Controlling Power Generation and Ancillary Services from Wind and Solar in India

Presenter:
Dr. Thomas Ackermann
Energynautics GmbH, Germany

Partners/Co-Authors:
U. Focken (energy & meteo systems), S. Garud (The Energy and Recources Institute), C. Nabe (Navigant Energy), M. Kaur (GIZ, India), E. Tröster (Energynautics), T. Schlösser (Energynautics), D. Masendorf (Energynautics)

Contracting Authority:

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Consortium:

teri The Energy and Resources Institute

ECOFYS A Navigant Company

energy & meteo systems

energynautics solutions for sustainable development

Agenda

1. Current Situation in India
2. Grid Code Recommendations
3. Retrofitting Possibilities
4. Market Recommendations
5. Summary

Project Motivation

Wind and Solar Penetration Levels

State	Wind and Solar Penetration (2018-19)	Maximum Daily Energy Penetration of Wind and Solar	Maximum Instantaneous Penetration of Wind and Solar
Karnataka	23 %	56 %	90 %
Tamil Nadu	13 %	38 %	48 %
Andhra Pradesh	21 %	51 %	71 %
Gujarat	11.6 %	33.2 %	39.5 %
Maharashtra	5.7 %	18 %	23 %
Madhya Pradesh	8.7 %	30 %	42 %
Rajasthan	14.2 %	34 %	50 %
Western Region	8.3 %	20 %	24.2 %
Southern Region	15 %	30 %	47 %
All India	**8 %**	**15.1 %**	**19.4 %**

Worldwide Solar plus Wind Penetration Levels in Large Grids

Europe: ~ 13 – 14 %

USA: ~ 10 %

China: ~ 6.6 %

Source: ENTSOE; https://docstore.entsoe.eu/Documents/Publications/Statistics/Factsheet/entsoe_sfs2018_web.pdf
US;https://www.eia.gov/electricity/data/browser/
China: https://chinaenergyportal.org/en/2017-electricity-other-energy-statistics-update-of-june-2018/

Grid Code Transition

Current Developments in Indian Power Sector:

- Increase in Renewable Energies (Decentralization)
- Ancillary Services get more important
  - Frequency and Voltage Control
- Renewables will also have to provide Ancillary Services

Methodology:

- India's Grid Code in Technology-Follower Position
- Can profit from international best practices AND mistakes

➢ Recommendations based on international experience

BUT: Each country is different! Open discussion is very important.

Indian Grid Code

Requirements for renewables have been updated recently:

- **Technical Standards for Connectivity to the Grid (Amendment) Regulations** published in February 2019

- Specifies requirements for renewables for:
  - Operation range (voltage, frequency)
  - Fault-ride-through
  - Frequency response
  - Remote controllability

Indian Grid Code

Frequency

- All RE generating unit shall be capable of operating in the frequency range **47.5 to 52 Hz**
- All RE generating unit shall be able to deliver **rated output** in the frequency range of **49.5 Hz to 50.5 Hz**

Voltage

- All RE generating unit shall be able to maintain their performance with voltage variation of up to **± 5%**

Fault-Ride-Through:

- During FRT, priority is given to **reactive power**. Active power shall preferably stay constant

Indian Grid Code

RE Generators with rated power of more than **10 MW** connected to **33 kV** or above:

- Shall have the facility to control **active power** based on **directions** from SLDC or RLDC (telephone call)
- Shall be equipped with the facility for controlling the rate of change of power output at a rate of not more than **± 10% per minute**
- Shall have frequency controllers at a **droop of 3 to 6%** and a **dead band** not exceeding **±0.03 Hz**
- No reactive power requirements yet

Only Generators with rated power of more than **500 MW**:

- Shall have the facility to control **active** and **reactive power** based on **signals** from SLDC or RLDC

Frequency Reserves

Primary
- 5s-5min

Secondary
- 30sec-15min

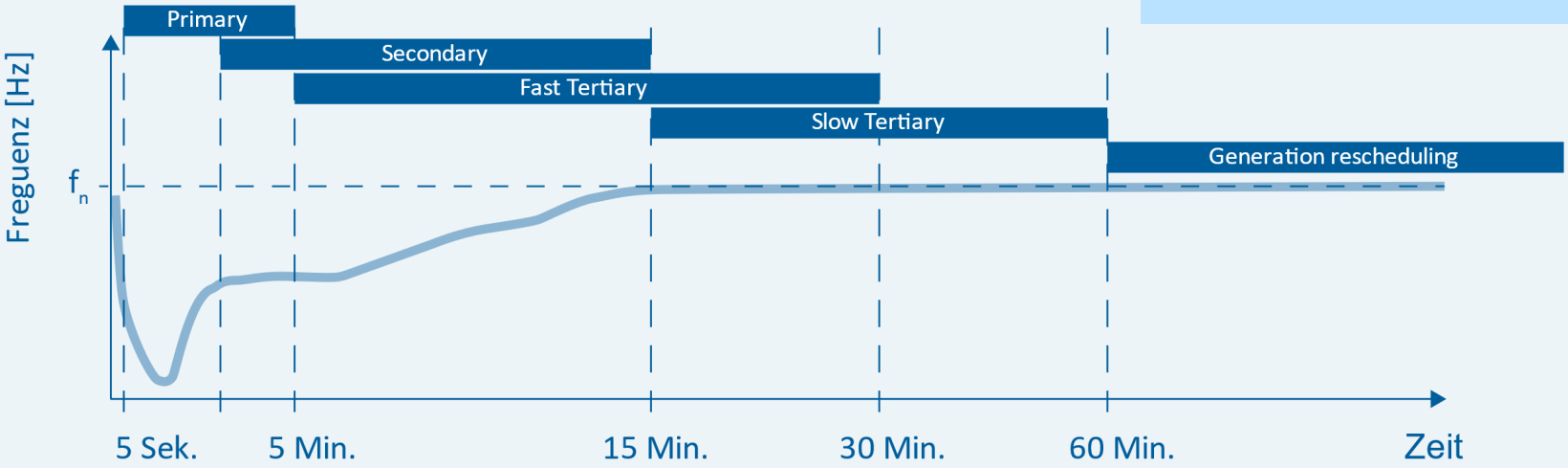
Fast Tertiary
- 5-30min

Slow Tertiary
- 15-60min

Generation rescheduling
- 60min+

India Current Situation:
- No specific market for renewables yet

Recommendation:
- Improve markets with renewables in mind
- Short gate closure
- Pooling



Indian Reserve Market

- Only primary and tertiary reserves are implemented so far

Primary reserve

- Regulated by **Indian Electricity Grid Code**
- To be provides by:
  - Thermal units of 200 MW and above
  - Hydro Units of 10 MW and above
- Shall operate in "**Restricted Governor Mode**":
  - Droop setting between 3% and 6%
  - No power reduction below 50.2Hz
  - Ripple filter of ±0.03Hz

Indian Reserve Market

Tertiary reserve

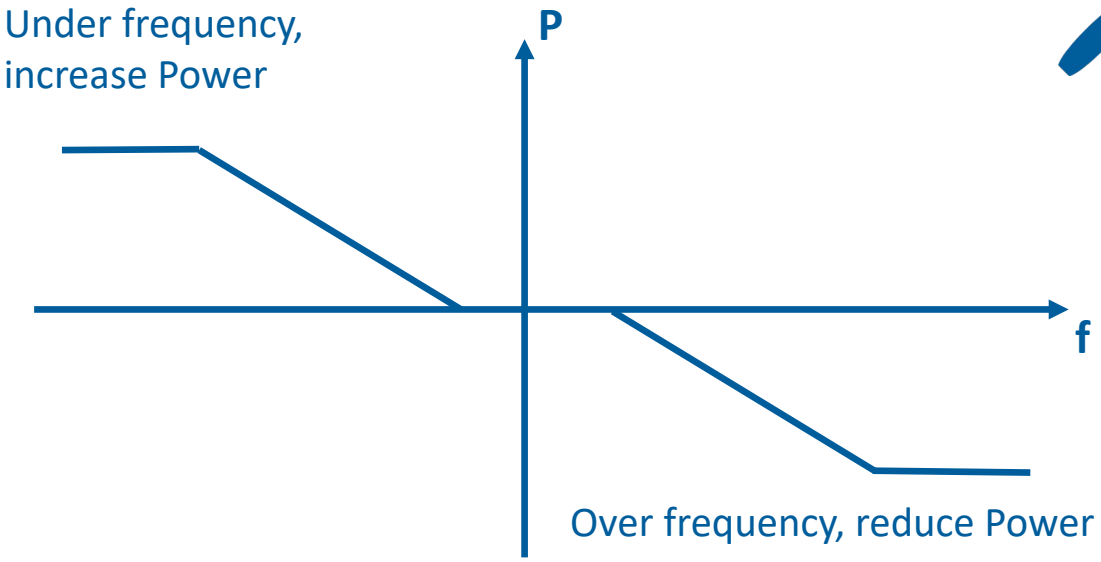
- Regulated by CERC (Ancillary Services Operations) Regulations, 2015
- Currently only central **government owned thermal power plants** included in tertiary reserve provision (approximately 67 power plants across India)
- Nodal agency creates merit order of costs of all **available** generation surplus
- Nodal Agency directs ancillary service providers according merit order, when required

Grid Code Recommendations

Limited Frequency Sensitive Mode (LFSM)

Change of active power depending on the frequency

- Renewables on plant level
- Tolerance and steepness are the main parameters
- Over-frequency: Ramp down always possible
- Under-frequency: Ramp up, only in curtailed mode



India Current Situation:

- Required from 10 MW +

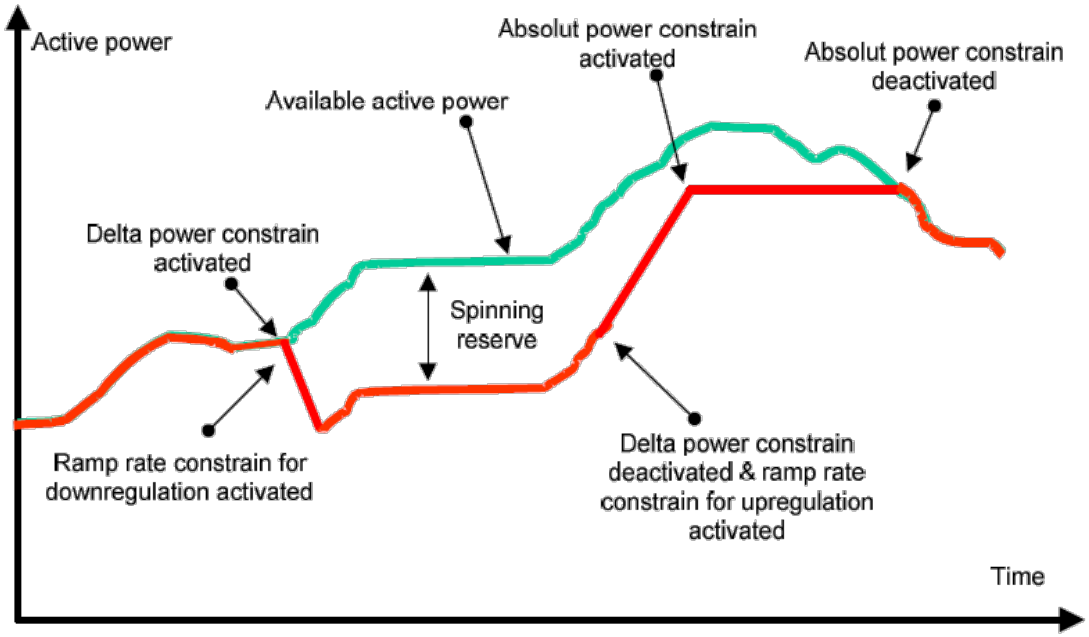
Recommendation:

- Include for all plants
- **Adjustable** tolerance (±0.6 Hz) and steepness (2-12%)
- Remote parameter change

Delta-Control

Provide LFSM-u headroom

- Plant operating in curtailed mode
- Good Forecasting & Gate closure times necessary
- Virtual Power Plants helpful to reduce error



India Current Situation:

- Not required

Recommendation:

- Require basic capabilities of all plants
- Exact parameters in later Grid Code amendment
- Remote parameter change

Delta Control in India

Grid Code Amendment Applicable for generation stations larger 10 MW connected to 33kV+

Paragraph:

(ii) **shall have** governors or frequency controllers of the units at a droop of 3 to 6% and a dead band not exceeding ±0.03 Hz

Provided that for frequency deviations in excess of 0.3 Hz, the Generating Station **shall have the facility to provide** an immediate (within 1 second) real power **primary frequency response of at least 10%** of the maximum Alternating Current active power capacity;

Problems:

- Capability vs. Constant Requirement (1. Generation Costs; Legal Disputes)
- 1 Second Reaction (1. Wind and Synchronous Generation)
- 10% of Capacity (1. Solar at Night?; 2. VRE Forecasting)

Voltage Control

Voltage needs to stay in dead band

- Reactive Power to keep nominal Voltage
- Exact values sent by grid operator
- Potential increase in hosting capacity
- Reactive power dependent on nominal active power (active power output independent) not power factor
- Methods: Constant Q and Q(U)-Control

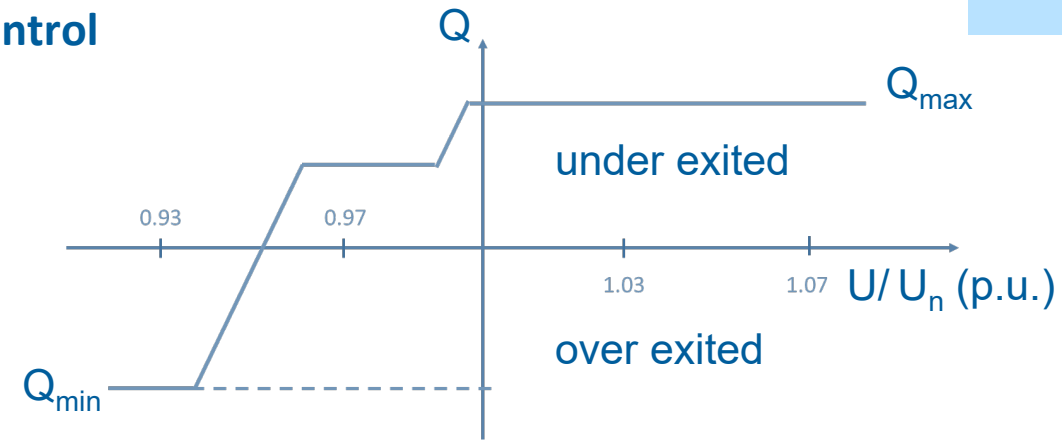
India Current Situation:

- Not required

Recommendation:

- Include for all plants
- Require reactive power range of $\pm 0.33\ Q/P_{inst}$
- Remotely Controlled
- Const. Q & Q(U)-Control

Q(U)-Control



Grid Code Compliance

Grid Code needs to be enforced

- Disconnection of non-compliant generators
- Declaration
  - Risk of cheating
  - Low bureaucracy
- Model Certification
  - Cost intensive
  - Dynamic analysis
- Actual testing
  - Restricted to some parameters
  - High effort for large power plants

India Current Situation:

- Enforcement unclear

Recommendation:

- Accept Compliance of similar Grid Codes (EU)
- Run ex-post tests
- Start building up modelling capabilities

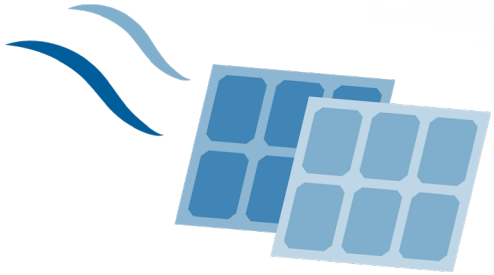
Retrofitting Possibilities

Retrofitting methodology

For Wind and Solar in South India:

(Andhra Pradesh, Karnataka, Kerala, Telangana and Tamil Nadu)

1. **Analyze existing Parks**
   a. (Re)-active power control possible?
   b. Scada connection available?
   c. Control logic available?



2. **Cost analysis**
   a. Broken down for each generator type

&

3. **Incentives**
   a. The case of Germany

Wind Power Plant in South India

- **Installed capacity:**
  - 18.2 GW (MNRE, 31-05-19)
- **Surveyed turbines:**
  - Suzlon, Windworld, GE, Gamesa and Vestas
    - ➔ 75% of installed capacity (GlobalData database)
- **All turbines have (re)-active power control capabilities**
  - Except Vestas V39 (~1% ; 137 MW installed capacity)

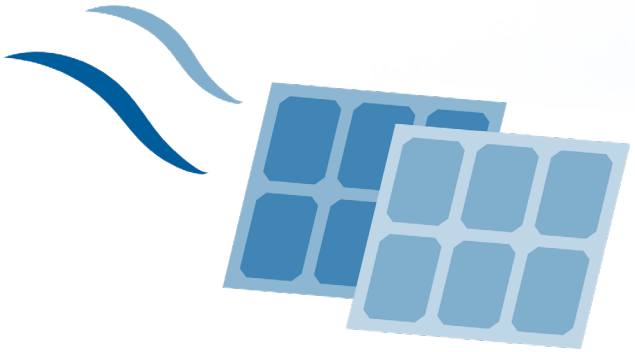
- **<u>However</u>**, farm's control devices are missing in **all** farms
  - Currently, active power regulation is a manual process locally
  - Proprietary solution from each manufacturer
  - No Reactive Power Control

Wind Power Plant Retrofitting Cost

Manufacturer	Turbine type	Solution name	Costs [mil. rupee/park]
Windworld	E 53, E 48, E30	RTU-I RTU-C (or FCU)	2 (RTU-I open-loop) 3.6 (RTU-C closed-loop)
Vestas	V82, V100, V110, V120	Vestas Power Plant Controller	3.2
	V39	Vestas Power Plant Controller + Turbine retrofitting	12 (only open loop active power control)
GE	GE 1.7-103	GE WindCONTROL	4
Siemens Gamesa	G90, G97, G114, G52	CPC controller	4-8
Suzlon India	S88, S97, S111, S120, S64, S66, S70, S82, S52	Power Plant controller	Estimated: 4-12 (higher cost for older plants)

Solar Power Plant in South India

- **Installed capacity:**
  - 13.2 GW (MNRE, 31-05-19)
- **Surveyed capacity:**
  - ~30% (Interviews)
- **All Inverters** have (re)-active powercontrol capabilities
- **All SCADAs** have grid operator interface and set point capability



- **<u>However</u>**, no logic is currently implemented in Plant-SCADA
  - Currently, active power regulation is a manual process in SCADA

Solar Power Plant Retrofitting Cost

Technology	Solution	Estimated Costs per park
Solar Parks	Specific Solution: Implementing logic in existing SCADA	0 – 160,000 rupees for the hardware + 20 person days
	General Solution: Additional PLC (programmable logic controller) and implement necessary logic in the device	One time: 40 person days for development Per integration: 320,000 rupees for hardware + 5 person days

Retrofitting Incentives (Germany)

2008	2009	2011	2012-2014
•Mandatory retrofitting of simple active power control	•Mandatory provisioning of ancillary services for new wind parks	•Optional bonus for retrofitting reactive power control	•Optional market participation with floating market premium
		(0.7 €ct /kWh; 5 years) = 0.55 INR /kWh	(0.1-0.2 €ct/kWh) = 0.08 – 0.16 INR /kWh

From 2014 onwards no bonus, but market premium is lost, if your plant is not controllable

Market Recommendations

Reserve market recommendations (1/2)

Ensure that reserves from conventional generation are provided in an economic way

- Important market reforms are underway
  - Decrease costs of reserves from conventional generation
- Reserve markets should enable the provision of reserves from all conventional generators (incl. inter-state)
- Economic tipping point depends mainly on:
  - Conventional generator inflexibility
  - Grid situation
  - Instantaneous penetration of renewables

India Current Situation:

- Reserve market reforms underway
- Not clear when primary and secondary reserves from renewables are needed

Recommendation:

- Enable reserve provision from conventional generation on a large scale
- Determine timing for the expected use of reserves from renewables

Reserve market recommendations (2/2)

Enable renewables for long-term reserve market participation

- The must run status needs to specified to allow compensation for curtailment (equivalent to provision of negative tertiary reserves)
- New renewable generators should be technically ready to provide fast reserves
- The definition of new market rules for renewables should already now consider the specific properties of renewables (short lead times, pooling permitted) – no technology agnostic approach
- The achievable prediction accuracy of renewable generation is important to define the requirements in the Indian context

India Current Situation:

- Unclear must-run status of renewables
- Renewables are not ready to provide fast reserves
- Current market reform discussions discriminate against renewables

Recommendation:

- No technology agnostic approach
- Short lead times for procurement, pooling permitted

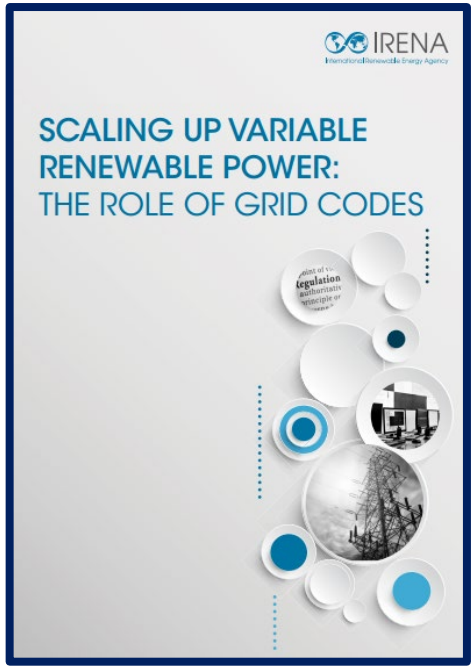
Summary

Summary

1. Ancillary Service Capabilities should already be required today
2. Retrofitting comes at relatively low cost
3. Retrofitting should be incentivized for frequency control
4. For new parks LFSM & Q(U)-control should be required right away without reimbursement
5. Frequency operation reserve markets are under way
6. General market barriers (PPA's, Interstate Energy Trading) have first priority

➡ Foundation for Ancillary Service by Wind and Solar has to be set today

IRENA Grid Code Report



Link:

http://www.irena.org/DocumentDownloads/Publications/IRENA_Grid_Codes_2016.pdf

(or google "IRENA Grid Codes")

Thank you for your attention!