Large Scale Grid integration of Renewable Energy Sources - Way Forward

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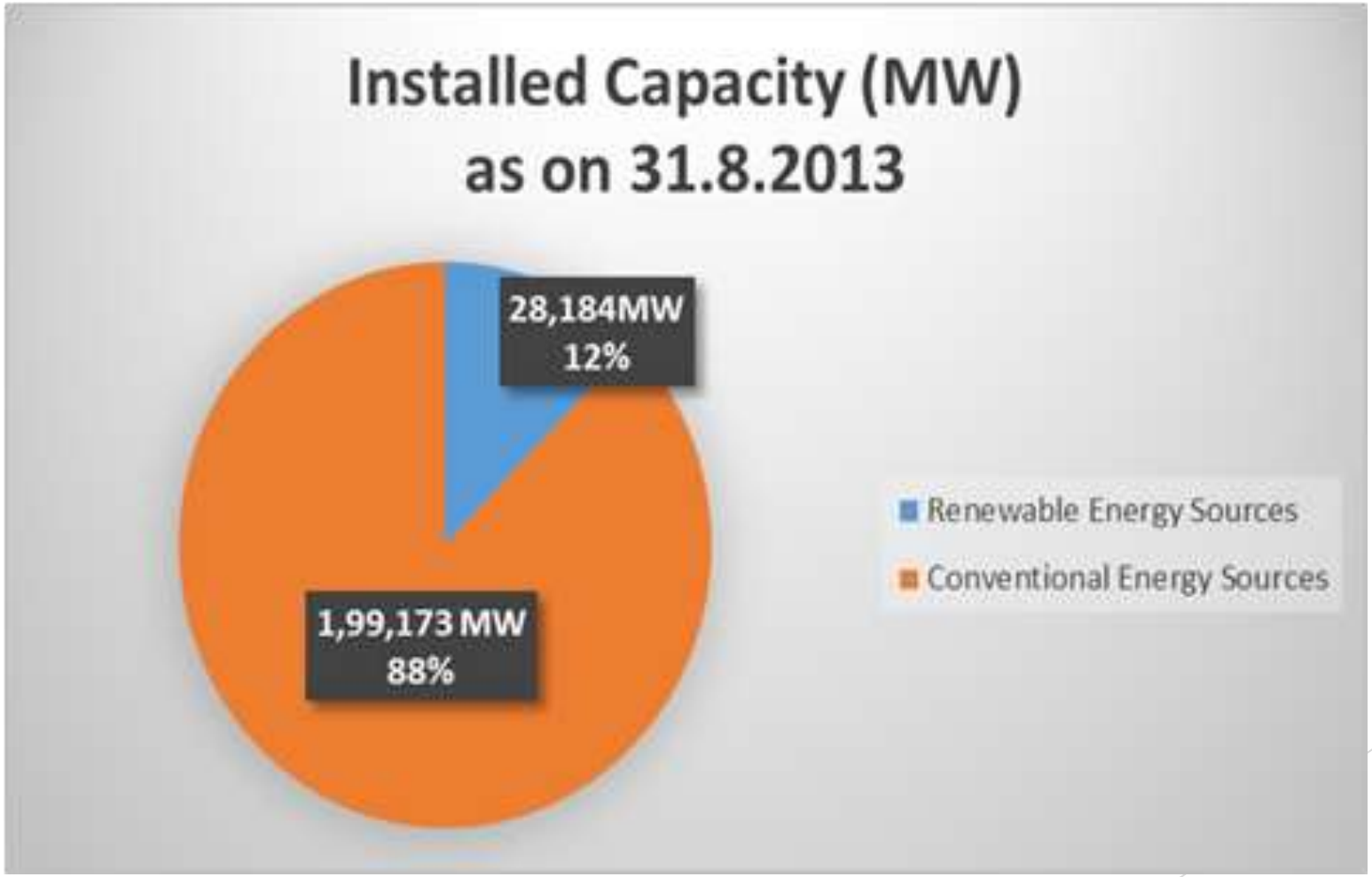
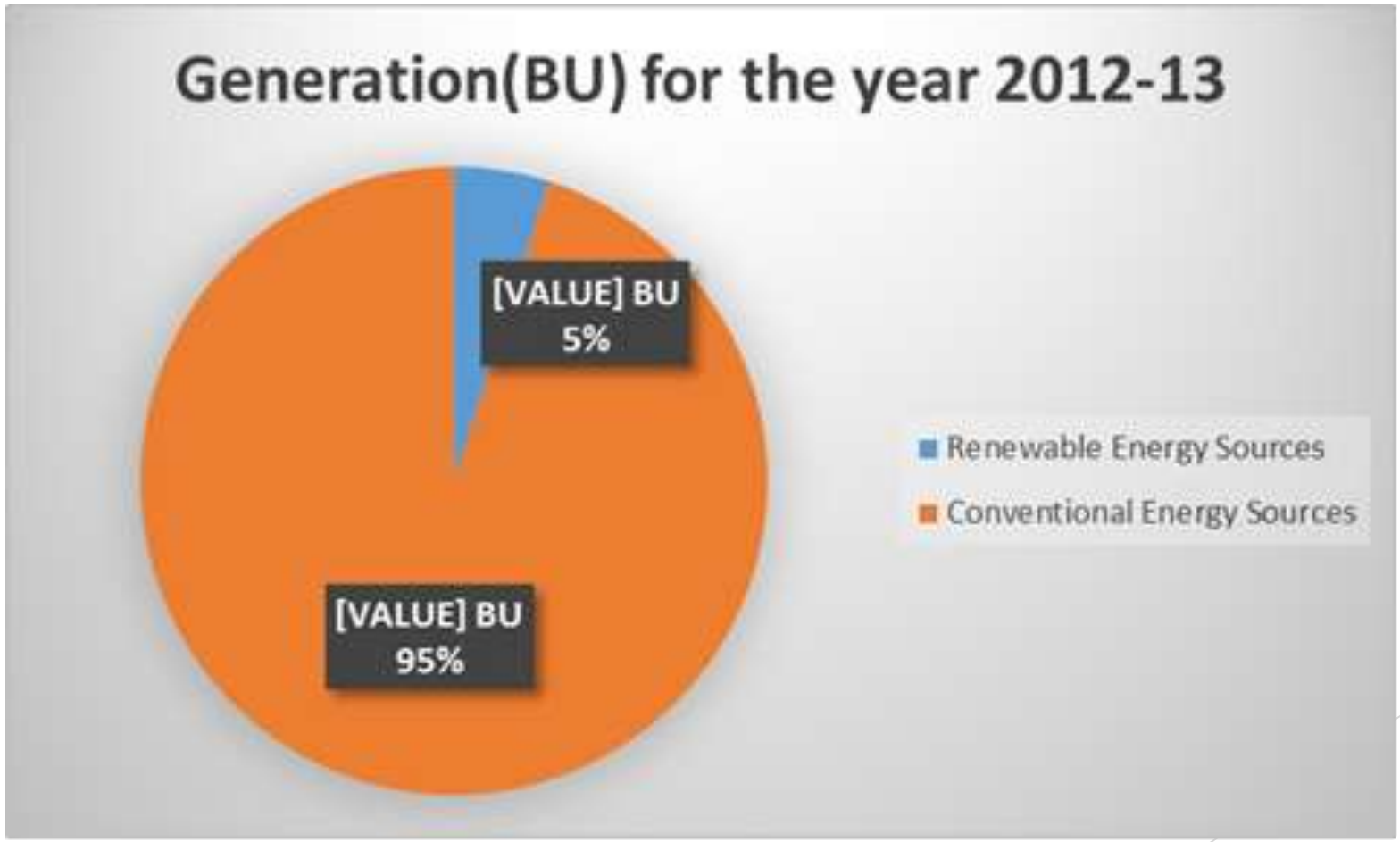
Basis of Report

The Report has been prepared on the basis of detailed discussions and inputs furnished by Gujarat, Rajasthan and Tamil Nadu

All-India Installed Capacity (MW)



All-India Generation (MUs)



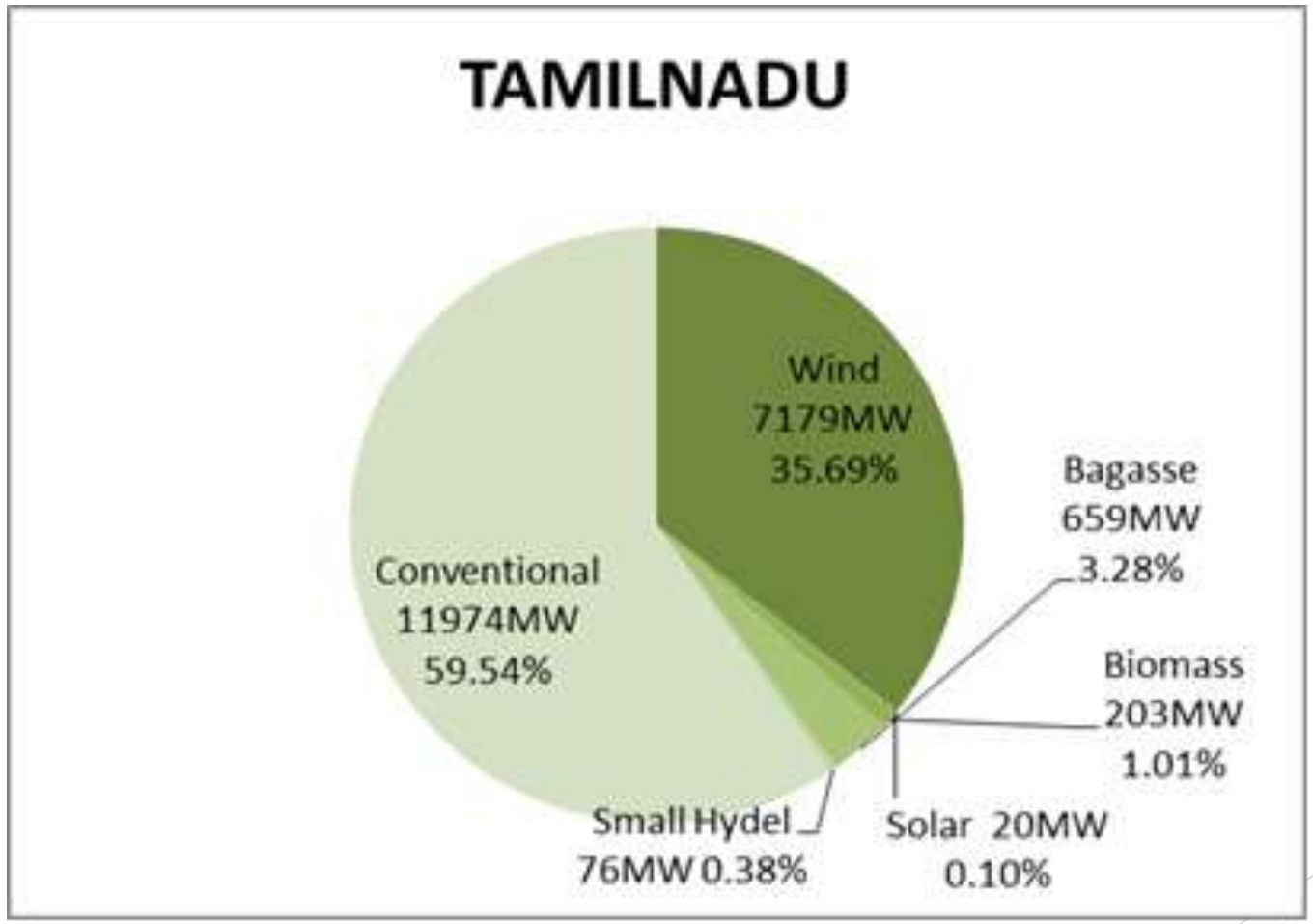
State-wise Penetration of Renewables

Sl.No.	**State**	**RES capacity as % of total generating capacity**
1	Rajasthan	26%
2	Gujarat	18%
3	Maharashtra	14.7%
4	Karnataka	28.6%
5	Tamil Nadu	40.2%
	Total	23.86%

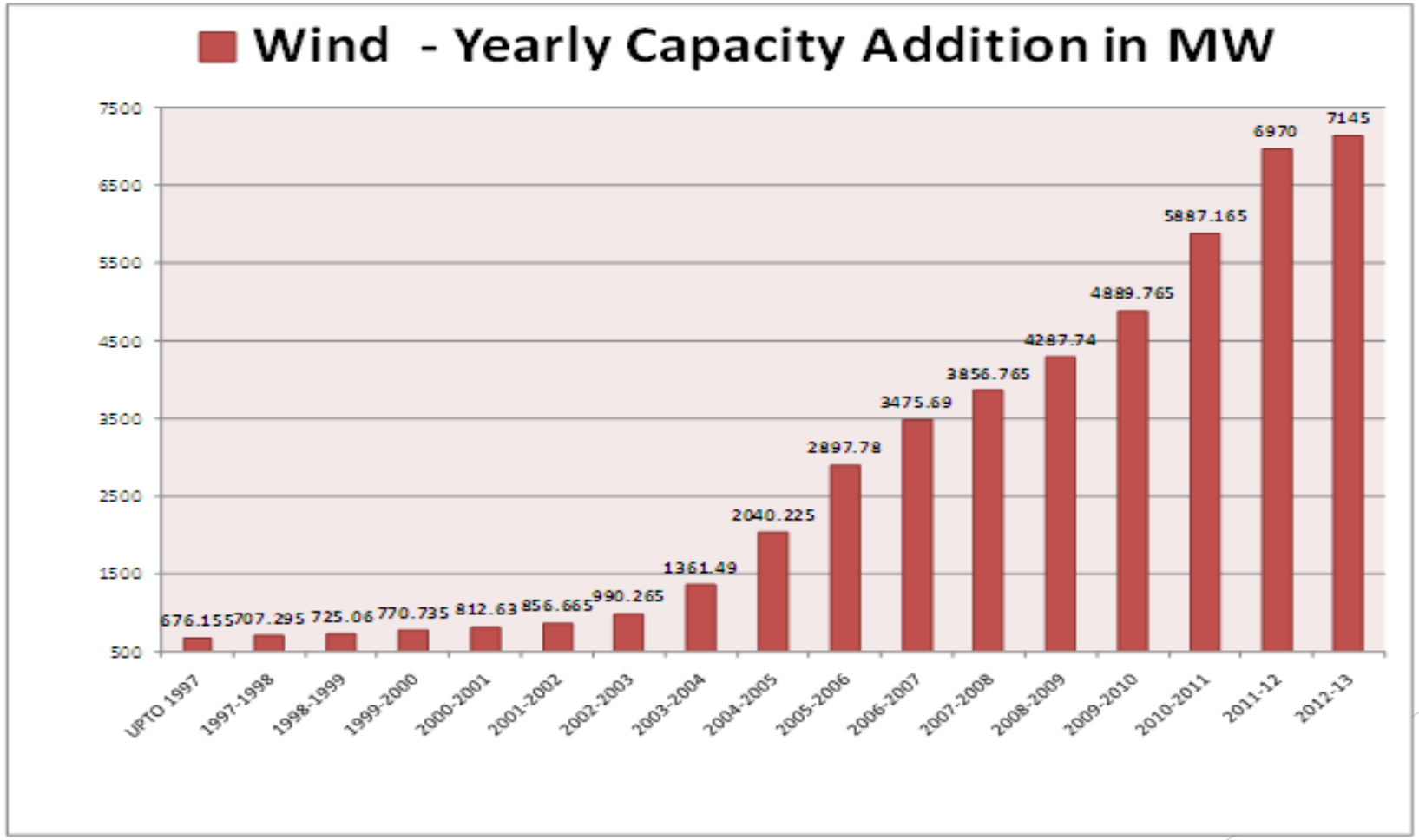
Penetration of variable generation

- Gujarat, Tamil Nadu and Rajasthan have substantial percentages 18%, 40.5% and 26% of the RES in their total installed capacity respectively, predominant of which is wind and solar.
- These three States put together have 70% of the wind generation capacity and 91% of Solar generating capacity of the total all India wind (18500 MW) and Solar capacity (1500 MW) respectively.

Penetration of variable generation in Tamil Nadu



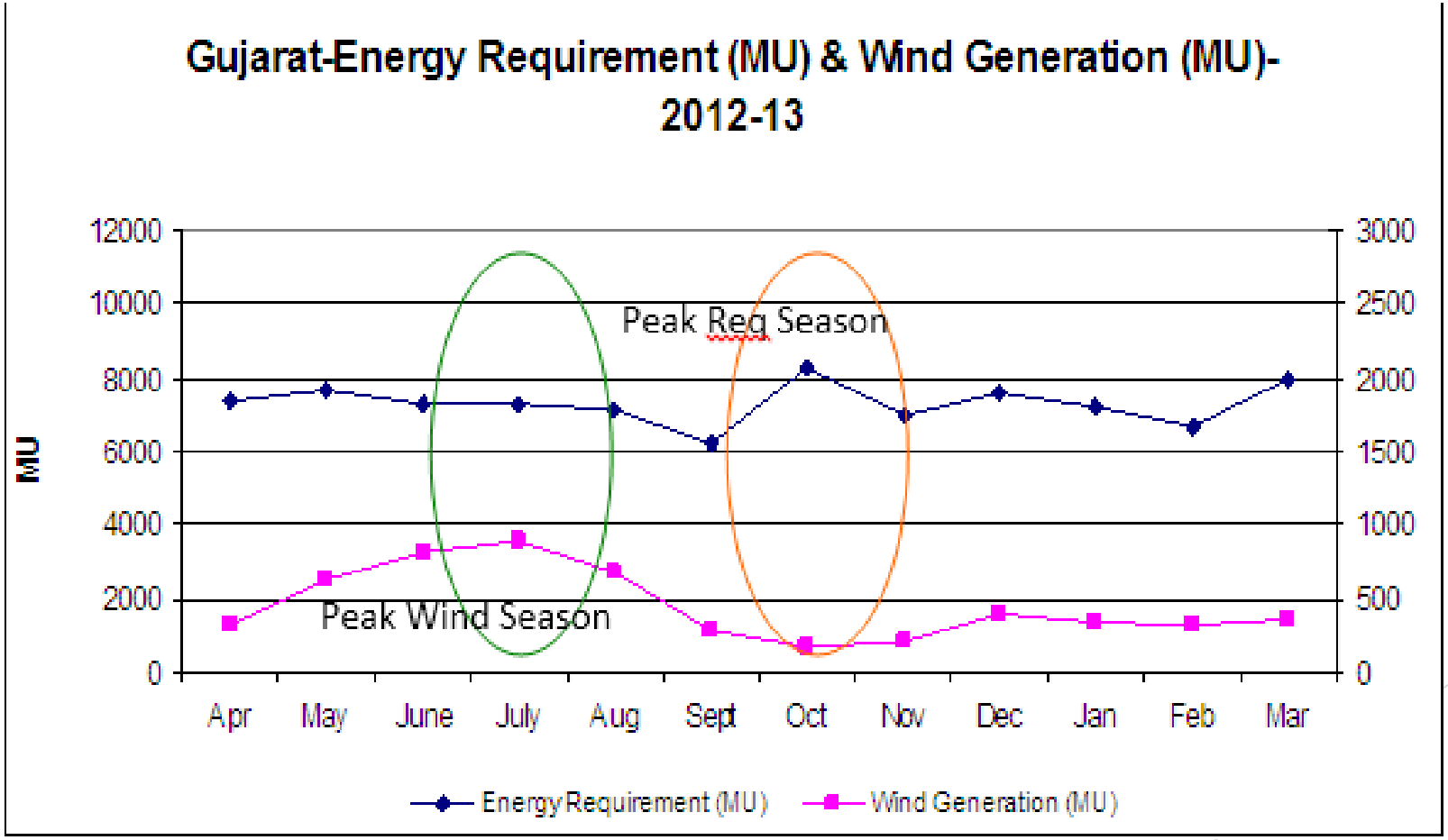
Growth of Wind Generating Capacity in Gujarat



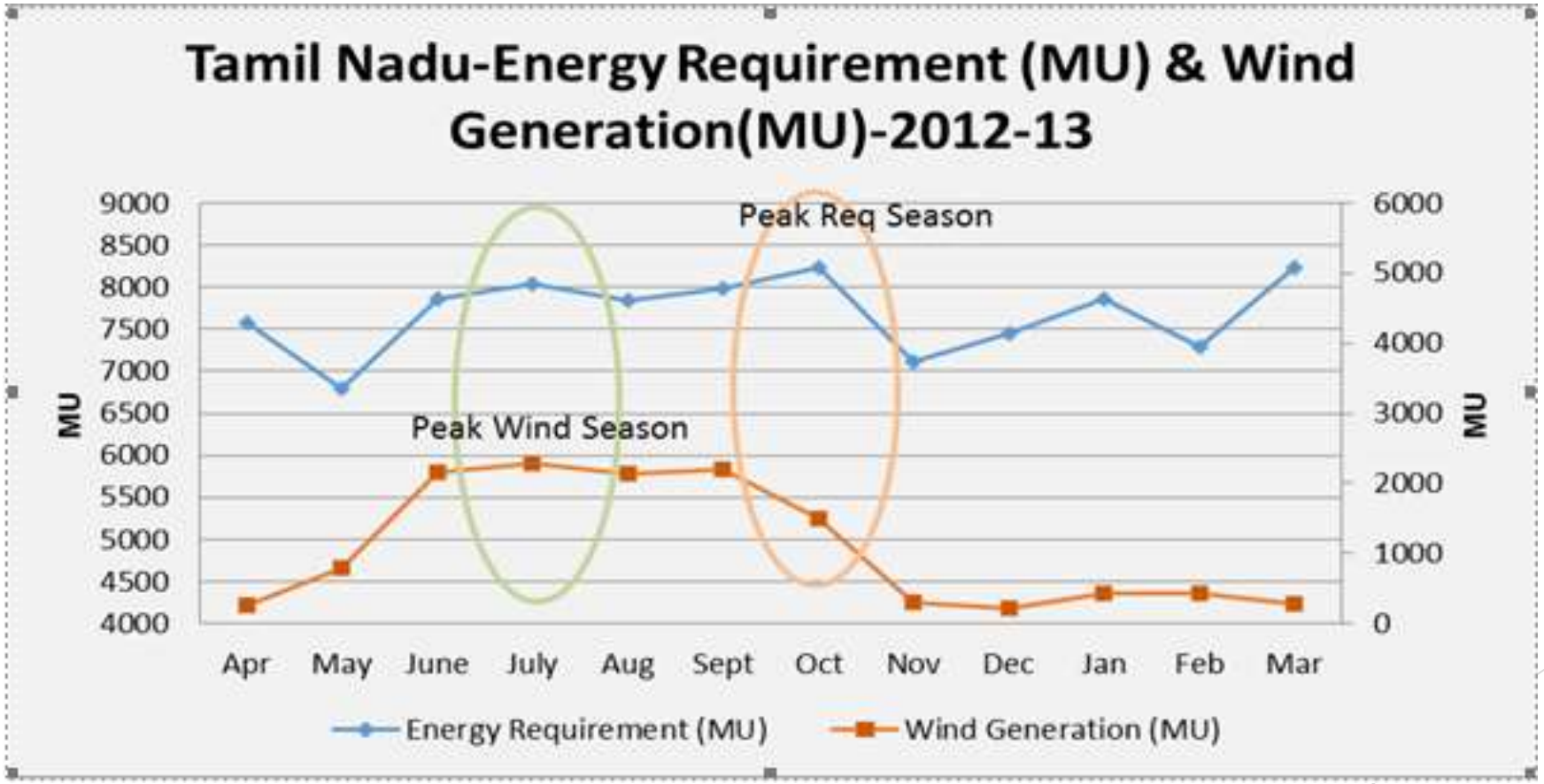
12th Plan Capacity Addition

- During the12th five year plan, capacity addition of around **88,537 MW** has been planned from conventional generation.
- CEA has made an assessment of capacity addition (wind/ solar/ small hydro) likely to come up during the 12th Plan and it is envisaged that about **32,000 MW** is likely to come up in eight RE rich states i.e. Tamil Nadu, Karnataka, A.P., Maharashtra, Gujarat, Rajasthan, Jammu & Kashmir and H.P.
- Out of the 32,000 MW of RES, consisting of Wind, Solar and Small Hydro, about **30,000 MW** is expected to come from solar and wind energy.

Peak Wind Season and Peak Requirement Season displaced - Gujarat



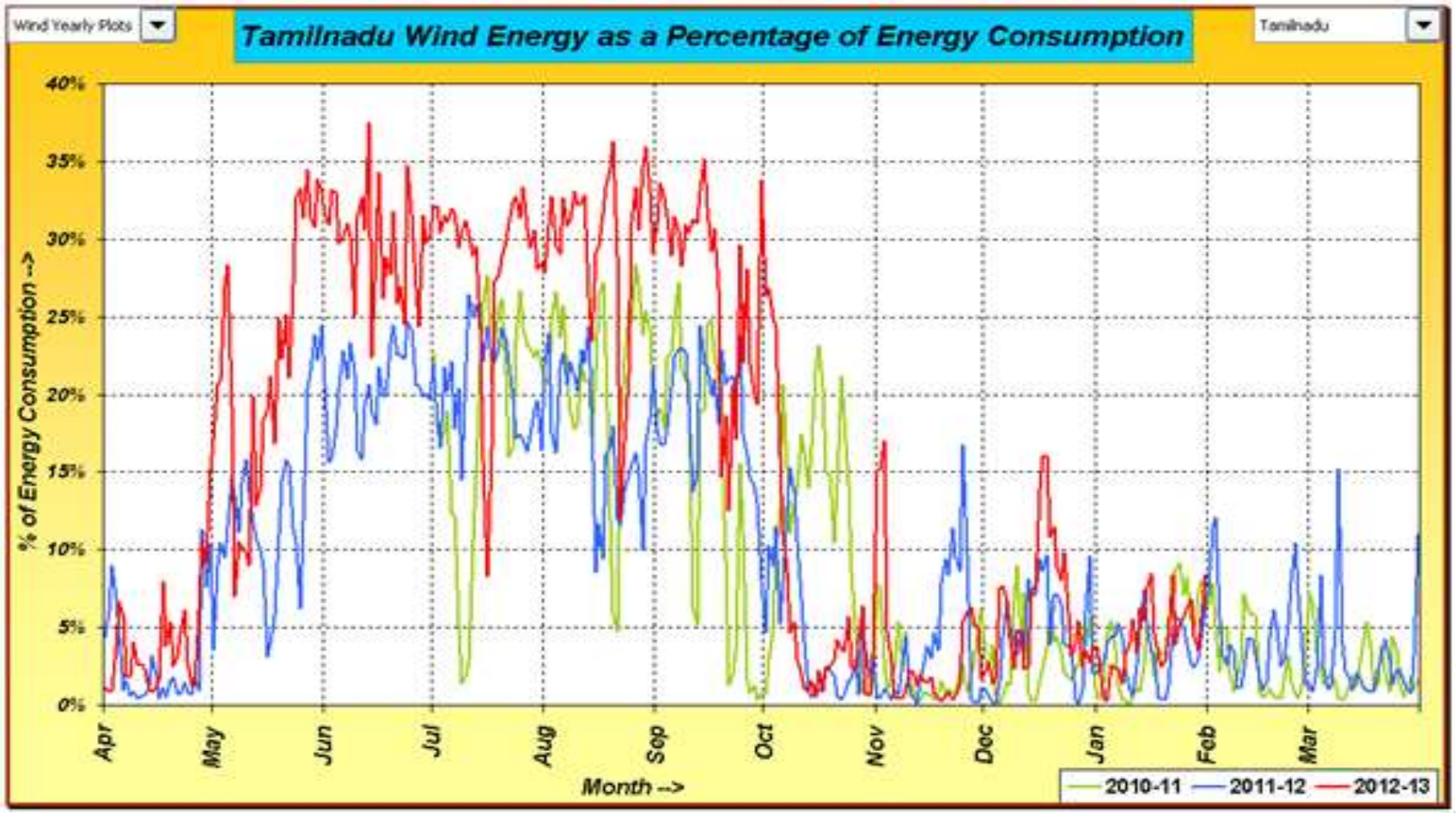
Peak Wind Season and Peak Requirement Season displaced – Tamil Nadu



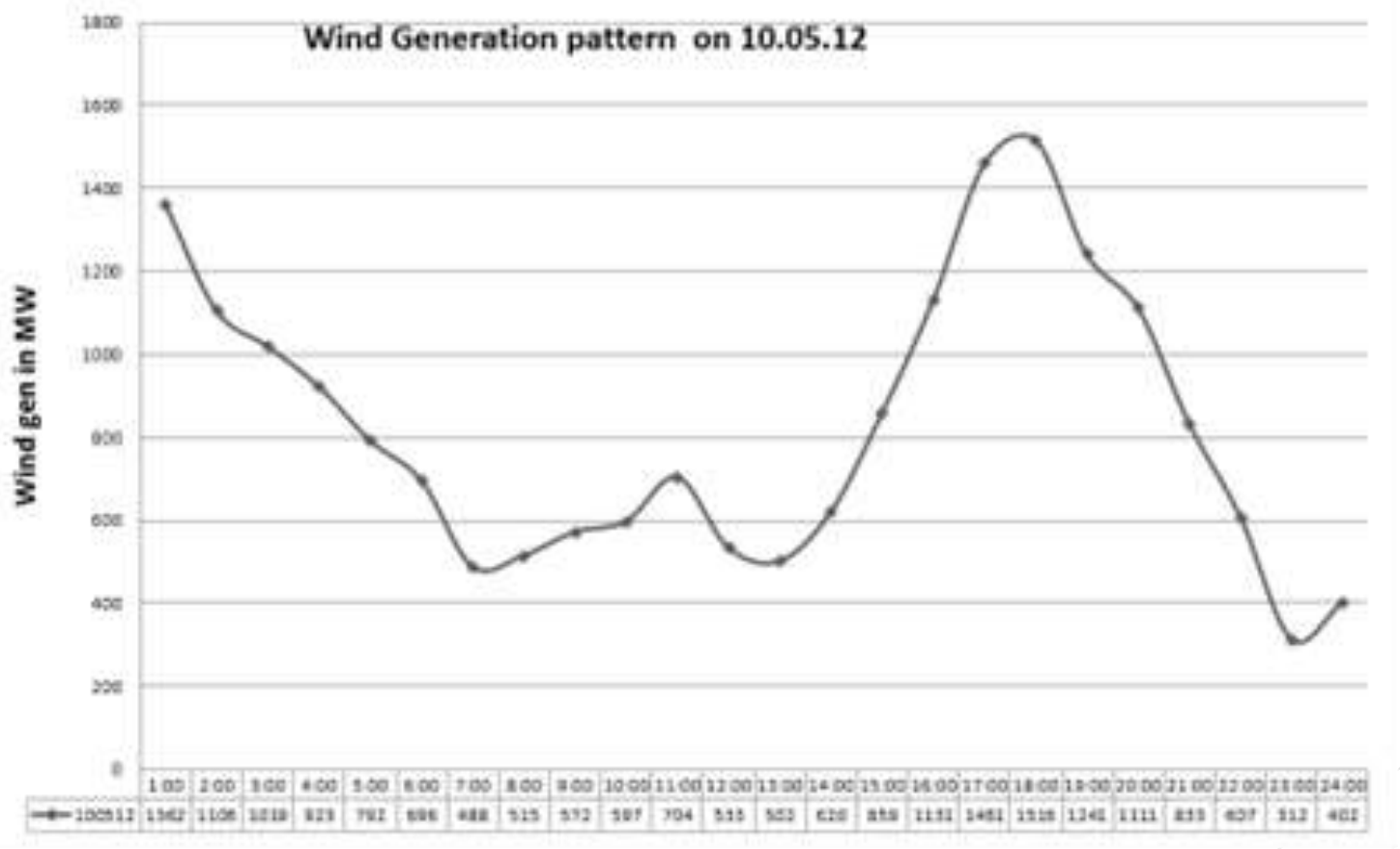
Wind Penetration

- The main wind season in Tamil Nadu is from June to September. During this season, wind contributes about 30-35% of the total energy consumption in Tamil Nadu.
- In other wind-rich States, wind contributes about 20% in Karnataka and Rajasthan, 15% in Gujarat and 10-12% in Maharashtra.

%age contribution of wind energy to the energy consumption in Tamil Nadu, over last three years



Predictability of wind generation



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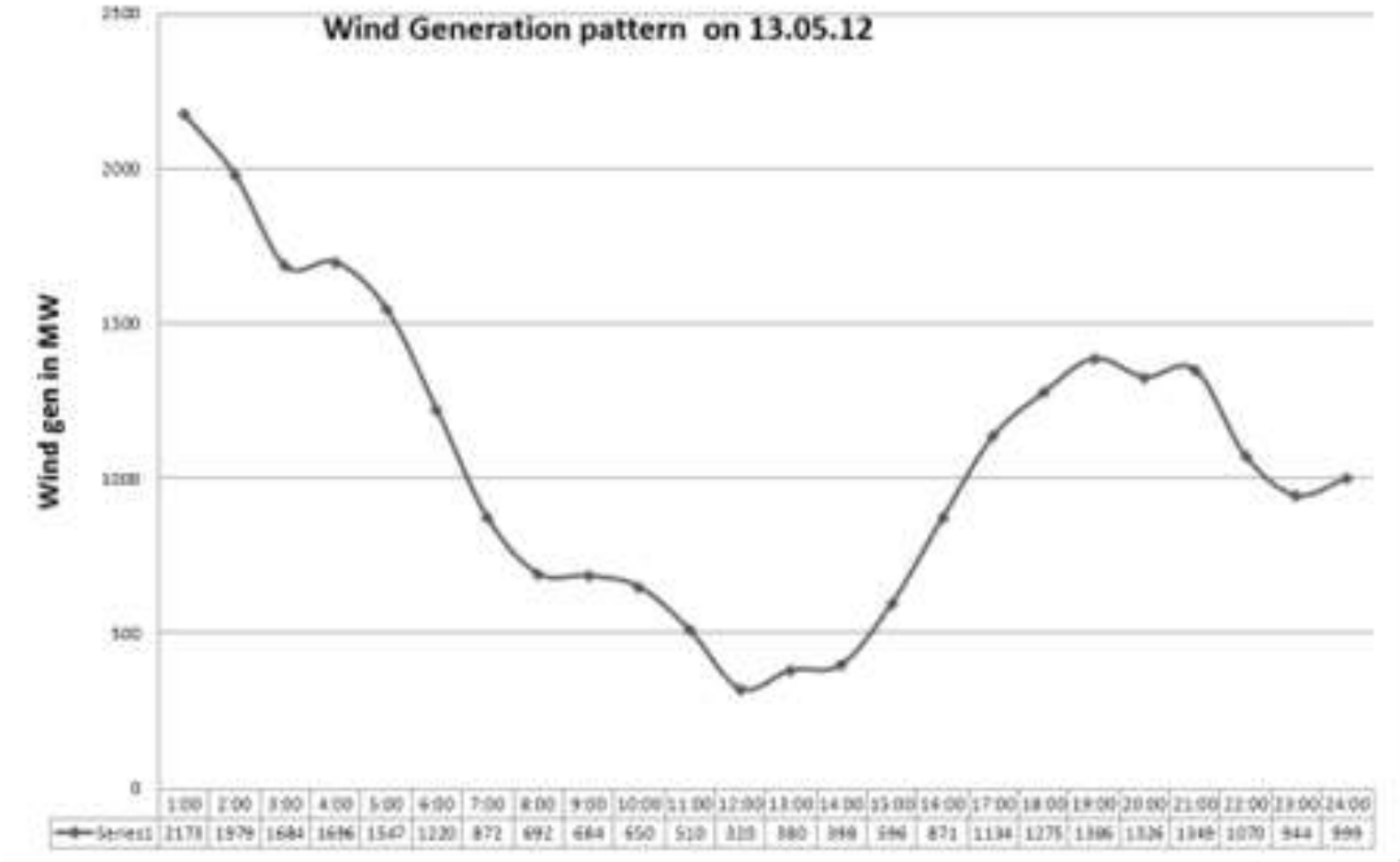

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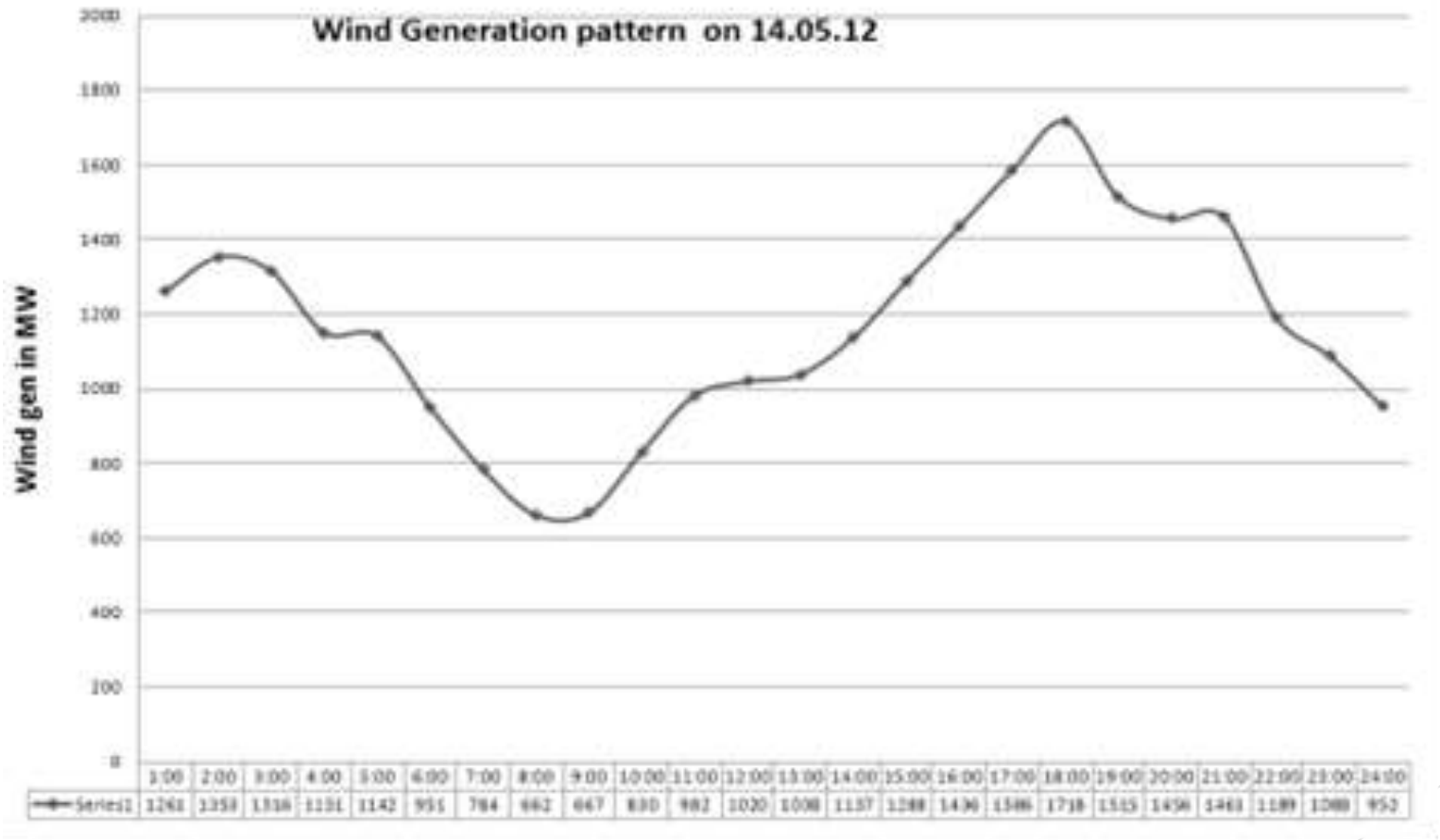
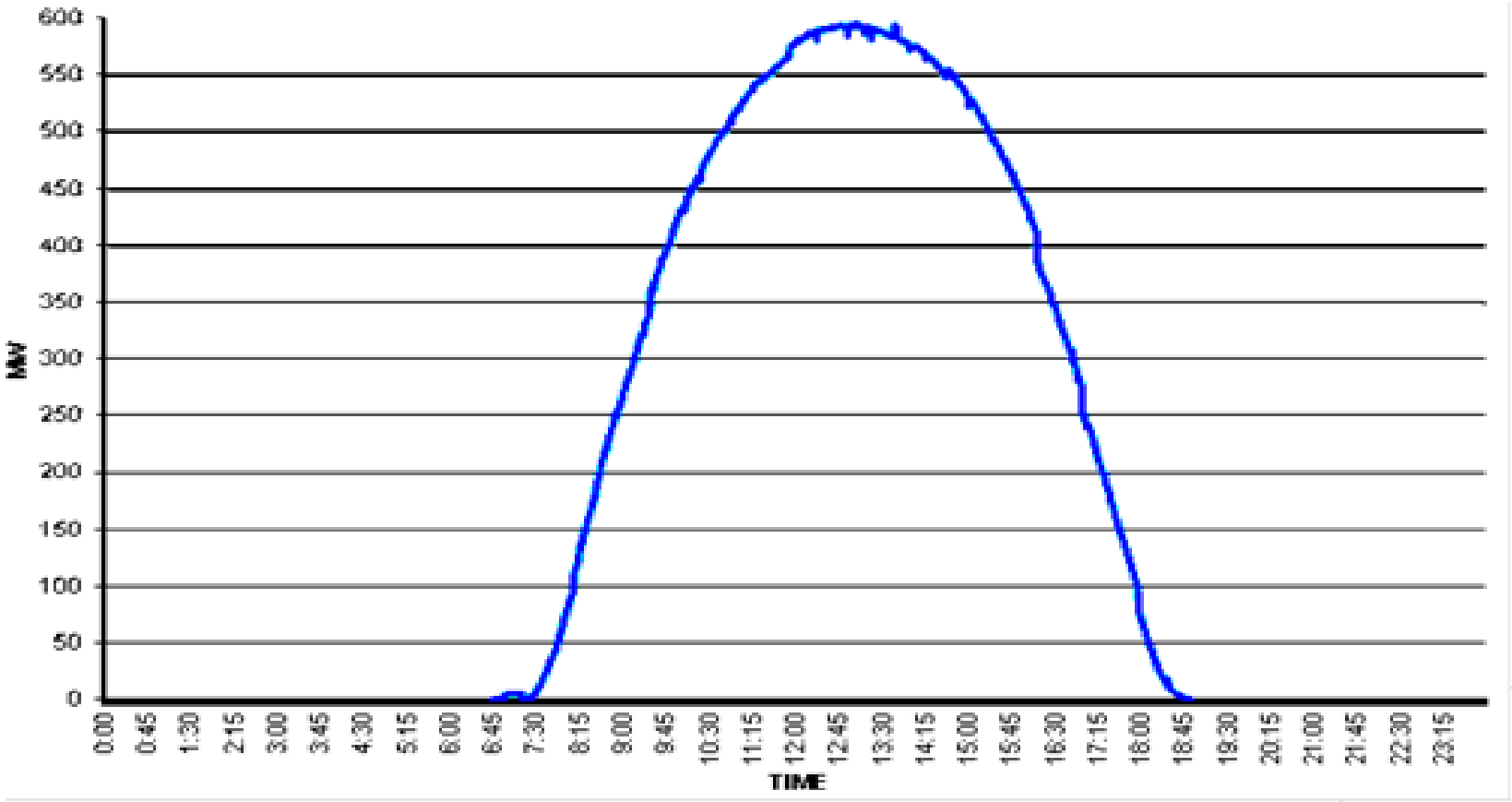


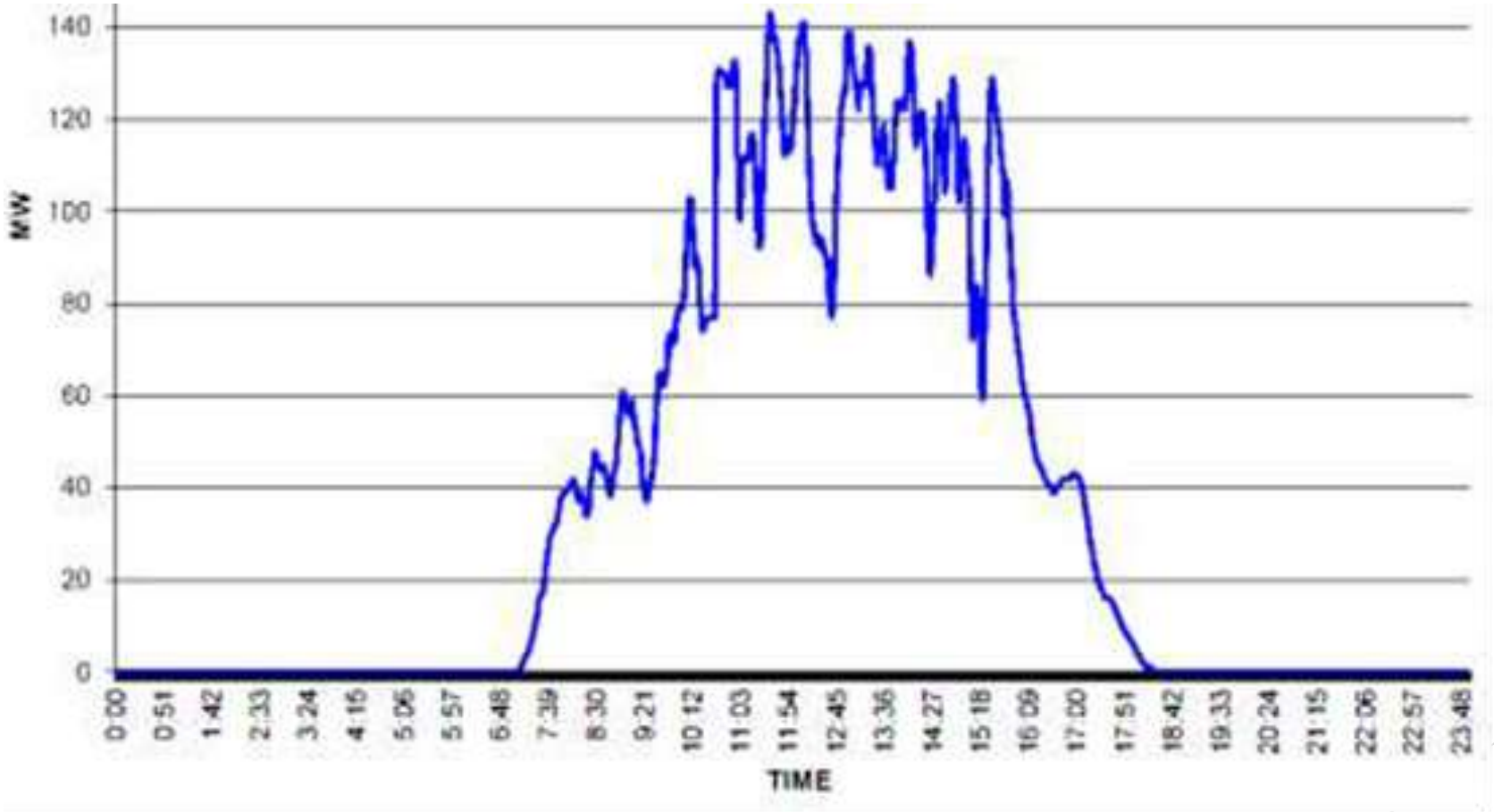
Variability of wind generation in a day

States	Variation Band (MW)	Days
Gujarat	> 500 &<1000	243
	> 1000 &< 1500	55
	1547	1
Tamil Nadu	> 500 &<1500	175
	>1500 & <3000	84
	>3000	2
	3385	1
Rajasthan	>500 & <1000	154
	>1000	11
	1164	1

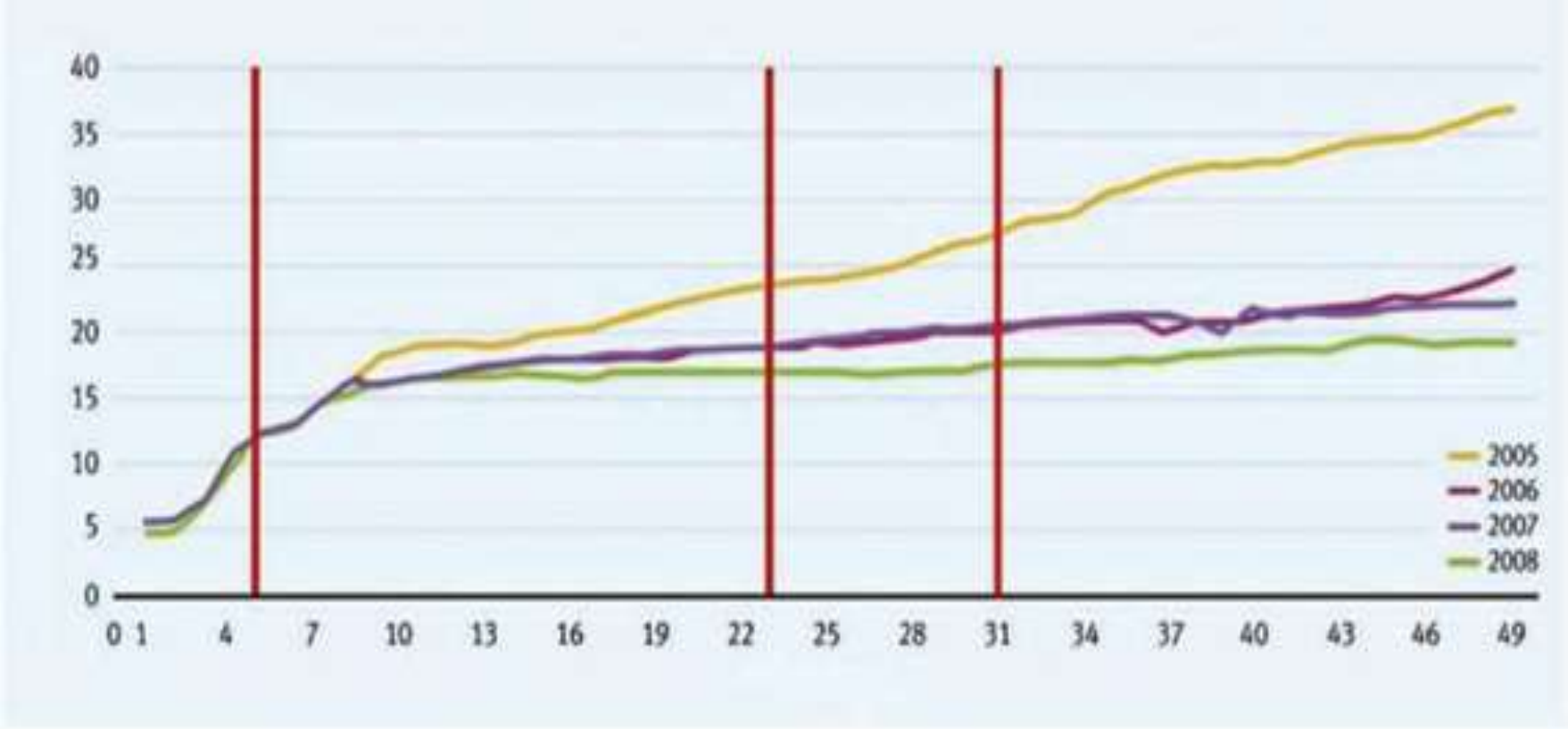
Typical generation from solar power plant



Cloudy day in the Charanka Solar Park, Gujarat



Evolution of Wind Forecasting Errors versus Lead Time, 2005-2008 (%age vs hrs.)



Solutions

- Wind forecasting is done by the system operator and balancing requirements for the same are assigned to various additional system operators; in other words, the balancing requirements are socialized.
- Market integration of the countries in Europe in order for this variability to be spread out over a wider area for balancing.
- Proposal to construct transmission corridors linking the high wind generating areas in Spain, Germany etc. with the hydro reservoirs in Norway.

Present methods of balancing by Tamil Nadu

- Tamil Nadu has stated that it manages the variability through reduction of generation in their coal-based power plants.
- The non-irrigation based hydro stations which could only be regulated according to the grid requirements is only 1325 MW.
- As June- September period has both high winds and high inflows to the reservoirs, the hydro stations have to be operated at full load and as such are not available for balancing. Further, the only available Pumped storage scheme of 400MW Kadamparai is also not operated since both upper and lower reservoirs i.e. Upper Aliyar & Kaddamprai are filled up to their maximum level.

Present methods of balancing by Gujarat

- Gujarat presently uses both its thermal and hydro power stations for balancing.
- It keeps a margin in its thermal and hydro generation to balance the variations of wind and solar generation.
- However, they incur a commercial loss.
- The increased cycling and rapid ramping up and down results in wear and tear leading to increased capital and maintenance costs. Heat rates and emissions from fossil fuel generators are higher during cycling and ramping than during steady state operation.
- Against a wind must-run generation with an average tariff of Rs. 3.56 per unit in June 2012, they had to back down cheaper generation of about Rs. 2.50 to Rs. 2.70 per unit. In addition they had to buy costlier power from the market.

Technical Challenges

- Basic technical challenge comes from the variability of wind and solar power which effects the load generation balance, varying demand for reactive power and impact on voltage stability.
- Recently 16 SVCs (+300/-200, +400/-300, +600/-400 MVAR) / STATCOMs (± 200 MVAR – 7 nos., ± 300 MVAR- 6 nos.) have been decided to be installed at various points in the Indian grid to provide dynamic voltage compensation.
- Most of the wind generators, being induction type are absorbing substantial reactive power during startup and some reactive power during normal operating condition.
- Due to intermittent characteristic of wind, generator start up takes place multiple times during a day, resulting in huge quantum of reactive power absorption from the grid and causing voltage excursions/ voltage stability.

Renewable Regulatory Fund

- IEGC specifies the wind energy forecasting on day ahead basis with 70 % accuracy. If the variation in actual generation is beyond +/- 30% of the schedule, wind generator would have to bear the UI charges.
- For actual generation within +/- 30% of the schedule, no UI would be payable/receivable by the wind generator.
- For variation of actual generation within +/- 30% of the schedule, the host state shall bear the UI charges which shall be shared among all the States of the country in the ratio of their peak demands in the previous month based on the data published by CEA, in the form of a regulatory charge known as the Renewable Regulatory Charge operated through the Renewable Regulatory Fund (RRF).

Solutions for India

- India has huge hydro power potential and storage type hydro plants are suitable for providing balancing service. The hydro turbine design should be of the Pelton wheel type, wherever possible, since the generation from this type of hydro generator can vary easily from zero to full capacity. Pumped storage power plants should be encouraged.
- Gas based plants have a high ramping rate and are suitable for such purpose.

Way Forward

- Forecasts are crucial for resource adequacy during operation and grid security.
- Real time markets (i.e the opportunity to buy and sell power about two hours ahead) should be started.
- Technical and regulatory measures to enhance the flexibility of conventional generation to increase the balancing capacity of the grid.
- International cooperation for developing REMCs in the RE rich states, balancing capabilities using indigenous sources of conventional power, optimum development of enabling transmission infrastructure and capacity building of grid operators has become necessary at this stage of RE development.

Thank you