Presentation in the 'WinGrid Scientific Workshop on Power System Balancing and Operation with Large Shares of Wind Power'

Grid Code Requirements for Wind and Hybrid Power Plants: perspective from wind turbine Manufacturers

18th June 2021

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Suzlon S128 Prototype

Agenda

01 About Suzlon

RE Growth Overview

02 Round the Clock Hybrid Park regulations

03 Wind solar Hybrid Park Guidelines in India

04 Grid Codes Overview

05 References

Suzlon Company- Some Facts

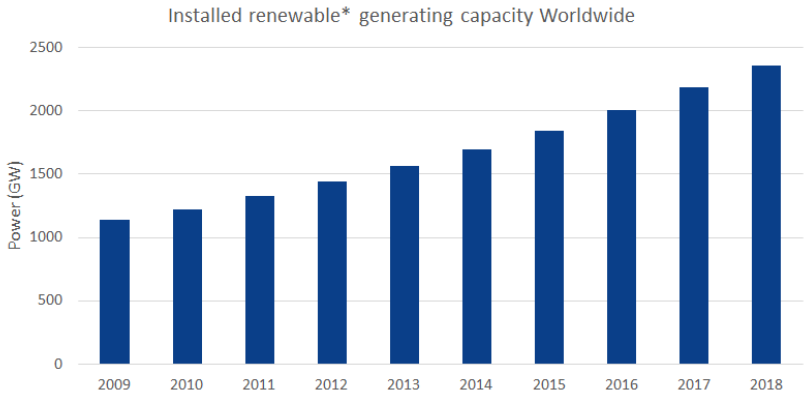
- Founded in April 1995 with just three employees in Ahmedabad, Gujarat (India) and grown to over 7,000 employees and installations in 19 countries
- SUZLON combined with Senvion (sold April 2015) *was* the world's 6th largest wi power company in 2014 in terms of cumulative installations
- Suzlon supplied over 12,000 WTGs across the world to 1800+ customers and its cumulative installation base is 18.8 GW and growing´and more than 300MW of Solar PV in India
- Market leader in India wrt installed capacity
- Stock listed on Bombay Stock Exchange (BSE) and National Stock Exchange (NSE) in India since IPO October 2005 with over 960,000 shareholders.
- Operations across North and South America, Asia, Australia, Europe and Africa
- Fully integrated supply chain with manufacturing facilities setup on three continents; North and South America, Asia
- Research and development of overall wind turbine technology in India, Germany and Denmark, blade development in The Netherlands and India.

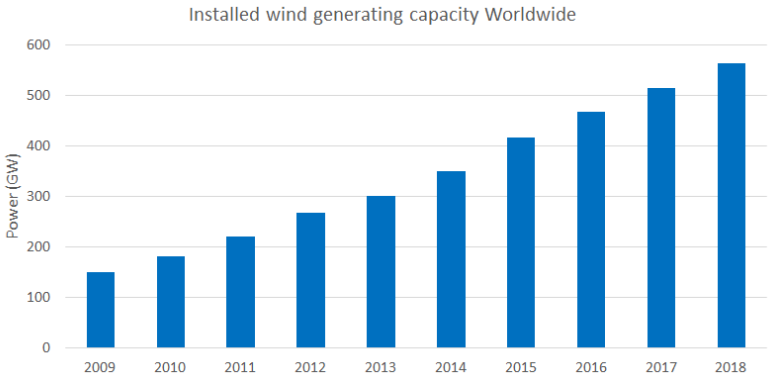
Technology – Where We Are

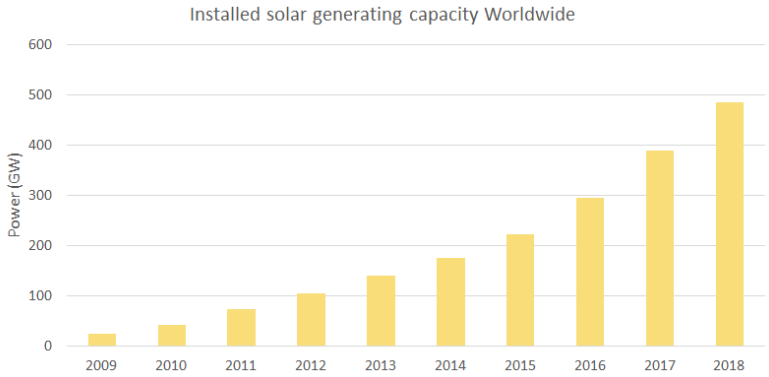
Suzlon Technology Locations:		
Germany	Hamburg	- Management - System Engineering, Drivetrain (D&I) - Certification
	Rostock	- Development & Integration - Design & Product Engineering
The Netherlands	Hengelo	- Blade Development
India	Pune	- Design & Product Engineering - Technical Field Support - Blade Engineering
	Vadodara	- Blade Testing Center
	Chennai	- Gear Box Team
Denmark	Aarhus	- SCADA

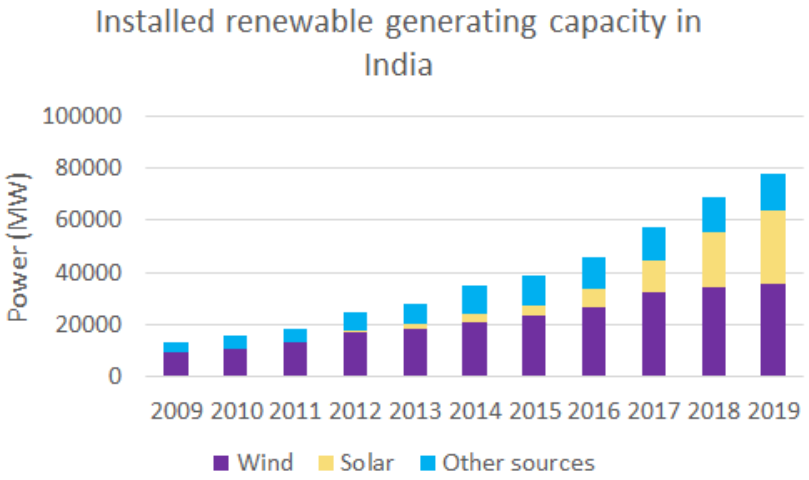
Best match between skills & location

Renewable Energy Growth: Worldwide Overview









* Includes Hydro power, Wind, Solar power, Marine energy, Bioenergy and Geotherm

**Source : IRENA Renewable Energy Statistics 2019

- **Source (India) : CEA Annual Report 2019

Global Climate Change, Energy independence & security, growing electricity demand driving Renewable Energy installation,

Expected to become major source of electricity in developed countries by 2040 and beyond, 100% RE beyond 2050 in some developed nations

Hybrid Park Tenders, India 2018/19

1. **Setting up of 1200 MW ISTS-Connected RE Projects with assured Peak Power Supply in India**

   RfS No : SECI/C&P/HPD/ISTS-VII/RfS/1200MW/082019

   Issued on : 01.08.2019.

2. **Selection of RE Power Developer for ‘‘Round-the-Clock’’ Supply of 400 MW RE Power**

   RfB No : SECI/C&P/RPD/RTC-I/RfS/400MW/102019

   Issued on : 18.10.2019.

3. **Setting up of 2500 MW ISTS-Connected Wind-Solar Hybrid Power Projects**

   RfS No : SECI/C&P/HPD/2500MW/HYB/T1/RfS/062018

   Issued on : 22.06.2018

4. **160 MW Solar-Wind Hybrid Power Plant with BESS including 10 Years Plant O&M under International competitive bidding**

   RfB No : SECI/C&P/RfB/2018/160MWH/WB/01

   Issued on : 17.08.2018.

Hybrid Park Tenders, India 2020

1. **Setting up of 1200 MW ISTS-Connected Wind-Solar Hybrid Power Projects**

   RfS No : SECI/C&P/HPD/T3/1200MW/RfS/012020

   Issued on : 14.01.2020.

2. **Setting up of 14 MW Solar Power Plants with 42 MWh BESS**

   RfS No : SECI/C&P/RfS/PMDP/LK/2020

   Issued on : 31.01.2020.

3. **Setting up of 4 MW Grid Connected floating Solar PV Power Project with 2 MW/1 MWh BESS**

   RfS No : SECI/C&P/SPD/RfS/A&N/04MW/012020

   Issued on : 13.01.2020.

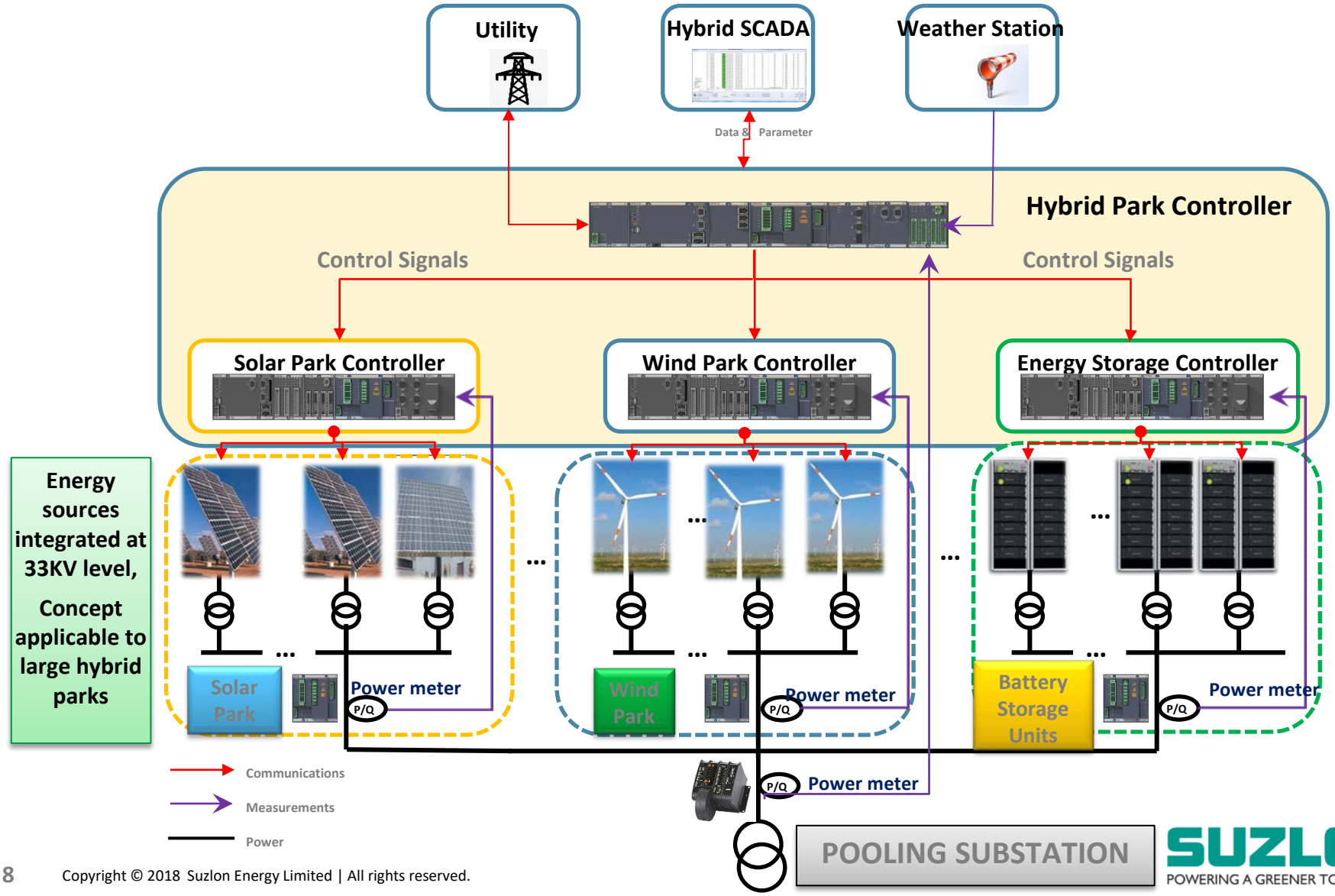
4. **Procurement of 5000 MW power on "Round-the-Clock" basis, from RE Power Projects, complemented with power from Thermal Power Projects**

   RfS No. SECI/C&P/RPD/RTC-II/RfS/5000MW/032020

   Issued on: 17.03.2020.

Typical Wind-Solar-storage Hybrid Park Configuration

To reduce generation variability, increased plant factor, competitive



Round-The-Clock (RTC) power

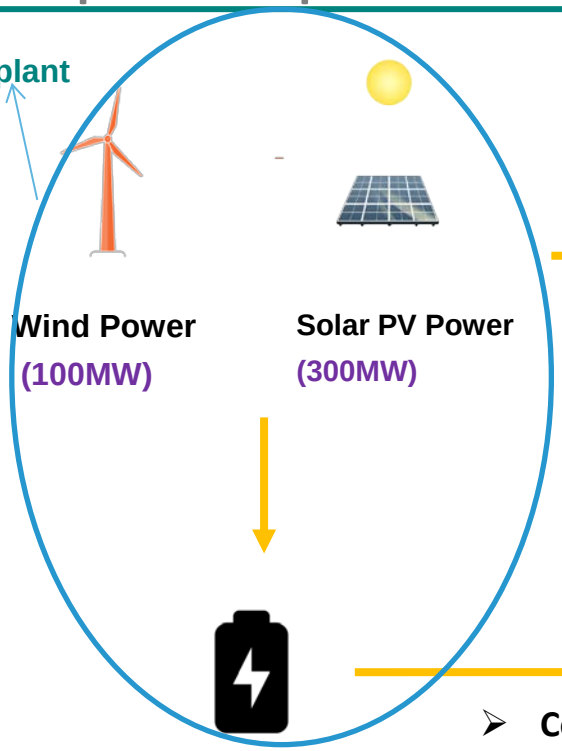
Objectives

To provide Round-The-Clock (RTC) power to the DISCOMs from renewable energy sources complemented/balanced with firm power from any other source or storage

- To address the issues of intermittency, limited hours of supply and low capacity utilization of transmission infrastructure
- New concept —bundling, wherein firm power from any other source or storage is bundled with renewable energy, and provided round-the-clock to the distribution company
- In other words, firm power from thermal/hydro or other sources or storage can be utilized to balance renewable energy and provide round the clock (RTC) power to the DISCOM thereby obviating the need for DISCOMs to balance power

RTC project Configuration

RE plant complemented with Thermal or any other source



Thermal or any other source
(only one Non RE source,
to balance the RE power) (200MW)

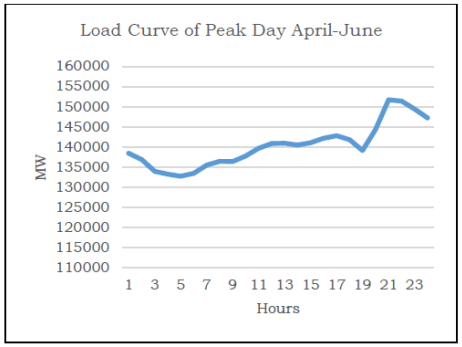
GRID
Power injection in MW,
limited to contracted
MW capacity (500MW)

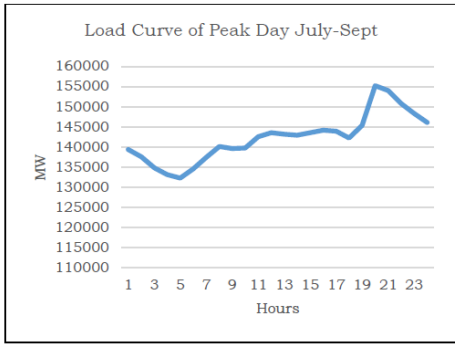
- Co-located or at different location
- Project capacity can be greater than contracted capacity
- Minimum annual availability of 85%: for overall Project and during peak hours
- Minimum 51% of annual energy shall be from RE plant
- RE generation- must run as per IEGC
- Peak hours: 4hrs /day (to be defined by RLDC)

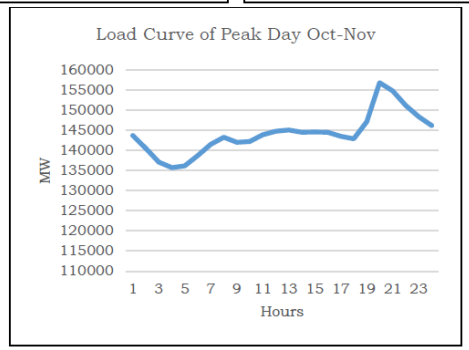
Generator shall supply despatchable RE power in Round- the-Clock manner complemented with other firm sources

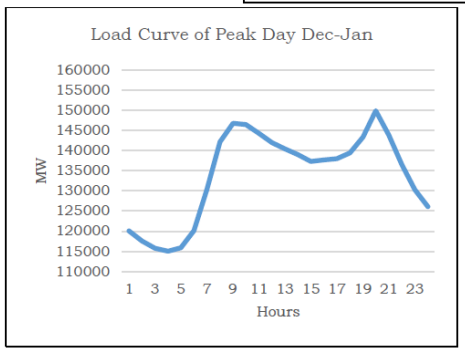
Load demand India basis

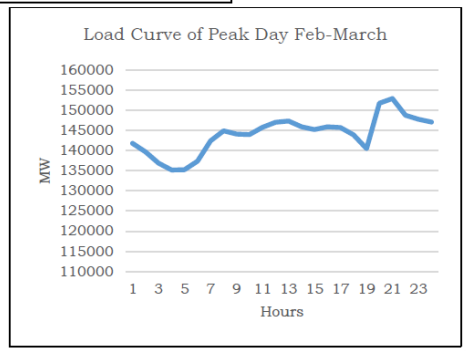
Peak demand in evening greater than morning







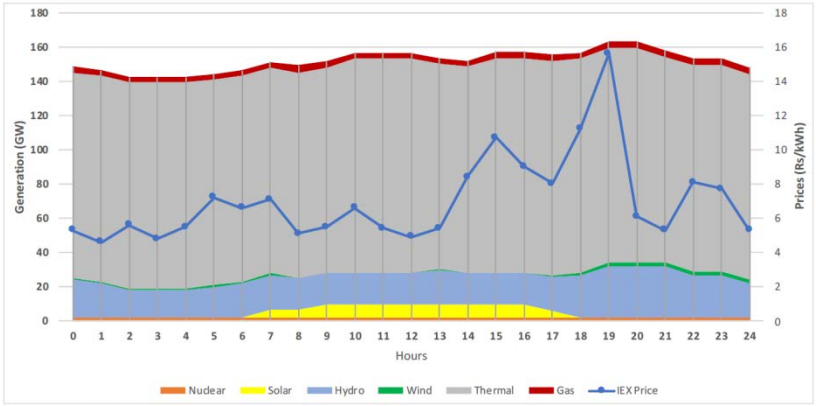




Wind Power could meet peak load demand using storage/conventional plant

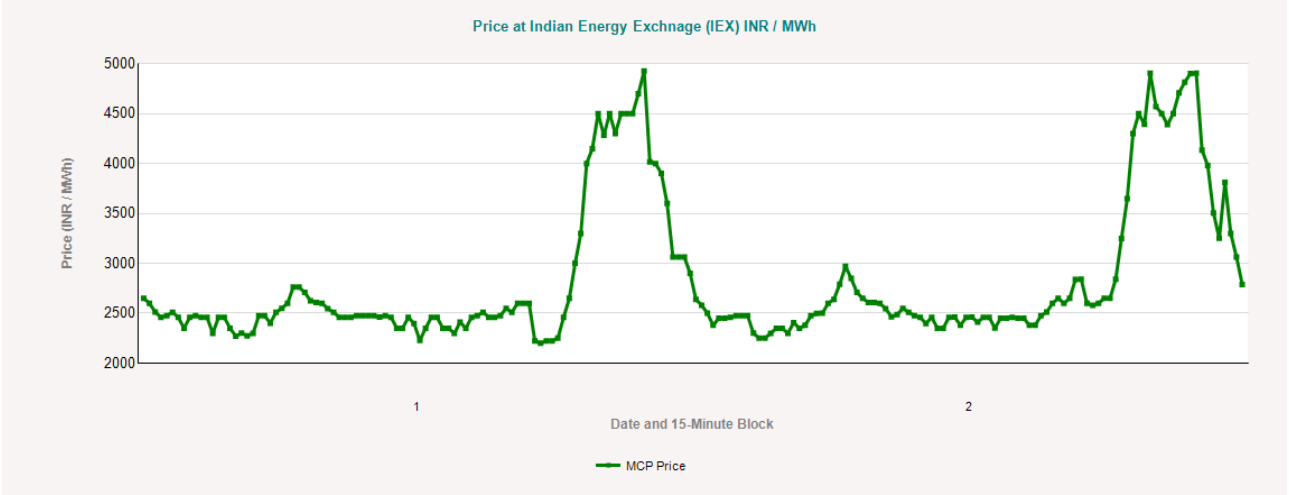
Load demand India basis

Peak Power pricing: on 3rd Oct 2018 at Indian Energy Exchange



Source: NLDC, IEX, IEEFA.

on 3rd Oct 2018



1st Sept 2020

Evening Peak load demand: appropriate wind power could be right solution

SECI RTC Tender 5000MW Generation requirement

Illustration: Monthly generation data

Declared availability in each time block								
Time Block	**Duration (hrs)**	**RE (MW)**	**Thermal (MW)**	**Total (MW)**	**Offered MWh (RE)**	**Offered MWh (Thermal)**	**RE %**	**Availability**
T1	60	250	200	450	15000	12000	55.6%	90%
T2	60	300	200	500	18000	12000	60.0%	100%
T3	60	350	50	400	21000	3000	87.5%	80%
T4	60	50	140	190	3000	8400	26.3%	38%
T5	60	50	200	250	3000	12000	20.0%	50%
T6	60	50	100	150	3000	6000	33.3%	30%
T7	60	200	200	400	12000	12000	50.0%	80%
T8 (Peak hours)	60	150	200	350	9000	12000	42.9%	70%
T9 (Peak hours)	60	100	200	300	6000	12000	33.3%	60%
T10	60	50	200	250	3000	12000	20.0%	50%
T11	60	150	200	350	9000	12000	42.9%	70%
T12	60	100	200	300	6000	12000	33.3%	60%
Total		**1800**	**2090**	**3890**	**108000**	**125400**		
Total MWh offered					**233400**			
Average (=Monthly availability)							**40.87%**	**64.83%**

Round-The-Clock (RTC) power

penalty for shortfall in availability, Excess/shortfall Generation

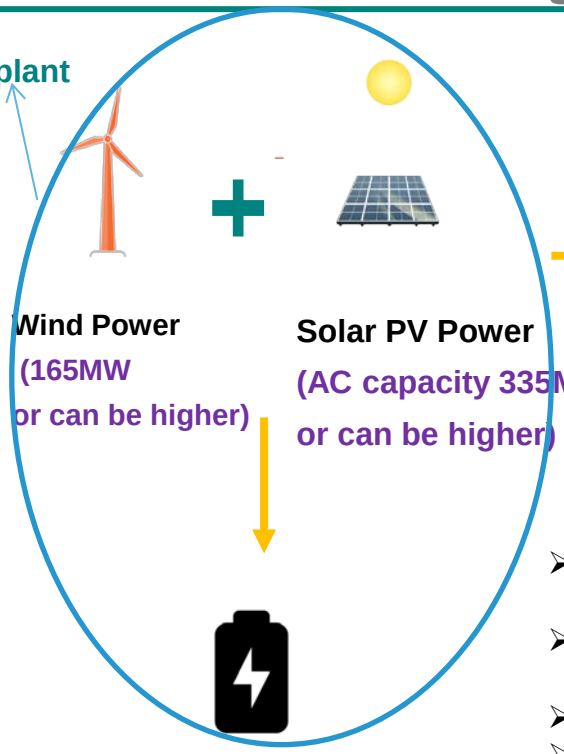
- In case the project **availability is less than 85% on annual basis**, **or during the peak hours**, for **reasons attributable to RTC Power Generator**, the Generator shall be liable to pay to the Procurer, **penalty for such shortfall in availability**.
- The amount of such **penalty will be 400% of the cost of this shortfall in energy terms**, calculated at the applicable tariff payable during the year.
- In a particular contract year, in case of shortfall in annual availability below 85%, shortfall in annual availability of peak hour below 85%, shortfall in offering RE power below 51%, the maximum of the three would be applicable (amendment -02)

- In order to allow optimization of operation of RE and Non RE Power Generating Systems, **the Generator is allowed to supply power from the Non RE power plant in excess of contracted capacity**, to any third party or power exchange **without requiring any No-Objection Certificate** from the Procurer.
- The Generator may also **sell the power which was offered to procurer (within Contracted Capacity)** but **not scheduled by Procurer**, **to any third party** or power exchange **without requiring NOC** from the Procurer on day ahead basis

- the Generator shall also be liable for **penalty for any shortfall in offering energy from RE Sources** out of total energy in a contract year **below the proportion of energy from RE sources**, quoted at the time of bidding, **for reasons solely attributable to Generator**.
- The penalty corresponding to this shortfall in RE power shall be calculated **at 400% of applicable tariff payable** during the year for each unit of shortfall

Hybrid Project Configuration, India

To be connected to ISTS grid @220KV or higher



GRID

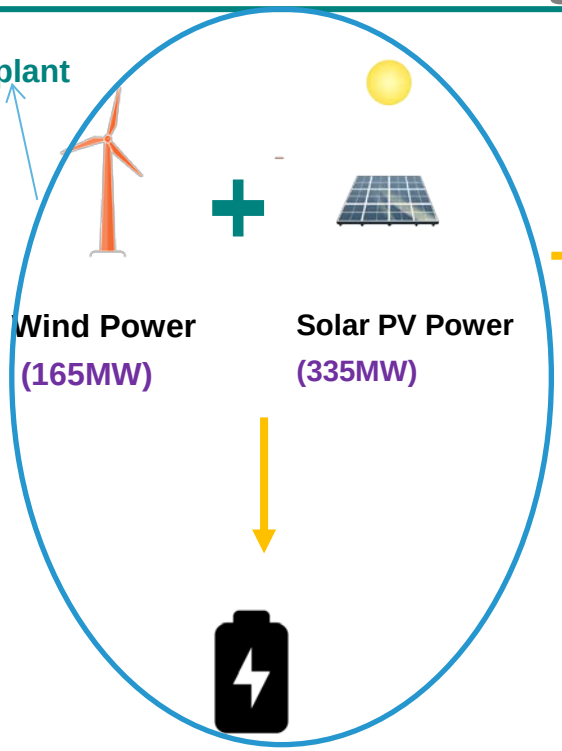
contracted MW AC capacity

(500MW)

- **Rated power capacity of one resource (wind or solar) shall be at least 33% of the total contracted capacity**
- **Project capacity need not be equal to the arithmetic sum of installed capacities of individual components** (Amendment 01)
- **Co-located or at different location**
- **Project Size: Minimum 50MW**
- **Minimum annual CUF: 30% (to be declared at the time of bidding, one time revision in first 3 years of operation)**
- **Allowed range of CUF during PPA period: 90 - 120% of declared CUF**
- **MUST RUN status as per IEGC**
- **Repowering is possible during PPA duration**
- **Installed Capacity: The installed capacity can +/- 5% of the Contracted Capacity** (Clarification 01)

Hybrid Project Configuration, India

To be connected to ISTS grid @220KV or higher



GRID

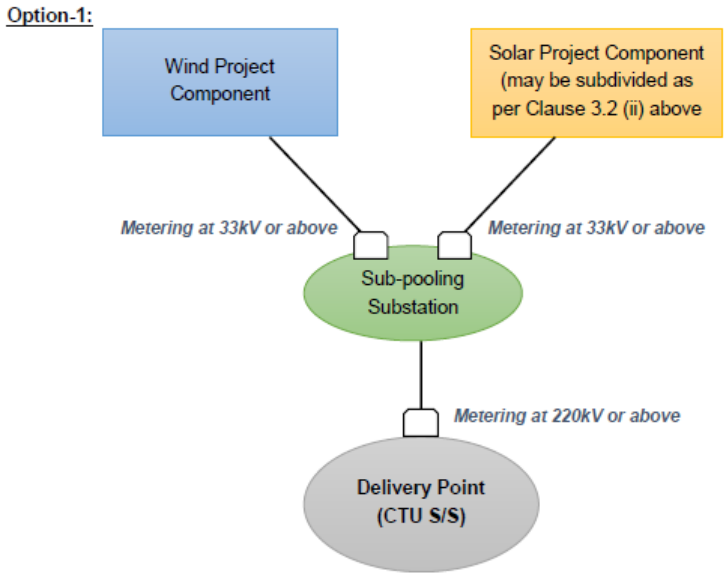
limited to contracted MW capacity (500MW)

Energy Storage may be added to the hybrid power project:

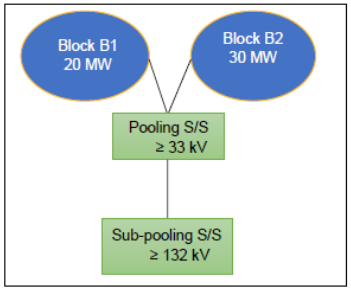
1) To **reduce the variability** of output power
2) **Providing higher energy output** for a given capacity (sanctioned capacity) at delivery point, by **installing additional capacity of wind and solar power**
3) To ensure **availability of firm power** for a particular period

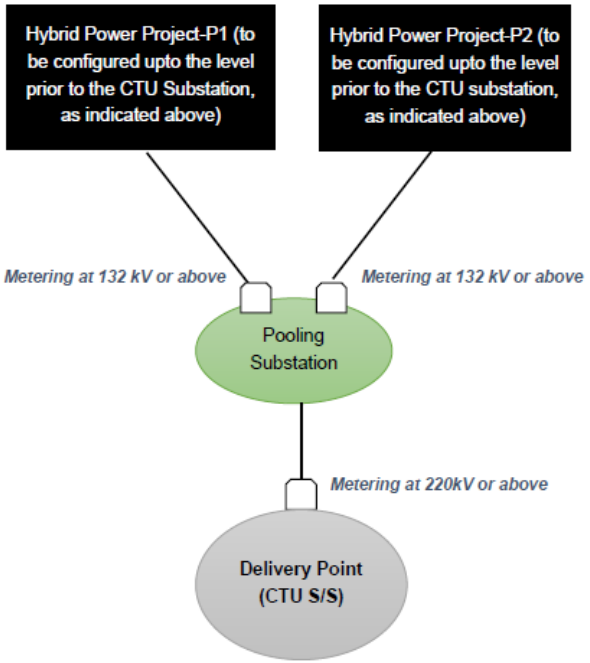
Hybrid Power Project, India

Configuration: two options allowed



SOLAR PROJECT COMPONENT CAPACITY: 50 MW





Hybrid Power Project

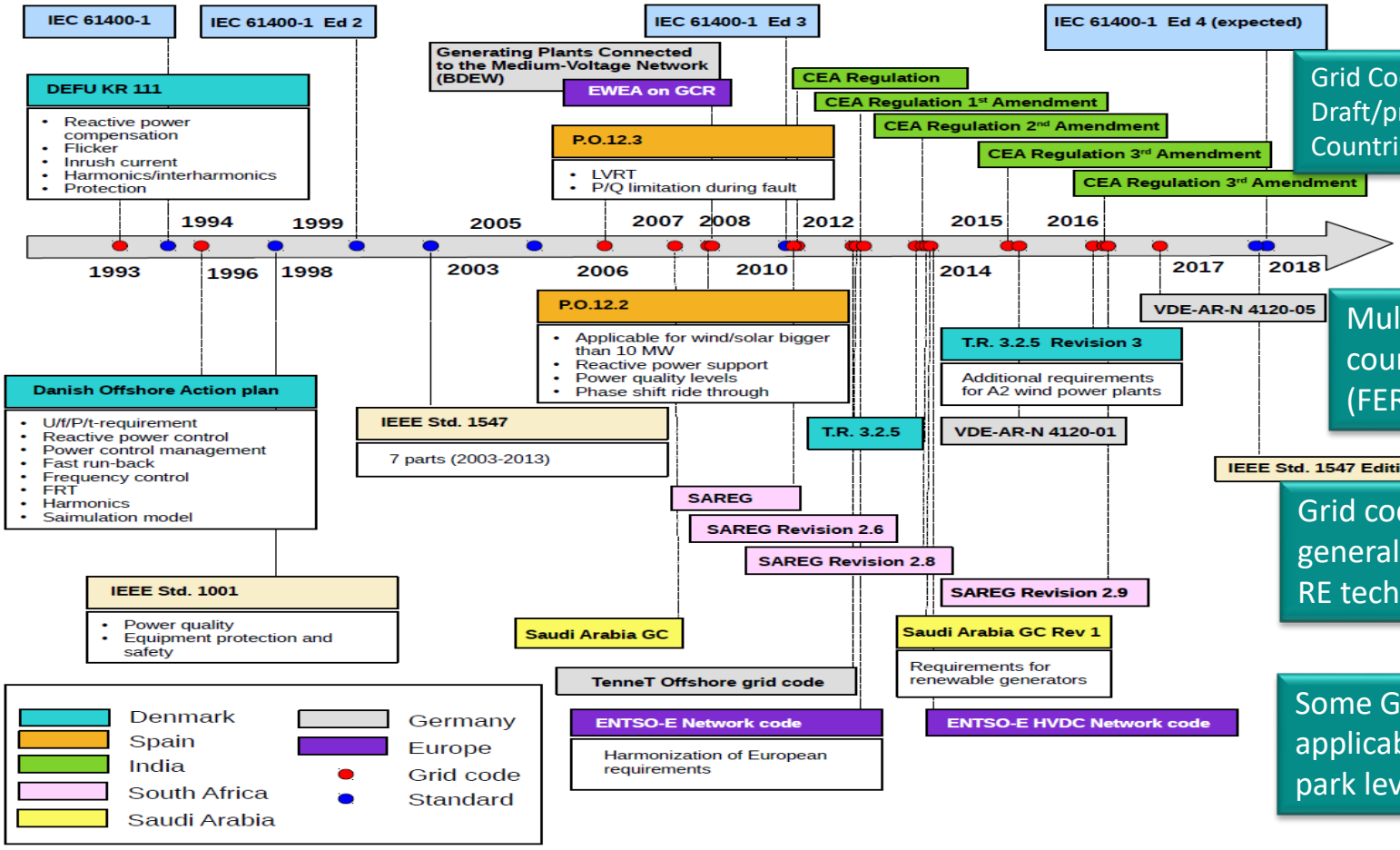
Excess/Shortfall in Generation

- In case of availability of energy more than the maximum annual CUF specified, Generator will be free to sell it to any other entity provided first right of refusal will vest with the Procurer
- In case the Procurer purchases the excess generation, the same may be done at 75% of the PPA tariff (specified in Amendment 05)
- Procurer only obliged to buy power within specified CUF in the PPA

Penalty for shortfall in availability

- In case the project supplies energy less than the energy corresponding to the minimum CUF, compensation for the shortfall in energy terms will be calculated @ 50% of the PPA tariff

Evolution of Grid Code & Standards to address large RE Energy Integration challenges



Grid Codes >232
Draft/proposal stage > 50
Countries published GC > 63

Multiple GC in some country, eg USA (FERC, ERCOT..)

Grid code are in general
RE technology neutral

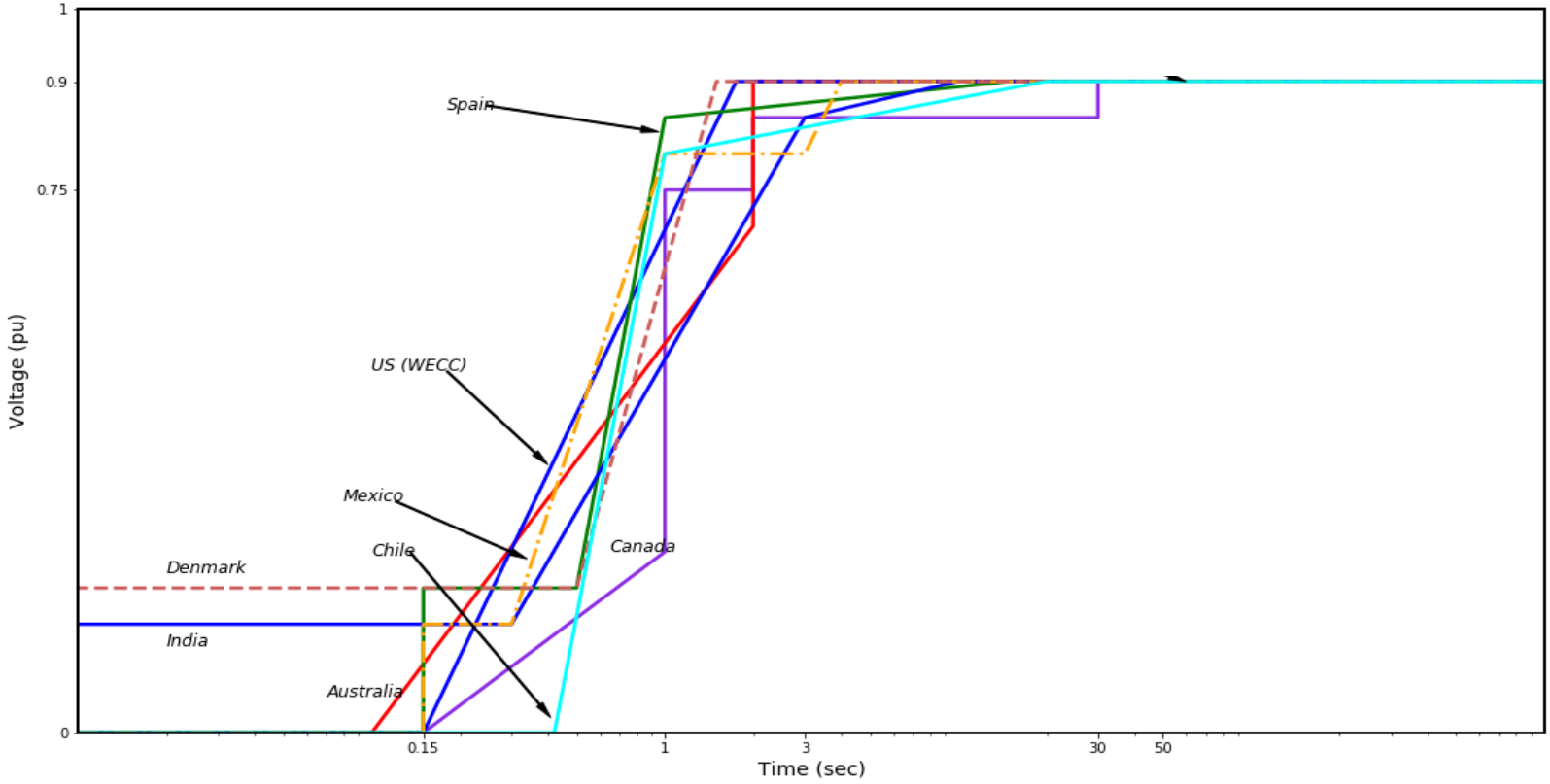
Some GC requirements applicable at WTG and or park level (India)

Capabilities requested to provide ancillary services at par or better than traditional generators, technical requirement trend in direction of replacing traditional generators

… To support higher RE integration challenges and meet Government targets

Low Voltage Ride Through (Wind, Solar, Storage, Hybrid)

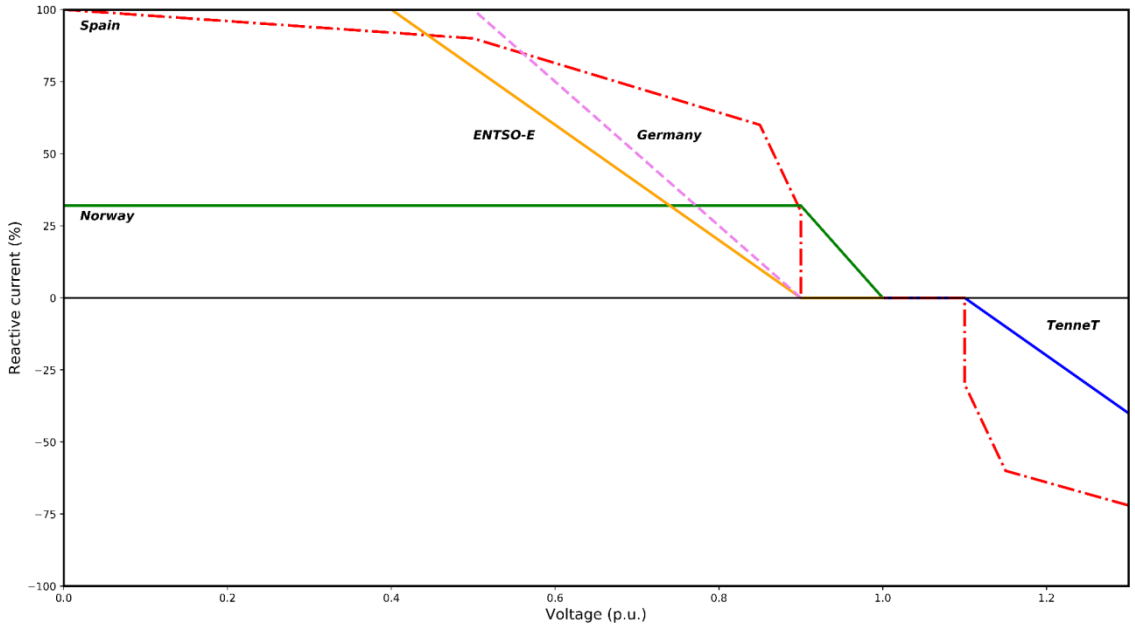
Key requirement with varied performance



- LVRT Testing of wind farm at point of connection not possible
- Prove compliance with real fault

Performance during Fault Ride Through

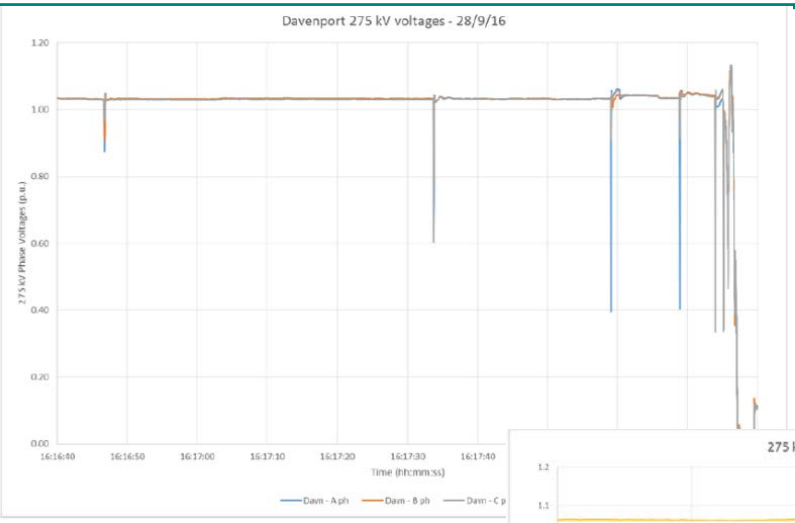
Controlled and co-ordinated magnitude of reactive current injection/absorption

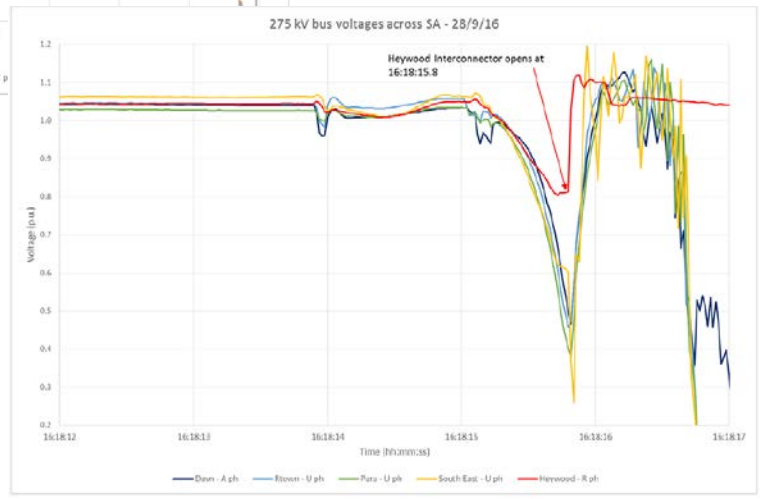


- To support grid voltage stability and frequency stability
- state of art Wind, Solar and storage converters capable to meet these requirements
- **We should define how Wind and Solar generators should behave considering local grid protection and operation philosophy and not according to certification agencies/other grid codes like Entsoe**

South Australia Grid Collapse: an example

Six voltage drops in 88 seconds on transmission system





28th Sept 2016:

- Lightning, wind speed forcasted upto 120km/h,
- prefault load of 1895MW
- 850,000 electricity customers
- Interuption for 65 minutes
- Instantaneous loss of 900 MW due to LVRT protections systems in wind farms

- Plant shall be designed considering Extreme weather conditions like in S.Australia that happended once in 50 years
- Grid interfacing converters in Wind and Solar plants sensiotive to disturbances
- Challenge in ensuring power system stability under such events when RE become major source…….

  No mention of such requireemnts in grid codes or IEC/IEEE standards

LVRT test facility

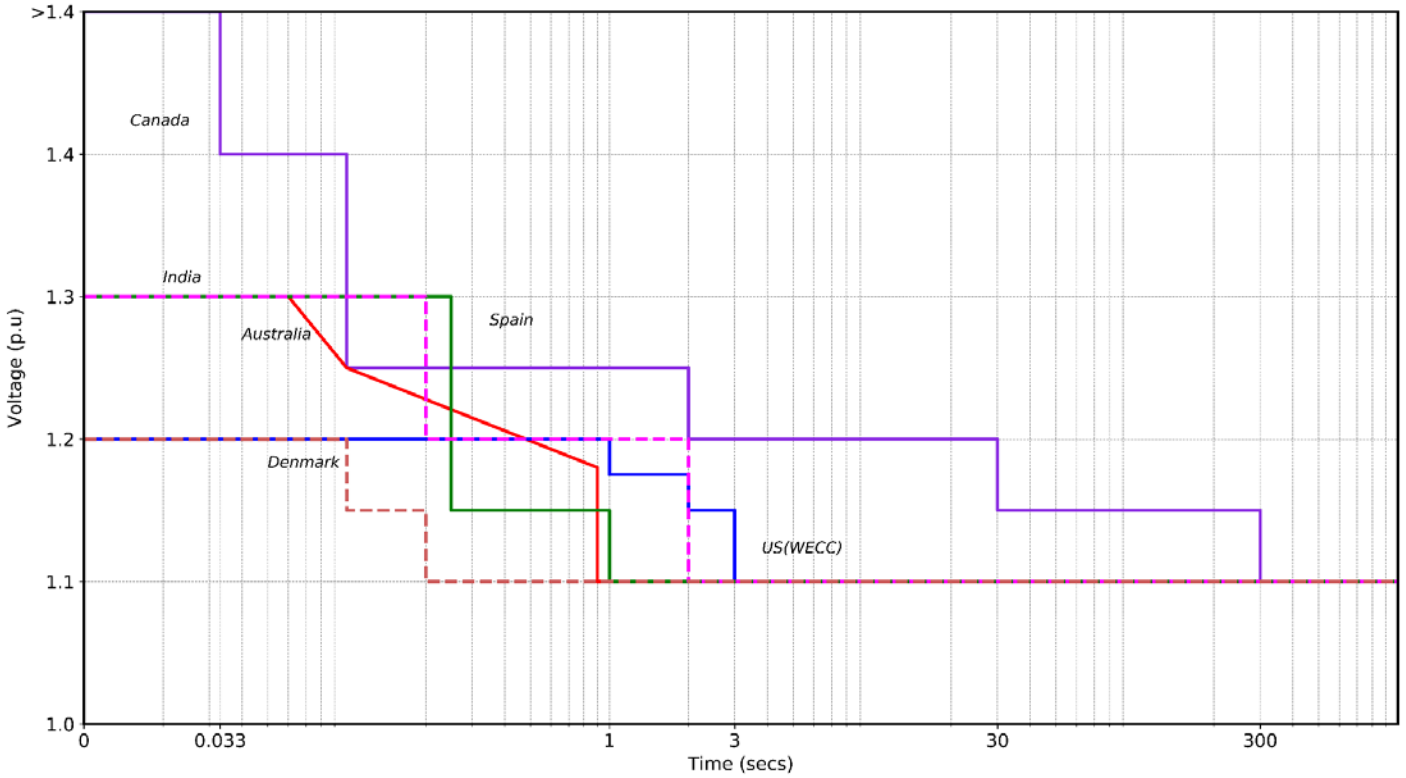
Suzlon mobile LVRT/HVRT Laboratory at site in India

Wind turbines extensively tested at 33KV voltage level with direct connection to grid

Testing needs to consider wind season (once in a year, 3-4 months duration, few weeks of rated wind), testing as per IEC standard 61400-21-1
Not possible to test the entire park at POI/PCC

High Voltage Ride Through (wind, solar, storage)

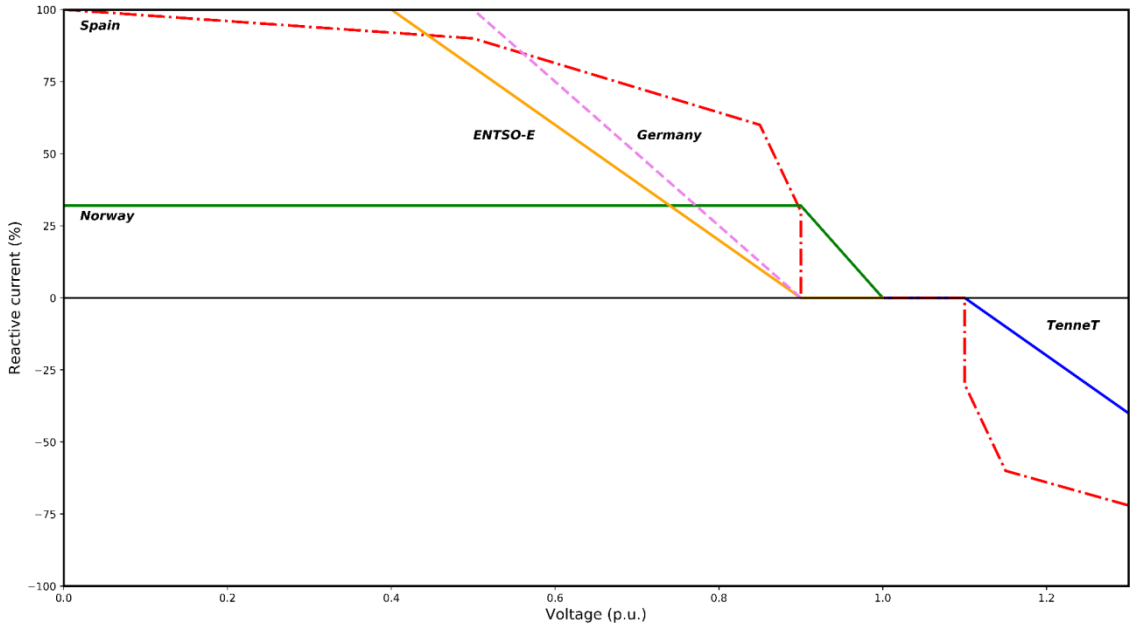
HVRT at park level (point of common coupling)



- Testing of wind farm/RE parks at point of connection not possible
- Prove compliance with real fault at park level....long wait for event and then approval process
- Acurate model and simulations using state or art software

Performance during Fault Ride Through

Controlled and co-ordinated magnitude of reactive current injection/absorption



- To support grid voltage stability and frequency stability
- state of art Wind, Solar and storage converters capable to meet these requirements
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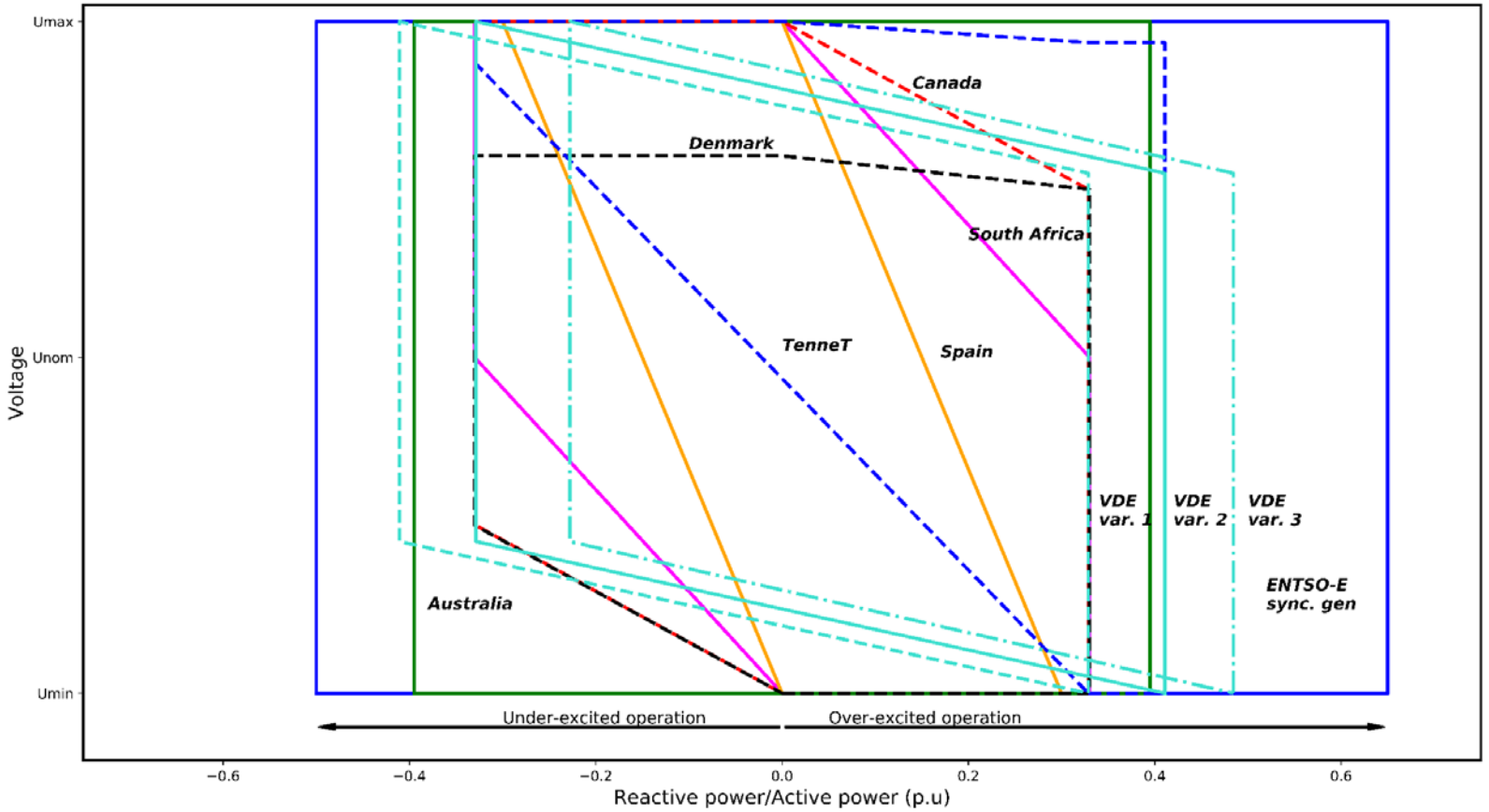
Reactive power capability requirement



- Reactive capability of wind and solar plants is available 24X7, could be utilised to regulate grid voltage , improve voltage regulation and stability with proper co-ordination
- RE plants provide very fast response (<20ms), accurate control, low loss

Grid Frequency Regulation

Worldwide Overview, Frequency response critical to ensure reliable power system operation

Country	Applicability	Droop range	capability	Market driven
ENTSO-E, Europe (36 countries, 46 TSO)	yes	2-12%	yes	Yes, vary country to country, under adoption phase
ERCOT, USA	yes	5%	YES (reserve headroom)	YES
Ontario IESO	yes	2-7%	Yes, additional synthetic inertia	
PJM	yes	5%	yes	
California ISO	yes	5%		yes
National Grid, UK	Yes, conditional	3-5%	Yes, enhanced frequency response	Yes, procured from batteries
AEMO, Australia	yes		yes	yes
Spain	yes	1.5%	yes	yes
Brazil	yes	2-8%	yes	
Singapore	yes	3-5%	yes	yes
Switzerland	yes	2-12%	yes	yes
India	yes	3-6%	yes	in discussion

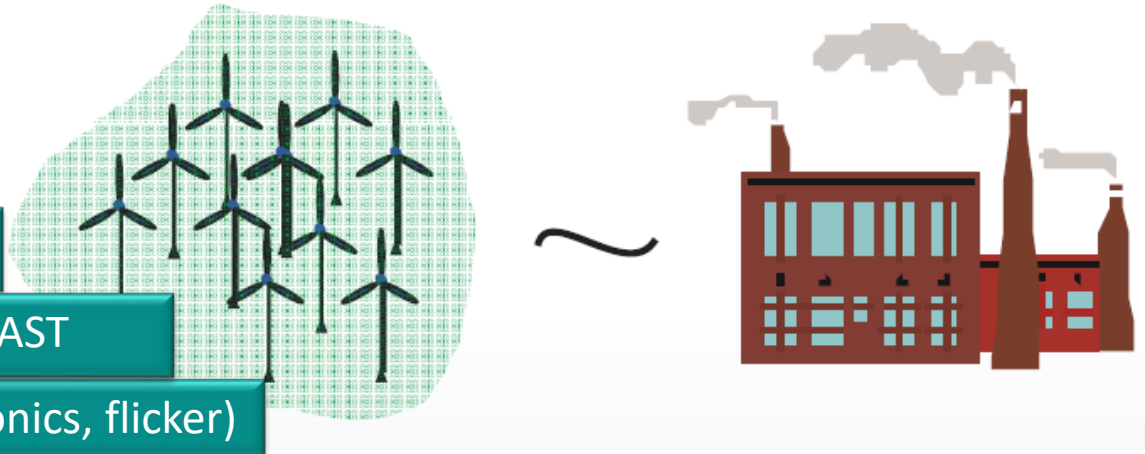
Frequency response and regulation requirements included in grid codes of most countries with different performance parameters with separate commercial settlement mechanism

Common technical requirements/grid code world wide?

Due to the differences in the composition of the power generation mix, load characteristics, evolution of power grid, and other specific circumstances, there would not be identical grid codes.

Countries with less experience in wind & solar technology would adopt technical requirements from other advanced grid codes

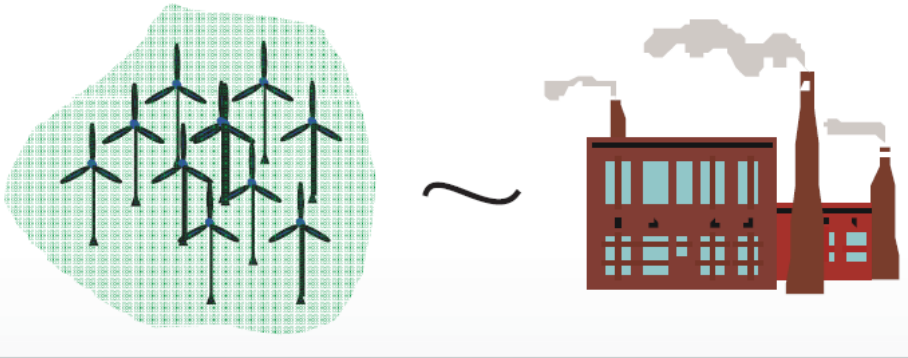
Technical performance expected from RE parks.. in near future…



- SYNTHETIC INERTIA
- FAST FREQUENCY REGULATION
- ACCURATE GENERATION FORECAST
- POWER QUALITY (Harmonics, flicker)
- VOLTAGE & FREQUENCY RIDE THROUGH
- POWER OSCILLATION DAMPING
- Unbalance low/high voltage ride through capability
- Reactive Power/Voltage Support during no wind
- Wind independent power ramp up/down
- BLACK START

Industry standards (IEC/IEEE) for compliance, testing etc under research and development

Expected performance



SECURITY, RELIABILITY, STABILITY and QUALITY of POWER Supply from RE parks same or better than traditional power plants

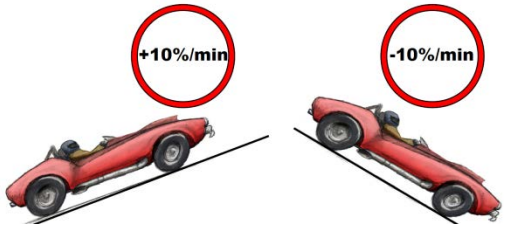
Current trends = future mandatory technical requirements

Failure to remain compliant with grid code could lead disconnection of RE parks from grid, causing huge revenue loss to generation companies

Example: Technical standards for connectivity to Grid (CEA 2019, India)

Major requirements: Wind park, solar Park, Hybrid Park

1. power ramp control



➢ **Compliance at Park level**

Generating stations shall be equipped with the facility for controlling the rate of change of power output at a rate not more than ± 10% per minute

3. High Voltage Ride Through

(voltage up to 130% for 0.2 sec)

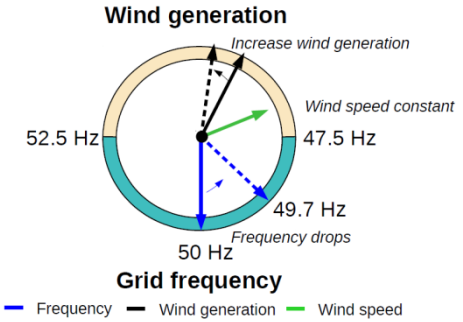
➢ **Compliance at Park level**

4. Low Voltage Ride Through

(Active power recovery in 1 sec)

➢ **Compliance at Park level**

2. Frequency Response



➢ **Compliance at Park level**

- **Provided that for large frequency deviation e.g. in excess of 0.3 Hz, the Wind and Solar 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 AC active power capacity**
- **The operating range of the frequency response and regulation system shall be from 10% to 100% of the maximum AC active power capacity, corresponding to solar insolation/wind speed**
- **Governors/frequency controllers of the units (WTG) shall have a droop of 3 to 6% and a dead band not exceeding ±0.03 Hz**

Challenging technical requirements, require innovative solutions

POWERING A GREENER TOMORROW

References

More amendments expected in RfS of RTC 5000MW before bidding

1. Flexing India's Energy System Making the Case for the Right Price Signals Through Time-Of-Day Pricing, 8 Jan 2019, IEEFA, India
2. Report on optimal generation capacity mix for 2029-30 by Ministry of Power & CEA, Jan 2020
3. Amendments to the Guidelines for Tariff Based Competitive Bidding Process for Procurement of Round-The Clock Power from Grid Connected Renewable Energy Power Projects, complemented with Power from Coal Based Thermal Power Projects, 3rd November 2020
4. Guidelines for Tariff Based Competitive Bidding Process for Procurement of Round-The Clock Power from Grid Connected Renewable Energy Power Projects, complemented with Power from Coal Based Thermal Power Projects, 22 July 2020

Amendment-01 to RfS for Selection of RE Power Developers for Supply of 5000 MW of Round-the-Clock (RTC) Power from Grid-Connected Renewable Energy (RE) Power Projects, complemented with Power from Coal based Thermal Power Projects in India under Tariff-based Competitive Bidding (RTC-II)

Amendment-02 to RfS for Selection of RE Power Developers for Supply of 5000 MW of Round-the-Clock (RTC) Power from Grid-Connected Renewable Energy (RE) Power Projects, complemented with Power from Coal based Thermal Power Projects in India under Tariff-based Competitive Bidding (RTC-II)

Clarifications to queries on the RfS for Selection of RE Power Developers for Supply of 5000 MW of Round-the-Clock (RTC) Power from Grid-Connected Renewable Energy (RE) Power Projects, complemented with Power from Coal based Thermal Power Projects in India under Tariff-based Competitive Bidding (RTC-II)
(RfS No. SECI/C&P/RPD/RTC-II/RfS/5000MW/032020)

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- Guidelines for Tariff Based Competitive Bidding Process for procurement of power from Grid Connected Wind Solar Hybrid Projects, 14 Oct 2020
- REQUEST FOR SELECTION (RfS) DOCUMENT FOR SETTING UP OF 1200 MW ISTS-CONNECTED WIND-SOLAR HYBRID POWER PROJECTS (TRANCHE-III), RfS No SECI/C&P/HPD/T3/1200MW/RfS/012020, 14.01.2020
- Amendment-08 to the RfS for 1200 MW ISTS Connected Wind-Solar Hybrid Power Projects (Tranche-III) , 28.11.20 (related to change in law clause)
- Amendment-07 to the RfS for 1200 MW ISTS-Connected Wind-Solar Hybrid Power Projects (Tranche-III), 25.11.20 (related to change in law clause)
- Amendment-06 to the RfS for 1200 MW ISTS-Connected Wind-Solar Hybrid Power Projects (Tranche-III), 19.11.20 ((related to bank guarantee)
- Amendment-05 to the RfS for 1200 MW ISTS Connected Wind-Solar Hybrid Power Projects (Tranche-III) , 27.10.20
- Amendment-04 to the RfS for 1200 MW ISTS Connected Wind-Solar Hybrid Power Projects (Tranche-III) , 26.06.20
- Amendment-03 to the RfS for 1200 MW ISTS-Connected Wind-Solar Hybrid Power Projects (Tranche-III), 24.04.2020
- Amendment-02 to the RfS for 1200 MW ISTS Connected Wind-Solar Hybrid Power Projects (Tranche-III) , 19.03.2020
- Amendment-01 to the RfS for 1200 MW ISTS-Connected Wind-Solar Hybrid Power Projects (Tranche-III), 25.02.2020

- Clarifications-02 to the RfS for 1200 MW ISTS-Connected Wind-Solar Hybrid Power Projects (Tranche-III), 06.11.20
- Clarifications to the queries on the RfS , 25.02.2020
- Draft IEGC 2020
- Grid codes of India, South Afrika, Australia, Europe, ENTSO-E, USA, UK, and other countries

Thank you

for your attention