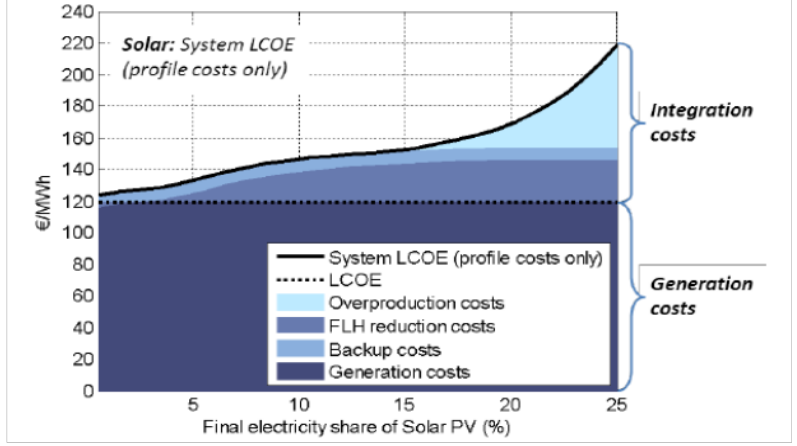
Typical costs (approx.), depending on grid penetration of VRE:
Grid Costs - 3 to 15 Euro /MWh
Balancing Costs - 3 to 6 Euro /MWh

	Solar	Wind
Present	3.6%	9.7%
2022	19.1%	11.4%

Effect of increasing share of wind on Profile Cost



Effect of increasing share of solar on Profile Cost



Grid & Balancing Costs are not considered in the above graphs

Source Weblinks –
(1) https://www.mcc-berlin.net/uploads/media/Ueckerdt_Hirth_Luderer_Edenhofer_System_LCOE_2013.pdf; (2) http://www.internationalenergyworkshop.org/docs/IEW%202013_4E1Ueckerdt.pdf
(3) http://www.irena.org/DocumentDownloads/Publications/IRENA-ETSAP_Tech_Brief_Power_Grid_Integration_2015.pdf

System Levelised Cost of Electricity : Inference

- At high level of solar integration, for example at 25%, even if the solar tariff offered is ZERO, the cost at system level to the consumer is expected to be of the order of 10 Euro Cent per kWh (Rs. 7-8 per kWh)
- Similarly for wind penetration level of 40%, if the wind tariff offered is ZERO, the cost at system level to the consumer is expected to be of the order of 7 Euro Cent per kWh (Rs. 4 - 5 per kWh)
- Non variable renewable energy such as hydro, hydro with pumped storage, biomass, solar thermal, solar with storage, geothermal, waste to energy do not have such hidden system costs.
- The cost of electricity from common non variable renewable sources are as below:

S.No	Non Variable Renewable energy	Typical tariff (Rs./kWh)
1.	Biomass	7 -8
2.	Hydro/Small Hydro	4 – 6
3.	Geothermal	8-10
4.	Solar Thermal	12
5.	Solar with storage	12 - 14
6.	Pumped storage	7 - 9

- The cost to consumer from non variable RE is much less than the cost of solar and wind even with sharp fall in their prices. Therefore, they may be expedited to achieve full potential, in the benefit of consumers and existing infrastructure.

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Impact on Coal/gas based Plant (Flexible Operation and Damage Mitigation)

It is Time For Flexible Generation Management

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Actual Cost of Generation(Cyclic Load)= Cost of generation (Base load) + Integration Cost

- Time to learn how to minimise equipment damage and asses the true cost of cycling to find out actual cost of generation.
- True cost of operation arrives often years later. So, if cost of cycling is unknown making profits becomes a matter of luck rather than good management.
- Find out what, in terms of fuel cost and cycling cost , is the least expensive combination of units to meet system load?
- Knowing cycling cost would help in deciding either shut down unit (and incur cyclic damage) or to operate at minimum load.
- High fuel cost units(poor merit order) may require to cycle more than low fuel cost units, so they should be designed accordingly for heavy cycling duty. Old units with suitable cyclic modification, if required, can also be allocated for cyclic duty.

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Comparison : Cost to Cycle a Unit, Per Operation

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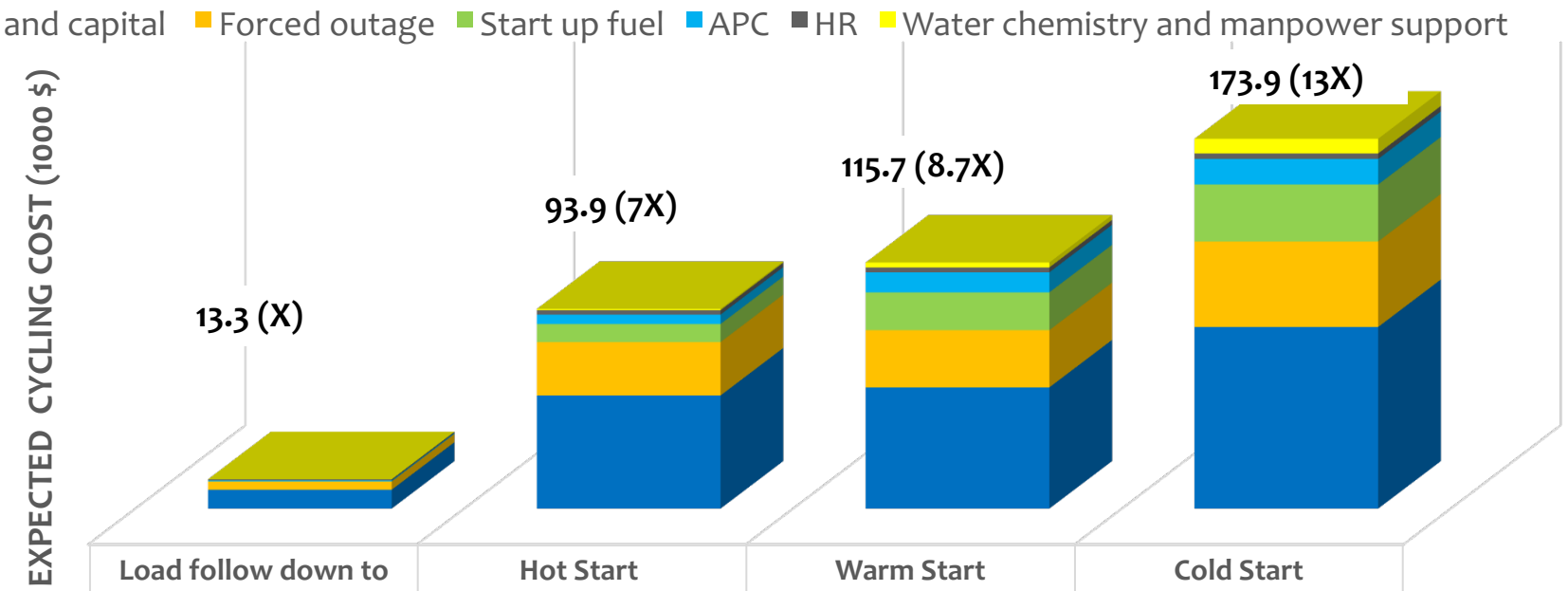
TYPICAL CYCLING COST FOR A 500MW COAL FIRED POWER PLANT (USA) (COST ARE SHOWN IN 2008 DOLLARS) ,SOURCE:-INTERTEK APTECH

Warm and cold starts are the most damaging for units. Whereas load following up to technical minimum is the least damaging.



	Load follow down to 180MW	Hot Start	Warm Start	Cold Start
Water chemistry and manpower support	0	0.6	2.3	6.9
HR	0.5	2.1	2.3	2.6
APC	0.5	4.4	9.4	12
Start up fuel	0	8.5	17.8	26.8
Forced outage	3.9	25.1	26.9	40.2
Maintainance and capital	8.9	53.2	57	85.4

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Initiatives for Flexibilisation study

- Special task force has been constituted under the aegis of Indo-German Energy Forum (IGEF) – members : CEA, NTPC, POSOCO, EEC, VGB, GIZ and KFW
- Two of NTPC stations have been identified for pilot study (Dadri and Simhadri)
- The study covers the following –

  (A) Demonstration of technical and economic feasibility

  (B) Analysis of legal framework conditions

  (C) Capacity building of coal fired power plants operators
- Training programs, workshops with seminars already conducted
- Development of operator training concept is underway
- NTPC is also engaging an international consultant to study the cost and impact of cyclic loading on thermal units

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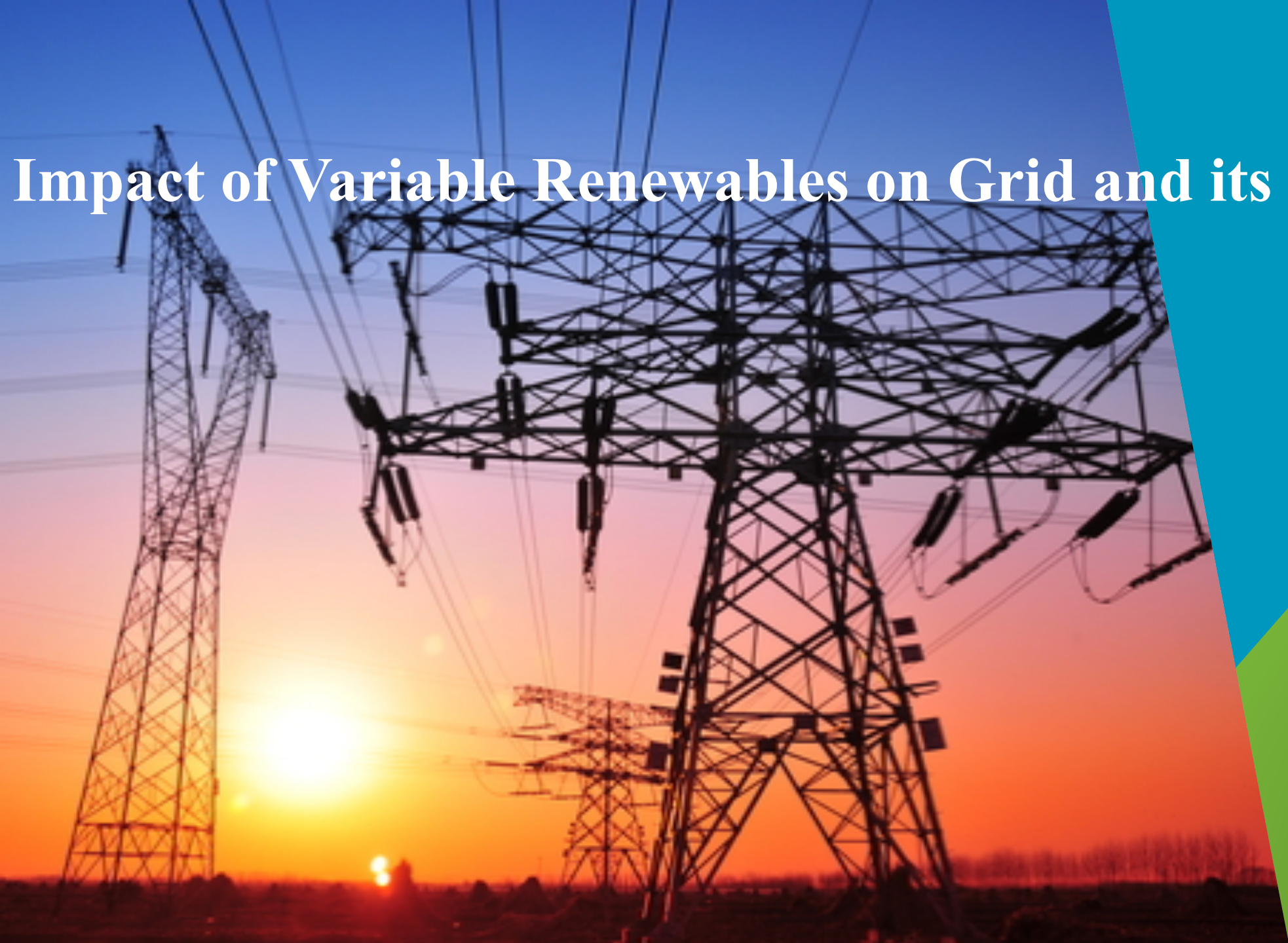
Impact of Variable Renewables on Grid and its Mitigation



Renewables Integration into Power Grids

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The integration of a significant share of variable renewables into power grids requires a substantial transformation of the existing networks in order to:

a) Promote and prioritise non Variable RE such as Hydro, Biomass, Geothermal, Solar with storage, Solar Hybrid;

b) Establish an efficient electricity-demand and grid management mechanisms aimed at reducing peak loads, improving grid flexibility, responsiveness and security of supply in order to deal with increased systemic variability;

c) Improve the interconnection of grids at the regional, national and international level, aimed at increasing grid balancing capabilities, reliability and stability;

d) Introduce technologies and procedures to ensure proper grid operation stability and control (e.g. frequency, voltage, power balance) in the presence of a significant share of variable renewables leading to variation in equivalent grid inertia.

e) Introduce energy storage capacity to store electricity from variable renewable sources when power supply exceeds demand and aimed at increasing system flexibility and security of supply.

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Strategy to Improve overall Grid Operation Efficiency

Upgradation of Grid technology	Centralized RE forecasting mechanisms need to be tightly integrated with system operations. Advanced decision-making and control systems need to be implemented that enable system operators to respond significantly faster to changed grid conditions.
Upgradation of Grid Protocols	Currently, in India, scheduling occurs on a day-ahead basis while dispatch occurs on a 15-minute basis. System operations technologies and protocols need to be updated to enable five-minute scheduling and dispatch of all resources connected to the grid and automated incorporation of RE forecasts. This will also lower ancillary service requirements and hence the over all cost to consumer.
Promote Flexible Demand & Supply Resource	Power systems, especially those with a high share of RE, require access to sufficient flexible resources (e.g. gas turbines, hydroelectricity, flexible coal units with AGC etc.) to ensure continued stability of the grid at each moment. India has 22% of total installed capacity of these flexible resources (gas and hydro power).
Expand Balancing Areas	More and more units should be brought under AGC, so that effective ramp rate requirement on individual units can be minimised and better load frequency control can be obtained.

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Market Redesign

- For ancillary products like Peakers – active and reactive power support, frequency regulation, ramp rates, etc.
- Time of day metering: In order to promote consumption during RE peaking hours
- Incentivizing Storage : Pumped storage, Battery, Molten salt, etc.
- Balancing capacity charges for units earmarked for Flexibilisation

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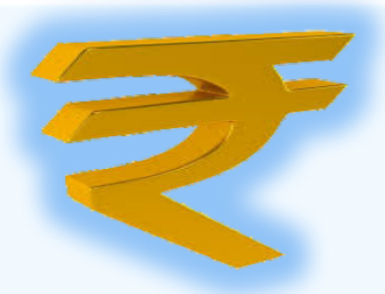
Policy Advocacy



Units catering to variable load requirement may be sufficiently compensated for increased retrofit cost, operation and maintenance costs through special tariff.

Cost of VRE is not a true indicator of the cost of electricity to consumer because it imposes additional cost on dispatchable generation. Keeping the affordability issue in mind, the targets for VRE integration should be decided. However, non-variable RE may be integrated on priority.

The policy should be oriented towards minimising **levelised system cost of electricity rather than looking at RE tariff in isolation**, ensuring grid stability and reduction in overall system operation cost in long run by reducing the extent of cycling on coal based generating stations as far as possible.

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Conclusion

Integration of variable renewable energy (VRE) impacts both grid stability as well as other generating units connected to grid, thus increases cost of transmission and generation and finally cost to consumer.

However , these cost can be reduced by adopting suitable operation practices, mitigation technologies, a better policy in picture, though it can not be eliminated totally. After all, we have to pay for better environment.

Thank You

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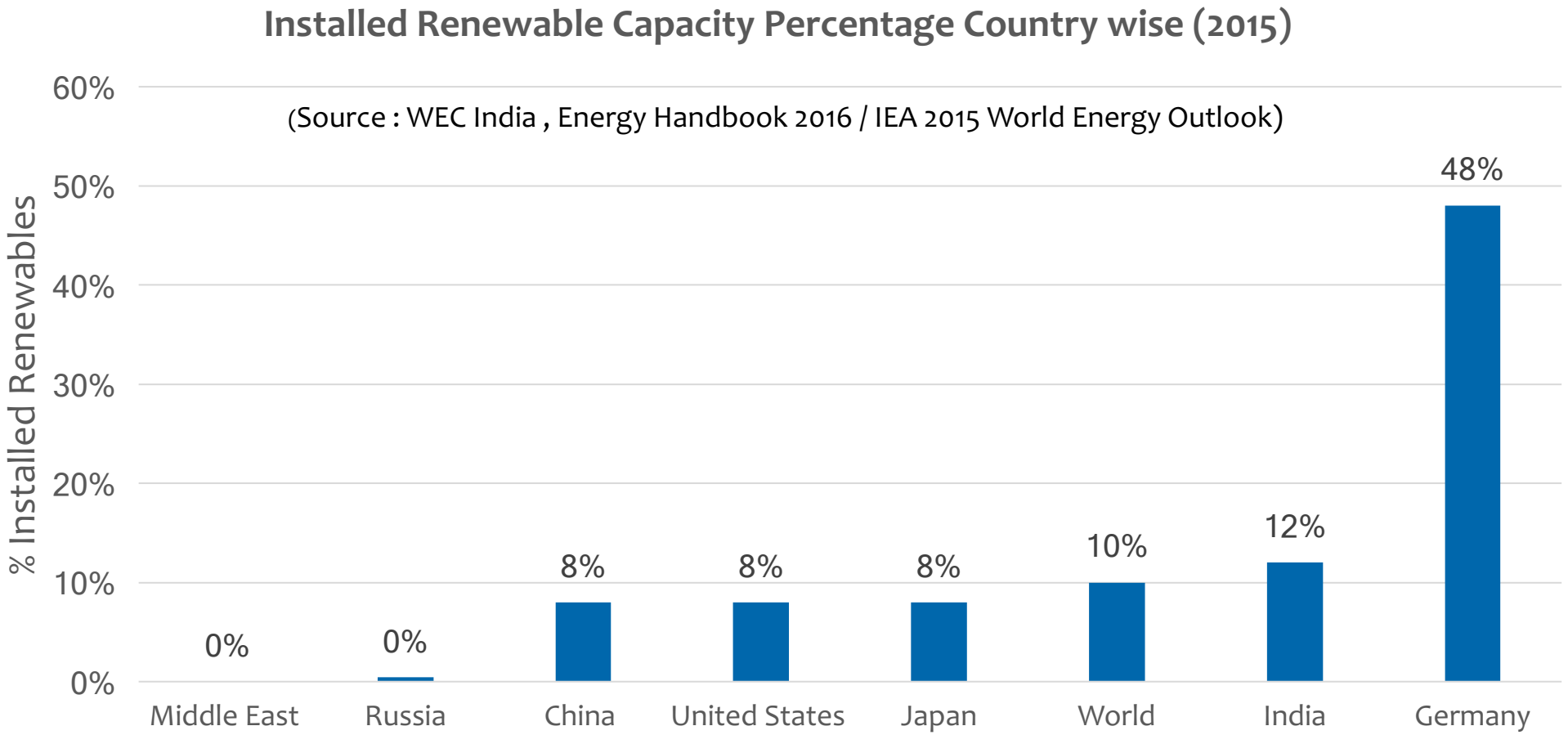
World Renewable Scenario



*Renewable includes Solar, wind, biomass power and small hydro (<25MW).

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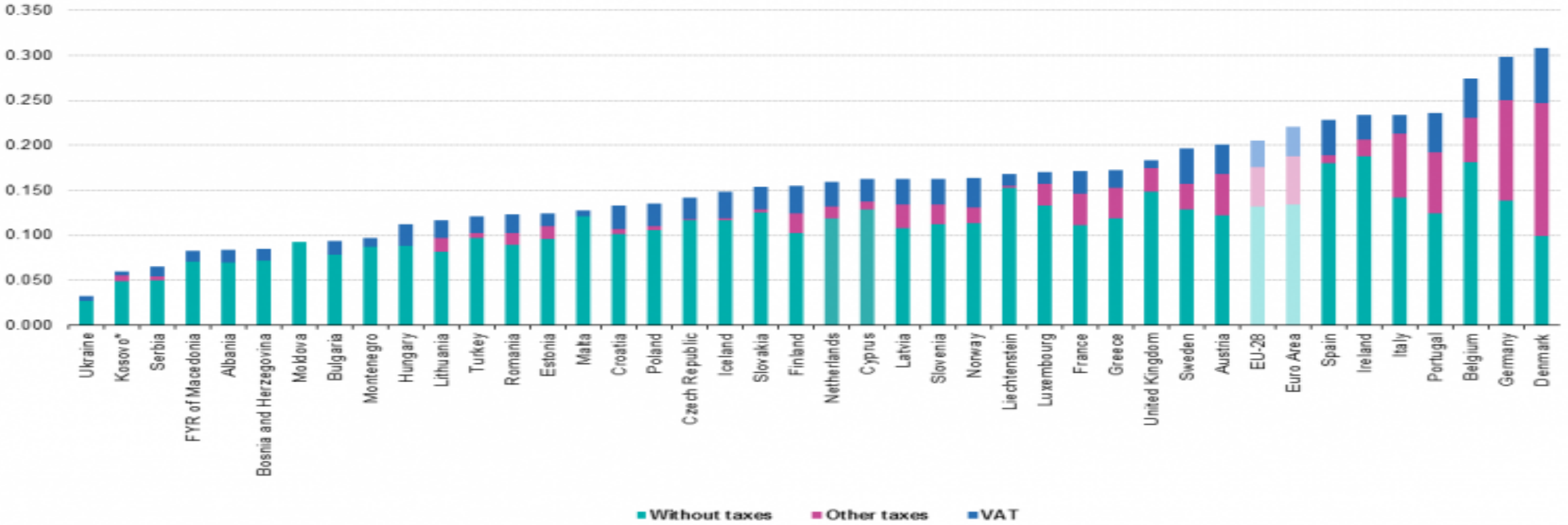

*This designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo Declaration of Independence.

Source: Eurostat (online data code: nrg_pc_204)

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Welcome to all participants of
Meeting on
third meeting of the Technical Committee constituted by CEA for study of optimal location of various types of balancing energy sources/energy storage devices to facilitate grid integration of Renewable Energy Sources (RES) and associated issues

at

Vadodara on 05-06-2017

Outline

1. General Overview of RES in Western Region.
2. Grid Challenges on Integration of RES in WR
3. Telemetry Requirements/issues.
4. Low Voltage Ride Through (LVRT) requirement and issues.
5. Forecasting of Wind RES in Western Region.

Western Region Power Scenario

Total Installed Capacity – 110 GW

Wind-RE 11522 MW

Max Total Gen – 58786 MW

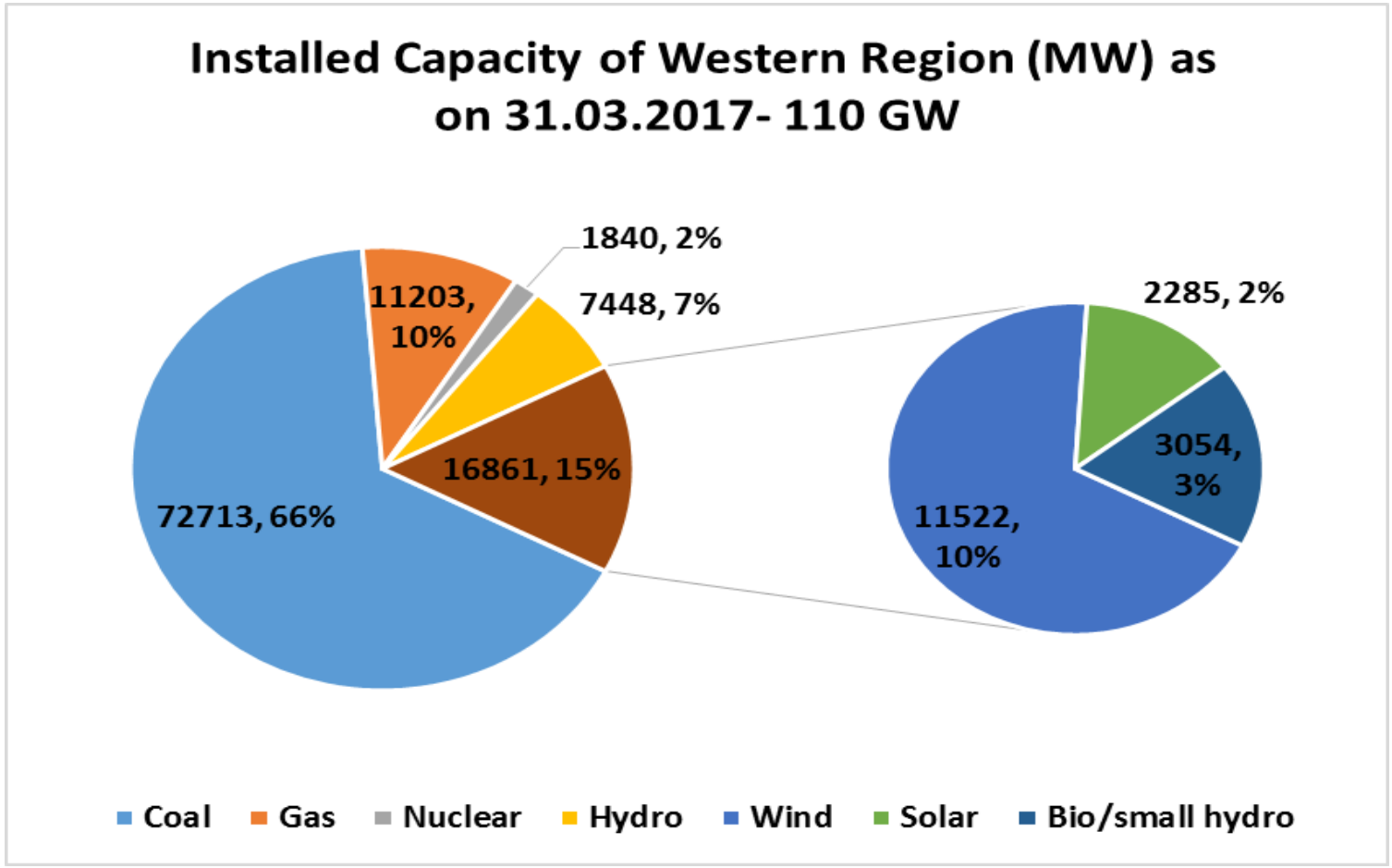
Max Wind Gen. 6431 MW

Peak Demand met: 51 GW

Peak Energy Met 1165 MU/day

Max Wind Energy Gen: 140 MU/day

Type Wise Capacity



Wind Generation Targets by 2022 in Western Region:

Wind Power Capacity in WR (in MW)			
Constituents	**As on 31.03.2017 (A)**	**Target by Year 2022 (B)**	**Balance (C=B-A)**
Gujarat	**4623**	**8800**	**4177**
Maharashtra	**4662**	**7600**	**2938**
Madhya Pradesh	**2237**	**6200**	**3963**
Total	**11522**	**22600**	**11078**

SOLAR Generation Targets by 2022 in Western Region:

SOLAR Power Capacity in WR (in MW)			
Constituents	**As on 31.03.2017 (A)**	**Target by Year 2022 (B)**	**Balance (C=B-A)**
Gujarat	**1118**	**8020**	**6902**
Maharashtra	**362**	**11926**	**11564**
Madhya Pradesh	**835**	**5676**	**4841**
Total	**2315**	**25804**	**23489**

Telemetry Issues

Telemetry of Renewable Energy Sources in WR

- WR RES Installed Capacity
  - Wind: 11523 MW
  - Solar: 2287 MW
- Visibility/Observability of RES at WRLDC: 60%

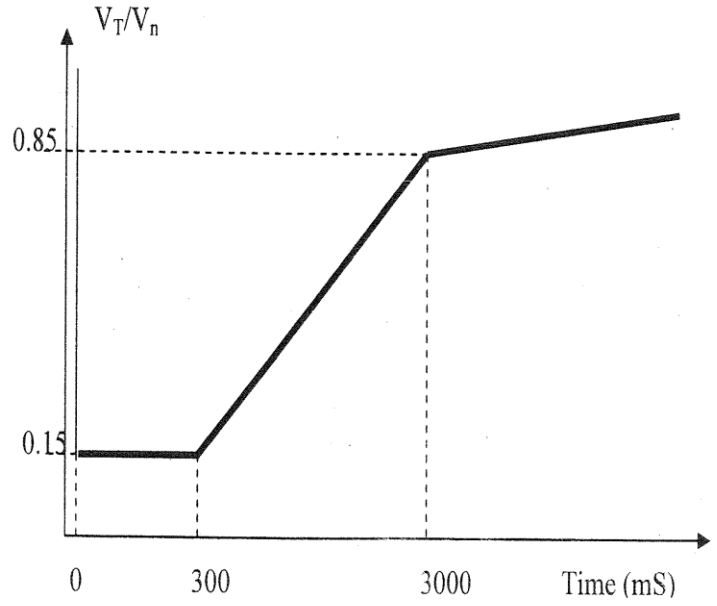
State/Region	RES Installed Capacity (Wind+Solar) in MW	Telemetered RES Capacity at WRLDC (Wind+Solar) in MW	% of RES Visibility/ Observability at SLDC/WRLDC
Gujarat	5740 (4622+1118)	5734 (4616+1118)	99%
Maharashtra	5024 (4662+362)	1660	32%
Madhya Pradesh	3036 (2239+797)	2564 (2076+488)	84%
Chhattisgarh	76 (0+76)	66 (0+66)	87%
Diu	9 (0+9)	0	0%
Daman	1 (0+1)	0	0%
	13810		

COMPLIANCE OF CEA STANDARDS W.R.T TO LOW VOLTAGE RIDE THROUGH CAPABILITY (LVRT)

Regulation Part II (B2) (3) of the CEA (Technical Standards for Connectivity to the Grid)

- Notified on 15th October 2013 mandates as under:
  - "B2. For generating station getting connected on or after completion of 6 months from date of publication of these Regulations in the Official Gazette.

    ....
  - (3) ***Wind generating stations connected at voltage level of 66 kV and above shall remain connected to the grid when the voltage at the interconnection point on any or all phases dips upto the levels depicted by the thick lines in the curve***



Where

V_T/V_n is the ratio of the actual voltage to the nominal system voltage at the interconnection point

CERC Order on LVRT

- Hon'ble Central Electricity Regulatory Commission vide its order dated 05.01.16 in Petition No.420/MP/2014 mandated that
- ***"……We are of the view that LVRT should be implemented for all wind turbines commissioned before 15.4.2014 and connected to voltage level of 66 kV and above except for Stall Type WTGs, which are not technically feasible to be retrofitted with LVRT. However, keeping in view the suggestions of IWTMA, we are of the view that presently LVRT should be implemented for all wind turbines (except Stall Types) commissioned before 15.04.2014 having installed capacity equal to or more than 500 KW."***

Format for Information of Wind Turbines and LVRT compliance

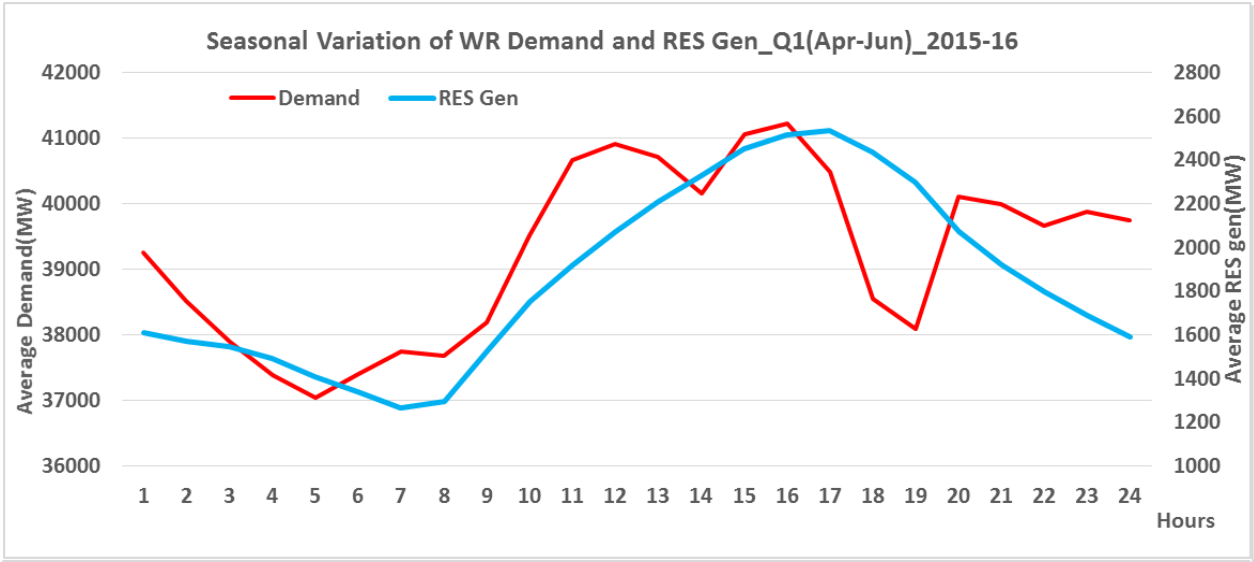
Location	Developer	Pooling Station	Turbine make	Turbine type	Turbine Capacity	If turbine commissioned before 15.04.2014, Expected date of completion of retrofitting	If turbine commissioned after 15.04.2014 whether compliant to LVRT (Yes/No)
…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…

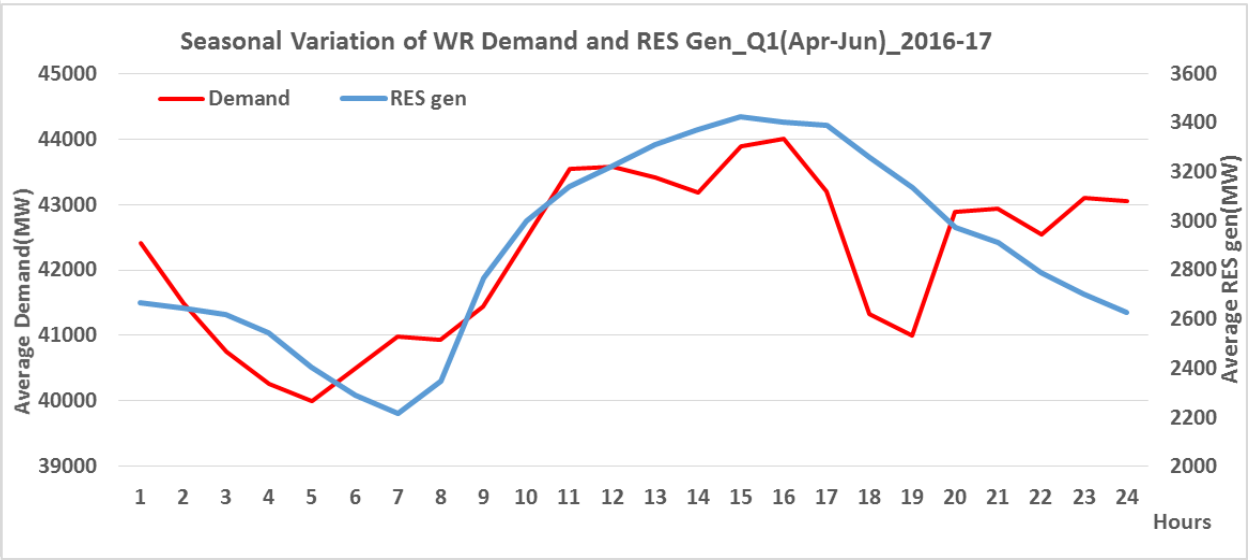
Thank you!

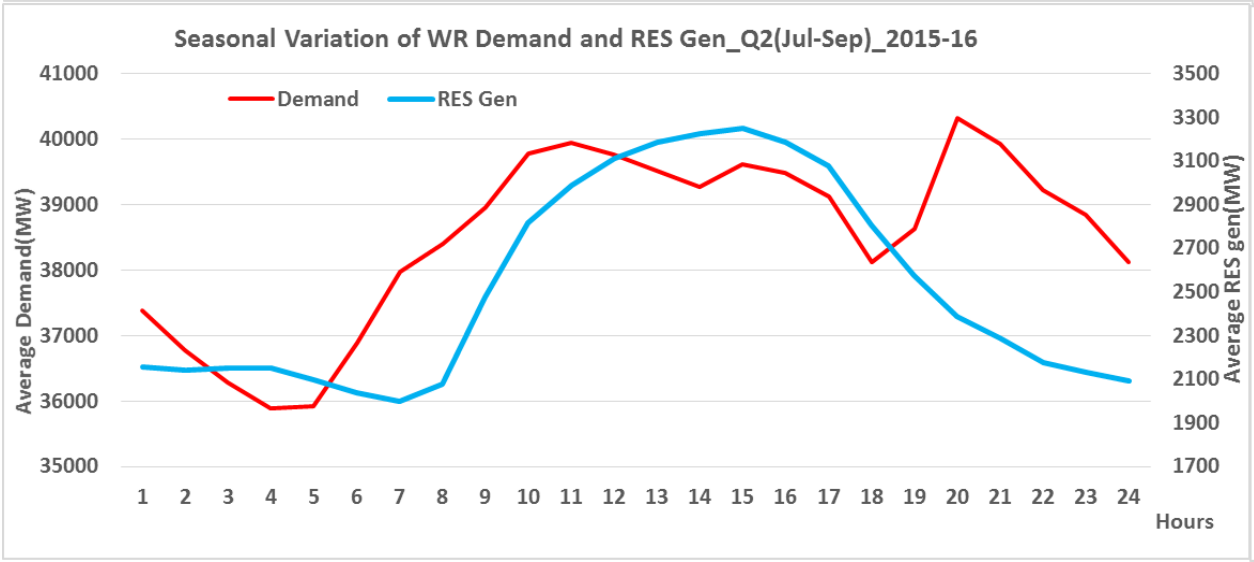
Variation of Demand and RES(Wind+Solar) Generation in Western Region

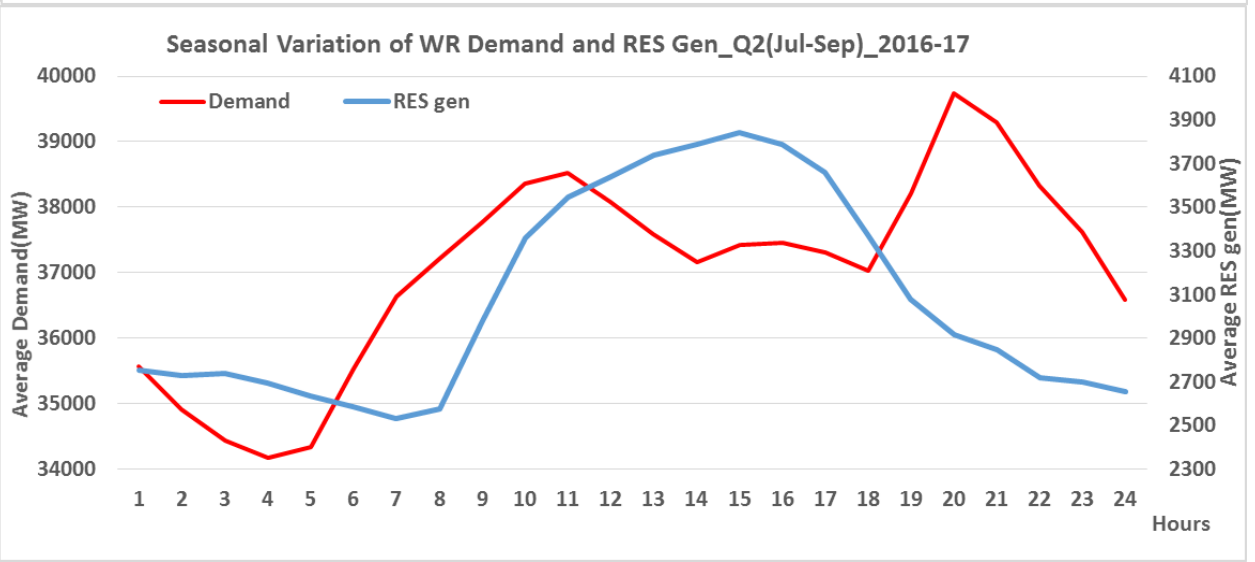
2015-16_&_2016-17

Western Region_ Seasonal Variation

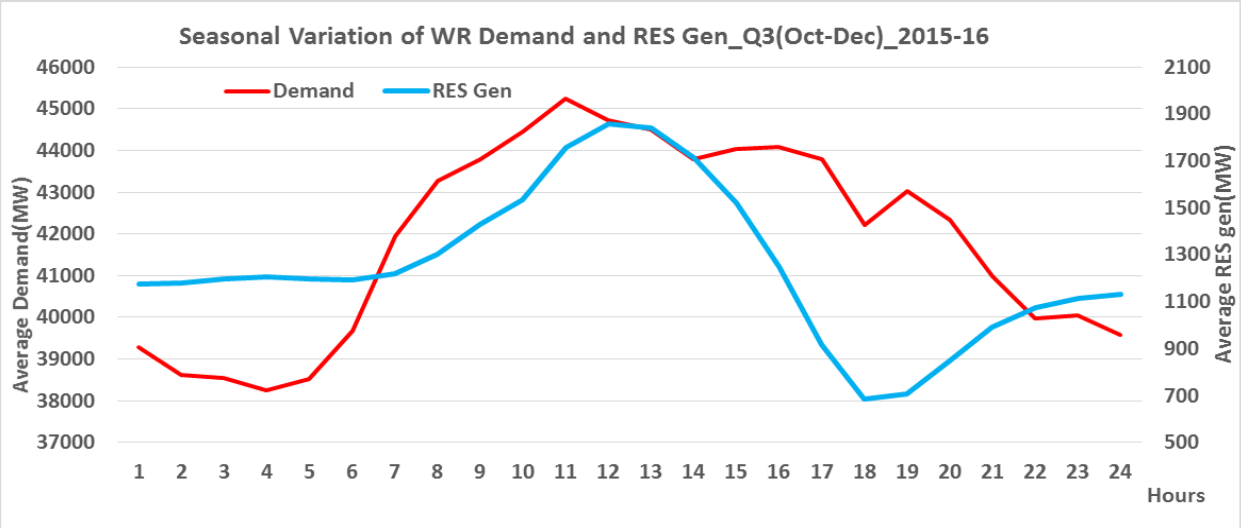


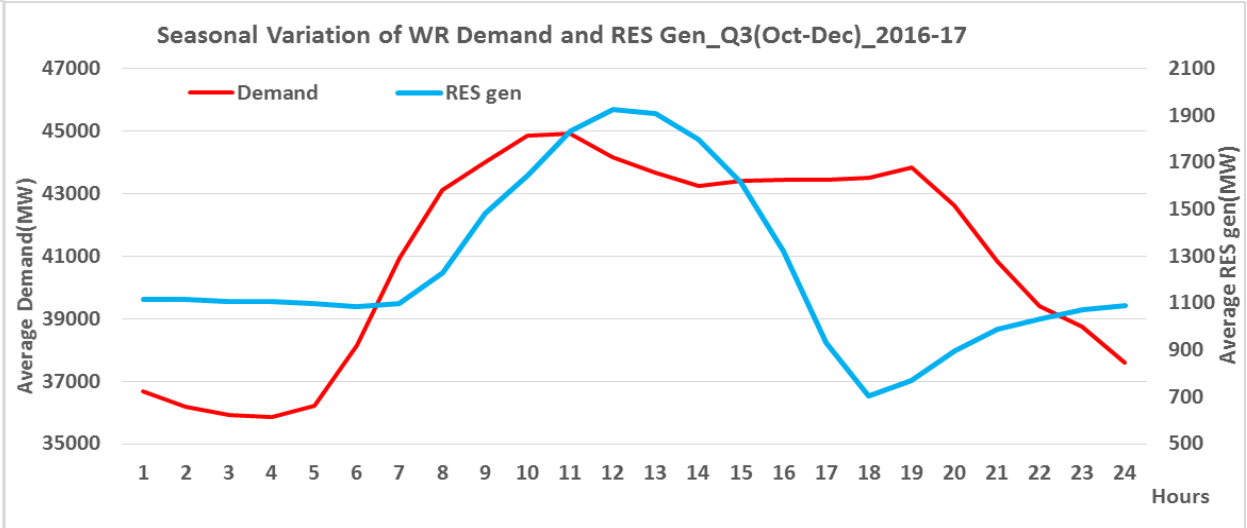


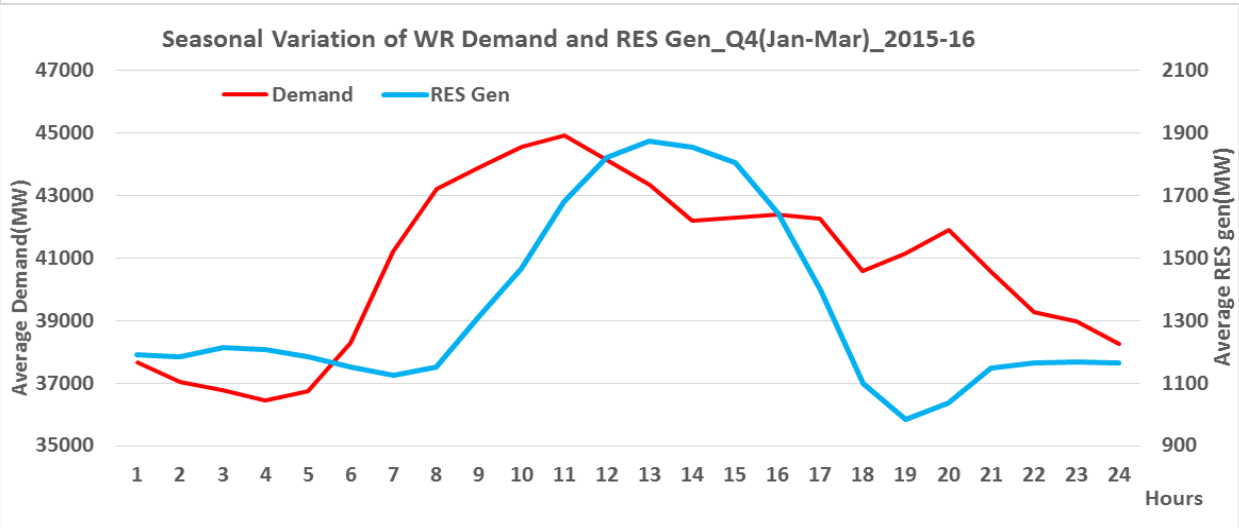


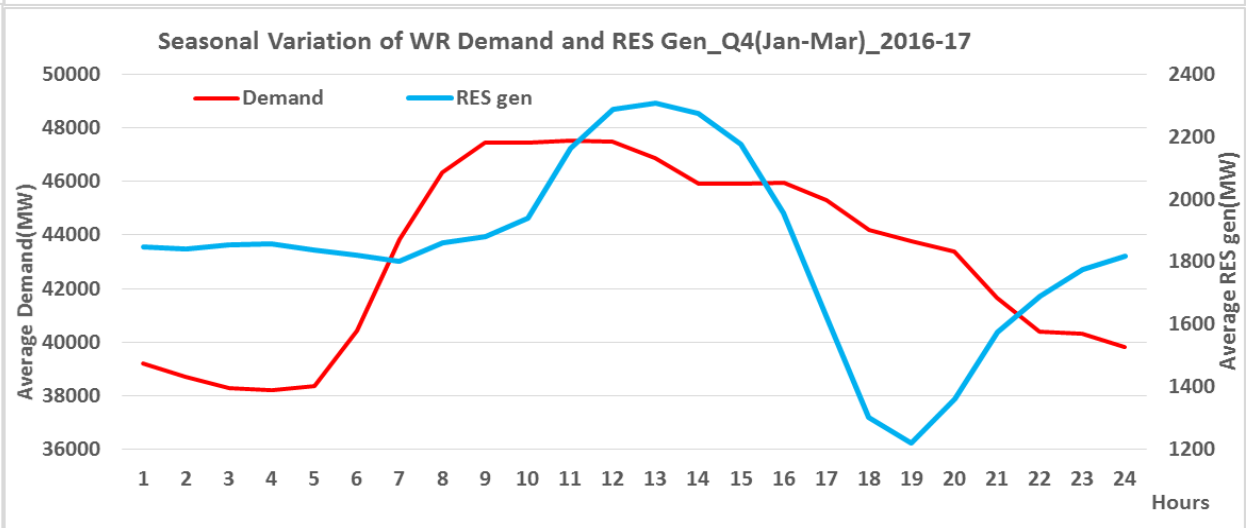


- April-June and July-September in WR, the RES(Wind+Solar) generation supports the WR demand for whole day except evening ramp-up. RES generation helps in morning ramp up and reaches at its peak when demand is high. It is also supporting the ramp down in the system.



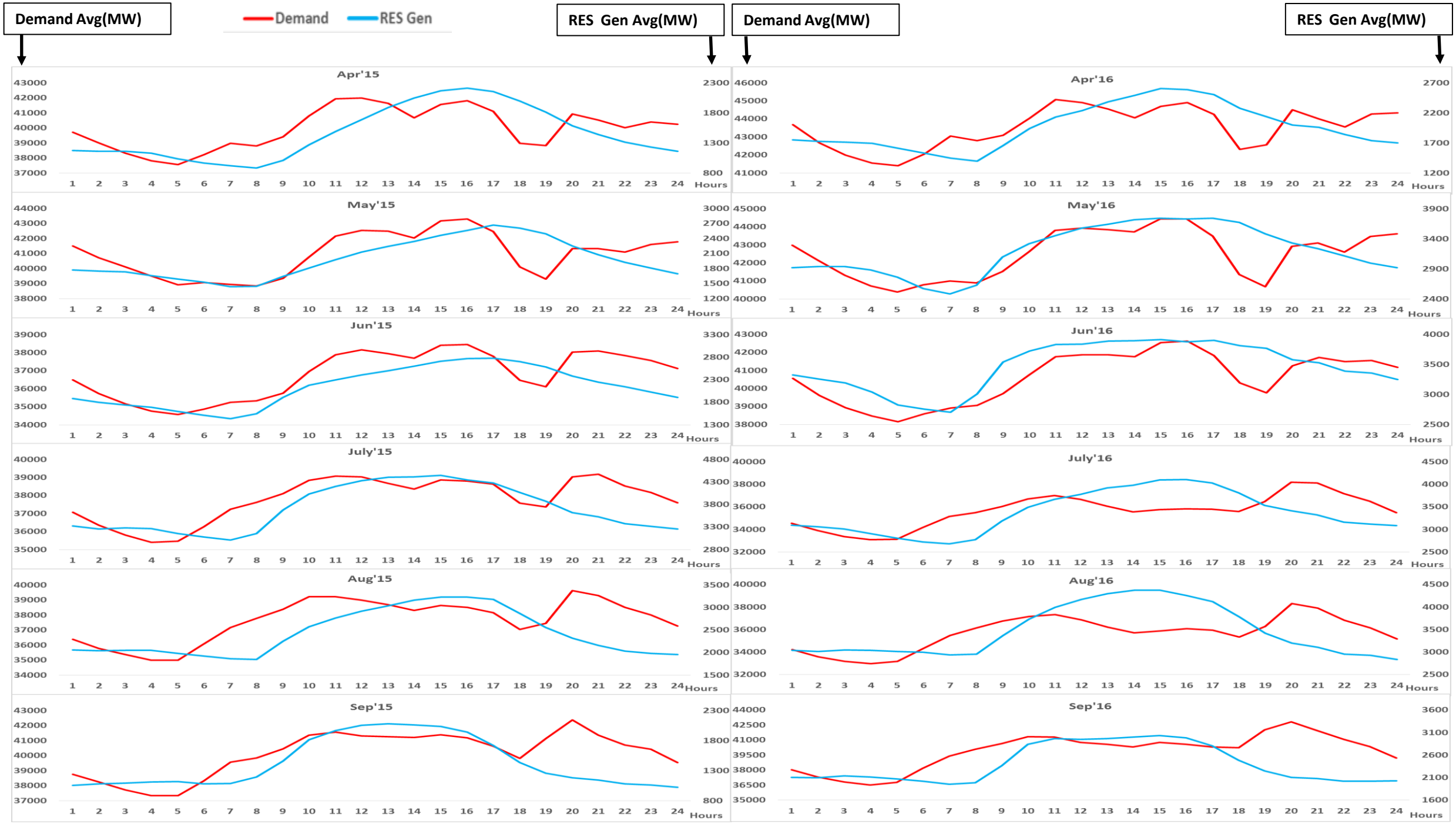


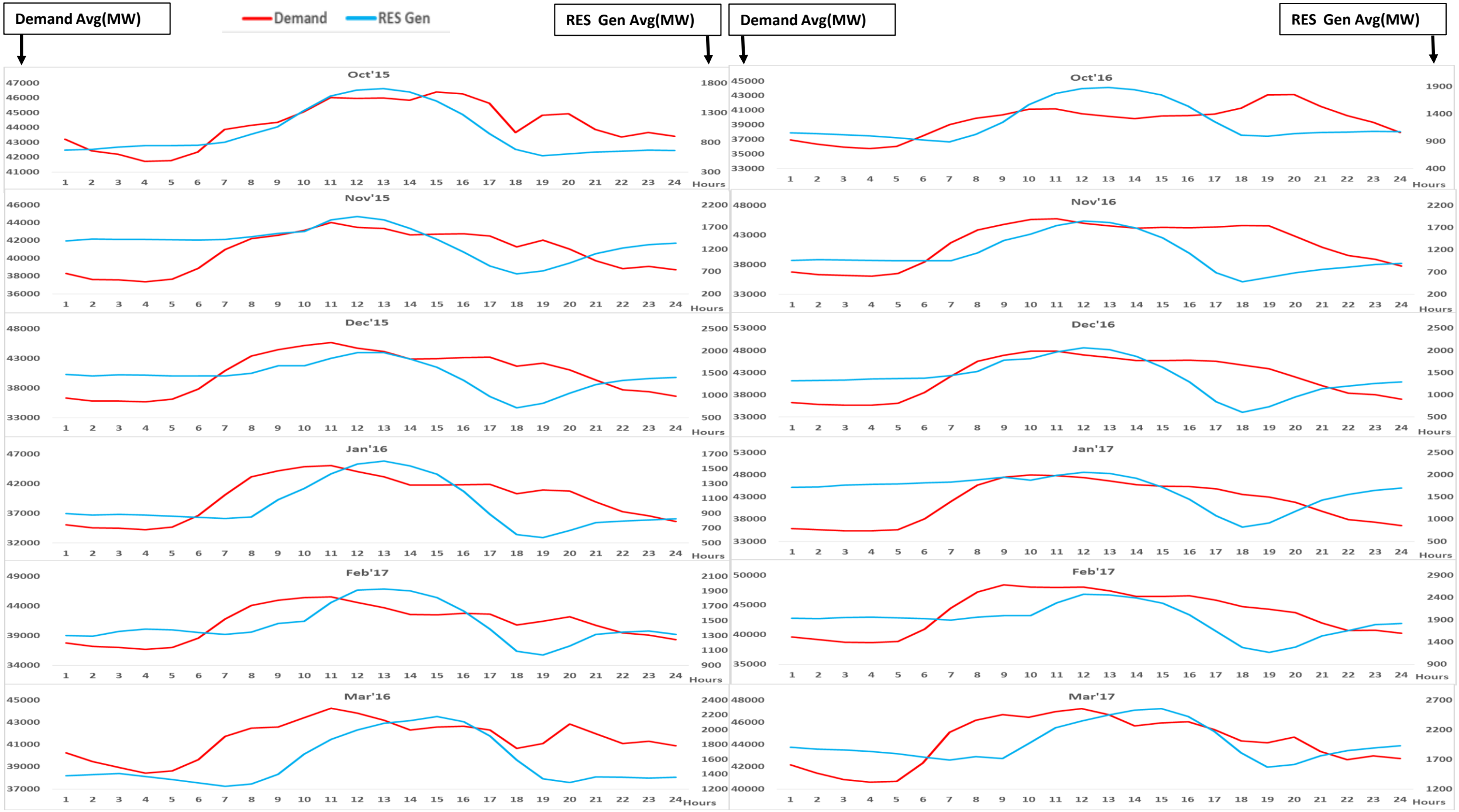




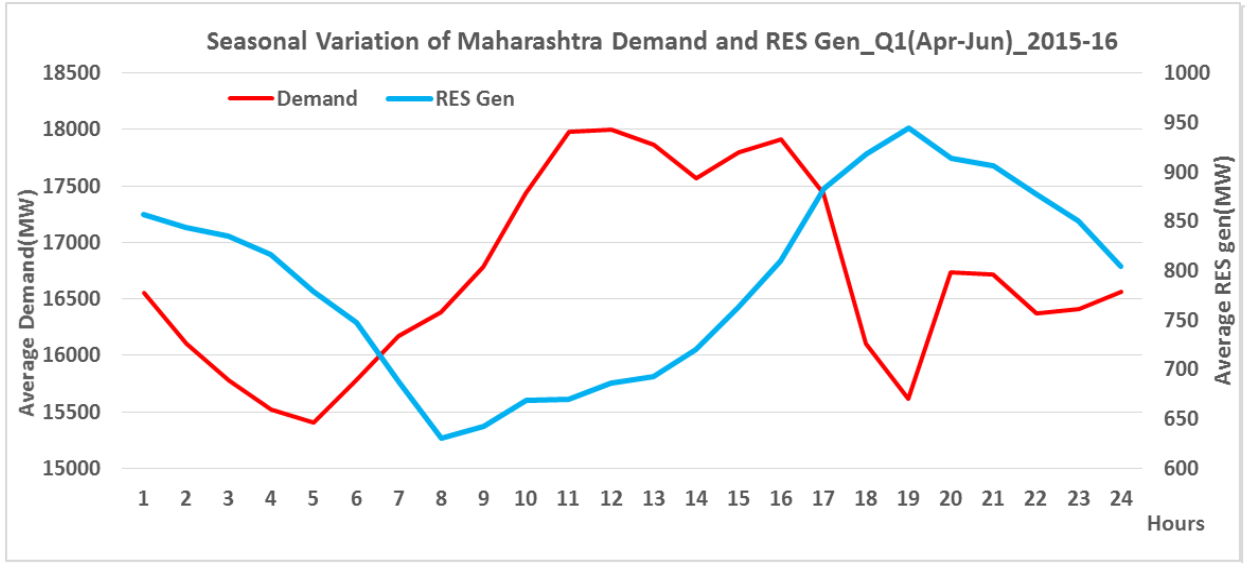
- October-December and January-March RES gen supports ramp up and high demand period but it opposes the ramp down in demand in the evening. Wind generation starts reducing after rainy season & it reaches at its minimum during Oct-Dec. During this period solar picks up and achieves its peak during March. The peak reflected in RES gen curve is basically the solar peak around 12-13 hrs because the wind generation during this time remains at its lean. It reaches at its minimum value at 18-19 hrs when solar becomes zero.

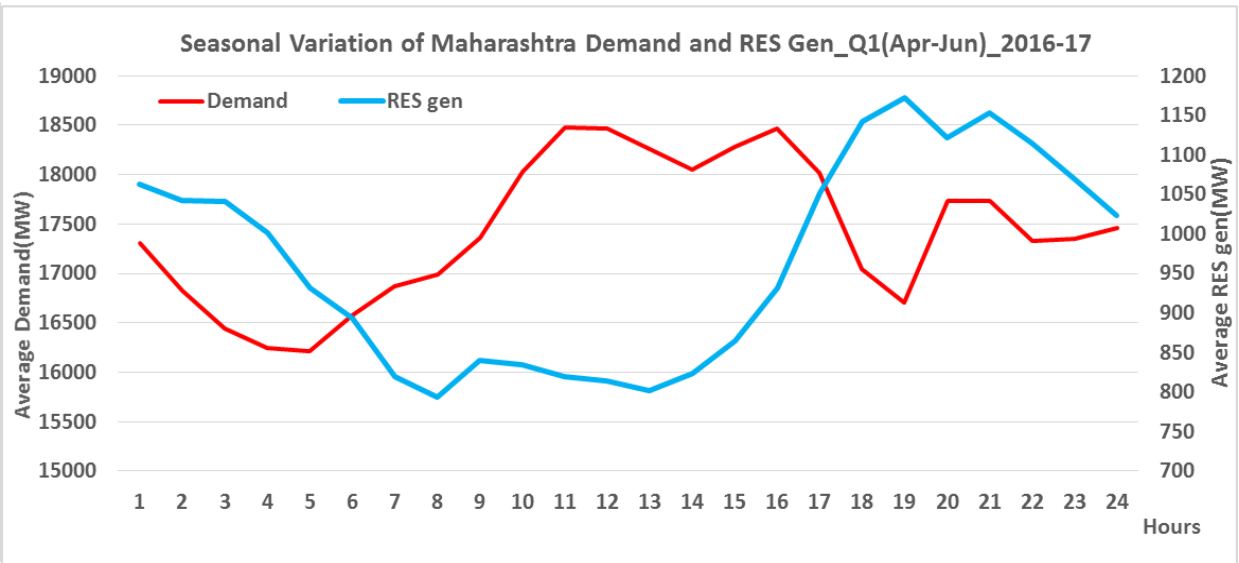
Western Region_ Monthly Variation

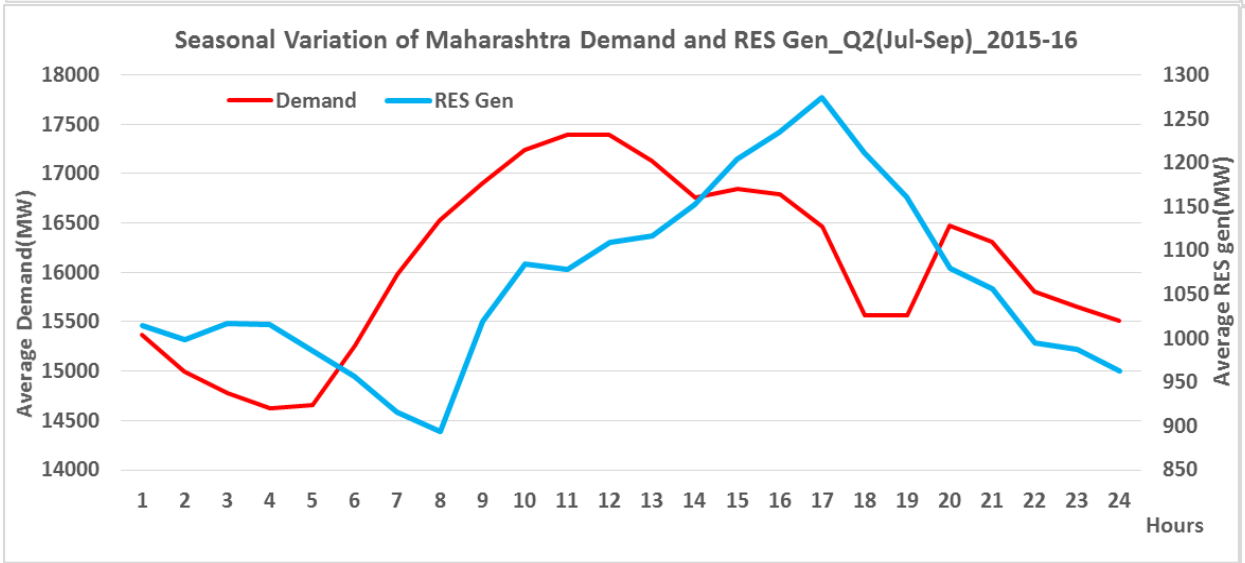

Demand Avg(MW)
Demand
RES Gen
RES Gen Avg(MW)
Demand Avg(MW)
RES Gen Avg(MW)
Apr'15
May'15
Jun'15
July'15
Aug'15
Sep'15
Apr'16
May'16
Jun'16
July'16
Aug'16
Sep'16
Hours

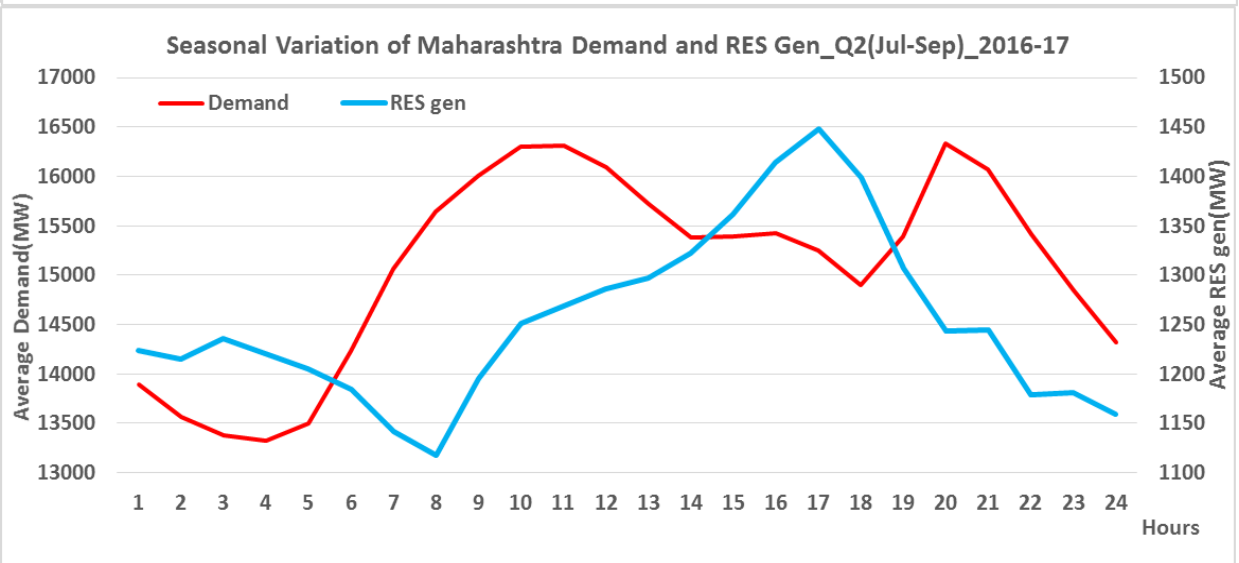

Demand Avg(MW)
Demand
RES Gen
RES Gen Avg(MW)
Demand Avg(MW)
RES Gen Avg(MW)
Oct'15
Oct'16
Nov'15
Nov'16
Dec'15
Dec'16
Jan'16
Jan'17
Feb'17
Feb'17
Mar'16
Mar'17
Hours

Maharashtra _ Seasonal Variation

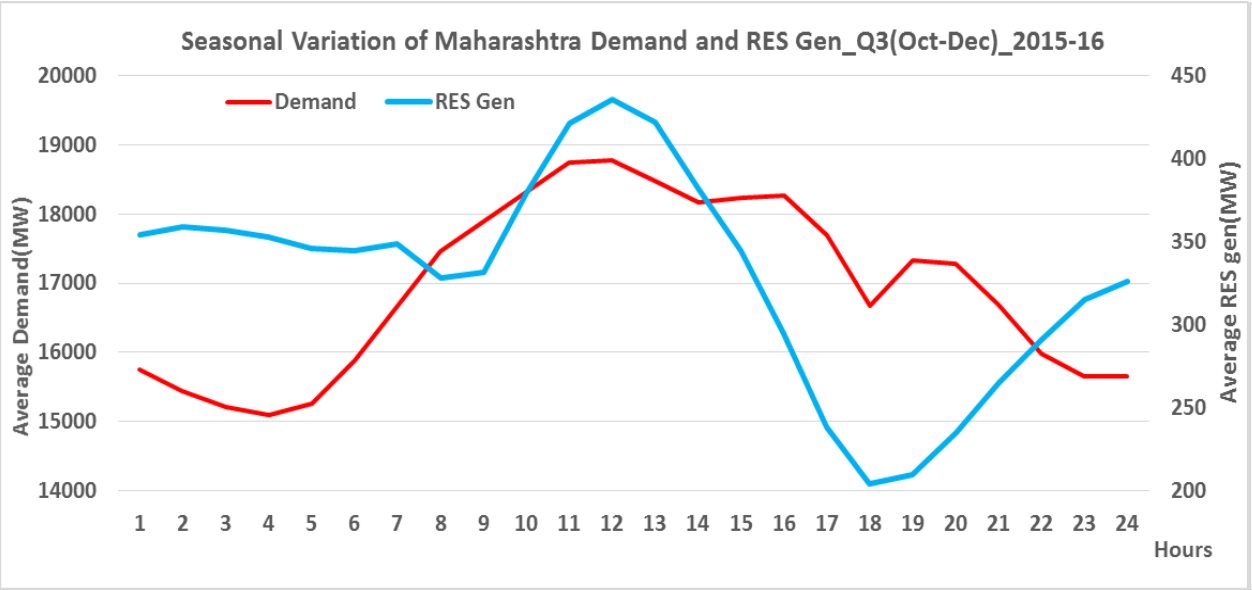


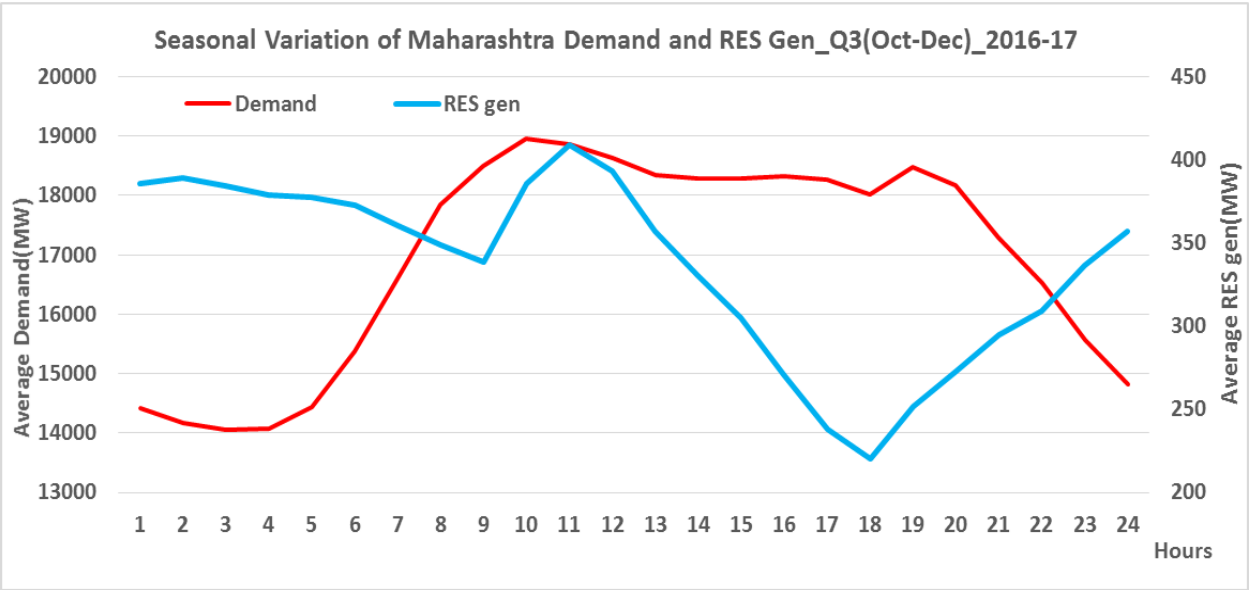


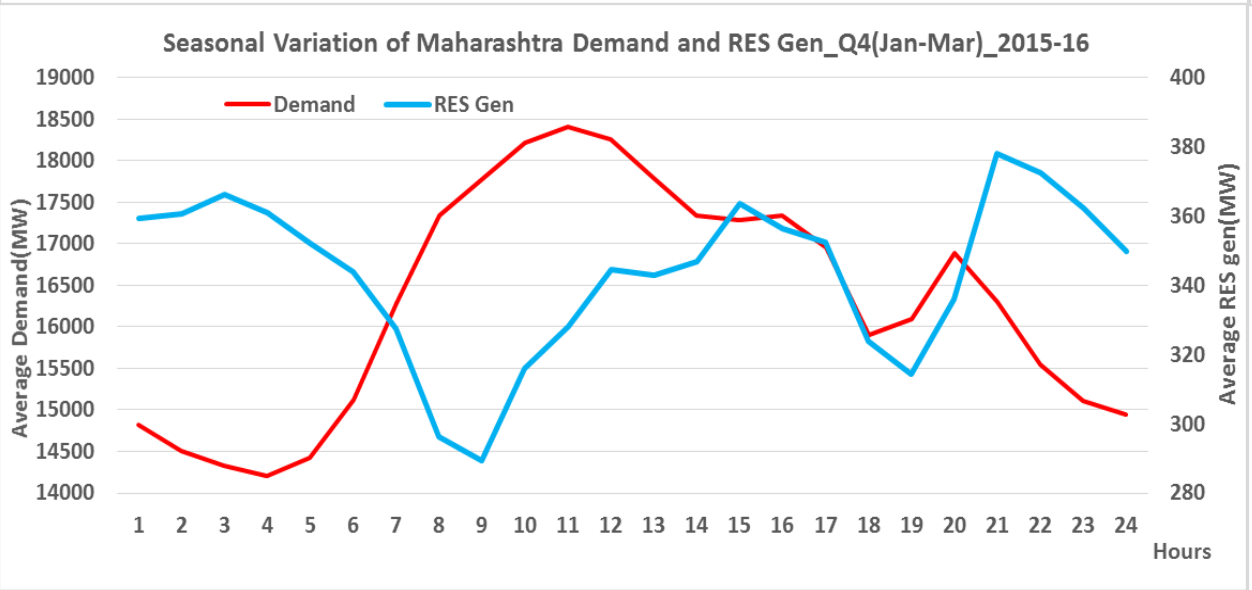


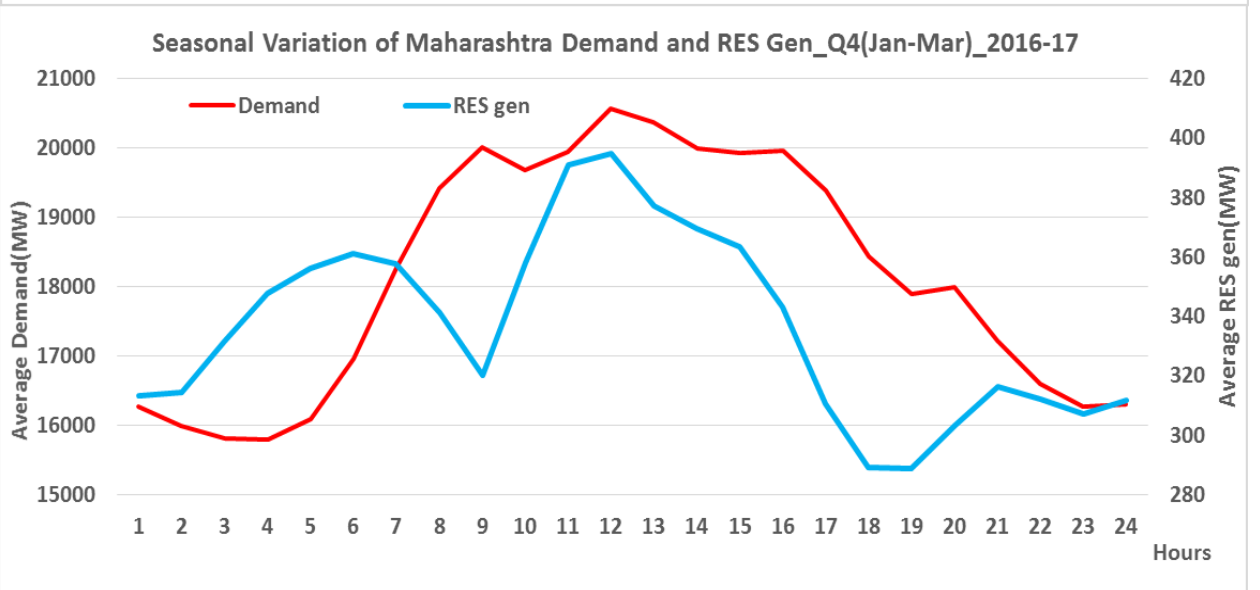


- April-June RES generation pattern in Maharashtra is the reflection of Wind generation as solar in Mah is very low. The RES gen supports the Mah demand during eveing(20Hrs) upto night hrs in ramping down.
- July-September RES generation is following the ramping up in demand during morning and ramping down in evening hours.



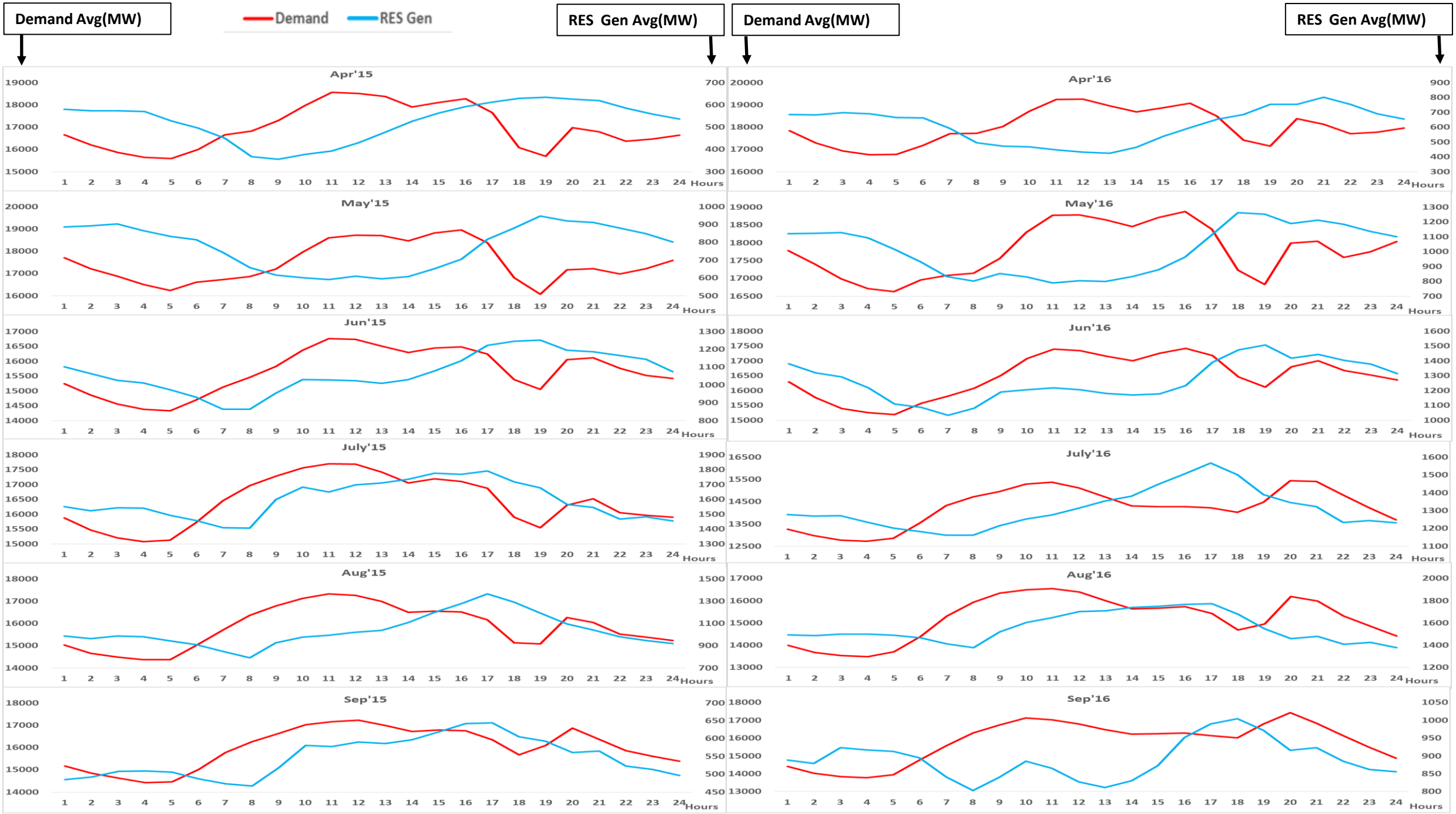


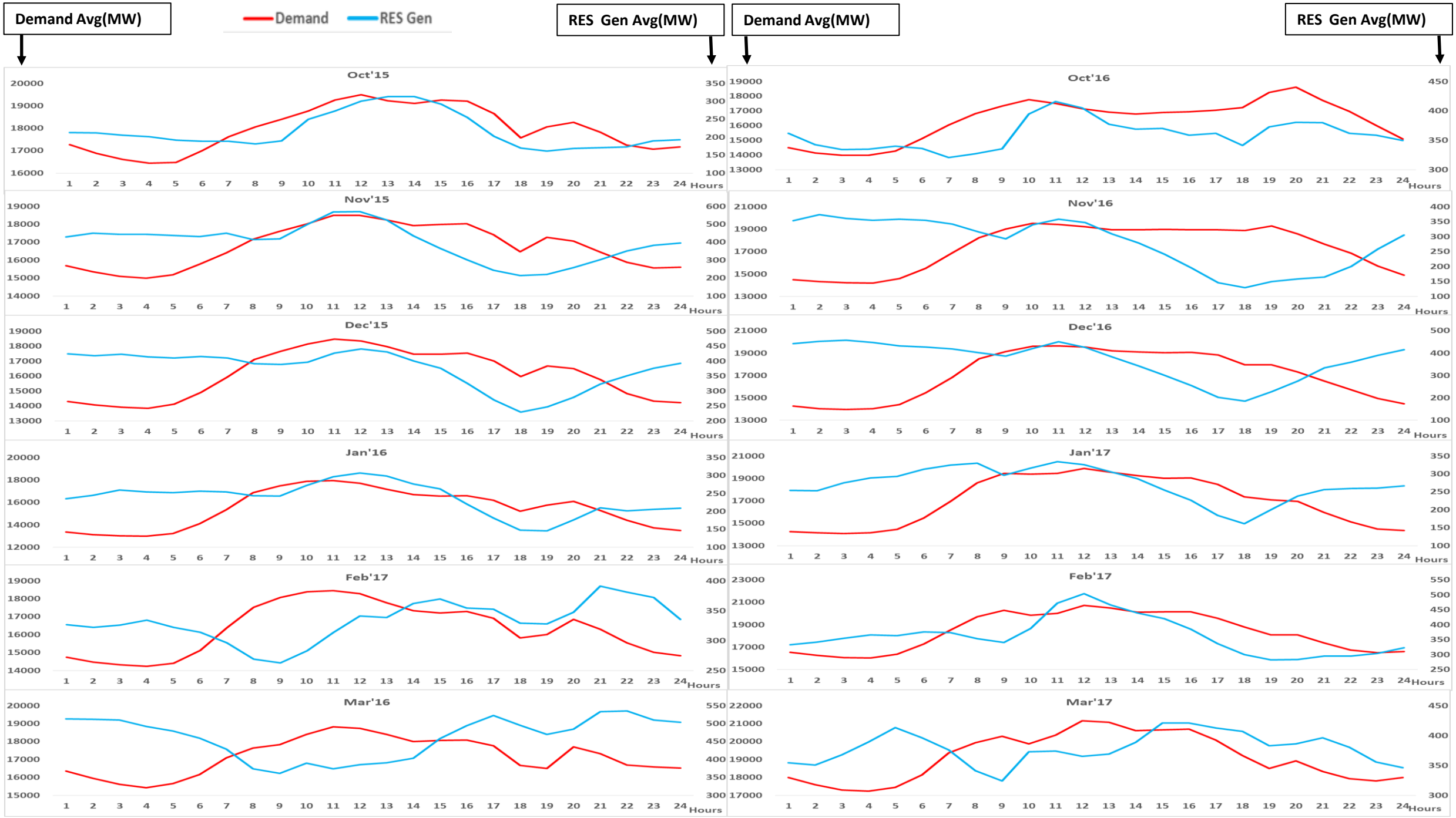




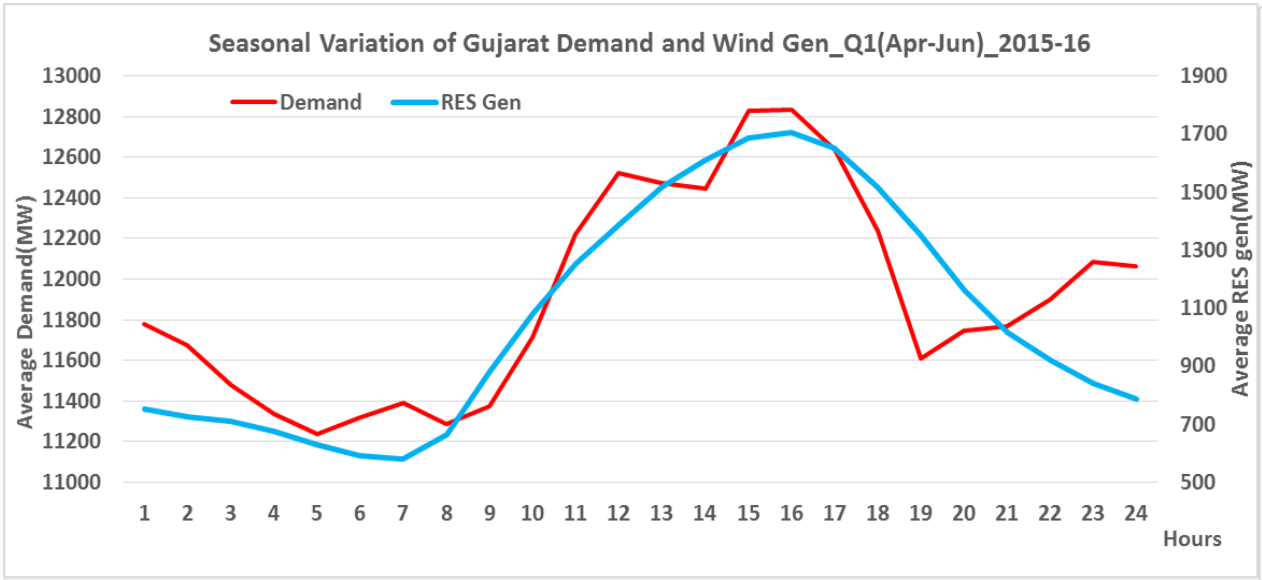
- October-December RES generation in Maharashtra is helping it during the Peak time.
- January-March RES generation is supporting Maharashtra at peak time and also helping in ramping down in the evening.

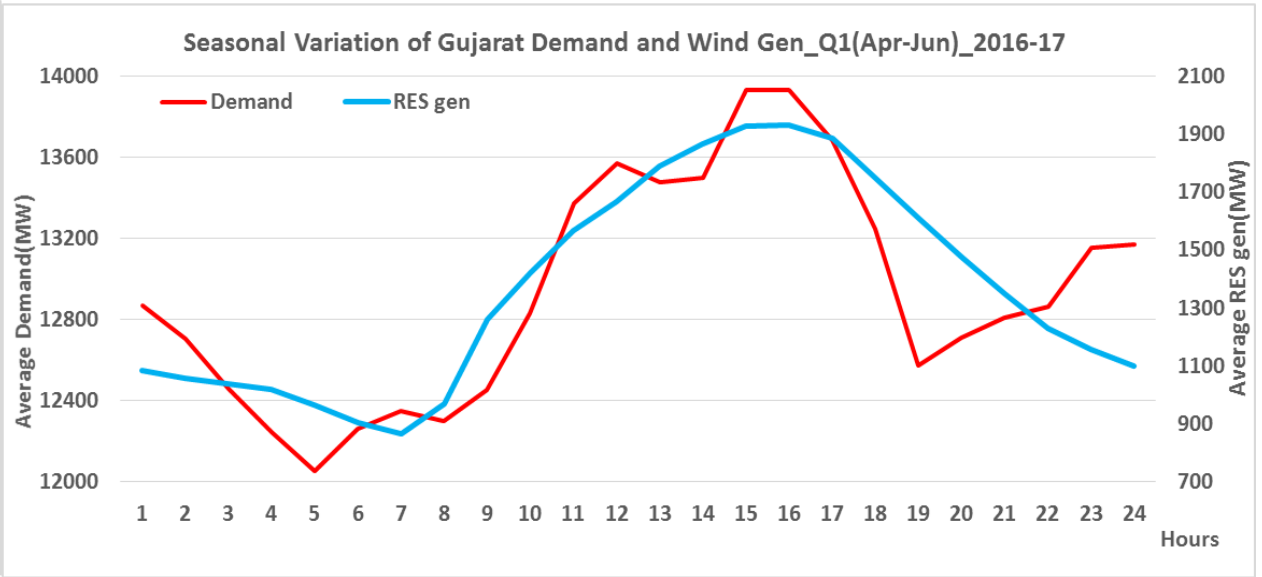
Maharashtra _ Monthly Variation

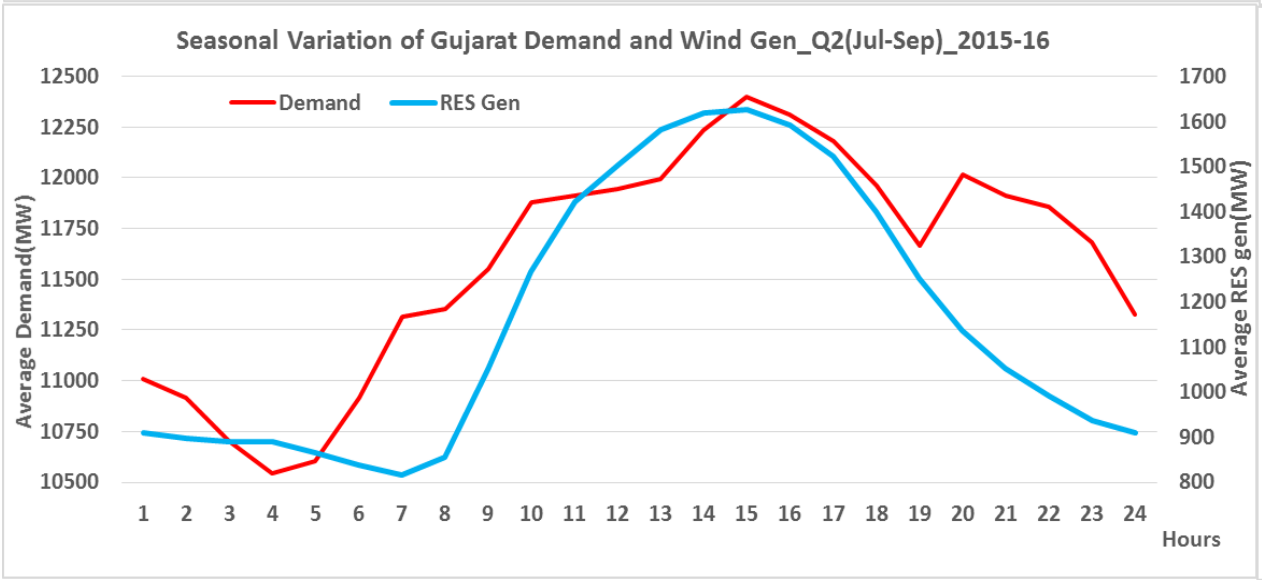

Demand Avg(MW)
Demand
RES Gen
RES Gen Avg(MW)
Demand Avg(MW)
RES Gen Avg(MW)
Apr'15
Apr'16
May'15
May'16
Jun'15
Jun'16
July'15
July'16
Aug'15
Aug'16
Sep'15
Sep'16
Hours

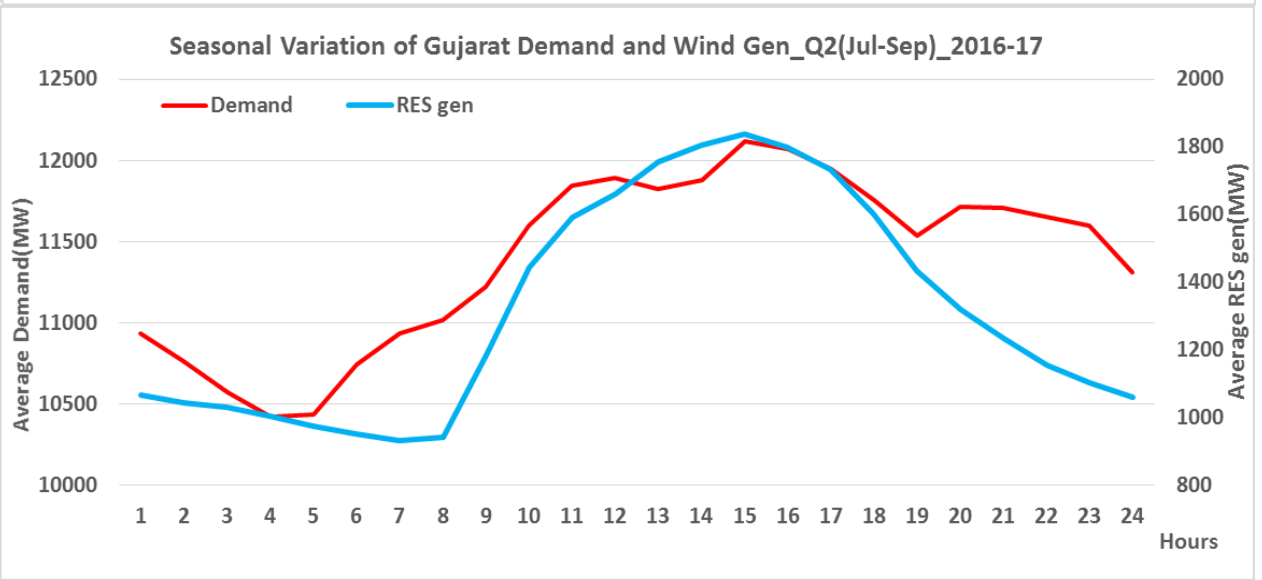

Demand Avg(MW)
Demand
RES Gen
RES Gen Avg(MW)
Demand Avg(MW)
RES Gen Avg(MW)
Oct'15
Oct'16
Nov'15
Nov'16
Dec'15
Dec'16
Jan'16
Jan'17
Feb'17
Feb'17
Mar'16
Mar'17
Hours

Gujarat _ Seasonal Variation

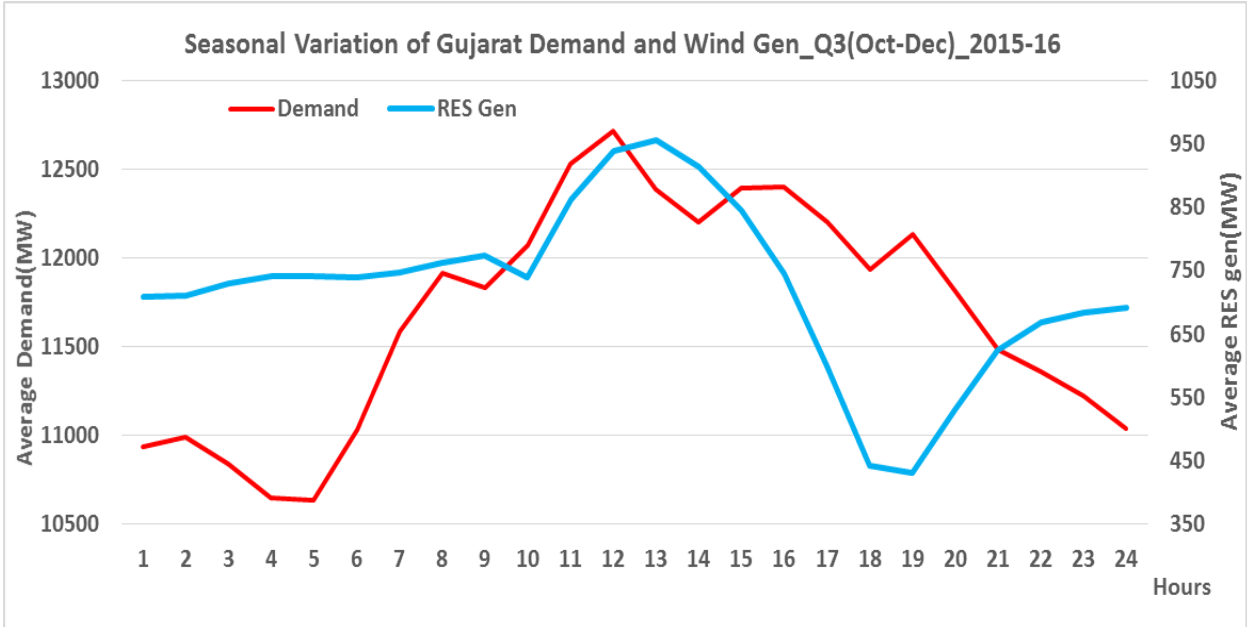


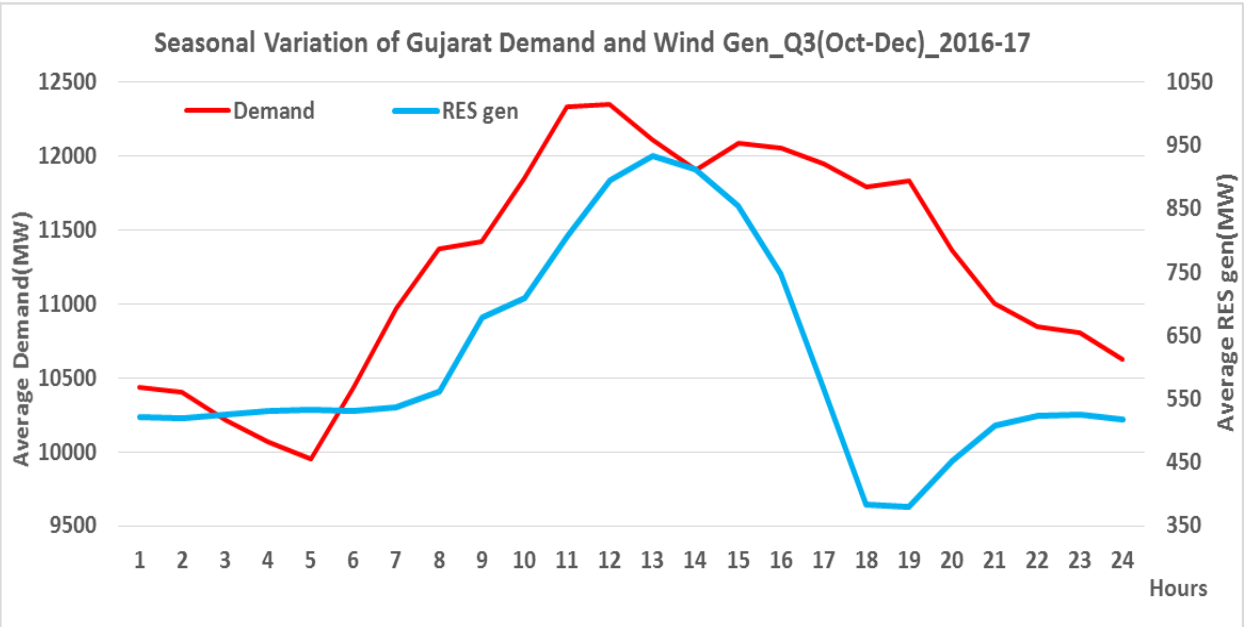


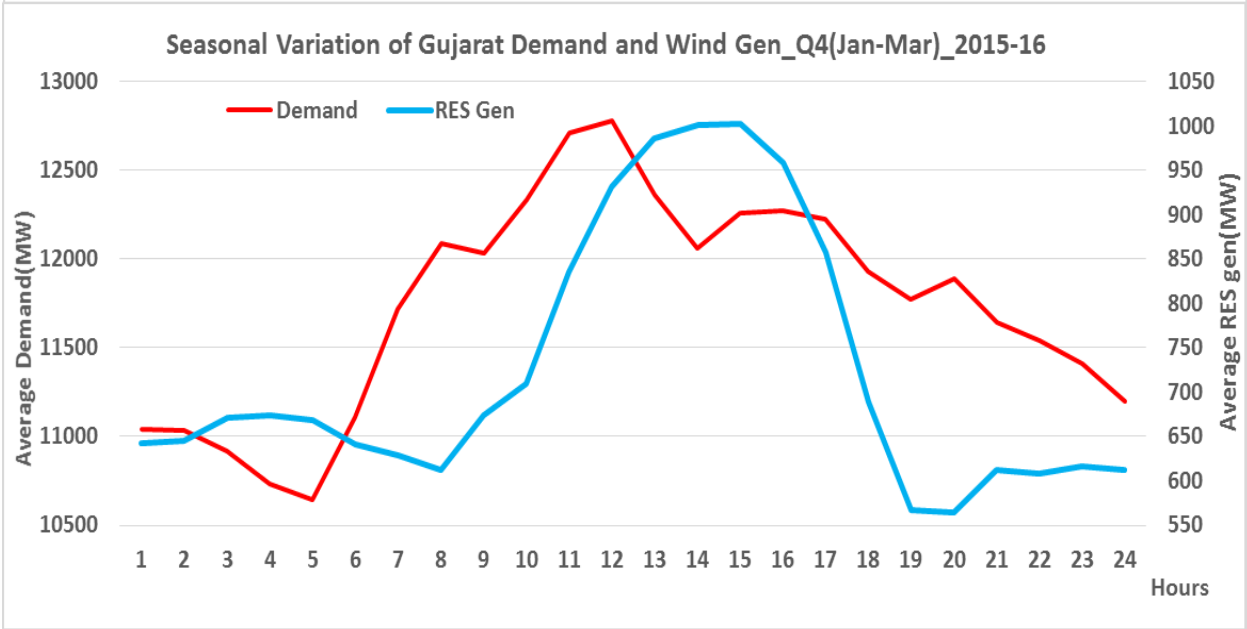


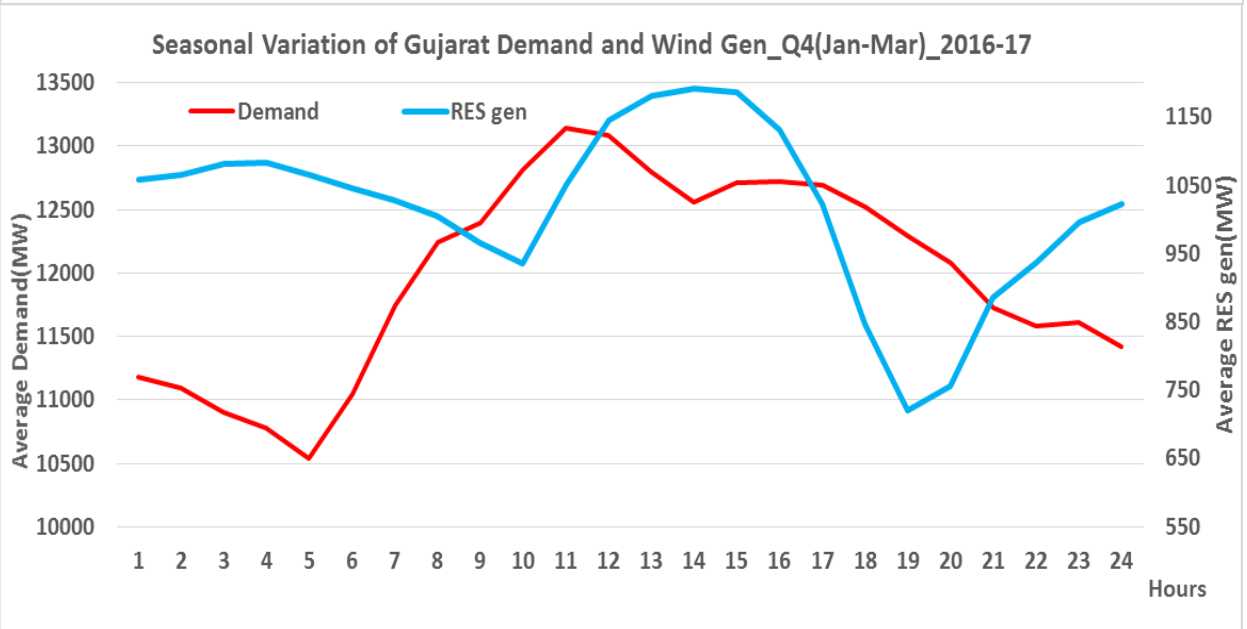


- April-June and July-September RES generation is supporting the Gujarat demand in ramping up, down and meeting the peak load during the day time.



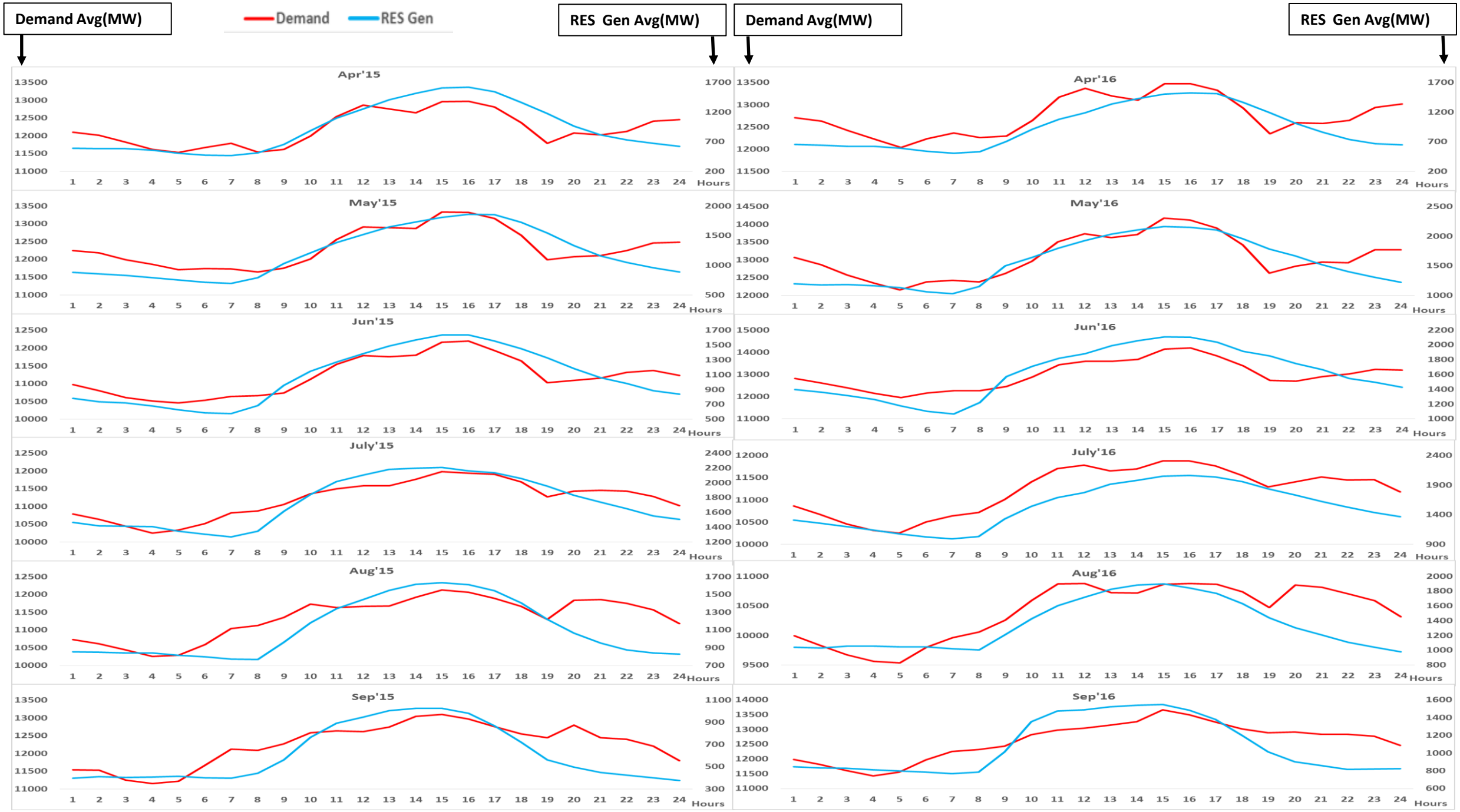


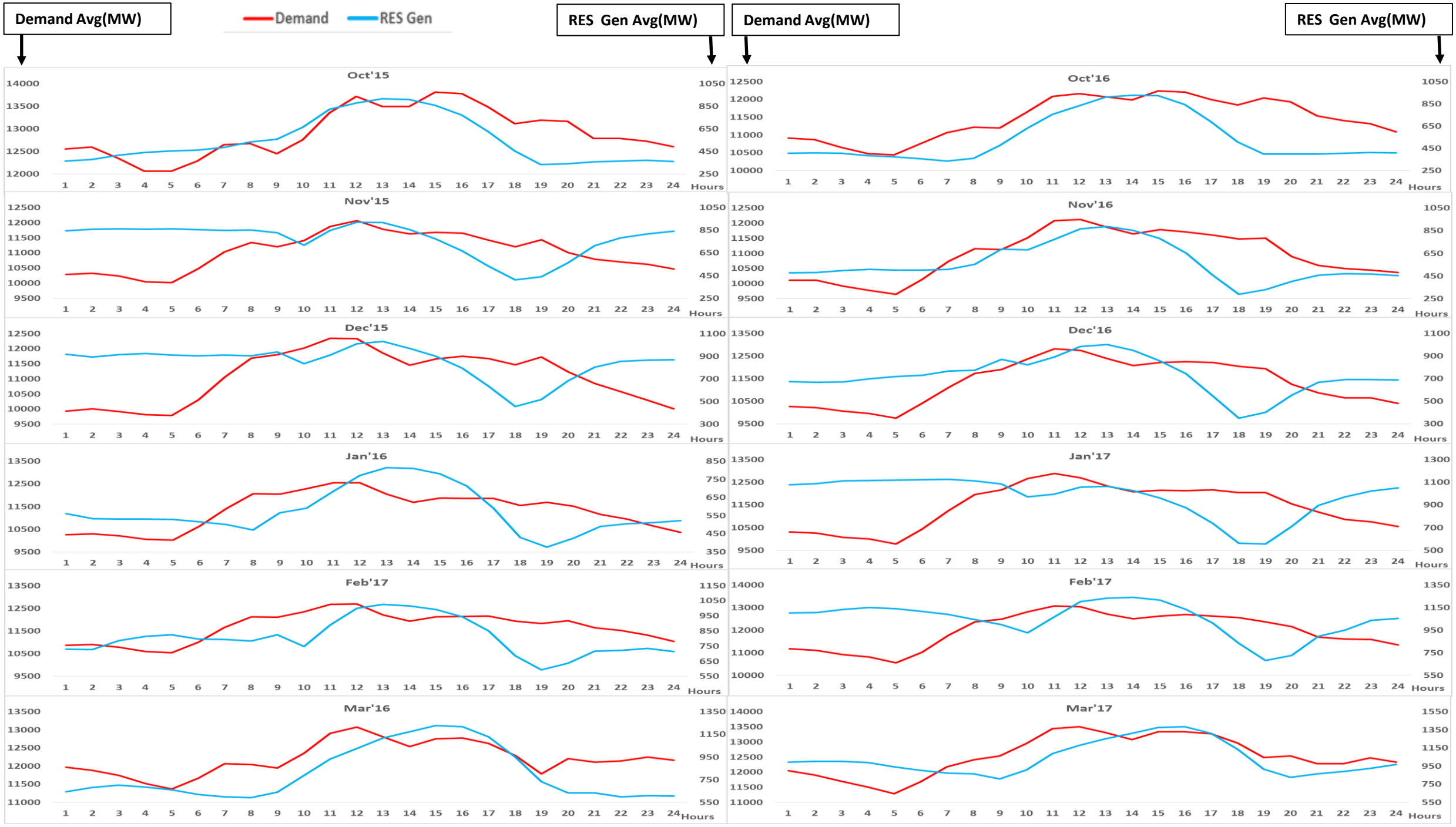




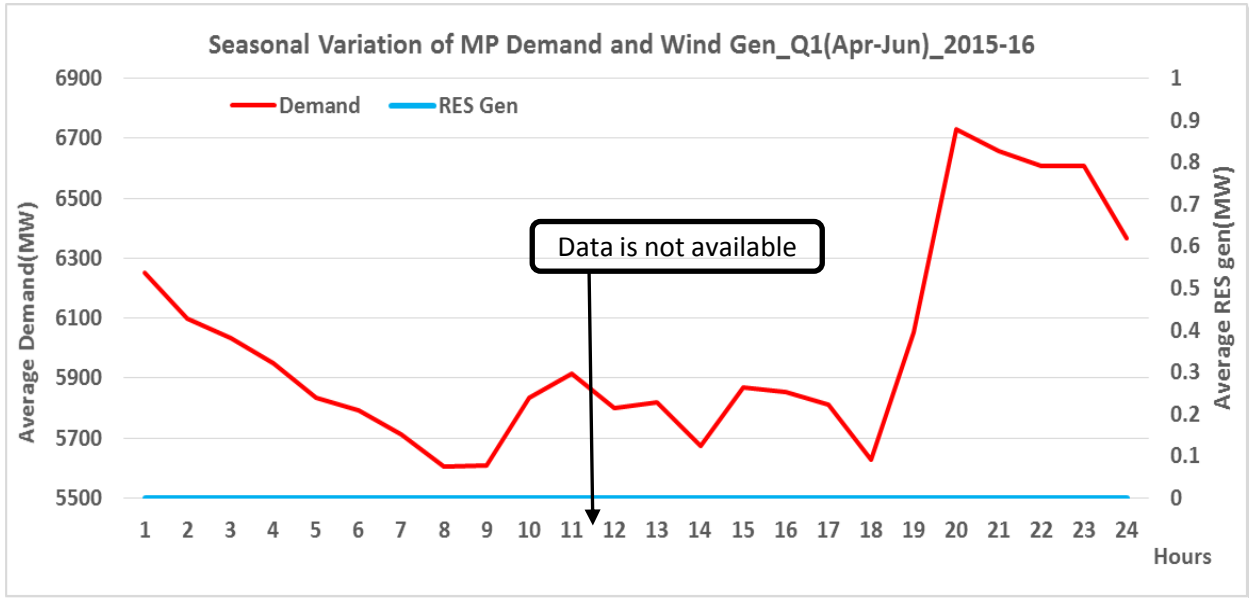
- October-December and January-March RES generation is Helping in ramp up and meeting the peak demand of Gujarat.

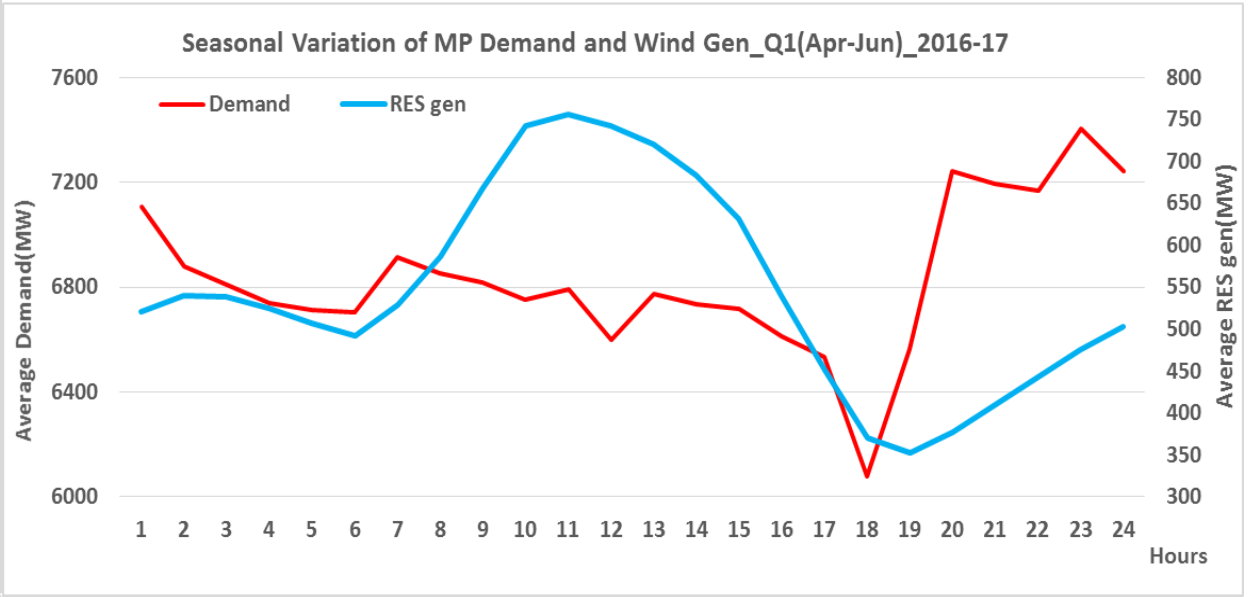
Gujarat _ Monthly Variation

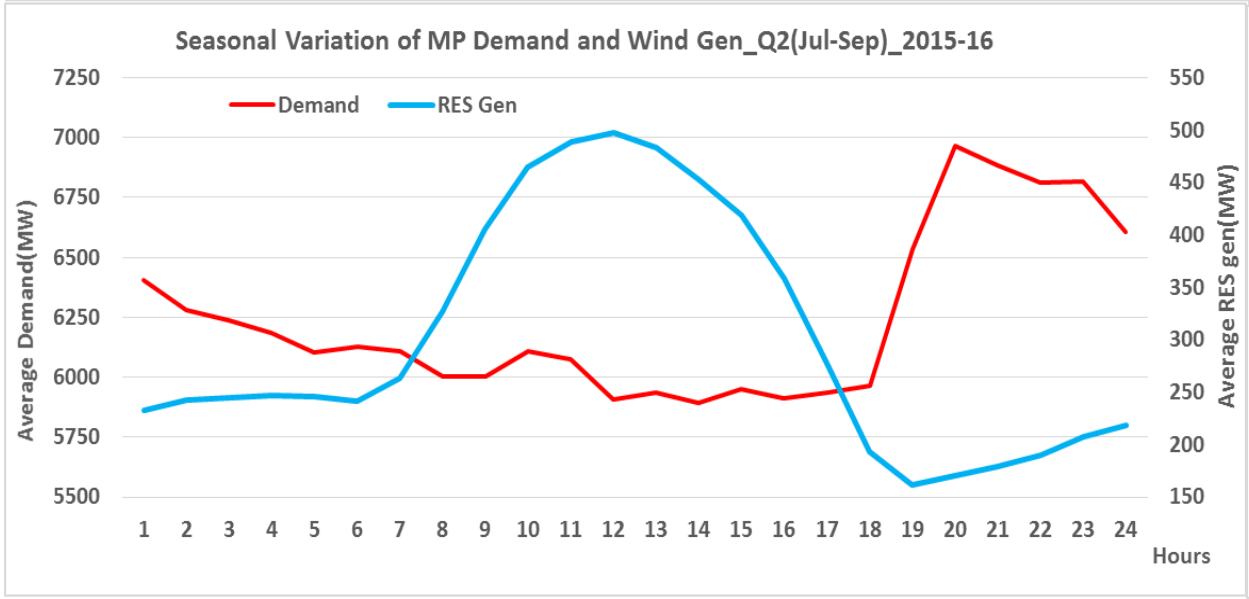

Demand Avg(MW)
Demand
RES Gen
RES Gen Avg(MW)
Demand Avg(MW)
RES Gen Avg(MW)
Apr'15
Apr'16
May'15
May'16
Jun'15
Jun'16
July'15
July'16
Aug'15
Aug'16
Sep'15
Sep'16
Hours

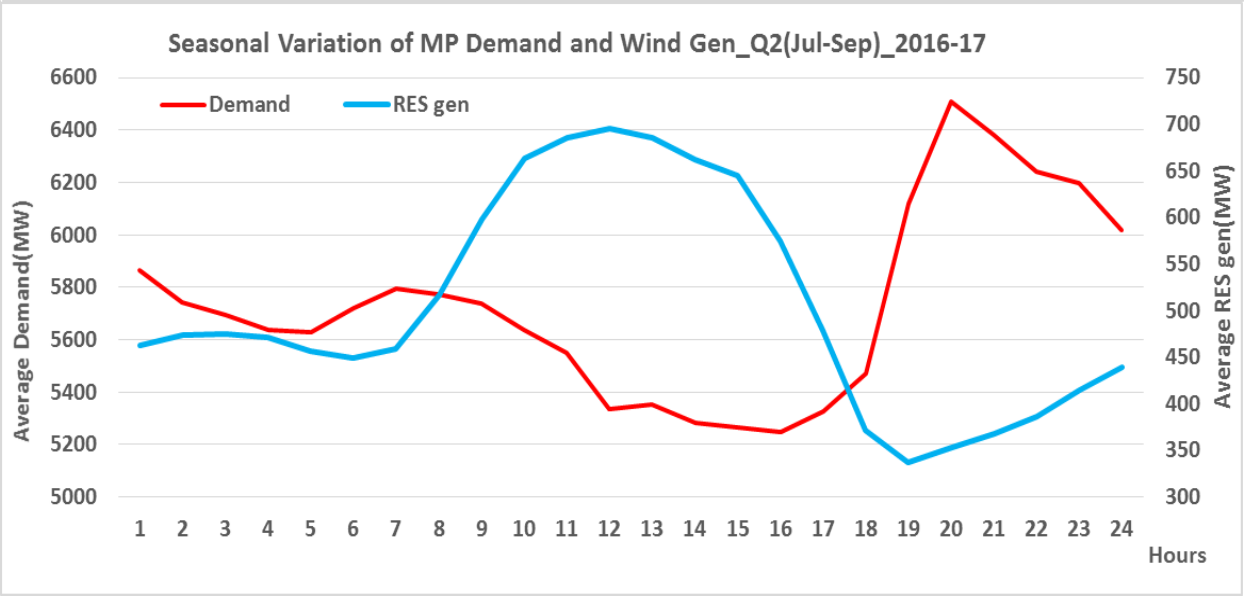

Demand Avg(MW)
Demand
RES Gen
RES Gen Avg(MW)
Demand Avg(MW)
RES Gen Avg(MW)
Oct'15
Oct'16
Nov'15
Nov'16
Dec'15
Dec'16
Jan'16
Jan'17
Feb'17
Feb'17
Mar'16
Mar'17
Hours

Madhya Pradesh _ Seasonal Variation

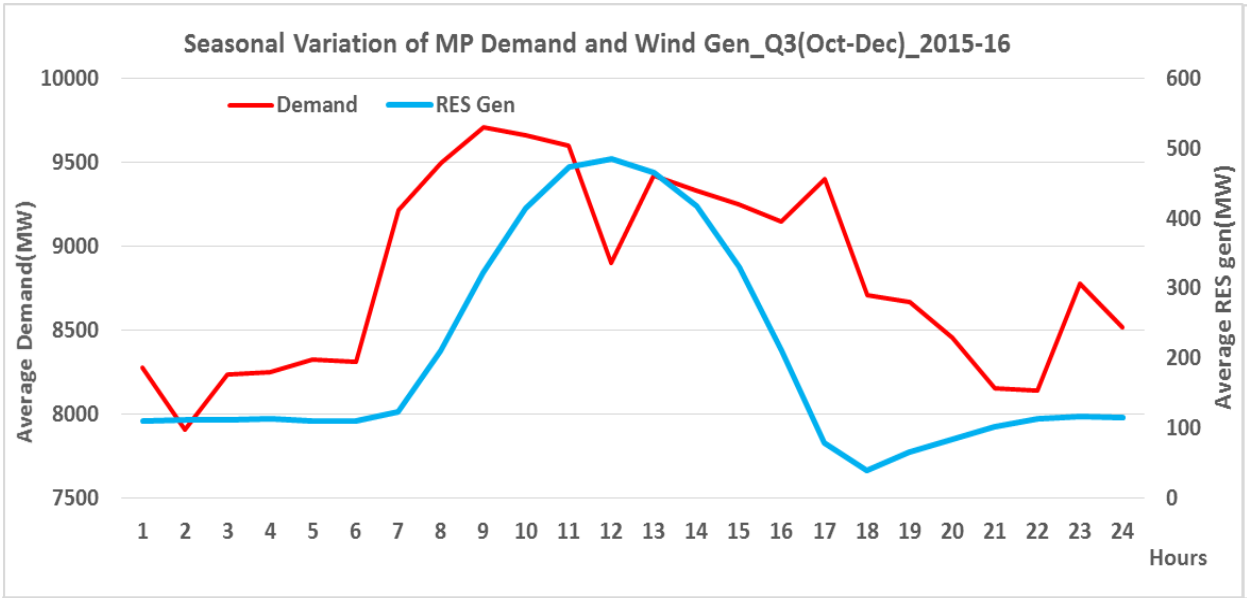


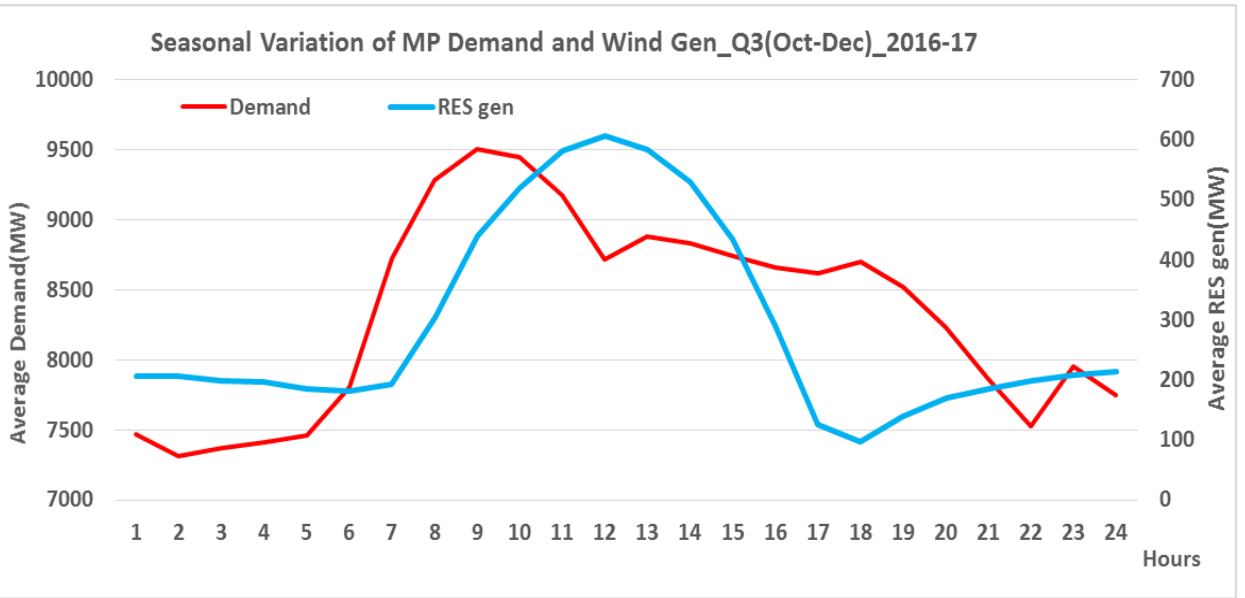


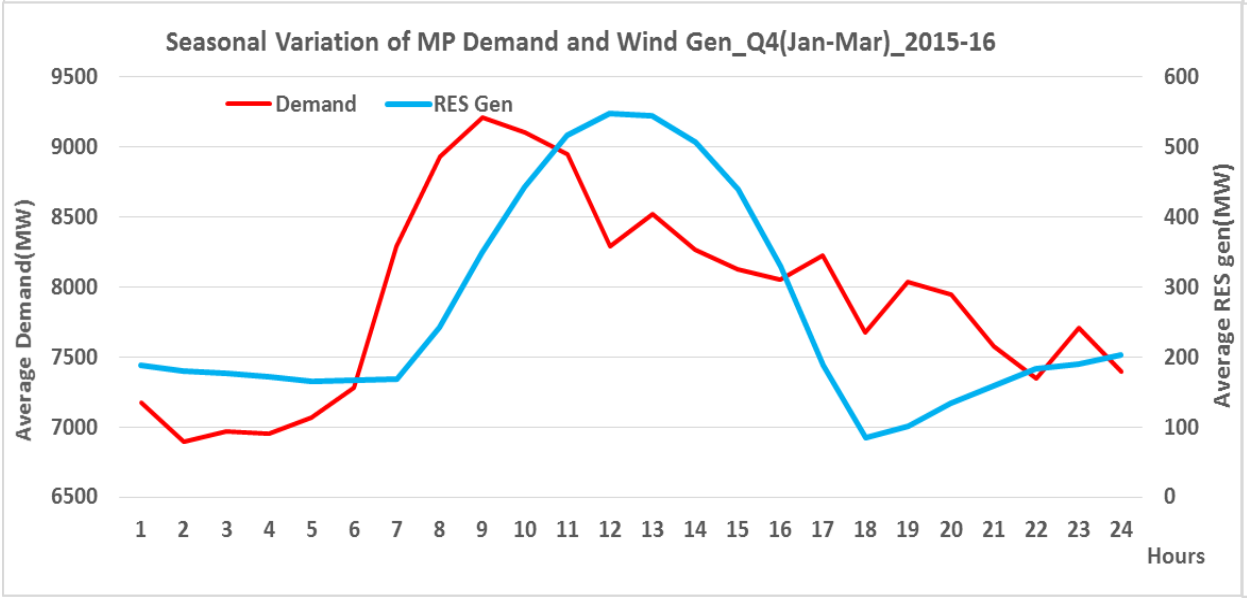


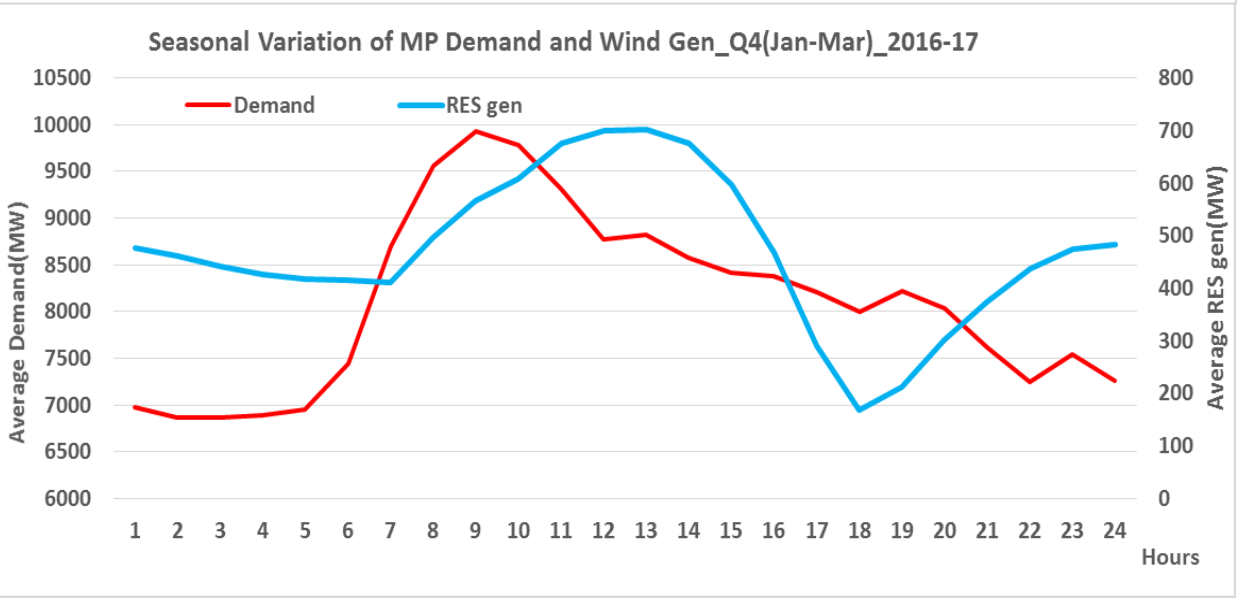


- April-June and July-September RES generation is not supporting MP as the RES gen is high during low demand period and low when demand is high.



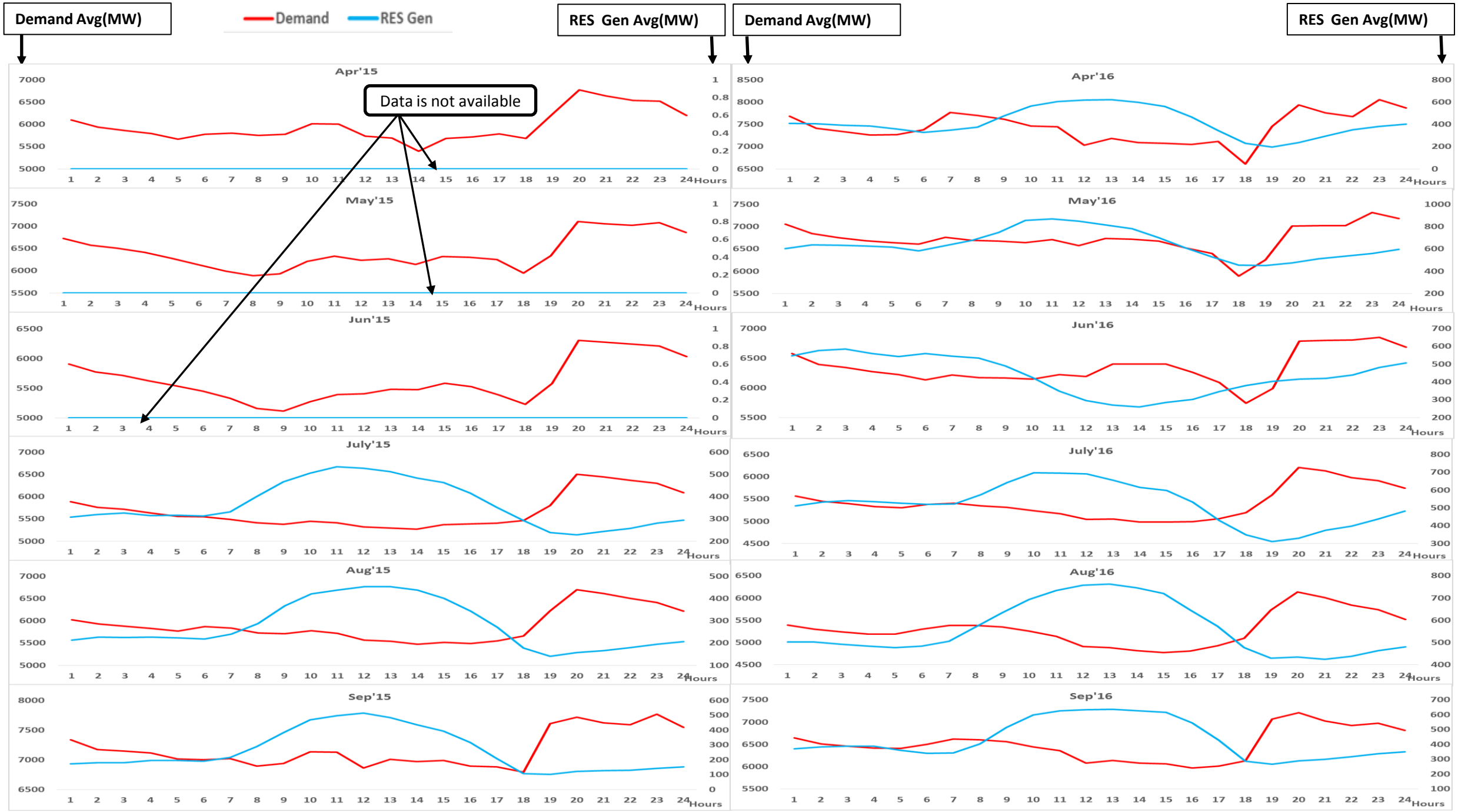


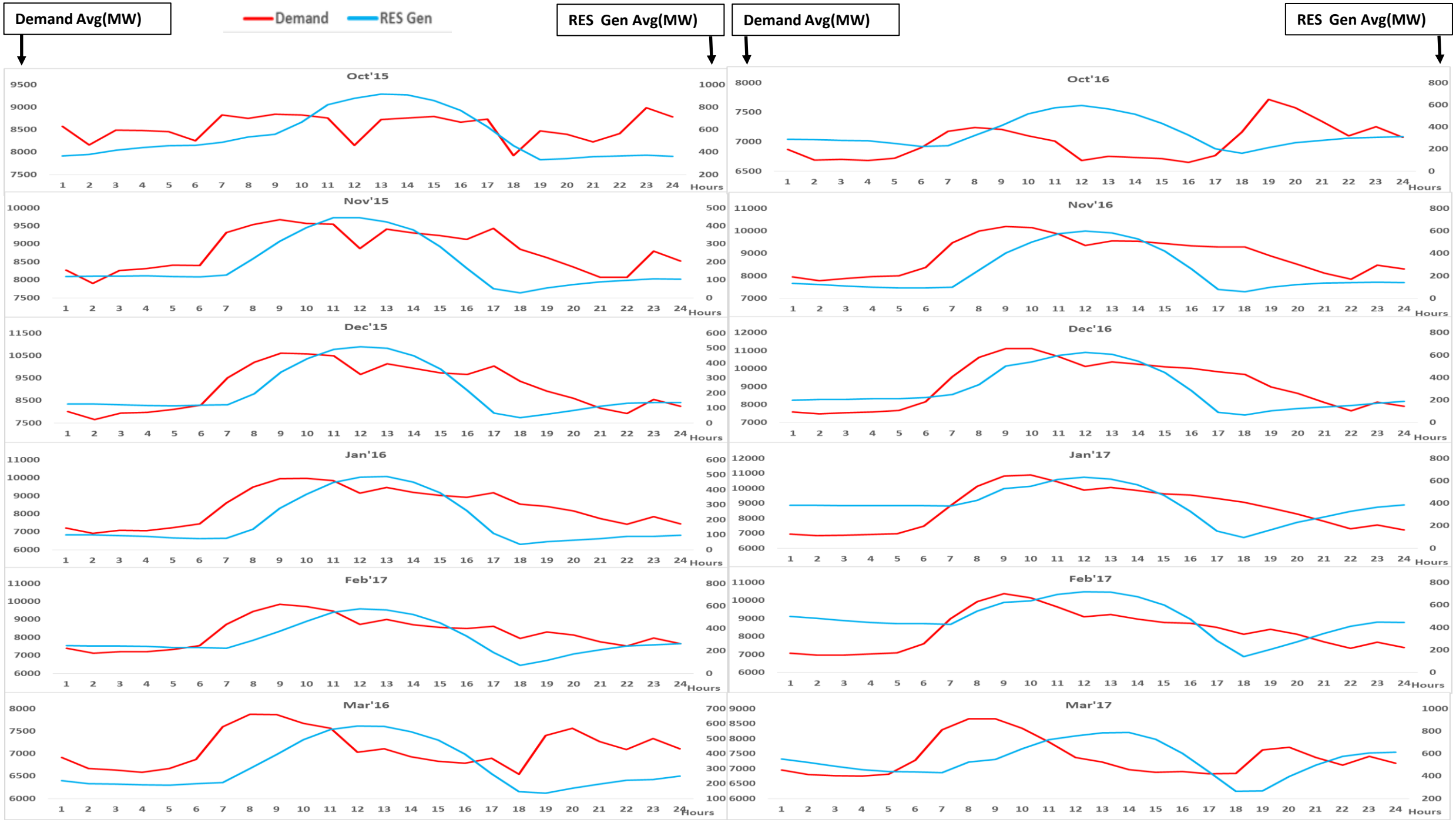




- October-December and January-March RES is increasing when demand is increasing in MP and it's also supporting the ramp down.

Madhya Pradesh _ Monthly Variation


Demand Avg(MW)
Demand
RES Gen
RES Gen Avg(MW)
Demand Avg(MW)
RES Gen Avg(MW)
Data is not available
Apr'15
May'15
Jun'15
July'15
Aug'15
Sep'15
Apr'16
May'16
Jun'16
July'16
Aug'16
Sep'16
Hours


Demand Avg(MW)
Demand
RES Gen
RES Gen Avg(MW)
Demand Avg(MW)
RES Gen Avg(MW)
Oct'15
Oct'16
Nov'15
Nov'16
Dec'15
Dec'16
Jan'16
Jan'17
Feb'17
Feb'17
Mar'16
Mar'17
Hours

Thanks……..

Keep Renewing the Renewables