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Horizons

Renewing renewables:

The next chapter in the energy transition

September 2026

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For the past 25 years, the general approach to renewables has been to add more: more turbines, more panels, more sites. It's an operating model that has been highly successful. By the end of 2025, more than 3.5 terawatts (alternating current) of wind and solar capacity was in operation globally.

However, as the sector matures, a new story is emerging that is changing the logic that built the industry. A story that we believe will not only materially increase annual installations of wind and solar but improve project economics and affordability.

Unlike an oil or gas well, a wind or solar site never exhausts its resource. The wind continues to blow and the sun continues to shine.

What does age is the equipment, sometimes because it physically wears out and sometimes because advances in technology leave it lagging the curve.

Consequently, as the first great wave of turbines and modules reach the end of their design life, owners are having to decide whether to abandon their sites, invest in extending their lifespans or renew them.

We forecast that more than 2.5 terawatts of wind and solar projects will face this decision in the 2040s.

As we transition to a new era of renewal, repowering old sites with new equipment will become as important a driver of installations and output growth as opening new ones.

In this edition of Horizons, we quantify the coming wave of decommissioning and repowering and show why, for many markets, this overlooked issue will be one of the most important factors shaping future growth.

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Wind and solar assets are starting to feel their age

Wind decommissioning is already happening as turbines degrade towards the end of their design life, typically 20 years. By the end of 2026, more than 30 GW of wind capacity will have been decommissioned worldwide, two-thirds of it brought offline between 2022 and 2026. In some cases, the equipment was taken down and the site abandoned, while in others, asset owners repowered the site with new equipment.

This considerable increase in wind decommissioning aligns with the growing maturity of the global installed wind base. As of 2026, almost 50 GW of wind capacity has been operating for more than 20 years; that is set to rise to more than 230 GW by 2040 and perhaps 440 GW by 2050.

The solar industry began its phase of rapid deployment later than wind, but will see its ageing fleet – older than 20 years – overtake wind before 2040.

An owner's decision to decommission wind or solar equipment and install new equipment essentially involves weighing up the net present value (NPV) of investing in extending the existing project's lifespan, including technical and non-technical considerations, against completely repowering the asset.

Although these factors apply to both wind and solar projects, we have taken a technology-specific approach to our wind and solar decommissioning forecasts. Solar modules are sold with 25- to 30-year warranties, with pre-defined degradation guarantees. We use these in our forecasting for solar, but warranties are not the only factor driving decommissioning and repowering.

Solar is a less mature technology than wind, meaning it is currently seeing greater technological advancements. Over the past decade, a new technology has been introduced every other year.

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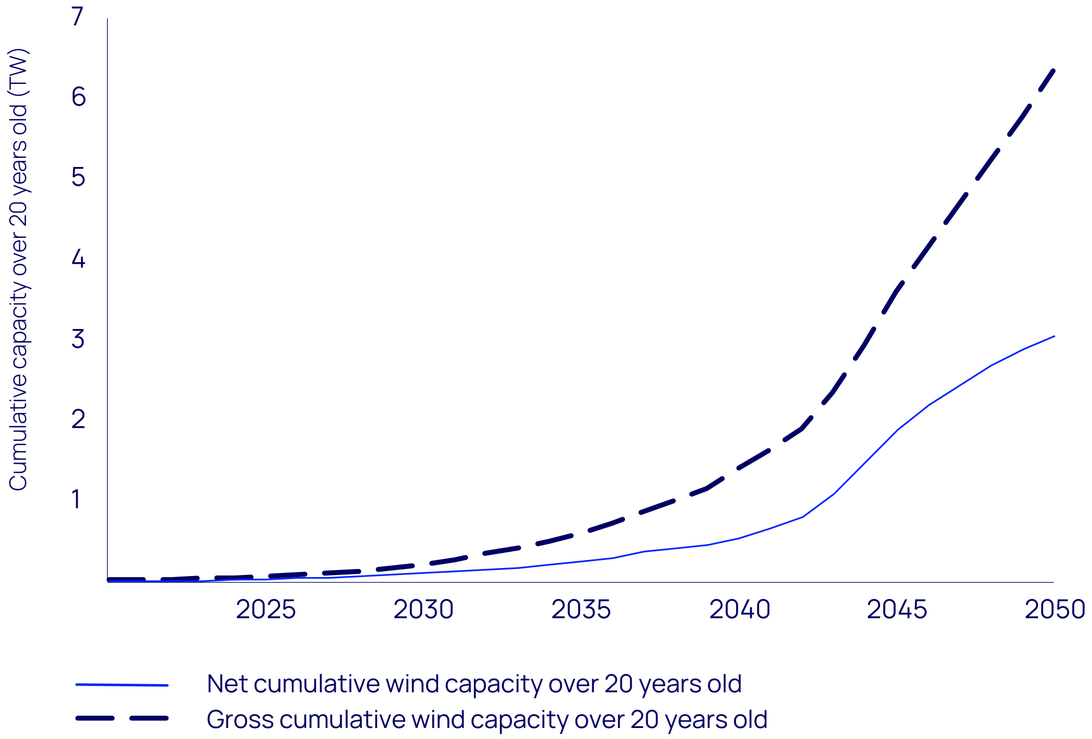
Figure 1: Cumulative global wind and solar capacity over 20 years old



Note: Global excludes Africa, Middle East, Russia and the Caspian; Latin America only includes Argentina, Brazil and Chile. Net cumulative accounts for capacity that is decommissioned and/or repowered, whereas gross is the total capacity connected.

Source: Wood Mackenzie

In a repowering context, this means solar assets have a shorter operational lifetime than they are designed for, as asset owners look to capitalise on new technological advancements rather than repair existing assets.

As solar technology has advanced apace, it has made locating outdated spare parts for existing plants more challenging.

It is more common to see component replacements or repairs in the distributed segment than in utility-scale projects, as these benefit from better upkeep.

Wood Mackenzie has tracked 25,000 decommissioned wind turbines and used this information alongside data on operational projects to derive lifetime assumptions.

As our historical data are project based, we can apply these lifetime assumptions at the project level based on turbine technology, owner type and market-specific factors, accounting for increases in the average project lifespan over time.

Wind as a technology is also structurally different to solar. While a solar panel today can be 300 W, a wind turbine can be up to 15 MW and cost 800,000 times more.

Wind asset owners are, therefore, also opting for more comprehensive operations and maintenance (O&M) programmes, including the replacement of key components that extend the life of the asset beyond the design life of its technology.

This also means that while the wear and tear on a wind turbine is greater because of its many moving parts, it can still outlast a solar panel in some cases.

Repowering sparks decades of innovation and benefits

The fundamental aim of repowering is to either recapture capacity lost to degradation or maintain – or even increase – a site's capacity, boosting the gigawatt hours (GWh) the project produces as a result. Increasing a project's capacity can be a major challenge for owners due to permitting restrictions and grid limitations.

Often, capacity stays the same. Still, repowering can sometimes get additional energy to the market faster than a greenfield project, as it does not have to wait for a grid connection and moves faster through the permitting process.

A repowering project generally competes for the same offtake contracts and subsidies as a greenfield project. The capital and operating expenditures are similar, so the economic advantage largely boils down to higher output.

For example, the wind speeds of the sites that have been decommissioned in Germany so far this decade are 4% higher than the greenfield projects coming online, on average, and the difference can be as much as 30%. A 4% increase in wind speeds roughly translates into 7% higher capacity factors and a 7% lower levelised cost of energy, all else being equal.

There are several ways of repowering wind and solar assets, but the most common is the full decommissioning of the original project and the installation of new wind turbines or solar modules on the same site, while retaining some of the associated infrastructure. Other than being situated in the same location, the outgoing unit and incoming unit are different in almost every way, as the new unit can house more than 20 years of technology innovation.

Repowering can sometimes get additional energy to the market faster than a greenfield project

The most significant innovations are longer lifetimes, lower levels of degradation, more efficient technology and less land use:

1 **Wind turbines and solar modules have become significantly more efficient in recent decades, producing more power on a fraction of the land.**

The average turbine rating has increased from 1.5 MW in 2006 to 6 MW in 2026 and is forecast to reach 7.5 MW by 2036.

This also means that the net number of turbines added is declining as megawatt capacities increase. These efficiencies have been bolstered by higher hub heights, longer rotor diameters, automatic controls and software, condition-monitoring systems and many other improvements that deliver greater efficiency, reliability and performance.

2 **The same applies to solar. Module efficiencies have increased 69% between 2005 and 2025, on average, and technology is already available that could increase cell efficiency by more than 50% to 2045, allowing for more output on less land.**

Average solar sites today are often as much as 30% smaller, with the same capacity as in 2010 – a trend that is expected to continue as new and more efficient modules are introduced.

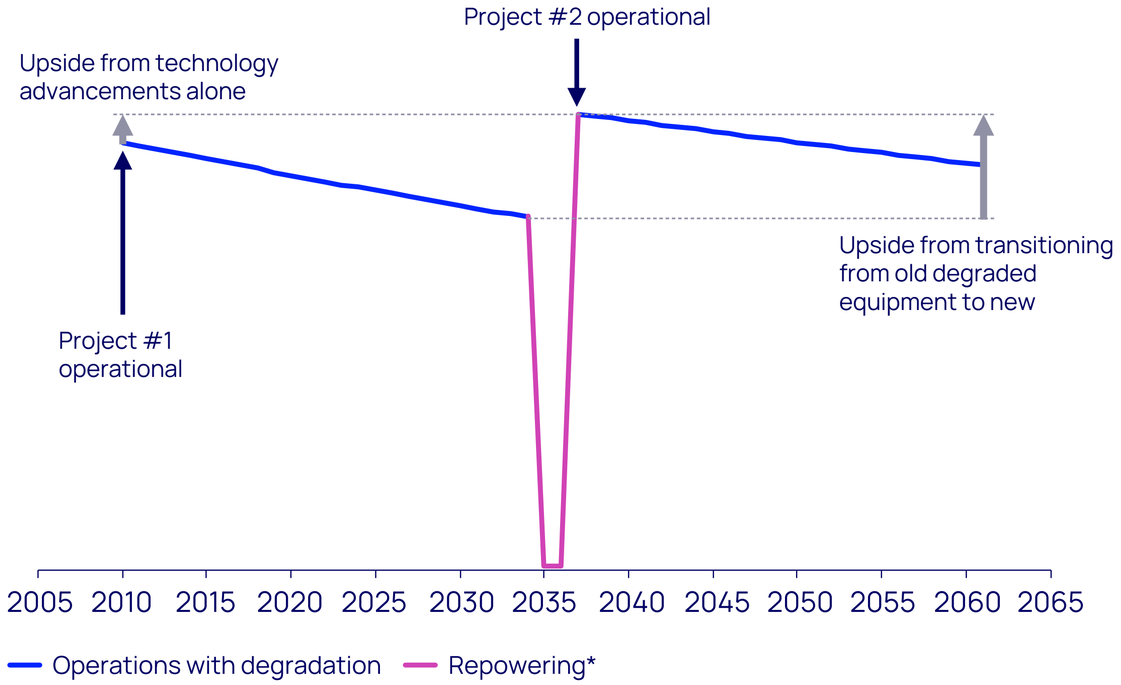
3 **Turbines and modules are not just getting more efficient, they are also getting more durable. The design life of wind turbines has climbed from 20 years to more than 30, while time-based availability has climbed to 97% post-degradation.**

In the case of solar, warranties have jumped from 25 years to 30, while degradation levels in year 25 have improved by 9% over the past decade, and we expect these improvements to continue. This will not only benefit asset owners, but society as a whole, by reducing waste.

The overlooked downsides of decommissioning and the rewards of repowering

The impact of repowering depends on the level of degradation of the existing plant, the technology advances that have accrued since it was built and the extent to which the repowering downtime is optimised. The greater these benefits, the more repowering will help to grow the global renewable energy mix.

Figure 2: Cumulative global wind and solar capacity over 20 years old



Notes: Project #1 and #2 have the same nameplate capacity. *During repowering, the existing equipment is removed and new equipment is installed.

Source: Wood Mackenzie

1 **Decommissioning will increasingly challenge cumulative capacity growth. Governments frequently set renewable supply targets framed as megawatts of capacity, but rarely take decommissioning into account.**

This will make already ambitious targets even loftier. The European Commission, for example, has targeted 500 GW of wind power by 2030, meaning that about 37 GW per year needs to be added between 2023 and 2030. The sector is already falling short on this front, and we expect 17 GW to be decommissioned during that time, so an extra 2 GW will need to be added every year, on average, to achieve the goal. As governments set targets for the 2030s, the drag from obsolete and worn-out equipment will become ever more significant.

2 **Repowering can have a material impact on power markets. In Europe's largest power market, Germany, many assume that the capacity coming offline will be replaced by capacity with the same capacity factor – in other words, that it will produce the same gigawatt hours as the original.**

This fails to capture both the impact of degradation and the potential benefits of repowering. By our calculations, the increased efficiencies from these factors will increase the post-curtailment output for onshore wind in the country by 16% in 2050. In absolute terms, that is the equivalent of almost one-third of Germany's current annual power production from wind, or the entire power demand of Portugal.

Most wind and solar projects built today have contracts that provide revenue support or certainty for the first 10 to 25 years of their life.

Once the contracts expire, asset owners rely on merchant revenues or corporate power purchase agreements, both of which are exposed to the volatility of wholesale power prices. The gains from repowering could create downside risk to post-contract revenue on those projects if nothing else changes, making this a critical issue that companies should be thinking about right now.

For instance, in the case of Germany, the increase in power output from repowering would decrease power prices by between 12% and 19% in the 2040s, all else being held constant.

3 **Without repowering, annual new solar and wind installations would decline. Over the past 20 years, wind and solar have been growth businesses, as cost reductions and greater policy support for decarbonisation have led to more and more renewable installations each year.**

However, in 2026 global wind and solar capacity will decline and without repowering, this decline would continue due to various local factors: slumping policy support in regions such as the US; the achievement of high levels of decarbonisation in places such as Europe; and challenges in expanding the pace of installation in places such as China due to grid integration issues. Repowering will ensure that wind and solar remain a growth business for equipment suppliers.

We estimate that while annual net additions of solar and wind will decrease gradually through 2050, actual equipment sales in 2050 will be more than 60% higher than in 2026 due to the need to replace ageing equipment

Some 44% and 23%, respectively, of the wind and solar buildout in the 2040s will be driven by decommissioning. Repowering will hit the early adopters of renewables more than the new markets.

Consequently, we will see decommissioning driving more than 70% of installations in Europe's established markets in the 2040s, while new markets in Asia could see as little as 1%.

Year-to-year uncertainty in the level of decommissioning will be yet another challenge that equipment suppliers will need to navigate and it will also complicate the efforts of governments to build or maintain domestic manufacturing capabilities.

Depending on the politics of economic nationalism and energy security, it is also possible that developers could repower their sites with a different technology to that originally built.

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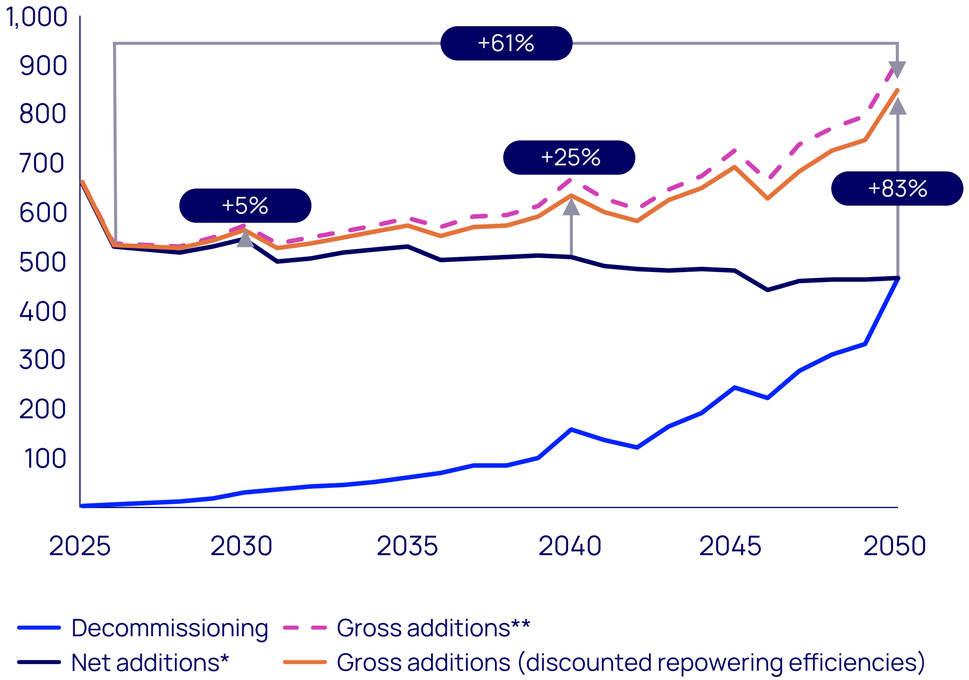
Figure 3: Global wind and solar decommissionings, net additions and gross additions



Notes: Global excludes Africa, the Middle East, Russia and the Caspian Sea. Latin America only includes Argentina, Brazil and Chile. *Net additions refer to the cumulative capacity in a given year minus the cumulative capacity the previous year. **Gross additions are calculated by taking the net additions and adding the decommissioned capacity, as this will also have to be replaced by new capacity.

Source: Wood Mackenzie

Repowering shifts the entry point for asset owners

Widespread ageing of wind and solar assets will mean that, for many projects, the long-term value is not just in the wind turbines and solar modules, but in the site itself, with an existing grid connection, good resource quality, easy access, prior zoning for development and support from local communities. This is fuelling a new phenomenon, whereby companies acquire an operational project in a prime location, decommission it and then install a completely new project.

This will become increasingly common in markets with limited land availability and grid capacity, but also in regions where government or local support for wind and solar is low, making it difficult to secure planning approval for new projects. Leading markets across Europe and the US are the most prone to these trends, however, they could easily spread to markets in Asia Pacific and the Americas.

The large number of small-scale projects in markets such as Germany and France, with private owners and the potential for expansion to improve with economies of scale, could exacerbate this development.

Successful investment will be about timing. It will be about identifying the sites where forecasts of future revenues and government policies align with a willing seller who doesn't recognise the value or lacks the capabilities to seize these opportunities. For owners of existing assets, it will be about estimating the residual value of their assets to know if it makes sense to sell the asset, extend its life or repower it. For the major solar module and turbine original equipment manufacturers (OEMs) an ageing fleet could also present opportunities for both more work and, in some cases, equity if the OEMs can better estimate residual life and more efficiently extend the life of the assets.

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Conclusion: from energy transition to energy renewal

Demand growth is the main theme today, but it will only be half the story in future.

Decommissioning is an increasingly important issue for the renewables sector and is frequently overlooked or misunderstood. Often, it is overshadowed by a focus on policy and demand growth.

We are set to enter a new chapter in the energy transition, energy renewal, which will drive increased renewable investment for decades to come.

In the 2040s, we forecast the rate of growth in global power demand to slow, but solar and wind installations to increase because of decommissioning.

In fact, we are expecting the era of renewal to lead to more installations than ever before.

While the full consequences of this shift may seem some way off, they should be influencing decisions being made today.

If they do not, governments will miss their targets, suppliers will fail to gear up for future demand and owners will overestimate future power prices and potentially miss out on current opportunities.

With thanks to: Sasha Bond-Smith, Michelle Davis, Khalif Ahmad Zikri and Rishab Shrestha.

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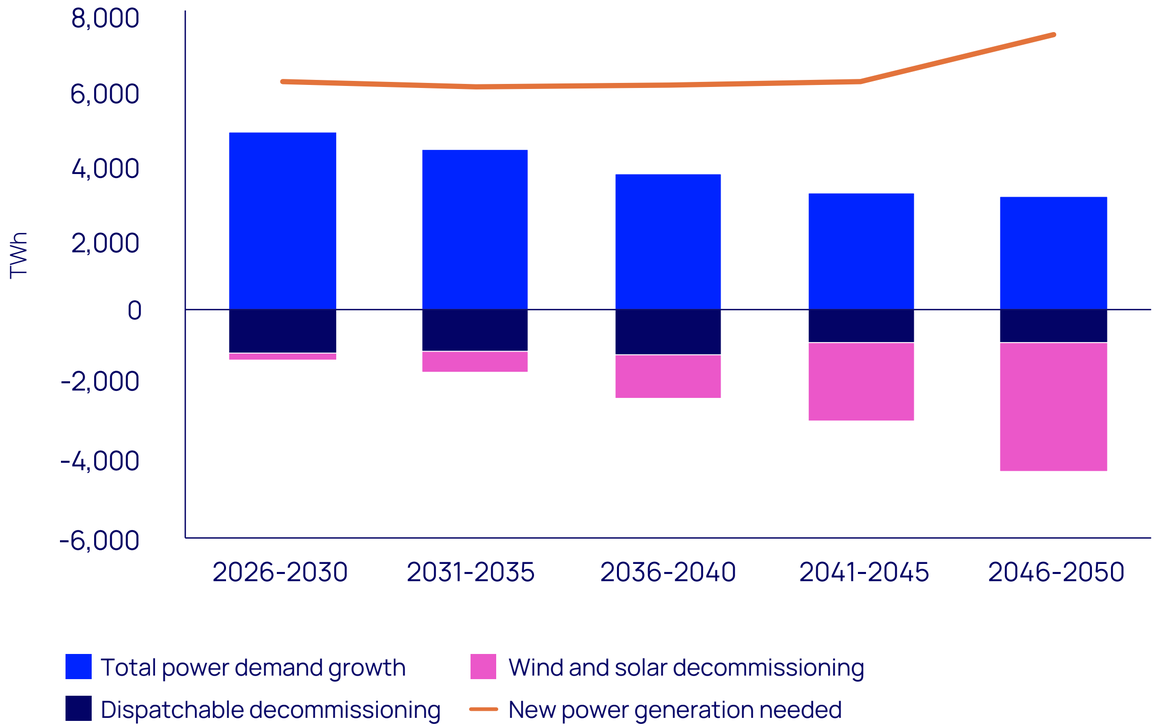
Figure 4: Global wind and solar decommissionings,net additions and gross additions



Notes: Global excludes Africa, the Middle East, Russia and the Caspian Sea. Latin America only includes Argentina, Brazil and Chile. Dispatchable generation includes conventional power, nuclear, biomass and other technologies. Decommissioning of other renewables, including hydro, is excluded, as it only makes up 1% of total decommissioning

Source: Wood Mackenzie

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