Welcome to Presentation on Integration of RES to the WR grid

02nd Sept, 2015

Taj Lands End, Mumbai

Todays Topic

Injection of Renewable power on a large scale and its effect on the stability of the grid and operational cycle of conventional thermal power plants

Agenda

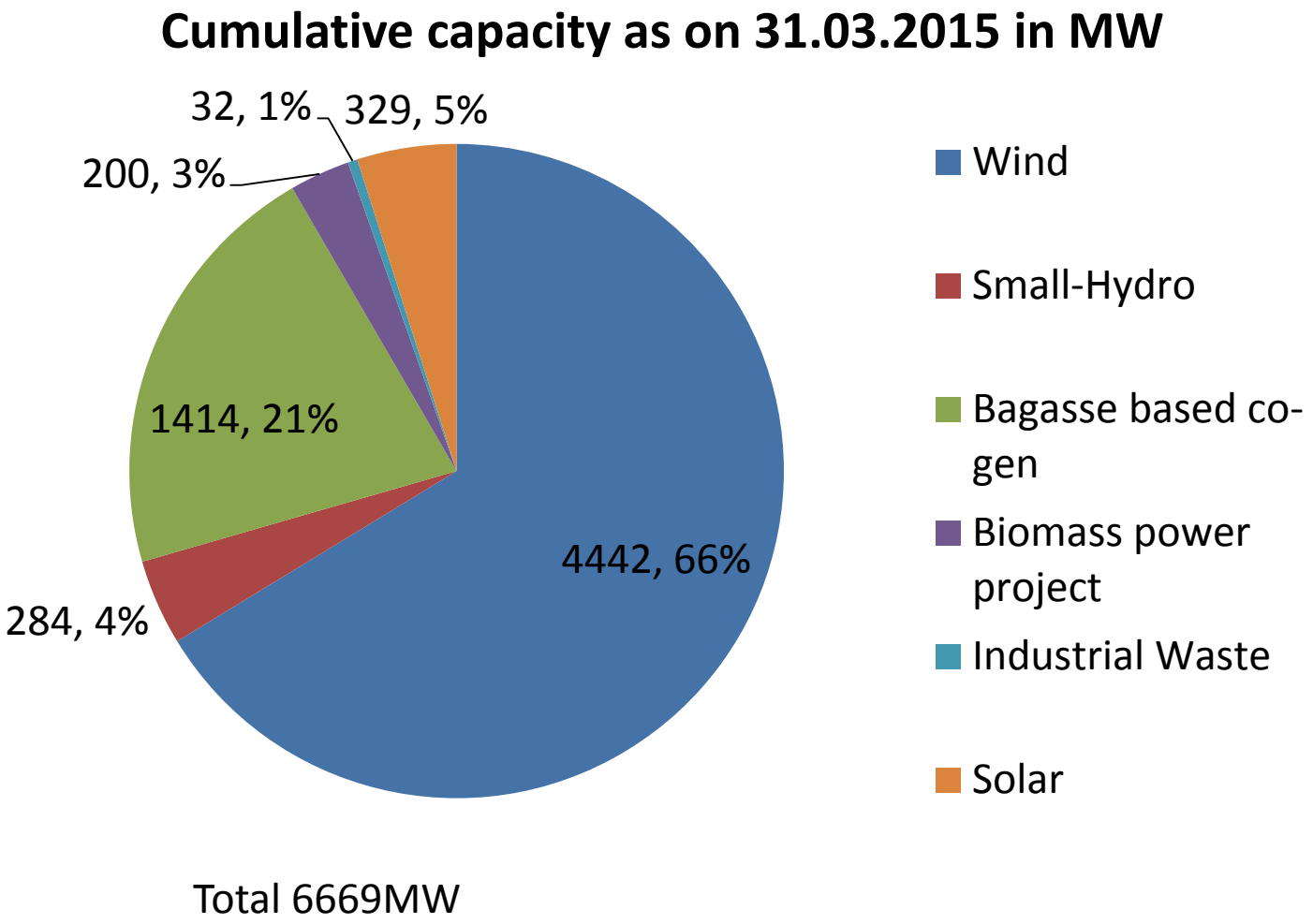
- Installed capacity – Statistics
- Variation in RES
- Forecasting tools
- Regulatory mechanism
- Impact on load generation balance
- Impact on Transmission system
- Impact on Deviation Settlement Mechanism (DSM)
- Impact on Thermal generation units

RE in Maharashtra Grid

Renewable Energy Source	Cumulative capacity as on 31.03.2015 in MW	Proposed Expansion as per State RE policy 2015
Wind	4442	5000
Small-Hydro	284	400
Bagasse based co-gen	1000	1440
Biomass power project	200	300
Industrial Waste	32	200
Solar	329	7500
Total	6669	14400

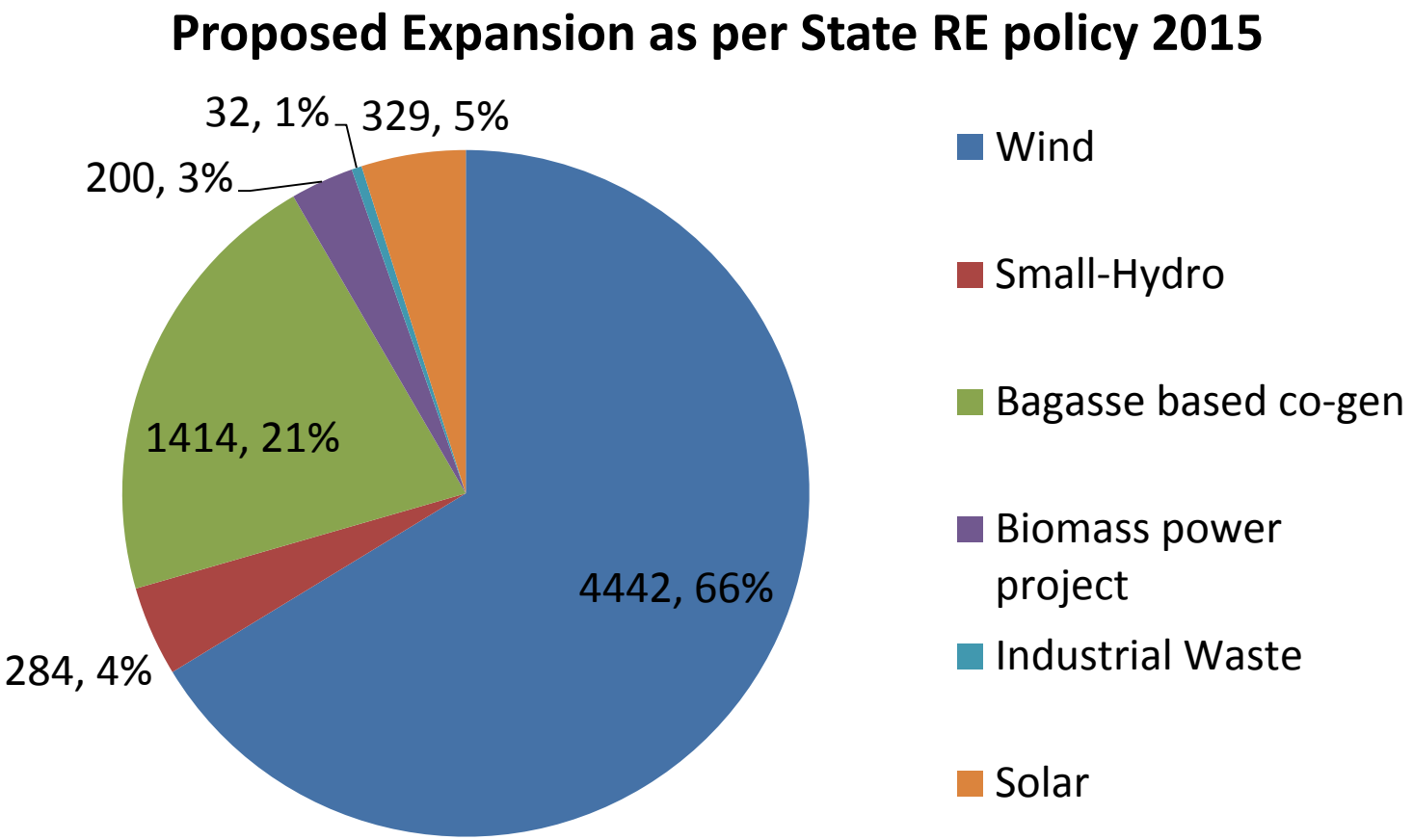
Source- MEDA and GoM Policy

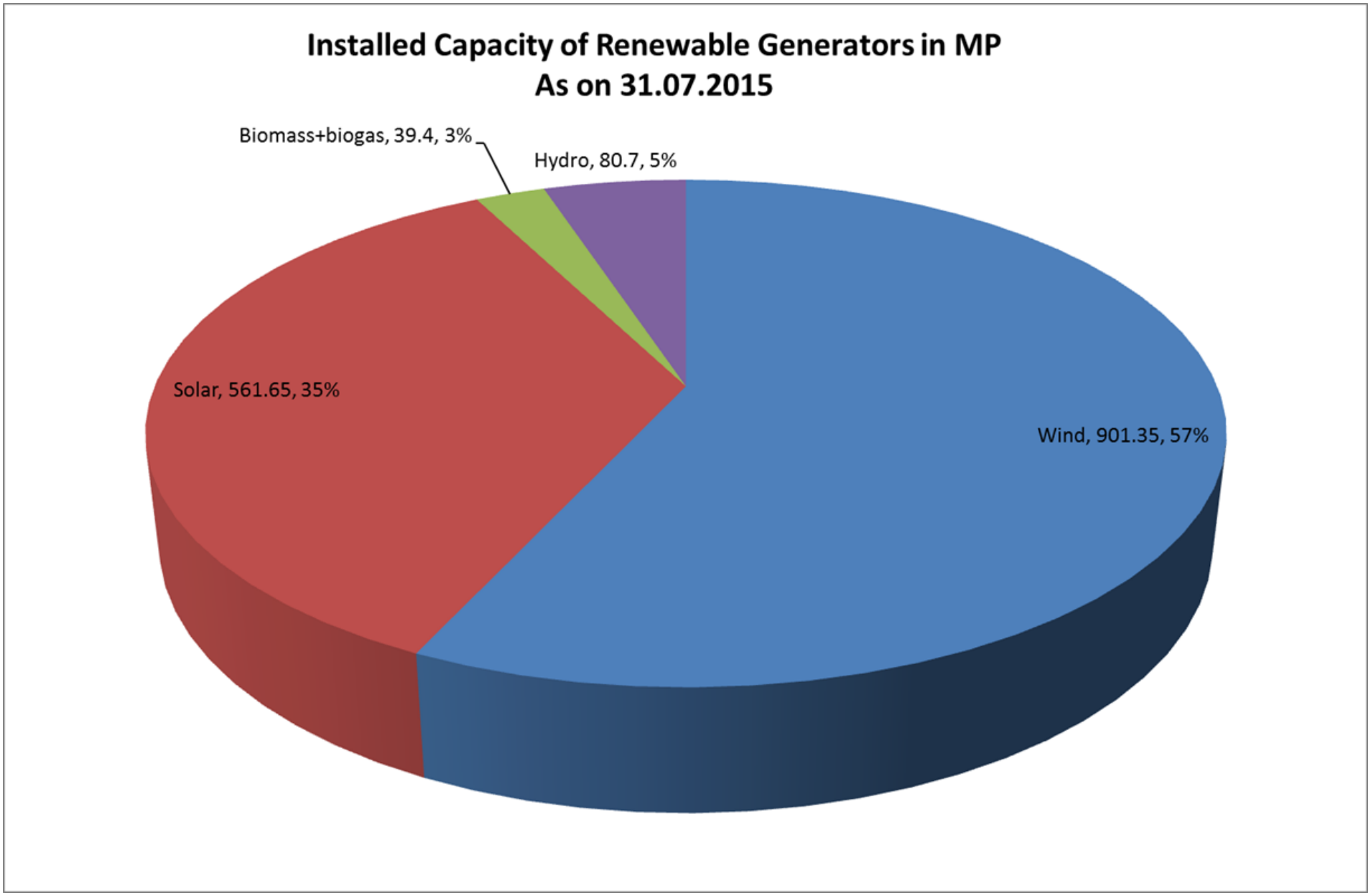
RE in Maharashtra Grid



Total 6669MW

RE in Maharashtra Grid




Installed Capacity of Renewable Generators in MP
As on 31.07.2015
Biomass+biogas, 39.4, 3%
Hydro, 80.7, 5%
Solar, 561.65, 35%
Wind, 901.35, 57%

Growth of Installed Capacity of Renewable Energy in MP

Fig in MW

Year	Wind	Solar	BioMass +Bio gas	Hydro	Total	Growth MW	Growth %
2010-11	278.60	0.00	3.95	80.70	363.25		
2011-12	308.90	2.50	12.65	80.70	404.75	41.50	11.42
2012-13	324.50	32.13	13.85	80.70	451.18	46.43	11.47
2013-14	346.90	320.51	21.90	80.70	770.01	318.84	70.67
2014-15	844.35	421.65	24.4	80.7	1371.1	601.09	78.06
2015-16 upto Jul 15	901.35	561.65	39.4	80.7	1583.1	212	15.46

Year wise Actual Injection of RE Generators in MP

Fig in MU

Year	Wind	Solar	BioMass+ Bio gas	Hydro	Total	% Growth
2010-11	267.81	0.0				
2011-12	328.01	0.00	5.54	227.38	560.93	560.93
2012-13	576.19	11.86	15.12	228.05	831.22	270.29
2013-14	515.63	242.86	37.67	289.95	1086.11	254.89
2014-15	604.85	609.15	78.31	208.15	1500.46	414.35
2015-16(upto	669.504	267.4	40.803	26.15	1003.857	

Total Installed Capacity in Gujarat as on July 31 2015 and % of RES component

Sr. No.	State	As on 31st July 2015			
		Conventional	RES	% of RES wrt total IC	% Growth in RES w.r.t. previous year
1	Gujarat	24,148	4,802	17%	8%

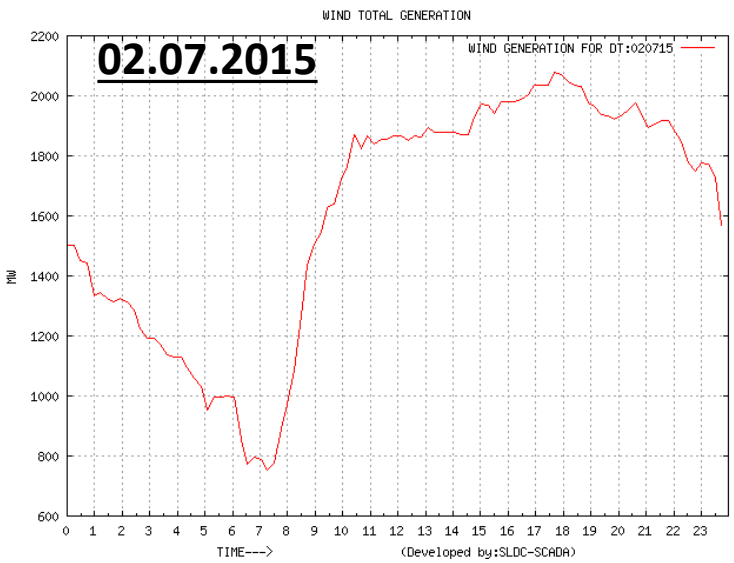
Total Installed Capacity in Western Region from 2012-13 to 2014-15 and % of RES component

Pattern of RES in GUJ

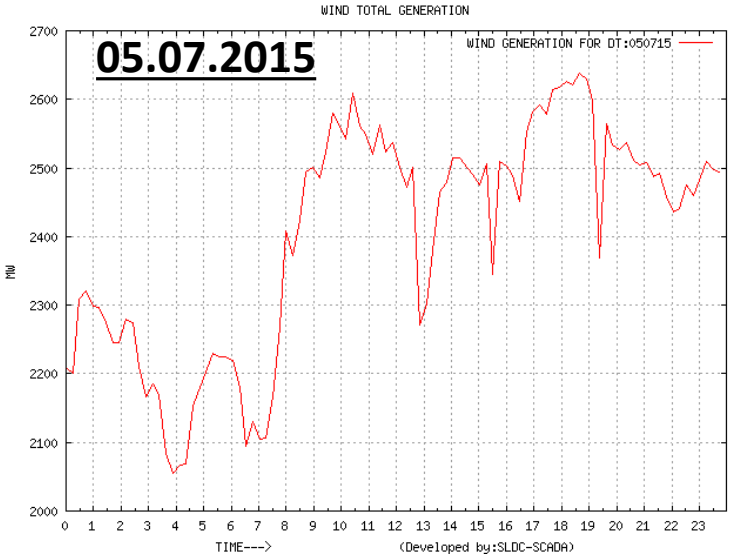
RE – Characteristics & Grid integration issues :

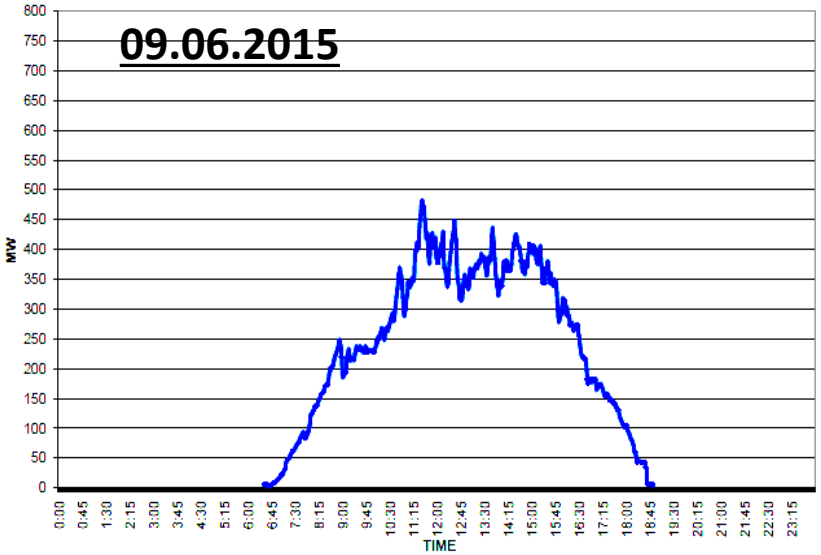
- **Uncertainty, Variability and Intermittency:**

The generation of RE resources are weather dependent – output is

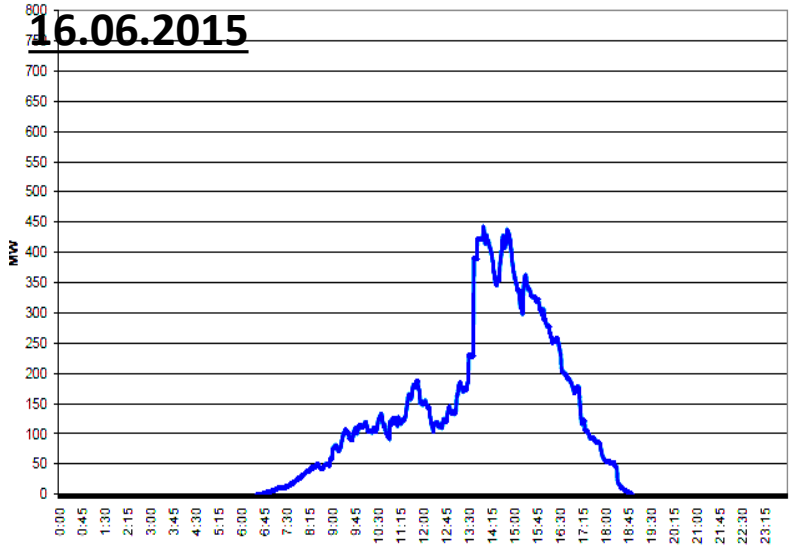


Wind





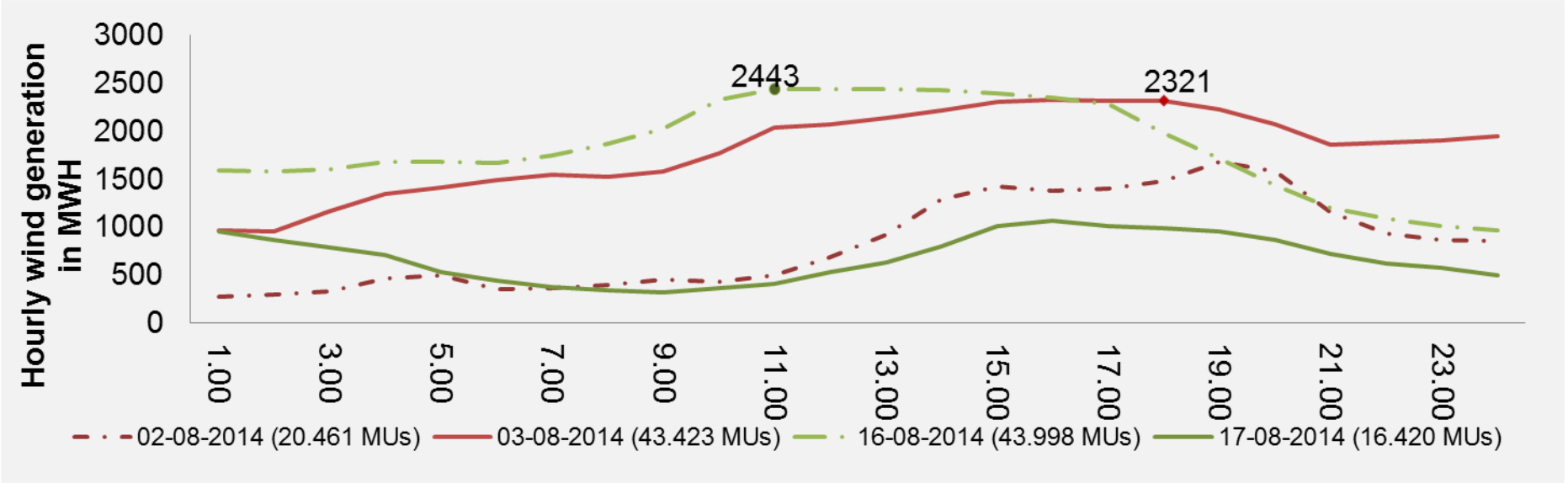
Solar



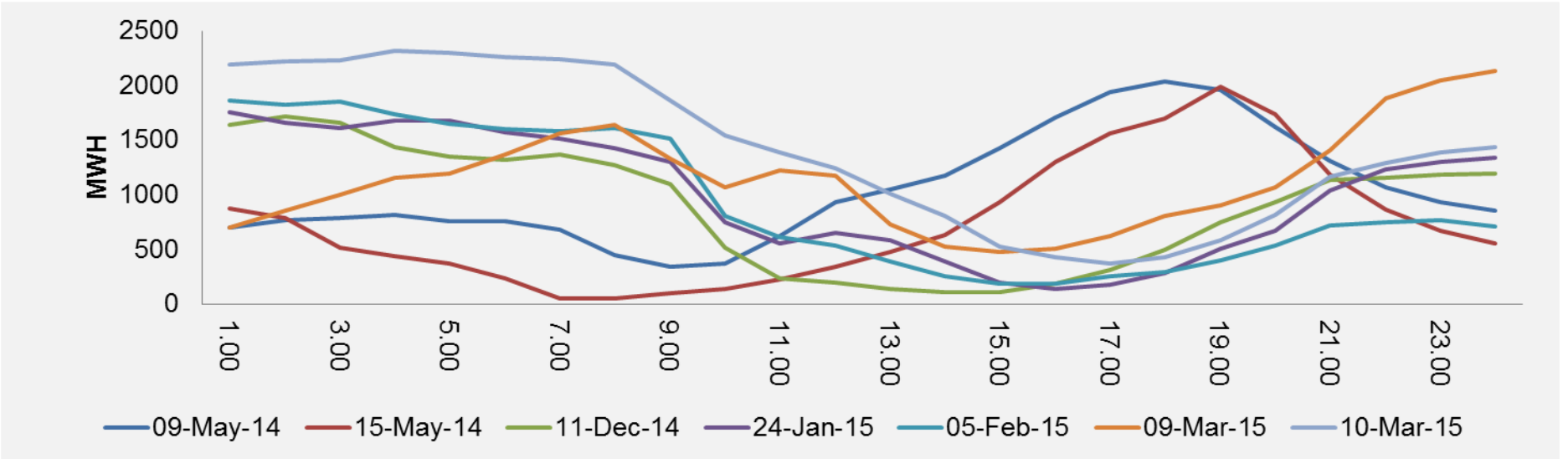
RE – Characteristics & Grid integration issues :

- **Uncertainty, Variability and Intermittency:**

Maximum variation in wind energy generation in MUs on two consecutive days:

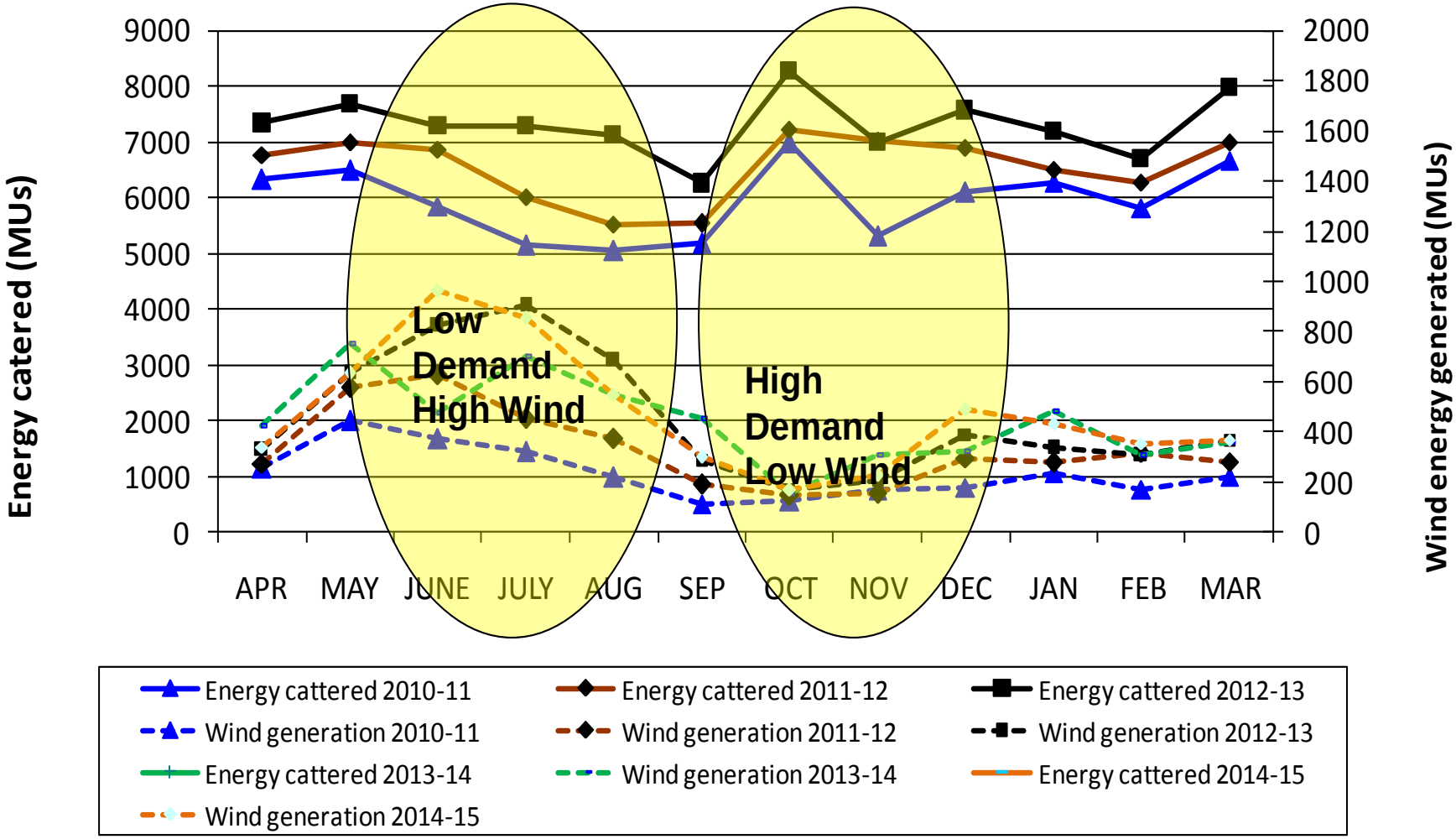


More than 1600 MW Wind variation in a day

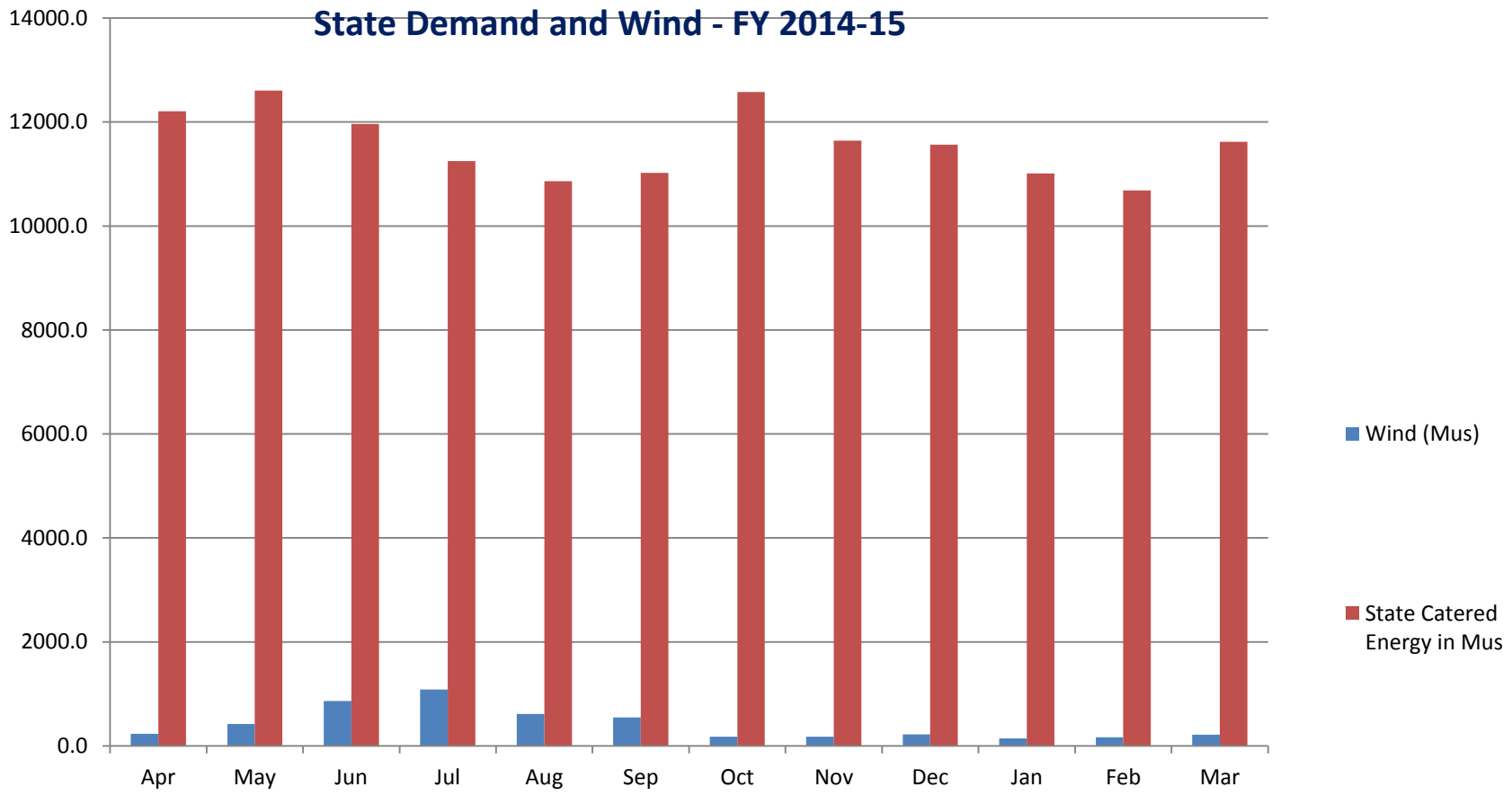


RE – Seasonal Availability

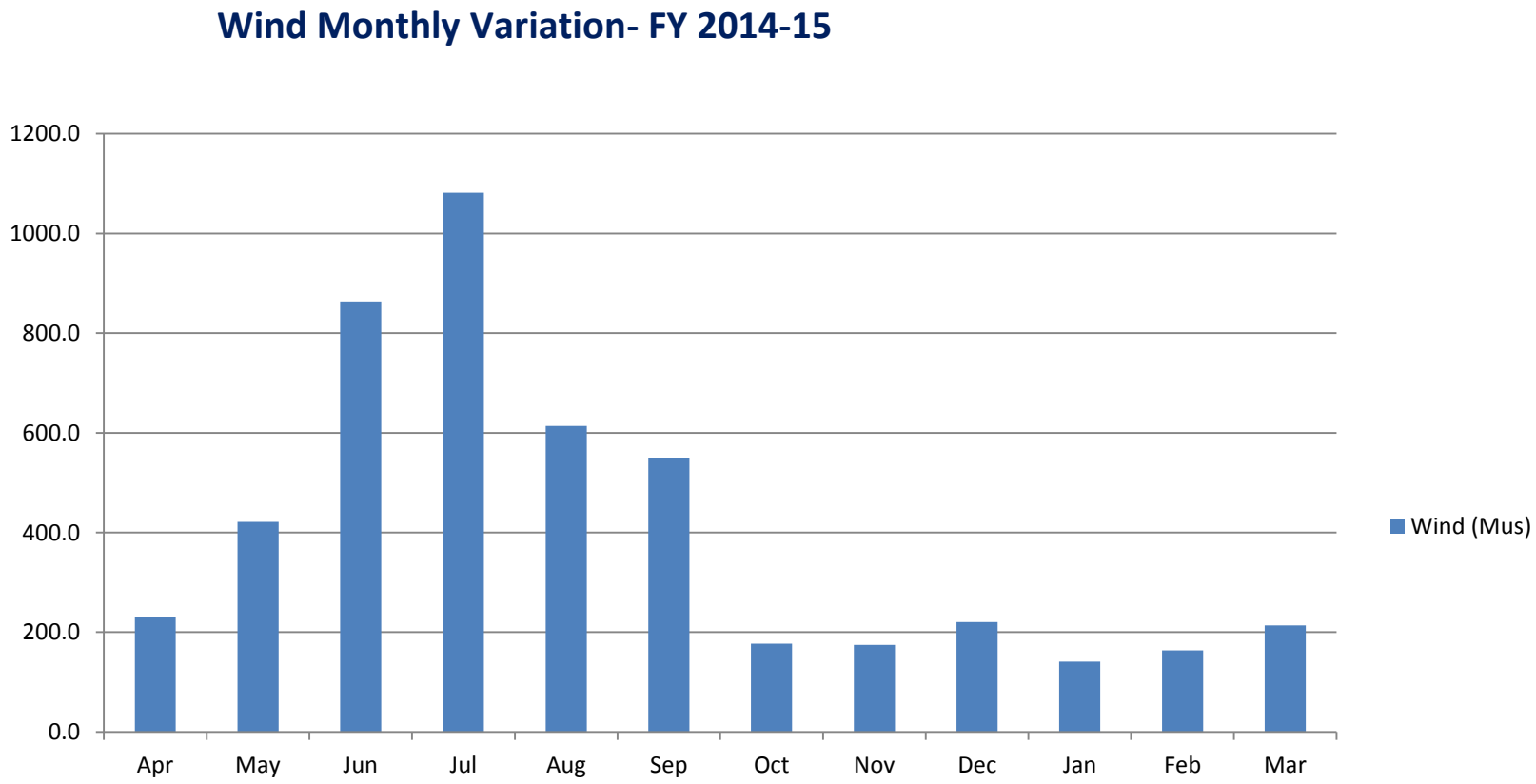
High wind availability in monsoon period – low domestic and agriculture consumption



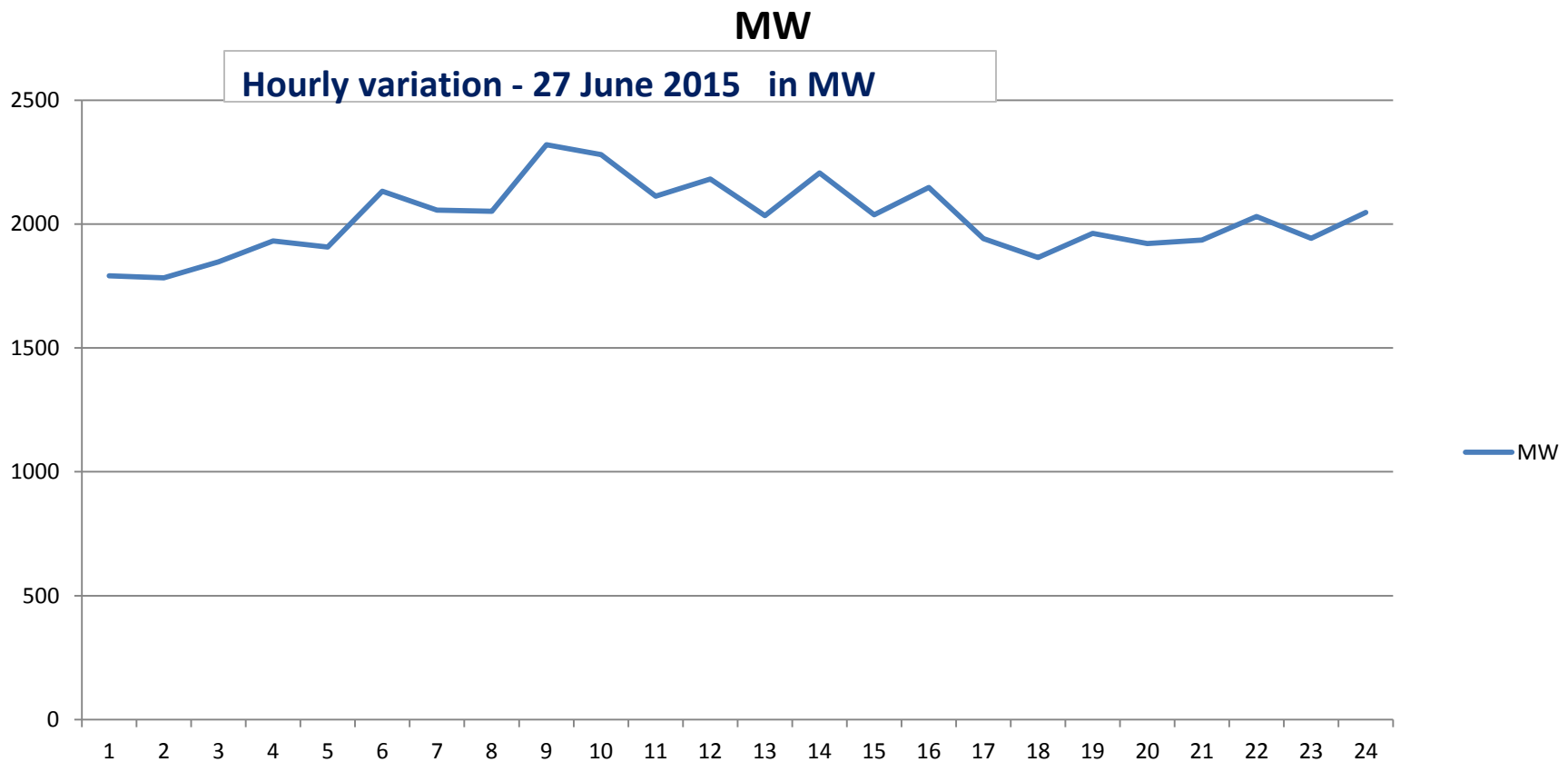
Contribution of wind energy to state demand



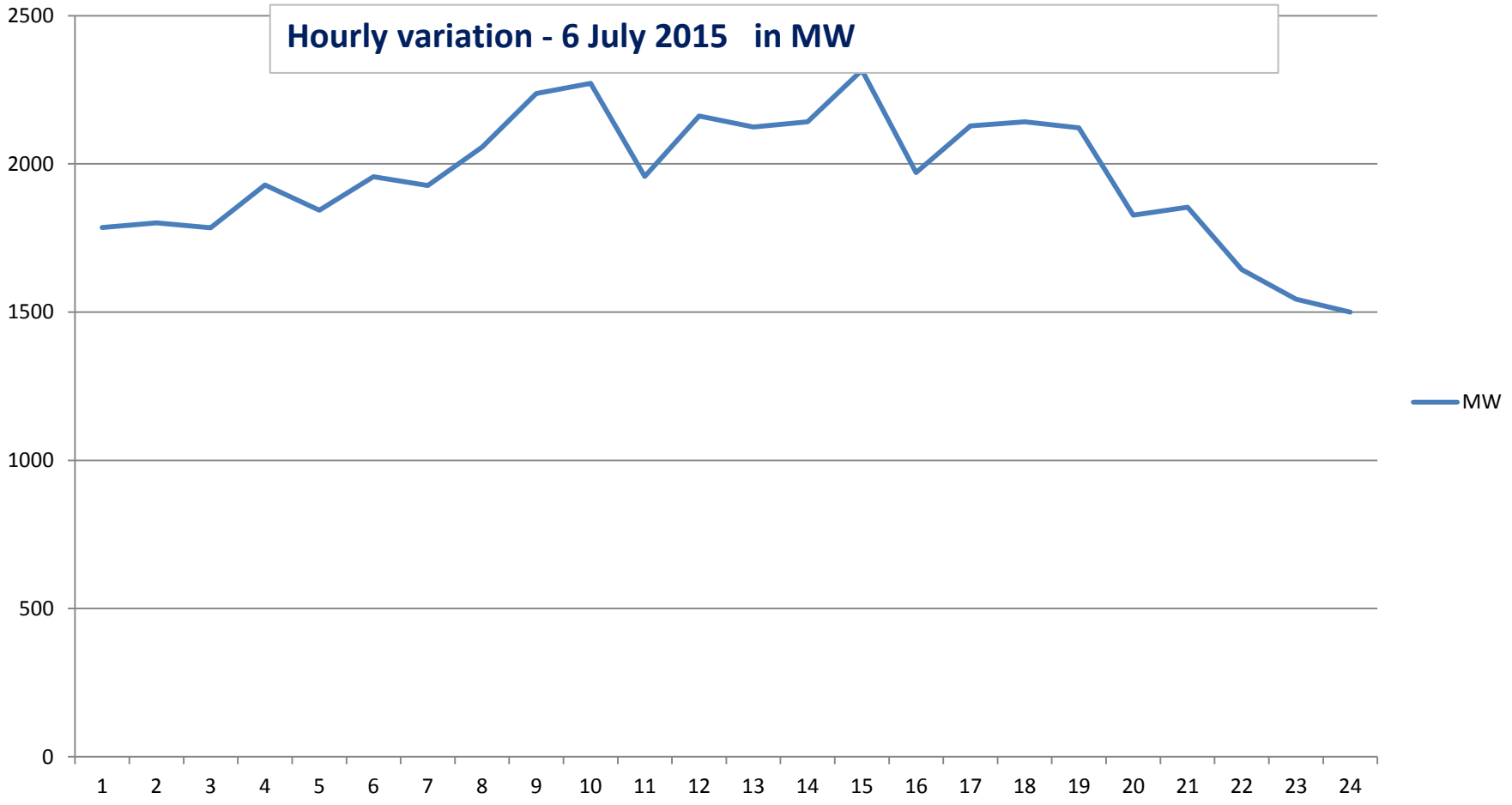
Wind- Monthly Variation



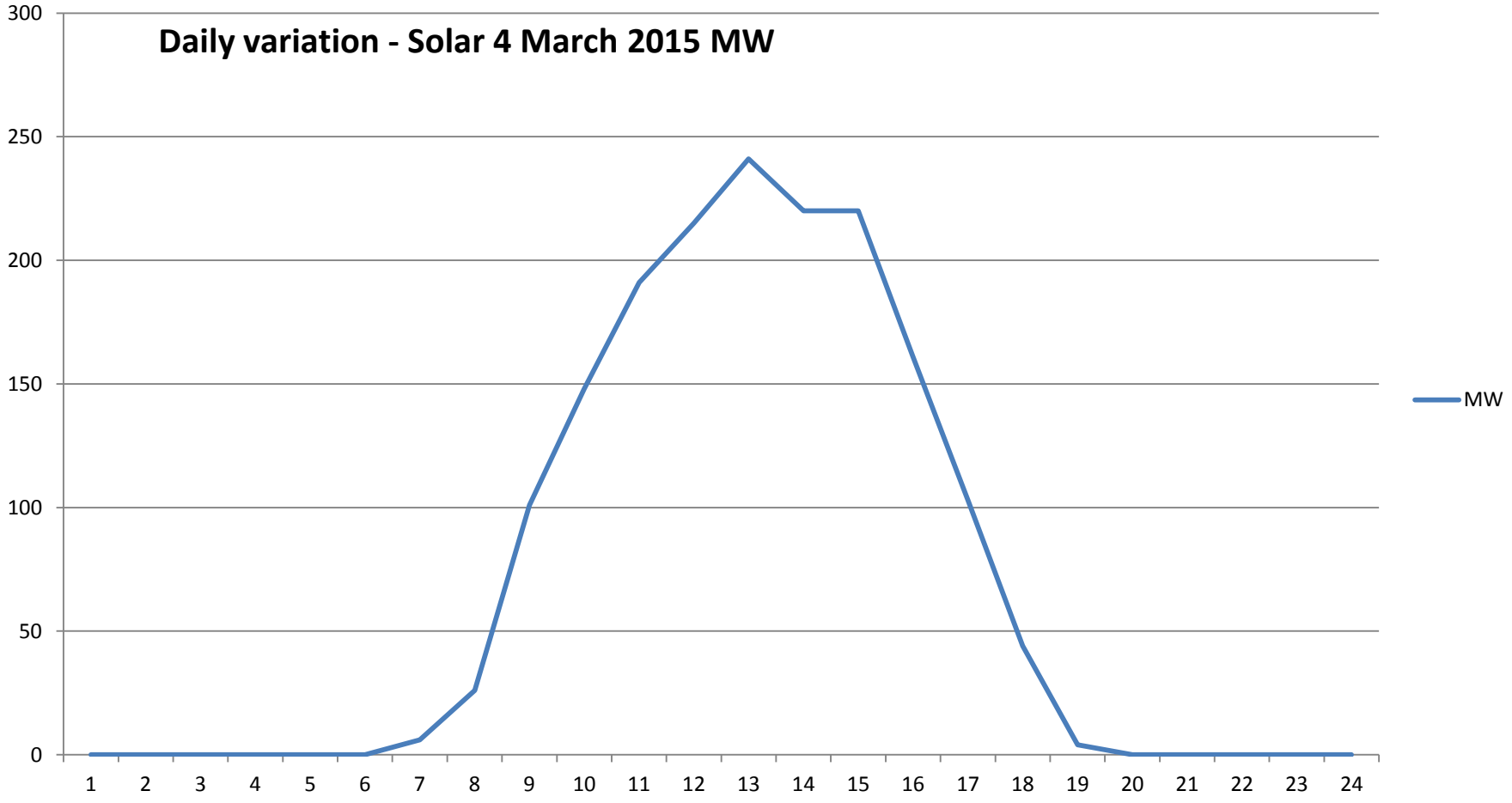
Wind- Hourly Variation



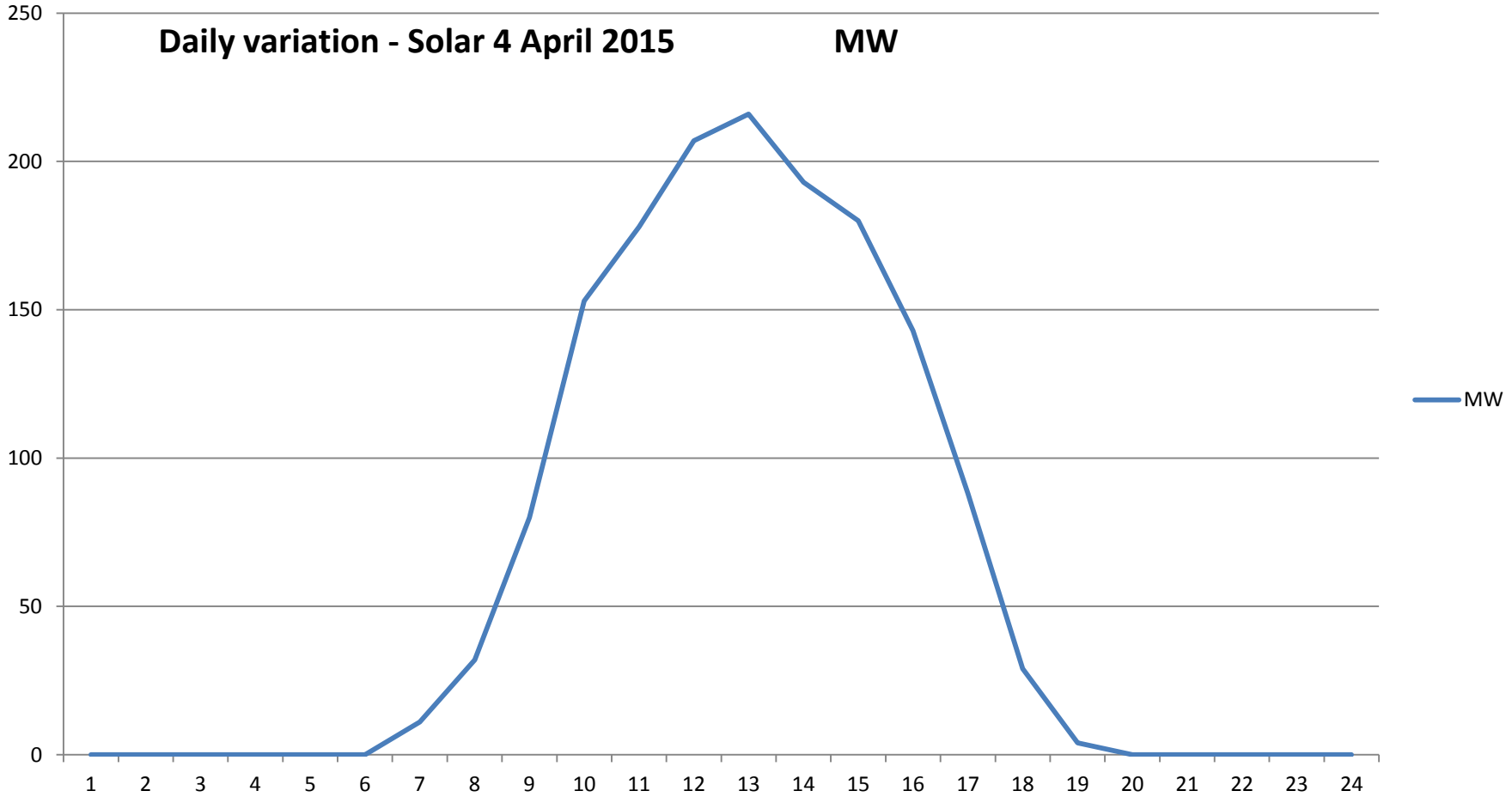
Wind- Hourly Variation



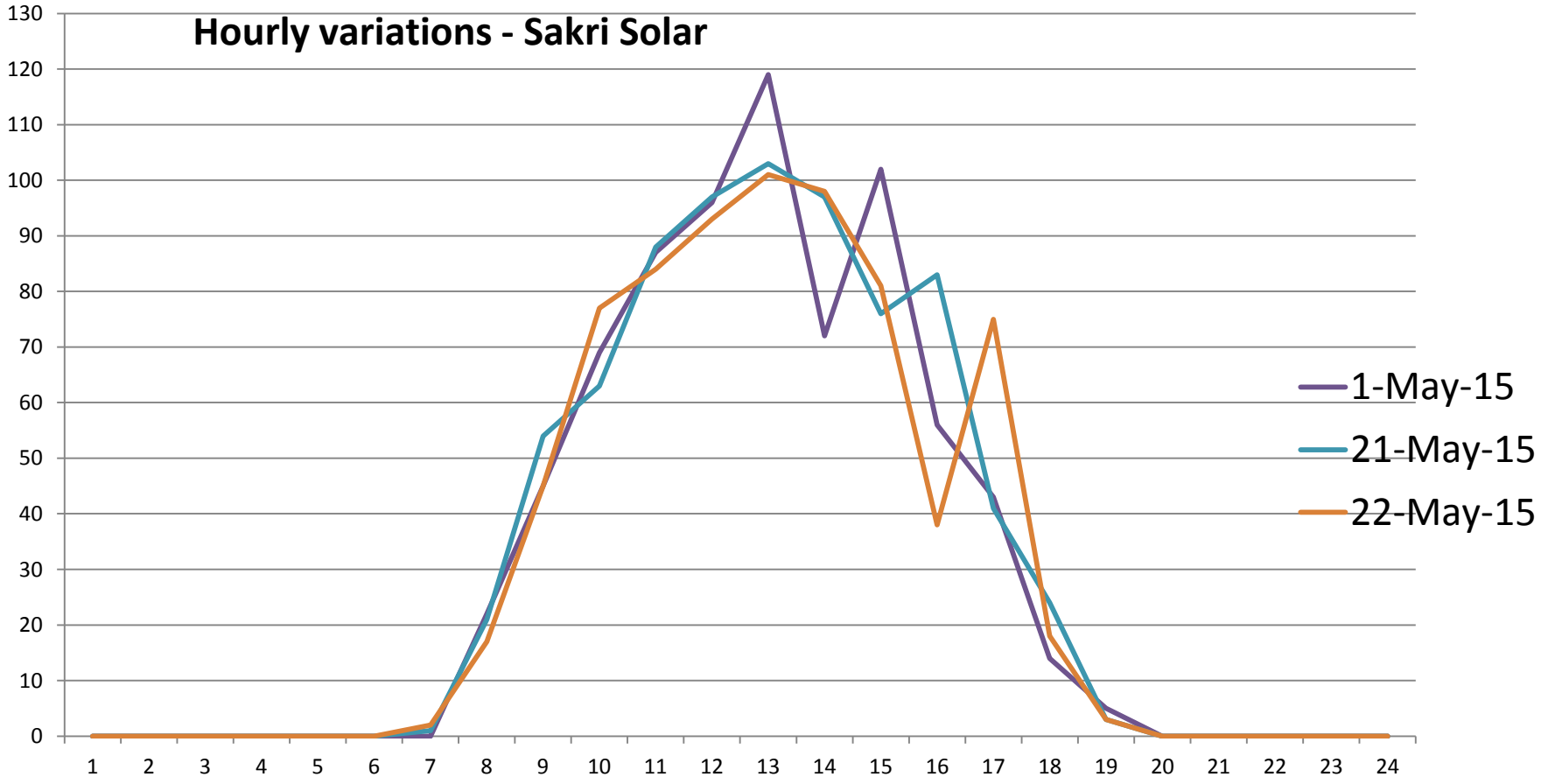
Solar- Hourly Variation



Solar- Hourly Variation

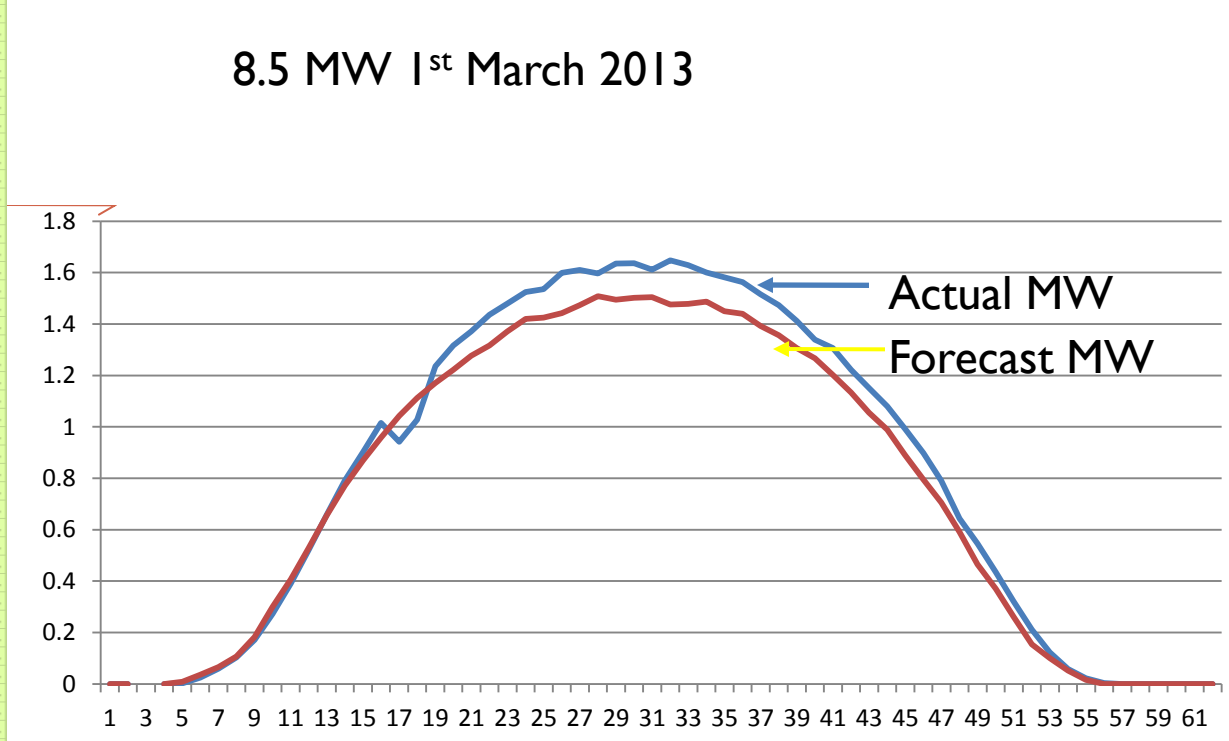


Sakri Solar- Hourly Variation

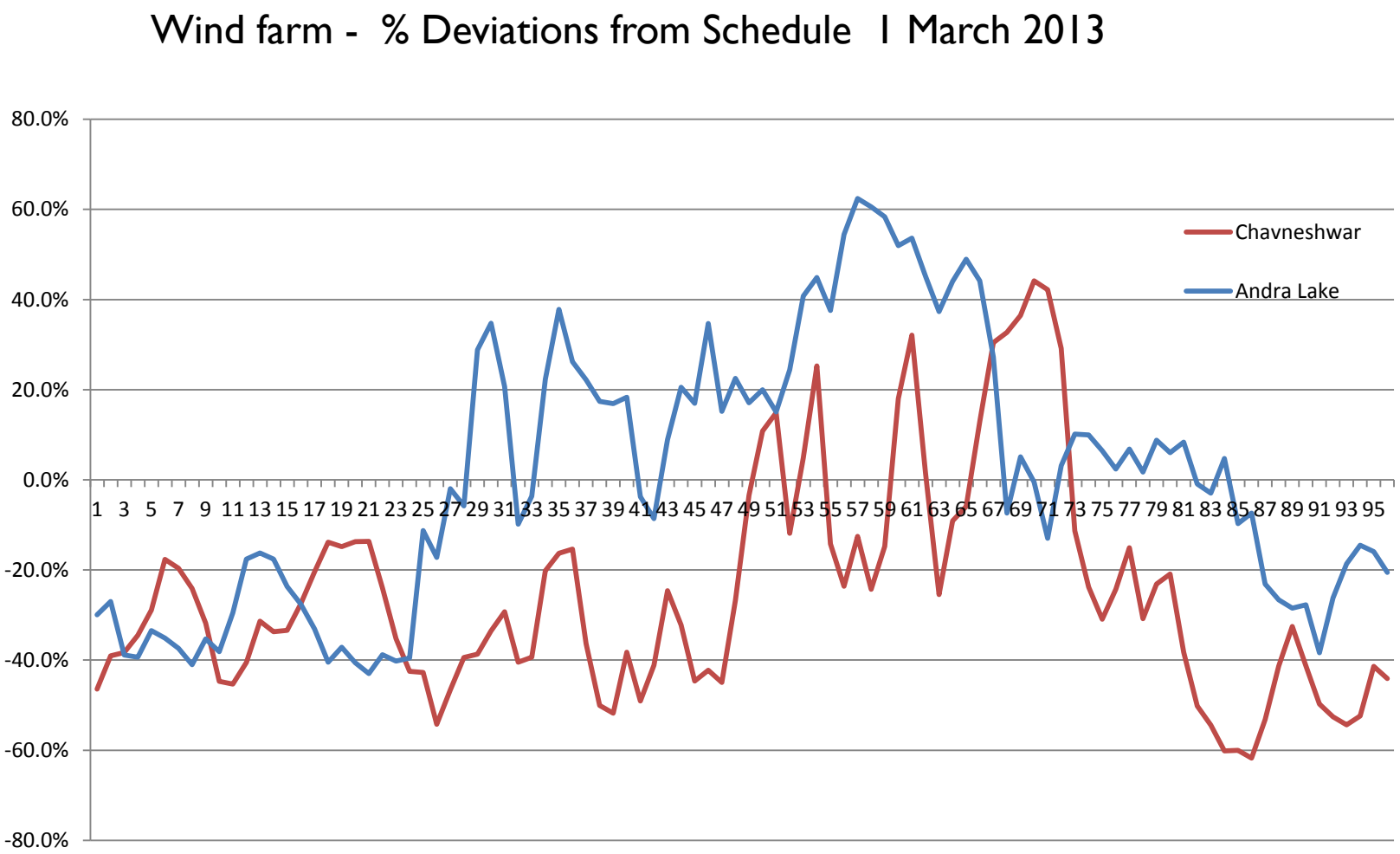


Solar Forecasting Performance

Block	Sch	Act	Dev%
5	0.001472	0.00781	430.4%
6	0.02417	0.03594	48.7%
7	0.058683	0.06484	10.5%
8	0.102504	0.10703	4.4%
9	0.1714	0.18203	6.2%
10	0.271882	0.3	10.3%
11	0.390219	0.40625	4.1%
12	0.521134	0.52813	1.3%
13	0.659005	0.65703	-0.3%
14	0.791456	0.77109	-2.6%
15	0.901654	0.87031	-3.5%
16	1.015183	0.95781	-5.7%
17	0.942118	1.04219	10.6%
18	1.027836	1.1125	8.2%
19	1.236374	1.17109	-5.3%
20	1.316501	1.22188	-7.2%
21	1.371348	1.27656	-6.9%
22	1.436072	1.31719	-8.3%
23	1.48016	1.37109	-7.4%
24	1.524253	1.41953	-6.9%
25	1.53609	1.425	-7.2%
26	1.599161	1.44219	-9.8%
27	1.610052	1.47344	-8.5%
28	1.597253	1.50859	-5.6%
29	1.635076	1.49453	-8.6%
30	1.636261	1.50234	-8.2%
31	1.611443	1.50469	-6.6%
32	1.648406	1.47578	-10.5%
33	1.628981	1.47891	-9.2%
34	1.600085	1.4875	-7.0%
35	1.58174	1.45	-8.3%
36	1.563329	1.43984	-7.9%
37	1.516144	1.39219	-8.2%
38	1.473729	1.35703	-7.9%
39	1.412327	1.30703	-7.5%
40	1.339728	1.26641	-5.5%
41	1.306551	1.20156	-8.0%
42	1.22265	1.13359	-7.3%
43	1.151023	1.05469	-8.4%
44	1.079776	0.98984	-8.3%
45	0.991467	0.88984	-10.3%
46	0.898997	0.79531	-11.5%
47	0.790599	0.70547	-10.8%
48	0.64355	0.59141	-8.1%
49	0.545423	0.46563	-14.6%
50	0.435453	0.37031	-15.0%
51	0.320944	0.26094	-18.7%
52	0.211146	0.15391	-27.1%
53	0.122857	0.1	-18.6%
54	0.057667	0.05156	-10.6%
55	0.022202	0.01563	-29.6%
56	0.003274	0	-100.0%
57	0	0	



Wind- Deviations from forecast



RE – Grid integration issues : Operational (Guj)

- **Variation in Wind Generation : impact**

Variation in wind generation in MW	No of Days 2012-13	No of Days 2013-14	No of Days 2014-15
more than 1000 MW	60	82	94
more than 500 MW	252	267	257
less than 500 MW	113	98	108

Wide variation of 1000-1200 MW generation in a day from renewable sources in a day is quite common.

CERC (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations, 2012 dated Dated: 06.02.2012

Regulation : 11. Despatch principles for electricity generated from Renewable Energy Sources:

(1) All renewable energy power plants, except for biomass power plants with installed capacity of 10 MW and above and non-fossil fuel based cogeneration plants, shall be treated as 'MUST RUN' power plants and shall not be subjected to 'merit order despatch' principles.

CERC (IEGC) Regulations, 2010.

Must run provision

Regulation 5.2 (u) : Special requirements for Solar/ wind generators

System operator (SLDC/ RLDC) shall make all efforts to evacuate the available solar and wind power and treat as a must-run station. However, System operator may instruct the solar /wind generator to back down generation on consideration of grid security or safety of any equipment or personnel is endangered and Solar/ wind generator shall comply with the same. For this, Data Acquisition System facility shall be provided for transfer of information to concerned SLDC and RLDC

Central Electricity Regulatory Commission (Deviation Settlement Mechanism and related matters) (Second Amendment) Regulations, 2015, Dated 07Aug 2015:

to come into force with effect from 1st November, 2015

Scheduling of RE energy

- RRF (Renewable Regulatory Fund) mechanism was introduced by CERC from July 2013, however subsequently it was suspended due to implementation issues.

- CERC has now issued a 'Framework for Forecasting, Scheduling & Imbalance Handling for Renewable Energy (RE) Generating Stations based on wind and solar at Inter-State Level', however the same is applicable only to CTU connected wind and solar generations.

- CERC is also in process of preparing a model for state embedded generators.

- State Regulator has exempted all RE generators from scheduling.

Roadmap for forecasting and scheduling

- Identify a lead generator/coordinating agency at pooling station level.
- Ensure infrastructure for telemetry and forecasting
- Static data of wind turbines under pilot, like turbine capacity, type, MSL, hub height, lat/long power curve etc
- Appoint a forecasting agency equipped with required resources and forecasting tools
- Establish a protocol for data and information exchange with SLDC
- Daily monitoring of schedules vs actual for assessment of forecasting accuracy

. .. Let us work together and make a start to move forward ..!.

Generation forecasting

- All generation and load forecasting at SLDC takes place at 15 min time blocks over a day.
- Declared generation capacity has to be matched with forecasted load.
- Thus generation is planned i.e. scheduled as required for meeting the load.
- Certain generation like irrigation/drinking water linked hydro and RE is classified as must absorb i.e. ‘MUST RUN’.
- On account of this, conventional generation is regulated on Merit Order Dispatch Principles, based on forecasted availability of small hydro and RE generation.

Issues in inter-state open access of RE

- No mechanism for settlement of deviations by RE generators.
- Power transaction in inter-state is scheduled by RLDC.
- In case of RE at present, RLDC schedules RE power just like a conventional power.
- Therefore the buyer state gets power as per the schedule.
- However, MERC ABT mechanism exempts RE generators from imbalance charges.
- Deviations by the RE generator have to be absorbed by the state in which the generator is embedded.

Forecasting of RE generation

- The patterns of variations in demand are known for many years and can be fairly predicted.
- Scientific tools available for demand forecasts are able to forecast load to the accuracy level of 4-5%.
- Among RE category, bagasse based co-generation and solar power has comparatively fair accuracy of forecast.
- Such is not the case with wind power.
- Although forecasting tools of high accuracy are available, practically no wind generators/developers are not providing forecasts to SLDC.

Grid Operation

- The most important responsibility of an SLDC is to ensure integrated and secure operation of the grid.
- The second most important function at SLDC is balancing of load and generation in real time with due consideration to economic dispatch.
- The above two activities are ‘mission critical’.
- Scheduling of power for day-ahead and in real time current day thus assumes significant importance.
- Scheduling in turn is dependent upon generation and load forecasting.

Challenges of RE Energy for

- Transmission grid operation
- Conventional plant

RE – Grid integration issues : Transmission Grid

- **Grid operation constraints:**
  - **High voltage scenario** during less RE injection
  - Under utilization of EHV network
  - **Reactive power** management
  - **Consumption of Reactive Power**
  - **increases system losses**
  - **low voltage at tail end and hence voltage stability of the grid is affected.**
  - **Voltage control and stability of the grid - affected.**

RE – Grid integration issues : Transmission Grid

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

  ➢ planned separation or isolation of network is carried out to avoid major black out.

- **Harmonic resonance in RE Energy Source.**

  ➢ interaction of harmonic currents from the devices with high impedance caused due to parallel resonance leads to a high harmonic distortion in voltage. Such **high harmonic voltage can adversely impact system equipment and other customer loads.**

RE – Grid integration issues : Transmission Grid

- **Large amounts of RE generation**

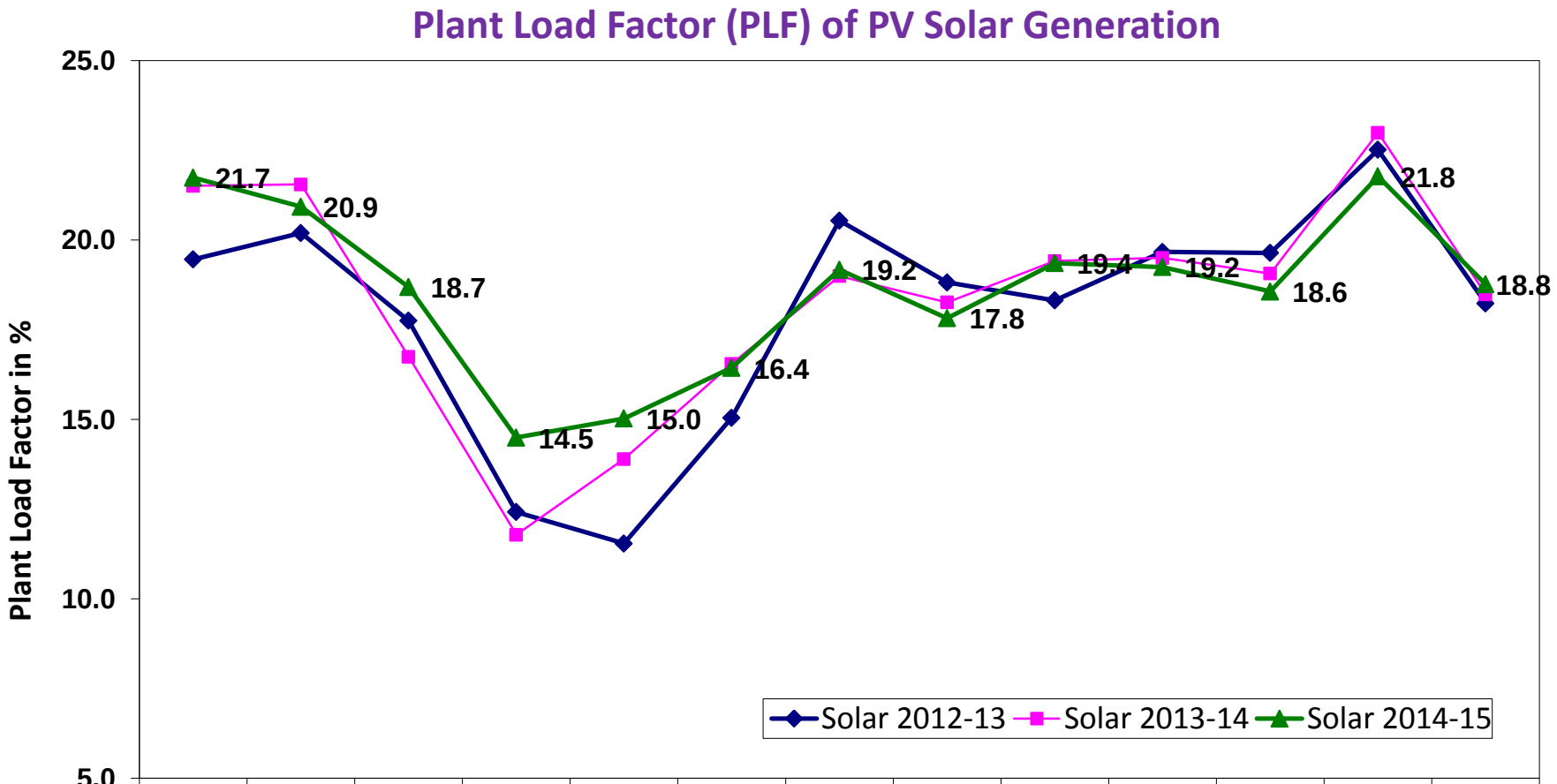
  Operational **reliability issues.**

- **Over drawl (OD) / Under drawl (UD) within ± 150 MW** of ISGS schedule to be adhered to for grid discipline compliances under Deviation Settlement Mechanism (DSM)

- **Difficult to manage Over Drawl and Under Drawl**
  - Within limit of ± 150 MW or 12 % of its schedule whichever is less as per Hon'ble CERC, Deviation Settlement Mechanism (DSM) regulation.

RE – Network Utilization: solar

Low PLF does not justifies transmission infrastructure cost.



	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Overall
Solar 2012-13	19.5	20.2	17.8	12.4	11.5	15.0	20.5	18.8	18.3	19.7	19.6	22.5	18.2
Solar 2013-14	21.5	21.6	16.7	11.8	13.9	16.6	19.0	18.3	19.4	19.5	19.1	23.0	18.5
Solar 2014-15	21.7	20.9	18.7	14.5	15.0	16.4	19.2	17.8	19.4	19.2	18.6	21.8	18.8

RE – Grid integration issues : Transmission Grid

- **Location at remote places**
  - adequate grid infrastructure is needed to transmit the RE energy to the load centers **leads costing and voltage stability issue.**
- **Long distance**
  - causes constraints in the grid parameters in the form of **over voltage & voltage fluctuations.**
- **Seasonal availability**
  - transmission network developed for RE stations remains unutilized during low RE generation scenario.
  - **high voltage** scenario during low wind generation and off-peak condition.
  - Due to intermittent characteristic of RE, generator start up will take place multiple times during a day, resulting in **huge quantum of reactive power absorption from the grid and causing voltage excursions / voltage stability.**

RE – Grid integration issues : Conventional Plant

- **Impact due to cycling - Increased capital and maintenance costs**

Increased cycling and rapid ramping up and down **may result in wear and tear impacts** that lead to increased capital and maintenance costs and degraded performance over a period of time.

- **Impact on heat rate of thermal power plants-**

heat rate shall increase due to running of generator below rated capacity.

RE – Grid integration issues : Conventional Plant

Inefficient operation

– Technical minimum operation

Frequent back down / ramp up to honor "Must Run" status

– Higher Heat rates and emission from fossil fuel generators

– Affects performance of Conventional plants

Backing down of cheaper generation

– to restrict OD / UD within 150 MW, to honor "Must Run" status, cheaper generation is backed down

– Backing down of conventional generation of large size efficient units.

Financial Impact (Maharashtra)

- Due to capping and charges on under-drawal of energy from the national grid under Deviation Settlement Mechanism (DSM), states are losing heavily especially because of unexpected variations in wind energy.

- Discoms have to pay to wind farms at preferential rate on one hand and receive nothing/pay to regional pool for the same in case of under-drawal on the other hand.

- On 8 Sept 2014, variation in wind power was witnessed from 1528 MW min to 2286 max (about 250 MW under-drawal at high frequency) generating 48.7 Mus.

- Maharashtra has lost around Rs 1.80 crore towards capping on under-drawal (which was 7.5 Mus) in the same day, while in the same week the state has lost Rs 4.42 crore due to capping on deviation charges.

Issues in intra-state open access of RE

- RE generators get connectivity from discom/transco.
- RE generators apply for open access after the connectivity and synchronization
- Commencement of open access takes 1-2 months as the same has to be taken from -
  - Discom in which the generator is located
  - STU/SLDC for transmission OA
  - Discom in which the buyer is located
- As per MERC OA regulations, power cannot be injected without open access

Deviation Settlement Mechanism

Charges for deviation as per Hon'ble CERC regulation w.e.f. 17.02.14

No over drawl is allowed. Overdrawl @ 16.48 Rs / KWh i.e. 100% additional charge of Freq 49.70 Hz

Under drawl / over injection Penalty @ 1.78 per KWh

Frequency range								
49.70	49.75	49.80	49.85	49.90	49.95	50.00	50.05	50.10
Rate in Rs per KWh								
8.24	6.99	5.94	4.90	3.86	2.82	1.78	0.00	0.00

Under drawls by the buyer / Over injcetion by seller in a time block in excess of 12% of schedule or 150 MW, shall be zero".

If 12% of drawl schedule is more than 150 MW, then additional charges is as below:

- OD in range (150 to 200 MW) 20% additional charges.
- OD in range (200 to 250 MW) 40% additional charges.
- OD more than 250 MW , 100 % additional charge

If 12% of drawl schedule is less than 150 MW, then additional charges is as below:

- OD in range (12% to 15%) 20% additional charges.
- OD in range (15% to 20%) 40% additional charges.
- OD more than 20%, 100 % additional charge

Sustain deviation from schedule in one direction (+/-) of entity, entity shall have to make sign change at least once after every 12 time block.

Impact of variation in wind generation on Deviation Settlement Mechanism

- SGS/ISGS cannot be back 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 excess of 12% of schedule or 150 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 12% of schedule or 150 MW which ever is lower)
- Similarly, as per DSM, every entity has to make sigh 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.

Table – I: Deviation Charges in case of under injection (Maharashtra)

Sr. No.	Absolute Error in the 15-minute time block	Deviation Charges payable to Regional DSM Pool
1	< = 15%	At the Fixed Rate for the shortfall energy for absolute error upto 15%
2	>25% but <=35%	At the Fixed Rate for the shortfall energy for absolute error upto 15% + 110% of the Fixed Rate for balance energy beyond 15% and upto 25% + 120% of the Fixed Rate for balance energy beyond 25% and upto 35%
3	> 35%	At the Fixed Rate for the shortfall energy for absolute error upto 15% + 110% of the Fixed Rate for balance energy beyond 15% and upto 25% + 120% of the Fixed Rate for balance energy beyond 25% and upto 35% + 130% of the Fixed Rate for balance energy beyond 35%

Table – II: Deviation Charges in case of over injection (Maharashtra)

Sr. No.	Absolute Error in the 15-minute time block	Deviation Charges payable
1	< = 15%	At the Fixed Rate for excess energy upto 15%
2	>15% but <= 25%	At the Fixed Rate for excess energy upto 15% + 90% of the Fixed Rate for excessenergy beyond 15% and upto 25%
3	>25% but <=35%	At the Fixed Rate for excess energy upto 15% + 90% of the Fixed Rate for excess energy beyond 15% and upto 25% + 80% of the Fixed Rate for excess energy beyond 25% and upto 35%
4	> 35%	At the Fixed Rate for excess energy upto 15% + 90% of the Fixed Rate for excess energy beyond 15% and upto 25% + 80% of the Fixed Rate for excess energy beyond 25% and upto 35% + 70% of the Fixed Rate for excess energy beyond 35%

- Fixed Rate is the PPA rate as determined by the Commission or adopted by the Commission.

- In case of multiple PPAs, the weighted average of the PPA rates shall be taken as the Fixed Rate.

- States do not have regulatory framework for handling the deviation of Solar/Wind generation.
- Therefore there are no deviation charges for intra State Solar/Wind generators and the deviation by States in the regional DSM A/cs due to these variations have to be absorbed by States.

Impact of RE Generation - conventional plant

- **"Must Run" status** – State generating plants to account for RE variability and not the Interstate Generation Station (ISGS)

- **Uneconomical operation of power plants**

  - **Scheduling of costlier generation** when the system demand is high and RE generation is on lower side.
  - **Backing down of cheaper generation**, particularly in night hours when system demand is remaining less and wind generation is on higher side.
  - **Reserve capacity** of 500 MW to 1000 MW is needed to balance the RE generation variations.

Conclusion

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Ambitious target of 60,000 MW wind generation by 2020 – 22.

- Network development (Green Corridor) seamless grid operation with balancing mechanism to overcome wind characteristics,

- Establishment of REMC with full-fledged forecasting mechanism in collaboration with stake holders,

- RE grid code,
  - Sharing of static & variable data by Wind developers
  - Sharing real time wind generation data of each wind mills existing and up coming
  - Sharing real time weather data of each wind mills existing and up coming

- last but not the least, regulatory and commercial frame work to even out the burden on hosting State due to suspension of RRF mechanism.

Way forward

Introduction of new regulations:

- **Need of separate grid code**

- Grid operation parameters
- Grid operation rules
- Grid support systems
- Grid connectivity
- Grid code obligation
- Role & Responsibilities of each stake holder
- Responsibilities of RE owners to meet grid operation requirements
- Network development responsibility
- Reactive power management
- Voltage mitigation
- Type of wind generators
- Type of technologies in Solar
- Incentive schemes for host RE generation States Energy Accounting
- Balancing Mechanism

Modification of regulations:

- **Revision and implementation of the RRF mechanism & Draft forecasting, scheduling regulation**

  - Applicability to Inter as well as intra state.
  - Applicability to all renewable generators irrespective of installed capacity and date of commissioning.
  - Regulator should provide more flexibility to grid operator by revising DSM regulation.

Grid management:

- **Realistic and accurate wind generation forecasting**

- **Balancing Mechanism**
  - Developing gas based generating station & special APM gas allocation.
  - Development of Micro and Mini grid with RE generation.
  - Pumped storage. (No installation & old non-working)

- **Authority at State and Regional level could be decided for:**
  - RE generation forecasting with role and responsibility of each stake holder.
  - Develop Renewable Energy Management Center (REMC).
  - Transmission network development for smooth evacuation of renewable generation both at State and Central level.
  - Tie up with R & D agency which should also carry out regular study of grid in respect of Harmonics, Var injection / absorption, PV curve etc.

Thanking you !!!