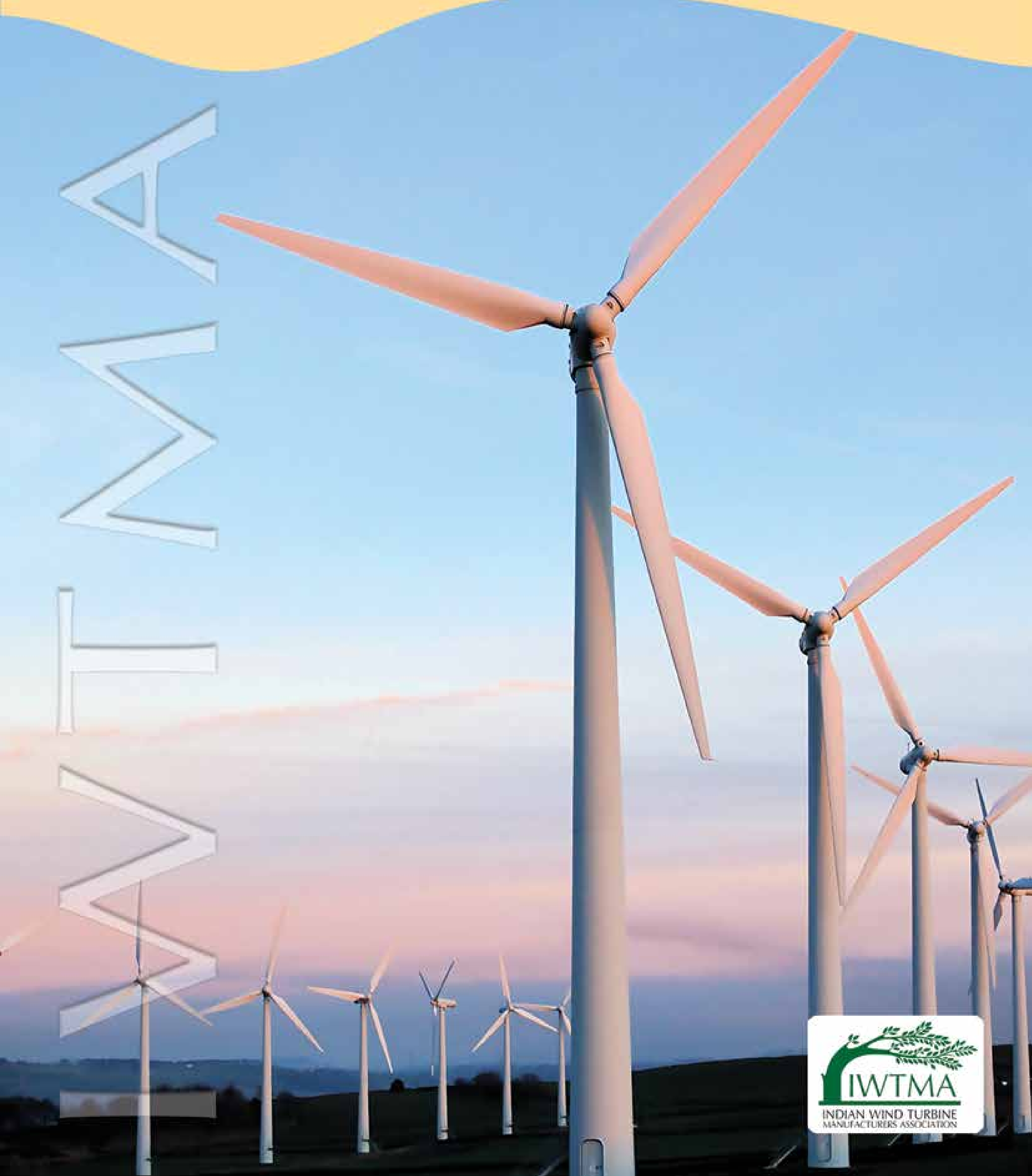
Volume: 6 Issue: 1 April - May 2020 ₹ 10/-
Bimonthly, Chennai

Indian Wind Power



Expertise and Research & Development for Wind and Solar Energy Stakeholders

Resource Assessment

Wind Energy

- Carry out Nationwide Wind Resource Assessment
- Estimation of Wind Potential in the country through Wind Atlas preparation
- Design and implement the comprehensive Resource Assessment Programme
- Analysis of wind data to identify Wind Farmable locations
- Verification and vetting of wind data generated by private entrepreneurs
- Consultancy services for Feasibility Studies, Technical Due Diligence, Micro-siting and preparing DPR for Wind Farming and Repowering assessment

Offshore Wind Energy

- Nodal Agency for Offshore Wind Energy development in India
- Met-Ocean Measurement.
- Demarcation of Offshore Wind Energy Blocks
- Geophysical and Geotechnical Studies

Solar Energy

- Solar Radiation Resource Assessment
- Investor & bankable grade Solar / Meteorological data
- GIS enabled Indian Solar Atlas
- Calibration of solar sensors as per International Standards
- Consultancy on Solar Energy Projects

Forecasting

- Wind Power Forecasting Services
- Solar Power Forecasting Services

Testing (Large & Small)

- Power Performance measurements
- Load measurements
- Power Quality measurements
- Safety and function tests
- Yaw efficiency test
- User defined measurements
- Duration Test

The services are as per internationally accepted procedures & stipulations and certified as per the requirements of ISO 9001 & NABL accredited as per the requirements of ISO/ IEC 17025 : 2005

Standards & Certification

- Preparation of Indian standards on wind turbines
- Accord Type Certification to Wind Turbines. Type Certification Services are certified as per ISO 9001
- Issue the recommendation for grid synchronization to facilitate installation of prototype wind turbines
- Technical Due Diligence for Wind Farm Projects

Training

National, International and Customized Training on:

- Wind and Solar Resource Measurement & Analysis
- Wind and Solar Energy Technology
- Testing and Certification of Wind Turbines
- Installation, Commissioning and Operation & Maintenance of Wind Turbines
- Grid Integration of Renewable Energy System
- Forecasting of Wind and Solar Energy Production
- Seminar / Workshops on Wind and Solar Energy

NIWE

NATIONAL INSTITUTE OF WIND ENERGY

An Autonomous Research & Development Institution under the Ministry of New and Renewable Energy, Government of India

Velachery - Tambaram Main Road, Pallikaranai, Chennai - 600 100

Phone : +91-44-2246 3982 / 83 / 84 Fax : +91-44-2246 3980 E-mail : info.niwe@nic.in Website : http://niwe.res.in

IWTMA
INDIAN WIND TURBINE MANUFACTURERS ASSOCIATION

Indian Wind Power

A Bi-monthly Magazine of Indian Wind Turbine Manufacturers Association

Volume: 6 Issue: 1 April - May 2020

Contents

Indian Wind Turbine Manufacturers Association

4th Floor, Samson Tower, 403 L, Pantheon Road, Egmore
Chennai - 600 008.
Email : secretarygeneral@indianwindpower.com
associatedirector@indianwindpower.com
Website : www.indianwindpower.com

(For Internal Circulation only)

From the Desk of the Chairman – IWTMA

Greetings from IWTMA!

Hope each one of you is doing well?

On behalf of IWTMA, I am happy to share that our magazine 'Indian Wind Power' has entered the 7th year of publication. This has been possible mainly due to advertisement support by the Industry, authors and readers who have encouraged us to bring out articles in our march towards 'Clean & Green Energy' and making WIND IS THE ANSWER.

In this time of uncertainty with pandemic, our Union Power Minister Shri R. K. Singh interacted with the Power Stakeholders on 'Atmanirbhar Bharat' and 'Make in India' initiative. It is a matter of pride that Wind industry has already achieved 80% localization and we pledge our support to the Government for achieving the ultimate goal of 'Make in India'. India has the potential to be a Global hub for Renewable Energy components as well as services. Government has set a laudable target of 175 GW by 2022 and 450 GW by 2030 of which wind has a share of 60 GW by 2022 and 150 GW by 2030. Government is committed to affordable power for all and RE (Wind) can play a significant role.

Our Association has been advocating multiple procurement models to leapfrog capacity addition as the country today is totally dependent on Centralized Procurement. The multiple procurement models include Open Access for ISTS transaction for Captive and Group Captive, incentivize wind states with REC who exceed their RPO, opportunity for small investors who have built the first 25 GW of Wind Power in the country and Uniform Wheeling and Banking Policy to encourage captive users of power intensive industry to hedge and future proof power cost. Our Association has given a representation outlining suggestions to the Amendments in the Electricity Act for consideration.

The Government has been very supportive of the Renewable energy sector and has taken quite a few steps that have been commendable.

- The Finance Minister's move to inject Rs 90,000 crore to revive the DISCOMs and their privatisation in Union Territories will boost the power sector.
- The Ministry of New and Renewable Energy (MNRE) has started the process to engage a consulting firm for preparing institutional framework for implementing the ambitious 'One Sun, One World, One Grid (OSOWOG)' programme. Under the programme, India envisages to have an inter-connected power transmission grid across the nation for supply of clean energy.

US Agency for International Development (USAID) and Ministry of New and Renewable Energy (MNRE) recently launched a new partnership to increase India-US collaboration for clean energy development. I believe that we can truly make India a Global leader to champion renewable energy and establish a global manufacturing hub to create a truly 'Aatmanirbhar Bharat'.

With regards,

Tulsi Tanti
Chairman

Monitoring of Key Project Parameters-Concept to Commissioning of RE Projects

Dr. S. Gomathinayagam, Independent Technical and Management Advisory
(Renewables: Wind, Solar, Structural, Foundations, Project Management)
sgetgoms@gmail.com

Summary

Most projects need rigorous planning and execution. Renewable energy projects are no exception and in fact their being highly interdisciplinary science and engineering projects; more comprehensive approach is resorted to. Concept and objectives, resource potential, choice of site specific renewable energy technology, feasibility of scale and capacity, financial viability, sustainability and social inclusiveness are essentially the key project parameters through the process of execution of any renewable energy project today. If one does take care of these key parameters in the very beginning, the "cost and time over-run" of renewable projects can be very well avoided or potential damage of project performance can be minimized. This article is focussing on these project monitoring needs of various renewable energy (RE) projects with specific reference to wind energy in India, especially in the most difficult "post-Corona" worldwide economic recession and investment scenario.

Introduction

The key parameters are often driven by government policies, investor interests, business case in use of electricity and so on. In this article we will run through the various project key parameters which need to be understood as early as in planning stage, so that the Project Management (PM) (Figure 1), can be completed in time, scope and capital investment cost is seamless without "cost and time overruns" (Figure 2).

Figure 1: Positive Returns Only After Project Commissioning

Wind energy projects as of now suffer several blows especially in India, owing to solar competition in the new policy of auctioning and electricity unit price determination by reverse bidding option. Again with the best sites being already occupied in India, lack of old investors' interest to reinvest for repowering in high technology modern large wind turbines, delayed payments from loss making DISCOMs, lack of policies towards innovative cross coupled technologies and renewable hybrids with storage

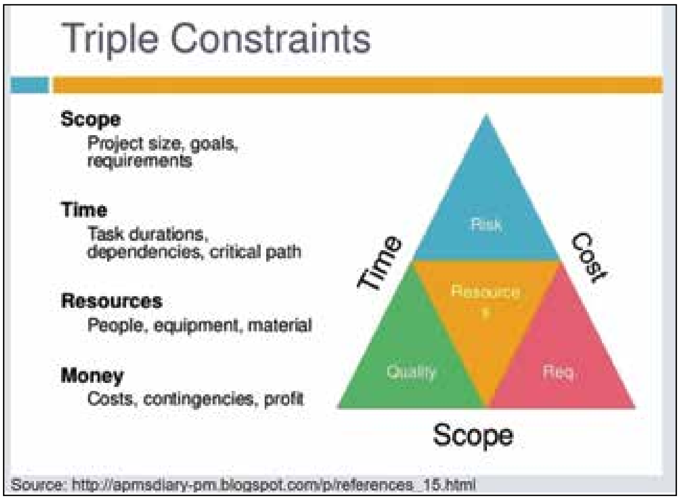


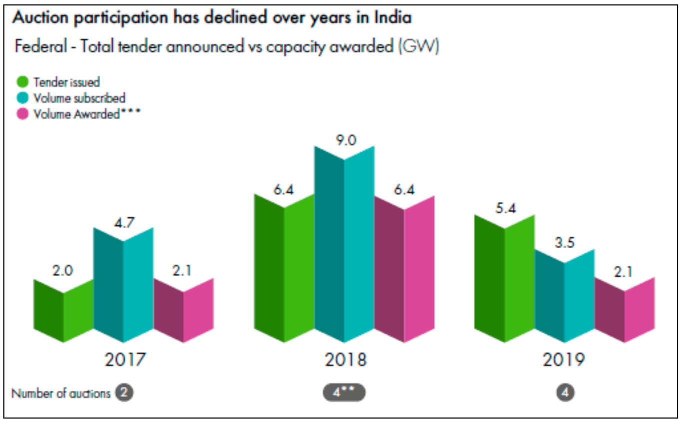
Figure 2: The Project Management (PM) - Triangle Applicable up to Commissioning Phase

assisted 24x7 dispatch of power, are just a few well known barriers for accelerated wind power deployment in India. There are specific societal and several other issues in every new green field project whether onshore or offshore (yet a non-starter of real projects).

Key-Parameter: Concept and Objectives

Historically India as well as rest of the world had promoted wind energy with feed-in-tariff associated with or without accelerated depreciation benefits and PTC (production tax credits). Today's auctioned tariff pricing regime has its own advantages of competitive innovations to attract investors with improved technologies of performance and enhanced profits. The earlier objective and concepts chosen may be captive use in balance sheet financing (profit share invested), today it's mostly energy sales driven and most projects come off from independent power producers or Governmental initiatives for auctioning wind power (Figure 3). So, the objective of a wind farm of the deemed industrial consumer, is literally outsourcing to energy supply companies the power demand for their production.

According to GWEC market analysis, there are innovative hybrids and storage based wind solutions, off-grid hydrogen generation, desalination, micro-grid support system, EV charging



** Auctions retendered with changes in design have been considered as single auctions (Applicable on SECI V and Gujarat II)

*** Projects abandoned at a later stage after contract award are a part of volume awarded

Figure 3: Impact of Low Bid-in-Tariff (BiT) in India (GWEC Report 2019)

infrastructures with other renewables should form the new concept and objectives for wind farm developers.

Key-Parameter: Resource Potential

For wind farm developers, resource potential even though seasonal, bankability of data would be higher if several years of wind data can be simulated and long-term prospects scientifically quantified. In the case of solar ground based large MW class grid connected projects, national level well verified and calibrated radiation data would save considerable long-term revenue loss. The National Institute of Wind Energy (NIWE), under the Ministry of New and Renewable Energy and its sister institutions NISE and NIBE provide most of the necessary renewable energy data in India. NIWE's wind solar data for preliminary assessment of wind and solar resource even accessible through mobile app like "SWurja" (Figure 4) are highly useful.

There are several other renewable energy resource atlases

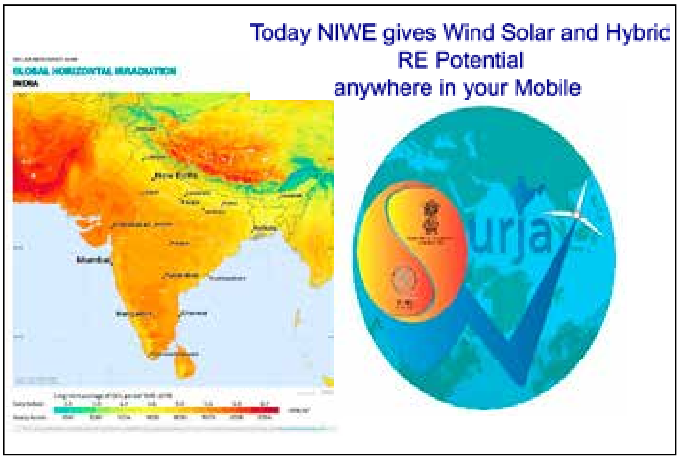


Figure 4: SWurja Mobile App for Ready Reference Potential - NIWE, Chennai

covering the various regions of countries around the world. In the present scenario of renewable energy projects, the so called intermittency needs to be overcome through hybrid projects with appropriate marriage of resource availability based technologies, may be coupled with partial storage systems.

Key-Parameter: Choice of Site Specific RE Technology

Renewable energy technologies have been on the upscale continuously improving in performance and efficiency, in order to mitigate global warming and climate change. Right choice of site specific RE technology/hybrid technologies has become extremely important. For instance, if one goes for wind energy, the first and foremost thing will be to maximize annual energy production (AEP). This needs a perfect matching of wind resource availability and the suitable wind turbine model at the proposed site (Figure 5). Today the level of competition demands to look into much finer aspect of wind conditions, turbulence, active incoming wind sensing pitch regulation systems, innovative blade surface aerodynamic tuning, to have a consistent AEP for the entire design life of 20-25 years and beyond. It is very much essential not to over design wind turbines to cover all weather conditions such as deserts, high altitude mountains, snow loads of cold regions near the poles, and coastal sea or deep ocean wind. If one chooses a universal wind turbine, the cost of machine (capital as well as operational) would be uneconomical when it is selected for a large wind farm.

Key-Parameter: Feasibility of Scale and Capacity

Technical due diligence of renewable energy projects are inevitable mainly because of the need for site specific sizing of the capacity of projects. Techno-economic feasibility of projects is the first step for investment protection. If the land is contiguous large area, very large scale project design is possible earlier, but with the present technologies of IoT (Internet of Things), IIoT (Industrial Internet of things), and ICT (Information and Communication Technologies), even large scales and capacities can be designed with installations spread across continents. Energy asset management has become highly oriented to data science and data analytics.

Specific Challenges in RE implementation Methodologies

An excellent overview is presented in an exhaustive report on concept to operation of renewable energy projects by Sargent and Lundy in a NREL (National Renewable Energy Laboratories, USA) report (Figure 6). Even planning for onshore wind and offshore wind projects have significant changes in project activity planning and execution. For instance, the wind turbine cost in the onshore may be 60% of total project cost, while the same in offshore installations may be 30% of total project cost or even less. The offshore wind projects' wind turbine support platform, erection and commissioning may have a large fraction of EPC-contracts close to 60%. In the context of renewable energy

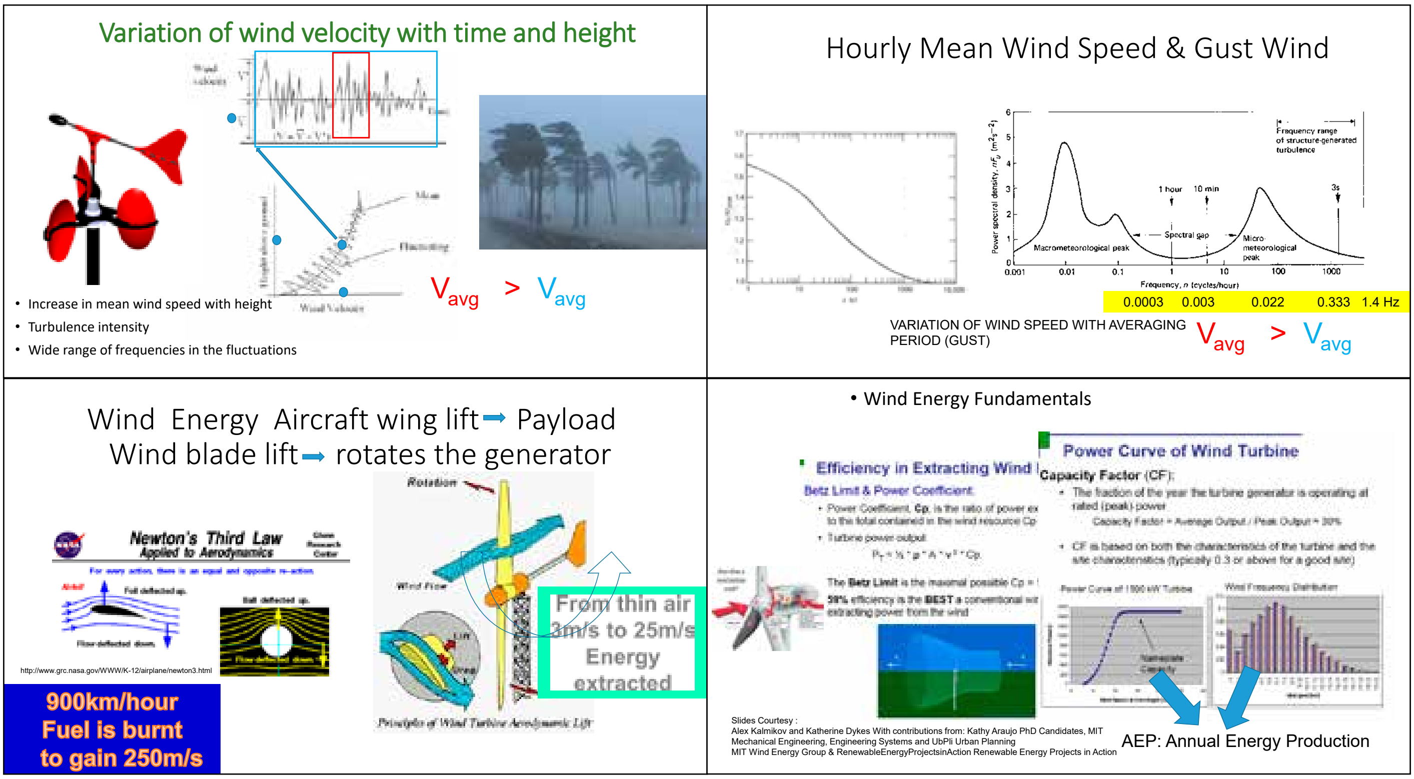


Figure 5: Wind Conditions for Maximizing Annual Energy Production from Wind at a Site

projects feasibility of large Giga Watt scale projects will show significant cost reduction, as expensive special installation ships hiring hours can be minimized. Simulation studies on Micrositting of wind turbines in a wind farm cluster are a must to maximize energy production.

Large scale solar PV (photovoltaic) or solar thermal projects need sizing capacity of inverters modular upgradability of the plant, DC cabling loss minimization, effective maximum power point

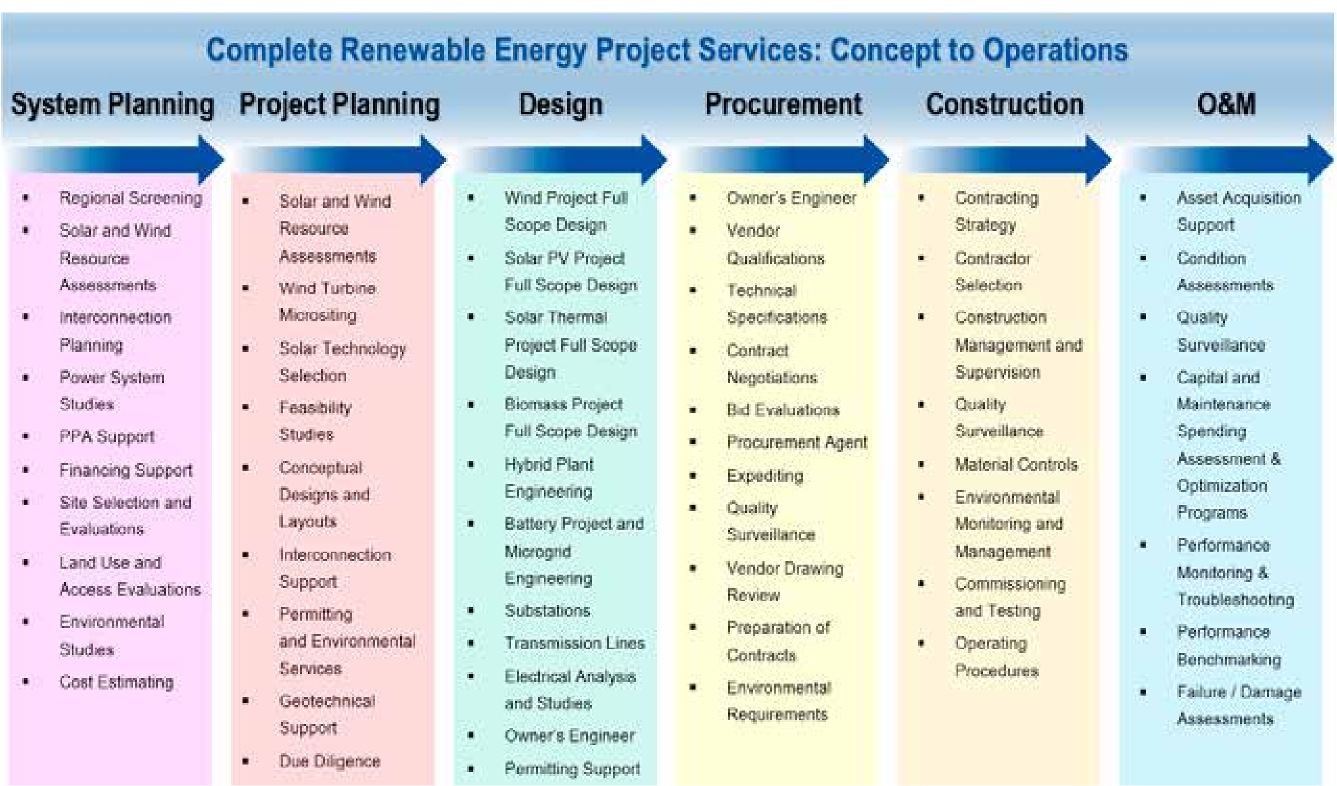


Figure 6: Project Phases for Renewable Energy Development Source: NREL 032-007, Sargent & Lundy

tracking for improved energy production would be very much essential right in preliminary feasibility of scale and capacity of the proposed plant. If solar plant has to provide energy in the night additional capacities with managed storage infrastructures should be established.

The feasibility studies of scale and capacity should adequately address the future concerns of possible hybrid integration from cross coupled technologies to cater to E-vehicle charging, battery swapping, and desalination water, hydrogen generation and storage or even load demand needs of micro grid operation.

Operational phase of renewable energy projects specially wind & solar should have sufficient data flow infrastructure for real time forecasting of exported power to the Grid (Figure7).

Key-Parameter: Financial

The most important key parameter is the financials during various phases of project. Even prior to Covid-19 scenario, the payment delays were there by the state's DISCOMs (Distribution Companies) which are already in financial distress and most of them are loss making. When accelerated depreciation was available in India till 2010, there has been balance-sheet financing of renewables with net profits being pumped in the RE-projects. The captive use of energy, tax holidays on income from renewable generation, banking of energy and use at times of need, enabled borrowed capital with moderate interest rates became the flow of investments. While the awareness and knowledge of "various renewable technologies" of industrial investors being limited, earlier the OEMs (Original Equipment Manufacturers) were mostly the project developers providing turn-key solutions including operation and maintenance (O&M) post commissioning of projects. Then we had investments into renewables pouring in from various venture capitalists and independent power producers, IPPs. These were financiers with specific purpose of making profit through energy sales, and were able to tap any OEMs to supply the engineering equipment and were instrumental in bringing in Asset-management concept

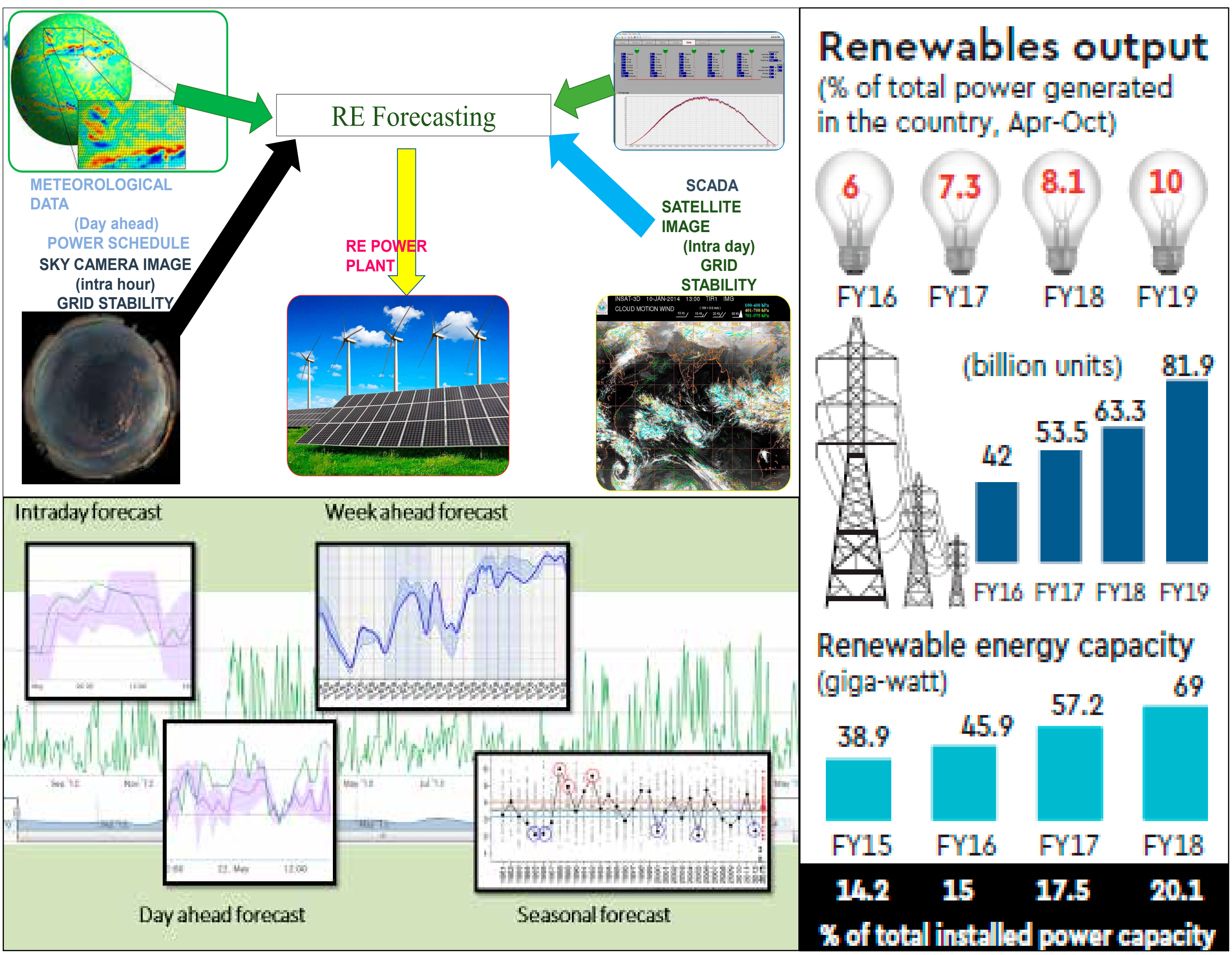
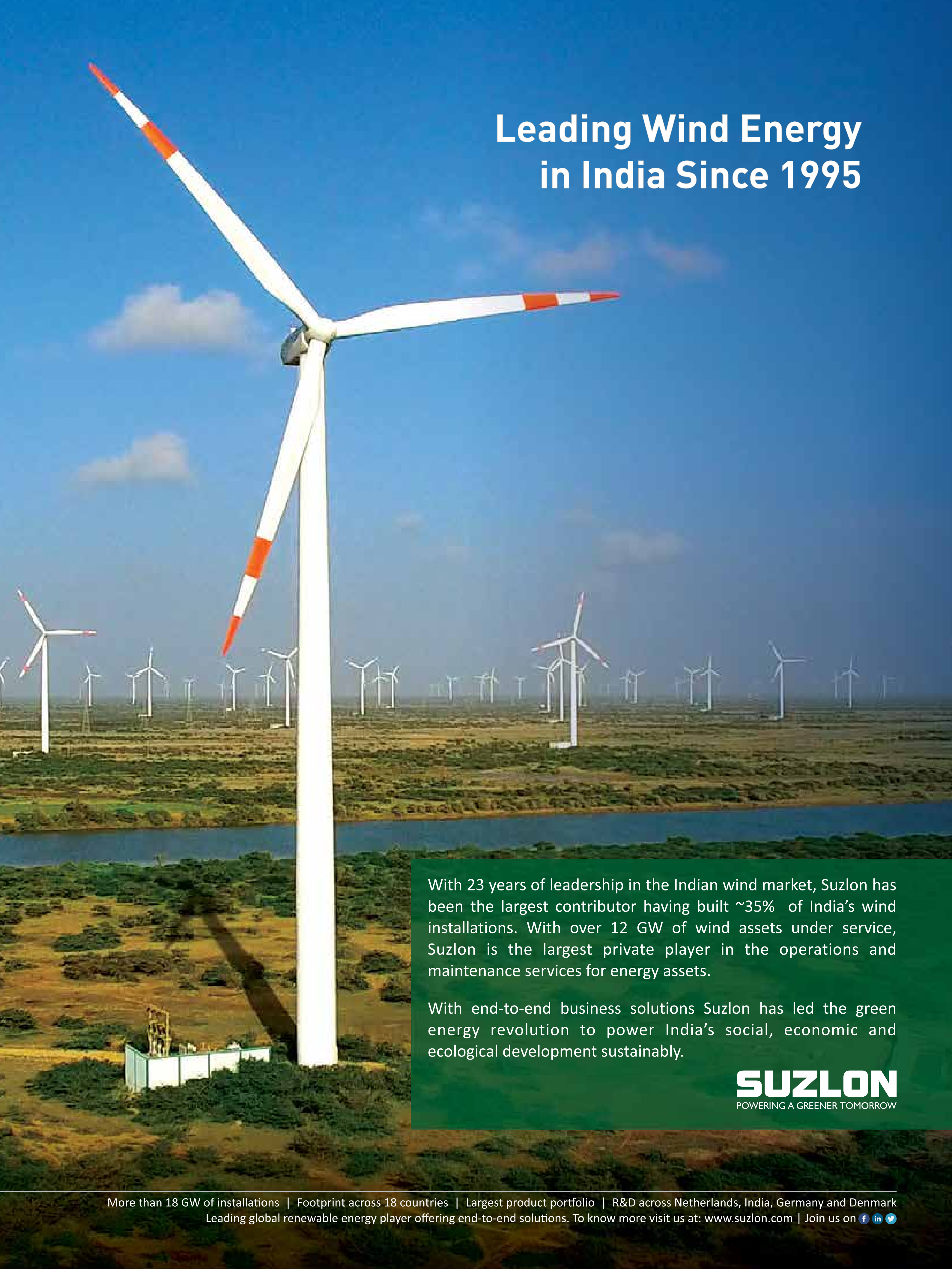


Figure 7: RE Penetration (10%) in India-Well Engineered by Accurate Real Time Forecasting


Leading Wind Energy
in India Since 1995
With 23 years of leadership in the Indian wind market, Suzlon has been the largest contributor having built ~35% of India's wind installations. With over 12 GW of wind assets under service, Suzlon is the largest private player in the operations and maintenance services for energy assets.
With end-to-end business solutions Suzlon has led the green energy revolution to power India's social, economic and ecological development sustainably.
SUZLON
POWERING A GREENER TOMORROW
More than 18 GW of installations | Footprint across 18 countries | Largest product portfolio | R&D across Netherlands, India, Germany and Denmark
Leading global renewable energy player offering end-to-end solutions. To know more visit us at: www.suzlon.com | Join us on

in the renewable installations. But, today the very low Bid-in-Tariffs for both wind and solar has certainly hit most RE-investors below their belt, demanding mid-course correction to maintain flow of investments into matured technologies, ensuring timely payment from DISCOMs, providing additional fiscal incentives for the avoided billions of tones of CO_2 in the mother earth's atmosphere, and by pruning the tariffs for hybrid RE-power fully backed with storage infrastructure projects operating 24x7. Think of personal income tax incentivized global crowd funding for both wind and solar power plants, from the like-minded persons interested in Sustainable Global Energy Transition (S'GET), and climate change mitigation.

Key-Parameter: Sustainability and Social Inclusiveness

Missing BETD-2020 (Berlin Energy Transition Dialogue) owing to lockdown imposed by the terrifying virus COVID-19, we derive a chance to revisit Berlin Energy Transition Dialogue, April 9-11, 2019, BETD-2019, which has demonstrated that as per the Figure 8, in the last 20 years globally alternate energy, mostly renewables has increased from a level of 18% to 25%. Use of electricity for vehicles (mobility) has increased in the rest of the world from 17% to 20%. In short, the deployment of wind energy-based electricity generation has increased 10 times and the solar electricity by over 25 times.

However, if one looks at the atmospheric air pollution with higher levels of $CO_{2,}$ the current status is illustrated in Figure 9. In the atmospheric air 60% CO_2 needs to be reduced, for which almost 86% electricity generation should be using renewable sources and 66% electricity usage in terms of energy should be renewably generated green electricity. This essentially means 50% of energy used in the world should be electricity and that too generation of electricity should be without any atmospheric air pollution. Today's electricity generation stagnates still at 20% (Figure 9 and Figure 10) in which renewable contribution is quite good at 25%. While generation from solar energy seems to be fast tracking there is need to push the matured wind generated power to higher rates of growth. Globally even though 6 million (60 Lakhs) electrically operated vehicles are operational, India is yet to kick start the EV2030 targets. Applications of alternate energy as well as electricity should be increased in heating and cooling needs of the community as well as industry. There should be increased use of hydrogen as fuel and hydrogen generation should be using renewable sources of energy.

India is unique in spite of high population, to remain in the top 5 countries of the world in electricity production and consumption (Figure 10 and Figure 11).

From Figure 10 it is easy to infer that world over in spite of dominance of fossil fuel (coal, oil and gas) in electricity generation their growth rates are reducing significantly with the higher penetration of renewable energy. The highest growth rate of renewables is happening at 11% world's highest level both in India and China (Figure 11). Among the 16 defined Sustainable Development Goals (SDG), the seventh is SDG-7. Affordable and clean energy, will influence more than 12 of the 16 SDG as shown in Figure 12.

IRENA Global Energy Transformation Road Map 2019, report advocates that in electricity generation wind, solar, biofuel/energy and other alternate forms of energy should become mainstream. Eletricity transmission and distribution, smart metering, electricity conservation and storage should have better augmented strong infrastructure. Transport vehicles, industries and buildings should use directly as well as electricity generated from renewables, with a clear focus on energy efficiency too.

Seeing the Figure 13 to 15 one can easily understand the way forward for environment friendly technologies for electricity generation and need for proliferation of electric vehicles. Figure 16 indicates the pollution is close to 25% even while using electricity, since the generation being mostly from conventional thermal power plants and fossil fuels, as of now.

Cost of establishing battery charging/swapping stations will be less than that of a normal petrol bunk. Car travel sharing is common in USA and Europe, even though it is yet to be popular in India. Yet, Ola, Uber like IoT services are getting accepted in tier one cities and probably in some big towns as well. Mobile APP based selectable multi-owned cars (instead of single or self-owned) are yet to be operational in India, if that picks up BEV proliferation on the roads can happen. Just like multi-purpose hydro-electric power houses (flood control, irrigation and power generation), several multi-purpoe engineering research with solar thermal is possible to be done leading with indigenous knowhow and technology for power, drinking water from sea water, electric car battery charging-/or battary swapping station establishment, as well as industrial pre-heating and air conditioning.

Conclusion

Monitoring key parameters of renewable energy projects has to be down to earth owing to the unforeseen recession owing to COVID-19 scenario around the world. Now that loss of employment is spread across the entire humanity, renewable energy projects will have an advantage of facilitating an all-round growth of economy with much needed inclusive development. While monitoring key project parameters during all the phases of RE-project, lessons learned in each one of them are unique and should be duly utilized for future project sustainability improvements. A corporate social responsibility programme, (Figure 17) which is highly focussed on sustainable technologies, for aforestation, drinking water management, waste to energy, environmental protection, mitigation and counter efforts for carbon emission from power generation, renewable energy expolitation, green technology adoption, skill development, human resource development, inclusive economic growth, earth saving environmentally benign development, is a must.

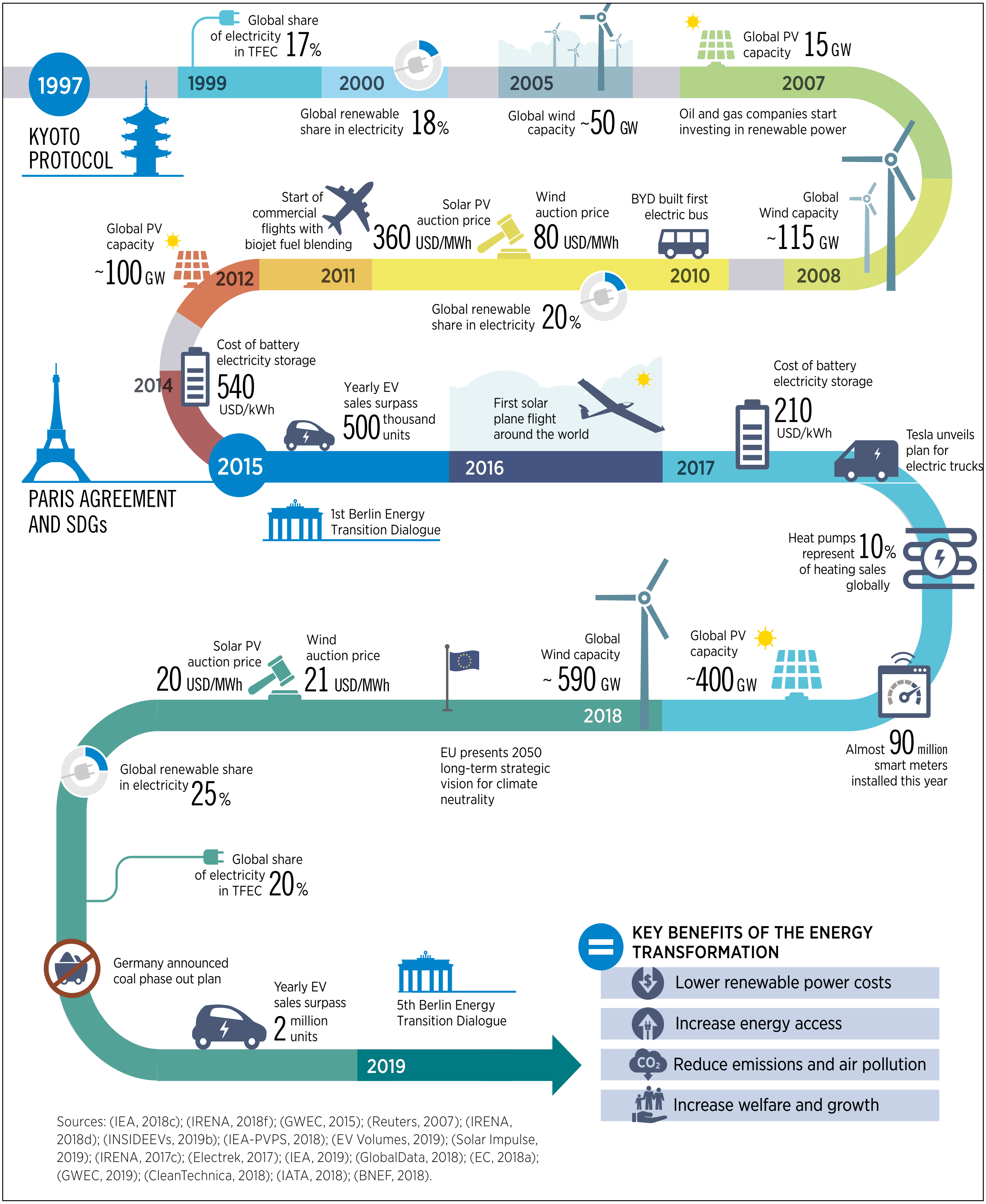


Figure 8: Global Energy Transition Status (IRENA - Global Report 2019)

	2010	TODAY (2017/2018)	REMAP CASE 2030	REMAP CASE 2040	REMAP CASE 2050	ON/OFF TRACK	IMPLICATIONS
ELECTRIFICATION WITH RENEWABLES							
Share of electricity in final energy consumption (TFEC)	18%	20%	29%	38%	49%	Off track	Focus on electric mobility and electrifying heat in buildings and industry, and on synthetic fuels and feedstocks – see further recommendations below.
Renewable energy share in power generation	20%	25%	57%	75%	86%	Progress	Emphasise solar and wind deployment, but also maximise solid biomass and biogas in the niche applications where they make sense.
Annual solar PV additions	17 GW/yr	109 GW/yr	300 GW/yr	355 GW/yr	360 GW/yr	Progress	Accelerate solar deployment by reinforcing existing policy and market support.
Annual wind additions	31 GW/yr	54 GW/yr	200 GW/yr	210 GW/yr	240 GW/yr	Off track	Plan for wind industry and required logistics to enable accelerated deployment. Consider the large potential of offshore deployment.
Passenger electric cars on the road	<0.5 mln	6 mln	157 mln	745 mln	1166 mln	Progress	Enact measures to support getting electric cars purchasing price down and invest heavily in charging infrastructure.
Heat pumps		20 mln	155 mln	259 mln	334 mln	Off track	Promote public awareness about the advantages of heat pumps and create special lines of finance to project developers that can disseminate the technology.
Hydrogen production with renewable electricity			3 EJ	8 EJ	19 EJ	Emerging	Find the niches where this makes sense today and support commercial-scale pilot projects.

Figure 9: Electricity Generation from Renewables and Their Growth Variations
(IRENA, Global Report on Energy Transformation, 2019)

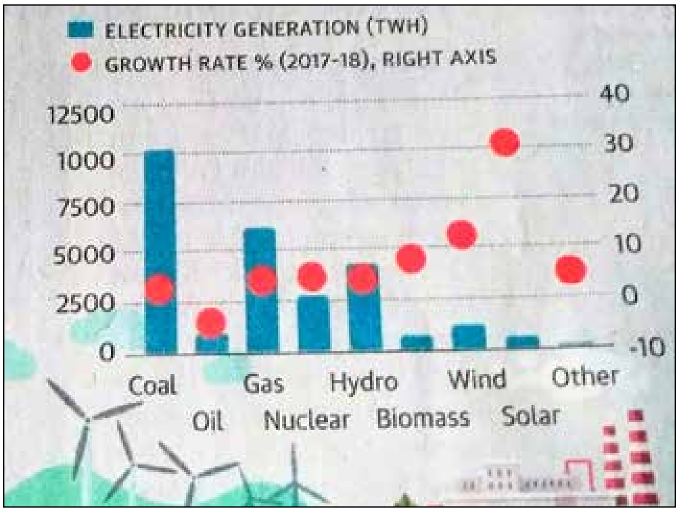


Figure 10: Fossil Fuel Usage Need Curtailment of Growth Rate

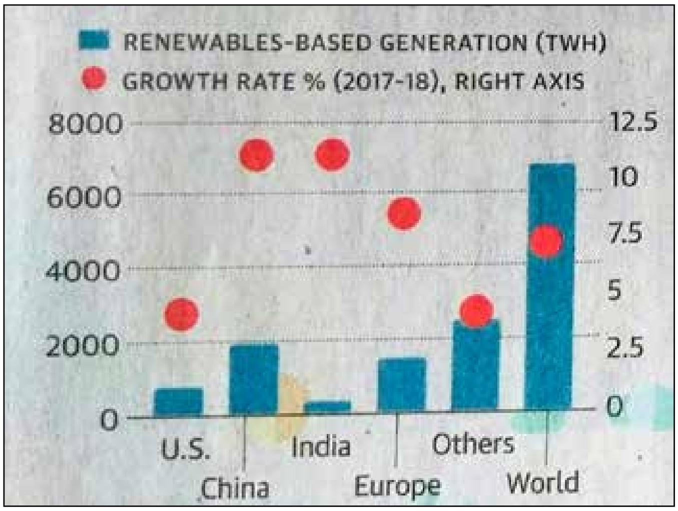


Figure11: Significant Higher Rate of Growth of Renewable Energy in India

(Reference: The Hindu, International Energy Agency, IEA, 2018)

Figure 12: Sustainable Development Goals- SDG *(Reference: SDX India Index 2018 NITI Aayog)*

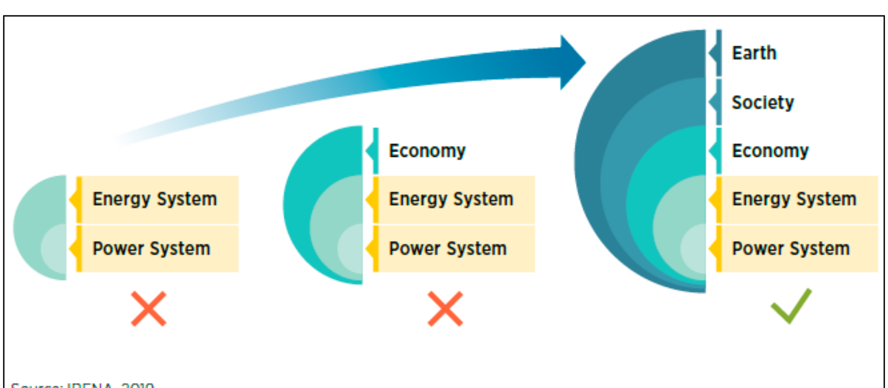


Figure 13: Energy Transition is now Inclusive of Economy, Earth and the Society

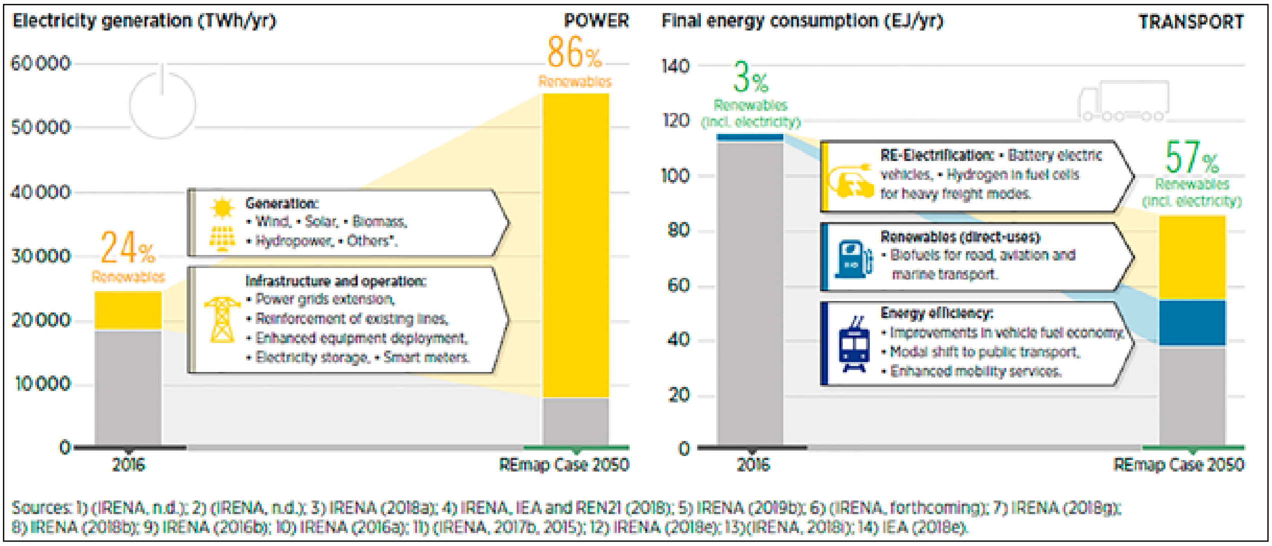


Figure 14: Electricity Generation and Usage of Energy for Transport Mobility

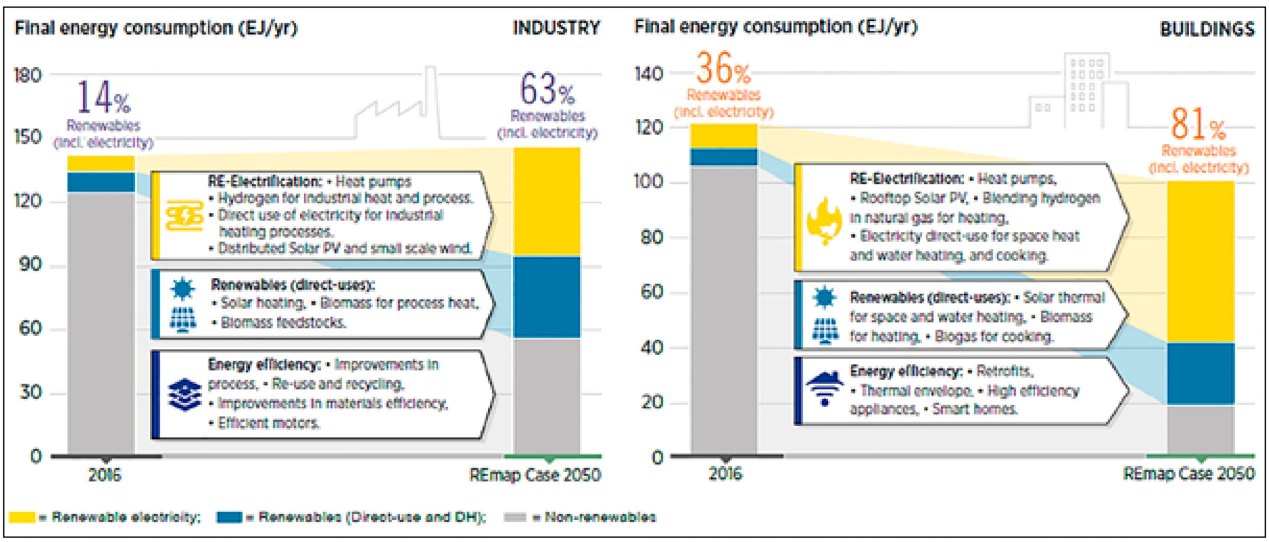


Figure15: Energy Usage: Industries and Buildings

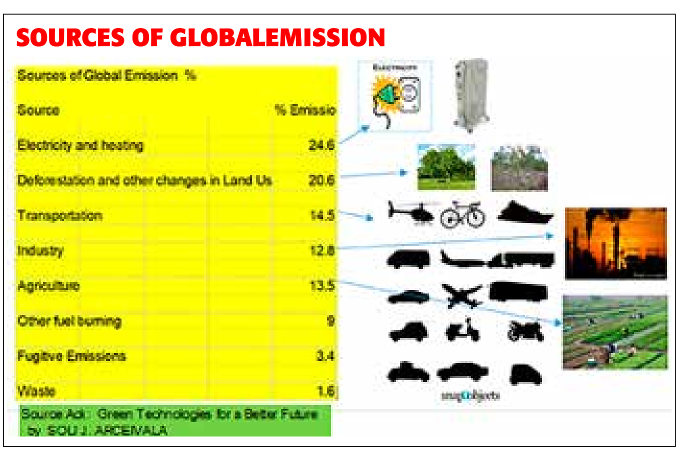


Figure 16: Electricity is Major Pollutor since Fossil Fuel still is the Main Stream for Generation

RE-Assure Your and Yours'
(Future Generations, by S'GET)
(Sustainable Global Energy Transition)

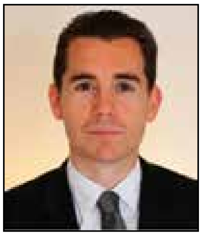
- You have enjoyed, BUT CO_2 emitted stays over 120-150 years- S'GET
- Renewable plays a vital role for S'GET.
- Shine/heat cool with solar for S'GET
- Wind with Wind (Onshore/offshore) sea-land breeze too for S'GET
- Think Small, Do and get done by the mass for S'GET
- Infirm Renewable Energy, Not anymore with Smart Grids... S'GET
- God has created No Waste, Only Wealth, ...S'GET
- Future of Sustainable Mobility is IoT, ICT, IIoT...... for S'GET
- WE ARE THE ONLY GENERATION WHICH CAN SAVE THE FUTURE OF MANKIND AND MOTHERR EARTH BY S'GET

Figure 17: Sustainable Global Energy Transition: S'GET - A Way of New Life

"Think Global, Act Local" will be the mantra for the future of RE-projects in India, as well as to the rest of the world.

Acknowledgements: MNRE and resources compiled from latest 2017-2020 Web Published Reports from IEA, GWEC, IRENA, NITI Aayog, MNRE-GoI, NIWE, NISE, and NIBE

The Challenges of Designing a Modular Blade



Miguel Turullols Sanz
Marketing and Communication Manager, Nabrawind, Spain

Modular blades are not something new in the wind industry. More than a decade ago, some companies such as Gamesa or Enercon released their own split blades. However, at that time other logistic alternatives were mass adopted for the transport of blades, limiting the implementation of these pioneer blades.

Nevertheless, nowadays the wind market's trends reveal a renew interest in them. Almost all the OEMs are greatly investing in developing this technology as they asume it crucial for the future.

Still, the challenges of this kind of technology remain. Nabrawind has joined the race for optimizing the blade's modularity and by doing so has developed an innovative solution that will be explained in detail in this article.

Before deepening in the technical part, a question arises and needs an answer: Are modular blades again a temporal trend or are they here to stay? According to current market forecasts (see Wood Mackenzie forecast, table below), it seems this time mass adoption of split blades will happen. In fact, Wood Mackenzie forecast establishes that by 2025 half of the blades market will be modular. In particular, the 38% of the market will correspond to 80-89.9 meters length blades, which will most likely require modularity to be transported. Furthermore, also in 2025, 90-99.9 meters length blades will represent the 25% of market.

The transition to modularity will not stop here and by 2027 extremely long 90-99.9 meters length blades will cover the 40% of market. Even more, by this year the first 100-109.9 meters blade models will be introduced in the onshore market.

All in all, modularity will exponentially grow in the following years until represent more than 50% of the market by 2025, again according to Wood Mackenzie forecast.

Figure 1: Prototipe of our modular blade

Although modularity seems inevitable, it is also true that several challenges remain concerning this technology. The main barriers for its mass adoption are, so far, related to the added weight of the joint, the cost, its maintenance requirements and the field assembly process, among others.

There are different technologies trying to solve these issues related to modular blades. The main alternatives that can be found in the market are the following:

T-Bolt Connection

This is a very well-known connection in standard blades as it is one of the most commonly used blade root connection since it was applied for the development of the DEBRA 25 (100 kW wind turbine) in 1981. A T-bolt consists on a threaded bolt, a barrel nut and a standard nut. A high number of T-bolts are equally spread along the circumference of the blade root in order

Length of blades In Meters	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
70-79	4%	16%	38%	66%	63%	62%	40%	28%	10%	8%
80-89	0	0	0	2%	7%	23%	38%	45%	35%	35%
90-99	0	0	0	0	0	1%	25%	25%	40%	38%
100-109	0	0	0	0	0	0	0	0	8%	16%

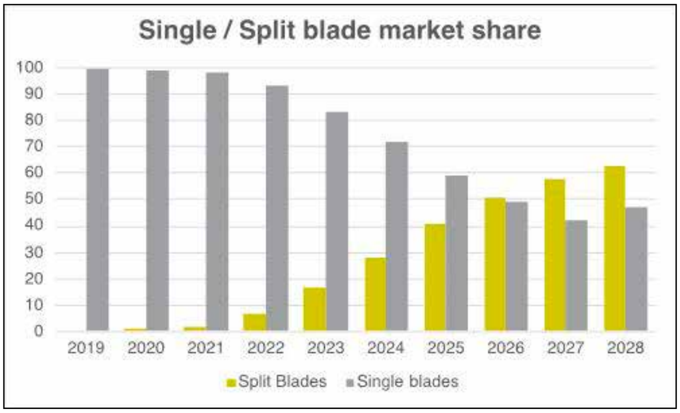


Figure 2: Single/Split Blade Market Share (Wood Mackenzie Forecast Scenario)

to create the blade-hub connection. This alternative has been historically one of the most used for modular blades, with split joints located close to the blade root.

Metallic Inserts

Another bolted joint alternative is the connection by means of metallic inserts. The inserts are metallic parts bonded into the blade laminate that enable the two blade segments to be bolted together by the use of intermediate connecting parts. Important wind industry players have developed this kind of technology and applied it in the blade segmentation.

Figure 3: An example of a T-Bolt Connection

Bonded Joints

Thirdly, there is the category of bonded joints, which are usually lighter than bolted joints, as they do not require metallic parts, but require to move a complex infrastructure to the wind farm in order to assure that the bonding process is made in controlled conditions.

Figure 4: An example of Metallic Inserts

Hybrid Solutions

Finally, there are also hybrid solutions, some of them recently implemented. These alternatives combine a bonded part with a mechanical union, but without using bolts. An example of this solution can be seen in the following figure.

Figure 5: An example of the Bonded Joints

So, there are already several alternatives in the market, confirming the industry interest in these segmentation solutions. However, we decided to think outside the box and that is how we came with an innovative solution called Nabrajoint.

Our proposal is based on a maintenance-free bolted connection using as basis metallic inserts. Differently to other insert options

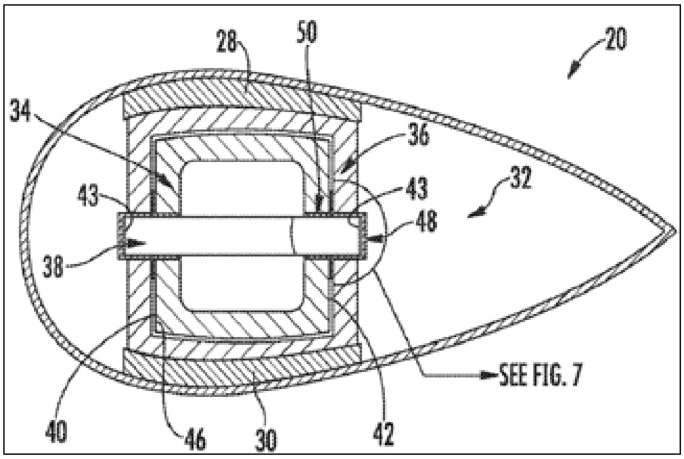


Figure 6: Hybrid Solutions

we designed a connection between blade modules by means of just a single stud. This reduces significantly the size and mass of the joint, and consequently its cost and load impact in the blade. Of course, in order to be able to do so, we needed a way to preload the stud. It was at that moment when our engineers' team came up with the XPACER, a dispositive which preloads the stud.

But let's take it one step a time. Three parts participate of our bolted joint:

First, a set of inserts bonded to the blade main composite structure, between each pair of which a stud is bolted. Secondly, the array of studs that connect the modules once they are threaded to the inserts. Finally, the preloading device.

The Figure 7 shows a general view of these elements. On the top, the studs are in yellow colour and below a picture of the inserts.

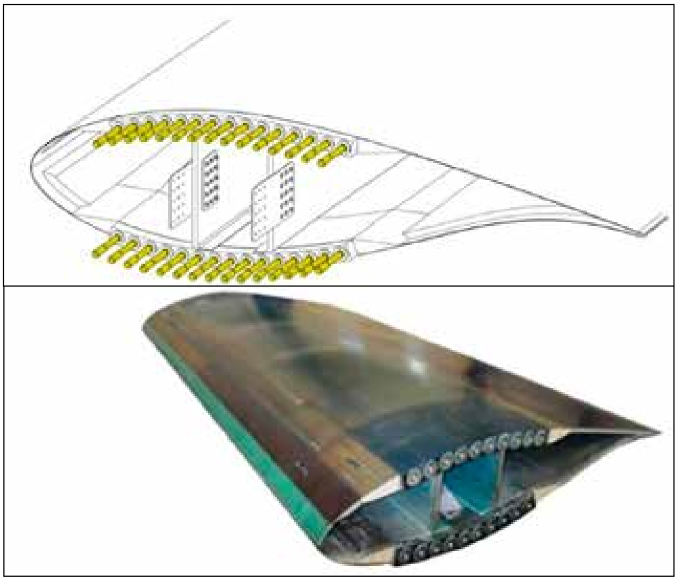


Figure 7: Studs and Inserts

The inserts are these metallic elements acting as the interface between the blade main composite laminate and the bolted connection in charge of joining the blade modules.

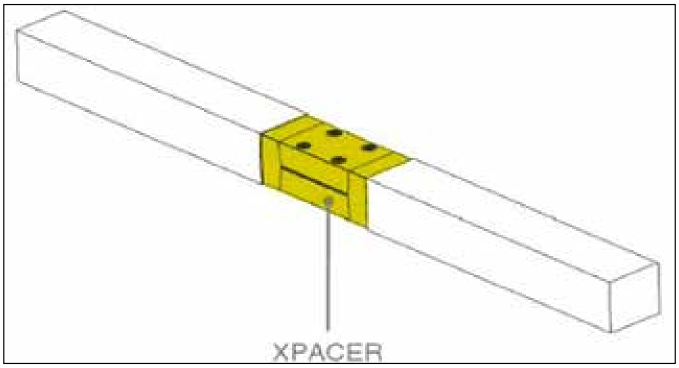


Figure 8: The Preloading Device

Figure 9: The Studs

The following pictures show a general view of these elements. On the left, the studs in yellow colour; on the right a picture of the inserts.

On the other hand, the studs, made of high strength steel, are bolted between each pair of facing inserts and are in charge of transferring the load between modules.

Then, the joint is completed by means of the patented expandable spacer. This device allows the precise preloading of the studs in order to improve their fatigue life. To that purpose, a preloading device is introduced between each pair of inserts in such a way that covers the central stud that joins them. A view of this device is shown below.

This preloading device is the key part of the joint, and it is formed by four elements: the Upper Wedge, the Lower Wedge, the Washers and the Tightening bolts.

In an initial state, the upper and lower wedges are not levelled with the washers, but they stand out above the washers' external surfaces. When the bolts are tightened, however, the upper and lower wedges slide over the washers' faces, and as a result of which:

- The external wedges and washers' surfaces level up.
- The stud is preloaded with a tension force and is therefore elongated.

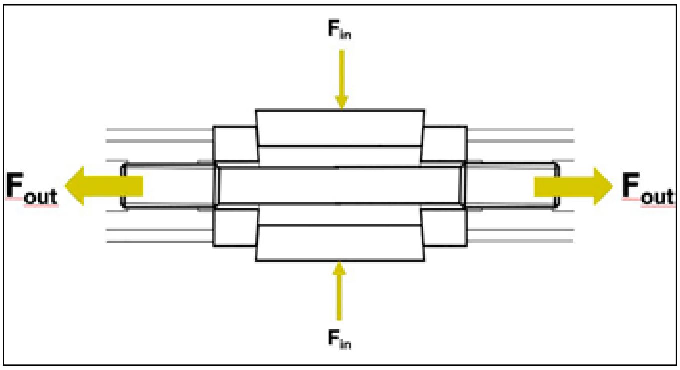


Figure 10: The Preloading Device


WE CREATE
BALANCE

Figure 11: Assembling Process

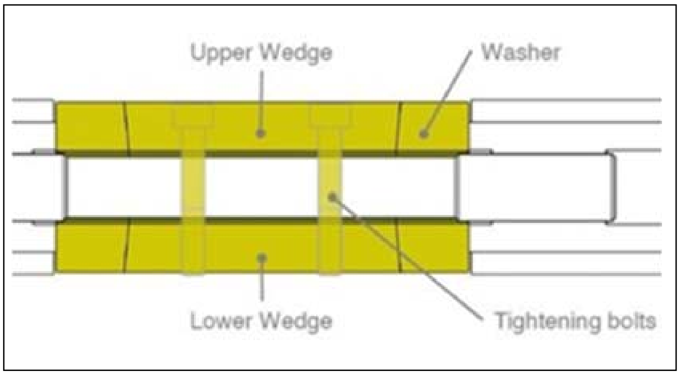


Figure 12: Components of the Preload Device

- The washers and wedges are compressed, acting as the clamped parts of a typical bolted preloaded joint.
- The system is locked after completing the preloading, assuring the maintenance of the stud preload and hence the non-necessity of re-tightening of the joint.

Thanks to the operative characteristics of the preloading device and to the high strength of the newly developed inserts, the number of elements needed for the joint are minimized, so the mass and cost are also reduced.

Moving to the field operation of the joint, in order to ease the assembly process, we have developed and patented an automatic tightening tool, which is purely mechanical and allows the quick and precise application of the required preload to the studs.

In addition to this, the engineering team had to deal with other issues related to the integration of the joint in the blades, using our vast experience in these design processes.

Firstly, we had to solve the integration of the joint in the blade shell. This is done by transition joints that are specifically tailored to the configuration of the blade to be joined with this technology

Secondly, the connection between webs is completed by metallic plates that are assembled and bolted between both webs extremes, assuring the shear load transfer between both parts.

This solution has been successfully validated through a rigorous certification process and its corresponding testing campaign. The validation process covered all the required tests, including materials, subcomponent, manufacturing and testing of two blade segments. These specimens have been submitted to the standard blade testing scheme, including static tests, fatigue tests and static post-fatigue tests. These tests were completed successfully at the beginning of 2020, validating the structural performance of the joint. Furthermore, the required certification tests were extended with static tests in a Fail-Safe configuration, reaching 118% of the design load (limit of the test bench) without incidence, proving thus the robustness of the solution.

All in all, after analyzing so many modular blades alternatives, what might seem clear is that modular blades will play a key role in the near term. There are several interesting solutions already in the market that, hopefully, will help to ease the logistic constrains to the blade's transport is already facing. We just hope to do our bit in this fascinating challenge that the wind industry has to solve.

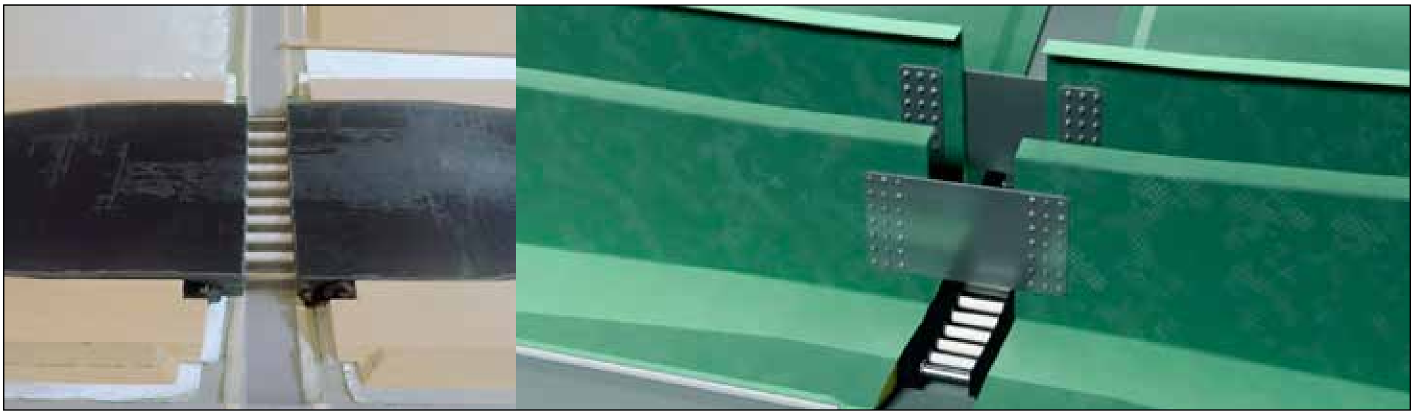


Figure 13: Webs Connection

Vacuum Handling Solutions for Rotor Blade Production

S. M. Jacob, General Manager-Projects-Windmill
Schmalz India Private Limited

Wind turbines are made bigger and bigger to harness more wind power from the atmosphere. The technologies are developing to increase the proportion of potential energy that the wind harvests by making the blades longer. The larger blades produce about 7.5 percent more electricity than those with smaller blades. They do not spin faster, but they extract more energy from the passing air.

Windmills have longer blades because longer blades will produce more torque. More the torque, more the force. Greater the force, greater the energy generated. The rotor blades are made of composite material due to which the blades can spin faster and capture winds at lower velocity. Composites offer wind manufacturers strength and flexibility in processing with the added benefit of a lightweight material.

Longer blades are expensive to manufacture and at the same time the design is more complex and unless it is handled carefully during the manufacture, will lead to rejection which one cannot afford at that stage.

Please see below the cut view of a rotor blade where you can see various components inside the blade. All these components are huge running throughout the length of the blade almost and demolding and handling during the manufacturing process is also of great importance.

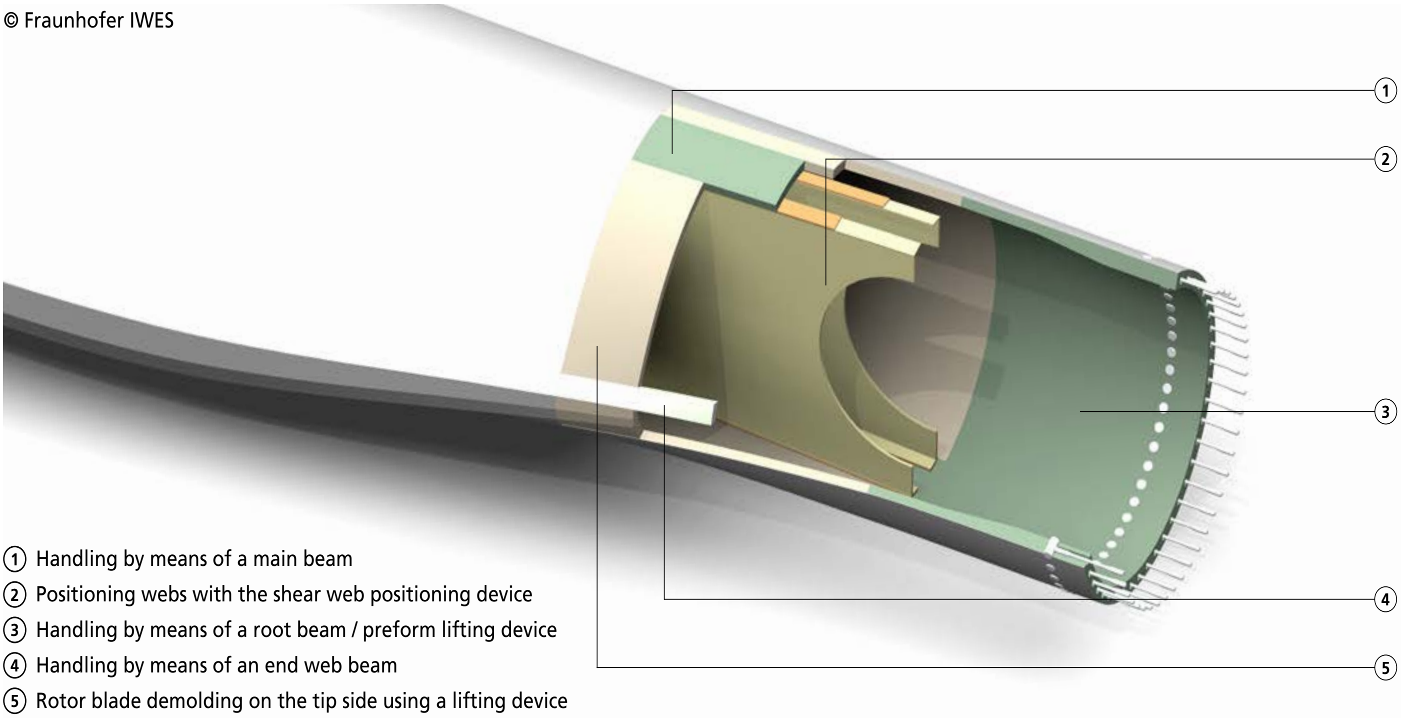


Figure shows the typical structure of a rotor blade on a wind turbine – © Fraunhofer IWES from the Blade Maker project

Figure 1: Cross Cut Section of a Rotor Blade

ne delivering

SIEMENS Gamesa
RENEWABLE ENERGY

1. Preform Lifting Device

Figure 2: Handling of Composites by means of a Needle Gripper

The composite materials use needle gripper for preform segments. These grippers enable energy-saving and safe handling of multiple layers which saves time in the main mold and both suction side and pressure side handling is possible.

2. Root Lifting Device

Figure 3: Transporting the Root Element for Installation

Careful demolding of the root elements is essential and is possible and the suction pads are to be adapted to the curved surface of the root area. Safe handling is possible due to large vacuum reservoir with non-return valve and additional safety straps. 90 degree swivel design for vertical positioning of the root elements as well as battery operated systems is available as optional features.

Figure 4: Handling the Rotor Blade Segment

Figure 5: Aligning and Positioning the Webs

3. Demolding and Handling of Girders, Shear Webs

With one equipment you can handle main and auxiliary girders and shear webs which will enable demolding, handling, storing and positioning and installing inside the mold. The handling is absolutely safe with vacuum and provided with redundant vacuum circuits and additional safety straps. Web turning device for horizontal demolding and vertical storage of a web is possible as option.

Figure 6: End Web Beam

A solution is available for aligning the shear webs in the shear web positioning device and can be used for different webs and bonding flange, taking into account parallelism and gap clearances. Suction side or pressure side positioning is possible. This will ensure perfect match in the mold and saves lot of time in return.

4. End Web Lifting Device

Careful and damage free demolding of end webs is possible with spring-mounted and jointed suction plates for lifting and setting down the load gently. Large vacuum reservoir with non-return valve for safe handling and remote controlled swiveling function for adjusting the demolding and insertion angle and precise positioning in blade shell or storage is possible with this device.

5. Rotor Blade Demolding and Lifting Equipment

With this device you can demold the huge rotor blade from the mold quickly in minutes, thereby considerable time is saved. Careful and damage free demolding is possible and the suction pads are designed to adapt to the surface of the rotor blade

Figure 7: Transporting the Rotor Blade with Demolding Beam on the Tip Side

Figure 8: Blade Demolding Device

contour. High level of safety is guaranteed due to adequate vacuum reservoir and additional safety straps and parking feet for storing the lifting device is provided and optionally wheels can be provided for internal transport. With one device you can handle blades having different contour.

Vacuum lifting devices thus guarantee precise, demolding and handling of the rotor blade components within the required tolerances which makes the production faster and at the same time ensuring safety at all levels.

Snippets on Wind Power

Govt. Proposes to End Power Tariff Differentiation among Consumers

Domestic power tariffs are low in India, while the industrial tariffs are among the highest in the world due to cross subsidisation. The Tariff Policy proposes six categories of consumers on voltage basis against the present 50-60 categories and sub-categories.

The other proposals of the tariff policy include laying service standards for power distribution companies (discoms) including 24x7 power supply, penalising gratuitous load shedding and ban on passing on more than 15% of commercial losses to consumer tariffs. The policy also proposes direct benefit transfers to agricultural and rural consumers and reduction of cross subsidies on large open access consumers to 20% within four years.

Source: ET Bureau, June 02, 2020, 08:24

Indian Energy Exchange Launches Real-Time Electricity Market

Indian Energy Exchange has launched the real-time electricity market (RTM) on its platform, a move that will help utilities buy and sell power just an hour before the requirement. The RTM enables consumers, including distribution companies (discoms) and captive users, to buy power on exchanges just an hour before delivery. The real time market is an endeavour by the regulator, CERC, to make the power market dynamic by enabling trade in electricity through half-hourly auctions. With the launch of RTM, the Indian energy markets are moving towards global standards of electricity trading and establishing the new energy order in the country.

Source: PTI, June 01, 2020

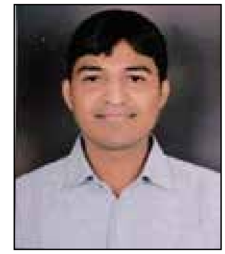
Government Should Include Wind Energy Projects in 12,000-MW CPSU Scheme: Tulsi Tanti, Founder, Suzlon Group

The government should include wind projects under the 12,000-MW Central Public Sector Undertaking Scheme, which currently covers only solar power projects, according to Tulsi Tanti, founder, Chairman and Managing Director (CMD), Suzlon Group and the Chairman of Indian Wind Turbine Manufacturers Association. This would help in utilising domestic manufacturing capacity more faster because India currently has 10,000 MW manufacturing capacity and we are utilising only 2,000 MW, which is only 20 per cent and would also help to accelerate capacity and in lowering costs of energy," he said at a digital interaction of Renewable Energy Minister Mr. R K Singh with CEOs from the power and renewable energy sectors, under the CII's Energizing India Series.

The CPSU Scheme Phase-II is aimed at setting up 12,000-MW grid-connected solar PV power projects under the government producers with VGF support for self-use or by government entities either directly or through discoms. According to Tanti, this is the right time for making India a global manufacturing hub for renewable energy and services or else this opportunity would go to the neighbouring countries. He added that if there is a strong four to five year visibility of the market, it would attract a lot of capacity to India. "This is the right time to increase exports and protect jobs and increase revenues," Tanti said.

Source: ET Energy World, May 19, 2020

Technological Advancement in Wind Energy Sector

Vitor Antao
Head Production Centre

Angad Gupta
Analyst

3Tier India R&D Private Limited

Wind energy is a key component to help countries meet their environmental goals to reduce carbon emissions. Developments in technology have been made over the years to ensure secure, reliable and affordable energy. There are three main areas of development:

1. Turbine Technology – Higher capacity, higher hub heights and larger rotor diameters
2. Wind Resource Assessment – Measurements, Wind Flow models and Wake models
3. O&M – Monitoring systems, O&M practices and predictive maintenance

1. Turbine Technology – Higher Capacity, Higher Hub Heights and Larger Rotor Diameters

With the development of the industry over the years, the focus has been on extracting more energy from the available sites. This has been achieved by increasing the size of rotor diameter to capture more energy and by increasing hub heights to capture the higher wind speed at higher heights. Today projects under construction/planning in India consider turbine models with rated capacities between 2MW and 3MW with hub heights between 100m and 140m. This trend is expected to continue to grow in India.

2. Wind Resource Assessment – Measurements, Wind Flow Models and Wake Models

Over the years, the understanding of wind resource has experienced several developments, through measurements, wind flow models and wake models.

Measurements

The latest developments in wind measurements have been related to remote sensing; namely SODAR (SOnic Detection And Ranging) and LIDAR (LIght Detection And Ranging). The main advantages of remote sensing devices are being more portable than a met tower and measuring at higher heights up to or above the tip blade. Some recent wind resource assessments have been completed with a combination of both traditional meteorological towers with cup anemometers and remote sensing.

Wind Flow Models

Wind is the fuel of wind power plants; therefore, understanding its behavior in both time and space is of utmost importance. In recent years, there has been an evolution in wind flow modeling, which is the ability to predict wind speeds across a project area. There are several techniques that have been

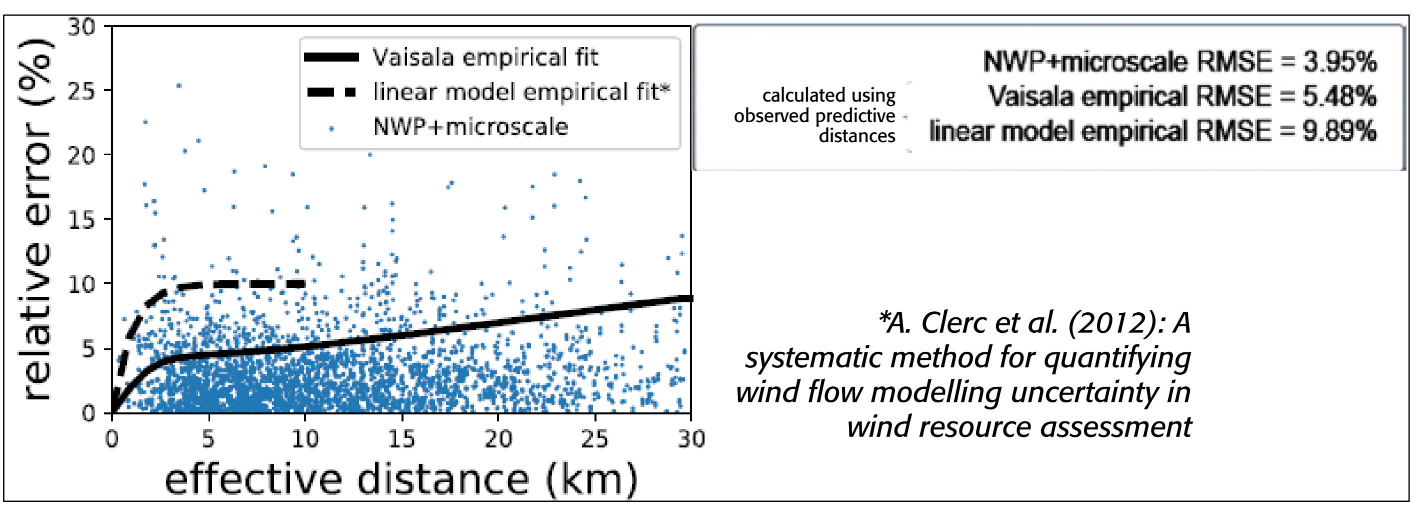


Figure 1: Plot Showing the Relative Error Versus Effective Distance

developed in the field of Numerical Weather Prediction (NWP), Computational Fluid Dynamics (CFD), Digital Elevation Modeling (DEM), etc. A recent study[1] shows NWP models can reduce the wind flow error from 10% to 4%, when compared with linear flow models commonly used in wind resource assessments. The results of the study which included 3438 tower pairs at different types of terrain are shown in Figure 1 and clearly shows that NWP models and a good measurement campaign significantly improve modeling uncertainty.

Additionally, with the advent of hybrid projects (wind-solar storage), there is an increased demand on calculation in the time series domain, rather than the frequency distribution domain.

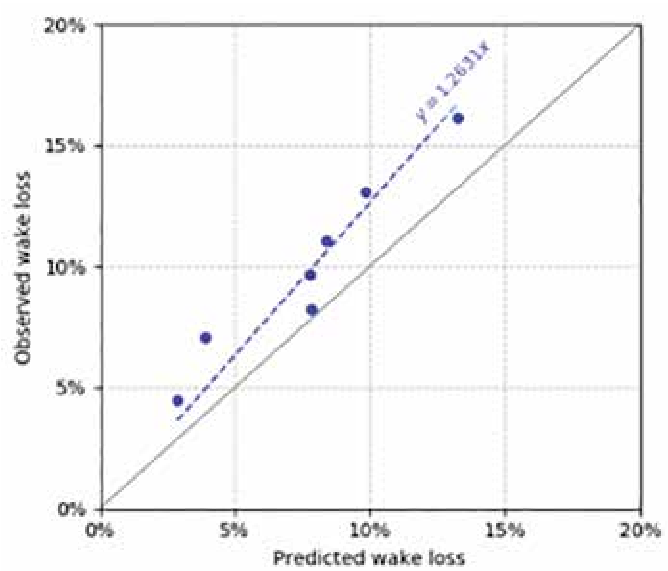


Figure 2: Scatter plot of observed project wake loss (y) versus predicted wake loss (x). Best-fit line forced through the origin (clue dashed line) Grey line is the 1-1 ("perfect prediction" line, for reference).

Wake Model

Typical the largest losses in a wind farm are from the wakes from wind turbines. The wake loss is the result of the reduction of wind speeds at downwind turbines due to wakes caused by upwind turbines, both internal and external to the project. In recent times, it has been recognized that wake losses have been historically under-estimated. A recent study[2] including seven wind farms clearly shows the observed wake losses were higher than the predicted wake losses (see figure 2). It was concluded that the wake losses were, on average, 21% larger than what Vaisala's existing method predicted (e.g. previously estimated 10% wake loss, with more recent methods could be 12.1%), which led to an adjustment to the wake loss estimation method.

3. O&M Practices – Monitoring Systems, O&M Practices and Predictive Maintenance

As project margins are becoming narrower with every auction, project developers are looking for new and innovative methods and techniques to improve the performance of wind projects. This is achieved by increasing turbine performance and reducing downtime. Today, most wind farms are monitored with Central Monitoring Systems 24x7, by both turbine manufacturers and wind farm owners. There have been developments in turbine inspection through drones, blade cleaning using robots and drones and the use of data analytics for early detection of under-performance and possible failures.

Summary

Wind turbines are getting bigger and higher. There have been improvements on energy predictions, through development of remote sensing technologies such as SODAR and LIDAR, usage of more advanced wind flow models such as NWP to reduce errors in wind speed predictions across a wind farm. The wake losses, the largest loss factor, which have been historically under-estimated has led to an adjustment to the wake loss estimation method to capture the actual losses in a more accurate way. Performance of operating wind projects have been improving using O&M modern tools such as Central Monitoring Systems, drones, robots and data analytics.

References

1. C. Hilgenbrink, "Round-Robin Validation of Spatial Wind Modelling Using NWP at Large Number of Sites in Diverse Environments," tech. rep., Vaisala, 2019
2. M. Stoelinga, "A Multi-Project Validation Study of Vaisala's Wake Loss Estimation Method," tech. rep., Vaisala, 2019

Snippets on Wind Power

IREDA Sets Aside Rs. 100 Billion for RE in 2020

Mr. Anshuman Gupta, Deputy Manager, Indian Renewable Energy Development Agency Limited (IREDA) has said in a webinar that IREDA has plans to lend around Rs. 100 billion (US$1.3 billion) to the solar and wind sectors and the funds are mainly meant for power generators.

Source: Mercom India, June 05, 2020

The Winds of Change – The Storage Revolution

Debmalya Sen
Senior Consultant – Emerging Technologies
Customized Energy Solutions

The Changing Indian Power Generation Mix

The Indian Power Sector has changed in many ways over the last one decade. The grid once dominated by conventional sources of energy has now slowly been transforming to a more diverse grid. If we compare the capacity mix over the decade it shows that the percentage of coal in the Indian grid has not changed much, what has changed over time is the increase in the percentage of

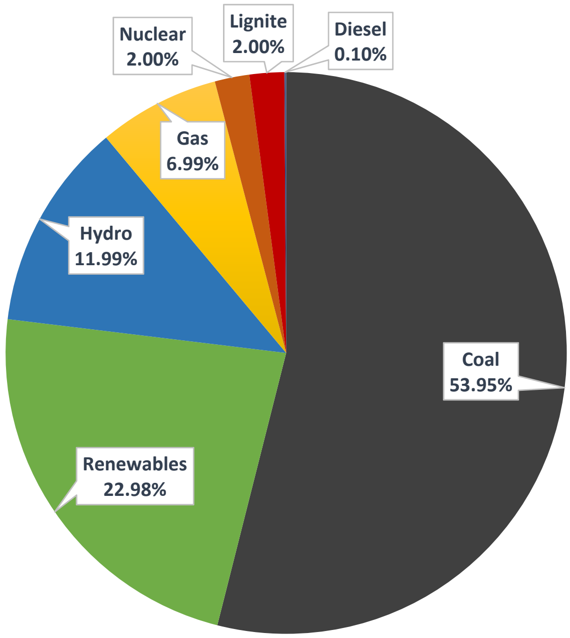


Figure 1: Generation Mix - 2020

renewables in the Grid and the decrease of other sources like diesel, gas, oil, etc. In 2015, when the Government of India set itself the target of 175 GWs of renewables by 2022, it was seen as a very ambitious target. But when we see back today there has been considerable growth that the renewable sector has witnessed over the last 5 years.

The Growth of Renewable Energy

In the starting of the decade renewables represented 10% of the generation mix, today it represents 23% of the capacity mix and around 14% in terms of generation mix. The government has promoted the growth equally with policies like Must Run Status for renewables and formalizing competitive bidding from the erstwhile Feed-in-Tariff regime. The wind industry alone has seen growth of more than 200% over the last decade. The growth

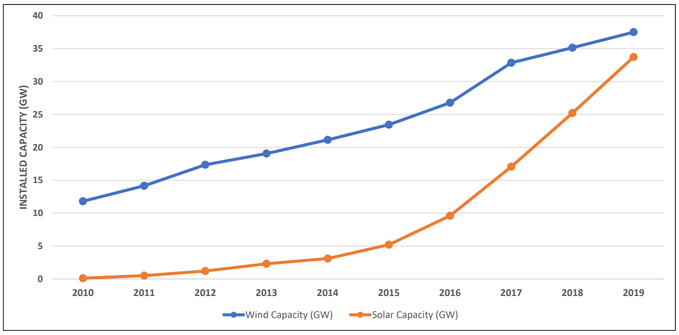


Figure 2: Renewables Growth 2010-2019

has seen some plateauing over the last two years but overall the Industry has been steady. The tariffs also have reduced considerably from the ranges of INR 4 to 5/kWh to INR 2.8/kWh. The total wind potential of India is calculated as 302GW at

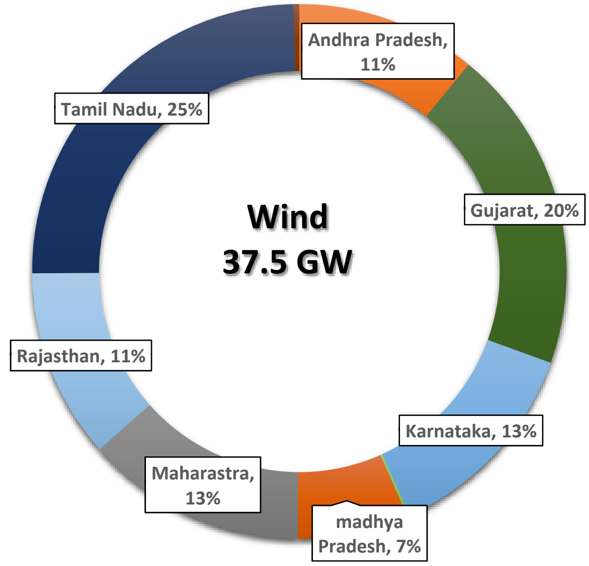


Figure 3: Wind Generating States

100 meter height and 600+ GW at 120 meter height. Today we are just at 37.7 GW, which means a lot more is to come in the wind industry alone. With improvements in technology, there has been an increase in efficiency, life and thus has further resulted in lower Levelized Cost of Energy (LCOE) numbers. As per report from Bloomberg NEF ('BNEF'), LCOE for wind ranges from 37 to 50 $/MWh as on today and will be seeing further reduction going forward.

The Spread

When we look into the wind generation spread across India, almost 93% of the total generation from wind is coming from 6 states, namely Tamil Nadu, Gujarat, Andhra Pradesh, Karnataka, Rajasthan and Maharashtra. The wind capacity is projected to reach 140 GW by 2030 representing 17% of the total generation

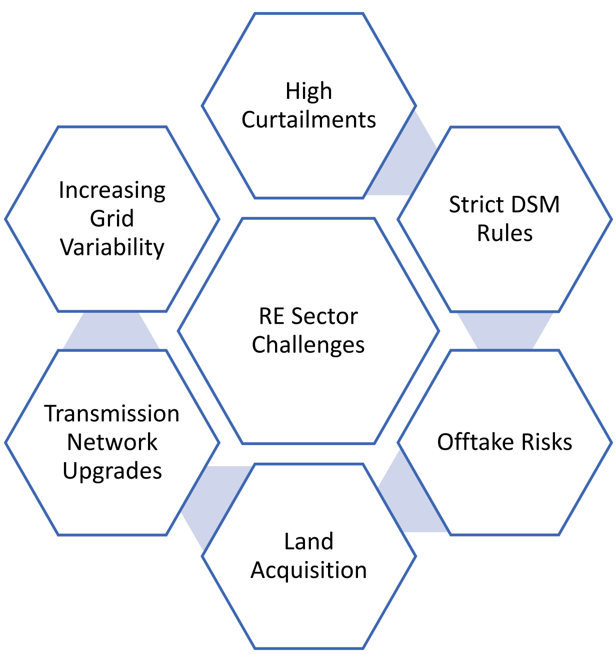


Figure 4: Industry Challenges

capacity of the country. We are today at 37.7 GW which is 62.5% of our 2022 target of 60 GW. IESA (India Energy Storage Alliance) analysis projects that in business as usual condition, India can achieve the target of 60 GW by 2024, but with more proactive approaches and policy clarities, the same is possible to be achieved by 2022.

Challenges Ahead

With the increase of wind penetration in the grid, the variability in grid also increases. To cater to this high penetration of wind energy the conventional power sources are either run at part loads or are completely shut down and operated as switching units. This is eminent seeing the increase in spinning reserve percentage in the grid. Also, as per a recent study a sizable amount of the calculated potential of wind falls under agricultural land where installation of projects will bring about challenges, especially when acquisition of land has been one of the prime challenges for new projects. Therefore, the way ahead for wind industry will be a bit more difficult than it has been still now. Added to this is the mismatch between RE expansion and grid expansion. This often has resulted in curtailing of generation from renewable sources in high wind seasons thus yielding in revenue loss. The problem of long DISCOM payment dues has also plagued the wind industry to a great extent. Initiatives like UDAY, ATAL has brought in some lights but there is still a lot much to be done to make the wind industry maintain the sustainability edge.

The Way Forward

One requirement at this stage to make wind more responsible is to make the load firmer and more reliable. This brings in the requirement of storage, which can help in firming the load and also act as a buffer to absorb the excess load when wind generates more than requirement (schedule) and also discharge through storage mediums in such conditions when the actual generation is less than the scheduled load. This is more required

Project Name	Location	Renewable Source	Battery Type	Energy
Zhangbei National Wind and Solar ESS Project	Hebei, China	100 MW (Wind) + 40 MW (Solar)	Lithium Ion	46 MWh
Bosch Brderup ESS	North Sea Coast, Holstein, Germany	18 MW Wind	Lithium Ion and VRB	3 MWh
AES Kilroot Advancion ESS	Northern Ireland's Kilroot Power Station	600 MW Wind	Lithium Ion	10MWh
Grand Ridge ESS	LaSalle, Illinois	210 MW (Wind) + 20 MW (Solar)	Lithium Ion	32 MW
Hornsdale Windfarm	Hornsdale, Australia	315 MW Wind	Lithium Ion	129 MWh

Examples of some Hybrid Projects Globally

Figure 5: Hybrid Tenders Trend

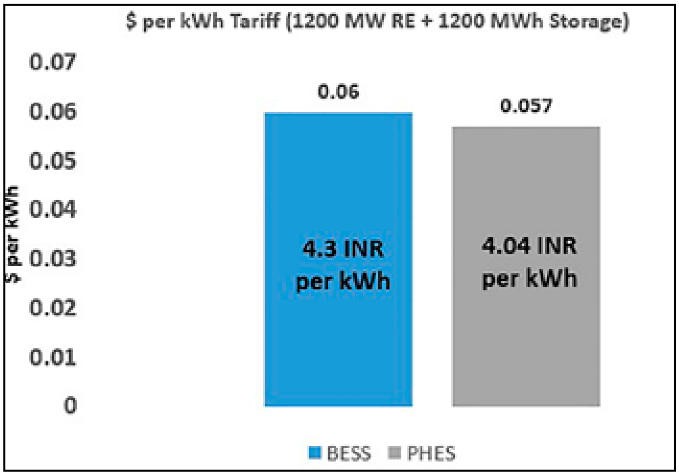


Figure 6: SECI VII Tender Result (RE + Storage)

today with the DSM rules becoming stringent and penalties are also increasing. Another solution that is seen here is through the rise of hybrid tenders. This specially works well as wind and solar are complimentary to each other and thus when clubbed together can give more benefits. Though the hybrid tenders released till date did not see a very promising uptake by the Industry, this have been mainly due to the low ceiling tariffs which were mandated in these tenders, but now with the ceiling

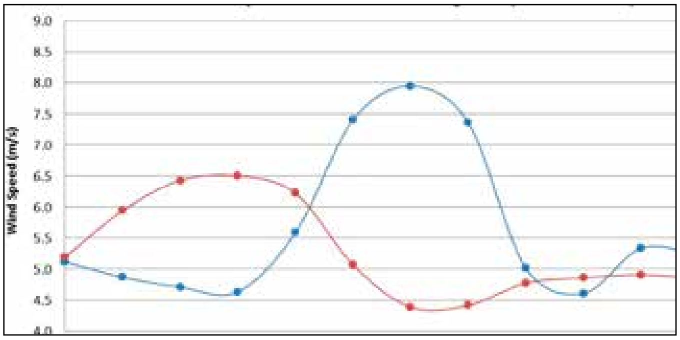


Figure 7: Wind and Solar Complimentary Pattern

tariffs being reduced, it is being anticipated that more hybrid tenders will be floated by tender authorities. On the other hand, the recently concluded SECI tender including RE with storage for peaking power also showed that storage is another option which is being competitive with the other options.

Energy Storage – The Enabler

The importance of energy storage to make renewables growth more sustainable over long-term is well understood and appreciated at large in todays energy market. What therefore needs to be answered is how. How do we bring about this integration and does the cost economics actually favor the same.

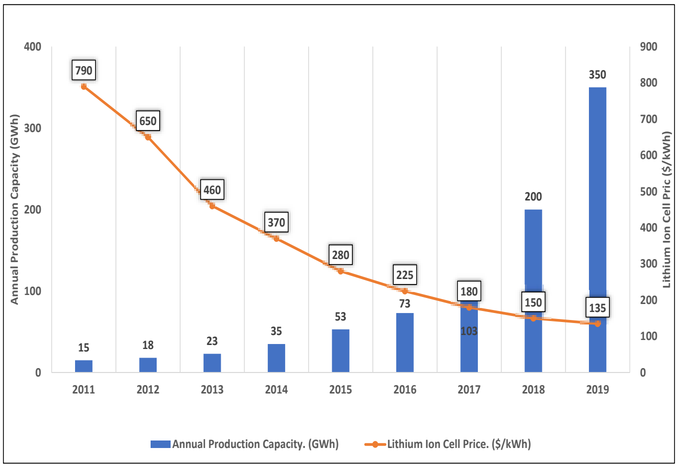


Figure 8: Battery Price Trend (2010-2019)

Till two years back when such a model was worked upon for India, the cost economics did not work, mainly due to the high CAPEX requirement for inclusion of storage and the added cost of generation being incurred due to the storage component. The same is justified too, the battery costs in 2016 too were quite high which did not help in making such projects viable. The tariff adder to add storage component for a duration of 4 hours to effectively handle grid curtailments alone yielded to a tariff adder of INR 10/kWh. The bigger problem though is that storage deployment to address one concern does not yield economic results. This is mainly due to the fact of seasonality of wind. The high wind season in India predominantly ranges between June to October and in the same too its not everyday that the wind assets are curtailed, thus the application of batteries deployed for storage finds a very small window to act. The rest of the year the batteries remain unutilized. Therefore, it is much required to see that storage deployment finds multiple applications to cater at. For wind, these can be forecasting and scheduling management by minimization of Deviation Settlement Mechanism (DSM) penalties, Curtailment minimization and catering to ancillary markets. This makes sure that the battery finds application to be utilized throughout the year and the revenue streams or savings continue on an annual basis rather than being seasonal.

Over the last decade the price of batteries has dropped 87%, what started off at above $ 1000/kWh today ranges in $ 150/kWh. The trend is expected to reach a point when by 2027 the prices will be below $ 100/kWh. The system cost of a standalone battery project is much higher than when such projects are collocated with renewables. This is primarily because of the Balance of System (BoS) cost being shared between the two. Also, with increase in size of the project and duration the overall cost reduces. It has been seen that the BoS costs reduces by a

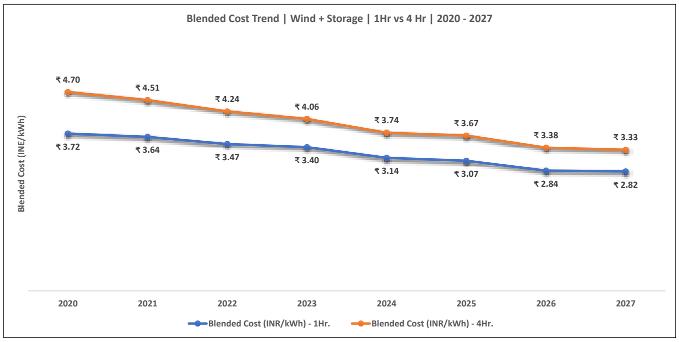


Figure 9: Blended Cost Trend (Wind + Storage)

significant margin for a 4 hr collocated storage system cost when compared to a 1 hour collocated system. The cost of the storage system depends on a number of factors like round trip efficiency, number of cycles that the battery runs in its lifetime, the depth to which the battery is discharged and also the surrounding temperature and conditions. If a battery is discharged fast or frequently, then the same has an effect on its life and also makes the battery more expensive, then when we go for a slow charge discharge cycle.

The Economics of Storage Integration

The integration of storage with wind will be gradual, this has also been observed in projects worldwide. The main reason for this is because wind though variable is available throughout the day thus the requirement of storage to store power and discharge when source is not available (like in solar) is less here. For wind, storage comes in more beneficial for shorter duration of storage ranging from 1 to 4 hours. It is expected that initially in projects the percentage of storage will be around 10% which slowly will increase to around 50% as the cost of batteries reduce. In a best-case scenario considering proactive policy support, tender authorities releasing more hybrid tenders with storage and the vision of 450 GW being realized by 2030, the storage capacity by 2027 can be around 12 GWh, on a conservative approach, it can be around 5 GWh. The tariff adder due to addition of storage will depend on the capacity of storage, depth of discharge, number of cycles and efficiency. As discussed before for a smaller duration of storage the tariff adder will be more than that for a longer duration of storage (4 hours). The range of this adder based on todays cost for a 4 hour storage is INR 7/kWh, this is expected to reduce to INR 3/kWh by 2027, whereas for a 1 hour storage, the present adder will be around INR 12/kWh, this is projected to be around INR 6/kWh by 2027.

The blended cost however is not a direct addition of the tariff of wind and the tariff adder for storage. The blended cost changes depending upon the size of the storage, as based on the size the amount of charging energy required from wind will also vary. The more the energy required from wind to charge the battery the tariff will also change accordingly. Based on todays costs and considering technological advancements for both wind and storage going forward, this cost is also expected to drop. At present for a 50% penetration, the blended cost for a 4 hour system can range between INR 5 to 8/kWh, this is expected to be around INR 2-4/kWh by 2027.

Final Thoughts

Overall, this looks to be the best way for winds future expansion. With land availability and acquisition being a challenge, it makes more sense to make utilize the land being available to the fullest and hybrids are a great solution to address this concern. With the government releasing the National Renewable Energy Hybrid policy and with the recent developments like taking off tariff ceilings, reduction in cost of storage, advancements in efficiencies, the forecast for hybrid projects looks good for India. Such projects work much better with a two-part tariff like we saw in the SECIs 1.2 GW project of renewable energy with storage. This helps in attaining better project economics based on today's costs. This will also increase participation of developers and IPPs in such upcoming bids. Even wind alone projects with storage which today is not that prominent will be coming up with the continuous decrease of storage costs and increase in efficiency and life of the same. It's ever changing and innovating world out there, where the normal has become to change and improve every-day to maintain one's competitive edge in the market and wind is no exception. It's time for the next inflection point!!!

Snippets on Wind Power

Power Minister Proposes a New Scheme Worth Rs 3 Lakh Crore to Finance Commission

Power Minister Mr. RK Singh has proposed a new scheme for the power sector amounting to Rs 3 lakh crore spanning five years, in his meeting with the 15th Finance Commission. Officials of the Power Ministry discussed the need to restructure the power system to make states responsible for the financial health of their power distributions companies (discoms). This would entail recalibrating state borrowing limits under the Fiscal Responsibility and Budget Management (FRBM) Act, to account for the added liabilities. The new scheme included an amalgamation of old schemes under the Power Ministry and focused on reducing losses in the power sector, separate feeders for agriculture and smart prepaid meters.

Source: ET Bureau, May 30, 2020


EWT
Direct Drive Wind Turbines
MORE ENERGY LESS COMPLEXITY
POWER YOUR BUSINESS WITH EWT 1 MW DIRECT DRIVE WIND TURBINE
(THE NETHERLANDS BASED COMPANY)
High energy yield
Low costs of ownership
High availability
High return on investment
24/7 monitoring rapid response
24/7
Advance Grid support Features LVRT, AVC, AFC
Less Maintenance

Bids Completed and

S.No.	Bids Completed	Capacity	SCOD	Bidder	Tariff	State	Bid Capacity	Project Commissioned			
								Capacity Break up	2018-19	2019-20	Grand Total
		MW			Rs./ kWh		MW	MW	MW	MW	MW
1	SECI - I (24th February 2017)	**1050**	**5-Mar-19**	MYTRAH	3.46	Tamil Nadu	250	250	624.8	375.2	1000
				INOX	3.46	Gujarat	250	200			
				OSTRO	3.46	Gujarat	250	250			
				GREEN INFRA/Sembcorp	3.46	Tamil Nadu	250	250			
				ADANI	3.46	Gujarat	50	50			
2	SECI-II (4th October 2017)	**1000**	**3-May-19**	RENEW	2.64	Gujarat	250	180	0	680	680
				ORANGE	2.64	Tamil Nadu	200	200			
				INOX	2.65	Gujarat	250				
				GREEN INFRA/Sembcorp	2.65	Gujarat	250	250			
				ADANI	2.65	Gujarat	50	50			
3	SECI - III (13th February 2018)	**2000**	**24-Nov-19**	RENEW	2.44	Gujarat	400		0	391.1	391.1
				GREEN INFRA/Sembcorp	2.44	Gujarat	300	300			
				INOX	2.44	Gujarat	200				
				TORRENT	2.44	Gujarat	499.8				
				ADANI	2.45	Gujarat	250	66			
				ALFANAR	2.45	Gujarat	300				
				BETAM/ENGIE	2.45	Tamil Nadu	50.2	25.1			
4	SECI - IV (5th April 2018)	**2000**	**28-Feb-20**	SRIJAN ENERGY/ CONTINNUM	2.51	Gujarat	250		0	0	0
				SPRNG ENERGY/ACTIS	2.51	Tamil Nadu	300				
				BLP/ENEL	2.51	Gujarat	285				
				BETAM/ENGIE	2.51	Tamil Nadu	200				
				INOX	2.51	Gujarat	100				
				ADANI	2.51	Gujarat	300				
				MYTRAH	2.52	Tamil Nadu	300				
				RENEW	2.52	Gujarat	265				
5	SECI - V (25th September 2018)	**1200**	**22-Sep-20**	TORRENT POWER	2.76	Gujarat	115		0	0	0
				ADANI	2.76	Gujarat	300				
				ALFANAR	2.77	Gujarat	300				
				SITAC	2.77	Gujarat	300				
				ECOREN	2.77	Karnataka	175				
				RENEW	2.77	Gujarat	10				
6	SECI-VI (15th February 2019)	**1200**	**Feb-21**	ADANI	2.82	N.A	250		0	0	0
				RENEW	2.82	Tamil Nadu	300				
				CONTINUUM	2.82	N.A	150				
				POWERICA	2.82	N.A	50.6				
				ECOREN	2.83	Karnataka	125				
				SOFTBANK	2.83	Maharashtra	324.4				
7	SECI-VII (14th May 2019)	**480**	**May-21**	ENGIE	2.79	N.A	200		0	0	0
				RENEW	2.81	N.A	50				
				SPRNG	2.82	MP	100				
				ADANI	2.83	Gujarat	130				
8	SECI -VIII (30th August 2019)	**440.64**	**Aug-21**	CLP	2.83	Gujarat	250.8		0	0	0
				Avikiran Energy/Enel	2.84	Gujarat	189.84				
TOTAL		**9370.64**							**624.8**	**1446.3**	**2071.1**

Commissioned So Far (1st April 2020)

NTPC & States Bids (Wind)											
S.No.	Bids Completed	Capacity	SCOD	Bidder	Tariff	State	Bid Capacity	Capacity Break up	Project Commissioned 2018-19	2019-20	Grand Total
		MW			Rs./ kWh		MW	MW	MW	MW	MW
9	NTPC (21st August 2018)	1200	May-20	SPRNG VAYU	2.77	MP	200		0	0	0
				MYTRAH	2.79	Tamil Nadu	300				
				SRIJAN ENERGY/CONTIN-NUM	2.8	Gujarat	50				
				RENEW	2.81	KAR/Gujarat	300				
				HERO	2.82	KAR/Gujarat	300				
				SITAC/EDF	2.83	N.A	50				
10	TAMIL NADU (28th August 2017)	450	May-19	REGEN POWERTECH	3.42	Tamil Nadu	200	50	50	0	50
				LEAP ENERGGY	3.43		250	0			
				NLC	3.45		0	0			
11	GUJARAT (GUVNL) (21st December 2017)	500	Oct-19	SPRNG ENERGY	2.43	Gujarat	197.5	197.5	104.9	357.4	462.3
				K.P. ENERGY	2.43		30	30			
				VERDANT/SITAC	2.44		100	100			
				BETAM WIND/ENGIE	2.44		29.9	29.9			
				POWERICA	2.44		50	50			
				RENEW	2.45		35.7	0			
				Oil India	2.43		18.9	18.9			
				SJVNL	2.43		38	38			
12	MSEDCL (6th March 2018)	500	Jan-20	ADANI	2.85	Gujarat	75		0	202	202
				KCT/RENEW	2.85	Maharashtra	75	75			
				INOX	2.86	Gujarat	50				
				MYTRAH	2.86	Maharashtra	100				
				HERO	2.86	Maharashtra	75.6				
				TORRENT	2.87	Maharashtra	124.4	124.4			
13	MSEDCL (1st June 2018)	87	Mar-19	SARLA PERFORMANCE FIBERS LTD	2.51	Maharashtra	6		0	0	0
				INOX	2.52		6				
				ESSEL MINING & INDUS-TRIES LTD	2.52		75				
14	GUVNL TRANCHE -II (13th May 2019)	745	May-21	AANISHA POWER	2.8	Gujarat	40		0	0	0
				POWERICA	2.81		50.6				
				VENA ENERGY	2.81		100				
				SARJAN REALITIES	2.87		100.8				
				VIRIDI	2.95		100				
				INOX	2.95		40				
				RENEW	2.95		200				
				ADANI	2.95		113.6				
TOTAL		**3482**							**154.9**	**559.4**	**714.3**
GRAND TOTAL		**12852.64**							**779.7**	**2005.7**	**2785.4**

SUMMARY

Total Wind Bids (SECI,NTPC,State)	**12853**
Total Wind Solar Hybrid Bids (SECI)	**1560**
Total	**14413**

Note: The figures may vary as it is collected verbally from several sources

Compiled by: Rishabh Dhyani
Executive - Regulatory Affairs & Liaison, IWTMA, New Delhi

Anticipating Complex Network Issues Through the Use of Advanced Simulation Models




Xabier JuanKorena
R&D Engineer

D. Velasco
Control Software & DFIG Regulation Engineer

I. Esandi
Control & Software Senior Engineer

E. Burguete
RD Engineer

Ingeteam Power Technology, Sarriguren, Spain

Introduction

Wind energy penetration in the transmission networks has been continuously increasing during the last decades. This situation propitiates integration problems with the electrical grid.

Regarding the power converter, these problems can be classified as follows:

- Working with very low SCR or quality factor grids: the resonance frequency of the harmonic filters decreases and can destabilize the current control loop.
- Sub-synchronous resonances: when series capacitors used in long transmission lines interact with the converter control loops, resonances at low frequencies appear.
- Parallel resonances: the use of capacitor banks on a wind farm level can have an influence on the system stability.

An accurate modelling of the converter control loops and its interaction with the grid becomes indispensable in order to overcome these challenges. Using SIL and HIL systems meet this requirement, but these systems are time-consuming. The modelling of the control loops, grid and generator systems as linear time-invariant (LTI) models, instead, allows high agility to run parameter sweeps and test new algorithms.

The LTI model allows to express the whole system (grid + control + generator) as one state-space matrix. The stability and dynamic behaviour of the system can be obtained easily from the LTI model.

The non-linearities of the system (converter switching, non-linear control algorithms…) must be linearized or eliminated.

Results

The following workflow is proposed to anticipate grid interaction problems:

- Characterization of all possible casuistics of a grid: parameter variations (e.g. number of turbines connected), network branches connected or disconnected, capacitor banks connected or disconnected.
- Generation of LTI models of all possible grid, generator

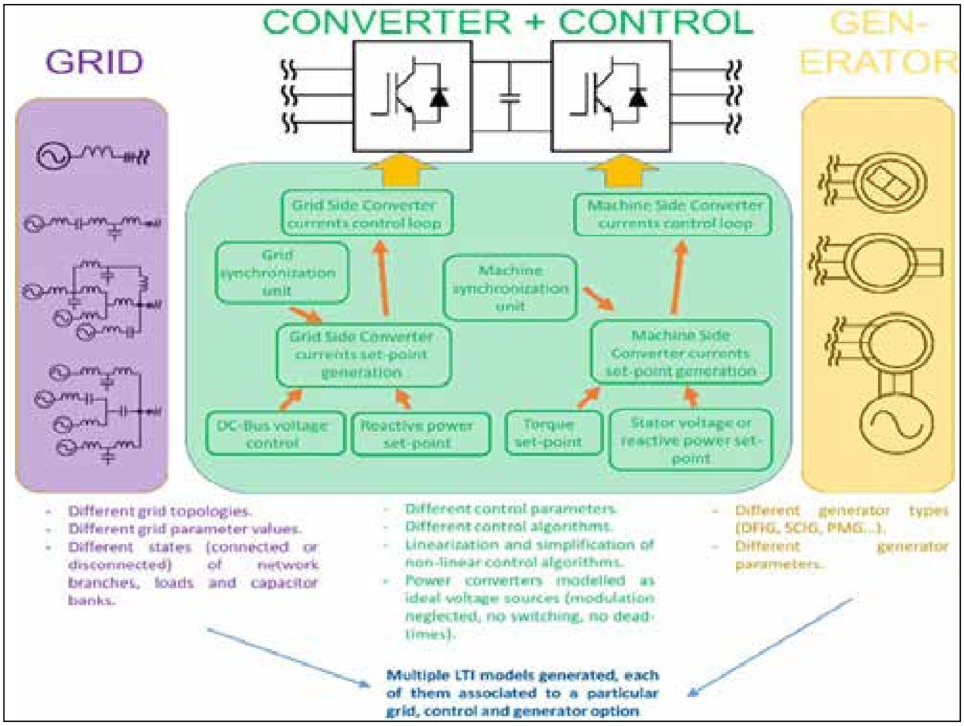


Figure 1: Generation of LTI Models Workflow

and control algorithm casuistics to analyze the control loops behavior and obtain the set of parameters or new algorithms to assure the good performance.

- Validation of the solution using SiL and HiL systems.

Generation of LTI Models

LTI model of a certain grid, LTI model of a certain converter control option and LTI model of a certain generator are combined to form an LTI model associated to a particular grid, control and generator combination.

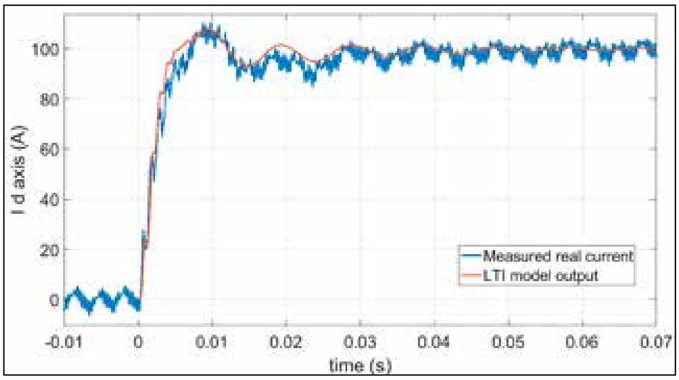


Figure 2: Real and LTI Model Current Response Comparison

Validation of LTI Modelling

Despite simplifications (no switching and dead-time, linearization of non-linearities), the LTI model replicates with sufficient precision the current response measured in real test-bench.

Obtaining an Optimized Control Structure

Low time (~100 ms) is needed to generate and analyze one LTI system. That brings the possibility to test high number of different control parameters and algorithms with all possible different grid and generator combinations, obtaining stability maps and dynamical behaviours.

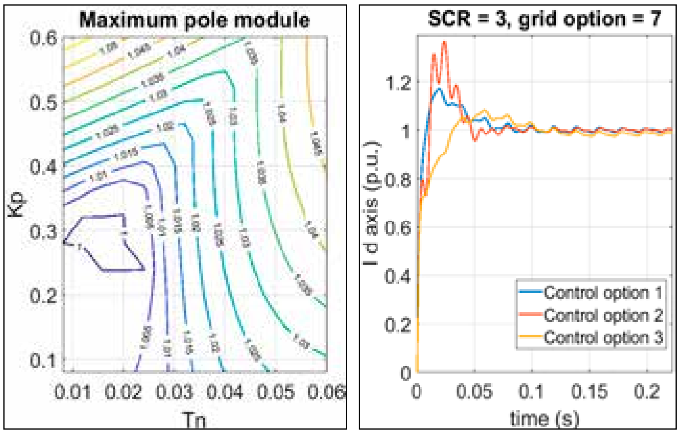


Figure 3: Stability Map (left) and Dynamic Behavior (Right)

The optimal control structure and its parameterization are selected, which are stable with all possible grid and generator casuistic and present best dynamical behaviour.

Validation of the Control Structure

The selected control structure and its parameterization are validated with SiL & HiL simulation platforms together with an automated testing procedure, to eliminate uncertainties due to simplifications and linearization of the control algorithms when generating the LTI model.

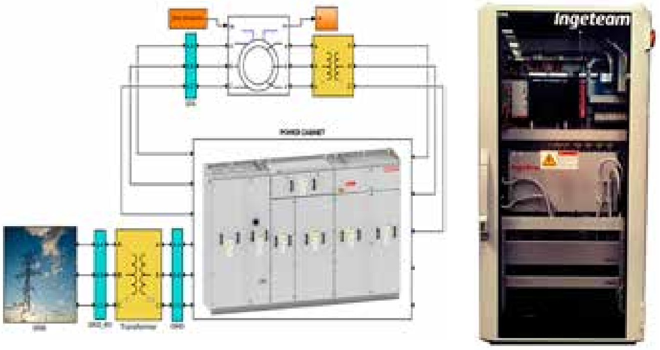


Figure 4: SiL Model (left) and HiL Simulation Bench (Right)

Conclusions

The use of LTI models is proposed to anticipate complex network issues. These LTI models are generated to each particular grid, generator and control algorithm and parameter casuistics, allowing to check in a fast way the stability and the dynamic behaviour of the whole system.

Simplifications must be done in order to generate the LTI models. Switching and dead time are neglected, and non-linear control algorithms must be linearized. In spite of these simplifications, the LTI model and real system responses have a good equivalence.

Through simulation sweeps using LTI models, an optimal control structure can be selected, that assures stability with all possible grid and generator casuistics and has acceptable dynamical behaviour.

The selected control structure and its parameterization are finally validated using SiL/HiL simulation platforms. In this way, the good performance of the selected control structure is totally guaranteed.

References

1. D. Velasco, J. Lopez, "Discrete-Time Domain Modeling of DQ-Frame Current-Controlled Systems through easy Implementation," 2018 IEEE 19th Workshop on Control and Modeling for Power Electronics (COMPEL), Padua, 2018, pp. 1-7.

2. D. Velasco, "Modelización de parques eólicos conectados a redes débiles," 2019. PhD thesis, Public University of Navarre, Pamplona, Spain.
3. L. Harnefors, X. Wang, A. G. Yepes and F. Blaabjerg, "Passivity-Based Stability Assessment of Grid-Connected VSCs-An Overview," in IEEE Journal of Emerging and Selected Topics in Power Electronics, Vol. 4, no. 1, pp. 116-125, March 2016.
4. D. Dong, B. Wen, D. Boroyevich, P. Mattavelli and Y. Xue, "Analysis of Phase-Locked Loop Low-Frequency Stability in Three-Phase Grid-Connected Power Converters Considering Impedance Interactions," in IEEE Transactions on Industrial Electronics, Vol. 62, no. 1, pp. 310-321, Jan. 2015.
5. A. Lorea, J. Aguirrezabal, "Development of INGECON® WIND LV Power Converter for DFIG topology Wind Turbines up 5.X MW, " Wind Europe, 2019.
6. J. M. Maciejowsky, "Mutlivariable feedback desing (1. edition). Boston, USA. Pearson Education, 1989.
7. J. Kukkola, M. Hinkkanen, K. Zenger, "Observer-based state-space current controller for a grid converter equipped with an LCL filter: Analytical method for direct discrete-time design," IEE Trans. Ind. Appl. 51, 4079-4090, 2015.
8. X. Li, J. Fang, Y. Tang, X. Wu, Y. Geng, "Capacitor-voltage feed forward with full delay compensation to improve wead grids adaptability of LCL-filtered grid-connected converters for distributed generation systems," IEE ETrans. Power Electron. 33, 749-764, 2018.
9. C. Zhang, X.F. Wang, F. Blaajberg, W.S. Wang, C. Liu, "The influence of phase-locked loop on the stability of single-phase grid connected inverter," Proceedings paper presented on IEEE Energy Conversion Congress and Exposition. Montreal, Canada. 4737 4744, 2015.

Snippets on Wind Power

Renewables Dethrone King Coal

For the first time ever, renewable energy supplied more power to the U.S. electricity grid than coal-fired plants for 47 days straight. The run is impressive because it trounces the previous record of nine continuous days last June and exceeds the total number of days renewables beat coal in all of 2019 (38 days). Today, renewable energy sources offer the cheapest form of power in two-thirds of the world, and they look set to get cheaper. They now provide up to 30% of global electricity demand; a figure is expected to grow to 50% by 2050. As a recent United Nations report put it: renewables are now "looking all grown up."

Source: IEE Spectrum, 22 May 2020

Germany to Help India Evaluate Optimal Power Balancing to Meet Renewable Energy Plans by 2022

Deutsche Gesellschaftfür Internationale Zusammenarbeit (GIZ) has contracted DNV GL to conduct a major control reserve study for southern region of India. It is the first control reserve study to be conducted in this part of the world and aims to quantify the control reserve requirements that are needed to balance the energy supply from wind and solar and energy demand, according to the renewable energy plans of India's southern states (Kerala, Tamil Nadu, Karnataka, Telangana and Andhra Pradesh) by 2022.

The study will quantify the secondary and the tertiary control reserve requirements that will enable optimal sharing of power between the states. Dimensioning of the states' control reserves will help ensure efficient and cost-effective integration of large-scale renewable energy supplies.

Source: TNN, May 26, 2020

SECI Concept Note on RE Projects

Solar Energy Corporation of India (SECI) has come up with a concept note on Firm and Flexible Renewable Energy Projects with High PLF. In order to address all the three requirements of High PLF, firmness and flexibility in renewable energy, a possible solution is developing Solar-Wind Hybrid projects with energy storage.

CERC Draft for RE Tariff Determination

Central Electricity Regulatory Commission has come with draft (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations, 2020. These regulations shall come into force on 1.7.2020, and unless reviewed earlier or extended by the Commission, shall remain in force up to 31.3.2023. Tariff for wind and solar power projects would be project specific on case to case basis.

Karnataka Electricity Regulatory Commission (KERC) Generic Tariff for Wind Power

Karnataka Electricity Regulatory Commission has come up with Determination of Generic Tariff for Wind Power Projects for the Financial Year 2020-21 on 6th May 2020. Commission decided that Rs. 3.26/unit will be the ceiling tariff for competitive bidding. This tariff will also be applicable for the payment towards any banked energy purchased by the Distribution Licensee.

Performance Optimisation of Wind Farms

Modini Yantrapati
Engineer, Technology & Innovation, DNV GL – Energy

Wind tariffs in India have fallen significantly due to the reverse auction model, and hence there is a pressure to optimise asset management of a wind farm in all possible ways for the financial viability. Traditionally, wind turbines are designed for one of the wind classes and micro-siting is for the predominant wind direction. The actual site conditions and ever-changing wind parameters that a turbine encounters are different from the optimised design & controller settings. The endeavour is now to run the turbine as closely to optimised parameters as possible. The other area of focus has been reduced the cost of operation & maintenance (O&M) through predictive maintenance and condition monitoring.

DNV GL has reviewed the performance of over 1,000 wind farms and 50,000 turbines worldwide, including IEC-based power performance testing, availability audits, operational energy assessments, performance monitoring and benchmarking. Wind farm performance can be optimized significantly and tracked through live operations monitoring and periodic detailed analysis. The SCADA data continuously recorded by each turbine and met masts on the wind farm can be interrogated to track performance and monitor the health of turbine components to minimize the risk of underperformance.

Implementing performance upgrades is one of the common practices to maximise the return. To determine if the safe implementation of a performance upgrade is possible at a specific site, a brief list of issues must be evaluated: turbine loading and structural reliability, site electrical capacity, failure rates for non-structural components and certification, contractual and insurance implications. While these upgrades are intended to improve energy production and thus increase project revenue, they will always come at a cost both directly in the form of payment for the upgrades and indirectly as additional operation & maintenance (O&M), impact on the turbine life etc. The challenges of evaluating these revenue gains and associated costs are significant. The increase in annual energy production (AEP) is evaluated against direct payment; however, the costs associated with increased O&M and reduced turbine life may not manifest for several years.

There are mainly two types of performance upgrades – aerodynamic modifications where add-on or aerodynamic devices improve the performance such as vortex generators, flaps, leading edge repair, etc. and control modifications where the manipulations are done on the control systems, for instance pitch optimization, improved soiling operations, uprating to optimize parameters which improve performance. There are also extreme measures taken up across industry such as blade lengthening and repowering of wind farms.

These upgrades can be at the turbine or the wind farm level. The turbine level changes include aerodynamic modifications, control strategy changes and other parametric changes based on site-specific considerations. Wind farm level changes include optimisation of turbine behaviour for the prevailing wake behaviour and better grid management. There are optimization techniques which are applied to the entire wind farm and help in augmenting the plant-level AEP. These optimizations apply different modifications to individual wind turbines in a plant to increase the overall production capability of the wind farm.

Efficient wake loss management can help in minimizing the losses that occur due to the deficiency of adequate wind behind the rotor of a turbine. The objective is to increase overall wind farm power production while maintaining or reducing turbine fatigue loads, by manipulating the individual turbine controllers to minimise wake interaction effects. Intelligent wake loss management leverages advanced algorithms and controls tools with real time data to alter individual turbine parameters such as pitch, rotor speed, etc. to increase the overall wind farm AEP. The two main concepts of wake loss management are axial induction and wake steering. Both concepts involve actively reducing the power output of few individual turbines in order to achieve a net increase in total production from the farm. In the case of axial induction control, turbine power reduction is achieved by increasing the pitch angle and/or reducing rotor speed in order to reduce rotor thrust, thus reducing the wake. In wake steering control, the turbine is deliberately yawed a little out of the wind direction, as this has the effect of changing the downstream path of the wake, which can thus be steered away from downstream turbines.

With wind-farm level active power control features, which are being increasingly adopted globally, it is possible to reduce the power across the wind farm exactly to the extent that is required. This helps significant amount of power curtailment when viewed from a long-term basis. Most of the OEMs now provide wind farm optimization services through wind turbines performance improvement upgrades and hardware and software based predictivity solutions.

The ultimate goal is to continuously optimise the performance at wind farm level at real time for ever-changing input conditions. Given the large number of variable parameters, it can be possible through use of high-end software and digital tools. In India, the scope of such optimisation is relatively large, and it is high time that we endeavour to get maximum out of the available natural resources.

Grid Connected Wind Solar Hybrid Power System in India

Anirudh Sharma, Assistant Manager, WRA – Industrial Services, TÜV Rheinland (India) Private Limited, NOIDA, U.P.

India has set an ambitious target of reaching 175 GW of installed capacity from renewable energy sources by the year 2022, which includes 100 GW of solar and 60 GW of wind power capacity. Various policy initiatives have been taken to achieve this target. As of December 2019, the total renewable power installed capacity in the country was almost 86 GW.

To meet the day to day increasing load demand, the conventional sources are no longer a viable solution as they are depleting rapidly. Solar, due to its dependence on sunlight can produce power only during the day, between 8 am–5 pm. Wind, on the other hand, starts blowing during late evenings and reaches its peak during the nights. Due to this complementary intermittent nature of wind and solar, power production can be leveled out all throughout the day with a solar-wind hybrid. This means the reliability of the grid is improved by ensuring peak power requirements are met.

The introduction of National Wind Solar Hybrid Policy has been instrumental in encouraging hybridization of existing wind and solar plants as well as promoting Hybrid plants in India.

Further, the objective of the policy is to optimise and improve the efficacy of the usage of transmission infrastructure and land, which in turn will mitigate inconsistencies associated with the generation of renewable power and help in attaining better grid stability.

The primary aspect of the hybrid plant is the configuration - AC or DC integration and the use of technology.

The second important aspect would be related to the sizing - which would depend on the resource characteristics. In order to achieve the benefits of hybrid plant in terms of optimal and efficient utilization of transmission infrastructure and better grid stability by reducing the variability in renewable power generation, in the locations where the wind power density is quite good, the size of the solar PVs capacity to be added as the solar-hybrid component could be relatively smaller. On the other hand, in case of the sites where the wind power density is relatively lower or moderate, the component of the solar PV capacity could be relatively on a higher side.

Advantage of Wind Solar Hybrid Plants

1. Complementary Resource Characteristics: Wind and solar energy resources are complementary on a diurnal basis, with peak wind times after sunset and before sunrise and peak solar times aligning with periods of lower wind resource.
2. Efficient Use of Land: To make efficient use of land between wind turbines which are spaced apart due to avoid row effects.
3. Analogous Technical Processes: Both wind and solar rely on natural sources and can be integrated into common AC or DC output to feed into the local utility grid.
4. Cost efficiency from shared infrastructure: Shared data collection systems, O&M service facilities and asset management, a common point of interconnection are beneficial for cost efficiency, especially for projects with higher capacities.

Investment Cost

The initial investment cost includes the cost of various equipment, like PV panels, wind turbines and battery bank and different power converters, defined as

$C_{in} = (C_{pv}N_{pv} + C_{wt}N_{wt} + C_{bs}N_{bs}) \times CRF$

where,

C_{pv} - cost of PV panel

C_{wt} - cost of wind turbine

C_{bs} - cost of battery

N_{pv} - number of PV panels

N_{wt} - number of wind turbines

N_{bs} - number of battery banks

CRF - Capital recovery factor, which is used to convert all the cost to present value

Operation and Maintenance Cost

Since the fuel is free of cost, the operation and maintenance cost is the major cost for the system. It is given by

$C_{o\&m} = C_{pv\ O\&m} \times t_{pv} + C_{wt\ O\&m} \times t_{wt} + C_{bo\&m} \times t_{bs}$

Where,

$C_{pv\ O\&m}$ - operation and maintenance cost of PV per unit time

$C_{wt\ O\&m}$ - operation and maintenance cost of wind per unit time

$C_{bs\ O\&m}$ - operation and maintenance cost of battery per unit time

t_{pv}, t_{wt}, t_{bs} are the operating times of PV, wind and battery systems respectively.

Implementation Strategy

According to MNRE, the implementation of a wind solar hybrid system will depend on different configurations and use of technology.

A. Wind-Solar Hybrid - AC Integration: In this configuration the AC output of both the wind and solar systems is integrated either at LT side or at HT side. In the latter case both systems use separate step-up transformers and the HT output of both systems is connected to the common AC Bus-bar. Suitable control equipment is deployed for controlling the power output of hybrid systems.

The only advantage of this system is that it is most compatible with the existing transmission framework in India.

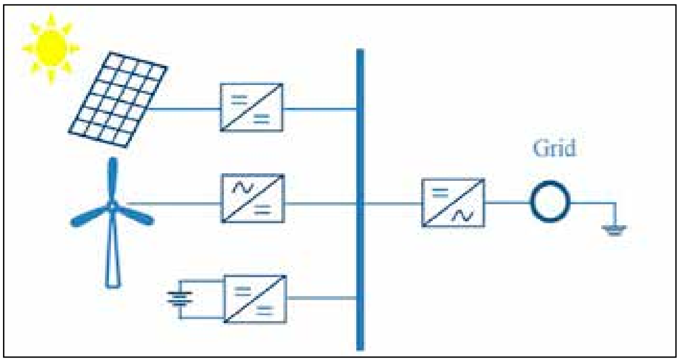


Figure 1: AC-Coupling Topology for Integrating the Wind/ Solar/Battery

B. Wind-Solar Hybrid - DC Integration: DC integration is possible in case of variable speed drive wind turbines using convertor - inverter. In this configuration the DC output of both the wind and solar PV plant is connected to a common DC bus and a common inverter suitable for combined output AC capacity is used to convert this DC power into AC power.

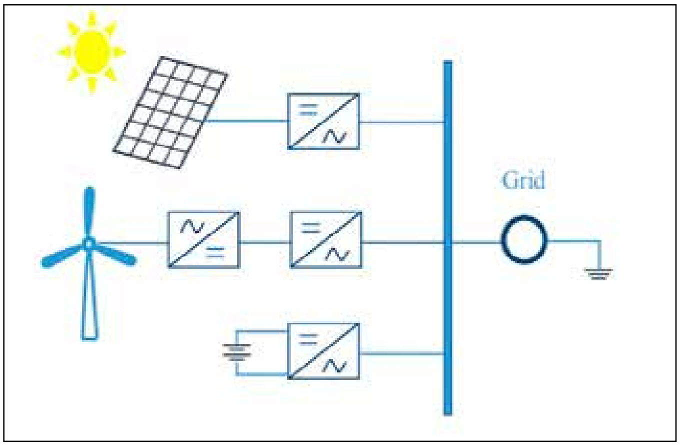


Figure 2: DC-Coupling Topology for Integrating the Wind/Solar/Battery

The DC-coupling topology has the advantages of simplified hardware, lower cost and higher energy efficiency.

Site Selection

Aim is to make maximum use of land area. Solar and wind resources could be explored separately in different regions or the same region but solar and wind resources should exhibit complementary peaks in production on an annual and daily level.

Sizing of Hybrid Power Plant

Optimization is the main objective that is to minimize the system cost with reliability.

Sizing is done by mathematical models to get the best output from the combination. The number of PV panels, wind turbines, battery cells, load profiles and available renewable resources plays a significant role in sizing of PV-wind hybrid power systems. In order to utilize the renewable energy cost effectively, many researchers have studied the algorithm to calculate the capacity of applicable generator units that can constitute a reliable power system with low cost. Many different sizing methods, such as iterative method and artificial intelligence method, have been reported to design a techno-economically optimum hybrid renewable energy system.

The battery bank with the total nominal capacity is permitted to discharge up to a limit defined by the minimum state of charge. For a good knowledge of the real state of charge (SOC) of a battery, it is necessary to know the initial SOC, the charge or discharge time and the current.

In large-scale problems, the optimum size of each component of hybrid energy systems will require complex computer programs and will need much time for computing.

Pt = Ps + Pw

(Excluded battery to reduce complexity)

Pt - Total Power Produced

Ps - Solar Power produced

Pw - Wind Power Produced

For quantifying the deviation between two power demand and power supply, the Least Squares (LS) approach can be used. The following equation describes LS:

$$LS = \sum_{i=0}^{n} (Di - Si)^2$$

LS = 0, hypothetically, demand is fulfilled

Factors to Consider during Energy Simulations

- Turbine Shading: Shading impacts generation of Solar PV panels. This is required to be quantified. Shading will cause mismatch losses in PV arrays.

- Roughness because of solar arrays needs to be quantified.
- Effective Hub Height of turbines will change because of PV arrays. This can be taken care of by using the concept of Displacement height.

Losses

Wind Farm Loss

- Wake Effects
- Availability (machine & electrical system)
- Electrical (component efficiencies, wiring)
- Turbine Performance (operation, power curve, high-wind hysteresis, inclined flow)
- Environmental (blade degradation, temperature shutdown, site access, lightning)
- Curtailments (directional, environmental, PPA, operational)

Solar PV Farm Loss

- Effective Irradiation (shading, soiling, reflection)
- Photovoltaic Conversion (mismatch, quality degradation, non-stc temperature & irradiance)
- Electrical (component efficiencies, wiring)
- Operational (availability, curtailment)

Hybrid Energy Uncertainty (Mutual Interactions)

Apart from individual uncertainties there are mutual interactions between the two resources that are needed to be taken into account.

Wind Uncertainty (Affected by PV Arrays)

a. Wake loss uncertainty (due to solar arrays)

b. Availability loss uncertainty (due to more difficult crane access around solar arrays)

Solar Uncertainty (Affected by Wind Turbines)

a. Turbine shading loss uncertainty

b. Shading-induced mismatch uncertainty

c. Inverter availability uncertainty due to shadow flicker

Constraints

a. Reliability constraint

b Fluctuations of power injected into the grid

c. Battery constraints - As the batteries are the components with the least lifespan in the system, they need to be given the most attention. In this method, the battery state of charge (SOC) is maintained within the minimum (SOCmin) and maximum (SOCmax) limits to ensure that the battery is neither completely discharged nor fully charged at any point of time.

d. Physical accessibility of turbines because of PV arrays

Source and Further Readings

National Wind-Solar Hybrid Policy — MNRE (2018)

M. Engin, "Sizing and Simulation of PV-Wind Hybrid Power System," Hindawi Publishing Corporation International Journal of Photoenergy, March 2018.

R. A. Badwawi, M. Abusara & T. Mallick (2015) "A Review of Hybrid Solar PV and Wind Energy System, Smart Science, 3:3, 127-138, DOI: 10.1080/23080477.2015.11665647

K. S. Sandhu and A. Mahesh, "Optimal sizing of PV/wind/battery Hybrid Renewable Energy System Considering Demand Side Management," from International Journal on Electrical Engineering and Informatics - Volume 10, Number 1, March 2018

C. D. Ziesler, P. N. Johnson, and J. R. Doty, "Wind-Solar Hybrid Design and Modeling," Webinar presentation from Underwriters Laboratories, September 2019.

Snippets on Wind Power

MNRE Sets up Foreign Direct Investment Cell to Process Proposals

The Ministry of New and Renewable Energy (MNRE) has created a foreign direct investment (FDI) cell within the ministry to process proposals of foreign acquisitions in domestic firms. The government had recently reviewed the FDI policy for curbing opportunistic takeovers and acquisitions of Indian companies due to the current COVID-19 pandemic.

Source: ET Energy World, June 08, 2020

Compiled By: **Mr. Abhijit Kulkarni**
Business Unit Head - Energy Segment
SKF India Ltd, Pune and
IWTMA Team

Printed by R.R. Bharath and published by Dr. Rishi Muni Dwivedi on behalf of Indian Wind Turbine Manufacturers Association and printed at Ace Data Prinexcel Private Limited, 3/304 F, (SF No. 676/4B), Kulathur Road, Off NH 47 Bye Pass Road, Neelambur, Coimbatore 641062 and published at Indian Wind Turbine Manufacturers Association, Fourth Floor, Samson Towers, No. 403 L, Pantheon Road, Egmore, Chennai 600 008.

Editor: Dr. Rishi Muni Dwivedi

Registered with REGISTRAR OF NEWSPAPERS for India, New Delhi
Vide No. TNENG/2015/60605

April - May 2020
Date of Publishing: 20.07.2020