Indian Wind Power

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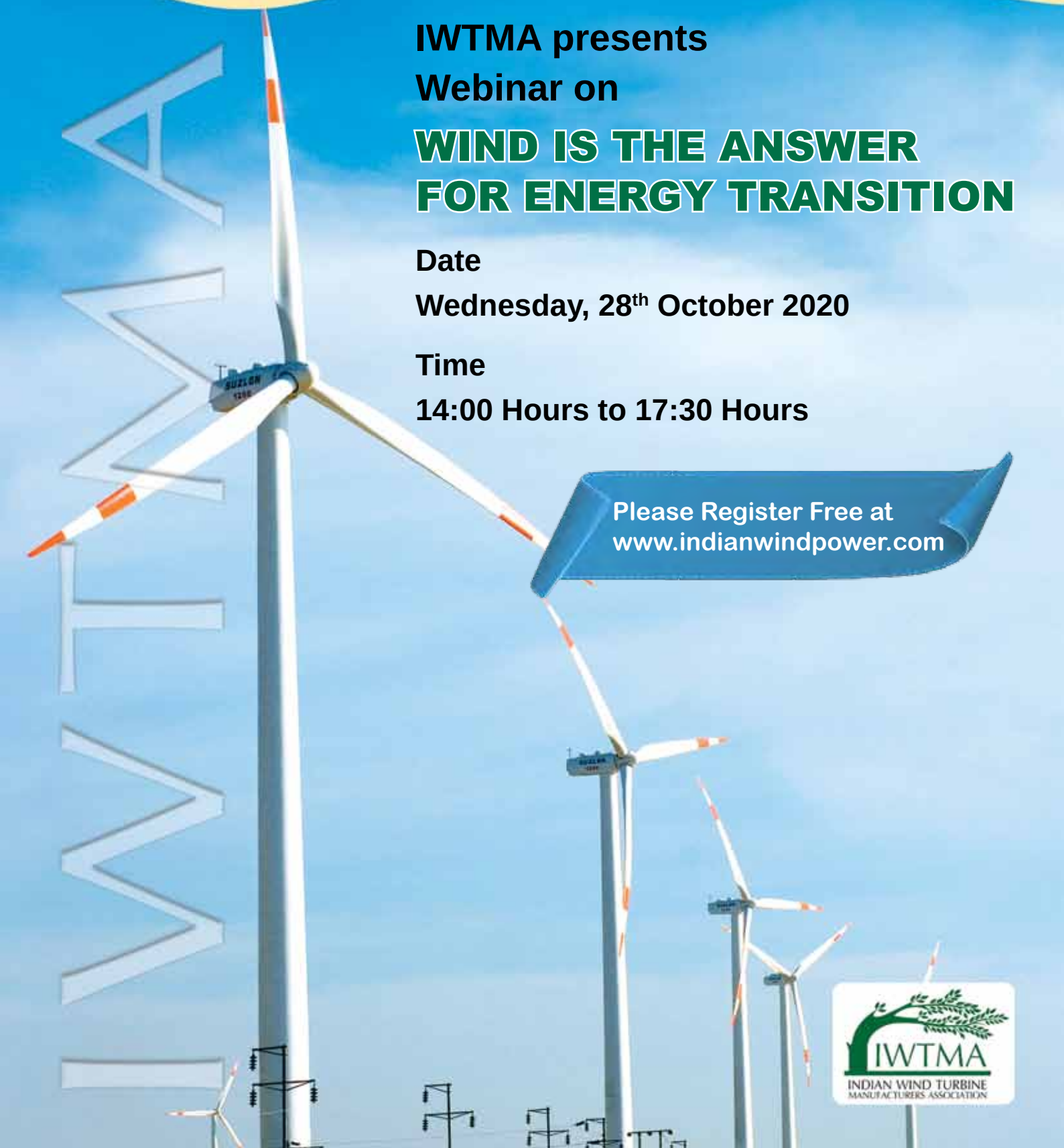

IWTMA presents
Webinar on

WIND IS THE ANSWER FOR ENERGY TRANSITION

Date

Wednesday, 28th October 2020

Time

14:00 Hours to 17:30 Hours

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INDIAN WIND TURBINE MANUFACTURERS ASSOCIATION

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- Demarcation of Offshore Wind Energy Blocks
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- Seminar / Workshops on Wind and Solar Energy

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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

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Volume: 6 Issue: 2 June - July 2020

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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

From the Desk of the Chairman – IWTMA

Greetings from IWTMA!

The Central Government has a challenging task to balance "lives and livelihood" during this unprecedented pandemic. We, as citizens of the country, have to be more careful as the unlock process is on, observe caution and adapt to the **"new normal"**.

The wind industry is no exception. It had its share of setbacks that primarily affected the MSME industries which serve as the backbone to the supply chain of wind turbine manufacturing activity. It is unfortunate that this situation resulted in closure of units, loss of jobs and virtual stoppage of projects since the workers were mostly migrant laborers. The silver lining is that in the last two months, the situation is slowly improving, and all activities have commenced both in manufacturing and project execution.

I truly believe that the Wind Energy sector is at an inflection point. The next five years will witness a significant positive momentum in the sector. The government is aggressive about renewable energy and the Power Minister Shri R. K. Singh has reinstated his confidence that the renewable energy capacity could touch 510 GW by 2030, including 60 GW of hydro power. In my view, several policy measures, including the recent ISTS and the new tariff policy that is awaiting cabinet's approval, are steps in the right direction. The market is on a path of recovery and tenders from earlier auctions are still open resulting in a promising order intake.

It is a moment of pride for me to state that the Wind Energy sector is supporting the government's vision of 'Make in India' by championing the cause and is truly 'Atmanirbhar'. The government's focus on 'Atmanirbhar Bharat' will boost domestic manufacturing and substantially benefit wind turbine manufacturers.

The Association has been in constant dialogue with the Government to find ways and means to increase capacity addition which will meet the Government's target. We believe increase in volumes will help further localization and create rural employment. In this regard, the Association is organizing a Webinar titled **"Wind is the Answer for Energy Transition"**. Participants of the webinar will discuss opportunities and challenges in the sector and, perhaps, create a new macro perspective on sustainability, climate change and how to achieve the same by discussing a new approach on Demand Creation, Challenges in Grid, Furthering localization from the current 80% and creating blue collared employment in the rural sector. We encourage our readers and all industry stakeholders to register for a non-transferrable invitation for which the admission is **'free of cost'**.

We are happy to inform the readers that the vision of the Hon'ble Prime Minister is to make Ladakh Carbon Neutral by setting up renewable energy projects of wind and solar. Since the terrain is complex and difficult, the project may accommodate sub-megawatt turbines with limitations of logistics. Our Association has taken this assignment on a war footing and is working with the Government in creating a landmark in renewables for the people of Ladakh and for the requirement of our Defence Forces.

Our Association is also pushing the Government on utilization of idle or unutilized state transmission capacity for wind energy transmission for interstate transmission. Besides, we have also campaigned for an investor friendly policy on Repowering as the best sites in the country are occupied by not so efficient first generation turbines.

Finally, wind energy is just not a business. It is a commitment by all of us in our march against the ill-effects of climate change and global warming. We envision a **"Clean Green World"** with pollution free energy for the growth of the economy.

It gives me great pleasure to wish all our readers a **"Happy Navratra"** and **"Diwali"**, the festival of lights.

Please stay safe and be healthy.

With regards,

Tulsi Tanti
Chairman

Commencement of Real-Time Market Mark a Win-Win Situation for Efficient and Sustainable Power Sector

Rohit Bajaj, Senior Vice President
& Head-Business Development,
Indian Energy Exchange Limited

Energy is the backbone of our economy. The Government of India's vision of affordable and uninterrupted 'Power for All on 24*7' is aligned to the fact that not only does electricity enable industrial and economic growth, but it also helps raise the human development index. This has never been more profound than today, as we are faced with uncertain times. To be able to function optimally, the energy sector however, needs structural and operational transformation and regulatory reforms that can reduce the financial stress of the distribution utilities and infuse the much-needed technology, efficiency and flexibility in the value chain. While the liquidity infusion by the government has been a relief to DISCOMs, it is important to remember that such measures are not sustainable, and much more is required to be done to ensure sound operational and financial health over the long run.

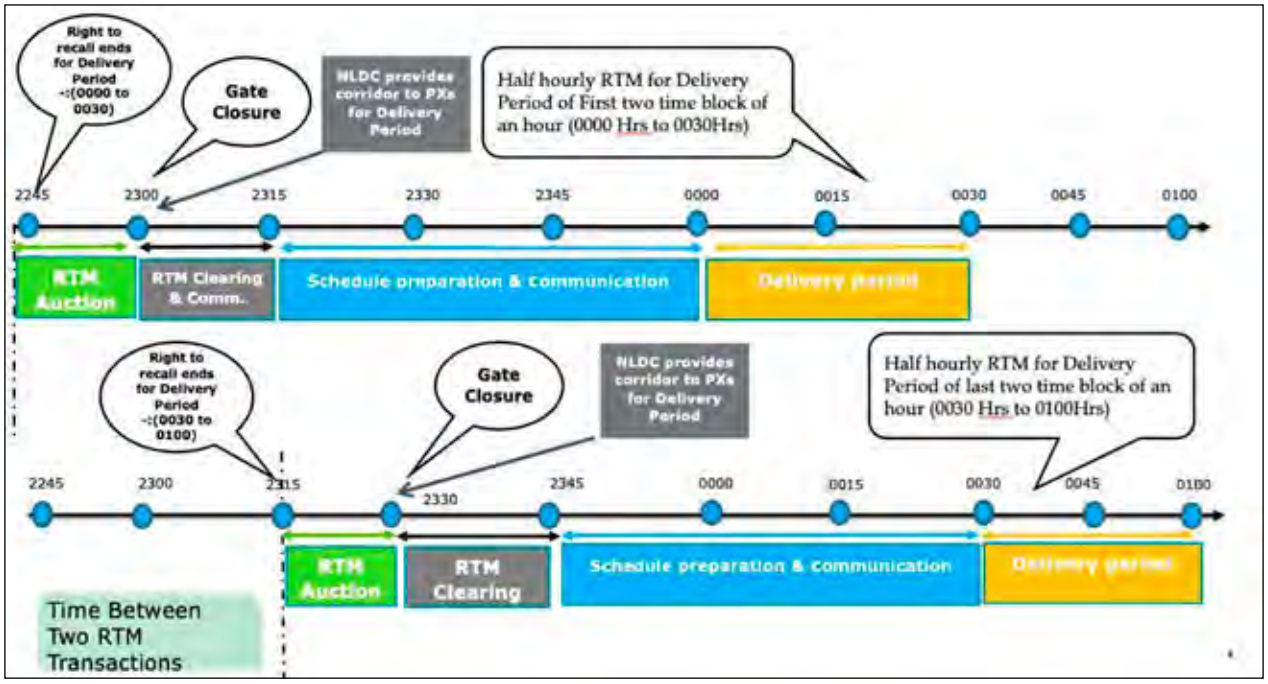
Power Markets boosting Industry and Economic Competitiveness

The power market has proved to be a boon to the distribution utilities, power generation companies as well as to commercial and industrial (C&I) consumers, enabling them to buy and sell power at transparent and market-driven prices in a flexible manner. Several States like Andhra Pradesh, Maharashtra, Gujarat, Telangana, Punjab etc. have been pro-actively leveraging low cost power in the market to maximize savings by replacing their costlier power procurement by exchange power and build up their stressed financial liquidity. For instances, Andhra Pradesh accrued savings of Rs 500 Crores in 6-7 months in FY20 and close to Rs 200 Crores in just two months March and April 2020.

To enable stakeholders in the energy sector to further capitalise on the benefits of a markets-based model, the Central Regulatory Electricity Commission (CERC), a key regulator for the Indian power sector, approved the launch of the Real-Time Market (RTM) starting June 1, 2020 on India's energy exchanges.

The Real-Time Electricity Market

The real-time market is an endeavor to make the power market dynamic by enabling trade in electricity through half-hourly auctions. There are 48 auction sessions during the day with delivery of power starting within one hour of closure of the bid session. Distribution utilities, generation companies and large open access consumers are the key beneficiaries of this market. This gives greater flexibility for optimal utilization of resources in intra-day trading by procuring power just an hour before delivery.



Trading Process

Market Features

- Trading of 15-minute contracts
- Double-sided anonymous auction bidding process
- Buyers and sellers to obtain Clearance from SLDC by based on availability of network and ABT meters
- Exchange to publish Area Clearing Price (ACP) and Area Clearing Volume (ACV)
- Exchange to manage risk management leveraging bank balance, requisite margin, including any additional margin as specified for the respective trading segment or the type of contracts

Benefits to the Participants – The Distribution Utilities and the Generation Companies

The market has greatly aided DISCOMs to manage power demand-supply variation and meet 24x7 power supply aspirations in the most flexible, efficient, and dynamic way. Until commencement of the real-time market, the already financially stressed utilities had to opt for deviation settlement mechanisms for balancing real-time requirements which resulted in huge financial penalties for them. They now have access to market auctions throughout the day and thus, can avoid paying the high deviation settlement charges, lowering the overall cost of procurement, encouraging financial liquidity and savings. Besides, the long impending concerns towards grid security are also resolved as the real time market supports grid operators in enhancing overall grid safety and security. In sum the real-time market enables distribution utilities to:

- Manage demand variation efficiently close to real time
- Manage renewable energy intermittency in an efficient way
- Reduce dependence on DSM and other internal resources to manage deviation. DSM tightening and sign change strengthen the case for making RTM part of portfolio planning
- Optimize state generation resources
- Sell surplus power efficiently with next day payment cycle

The generation companies now have an opportunity to sell any excess or un-requisitioned capacity on round the clock basis through this market to a wide set of buyers thus enabling efficient use of the installed generation capacity. Moreover, with several states having a renewable energy concentration, the utilities as well as the system operators in these states have had a huge challenge in managing deficit and surplus power requirements. The market will help these utilities and system operators to forecast and schedule green energy in an effective way thereby supporting the national green energy aspirations towards building India as a sustainable green energy economy. To sum, the new market segment enables generation companies to:

- Sell surplus power efficiently with payment on the next day.
- Manage generation variation efficiently close to real time
- Option to sell the unrequisitioned surplus power to reduce the thermal backing. Access market which can have better liquidity as compared to URS where there are limited buyers.
- Reduce dependence on DSM.
- Aid in sign change as required under CERC DSM regulations.
- Buy in case of forced outage to meet the supply commitments.
- Improve PLF by providing aid in ramping.

Key Highlights

The response for RTM from market participants has been quite encouraging. The Indian Energy Exchange has 99.89 % market share in the RTM segment till August 31, 2020. The market had achieved a cumulative trade volume of 1 BU in just 49 days. In fact, IEX crossed its second key milestone of 2 BU in just 88 days. The market saw 53.09 MU as the highest volume being traded since the launch on a single day on August 05, 2020.

The daily average prices discovered in the market in August 2020 ranged from a minimum of Rs 1.66 per unit to a maximum of Rs 2.98 per unit. The average price in August 2020 was Rs 2.26 per unit as compared to Rs 2.49 per unit in July 2020. This shows that the price discovered on this market is a true function of demand and supply. The key market highlights in the month of August 2020 are as below:

Total Sell bid	2503MU
Total Buy Bid	1061MU
Cleared Volume	856.53MU
Highest daily cleared volume	53.09 MU on 05th August 2020
Average Price	INR 2.26 per unit
Participation	242 customers

Way Forward

The quick traction in the newly commenced real-time electricity market indicates that the numerous benefits being seen by the value chain participants in the short to medium term including efficient demand management at 1-hour notice, renewable integration, utilisation of generation capacity, facilitating GENCO to purchase power and grid security for both buyers as well as sellers. The market has not only facilitated unrequisitioned surplus generation capacity find buyers but also facilitated generators to purchase power to fulfil obligations created due to outages. Setting a new precedent, two of our clients - Raipur Power and Raigarh Energy Generation became the first generators to have bought electricity to meet their commitment. Going forward, the real-time market has a great potential to make the power market even more dynamic. The introduction of National Open Access Registry (NOAR) will not only connect all the critical players from system operators to the generation companies, distribution utilities, and the power exchanges through technology gateway in an automated seamless way but also help to further reduce time taken from gate closure to delivery of power presently at 1 hour to 30 minutes or even lesser in future. With more market participants realizing its benefits, the real time market is expected to play a pivotal role in meeting aspirations related to large-scale renewable energy integration, grid safety and security as well as further deepen the energy markets in India.

Recyclable Epoxy Technology for Increased Sustainability of Wind Energy

Pradip Kumar Dubey
Senior President & SBU Head

Amit Dixit
Assistant Vice President (ADC)

Aditya Birla Chemicals (Advanced Materials)

1. Background

Wind energy as a renewable source of energy has come a long way in being recognized as a major alternative source to the conventional energy sources based on fossil fuels. The global cumulative installed capacity of wind power generators reached 651GW at the end of 2019 witnessing a 10 % increase over the previous year. The growth and maturation of the wind industry is duly supported by technological advancements in wind turbine rotor blades. The emergence of new – longer, stiffer and aerodynamically advanced rotor blade designs has enabled to harness more energy from the wind. Designers and rotor blade manufacturers are continuously looking for new performance driven, robust materials to support the latest and future developments.

Incidentally, the industry is also facing compelling issues, such as process waste management and end of life management of aged rotor blades. It is estimated that 85% of the components of a wind turbine can be recycled and re-used except the rotor blades due to the non-recyclable thermoset matrix. In addition it is estimated that 10% of the process waste generated during manufacturing of a rotor blade is non-recyclable. The present methods of waste management (Figure 1) such as landfills, pyrolysis, incineration, and pelletization are either not environment friendly or are energy intensive and fail to derive value. Solvolysis, involving nucleophilic substitution or elimination, is a clean and efficient method; however its use is limited due to non-recyclable nature of the epoxy thermoset.

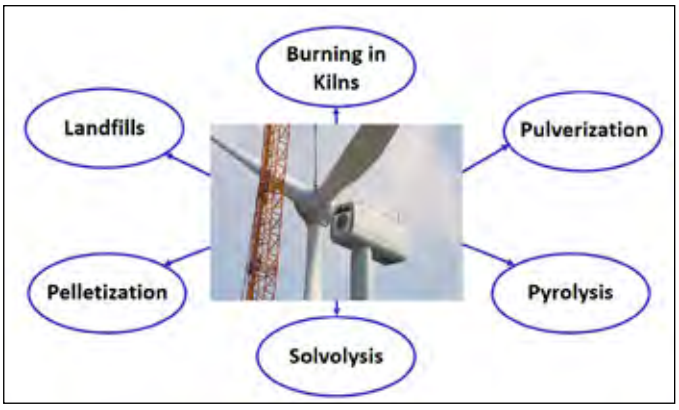


Figure 1: Present Methods for End of Life Waste Management of Rotor Blades

With >4000 aged rotor blades scheduled to be decommissioned annually and lack of full-proof or robust methods to manage waste, the growth and sustenance of wind energy is at stake.

1. Recyclamine: Concept and Technology

Epoxy resins are preferred as polymer matrix materials for manufacturing of rotor blades on account of their versatility and outstanding process & performance properties. The epoxy resin systems used as matrix for manufacturing of rotor blades comprise of epoxy resin component and curing agent or hardener component which react to cross link and cure into rigid three dimensional infusible network that cannot be re-formed, re-used or re-cycled. With emergence of new rotor blade designs, epoxy resin systems are being continuously developed to align with rotor blade manufacturer and the designer's requirement, however the non-recyclable nature of epoxy thermosets does not address the compelling issue of process waste management and end of life management of rotor blades.

Recyclamine - the recyclable epoxy thermoset technology provides an opportunity with path breaking and lasting solution that enables recyclable epoxy thermosets. The technology is based on specifically engineered recyclamine curing agents or hardeners which cross link with epoxy resins to provide a network with cleavage points. The matrix comprising of epoxy resin and recyclamine hardeners in polymer composites, can be cleaved by solvolysis under specific conditions, leading to recovery of reinforcement such as carbon fiber, glass fiber, kevlar® and the epoxy matrix as recyclable thermoplastic. The recovered reinforcement and epoxy thermoplastic can be re-used and re-purposed. The concept is depicted pictorially in Figure 2.

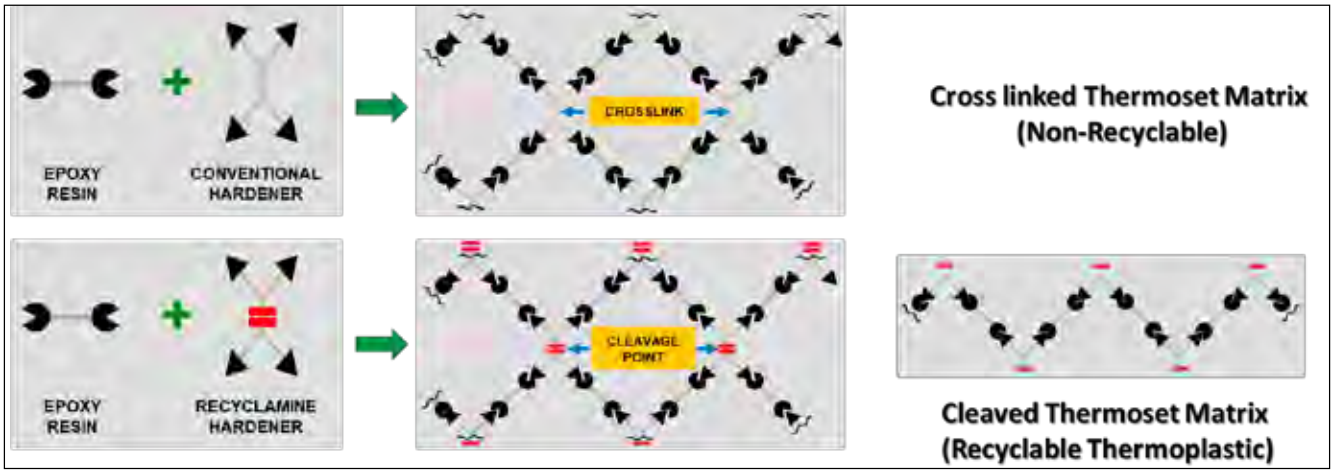


Figure 2: Schematic depicting Curing of Epoxy Resin Systems (Non-Recyclable v/s Recyclable)

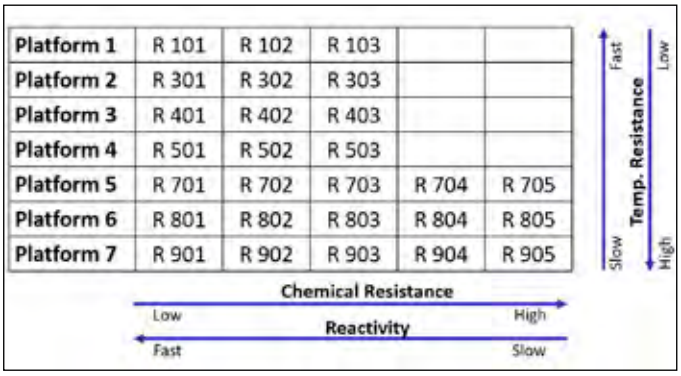


Figure 3: The Recyclamine Curing Agent Platform

The Recyclamine technology is a platform chemistry with series and wide spectrum of curing agents providing fast to slow reactivity & latency, low to high temperature resistance, chemical resistance and recyclability (Figure 3).

2. Recyclable Epoxy Systems from Recyclamine Technology

The Recyclamine technology has been leveraged for the development of recyclable epoxy resin systems for rotor blades. Laminating resin systems for wet lay-up process and infusion process have been developed by selecting suitable epoxy resins and appropriate Recyclamine hardeners. Series of recyclable systems with varying reactivity are developed and characterized for process and performance properties (Table 1).

Property	Unit	System A	System B	System C	System D	System E
Physical and Process Properties		**Wet lay-up Systems**		**Infusion Resin Systems**		
Mixing ratio	by wt.	100:32	100:22	100:20	100:24	100:29
AHEW (calculated)	gm/ eq	57.3	40.5	33.5	40.5	47.5
Resin viscosity @ 25°C	mPa.s	11,447	12,270	2,606	1,243	1,170
Hardener viscosity @ 25°C	mPa.s	9.11	8.83	4.92	7.29	8.3
Initial mix viscosity @ 25°C	mPa.s	780.4	889.8	283.7	219	194.1
Pot life, 100g mix @ 25°C	minutes	17.5	80.5	82.5	365	>800
T_g, cured @ 80°C/ 4 hours	°C	99.75	89.74	84.17	80.69	86.72
Mechanical Properties						
• Tensile Test (ISO 527)						
Tensile Strength	MPa	73.49	65.32	67.32	67.30	76.37
Tensile Strain	%	4.84	4.52	5.80	4.47	4.44
E-Modulus	MPa	3,280	2,958	2,302	2,872	3,104
• Flexural Test (ISO 178)						
Flexural Strength	MPa	131.11	114.26	128.89	108.51	132.12
Flexural Strain	%	6.38	5.20	4.78	6.06	5.90
E-Modulus	MPa	3,388	3,144	4,604	2,804	3,289

Table 1: Physical, Process and Mechanical Properties of Recyclable Epoxy Systems

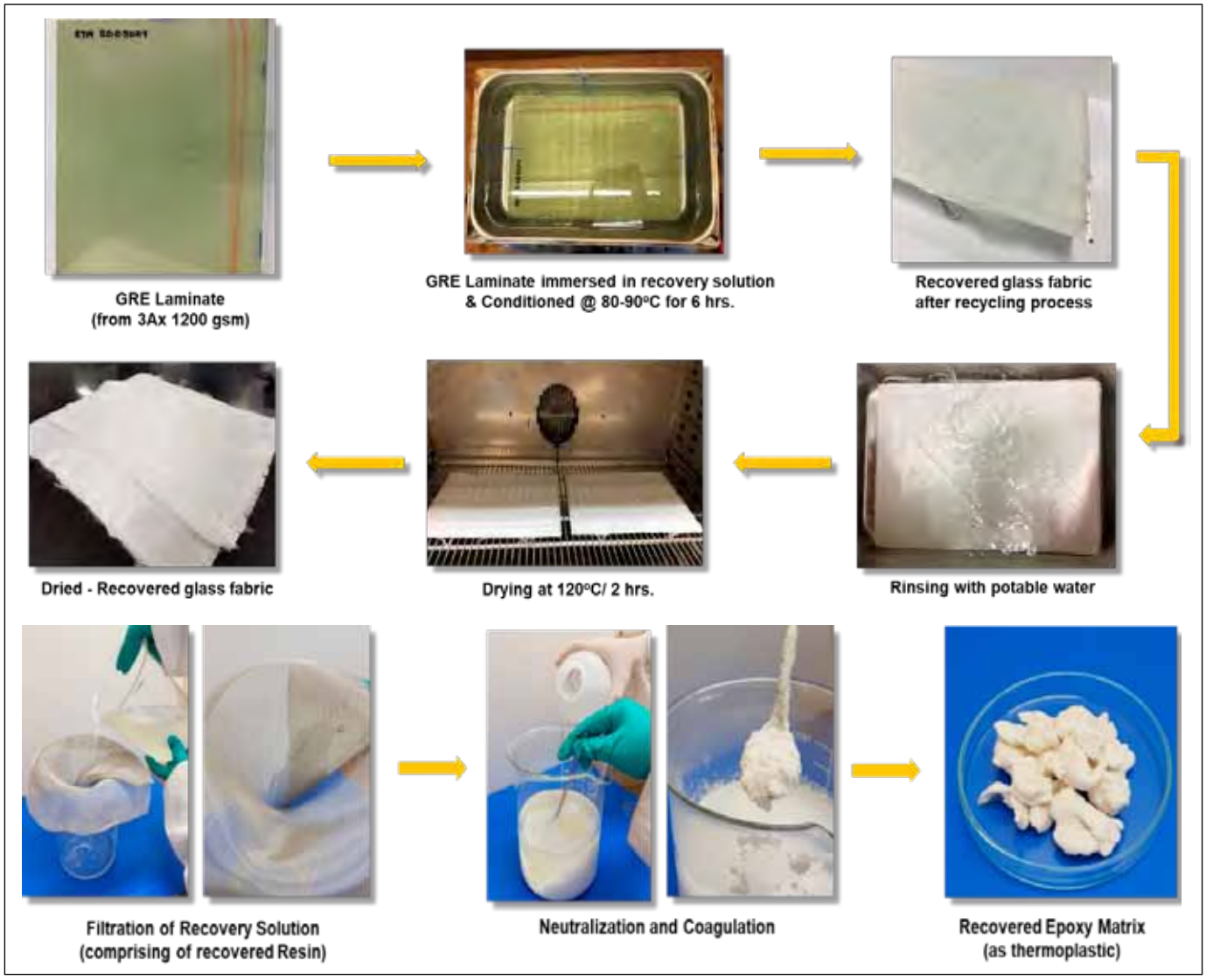


Figure 4: Recycling of Composite and Recovery of Matrix and Reinforcement

3. Proof of Concept

3.1 Recycling of Glass Reinforced Epoxy Composite and Recovery of Matrix & Reinforcement

The recycling of glass reinforced epoxy composite made from recyclable epoxy system and recovery of matrix and reinforcement has been demonstrated by preparing a laminate with Infusion process using tri-axial fabrics (1200 gsm). The laminate was trimmed and subjected to solvolysis by immersing in recovery solution and conditioned at 80°C for 6 hours to enable cleavage of the recyclable epoxy matrix and its dissolution in the recovery solution. The glass fabric reinforcement of the composite, recovered from the recycling process was rinsed and dried. Recovery solution containing the dissolved epoxy matrix was filtered, neutralized and coagulated to recover the epoxy matrix as thermoplastic (Figure 4).

4. Re-use of Recovered Reinforcement and Thermoplastic

The tri-axial reinforcement recovered from recycling process was re-used by preparing laminate by Infusion process using recyclable epoxy system E as the matrix. Laminate was also prepared with fresh tri-axial (1200 gsm) reinforcement keeping all parameters identical. Specimens were extracted from both laminates and characterized for tensile properties using Universal testing machine Instron 5569 and clip on extensometer. Results indicated 10% lower tensile strength and modulus for the laminate prepared from recovered reinforcement evidently due to distortion in fibre alignment, however the tensile strain was found to comparable to the laminate prepared from fresh reinforcement (Figure 5).

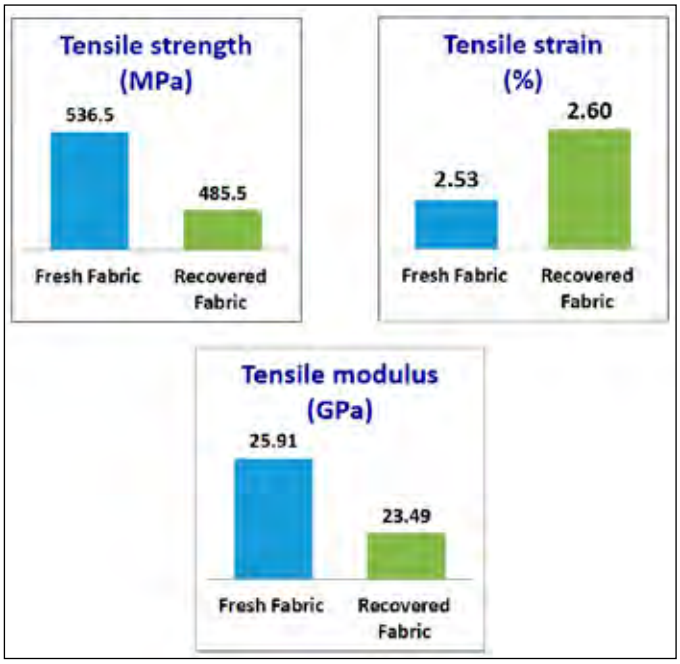


Figure 5: Comparative Tensile Properties of Laminate from Fresh and Recovered Fabrics

The epoxy thermoplastic recovered from recycling process was dried and characterized for physical, thermal and mechanical properties such as melt flow index, glass transition temperature, tensile and flexural properties (Table 2).

The thermoplastic was compounded with 80% polyethylene by weight and injection molded to re-purpose and make foot strap insert used in surfboards (Figure 6).

Recovered Thermoplastic	Test Method	Unit	Results (typical batch)
Melt Flow Index (190°C @ 2.16 kg)	ASTM D 1238	gm/minutes	10
Specific gravity	ASTM D 792	gm/cm³	1.19
Glass Transition Temp.	ASTM D 3418	°C	78
Tensile Strength	ASTM D 638	MPa	51.2
Tensile Modulus		GPa	2.90
Elongation at break		%	30-110
Flexural Strength	ASTM D 790	MPa	100
Flexural Modulus		GPa	2.7

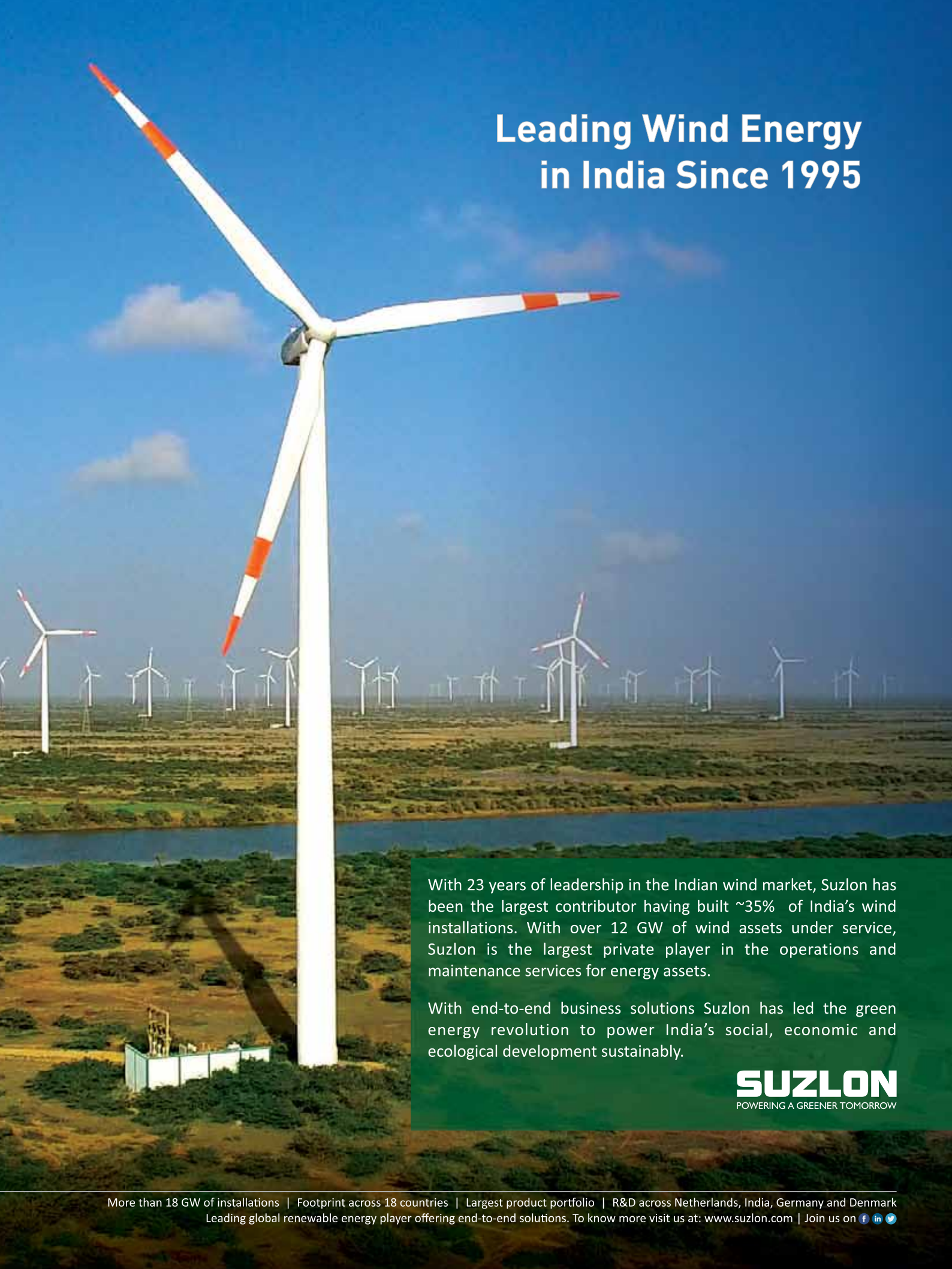
Table 2: Characterization of Recovered Thermoplastic

6. Summary and Conclusion

The Recyclamine technology enables recycling of epoxy thermosets and further recovery, re-use of reinforcement, epoxy matrix in fibre reinforced composite. The technology was successfully leveraged to develop series of recyclable epoxy resin systems for rotor blades thereby providing path breaking and lasting solution to the compelling issue of waste management faced by the wind industry.

Proof of concept is successfully demonstrated by recycling and recovery of composite laminate prepared from the system by solvolysis to recover reinforcement and epoxy matrix as thermoplastic. Re-use of the reinforcement and re-purposing of the recovered thermoplastic closes the loop to make wind energy "Sustainable for a Circular Economy".

Figure 6: Foot Strap Insert from Recovered Thermoplastic


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.
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Regulatory Update on Wind Power

Waiver of Inter-State Transmission Charges and Losses on Transmission of the Electricity Generated from Solar and Wind Sources of Energy (under Para 6.4 (6) of the revised Tariff Policy, 2016)

The Ministry of Power has issued an order dated 5th August 2020 directing exemption from the levy of transmission charges and losses for power plants (Wind/ Solar) commissioned till 30th June, 2023. Government has extended this relief for open access transactions as well provided electricity is being supplied to entities having a Renewable Purchase Obligation (irrespective of whether this power is within RPO or not). Ministry of Power order reflects that these conditions have been dispensed and competitive bidding requirement will only be necessary for supply of the electricity to distribution companies. Relevant clause of the guidelines is as follows:

"Power plants using solar and wind sources of energy, including solar-wind hybrid power plants with or without storage commissioned till 30th June, 2023 for sale to entities having a Renewable Purchase Obligation (RPO), irrespective of whether this power is within RPO or not, provided that in case of distribution licensees, the power has been procured competitively under the guidelines issued by the Central Government."

IEX Introduced Green Term Ahead Market (GTAM) Contracts

Central Electricity Regulatory Commission (CERC) has allowed Indian Energy Exchange (IEX) to introduce Green Term Ahead Market (GTAM) Contracts on its Platform vide its order dated 17.08.2020. CERC felt that the introduction of Green Term Ahead Market (GTAM) contracts in the power exchange will provide an additional avenue for short-term trading of renewable energy. Sellers of renewable energy can use this for sale of renewable energy whereas the obligated entities can procure green power to meet their RPO requirement. CERC further observed that initially there may be issues related to liquidity in the market. However, with the availability of the trading platform, it may attract participation from buyers and sellers and in the longer term may also promote RE merchant capacity. Shri R. K. Singh, Honorable Minister of State-Independent Charge for Power and New & Renewable Energy has launched the Green Markets in a digital event held on 1st September1, 2020.

Compiled by **Rishabh Dhyani,** Kshema Power

Snippets on Wind Power

Power Ministry Asks Industry to Make Import Replacements

The power sector currently imports 604 items, 392 of which are also made here. Roughly 212 items are not made here, but then local alternatives are available for 102 items. That leaves 100 items that need to be made locally. India's power gear imports stood at Rs 71,000 crore last year, including Rs 21,000 crore from China. The power ministry has dialled domestic manufacturers, including majors such as L&T and state-run Bhel, for launching a phased manufacturing programme to replace items being imported, especially from China, and assuring them of 100 per cent preference to 'Made in India' equipment in contracts.

Source: Times News Network, August 19, 2020

Rs 1,200-Crore Plan to Hook up Nubra, Zanskar in Ladakh to National Grid

The government is implementing a Rs 1,200-crore project to hook up Nubra valley in the country's northern tip, and Zanskar, among the least-explored regions of Kargil, with the national power grid, casting one of the first building blocks of Prime Minister's plan to make Ladakh carbon-neutral. Nubra, a popular tourist destination, is strategically located with Baltistan in POK (Pakistan-occupied Kashmir) on the west, Siachen glacier – the world's highest battleground – in the north and Chan-Chenmo range in the east. The project envisages laying two 220-kv lines across some of the world's highest mountains and inhospitable terrains.

Source: TNN, August 24, 2020

Snippets on Wind Power

Innovation: Scientists Derive Biofuel from Algae to Boost India's Clean Energy Efforts

With India exploring and using different clean energy alternatives to lower its carbon footprints, biofuel from algae of marine origin could be one of the low-emission solutions in the country in near future. Indian scientists, under the INSPIRE programme of ministry of science and technology, have developed low-cost biodiesel from microalgae. The technique to use microalgae is developed by a team of scientists led by T Mathimani from the National Institute of Technology (NIT), Tiruchirappalli.

Source: TNN, August 25, 2020

21,142 MW RE Capacity under Construction in India

Solar and wind energy projects of over 21,142 MW are currently under construction in India over and above the 88,000 MW already installed generation capacity based on the two clean resources. A number of wind and solar energy projects have timeline extension due to the COVID-19 pandemic in line with the government's Order. The delay in project construction is also due to delays in execution of power purchase and power supply agreements; land allocation issues; delay in finalisation of ISTS substation location; and delay in readiness of power evacuation infrastructure.

Source: ET Energy World, August 28, 2020

Power Ministry Proposes RPO for Round the Clock Renewable Energy

Power Minister Mr. R K Singh has proposed renewable purchase obligation (RPO) mechanism for round the clock (RTC) renewable energy, which will promote storage of electricity in the country. Once the RPO is mandatory for RTC renewable energy, it would encourage investments in renewable electricity storage projects. Mr. Singh has said that the Renewable energy is economically viable today. The only rider is storage and the prices of storage will come down over time.

States to Get 2 Years for DBT, Accounts with Discoms to be Used: Power Minister

The amendments to the Electricity Act, 2003, (Electricity Amendment Bill, 2020) is with the Law Ministry for vetting before being introduced in Parliament, has remodelled DBT structure with states being asked to subsidise tariff for certain identified consumers by transferring the subsidy amount in advance into the electricity accounts of consumers maintained by discoms, Minister of State for Power and New and Renewal Energy Mr. R.K. Singh told IANS in an interview. The new DBT structure for power will change the way the cash transfer schemes work in other sectors. Instead of getting subsidy amount into their accounts while paying electricity tariff at regulators determined rates based on cost of supply, section of households, other subsidised consumers and those identified by state for relief will continue to pay lower tariff as is the case now, while the gap between average cost of supply (ACS) and the actual tariff, will be paid by the state governments into the consumers accounts with discoms. As this payment is proposed to be made in advance, the discoms books could remain in green.

Source: IANS, August 31, 2020

India's First Manufacturing Unit for Li-Ion Battery Components

Mumbai-based Epsilon Carbon, a coal tar derivatives company has said that it has commissioned the country's first manufacturing facility in Karnataka to produce graphite anode materials for lithium-ion batteries (LiB). The firm plans to invest Rs 500 crore over the next five years in the facility that would produce 5,000 tonnes of anode material annually. It plans to triple this capacity to 15,000 tonnes in 2021 and to 50,000 tonnes per annum by 2025. The graphite anodes comprise 25% volume in LiB cells and are the highest single material component in a cell's chemistry. Till now, China supplies more than 80 per cent of the global demand for graphite anodes.

Source: E T Energy World, August 24, 2020

NTPC to Establish a Wholly-Owned Subsidiary for its Renewable Energy Business

NTPC has received the approval to set up a wholly-owned company for its renewable energy business. The disclosure to start a renewable subsidiary is crucial, even though the state-owned power company is generating 1.1 GW of renewable energy, NTPC has plans to push installations to 32 GW by 2032, which will constitute 24% of its power projects portfolio. The new subsidiary would be a shot in the arm for NTPC, which aims to generate 10 GW of renewable power by 2022, and is essential for India's goal of generating 175 GW of clean energy by the same year.

Source: Mercom India, Aug 24, 2020

Certification for Global Wind Organisation (GWO) Wind Safety Standards

Dr Sanjiv Kawishwar, Director
CORE (Center Of Renewable Energy), India

- Global Wind Organization (GWO) has published many standards for safety training of wind energy professionals and especially for those working on the wind turbine site.
- Overall aim of standardization is to support an injury-free work environment in the wind industry.
- Standards were developed on the basis of risk assessments and factual incident and accident statistics pertaining to the installation, service and maintenance of wind turbine generators and wind power plants.
- Most of the European companies/IPPs have made it mandatory for individuals to get safety training according to GWO standards and obtain certificate from accredited institute prior to starting the work at wind turbine site.
- Working at Heights, Manual Handling, Fire Awareness, First Aid, Advance Rescue Training (ART)-Hub/Nacelle, Electrical, Hydraulics and Mechanical are some of the popular training modules.
- GWO training standards teach you to understand and reduce the risk associated with safety hazards in the wind turbine industry. It ensures a safe work environment for anyone working in the wind turbine industry.
- The GWO framework aligns generic safety and technical training standards, common to all wind energy companies.
- It has improved the alignment and quality of basic safety training standards.
- Trained person is recognized as competent within basic safety in the wind industry and accepted as possessing the required knowledge to stop an unsafe work situation where they as duty-holders are accountable for safety.
- Standards are established as contractual pre-requisite in the wind energy supply chain, helping align the safety training activities of all contractors.
- There are four elements to GWO certification namely (i) Physical Resources, (ii) Management Systems, (iii) Staff Resources and (iv) Training (+ Assessment).
- Training organizations complying to aforementioned four elements can get accreditation upon successful completion of audit and verification by approved certification body.
- In India, most of the wind energy companies and IPPs demand GWO qualification for the employees working in O&M and wind turbine project site.
- Therefore, everyone working at wind turbine site/wind farm must aim to obtain GWO safety certification in order to ensure safe working.
- Where national legislation sets higher requirements for the specific training, CORE has incorporated those requirements into the training program.
- Center Of Renewable Energy (CORE) has been 'ACCREDITED' to provide the training according to GWO standards.
- Center Of Renewable Energy (CORE) will equip participants with the knowledge, skills and confidence to appropriately respond in the event of an emergency and to increase their safety through proper use of personal protective equipment, emergency equipment and procedures.
- Upon completion of the Basic Safety Training (BST) delegates will possess an awareness of the hazards encountered when working within the wind industry and how to control and mitigate these hazards.

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Renewable Power Pathways: Modelling the Integration of Wind and Solar in India by 2030

Honourable Minister of State (IC) of Power and Renewable Energy, and Minister of State, Skill Development and Entrepreneurship, Government of India Shri R K Singh has launched the report, titled 'Renewable Power Pathways: Modelling the Integration of Wind and Solar in India by 2030', along with the report titled 'Bending the Curve: 2025 Forecasts for Electricity Demand by Sector and State in the Light of the COVID Epidemic' on 21st July 2020 at the Energy Transitions Webinar, the second pre-event of the World Sustainable Development Summit 2021.

The two reports have been prepared by Energy Transitions Commission (ETC) India, which is a research platform based at the TERI headquarters in New Delhi. It is the Indian chapter of the global ETC, which is co-chaired by Lord Adair Turner and Dr Ajay Mathur, Director General, The Energy and Resources Institute (TERI). Sustainable Action Dialogue on Energy Transition, is a pre-event of the World Sustainable Development Summit, TERI's annual flagship event that is to be held in February 2021.

The Minister said that India has the fastest growth rate in the world in renewable energy and will have 60% power capacity from renewable energy by 2030. India can integrate more than 30% of wind and solar in its power system, while still maintaining security of supply and without raising the total economic costs of its electricity system, according to a new report by The Energy and Resources Institute (TERI). The report also identifies a number of strategies to achieve this.

The Minister that said India is transforming its energy sector, and is happy to engage with the challenge. He added, "We are aiming to make our thermal capacity flexible, almost 55% in the first stage and gradually extend it to the entire capacity. All our demand growth will be met by renewable energy. We are balancing power through hydropower. We are looking at growing capacity from floating solar. There have been innovative bids for meeting peak demand and for round the clock electricity through RE, and storage, all of which will bring prices down."

The report identifies a number of strategies that are required to accommodate the growth of variable renewables and allow for the achievement of India's mid-term renewables targets. Its key findings are:

- By 2030, India can achieve generation shares of variable renewables like wind and solar greater than 30%, and shares of total zero carbon generation including large hydro and nuclear greater than 45%.
- This can be achieved at no extra system cost, provided that a comprehensive portfolio of options is deployed in order to increase the flexibility of the power system. Absent this, India will not be able to achieve its 2030 objective of raising the generation capacity of renewables to 450 GW. It is time to shift the high-level focus of policy from the achievement of capacity targets, to the transformation of the operations and investment in the power sector required to integrate VRE. Something of the nature of a 'National Power System Flexibility Mission' is the need of the hour, otherwise India's renewable energy ambitions may falter.
- In the mid-term to 2030, the majority of power system flexibility will need to come from the conventional generators, in particular the coal and hydro fleet. India has a substantial coal fleet, which, by varying its output across the course of the day, can provide significant flexibility to integrate VRE. Additional supply-side flexibility comes from the dispatchable hydro fleet, i.e. those plants with reservoir, pondage, or pumped storage.
- In the mid-term, battery storage and coal flexibility are complementary, with batteries reducing the operational stress of the coal fleet. With the cost of battery technologies falling extremely rapidly and combined VRE and battery projects delivering competitive tariffs, it would be beneficial to define targets and policy frameworks for battery storage out to 2030.
- India's power system already benefits from the largest synchronous power grid in the world. The high level of interstate grid integration is driven by the strong presence of the federal level in India's power system value chain and policy and regulatory frameworks. The further development of this integrated grid is essential to increasing the share of variable renewables. Shifting power from areas of excess renewables production to areas of high demand, and vice versa during times of deficit renewables production is an essential strategy to drive greater penetrations of variable renewables.

Additional investment in coal-fired power beyond the current pipeline would be neither necessary from a system adequacy point of view nor financially justified, given the rapid cost declines in renewables plus storage and broader grid integration strategies.

The platform aims to foster the adoption of low-carbon pathways in India through intense and informed discussions between ETC members in India, key policy makers and others concerned with technology options.

"We are now at a time with renewable energy where the fundamental principle should be that all growth in electricity demand can be met by zero carbon sources. We then have to work our way through getting out of the existing coal capacity. This will be a huge contribution to delink from the problem of climate change," said Lord Turner.

"To integrate larger share of variable renewable energy in the power mix, a portfolio approach to power system flexibility is required. Enhancing the flexibility of the power system is now the most important bottleneck to achieving India's renewable energy ambitions. This report shows the way forward," added Dr. Mathur.

Courtesy: The Energy and Resources Institute (TERI)

Snippets on Wind Power

APTEL Postpones Trading of Renewable Energy Certificates

The Appellate Tribunal for Electricity (APTEL) has postponed the trading of Renewable Energy Certificates (REC) scheduled on July 29, by four weeks. In an order issued on July 24, APTEL postponed the RECs trading session scheduled on July 29, 2020 by four weeks in three separate appeals filed by Green Energy Association, IWPA (Indian Wind Power Association) and Techno Electric and Engineering Company Ltd against the CERC order issued on fixing REC floor and forbearance price. There was no trading of RECs or green certificates in July. REC trading is done at two power exchanges -- Indian Energy Exchange (IEX) and Power Exchange of India Ltd (PXIL) -- on last Wednesday of every month.

Source: PTI, August 02, 2020

CERC Gives Nod for Third Power Exchange in the Country

The Central Electricity Regulatory Commission (CERC) has approved the application of Pranurja Solutions Ltd, a company promoted by BSE, PTC Ltd and ICICI Bank, to set up a power exchange, which will be the country's third after IEX and PXIL with a condition that the promoters reduce their shareholding to not more than 25 per cent each. PTC holds 49% shareholdings in Pranurja Solutions BSE and ICICI Bank own 41% and 9.9%, respectively. The promoters have undertaken to reduce their shareholdings to not more than 25 per cent each.

The proposed shareholding pattern is as follows: PTC India Limited (25%), BSE Investments Limited (25%), ICICI Bank (9.9%), Greenko Energies (5%), Kirti Telnet (5%), Subrashi Vinimay (5%), Jindal Power (2%), Chamaria (3.1%), Tollman International (5%), Varanium Capital (5%), Lord Dholakia (5%), Meenakshi Power (5%).

Source: The Hindu Business line, August 04, 2020

Govt. Grants ISTS Waiver Extension for Solar, Wind Projects Until June 2023

The Power Ministry has extended waiver of Inter-state Transmission System (ISTS) charges and losses on supply of power generated from solar and wind energy including solar-wind hybrid power plants with or without storage commissioned till 30 June 2023. It added that no ISTS charges would be levied for 25 years from the date of commissioning of the power plants for the supply and sale to entities having renewable purchase obligations.

Source: ET Energy World, August 06, 2020

Retiring Old Thermal Power First Hurdle in Reducing Discom Debt of Well Over Rs.4.78-Lakh Crore

The Institute for Energy Economics and Financial Analysis (IEEFA) in its new report has proposed recommendations to reduce financial and operational inefficiencies across India's power distribution sector, which as of May 2020 had accumulated massive overdue payment liabilities of Rs 116,340 crore to generation companies while already carrying a total outstanding debt of Rs 478,000 crore (in FY2018/19). The report recommends, among other strategies, that discoms work with state governments to retire their old inefficient and expensive thermal power plants as a key pathway to reducing their average cost of power procurement. The report discusses various aspects in this matter.

Source: TNN, August 07, 2020

Innovations in Offshore Wind Turbine Technology

Dr. Raj Shah
Director

Kareem Mehdi
Chemical Engineering Intern

Koehler Instrument Company, Holtsville, New York

Introduction

Every year over 840,000 TWh of electricity is created by the winds of the Earth which is 40 times greater than global energy consumption[1]. With such a bountiful amount of renewable energy much new advancement are being made to convert these to usable electricity. One of the most common machines used is the wind turbine which consists of large fan blades that are turned by wind currents and moves a generator producing electricity. As worldwide energy demands continue to grow, much research is going towards developing new wind turbine designs to greatly increase their reliability and lower their costs. Advancements to fields such as turbine component design, offshore wind farms and digitization have led to increasingly advanced turbines.

History of Wind Turbines

Since antiquity people have used windmills to harness energy from the wind to power machines such as grain mills and sawmills. At the turn of the 20th century new windmills were installed to power remote areas. These turbines produced a small amount of electricity compared to contemporary turbines and soon fell out of favor as electrical grids expanded to rural areas. It wasn't until the Oil Crisis of 1973 and the increase in public opinion for renewable energy sources that wind turbines saw a resurgence in popularity with increased private and public spending towards developing what we now consider modern wind turbines.

Figure 1: MOD-0 Wind Turbine[3]

Many countries such as Denmark and other European nations experimented with wind turbines in the mid to late 20th century with engineers such as Johannes Juul proving the viability of wind power for electricity[2]. One of the first of the modern wind turbines built in the United States was the MOD-0 which was developed by NASA in 1975 as a proof of concept of a modern wind turbine; this turbine was able to produce 100kW of electricity and proved the viability of wind turbines. The MOD-0 was built using helicopter blades supplied by Lockheed Martin which, while long at 38 meters across, were too small to provide enough energy to power multiple houses. This led NASA engineers to theorize turbines with blades of 60-100 meters, which would produce multiple megawatts of electricity. The first of these high output turbines was the Tvindkraft, built in 1978 in Denmark; it has a maximum capacity of 2 megawatts from its 54 meter long rotors[4].

Land versus Offshore Turbines

While these turbines proved the viability of wind turbines one major drawback is that land based turbines have to be smaller to comply with local laws and regulations. Furthermore, land based winds tend to be weaker than the typically stronger winds of the open sea. Because of this, many new wind farms are now being installed on the surface of the ocean. Nearly all of these turbines are installed on platforms that are mounted on the surface of the ocean at fairly shallow depths and connected to the power grid on land. While these turbines can be much larger and more productive than land based systems there also are many drawbacks. Accessing turbines that are installed in remote locations in the ocean can be much more difficult than

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ones installed on the land and as such, these turbines can have much higher maintenance costs[5]. Furthermore these turbines endure much harsher conditions due to the higher winds and the tides and can break more often. We can see this in the Vindeby Wind Farm which was the first offshore wind farm built in 1991 but has since been decommissioned due to high maintenance costs[6]. Since then, many innovations have been made in the field of offshore turbines.

For the most part, offshore turbines are built near the shore as their platform must be affixed to the ocean floor. Engineering firms have been developing new wind turbine platforms that can be placed much further away from the coast, allowing for even larger turbines to take advantage of the powerful winds on the open ocean. There are two types of these deep ocean turbines, one is a variation of the typically fixed platform turbine, and the other is built on a floating platform. The deep water fixed platform wind turbine is similar to modern offshore turbines; however, they use much deeper foundations that are over 80 meters tall, allowing for much deeper placement. Another innovation uses a floating platform that allows for very deep water placements of wind turbines, allowing for much less interference in activities such as shipping and fishing. These systems consist of a turbine built onto a platform anchored to the bottom of the ocean. These turbines apply preexisting knowledge of petroleum refining platforms to develop capable wind turbine emplacements. So far, only one functional floating turbine farm, Hywind Scotland, has been built. This farm was constructed in 120-meter deep water 29 km off the coast of Scotland[7]. Many of the key components in offshore wind turbines are the same such as the pitch controllers which are able to handle the increased capacity however due to the stronger winds and larger blades that are mounted on offshore turbines many other components need to be changed. The gearbox, for example, must be able to withstand higher loads. Because of the many challenges posed by traditional gearboxes, many wind turbine manufacturers are beginning to equip new installations with direct drive systems[8]. Another key component is the structural components such as the tower that can corrode much faster than if they were on land. Furthermore, these structural components are typically carrying a heavier load than land based turbines. Because of this, ensuring structural integrity of the turbine is very important which is why many of these offshore wind turbines have sensors that measure incredibly small changes to predict if a turbine may require maintenance.

Gearboxes

Both land and sea based deployments of turbines can have high maintenance costs associated with them due to the many intricate parts that make up the drive assembly of the generator. Wind turbine blades tend to spin fairly slowly with very large amounts of torque however, in order to convert that to electricity it must first be passed through a gearbox which increases the rotational speed. This gearbox uses an intricate set of gears and driveshafts to step up the rotational forces. These many parts are under a large amount of stress and as such the gearbox is the most failure prone component of the turbine with 1 in 145 turbines experiencing a gearbox failure every year[9]. Nearly all gearbox failures can be attributed to failures in the bearings and gears. The main causes of these failures are poor service, compromised lubrication, sudden transient wind events, and mistakes in installation. One of the most common is transient events where a large gust of wind can lead to rapid changes in the direction or size of the torque[10]. These events can put a lot of strain on gearbox components with bearings being most affected as they absorb the majority of these events, this may be a contributing factor to the bearing being the cause of 70% of gearbox failures[9].

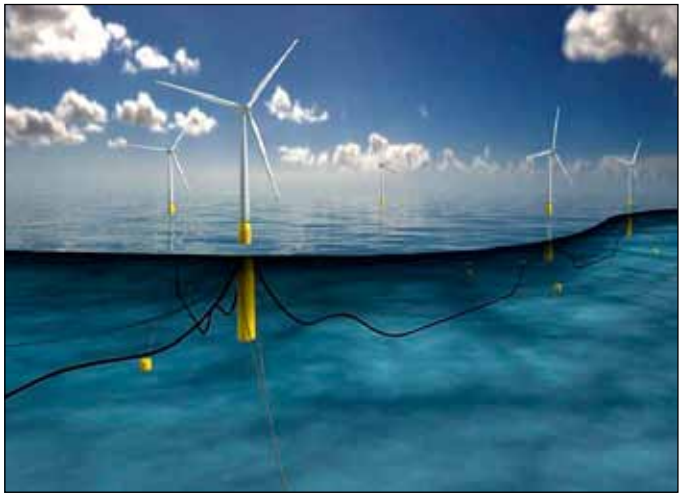

Figure 2: Hywind Scotland Illustration[7]

Because of the high failure rate associated with gearboxes, many companies, in conjunction with agencies such as the Department of Energy, are developing new drivetrain solutions to improve gearbox reliability. These new systems, known as direct drive turbines, use permanently magnetic elements such as neodymium to drive the generator, the result is a less complex and lighter assembly[11]. These systems represent a marked improvement in turbine reliability due to the fewer number of moving parts. Furthermore, the lower weight of these systems leads to lower rotational inertia which allows for more energy to be converted to electricity. Because of this, direct drive wind turbines are the focus of major research to improve the efficiency and develop new advancements.

Figure 3: Direct Drive Wind Turbine[11]

Advancements in Sensor Technology

Another rapidly expanding field in wind energy is the development of advanced sensors capable of measuring information about the health and operation of the turbine. One such sensor, the eddy current sensor, is capable of checking that vital components such as the shaft are receiving sufficient lubrication, these sensors can also detect the deflection from center the shaft is experiencing which can be caused by failing bearings. The displacement sensor is another very useful tool in determining the structural integrity of the windmill by measuring small movements at the base of the turbine which can be used to see both the amount and rate the foundation is moving. Accelerometers are also very important in monitoring a turbine as they allow for recording of transient events. Thermometer probes are also very useful as they allow for measurement of temperature which can correlate to developing problems such as lack of lubrication for gearbox components[12].

Digitization

These sensors are often connected digitally to maintenance operators that are able to run diagnostics remotely, this allows for lower overall maintenance costs as inspection of components can be done remotely without having to deploy a costly maintenance team[13]. These data streams, coupled with machine learning, can allow operators to accurately predict future failure points of the turbine and plan preventative maintenance. This can vastly increase the uptime and longevity of the turbine while also decreasing costs as technicians do not need to be near the turbines[14]. This takes some effort to implement however, as turbine digitization requires stable infrastructure and sensors to be installed in order to access and store this information. This data needs to be organized and stored in a format that is able to be processed by software packages. This data is only as useful as the program that it is being fed into with inferior artificial intelligence systems either producing false positives or failing to properly diagnose imminent failure points. Because of this, a highly sophisticated software package is required to accurately make diagnoses from the raw data[15]. This effort pays off however, with many companies who choose to implement these solutions seeing an appreciable increase in reliability of their turbines with turbine life increasing upwards of 36 months as future failure points are able to be fixed before they become large issues. Furthermore, the digitization of turbines allows companies to remotely monitor their turbine and need not send expensive inspection teams to these sites.

Many of these technologies have seen limited commercial deployments however as wind turbine technology continues to advance. We will see many more autonomous wind farms capable of producing much more energy at decreasing costs. As we reach the limit for size for onshore and shallow offshore wind turbines we will begin to see much larger, deep sea turbines with blades well in excess of 200 meters across that can produce incredible amounts of energy allowing thousands of homes to be powered from one turbine. These turbines, coupled with the advancements to drive technology and digitization will be cheaper than ever to run and will lead to renewable energies such as wind being economically competitive with traditional fossil fuels.

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Snippets on Wind Power

India Reserves 110 Power Plant Equipment, Services for Local Companies

The Power Ministry has issued public procurement order with separate lists of products with adequate manufacturing capacity in India and those being manufactured locally under technology license from foreign countries. The ministry's latest order dated July 28 mandates that tenders for these 110 equipment and works can be awarded only to local companies with high localisation. The equipment includes transformers, switch gears, cables and insulators, which are imported in large numbers in India despite available local capacity.

Source: ET Energy World, July 30, 2020

India is the World's Second Most-Polluted Country

India is today the world's second most-polluted country, and 84 per cent of India's population lives in areas where the annual average particulate level exceeds the WHO guidelines, according to a report on Air Quality Life Index (AQLI) by the Energy Policy Institute at the University of Chicago. "A quarter of India's population is exposed to pollution levels not seen in any other country, 248 million residents of northern India on track to lose more than 8 years of life expectancy, if the pollution levels persist", the report said.

Source: ET Energy World, July 28, 2020

MNRE Grants Five-Month Extension for Renewable Energy Projects Hit by COVID-19

The Ministry of New and Renewable Energy (MNRE) has granted extension in the scheduled commissioning date for renewable energy projects by five months from 25 March to 24 August 2020 to overcome the COVID-19 disruption. "This blanket extension, if invoked by the RE developers, will be given without case to case examination and no documents/evidence will be asked for such extension," MNRE said in a notification. The notification also said project developers may also pass on the benefit of such time-extension to other stakeholders down the value chain like Engineering Procurement Construction (EPC) contractors, material, equipment suppliers and Original Equipment Manufacturers (OEMs). Solar industry body, National Solar Federation of India (NSEFI), had asked the ministry to extend the period by six months.

Source: ET Energy World, August 13, 2020

GWEC Global Offshore Wind Report 2020 and Offshore Wind in India

Global Wind Energy Council (GWEC), Brussels has brought out the Global Offshore Wind Report 2020. The Report provides the detailed Market Status of 2019, Market Outlook 2030, Taking Offshore Global and Offshore Wind Technologies with observations on major offshore wind markets including India. Few major points of the report are reproduced below. The Foreword by Mr. Alastair Dutton, Chair of Global Offshore Wind Task Force, GWEC provides the information about global offshore wind in a nutshell.

Rapid Growth: Offshore wind energy took its first steps in the 1990s and has been growing in scale ever since. In recent years, however, growth has accelerated. From being 1% of global wind installations by capacity in 2009, offshore wind has grown to over 10% in 2019. Measured in investment terms that figure is much greater. Offshore wind is now a mature industry, but is only just beginning its expansion in earnest around the world. Given that more than 70% of the planet is covered by sea, and wind speeds are considerably stronger offshore than onshore, the fundamentals are promising.

Going Global: Offshore wind is going global, country by country. This piecemeal development is unhelpful for a supply chain which is seeking to make sound investments and continue to reduce costs. However, there are a number of initiatives which aim to accelerate offshore wind's deployment:

- GWEC's Global Offshore Wind Task Force, established in September 2018, has brought together the major industry players in offshore wind. Key interventions have been in Taiwan, Vietnam and Japan to assist market development.
- The World Bank's ESMAP Offshore Wind Development Program, launched in March 2019, is focused on expanding offshore wind to developing countries. The program is engaging numerous countries which will form part of the wider global market in years to come.
- The Ocean Renewable Energy Action Coalition (OREAC), launched in Dec 2019, targets 1.4 TW of offshore wind by 2050. This industry body is in answer to the UN High Level Panel for Sustainable Ocean Economy call for action in Sept 2019.

These initiatives are in co-operation and complement each other for greater effect.

Future Markets

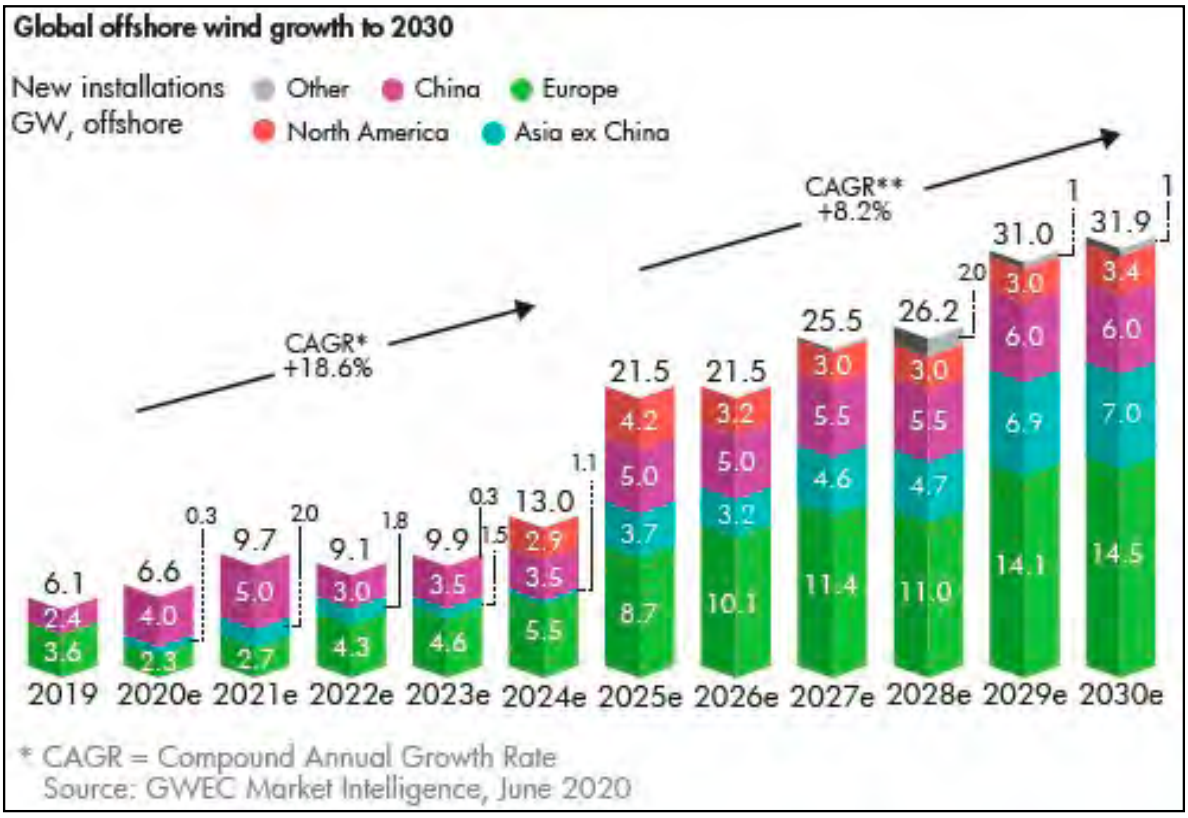
- Existing markets are hungry for more, notably UK, Germany, Denmark, Netherlands, Belgium and China. As an example, the UK is targeting 40 GW by 2030, up from 10 GW today.
- Emerging markets include Taiwan, US Atlantic Coast, Japan, South Korea and Vietnam. Not only do these markets want low cost electricity to decarbonize their footprint but they are keen to establish their own supply chains to benefit their economies. However, inflexible local content requirements could frustrate those economic hopes by raising the cost of electricity and creating inefficient local suppliers not able to compete on a regional or global market.
- New markets are in the preparation phase. Examples include Brazil, Mexico, India, Sri Lanka, Australia and many more. In Europe the existing market will expand into Ireland, Poland, Lithuania and others.
- Floating technology will come of age this decade, tripling the technical potential for offshore wind across the world. Initially, the key markets are France, Japan, South Korea, Scotland, Norway, Portugal, Spain and US Pacific Coast. Once commercial scale projects are established and costs come down many other locations will come into play, for example South Africa, Canada, Philippines and many island states.

Lessons Learned

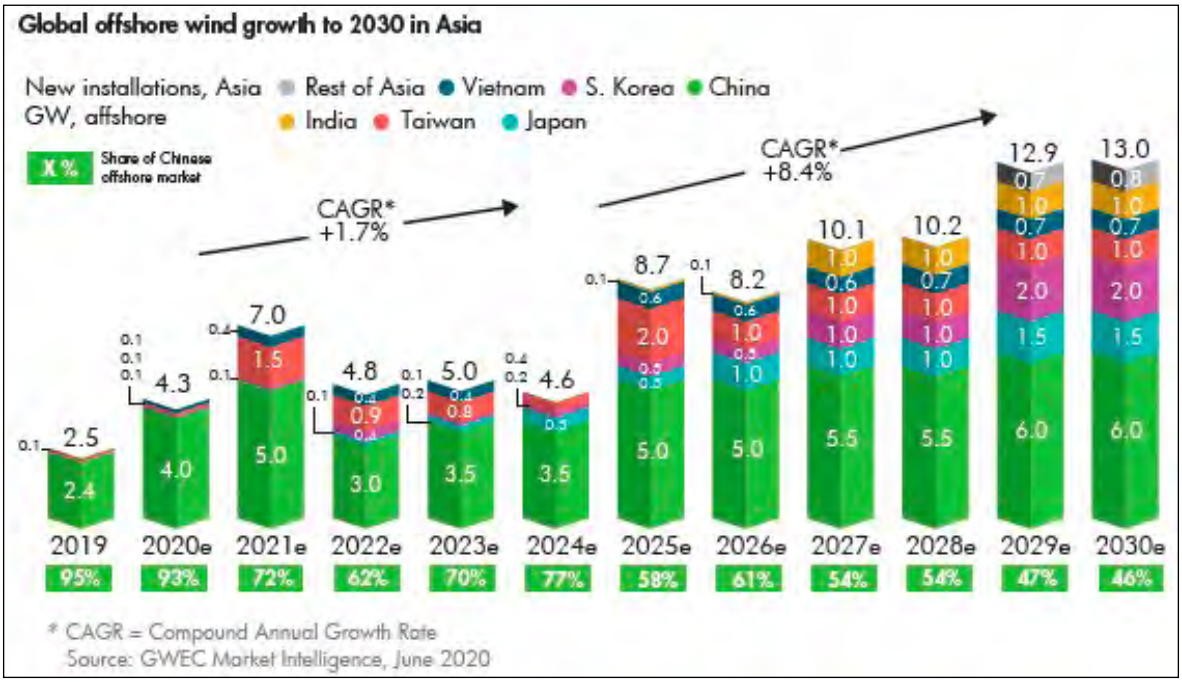
- Much has been learned from the last 30 years of offshore wind deployment in Europe. Those lessons are being taken worldwide by developers and consultants. Governments are adapting those lessons in the context of their particular political and fiscal backdrops.
- One of those lessons is the UK Sector Deal which outlines targets and plans for government and industry to work together to dramatically progress the sector for the benefit of all. This best practice is now being adopted in other markets such as Japan and Poland.

COVID-19: To date offshore wind has been less impacted than most energy sectors by the pandemic, and stands ready to be a material part of a green recovery package.

Conclusion: The potential of offshore wind to achieve the energy transition within the right time frame and contribute to post-COVID recovery is increasingly being understood around the world. At GWEC, we look forward to working with you all to realise this potential.



Global Offshore Wind Growth to 2030



Offshore Wind Growth to 2030 in Asia

At GWEC and its partners are also working tirelessly to ensure that the next round of emerging markets such as those in Latin America and India, capitalise on the lessons learned from the three decades of experience. This will increase our chances as an industry of reaching the global potential of offshore wind by 2050. On-going engagements are there with governments in India, South Africa, Colombia, Azerbaijan, Philippines, Nicaragua and others.

Knowledge Creation

The first report from the program was released in Oct 2019, entitled "Going Global: Expanding Offshore Wind To Emerging Markets". The report gives a general background on the offshore wind market, the dramatic fall in prices and lessons learned. It provides an estimate of the offshore wind technical resource potential in 8 developing countries, including India, Vietnam, South Africa, Brazil and Turkey. The report concludes that the resource is massive and emerging markets are well placed to benefit from growth of the offshore wind sector.

Exploring New Markets

From the perspective of GWEC Market Intelligence, it is important to highlight the potential development for offshore wind in newer markets. Even if actual installations will not happen immediately. The five selected markets, Ireland, Poland, Estonia, India, Australia are representative of markets with high offshore wind potential but varying political support and targets to date. Still, in all five markets there is an increasing awareness that offshore wind can provide an at scale, cost-competitive and efficient solution for these countries.

Offshore Wind in India

GWEC Market Intelligence is monitoring activities in 46 markets on a regular basis to document the opportunities and progress of taking offshore wind global. The report on offshore wind in India is as follows.

Development Stage

Nearly 70 GW potential area has been earmarked for offshore wind development, however the tender for the first 1 GW offshore wind project in the Gulf of Khambhat (Gujarat) has been delayed. Attention has now turned to the stronger wind resource area off Tamil Nadu.

Political Support

India had announced a national target to have 5 GW installed capacity by 2022 and 30 GW by 2030, the first target is now not feasible and the second would require a rapid deployment.

Challenge

Offshore wind in India is expected to compete with cheaper land-based renewables and it has stalled the market.

Next Milestone

Proper plans for the tender of the first projects, possibly beginning with a demonstration scale project are needed.

Courtesy: Global Wind Energy Council (GWEC)

Snippets on Wind Power

India's Renewable Energy Sector Should Move to Next Stage of Investment, Manufacturing: RBI Governor

Reserve Bank of India Governor Mr. Shaktikanta Das has said that the country now needs to move to the next stage of investment and manufacturing in the renewable energy sector. He said that investment should be done in solar and wind energy installations, and also in creating domestic manufacturing capacity for solar panels. Das said that a major factor driving the shift in energy mix has been the steep fall in generation cost of renewable energy and as a result, renewable power generation technologies have become the least cost option for new capacity creation in almost all parts of the world.

"Going forward, this landmark progress could result in a significant overhaul of the power sector, encompassing deregulation, decentralisation and efficient price discovery. Policy interventions in the form of renewable purchase obligations for discomes, accelerated depreciation benefits and fiscal incentives such as viability gap funding and interest rates subvention will have to go through a rethink," Das added. He said that India's changing pattern of energy production is in favour of renewables and India's progress in addressing the demand-supply balance has been remarkable. "India has now become a power surplus country and is exporting to other countries," said Das.

Source: ET Energy World, July 28, 2020

Determining Optimal Capacities in a Grid Connected Wind Solar Battery Hybrid Power System

Mohammad Ziaulhaq Ansari
TUV Rheinland India Private Limited

The Ministry of New and Renewable Energy (MNRE), Government of India has set an ambitious target of achieving 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.

The renewable installed capacity in the country as of now stands for almost 87.8 GW and Government of India is continuously introducing various measures and policy initiative to achieve ambitious target of 175 GW.

The National Wind Solar Hybrid Policy, introduced quite recently, encourages hybridization of existing wind and solar plants as well as promoting hybrid plants in India. The primary objective of this policy measure is combining different renewable energy sources and for that matter battery storage, or thermal power that complement each other, to reduce fluctuation and help maintaining a consistent supply thereby achieving minimum 80% annual availability.

With new approach of multi model procurement being introduced in market, that include wind-solar hybrid, Round The Clock (RTC) power, combining renewable and thermal under tariff based competitive bidding is another favorable move happening that is anticipated to provide balancing power further strengthening grid stability and to meet requirements during hours/periods of non-availability of renewable energy (RE).

Wind and solar are installed for a span of 20 to 25 years, therefore performance of these projects individually, depends upon precise wind resource analysis and solar resource assessment prior to installation. Solar output lasts only during the day on a daily basis, which is said to non-dynamic however, wind being dynamic in nature and fluctuating round the year, continues to operate throughout the day, it tend to be higher and reaches its peak during the nights and become much more uniform in predawn hours. Battery storage is added to reduce the variability of output power from wind solar hybrid plant.

The most significant aspect in a hybrid based plant is determining optimal project sizing configuration based on lowest Levelised cost model and sensitivity analysis. The optimal project sizing refers to minimum MWs of each individual energy source for a defined project capacity. Sensitivity analysis enables to determine the best combination of system components under different conditions. Solar resource and wind resource could be explored separately in different regions or same region but solar and wind resources should exhibit complementary peaks in production on an annual and daily level.

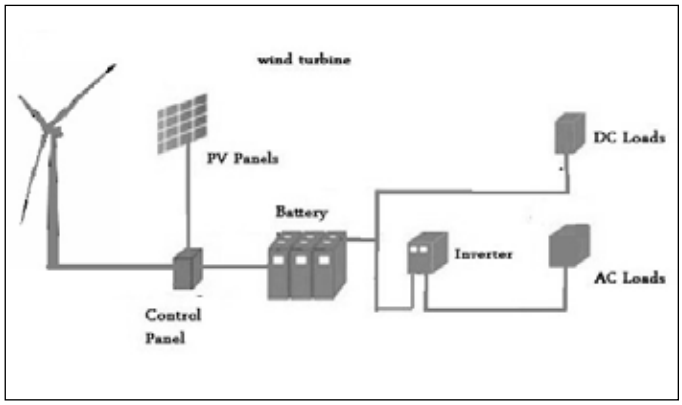


Figure 1: Components of Wind Solar Battery Hybrid System

1. Solar Resource Modeling

A variety of solar irradiation data sources are available. The datasets either make use of ground based measurement at meteorological stations or use processed satellite imagery. Meteonorm provides global climatological database and synthetic weather data simulator. An energy yield calculation is carried out using PVSYST model, considering average monthly irradiance, air temperature, wind velocity and no shading as few parameters. The solar power is estimated as :

P_S = Ins (t) x A_S x Eff (P_v)

where, Ins (t) = isolation at time t (kw/m^2)

A_S = area of single PV panel (m^2)

Eff (P_v) = overall efficiency of the PV panels and DC/DC converters.

Overall efficiency is given by, Eff (P_v)= H x PR

where, H = Annual average solar radiation on tilted panels. PR = Performance Ratio, coefficient for losses.

Boosting turbine performance and profitability

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2. Wind Resource Modeling

Just like solar resource modeling, for a given project site wind resource modeling is carried to estimate annual energy yield or energy estimation at 10 minute time interval from 10 minutes wind speed data given as an input into the model. Various mathematical equations, are used to assist in the predictions of total power output from a particular wind turbine technology. Wind speed frequency distributions are known to be well represented by the two parameters weibull distributions[1], described by shape parameter "k" and scale parameter "c". NIWE compilations (Mani 1990; Mani 1992; Mani 1994; Mani and Rangarajan 1996; Rangarajan 1998; Rangarajan 2005; Wind Energy: Resource Survey in India – VI) have also assumed wind speed distributions in India to be represented by Weibull distribution.

The Weibull probability density function[3,4] for wind speed "v" is given by f (v) =

$$f(U) = (k/c)\left(\frac{v}{c}\right)^{k-1} \exp[-(\frac{v}{c})]^k \quad (k>0,\ v>0,\ c>1) \text{ ------(1)}$$

The energy output from the wind turbine over time period T is given by

$$E = T\int_{Vin}^{Vr} P(V)f(v)dv + T\,Pr\int_{Vr}^{Vout} f(v)dv \quad \text{---------- (2)}$$

Where P (V) is the power curve of the wind turbine, Vin is the cut-in wind speed, Vr is the rated wind speed and Vout is the cut-out wind speed and f(v) is given by equation (1). The energy estimates are produced based on 10 minutes average wind speed for a given capacity of wind farm. In determining the gross energy output it is assumed there are no wake interactions happened between the turbines and no energy loss factors are applied.

3. Optimisation, CapEx, OpEX, Levelised Cost of Tariff, Sensitivity Analysis

Wind and solar both are capital intensive, but has no fuel costs. The parameters that governs the economics include investment cost, operation & maintenance capacity factors, economic lifetime and cost of capital. These factors are modeled for a particular wind, solar technologies and battery storage to determine levelised cost of tariff. All the commercial inputs with respect to technical, commercial and financial are taken into consideration.

When, energy output from both sources, wind and solar are derived, and PLF is computed, optimisation become necessary, to trade off between the sizing of wind, solar and battery for a given project capacity, NPA and fulfilling sensitivity factors i.e. keeping round the clock availability to 80%, and at least 51% of energy supply from RE sources, etc.

The optimisation is essentially carried out using HOMER or self made python software. The sizing is an output of mathematical

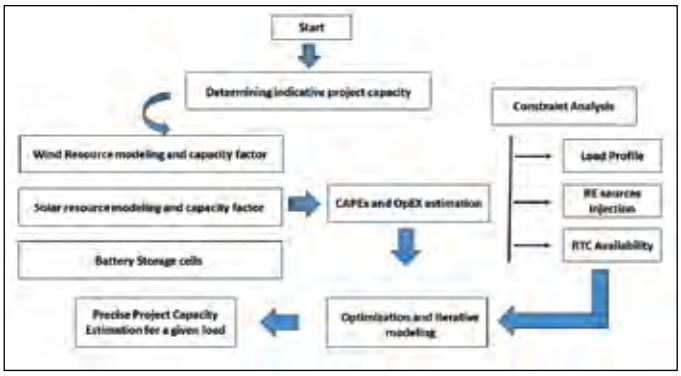

Figure 2: Flow Chart for Determining Precise Capacity Estimation for a Given Load

models to get the best output from combination. Iterative method and artificial intelligence method are used to design a techno-economically optimum hybrid renewable energy system that determine number of PV panels, wind turbines, battery cells, load profiles and available renewable resources that may constitute a reliable power system with low cost.

The iterative method calculate the optimal percentage of power produced by PV and WT based on analyzing different solar/wind ratios to satisfy a constant power demand and achieve the minimal capital cost. The deviation between the power demand and power supply is quantified using linear approach i.e. least square methods, considering constraints such as fluctuations of power injected into the grid, battery constraints i.e. battery state of charge or lack of power transmission, etc.

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A Comprehensive Overview on the National Wind Resource Assessment Programme (NWP)

A. Hari Bhaskaran
Deputy Director (Technical)

Dr. Rajesh Katyal
Deputy Director General & Division Head

R. Vinod Kumar
Junior Engineer

Wind Solar Resource Measurements/Offshore (WSOM) Division
National Institute of Wind Energy (NIWE), Chennai

India is blessed with abundant renewable energy resources like solar, wind, hydropower, biomass, etc., and has taken a leap in RE capacity additions in last few years as part of country's commitment towards sustainability. With more than two decades of experience, the wind sector occupies an important place in our RE portfolio. To substantiate this fact, during 2019, India was ranked as the fourth most attractive renewable energy market in the world and declared as one of the largest wind energy markets in the world. By July 2020, about 88 GW RE based capacity has already been installed in the country which represent 24% of India's installed capacity. Out of total RE capacity, wind energy represents a significant share of renewable energy portfolio.

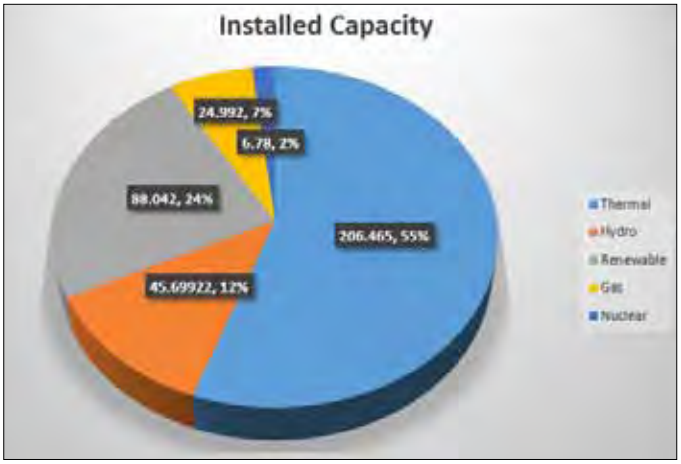

Figure 1: Total Installed Capacity as on July, 2020

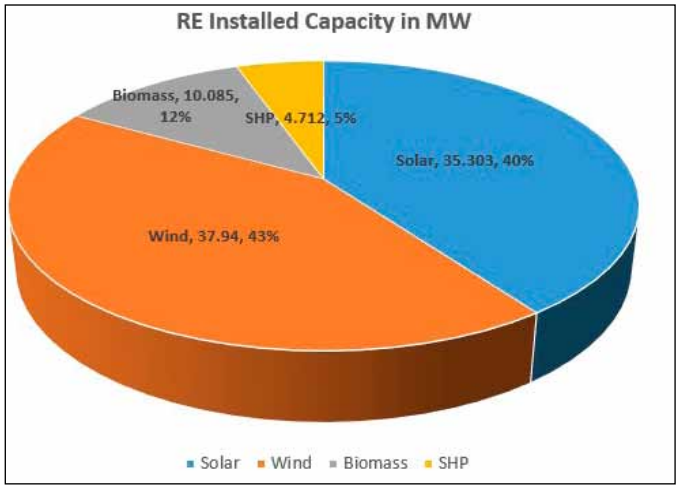

Figure 2: Renewable Energy Installed Capacity as on July, 2020

Indian wind energy sector is more than two decades old and Indian wind industry represents successful 'Make in India' narrative with all wind turbines being made in India and over 80% of the components manufactured indigenously. The installed capacity in India has grown on an average of 20% since last twenty years. The year-wise installed wind power capacity is shown on next page.

Recently, our Hon'ble Prime Minister of India while addressing the Climate Action Summit's opening ceremony organized by the UN Secretary General on the sidelines of the UN General assembly, he pledged that the share of non-fossil fuel will be increased, and by 2022 India's renewable energy capacity would be increased to much beyond 175 GW, and later till 450 GW. Hence, it can be inferred that the intentions and ambitious targets of Government of India are highlighting the needed focus on the green power's contribution in India's sustainable development. India is not only committed to refine and strengthen the business and regulatory framework governing wind power in India, but also to provide the necessary and reliable information on RE resources across the entire country. Hence, reliable background information on the availability of renewable resource and its geographical variation play a major role in achieving these targets.

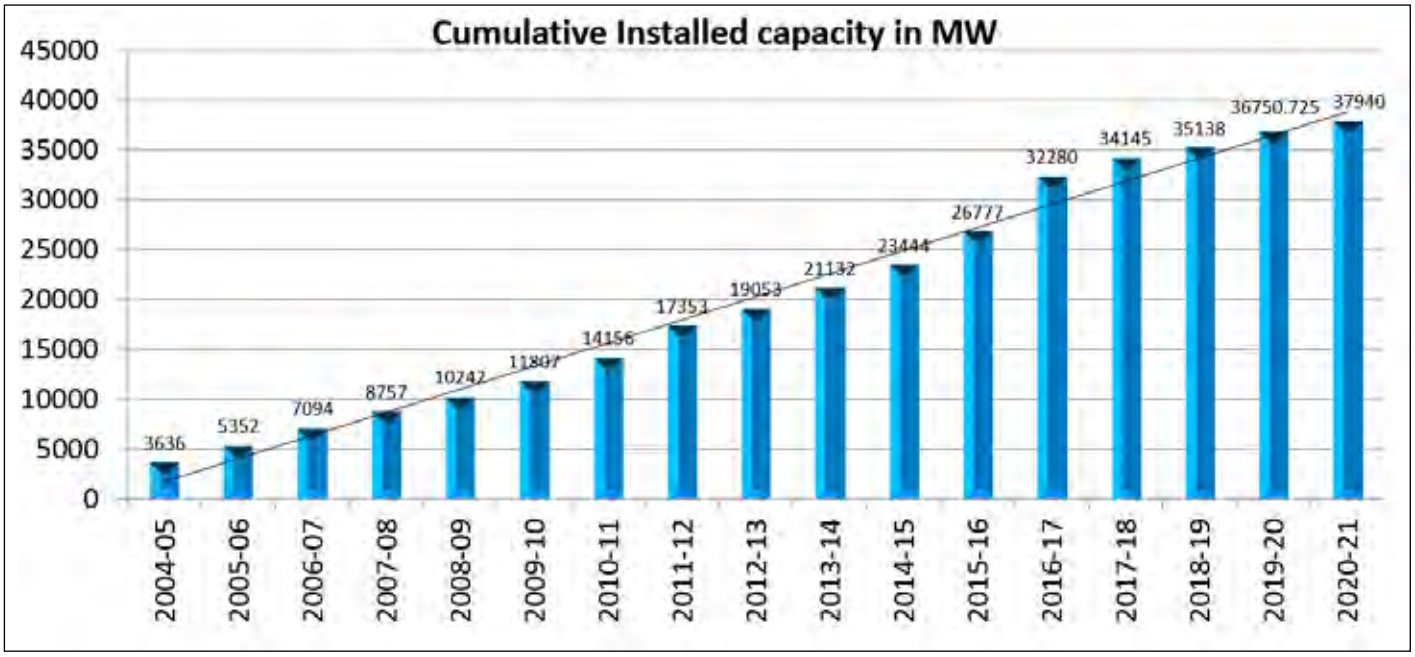

Figure 3: Year-Wise Cumulative Installed Capacity of Wind Power Projects

The wind power development program in India was initiated towards the last year of the Sixth Five Year Plan i.e., in 1983-84. In order to identify wind potential sites in the country, the Government of India launched 'National Wind Resource Assessment Program' in 1985. The program was designed for the selection of windy sites, procurement of suitable instruments, design and fabrication of 20m tall masts, their installation at the selected sites and collection & processing of the data. Nodal agency of each State also participated in the implementation of the program. After the establishment of the National Institute of Wind Energy (NIWE) [formerly, Centre For Wind Energy Technology (C-WET)] in Chennai in 1998, the National Wind Resource Assessment Program was transferred to NIWE. Under the program, 50m, 80m, 100m and 120m height masts have been commissioned to collect dedicated wind resource data at multi-levels. As on July 2020, cumulatively 888 stations including 5 nos. of 120 m wind monitoring stations was established under the national wind resource assessment program, which resulted in one of the largest wind power specific in-situ data bank in the world. Five numbers of 120m tall masts with multilevel instruments were commissioned at five major wind farm locations in the country (Akal/Jaisalmer - Rajasthan, Lamba/Jamnagar - Gujarat, Jagmin/Satara - Maharashtra, Jogimatti/Chitradurga - Karnataka and Kayathar, Tuticorin - Tamil Nadu) to assess the wind shear as well as to act as reference stations. For the benefit of various stakeholders including researchers & students, the wind data collected by NIWE are made available to the public on nominal pricing.

S. No	State/ UT	No. of Wind Monitoring Stations Established under NWP
1	Tamil Nadu	95
2	Gujarat	91
3	Odisha	19
4	Maharashtra	140
5	Andhra Pradesh	69
6	Telangana	24
7	Rajasthan	48
8	Lakshadweep	9
9	Karnataka	72
10	Kerala	31
11	Chhattisgarh	21
12	Madhya Pradesh	45
13	Andaman & Nicobar Islands	19
14	Uttarakhand	17
15	Himachal Pradesh	6
16	West Bengal	12
17	Pondicherry	6
18	Punjab	10
19	Jammu & Kashmir	24
20	Haryana	6
21	Jharkhand	3
22	Uttar Pradesh	14
23	Goa	4
24	Bihar	6
25	Arunachal Pradesh	17

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26	Assam	18
27	Tripura	11
28	Manipur	15
29	Mizoram	9
30	Sikkim	4
31	Nagaland	6
32	Meghalaya	17
	Total	**888**

The following map depicts wind monitoring stations commissioned by NIWE in the country till July 2020. It is noteworthy to mention that the private entities/developers had also extensively carried out ground measurements close to 2000 stations, but majorly in 8 windy States only.

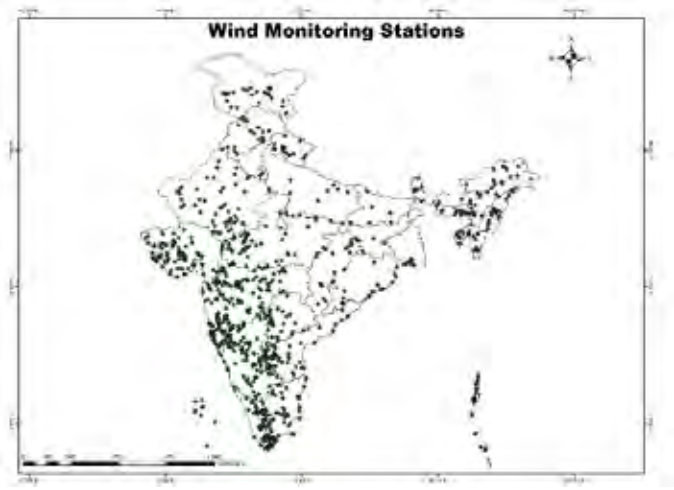

Figure 4: Wind Monitoring Stations Established by NIWE

As an outcome of this program, NIWE had estimated the wind power potential of the country as 49 GW and 103 GW at 50m and 80 m respectively. With advancing hub heights, this study was revisited at 100m agl in 2015 and wind power potential at 100m height was estimated as 302 GW.

As the wind speed increases with respect to height, the hub height extension is being looked into one of the effective solutions to enhance the energy yield from the wind turbines. With the technical advancements, the modern day turbines have reached the hub height of 120m to 130m and a further enhancement in hub height is foreseeable. Hence, to cope up with the increase in hub height and to expose suitable potential locations for the stakeholder's, higher height maps was felt essential. Accordingly, NIWE had estimated the wind power potential of the country as 695 GW @ 120 m agl (above ground level) with 5D x 7D micro-siting configuration. Out of the total estimated 695 GW potential, 340 GW could be installed in wasteland, 347 GW in cultivable land and 8 GW in forest area. It is also noted that wind potential of 132 GW is possible in high potential areas with CUF greater than 32% and wind potential of about 57 GW is possible in the areas with CUF greater than 35%.

As these meso-maps are prepared with the help of atmospheric model data sets, validation and fine-tuning of meso-scale potential map is essential to authorize its acceptability, which is circled around number of representative measurements considered for the analysis. Hence, in-situ ground measurements become sine-qua-non to understand the uncertainty in mapping and to derive at the realistic potential of the region of interest. Further, availability of bankable wind resource data of potential sites is required by the investors, which helps in early start of the project and to understand the techno-economic feasibility of the project to take much more informed decisions. In this regard, Ministry of New and Renewable Energy (MNRE) through NIWE have been continuing the wind resource assessment programme for the following reasons.

- Accelerate validation of country's wind power potential by assessing actual land availability for developing the wind power projects and assess wind power potential in new/ uncovered areas including hilly Himalayan region and NE regions in a stipulated time frame.
- Update wind resource maps and database every 2 years and update wind power potential of the country.
- Identify high wind potential pockets for large-scale capacity deployment.
- Expand wind resource assessment in new states.
- Undertake small-wind as well as repowering potential estimation activities.
- Increase private sector participation in WRA.

Wind Resource Assessment in Complex Terrains

In complex terrains such as NE region, Leh-Ladakh, Kargil, etc., there are scattered potential pockets available for wind farm development due to the localized wind flows and such pockets can only be identified through in-situ measurements. Accordingly, MNRE through NIWE had carried out ground measurements in more than 100 sites in NE region including Sikkim, Leh-Ladakh, Kargil using 25 & 50 m meteorological masts. From the wind power potential maps prepared by NIWE, some of the locations had shown good potential, however this needs to be re-checked with fresh long-term measurements to take much more informed and better decisions, since the map has been prepared based on meso scale modelled data and these models cannot predict the localized wind flow prevailing in the complex regions. In complex regions, localized wind flows plays a vital role and in-situ/ground measurements are the best way to find out such regions.

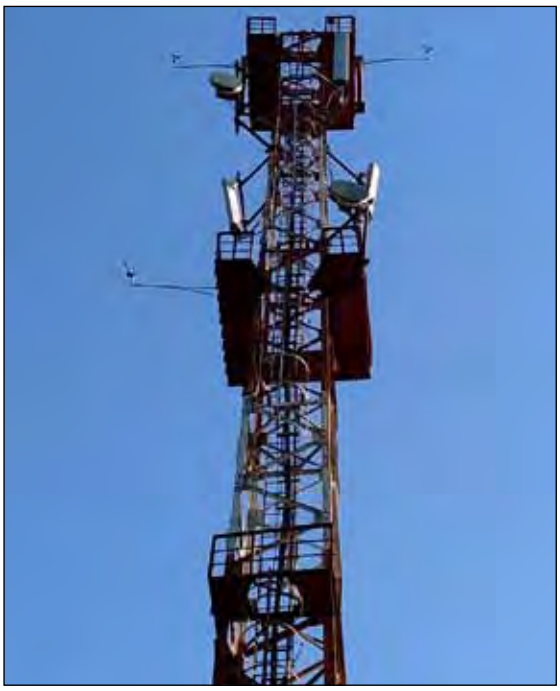

Figure 5: Wind Measurements Using Telecom Towers

As per the directions of the Ministry, NIWE had also tried to carry out the wind measurements using the existing telecom towers in the NE regions to expedite the data collection by overcoming the issues related to land availability, transportation of mast segment to remote areas, harsh climatic conditions, etc. As on date, 80 telecom towers in NE region are mounted with wind sensors and the data are being collected from these sites. The data from these towers will be used as a pre-cursor to identify the suitable locations for carrying out the long-term measurements using met masts as per international standards.

Offshore Wind Resource Assessment Studies

In order to assess the wind pattern and potential along the coast, NIWE had measured wind data using 74 meteorological masts along the coastal regions of India. The preliminary desktop studies revealed that the coastal line of Gujarat and southern part of Tamil Nadu had very good wind potential. NIWE had also carried out wind profile study for short duration during 2009 by using Sound based remote sensing instrument 'SoDAR (Sound Detection and Ranging)' at Dhanushkodi, Rameshwaram. The study revealed that at 120m height, the 10 min average wind speed was about 19.3 m/s for the measured short period.

In continuation to the preliminary studies carried out in the Indian waters, NIWE had also commissioned a 100 m high guyed lattice mast in the coastal line of Dhanushkodi, Rameshwaram and the data were collected for five continuous years (2013-18). The results obtained from the measurement campaign were very promising and attracting for offshore wind power development in India.

Figure 6: Wind Monitoring Stations Along the Indian Coast

Further to facilitate development of offshore wind energy, the National Offshore Wind Energy Policy was announced by the Government of India in October 2015. Subsequently, under FOWIND (Facilitating Offshore Wind in India) project, wherein NIWE was the knowledge partner had identified 8 zones each in Gujarat and Tamil Nadu coast as potential locations for the development of offshore wind power projects.

NIWE had initiated first of its kind LiDAR based wind measurements to validate the potential at the preliminary demarcated zones and the first site was selected at Gulf of Khambhat for carrying out the LiDAR based measurements on a monopile structure. Further, NIWE had also installed a 100m height meteorological mast at Jaffrabad coast in line of sight with the LiDAR location at a distance of 25 km, for the purpose of correlation & validation with the LiDAR measurement. Accordingly, a LiDAR based offshore measurement campaign was commenced on November 2017 in Zone B, Gulf of Khambhat, off Gujarat coast, which is first of its kind in the country and the measurements are still underway. For the benefit of various stakeholders, as per the directions of the Ministry, the detailed LiDAR wind data analysis report was uploaded in NIWE's website along with one year Offshore LiDAR raw data.

Further, as per the directives of MNRE, NIWE had identified additional probable locations off Gujarat and Tamil Nadu coasts for carrying out LiDAR based measurements on a monopile structures at the preliminary demarcated offshore potential zones and are likely to be established within next few years.

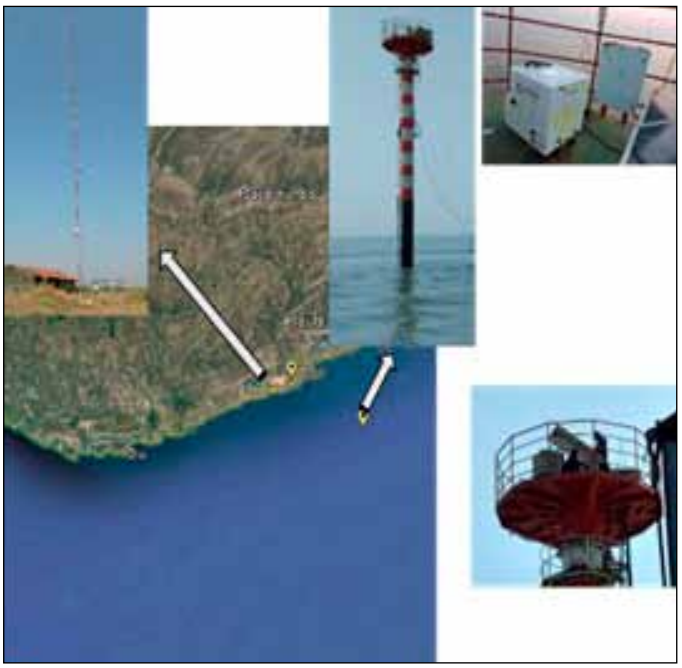

Figure 7: Offshore Wind Measurements Using LiDAR at Gulf of Khambhat and 100 m WMS at Jaffrabad

Integrated Wind-Solar Resource Assessment

The earlier studies of NIWE and other researchers had revealed that solar and winds are almost complementary to each other and hybridization of these two technologies would help in minimizing the variability apart from optimally utilizing the infrastructure including land & transmission system. In this regard, under the funding from MNRE, NIWE would be erecting 50 nos. of 100 m integrated wind-solar hybrid resource assessment stations at the carefully chosen sites to ascertain the hybrid (wind and solar) power potential and the data collected from these stations would be used to validate the wind-solar hybrid potential map being prepared by NIWE which would play a pivotal role for the stakeholders to identify suitable sites for the development of the hybrid projects.

Remote Sensing Technologies (RSD)

Recently, remote sensing devices based either on sound (SoDAR) or on laser (LiDAR) have made an entry into the market. Their clear merit is that they replace a mast which can have practical advantages. However, they often require more substantial power supplies which bring other reliability and deployment issues. Also more intensive maintenance is required since the mean time between failures does not allow unattended measurements for periods required for wind resource assessment. While the precision of a LiDAR seems to be superior to the SoDAR, and often comparable to cup anemometry, both instruments suffer at the moment from short-comings in complex terrain due to the fact that the wind speed sampling takes place over a volume, and not at a point. Remote sensing technologies are currently evolving very rapidly and it is expected they will have a significant role to play in the future. Due to above reasons and high initial cost compared to the met mast, the onshore wind measurements using RSD instruments are very limited under NWP. However, MNRE & NIWE are exploring the possibilities of deploying more number of RSD based studies in future by overcoming all its short comings.

From the above, it could be concluded that National Wind Resource Assessment Programme being implemented by MNRE/NIWE plays an essential role for India's energy needs and it has provided a good basis for taking Indian wind power sector to its present enviable position. It is a program based on a scientific and commercial necessity. The stakes in the wind power sector are especially high with very large wind farms being contemplated and considerable assurances about commercial viability are inevitable. Thus, the availability of long-term data has become an important issue and it is the subject of considerable complexity apart from being a scientific challenge. So, MNRE along with NIWE is determined and focused to continue its support to the Indian wind sector by continuing the National Wind Resource Assessment Programme specially to explore uncovered/new areas and identification of new potential locations for the development of wind power projects.

Snippets on Wind Power

MNRE Setting Up Wind-Solar Hybrid Parks to Overcome Land and Connectivity Bottlenecks

The Ministry of New and Renewable Energy has now identified areas where hybrid wind-solar parks can be set up. Ten such locations have been found. With hybrid parks it hopes to resolve two of the biggest issues troubling the wind industry- that of land and connectivity. "If you see the risk profile (of wind projects), land and connectivity are at the top of the list. All the infrastructure wind and solar farms need will be provided in advance at the parks." It will be plug and play for the developers. One such park in Khavda, in the Bhuj region of Gujarat, is in a fairly advanced stage of development.

Energy Infra Post, 14th August 2020

Brushless Doubly Fed Induction Machine-based Wind Electric Conversion System

Dr. V. Vanitha, Professor
Department of Electrical and Electronics Engineering,
Sri Krishna College of Technology
Coimbatore
vanitha55@gmail.com

Dr. R. Resmi, Assistant Professor
Department of Electrical and Electronics Engineering,
Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Coimbatore
resmidhun2010@gmail.com

Introduction

Offshore wind power contribution in terms of electrical energy supplied will be higher because of the availability of strong wind speeds and hence, offshore wind farms are gaining popularity. Variable speed wind electric generator is considered advantageous, because of better aerodynamic efficiency and reduced mechanical stress. Permanent Magnet Synchronous Generators (PMSG) and Doubly Fed Induction Generators (DFIG) with a wound rotor have been used as variable speed wind electric generators in offshore wind farms[1]. Disadvantage of DFIG is that these generators employ slip rings and carbon brushes in order to recover slip power from the rotor and deliver it to the grid. Carbon brushes are known to have limited life span and therefore are replaced for every couple of months. Moreover, slip rings also wear out due to the conduction of high rotor currents and therefore need replacement after every few years. Thus, the presence of both reduces the life time of the machine and increases the maintenance costs[2]. Overall maintenance cost of DFIG is high especially for offshore wind farms where maintenance is dependent upon weather conditions as turbine units can be accessed with difficulty during certain periods of the year. In PMSG, the use of permanent magnets and full rated power electronic converters make the system costly[3]. An alternative to overcome these drawbacks is the use of Brushless Doubly Fed Induction Machine (BDFIM), which has attracted considerable attention in recent years as it has robustness of the squirrel cage induction machine, power factor controllability of the synchronous machine, absence of brushes and slip rings as well as the use of fractionally rated power converters. However, these benefits are obtained in slightly more complex structure, higher cost (30%) and larger dimensions (10%) in comparison to the conventional induction machine[4].

Brushless Doubly Fed Induction Machine

Brushless Doubly Fed Induction Machine (BDFIM) promises remarkable advantages for wind power generation as they offer high reliability and low maintenance cost by virtue of the absence of slip rings and brushes. This is particularly important as more and more installations are being constructed offshore and in difficult to reach places. BDFIM has its origin from the technology of cascade induction machines, which has two stator windings known as the Synchronous Power Winding (SPW) and the Asynchronous Power Winding (APW) in the same casing that are connected independently to different three phase sources[5]. Rotor construction is of special type which couples the stator magnetic fields indirectly to make the machine always run in the synchronous mode. Schematic diagram of BDFIM based Wind Electric Conversion System (WECS) is shown in Figure 1, where the rotor of the machine is connected to wind turbine through gear box. SPW is connected directly to the power grid and APW is connected to the grid via two bidirectional converters, Machine Side Converter and Grid Side Converter. Machine Side Converter is used to compensate reactive power of BDFIM and extract maximum real power from wind. Grid Side Converter takes care of transferring the real power from the machine to the grid and reactive power exchange with the grid. With the appropriate control of converters, the real and reactive power can be regulated[6].

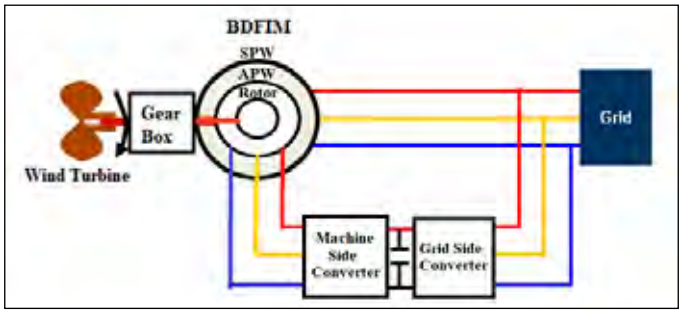

Figure 1: Schematic Diagram of BDFIM Based WECS

The major drawback of BDFIM is the presence of torque ripples due to spatial harmonics because of two stator windings and the complex rotor structure, which affect the speed-torque characteristic of the machine[4]. This has caused hindrance in the commercialization of the machine, which demands reduction in the harmonics content of air gap flux and hence torque.

Prototype of Brushless Doubly Fed Induction Machine

Literatures in induction machines show that hybrid delta-star winding in the stator can be used to improve fundamental winding factor and reduce air gap harmonics[7]. It is proved that delta-star winding in grid connected squirrel cage induction generator reduces reactive power consumption drawn from the grid[8]. There is an improvement in efficiency of machines by incrementing the fundamental winding factor of delta-star winding, which resulted in decrement of machine copper loss[9]. So, torque ripple reduction by use of delta-star winding on stator can be proposed in BDFIM, which will help for the commercialization of the machine.

BDFIM designs in the past used conventional star and delta windings in SPW and APW. Delta-star winding is considered in the present design of three phase, 415V, 3.5 kW, 2/6 pole BDFIM in APW in order to address the major issue of spatial harmonics and torque ripples. The designed BDFIM with nested loop rotor is simulated in ANSYS Maxwell software and based on the analysis of simulation results, usage of delta-star winding in APW provides a better result than the other winding connection in terms of torque ripple, spatial harmonics and rotor current harmonics[10]. When conventional star winding for SPW and delta-star winding for APW (Star/Delta-Star) are used, BDFIM gained 21% reduction in torque ripple when compared with the normal delta winding for both SPW and APW (Delta-Delta) winding design.

Based on the design of BDFIM, its prototype model is built incorporating the availability of standard stampings of stator and rotor at a local industry. The machine is fabricated using the stator and rotor stampings shown in Figure 2(a) and 2(b) respectively[10]. Figure 3 and Figure 4 show the stator core with windings and nested loop rotor respectively. Figure 5(a) and 5(b) show respectively the complete prototype of BDFIM coupled to DC machine and the stator winding terminals of BDFIM. 12 terminals are taken out from the delta-star winding and six terminals from the star winding.

Figure 2(a): Stator Stamping

Figure 2(b): Rotor Stamping

Figure 3: Stator Core with Two Windings

Figure 4: Nested Loop Rotor

Figure 5(a): Prototype Model of BDFIM Coupled to DC Machine

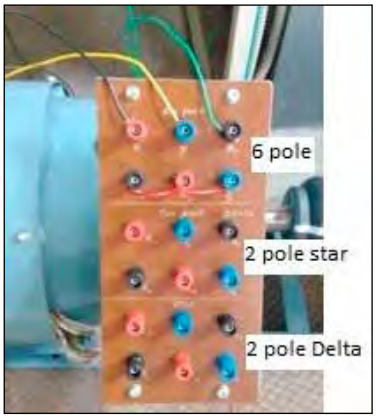

Figure 5(b): Stator Winding Terminals

Brushless Doubly Fed Induction Machine as a Generator

Figure 6(a) shows the test set up of BDFIM acting as generator in synchronous mode, where the coupled DC machine operates as the prime mover. One stator winding, SPW is directly connected to three-phase 415 V, 50 Hz grid supply and other winding, APW is connected to a dedicated variable resistance load. Table 1 shows the specifications of the test setup involving BDFIM and a DC machine. Figure 6(b) shows the plot of BDFIM generated power against shaft speed. With increase in input to the generator, the power delivered to the grid as well as the shaft speed increases. That the speed

varies with power is the desired feature for use as wind electric generator. A variation in shaft speed of 35% has been observed in the test, which is more than the published results in literature for DFIG, i.e. 30%[11].

Table 1: Specification of prototype BDFIM Coupled with DC Machine

Separately Excited DC Motor	BDFIM
Armature Voltage – 230V Current – 30 A Speed – 1500 rpm Field Current – 0.9 A Power – 5 kW	Voltage – 415 V Current SPW/APW – 5 A/7 A Natural Speed – 750 rpm Pole Configuration – 2/6 Power – 3.5 kW

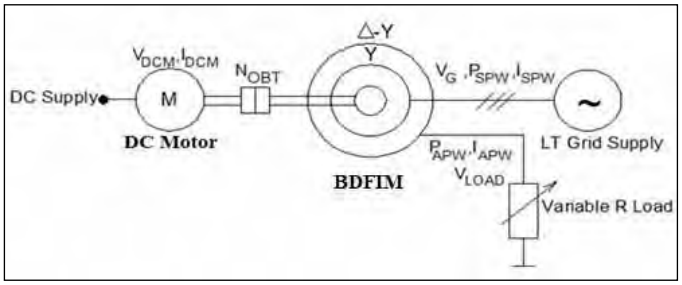

Figure 6(a) Test Set up of BDFIM during Generating Mode

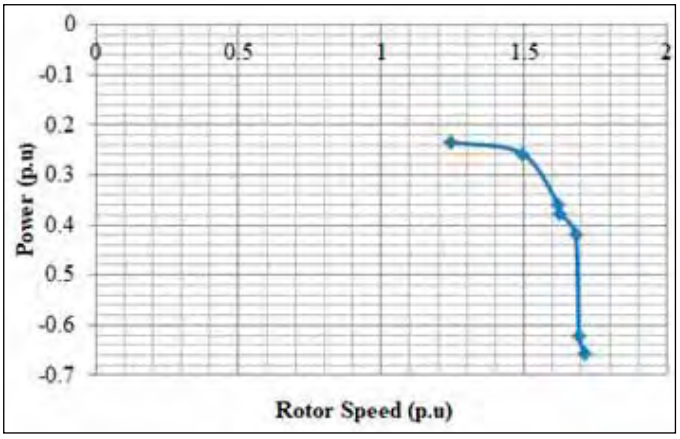

Figure 6(b): BDFIM Output Power with Shaft Speed

Laboratory Setup of BDFIM Based WECS

A Wind Turbine Emulator (WTE) is fundamentally a demonstration of a practical wind turbine in a laboratory, which provides a controllable test environment that allows the evaluation and improvement of control schemes for wind electric generators. The prototype BDFIM is tested as generator in WECS making use of WTE as prime mover. WTE is made using separately excited DC motor with a series resistor, where the input armature voltage to motor is taken equivalent to wind speed. The setup is run for different armature voltages, which shows a variation from 1013 rpm to 1240 rpm in shaft speed. This investigation was intended to establish the range of rotor speed variation of a BDFIM based WECS. Testing in the laboratory using WTE and prototype BDFIM showed significant speed variation even in a small range of wind speed variation. This is the feature required in a WECS that a variable speed generator will help the wind turbine operate on varying rotor speed upon different wind speeds to hold aerodynamic efficiency around its maximum value.

The laboratory test on WTE-BDFIM prototype had constraints on both low wind speed and high power. Therefore, a MATLAB Simulink simulation of the same hardware test set up has been done to explore the complete performance of the BDFIM based WECS. Equivalent circuit parameters of BDFIM needed for the simulation are determined from simple induction mode test and cascade induction mode test. By using these parameters, the 2/6 pole BDFIM model is developed in MATLAB Simulink and complete analysis of BDFIM based WECS is done successfully. The obtained power coefficient – tip speed ratio (C_P -) characteristic of WTE resemble the characteristics of the simulated wind turbine. Figure 7 compares the Cp- characteristics of the simulated wind turbine with that of WTE; it clearly shows that the two have the same profile. This also resembles the curve of a real wind turbine.

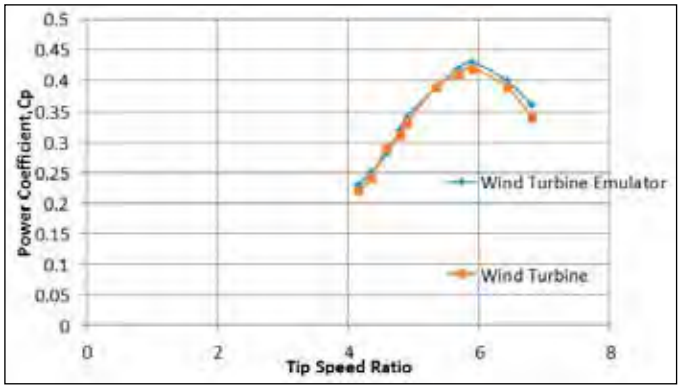

Figure 7: C_P - λ characteristics of Simulated Wind Turbine and Wind Turbine Emulator

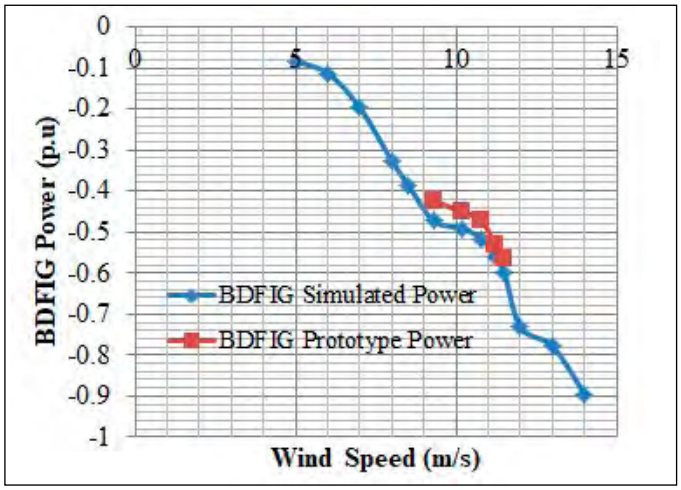

Figure.8(a): Wind Speed with BDFIG Output Power (Prototype and Simulation)

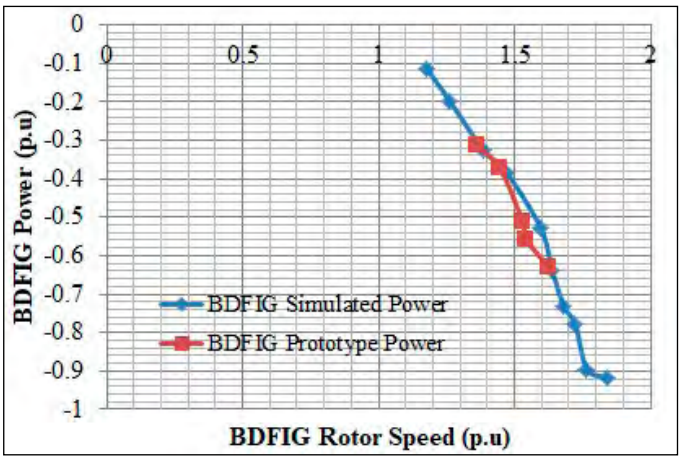

Figure 8(b): BDFIG Rotor Speed with BDFIG Output Power (Prototype and Simulation)

Figure 8(a) shows the plot of Wind Speed- Output power of Brushless Doubly Fed Induction Generator (BDFIG) for both prototype and simulation where, in WTE, varying armature voltages are mapped to wind speed. The power output of BDFIG at the rated wind speed is 3130.98W; Figure 8(b) shows the plot of BDFIG rotor speed- output power for both prototype and simulation. The results obtained validate the performance of BDFIM based WECS with a wind speed variation from 5 m/s to 15 m/s, which showed the generator speed range of 850 rpm to 1420 rpm between no load and full load conditions. The rotor speed variation observed in Figure 8 is from 1.13 p.u to 1.89 p.u; that means 67% is the change in rotor speed of the generator, having higher variable speed range operation of BDFIM as a wind electric generator. Rotor speed variation up to 40% in BDFIG is reported by Abdi et al.[12] Tir et al. reported a rotor speed variation of 30% in DFIG[13]. Higher range of rotor speed variation helps to increase the average efficiency of power conversion by the wind turbine. This establishes the superiority of BDFIG over DFIG. The power outputs of wind turbine and BDFIG at the rated wind speed are respectively 4561.42W and 3130.98W; the low efficiency of BDFIG can be attributed to lower capacity of the machine and laboratory scale manufacturing. From the results it is observed that, BDFIG is suitable for WECS with maximum power extraction.

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Snippets on Wind Power

Wind and Solar Produced 10% of Global Electricity in First Half 2020 - Report

Wind turbines and solar panels produced a record 10 per cent of the world's electricity in the first half of 2020 as coal-power declined, but steeper change is needed to meet targets set under the 2015 Paris climate agreement. Scientist say huge cuts to greenhouse gas emissions from the power sector are required over the next decade to limit global warming and curb the worst impacts of climate change such as floods, droughts and loss of species. Ember's report examined data from 48 countries which make up 83 per cent of global electricity production.

Source: Reuters, August 13, 2020

NTPC to Enter Distribution Business, Buyouts Planned

State-run National Thermal Power Corporation has said that it is "actively looking for" opportunities in the business of power distribution, a move that gels with its diversification drive. The development comes at a time when the government is planning to privatise the power departments in Union Territories, which it hopes will "provide a model for emulation by other utilities across the country".

Source: FE Bureau, August 19, 2020

India to have 60% Renewable Energy by 2030, Power Minister

India will have around 60% of its installed electricity generation capacity from clean sources by 2030, Power and New & Renewable Energy Minister Mr. R K Singh said on 21 July 2020. The minister also exuded confidence that the renewable energy capacity would touch 510 GW by 2030, including 60 GW of hydro power. In September last year at the United Nations Climate Action Summit, Prime Minister Mr. Narendra Modi had announced increasing the renewable energy target to 450 GW by 2030 from 175 GW by 2022.

Source: PTI, July 22, 2020

Big Bang Reform Coming: Paying Electricity Subsidy via Direct Benefit Transfer

In an exclusive interview to ET Now, Power Minister Mr. RK Singh informed the plan to directly subsidise electricity for only those people that need it. Key highlights are:

- Bold reform coming to roll out direct benefit transfer for electricity
- Idea is to plug leakages & make the power sector at large more viable.
- Only 1 in 5 discoms capable right now of servicing its debt. Discoms debt expected to touch all time high of Rs 4.5 lakh crores according to Crisil.

Source: .timesnownews.com,19th August 2020

Boost for Renewable Energy: RBI Issues Revised Priority Sector Lending Guidelines

The Reserve Bank of India (RBI) has issued revised guidelines for priority sector lending to enable better credit penetration to credit deficient areas and increase lending to small and marginal farmers besides weaker sections. In addition, the initiative will boost credit to renewable energy and health infrastructure. The RBI said bank finance to start-ups up to Rs. 50 crore, loans to farmers for installation of solar power plants for solarisation of grid-connected agriculture pumps, and loans for setting up compressed bio-gas (CBG) plants have been included as fresh categories eligible for finance under priority sector. Loan limits for renewable energy have been doubled.

Bids Invited for Renewable Energy-Based Power Solutions for the Himalayan Region

The Solar Energy Corporation of India (SECI) has invited bids to develop renewable energy-based solutions for meeting energy requirements in remote high-altitude areas (HAA) of the Himalayas. The last date for the submission of bids is November 06, 2020.

Source: Mercom India, 28th September 2020

Rs. 1 Lakh Crore Worth of Electricity Not Billed, Smart Metering is the Solution

Electricity worth around Rs. 1 lakh crore is supplied but never billed in India due to leakages in the power distribution system and smart metering can help address this issues that worsens the financial crisis for power discoms, Mr. Saurabh Kumar, Managing Director, Energy Efficiency Services Ltd (EESL) has said while, speaking at the ET Energy World Virtual Summit on Smart Metering on 21st July 2020. "The billing efficiency of the power sector as a whole is about 83 per cent, which means that 17 per cent of the energy sold is never billed.

Source: ET Energy World, July 21, 2020

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NGC Transmission

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NGC Transmission

Nanjing High Accurate Drive Equipment Manufacturing Group Company Limited (NGC) is headquartered in Nanjing, People's Republic of China. Founded in 1969, NGC was listed on the Hong Kong stock exchange in 2007 under the name "China Transmission".

After many years of successful growth, NGC has founded four businesses, focused respectively on wind energy gearboxes, rail vehicle gearboxes, industrial gearboxes and robot reducers. The NGC brand is famous throughout China and rest of the world. The company is one of the world's leading manufacturers of wind power equipment and one of the leading manufacturers of gear equipments.

Adhering to a corporate philosophy of "climbing step by step to the summit, striving piece by piece for perfection", NGC has accepted the challenge to make the world "Geared for a Better Future". With advanced technology, reliable quality and thoughtful services, NGC has the ability to provide products and services beyond user expectations.

NGC has constantly increased spending on research and development. Together, these assets have allowed us to create the complete 1.5 MW- 8.X MW series of wind energy transmission products and provide them for the global market, along with a complete zero-gap service network. These products can adapt to low temperatures, low wind speeds, high altitudes, maritime environments, and other challenging working conditions. To date, more than 80,000 of NGC's high-quality wind turbine gearboxes and 400,000 variable pitch & yaw gearboxes are in active and stable operations in more than 30 countries around the world.

NGC Transmission Chennai

Ground breaking ceremony of NGC Transmission Chennai for Wind MGB production factory was held on 24th Nov 2019 @ SEZ, Sricity, Andhra Pradesh, and production is expected to start by next year, focusing on both Export and Indian market. This will further enhance the globalization process of NGC and develop India & other new markets.

Factory Overview

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Aditya Birla Chemicals – Advanced Materials

Aditya Birla Chemicals is part of the Aditya Birla Group, a US$48 billion corporation. The Advanced Materials business at Aditya Birla Chemicals started in 1992 with plant in Thailand. From being a pioneer in the ASEAN region, the business has since expanded its manufacturing to India and Germany. It has 11 sales offices globally including in EU, US, India, Middle East, China. The company offers high level of technical expertise and works jointly with customers for customizing the offerings. We manufacture Epotec® & CeTePox® resins and systems, which are used globally in all the segments of epoxy applications; composites, electricals, electronics, coatings, construction and adhesives.

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Aditya Birla Chemicals' Epotec® & CeTePox® Epoxy Resin systems are well-established in the wind industry and are used by leading wind blade manufacturers globally. These Epoxy Systems are designed for wind applications and meet stringent process & application requirements as well as offer a unique combination of performance and cost effectiveness. The product portfolio comprises of Resin Infusion Systems, Resin Systems for Prepregs, Tooling Systems, Gel Coats, Expandable Epoxy Systems, Adhesives and Hand Lay-up Systems. These offerings are suitable for different processes & blade designs.

The company's latest innovation, **Recyclamine®, has enabled recycling of the rotor blades. This path-breaking patented technology addresses the long-standing concerns of process waste & end-of-life waste management** by enabling recycling of wind turbine blades with recovery and repurposing, helping the industry to contribute towards circular economy and become more sustainable. The company has stayed at the leading edge of developments in Wind Industry through sustained R&D. Other novel offerings include Ultra-Slow Resin Infusion Systems, Instant Thixotropic Structural Adhesive, Slow Reacting-High Strength Adhesive, Fast Curing Adhesives for Repair, among others.

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