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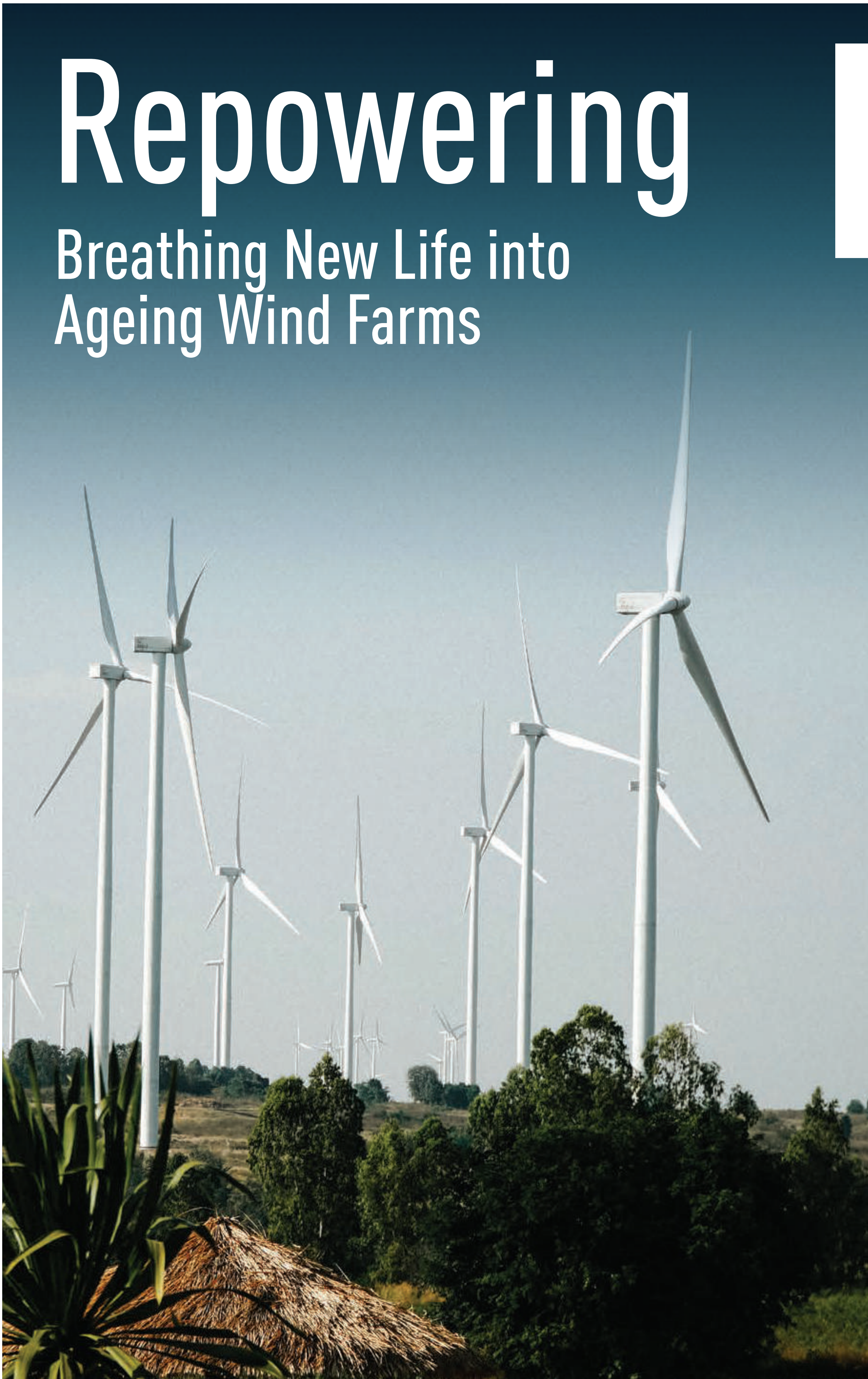


Repowering

Breathing New Life into Ageing Wind Farms

INSIDE

On Wind Repowering in Tamil Nadu

How the State Could Potentially Achieve a Near Doubling of its Wind Energy Generation

Tamil Nadu's current installed wind turbine capacity of 10.7 GW generates approximately 16.9 billion units of electricity annually. A significant opportunity exists to further bolster the state's wind power production. By strategically replacing older turbines with a combined capacity of 2.4 GW with newer, more efficient models boasting a total capacity of 7.3 GW, Tamil Nadu could potentially achieve a near doubling of its wind energy generation, reaching close to 30 billion units annually. This strategic repowering initiative would demonstrably increase the contribution of clean energy sources to the state's overall energy mix. A report by the Centre for Science and Environment (CSE) titled Accelerating Wind Repowering in Tamil Nadu, written by Binit Das, addresses in detail the potential for repowering in Tamil Nadu. The full report is available for download, but here, Indian Wind Power presents extracts from the report in three parts.

Part 1: On-Ground Experience of Wind Repowering: Case Studies from Tamil Nadu

Driving south from Tirunelveli city in Tamil Nadu, one encounters a bustling scene of buses, trains, students and labourers heading to their destinations. Along the way, hospitals, colleges, shops and numerous temples line the route.

Past Valliyur town, the landscape changes dramatically. Lush green fields surrounded by mountains, grazing livestock and the cheerful chirping of birds welcome travellers into the countryside. Amidst this scenic backdrop, towering wind turbines 50–80 feet tall dominate the horizon.

This picturesque setting unfolds near Muppandal, a village in Kanniyakumari district, renowned for housing India's largest operational wind farm since 1986. Nearby, Karungulam, a panchayat town 15 km from Aralvaimozhi, offers a glimpse of rural life in southern India. Aralvaimozhi Pass, a strategically significant gap in the Western Ghats' southernmost part, hosts wind farms collectively generating about 450 MW of electricity, with over 3,000 windmills.

The Muppandal wind farm, featuring turbines from various private players, was developed by the Tamil Nadu Energy Development Agency (TEDA). Notably, the wind turbines in this region are among the oldest in the country.

We selected the location because this region in Tamil Nadu has been home to windmills since 1986. It contains some of the oldest wind farms, with many turbines still operating despite frequent breakdowns and significantly lower Capacity Utilization Factors (CUFs).

We took a closer look at the following five repowered sites from the region.

- Narasus Spinning Mills, Karungulam
- Narasus Spinning Mills, Kumarapuram
- Hatsun Agro Product Ltd, Kumarapuram
- Ashok Wind Farm Private Limited, Karungulam
- T.P.S. Wind Farm Private Limited, Levengipuram (see Table 1)

Table 1: Comparison table: Specification of old versus new wind energy generators (WEGs)

Wind farm	Old WEG	New WEG	Change
Narasus Spinning Mills, Karungulam	Generators: 3 * 250 kW Hub height: 50 m Rotor diameter: 30 m	Generators: 3 * 250 kW Hub height: 50 m Rotor diameter: 30 m	No changes in generator capacity hub height and rotor diameter
Narasus Spinning Mills, Kumarapuram	Generators: 4 * 250 kW Hub height: 50 m Rotor diameter: 30 m	Generators: 2 * 500 kW Hub height: 50 m Rotor diameter: 47 m	Reduced the number of generators but increased their capacity, while also expanding the rotor diameter by 17 metre
Hatsun Agro Product Ltd, Kumarapuram	Generators: 4 * 250 kW Hub height: 30 m Rotor diameter: 30 m	Generators: 4 * 250 kW Hub height: 50 m Rotor diameter: 30 m	Increased the hub height by 20 metre
Ashok Wind Farm Private Limited, Karungulam	Generators: 2 * 250 kW Hub height: 30 m Rotor diameter: 30 m	Generators: 2 * 250 kW Hub height: 50 m Rotor diameter: 30 m	Increased the hub height by 20 metre
T.P.S. Wind Farm Private Limited, Levengipuram	Generators: 3 * 250 kW Hub height: 50 m Rotor diameter: 30 m	Generators: 3 * 250 kW Hub Height: 50 m Rotor Diameter: 47 m	Increased the rotor diameter by 17 metre

Our Observations

1. The companies that manufactured these old turbines of 250 kW have ceased their production and maintenance support, including spare parts. Now they are producing new-generation turbines with higher capacities. After more than two decades of continuous operation, these turbines experienced issues with slewing bearings (including blade/yaw bearings) and gearbox malfunctions, resulting in significant problems such as pitching failure, diminished energy output and current instability. Consequently, owners decided to replace all the old turbines.

2. Hub height and rotor diameter: Most owners opted to retain the hub height and rotor diameter, as increasing these parameters would necessitate a complete redesign of site spacing, posing challenges such as increased falling distance and micro-siting issues.

Wind turbines seen in the distance. Tamil Nadu has been home to windmills since 1986

3. Site spacing refers to the minimum distance required between wind turbines within a wind farm. As wind turbines spin, they create turbulence. If turbines are placed too close together, this turbulence can disrupt the airflow reaching downwind turbines, reducing their efficiency. Wind turbines are massive structures with large, heavy blades that spin at high speeds. In the unlikely event of a blade failure, falling debris could pose a serious threat to people and property.

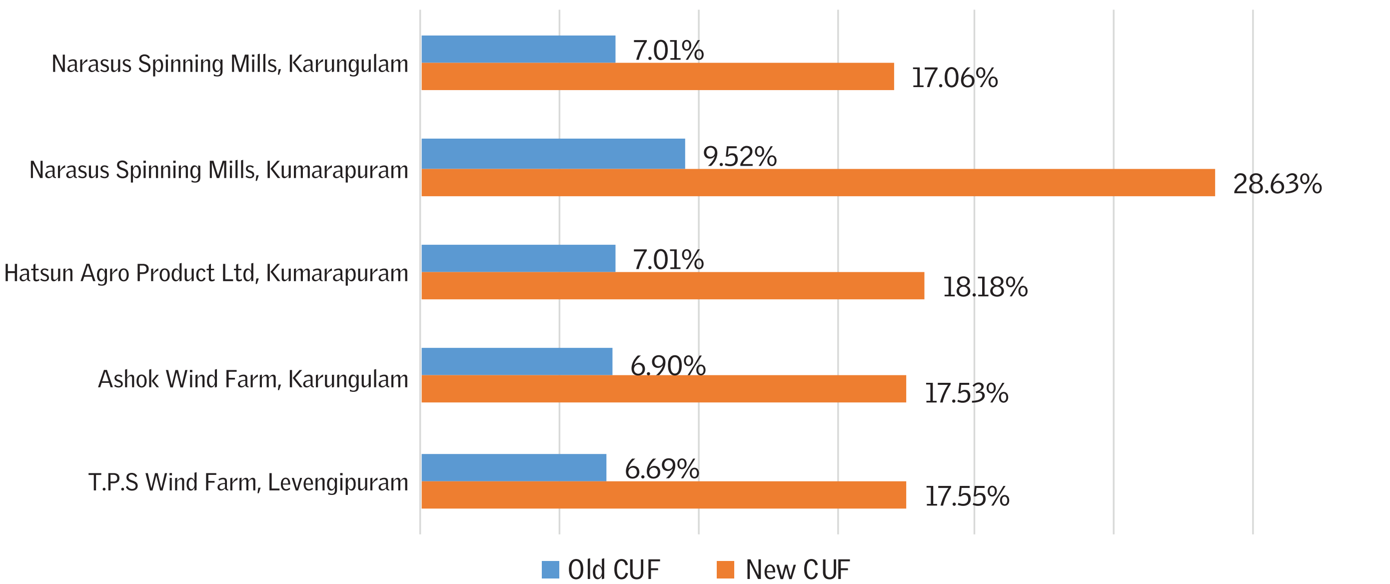
4. Wind turbine capacity: Wind repowering owners who interacted with CSE shared a common practice of maintaining the new capacity of the wind farm at the

The five sites that CSE visited featured turbines that were more than 20 years old

same level as the old one. This is because TANGEDCO has not agreed to increase the approved load of the old wind turbines. If they were to increase the load, they would also need to upgrade the substation capacity and components, which involves upgrading the evacuation voltage level and the infrastructure. This is the reason why wind turbine owners repowered but couldn't increase the turbine capacity.

5. The five sites that CSE visited featured turbines that were more than 20 years old. Repowering led to a significant tripling in both generation and Capacity Utilization Factor (CUF), mainly due to the replacement of outdated wind energy generators (WEGs) with newer turbines. The case studies on repowering clearly demonstrate this nearly threefold increase in generation. Additionally, in Hatsun Agro, the hub height was raised by 20 metre, and in T.P.S. and Narasus Spinning Mills in Kumarapuram, the rotor diameter was expanded by 17 metre, resulting in a substantial boost in yield (see Figure 1). CUF reflects the actual energy output relative to the maximum potential output, and higher CUF indicates better performance.

Figure 1: CUF comparison between old WTG and new WTG



Source: Author's analysis

6. The concrete foundation of Ashok and TPS Wind Farm had deteriorated, developing cracks due to the intense vibrations generated by the aged turbines. The vibrations compromised structural integrity and led to rainwater infiltration into the old concrete, weakening the foundation further. So the old foundation had to be removed and a new site rebuilt approximately 20 metre from the old one, with new tower stub for the repowered project.

7. During the interaction we found that a scrap dealer from Coimbatore managed the disposal of discarded turbine parts. They sorted through components like the gearbox, generator, foundations and towers, selling salvaged parts to local recyclers to ensure valuable materials were repurposed. However, recycling wind turbine blades and nacelles posed challenges due to their complex construction.

Mechanical disintegration techniques like cutting, shredding, crushing, or milling were used to break down the blades into smaller pieces, which were then repurposed as reinforcements in various composite products, insulation materials, or structural components. Recycled materials such as pellets and panels are used in flooring and wall installations, supporting sustainability in construction and manufacturing. Innovative solutions for nacelles include repurposing them to manufacture boat hulls for local fishermen, promoting environmental sustainability and fostering economic growth within the community.

Photographs taken on-site at the repowered sites

Wind farm owners in Tamil Nadu were found to have ambitious plans to increase their turbine capacity through repowering

Discussion

From our experiences we found that wind farm owners in Tamil Nadu had ambitious plans to increase their turbine capacity by four times through repowering, replacing old models with more powerful ones. However, TANGEDCO, the state's power utility, posed a significant obstacle. The Mupandal substation couldn't handle the surge in electricity from these upgraded turbines. Additionally, micro-siting restrictions and regulations regarding the minimum distance between turbines and homes (falling distance) hindered the ability to increase the hub height or rotor diameter significantly. With a more comprehensive and flexible policy, these limitations could have been addressed, enabling developers in quadrupling capacity and generation. Now, brand new turbines stand tall, ready to serve for the next two decades, but an opportunity to significantly boost Tamil Nadu's wind power is slipping away.

AUTHORS

Binit Das is a power and renewable energy professional. Currently serving as Programme Manager (Renewable Energy) at a prominent New Delhi-based think tank, Centre for Science and Environment (CSE). He has a rich background in research, project management, management consulting, green entrepreneurship, and skill development.
EPPPM, IIM Calcutta
BTech (Electrical); MBA, University of Petroleum and Energy Studies, Dehradun

Centre for Science and Environment (CSE) is hosting a workshop on accelerating wind repowering in Tamil Nadu. The workshop will center around CSE's latest report, which provides an in-depth analysis of the state's wind repowering potential and a critical review of the current policy framework.

Date: Friday, September 20, 2024
Time: 9:30 AM – 4:30 PM
Venue: Zone by The Park, Outer Ring Road, Chennai

Scan the QR code to register

Part 2:

The Economics of Wind Repowering

A Deep Dive into the Costs Involved

Dismantling and disposing of old turbine components, and other such activities, cost Rs 12 lakh for a 250-kW wind repowered project

After visiting the site and interacting with developers, CSE analysed the costs involved in the demolition, erection and supply of 250 kW wind turbines for both repowered and greenfield projects. The data highlights financial implications, potential savings and payback periods, offering valuable insights into the feasibility and cost-effectiveness of different projects.

Dismantling and disposing of old turbine components, such as towers and foundations, along with excavation, are significant cost factors in repowered projects. These activities cost Rs 14 lakh for a 250-kW wind repowered project.

Reusing existing foundations and access roads can result in significant cost savings of Rs 5 lakh for a 250-kW project. The feasibility of foundation reuse depends on the micro-siting conditions and the structural integrity of the old foundations to support newer, heavier turbines. Since most of the concrete in old foundations is unsafe for new turbines, this becomes an added cost.

Grid upgrade costs for repowering projects can vary significantly, typically in the range of 30–40 per cent of the total repowering investment. This variation depends on the existing grid capacity and the increase in power generation from repowered turbines. These costs directly impact the overall feasibility and payback for repowered projects.

The supply cost for a 250-kW wind turbine, including the nacelle, blade and blade hub, tower, and other components, is Rs 105 lakh. This cost is consistent for new installations and repowered projects. Consequently, the capital cost of the power plant varies significantly between repowered and greenfield projects. The greenfield project has a lower cost at Rs 148.4 lakh compared to the repowered projects, which cost Rs 170 lakh.

The annual power generation varies across projects, with repowered projects like the T.P.S. Wind Farm achieving the highest at 3.84 lakh kWh. Annual savings from wind power generation is close to Rs 27 lakh mainly due to the better efficiency of newer generation turbines.

The additional cost of Rs 22 lakh per 250 kW associated with repowered projects extends their payback period by one year. This highlights that greenfield projects, involving significant initial investments but streamlined processes without complexities like dismantling and grid upgrades, can achieve quicker financial returns.

The economic analysis reveals a substantial gap of approximately Rs 22 lakh per 250 kW turbine (roughly Rs 87 lakh per MW) between the costs of repowering and building new greenfield projects. To make repowering economically viable and attractive compared to greenfield developments, an additional investment of Rs 6,336 crore across Tamil Nadu's 7.3 GW of existing wind capacity would be necessary. This investment aims to bridge the economic disparity and promote the sustainable utilisation of existing wind resources in the region.

Table 2: Cost comparison of three repowered projects with new green field project

S. no.	Item description	Repowered project Narasus-Karungulam amount (Rs lakh)	Repowered project Ashok Wind Farm amount (Rs lakh)	Repowered project T.P.S. Wind Farm amount (Rs lakh)	Greenfield project amount (Rs lakhs)
1	De-erection of turbines	0.5	0.4	0.5	0
2	Disposing of old turbine components, towers, excavation, and foundations	14	14	14	0
3	11 KV line work/km	4	4	4	4
4	11 KV four pole EB DP structure	7	7	7	7
5	Transformer, CT PT and meter	7	7	7	5
6	NOC and clearance from authority	10	10	10	10
7	Civil foundation and rebuilding access roads	14	14	14	9
8	Erection	5	5	5	5
9	Safety certificate	1	1	1	1
10	Commissioning and PPA	1	1	1	1
11	Site and pathway clearance	0.6	0.6	0.5	0.5
12	Synchronization	0.5	0.4	0.4	0.4
13	Contingency	0.5	0.5	0.5	0.5
14	Supply and installation of a 250 kW Wind Turbine	105	105	105	105
	Total	**170.1**	**169.9**	**169.9**	**148.4**

Source: Data from the repowered project developers

Table 3: Comparison of cost–benefit analysis and project payback period

	Repowered project Narasus-Karungulam	Repowered project Ashok Wind Farm Value	Repowered project T.P.S. Wind Farm	Greenfield project
Capacity of the power plant (250 kW)	250	250	250	250
Investment of the project (Rs lakh)	170.1	169.9	169.9	148.4
Annual generation of the power plant (kWh)	373,565	383,894	384,240	373,565
Cost of grid power (Rs/kWh)	7.0	7.0	7.0	7.0
Annual savings to owner due to wind power generation (Rs lakh/year)	26.1	26.9	26.9	26.1
Payback period (year)	6.5	6.3	6.3	5.7

Source: Author's analysis

Part 3:

CSE's Proposal on Wind Repowering in Tamil Nadu

Recommended Strategies for Effective Repowering

Replacing small wind turbine generators (WTGs) with larger ones offers an opportunity for increased energy production and cost-effectiveness, as larger turbines can harness more wind energy and require less land per unit of energy generated. However, this comes with substantial upfront costs and suitability concerns based on wind patterns and grid constraints.

A more nuanced approach involves using lower-rated WTGs with taller towers to capture stronger winds at higher altitudes, enhancing efficiency without significantly affecting nearby turbines. Ultimately, the decision to replace small WTGs should be guided by a comprehensive feasibility assessment considering wind resources, site constraints, cost-effectiveness, and stakeholder feedback.

Given the evident issues with wind repowering, a holistic approach is necessary to address the gaps in Tamil Nadu's draft repowering policy, particularly regarding small wind turbine owners, who have been overlooked. Achieving results from this approach will require the collaborative involvement of all stakeholders.

The following strategies are recommended:

I. Strengthening draft wind repowering policy

Tamil Nadu's draft repowering policy aims to provide a detailed framework tailored to the state's specific needs, addressing the challenges and opportunities in the wind energy sector. The policy covers implementation arrangements, micro-siting norms, banking arrangements, power purchase agreements, falling distance regulations, and wind-solar hybrid installations to support repowering projects.

However, old turbine owners remain unconvinced by the policy support. Despite paying Rs 30 lakh/MW as Infrastructure Development Charges, wind project developers face additional, potentially discouraging costs for substation upgrades and alternative power evacuation depending on TANGEDCO substation capacity.

Tamil Nadu's aging wind farms, reliant on insufficient 11 kV lines for evacuation, face a bottleneck as repowering for higher capacity requires an upgrade to 33kV. The policy, however, remains silent on this crucial infrastructure upgrade.

Additionally, the policy neglects the challenge of fragmented ownership, a critical hurdle that plagued previous repowering attempts. The combination of banking charges and the cap of 50 per cent of total generation for encasing excess energy is also discouraging for power banking.

II. Need to upgrade transmission infrastructure

While the state's draft repowering policy aims to revitalise aging wind farms, a significant hurdle exists: the current power transmission infrastructure. Many of these wind farms rely on TANGEDCO's 11 kV power lines to evacuate the electricity they generate. However, repowering these farms to reach their full potential, with increased capacity and generation output, necessitates an upgrade to a minimum of 33 kV capacity for the generation feeder lines.

This is a critical bottleneck. Without this upgrade, the additional power generated by repowered turbines cannot be efficiently transmitted into the grid. It is concerning that there's currently no official circular issued by TANGEDCO regarding these crucial infrastructure upgrades. Furthermore, the draft repowering policy itself remains silent on this matter.

This lack of clarity creates uncertainty for wind farm owners. Upgrading infrastructure is a substantial investment, and they require clear guidelines and support from TANGEDCO to make informed decisions about repowering. Without addressing the transmission capacity issue, the ambitious goals of the repowering policy risk being hampered.

III. Need for land consolidation to benefit fragmented turbines owners

Imagine a wind farm where 20 turbines of 250 kW capacity each are replaced by three turbines of 2 MW capacity each. Since these turbines are owned by different individuals, consolidating them into fewer, more powerful turbines creates significant ownership issues. This fragmentation has been a major hurdle, causing previous attempts at repowering in Tamil Nadu to largely fail.

A land swapping programme can help address this issue. This programme acts like a matchmaking service for land with wind turbines. Landowners with small, scattered plots interested in repowering can participate. The programme facilitates connections between landowners with compatible parcels for mutually beneficial exchanges. It considers factors like size, location and potential wind resources.

Once a match is identified, negotiations take place, and if an agreement is reached, the swap is formalised with legal documentation and regulatory approvals.

Alternatively, a collective ownership model for wind farms can be explored. Here, several landowners within the wind farm's area co-own the repowered turbines. They contribute financially to the repowering project and share in the profits generated by the wind farm's electricity production. This approach fosters a sense of ownership and responsibility among community members, potentially leading to greater acceptance and project viability.

Both the land-swapping programme and collective-ownership models can

Allowing small wind turbine owners to sell their stored energy back to the grid could help balance grid demand and encourage greater energy storage

resolve issues of fragmented ownership and ensure equitable benefits, but they require careful planning, strong communication and robust governance structures for success.

IV. Financial incentive to nullify increase in payback period

The Green Energy Open Access (GEOA) can be a game changer for repowering wind farms. Introduced in June 2022, GEOA can significantly increase market access for repowered wind farms. It can enable these farms to bypass the traditional system of selling electricity solely to distribution companies (DISCOMs), allowing them to directly sell their power to a broader range of consumers, including large industrial and commercial entities. However, the draft policy only mentions that wheeling charges can be exempt from open access fees and does not address GEOA's potential benefits.

Repowering Tamil Nadu's 7.3 GW of wind turbines presents a significant opportunity. However, bridging the economic gap with greenfield projects would require an estimated additional investment of Rs 6,336 crore.

The following are some targeted financial instruments that can address these gaps:

- Generation-based incentives: Implementing incentive programmes that reward repowered wind farms for exceeding pre-determined performance benchmarks, such as increase in energy production, can encourage owners to optimise their projects.
- Loan guarantees: Government-backed loan guarantees can substantially lower the risk for lenders, prompting them to provide loans for repowering projects with reduced interest rates and extended repayment terms. Despite additional expenses compared to greenfield projects, the payback period for repowered projects is extended by approximately one year. To enhance the financial appeal of these projects, loan guarantees and interest rebates can help bridge the gap of 80 lakhs per MW. Essentially, a loan guarantee involves a third party committing to cover some or all of the risks associated with a loan for a client lacking adequate bank-worthy collateral.
- Feed-in tariffs (FiTs) for repowered projects: Introducing a stable, long-term (20 years) tariff for electricity produced by repowered wind farms can ensure owners receive assured revenue in the early operational stages, minimising risks of revenue shortfall. Currently, new wind projects adhere to a competitive bidding process based on tariffs, which means procuring electricity generated from wind farms by selecting developers who offer the lowest tariff. This tariff might slightly exceed the standard FiT to help cover the 80 Lakhs per MW gap.

V. Wind–solar hybridisation: A synergistic approach

The hybridisation approach leverages the complementary nature of wind and solar resources.

Wind and solar energy production often have different peak generation periods. Wind tends to be stronger during night-time and early morning hours, while solar generation peaks during midday. By combining these resources, overall energy production can be maximised throughout the day, reducing reliance on

fossil fuels and enhancing grid stability.

Utilising existing wind farm infrastructure for solar installations minimises the need for additional land acquisition. This not only reduces project development costs but also promotes responsible land-use practices.

VI. Need to go back to old banking regulation for repowered projects

The new draft policy allows annual wind energy banking for projects commissioned before March 31, 2018. Projects commissioned after April 1, 2018 can bank energy on a monthly basis, up to 50 per cent of total generation.

But what if all repowered projects had this annual banking option? The benefits could be even greater. Imagine developers strategically selling stored energy during peak hours when electricity prices are highest, boosting their profits. Plus, a larger energy reserve could be created by banking 100 per cent of the generated power. This means less reliance on expensive backup sources like diesel generators during low-wind periods, leading to significant cost savings.

However, there's always a flip side. Banking too much energy might overload the existing grid, necessitating upgrades. Additionally, if everyone banks all their energy, there could be an excess in the market at certain times, potentially driving down prices.

So, banking should be allowed 'slot-to-slot' adjustments only, preventing shifting from high to low generation periods. Slot-to-slot adjustments in energy banking refer to a system where excess energy generated in a specific time period (or "slot") can only be used to offset consumption in the same time period. This means that energy generated during peak hours can only be used to offset consumption during peak hours, and energy generated during off-peak hours can only be used to offset consumption during off-peak hours. The maximum bankable energy should be capped at 50 to 70 percent of the generation between May and September. Any excess banking will be forfeited. Additionally, at least one-sixth of the banked energy available on October 1 must be consumed each month from October to March. Failure to do so will result in the forfeiture of the remaining balance.

The current draft policy restricts the consumption of banked energy to non-peak hours only, i.e. within 8 a.m. to 4 p.m., to discourage high power consumption during peak hours. However, allowing small wind turbine owners to sell their stored energy back to the grid during evening peak hours at a premium rate could help balance grid demand and encourage greater energy storage.

Lower banking fees or rebates provided for utilising a higher percentage of banked energy should be win-win for both the TANGEDCO and the wind turbine owners by encouraging them to effectively utilise the banked energy and feeding energy during evening peak hours. TANGEDCO should estimate and determine banking charges to cover break-even costs.

Download the full report at
https://www.cseindia.org/accelerating-wind-repowering-in-tamil-nadu-12306

or

Scan the QR code

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