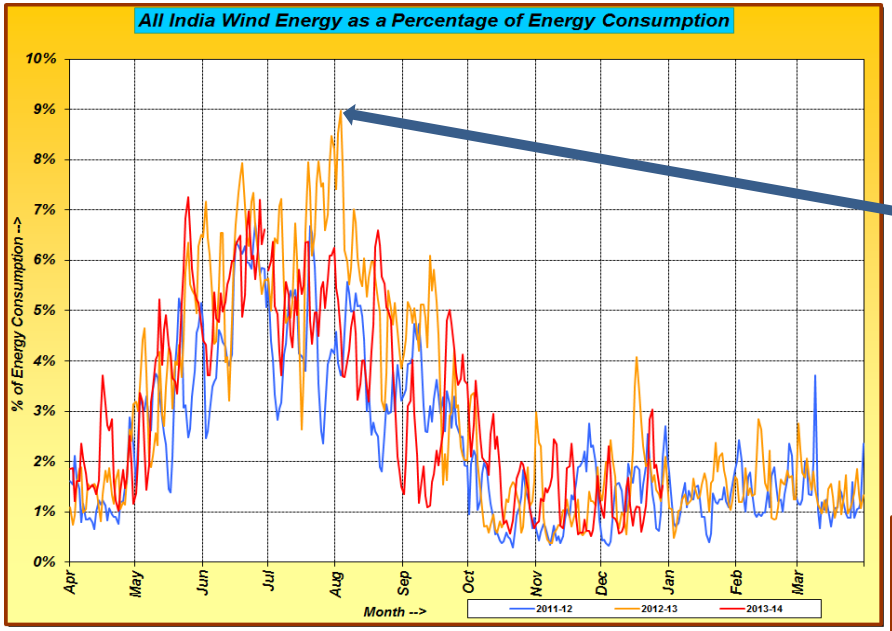
All India Wind Penetration (in Energy terms)

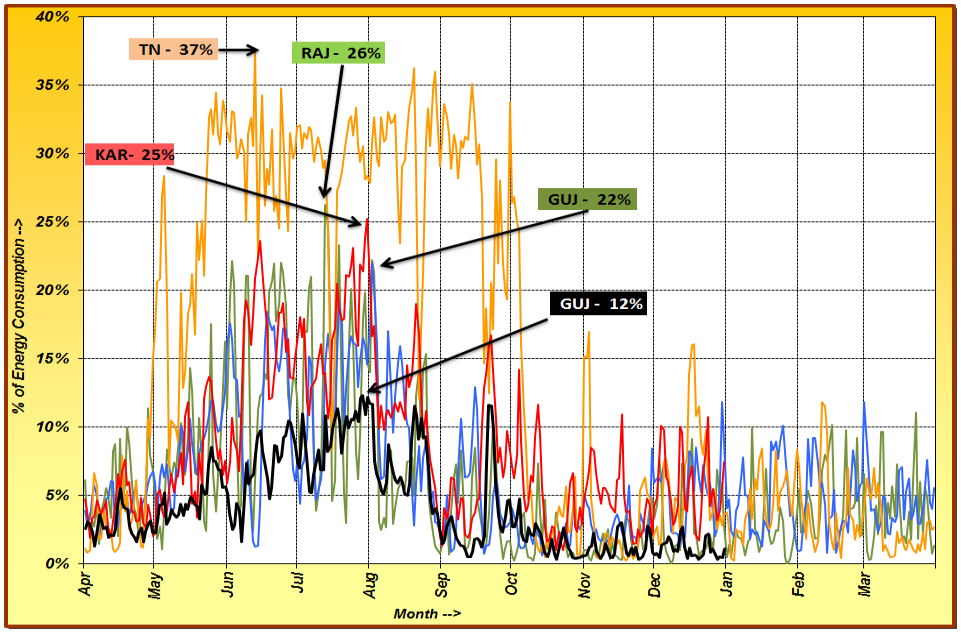


→ High Wind generation during June to August.

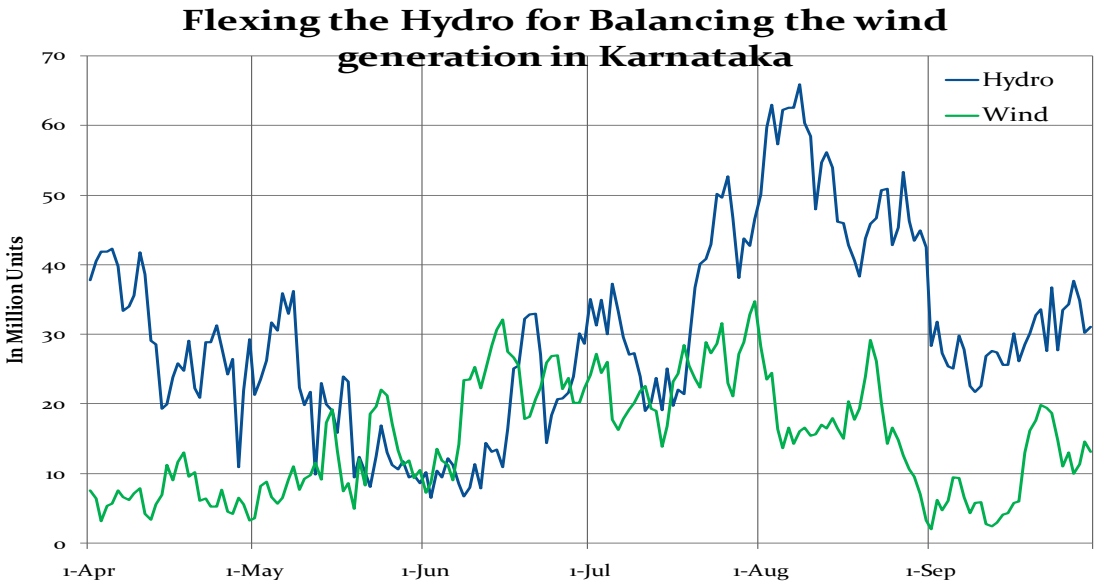
→ All India level penetration – 9% (max achieved)

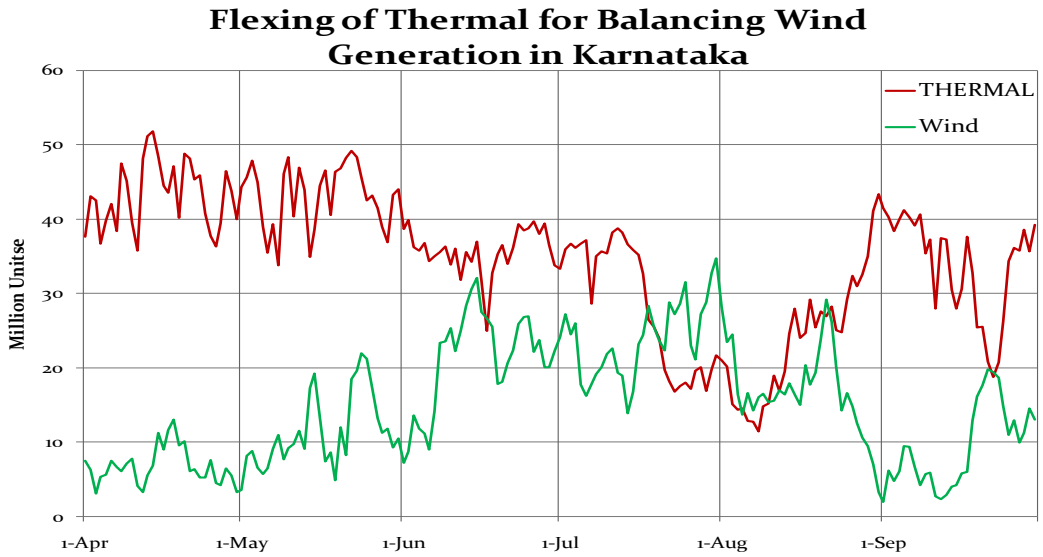
→ High Penetration in States:

1. Tamil Nadu
2. Rajasthan
3. Karnataka
4. Gujarat
5. Maharashtra



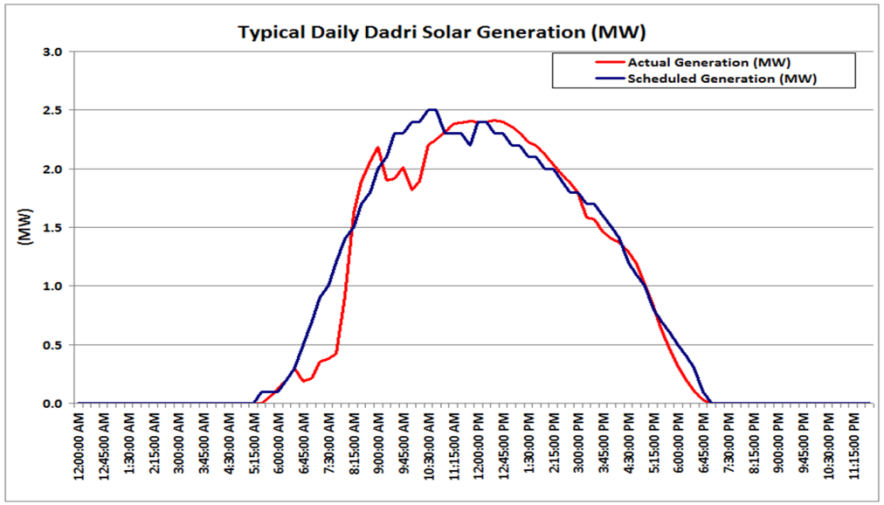
Balancing Renewable Generation

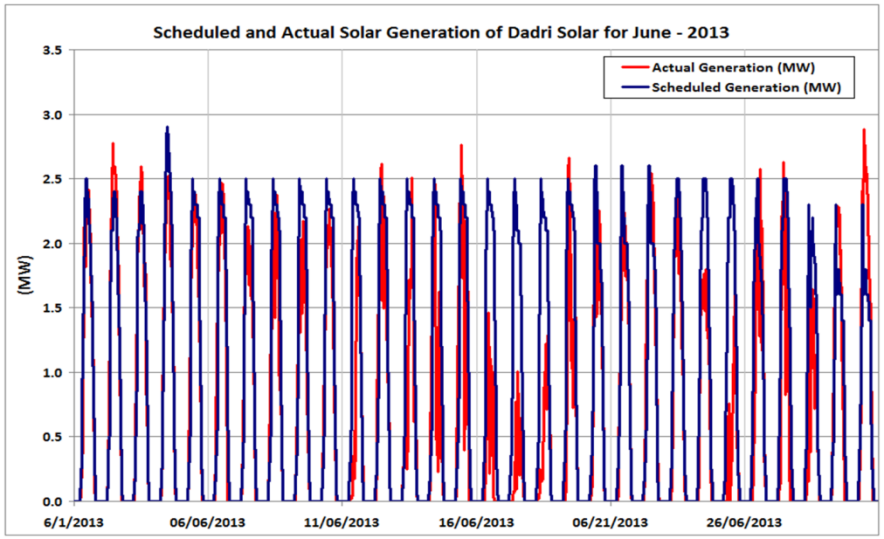




- **Challenges**
  - Variability, intermittency and ramping
  - Sudden onset or offset of wind generation
- **Remedies**
  - Generation balancing by the conventional energy sources.
  - Greater the penetration, greater the balancing requirement.
  - Forecasting of renewable generation (Solar and wind)
  - Ramp forecast is also essential.

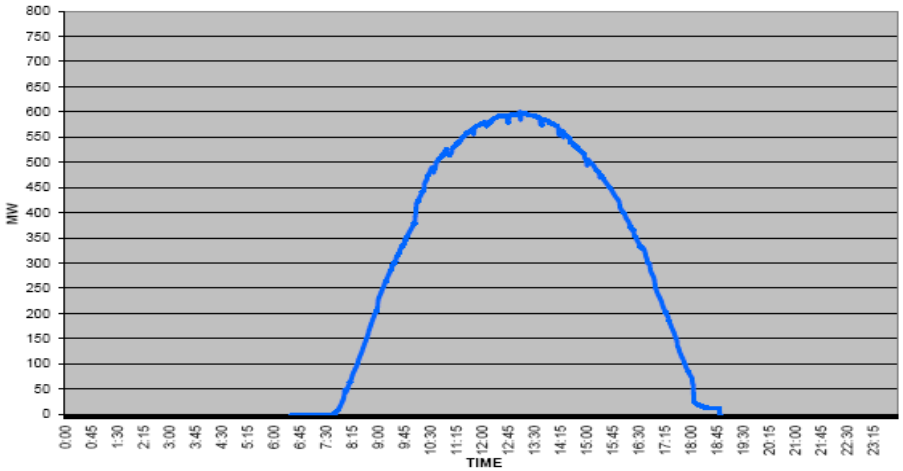
Inter-state and Intra-state solar generation scheduling taking place





- NRLDC
  - Dadri Solar
  - Unchahar Solar
  - Singrauli Solar
- Haryana
- Rajasthan
- Andhra Pradesh
- Maharashtra
- DVC

REALTIME GUJARAT SOLAR TREND :- 30/1/2015



Ecosystem for RE Integration…

Existing Ecosystem

- Separate Carriage & Content in Transmission at inter-state level
- Multi-Part Tariff
- Non-Discriminatory Open Access
- Freedom & Choice
- Multi Buyer – Multi Seller
- Robust Imbalance Handling Framework at Inter-state level
- Dispute Free Settlement Systems
- Zonal Transmission Charges & Losses

Further Ecosystem Requirements

- Frequency Control (Primary, Secondary, Tertiary)
- Load Forecasting
- RE Generation Forecasting
- Balancing Resources
- Generation Reserves
- Flexible Generation
- Ancillary Services Market
- Real Time Markets
- Imbalance Handling Framework at Intra-state level in all states

Need for Flexibility

- **CERC IEGC (4th Amendment) (Draft)**
- **Proposed Technical Minimum - 55%**
- **Proposed station heat rate degradation to be considered for the purpose of compensation:**

S.No.	Unit loading as a % of Installed Capacity of the Unit	Increase in SHR (for supercritical units) (%)	Increase in SHR (for sub-critical units) (%)
1	85-100	Nil	Nil
2	75-84.99	1.25	2.25
3	65-74.99	2	4
4	55-64.99	3	6

Forecasting

- **Centralized - Grid Security**
- **De-centralized - Scheduling and Commercial**
- **Forecast Error**
  - Absolute Error
  - Mean Absolute Error
    - Day
    - Week
    - Month
    - Year
  - Percentage Error
    - {(Actual Generation– Scheduled Generation) **/** (Available Capacity)} * 100 (%) to be effective from 01.11.2015

Scheduling

- **Scheduling in Proposed CERC RE Framework**
  - Wind/solar generators at the inter-state level whose scheduling is done by the RLDCs
  - To be paid as per scheduled generation
  - Maximum of 16 revisions for each fixed 1.5 hour time slot
  - Transact through long /medium/short-term trades.
  - Transmission charges (POC charges) and losses applicable
    - Only for Wind at present
    - Exemption to Solar projects commissioned till Jun-2017

Scheduling Enables Electricity Market Access to Renewables

Imbalance Handling and Settlement

- **CERC IEGC, 2010**
  - Mandates action by control areas to control inter-change
  - States revise requisitions / procure power from market

- **Salient Features of Proposed CERC RE Framework**
  - Deviation charges of RE generators delinked from frequency
  - More opportunities to revise the schedule
  - Commercial liability known upfront
  - Centralized as well as De-centralized forecasting
  - No additional charges, surcharges etc.
  - RECs to ensure physical energy balance

Aggregators

- **RE Ownership fragmented, many small investors.**
- **Scope for New Actors / Players**
  - Registered Generation Aggregator (RGA)
  - Qualified Scheduling Entity (QSE)
  - Solar Park developer
- **Need of nodal entity at connection point**
  - Responsible for coordinating with SLDC/RLDC on behalf of all the developers/generators.
- **Need for a separate Institutional Entity**
  - Recognized under regulatory framework
  - Qualified/certified/registered with System Operator
  - Undertake scheduling/commercial settlement/de-pooling/ communication/data management and co-ordination etc.
  - Suitable definition may be incorporated in the appropriate regulations including Grid Code.

Metering

- **CERC Proposed Framework**
  - Special Energy Meters (SEM) for boundary metering, accounting and settlement.
  - Weekly meter readings to the RLDC for energy accounting.
- **CEA Technical Standards for Connection of the Distributed Generation Resources**
  - *"4. General Connectivity Conditions - …(5) The applicant and the user shall coordinate with the appropriate licensee on the issues including but not limited to protection, safety, and metering…."*
  - *"8. Metering. - (1) Meters shall be provided as specified in the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006 for the purpose of metering under these regulations.*
  - *(2) Measurement of harmonic current injection, Direct Current injection and flicker shall be done with calibrated meters before the commissioning of the project and once in a year in presence of the parties concerned and the indicative date for the same shall be mentioned in the connection agreement…"*

Other Critical Requirements

- **Data Telemetry**
  - Need for providing data telemetry to the RLDCs by all RE generators
  - Communication infrastructure issues

- **Specification of Technical Characteristics of Solar generators**
  - Need for sharing information with the RLDCs
  - Essential input for facilitating forecasting by the Solar generators as well as the RLDCs

Adherence to Standards (1)

- **CEA Technical Standards for Connection of the Distributed Generation Resources**
  - *"…(e) "distributed generation resource" means a generating station feeding electricity into the electricity system at voltage level of below 33 kV;…"*
  - *"(6) Distributed generation resource operating in parallel with electricity system shall be equipped with the following protective functions…..*

*(a) over and under voltage trip functions, if voltage reaches **above 110% or below 80% respectively with a clearing time upto two seconds**; however, appropriate licensee may prescribe a narrower range of voltage for the purpose.*

*(b) over and under frequency trip functions, if frequency reaches **50.5 Hz and below 47.5 Hz with a clearing time upto 2 seconds**; however, appropriate licensee may prescribe a narrower range of frequency for the purpose…."*

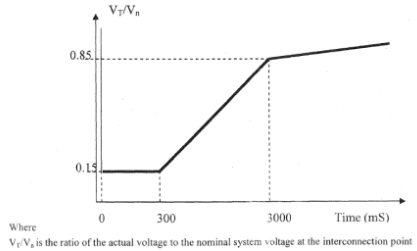
European Experience:

A large amount of PV installed capacity was initially tuned for automatic shedding at 50.2 Hz. A wide retrofitting campaign was performed since 2011 in order to avoid this technical specification, mainly on German and Italian areas. On German area 4 GW of PV installed capacity remains not retrofitted. For Italy the completion of retrofitting will be fulfilled in 2015

Source: Solar Eclipse March 2015: The successful stress test of Europe's power grid – more ahead ENTSO-E Policy Brief 15 July 2015

Adherence to Standards (2)

- **CEA (Technical Standards for Connectivity to the Grid) Amendment Regulations, 2013**
  - ***Power Factor Provisions*** *- B2(1) Power factor within the limits of 0.95 lagging to 0.95 leading."*
  - ***FRT / LVRT Provisions*** *- B2(3) Fault Ride Through provisions when voltage at the interconnection point on any or all phases dips up to the levels depicted*



  - ***Active Power Injection Provisions*** *- B2(4) control active power injection in accordance with a set point, based on the directions of the appropriate Load Despatch Centre…"*

Amendments in Connectivity Standards are applicable only to the Wind generating stations and generating stations using inverters
Need for clarity on Connectivity Standards for Solar stations/parks

Installed Pumped Storage Plants

S. No.	Name of Project / State	Installed Capacity		Pumping Mode Operation	Reasons for not working in Pumping mode
		No. of units x MW	Total (MW		
1	Kadana St. I&II Gujarat	2x60+2x60	240	Not working	Due to vibration problem
2	Nagarjuna Sagar Andhra Pradesh	7x100.80	705.6	Not working	Tail pool dam under construction
3	Kadamparai Tamil Nadu	4x100	400	Working	-
4	Panchet Hill -DVC	1x40	40	Not working	Tail pool dam not constructed
5	Bhira Maharashtra	1x150	150	Working	-
6	Srisailam LBPH Andhra Pradsesh	6x150	900	Working	-
7	Sardar Sarovar Gujarat	6x200	1200	Not working	Tail pool dam not constructed
8	Purlia PSS West Bengal	4x225	900	Working	-
9	Ghatgar Maharashtra	2x125	250	Working	-
		Total	4786		

Way Forward for RE Integration

- Forecasting Load and RE
- Adequacy & Balanced Portfolio
- Framework for integrating RE
- Intra-state deviation handling mechanism in all States
- Aggregators – New market entities
- Reserves
- Ancillary Services
- Frequency Response
- Market opportunities : more frequent clearing
- Communication & data telemetry
- REMCs
- Compliance to Standards
- Flexibility in conventional generation
- Capacity building

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Thank You !!