



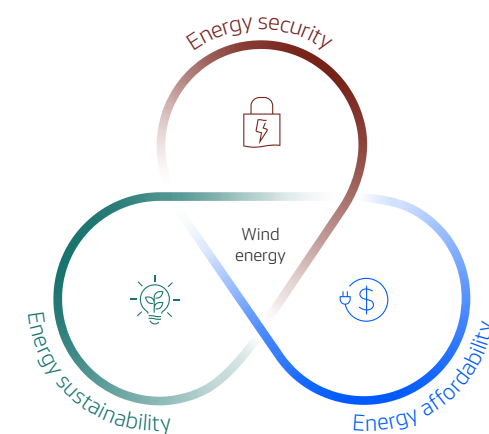
ENERGY IS POWER THE WHITE PAPER

Vestas[®]



Wind energy is our strongest line of defence in a world where our energy systems are increasingly threatened, while continuing to rely on imported energy. From cyber-attacks and geopolitical tension, to fluctuating energy bills and extreme weather events, it's time to rethink how we protect, and grow our energy systems.

This whitepaper outlines what is at stake, and how wind energy and Vestas can make energy systems more secure, affordable, and sustainable; protecting our energy from the risks we can see, as well as the ones we can't.



Secure

Energy systems around the world are targeted by hostile actors



Film still: From the campaign film developed as part of the National Air Force campaign.

Worldwide attacks on energy systems are increasing in both frequency and sophistication. Attacks can take several forms, including strategic disruptions to energy supply, and attacks designed to infiltrate digital control systems. According to the International Energy Agency (IEA), cyberattacks against energy organisations have risen steadily since 2020, with the average number of weekly attacks more than doubling between 2020 and 2022 and continuing to increase since.¹ [The NATO-EU Task Force on Critical Infrastructure Resilience warns that critical energy infrastructure faces a “heightened level of risk” from increasingly complex cyber, physical and hybrid threats, underscoring the growing security challenge facing energy systems worldwide.](#)²

Rather than focusing solely on immediate disruption, attackers are trying to influence energy markets, undermine critical infrastructure and gather intelligence. Threat actors are also seen quietly establishing a foothold in energy systems to lay the foundation for future attacks.³ As power systems become more electrified, digitized and interconnected, these threats are becoming more difficult to detect, anticipate, and defend against.

Some examples of modern attacks on energy systems include:

1. Disruption to energy supply

Energy infrastructure can be targeted to influence geopolitical outcomes or create economic pressure. The threatened closure of the Strait of Hormuz, through which around one-fifth of global oil consumption passes, demonstrates how geopolitical conflict can disrupt energy supply and create global price disruption and security risks. The 2021 cyberattack on the Colonial Pipeline, the largest fuel pipeline in the United States, temporarily halted fuel deliveries across the U.S. East Coast, triggering shortages and highlighting the vulnerability of critical energy infrastructure to cyber threats. Together, these incidents show how both physical chokepoints and cyberattacks can disrupt energy flows, with consequences extending far beyond the affected region.

2. Power outages

The RedEcho campaign showed that attackers can disrupt the delivery of electricity by manipulating grid-connected systems⁴. Security researchers identified that members of RedEcho (a cyberespionage group) attempted to manipulate power infrastructure in Mumbai, leading to the 2020 Mumbai power outage. The

incident highlighted how cyber operations can be used to create real-world impacts on electricity systems.

3. Pre-positioning

‘Pre-positioning’ means planting access to critical infrastructure to lay the foundation for future attacks. There have been several documented cases of cyber-attackers gaining access to energy systems through undocumented communication devices, or cyberespionage activity. Undocumented communication components have been found in batteries and solar power inverters.⁵ Cyberespionage group Volt Typhoon have been found to infiltrate infrastructure networks in both Europe and the U.S.⁶

The unique position of wind turbine suppliers

Wind turbine manufacturers occupy a uniquely influential position within modern power systems because they operate across both the physical and digital layers of turbine operation. Turbine manufacturers run a vast ecosystem of software and hardware from the overarching turbine controller, to pitch systems, SCADA interfaces, remote monitoring platforms, and the communications pathways connecting turbines, wind farms, substations, grid operators, and external networks.

The turbine manufacturer is the only party with visibility across all digital and physical operations. This position is significant because modern turbines combine electronic devices with remote connectivity. As grids become increasingly dependent on electricity generation and storage technology, the risk of disruption and manipulation from a hostile attacker increases.

[Turbine manufacturer-level access is essential for maintenance, optimization, software updates, and grid-code compliance. This privileged access can create potential vulnerabilities if turbine manufacturers are subject to influence, direction, or obligations from foreign governments. In periods of heightened geopolitical tension, such access could present security risks ranging from intelligence gathering to potential disruption of critical energy infrastructure, underscoring the importance of carefully assessing supply-chain and operational security risks in energy systems.](#)⁷

¹ [Cybersecurity – is the power system lagging behind? – IEA](#) ² [EU-NATO Final Assessment Report Digital.pdf](#) ³ [ATA 2026: China, Russia, Iran, North Korea Treat U.S. Infrastructure as a Standing Battlespace: Hostile States ‘Pre-Positioning’ for Cyberattacks on Critical Infrastructure, Canadian Security Agency Warns – NTD CANADA: NCSC CEO: Hostile states linked to three-quarters of cyber attacks affecting UK’s critical systems | National Cyber Security Centre](#) ⁴ [China-linked Group RedEcho Targets the Indian Power Sector Amid Heightened Border Tensions](#)

⁵ [Rogue communication devices found in Chinese solar power inverters | Reuters](#) ⁶ [The looming cyber threats to US ports, and critical infrastructure by ‘Volt Typhoon’ - The Loadstar](#) ⁷ [High-Risk ICT Vendors and Critical Infrastructure: European Approaches](#)

Vestas puts countries in control of their own energy systems

The majority of energy in Europe is still imported, with 57% of energy imported in 2024⁸. Accelerating the deployment of wind energy reduces dependency on imports, and creates the opportunity for countries to expand their energy systems to meet demand, while maintaining full control over them.

Wind energy, powered by Vestas, is the fastest way to meeting growing demand, with secure, domestically controlled energy.

Investments in the energy sector must be subject to the highest levels of national security scrutiny. Managing the digital attack surface of wind turbines and wind power plants requires close collaboration between national authorities, electricity and grid operators, technology manufacturers, and ultimately the asset owners. Governments are becoming increasingly aware of these risks and are likely to place even greater emphasis on energy security in the years ahead, and Vestas is ready to collaborate with governments to address this risk.

– **Cybersecurity** – Vestas delivers modular, scalable, cyber security solutions built to shape and uphold global standards, with a risk-based approach. This means that we continuously identify, assess, and prioritise the most relevant cybersecurity risks across the entire operational lifetime of energy assets. This includes ongoing assessment of technical and non-technical risks, vulnerabilities, supply chain dependencies, and evolving threats. With this approach we can ensure the resilience, availability, and integrity of wind power operations. We embed protection into operations from the ground up, from access control and encrypted data flows to continuous monitoring for nefarious activity.

– **Risk-profile:** Vestas is a low-risk partner with a proven track record of responsible business conduct, strong governance, and secure management of critical infrastructure. These attributes allow us to operate on the basis of trust and long-term partnership.

Vestas puts countries in control of their own energy supply

As the world's most experienced wind energy company, Vestas enables countries to translate the energy security benefits of wind into reliable, domestic power generation at scale.

– Countries that have increased the deployment of wind energy, have also benefitted from a consistent reduction in dependency on fuel imports – More than 100 countries have cut their dependence on fossil-fuel imports by continuing to invest in renewables.⁹

– **Wind energy reduces dependency on imports** – by generating electricity domestically instead of relying on imported fossil fuels.

– **Wind is home grown and quick to install.** The IEA's analysis of permitting, construction and grid connection times shows that onshore wind projects are typically completed in around 3-5 years, making them substantially quicker to deploy than other technologies.¹⁰

⁸ Energy in Europe: imports dependency - News articles - Eurostat ⁹ IEA: Renewables have cut fossil-fuel imports for more than 100 countries - Carbon Brief ¹⁰ Average observed lead time for permitting, construction and grid connection for selected energy projects - IEA



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Affordable

Volatility makes the price of imported energy unpredictable

Energy prices are more volatile in countries that are highly exposed to imported energy markets, with countries that have a higher share of wind energy better insulated from price volatility during periods of supply disruption.¹¹ Fossil fuel price volatility is creating major public finance costs and rising oil and gas prices are pushing up consumer costs across Europe and globally.

¹¹ From energy crisis to energy security: Actions for policy makers

Wind keeps the price of energy stable and predictable

Dependence on fuel imports will always create the possibility for volatility in energy prices. This volatility impacts not just energy bills, but on several facets of the economy.

- Fuel subsidies buy time, not solutions. Dependence on fossil fuels markets has led to the need for fuel subsidies in some countries.¹² Fuel subsidies can temporarily shield consumers from higher energy prices, but they do not address the underlying cause of those price increases. Wind reduces the need for fuel subsidies by reducing dependence on volatile fossil fuel markets.¹³
- Wind energy can help shield economies from inflationary pressures by reducing exposure to volatile fossil fuel markets. The International Energy Agency concludes that a renewables-rich energy system reduces overall exposure to fossil-fuel price volatility¹⁴, while the European Environment Agency finds that renewable electricity already acts as a powerful buffer against gas price shocks, saving European consumers €29 billion in 2026 alone.¹⁵
 - Ørsted's recent offshore tax dispute highlights that once built, wind farms generate electricity without requiring fuel purchases.¹⁶
- Wind keeps power prices stable and can support stability across borders in an interconnected energy system.

- Greater wind and renewable generation can stabilize electricity costs during periods of fossil fuel volatility. As the prices of oil and gas rose during the closure of the Strait of Hormuz, gas determined electricity prices only 15% of the time in Spain compared with 89% in Italy, helping keep Spanish power prices around half those of Italy.¹⁷

[12. Subscribe to read: "Fuel subsidies weigh on public finances as energy crisis deepens". The Financial Times](#) [13. Subscribe to read: "Fuel subsidies weigh on public finances as energy crisis deepens". The Financial Times](#) [14. Price shocks and affordability - Strategies for Affordable and Fair Clean Energy Transitions - IEA](#) [15. Renewable electricity: best buffer against gas price volatility | Publications | European Environment Agency \(EEA\)](#) [16. Ørsted claims victory in \\$1bn row over offshore wind 'double tax' | Recharge](#) [17. Subscribe to read: "Spain is a role model in weathering Iranian oil shocks". The Financial Times](#) [18. Lazard Releases 2026 Levelized Cost of Energy+ Report | Lazard](#) [19. Renewable Power Generation Costs in 2023](#) [20. Renewable energy and jobs: Annual review 2023](#) [21. Renewables 2023 - IEA](#) [22. The Effect of Renewable Energy Consumption on Current Account Balance: Panel Data Analysis](#) [23. Cyber Risk and Digitalized Energy Assets: Key Considerations for Debt and Equity Transactions](#) [24. Cyber Risk and Digitalized Energy Assets: Key Considerations for Debt and Equity Transactions](#)

- When comparing levelized-cost-of-energy, onshore wind has been found to be the one of the lowest-cost sources of new electricity generation¹⁸, substantially lower than fossil fuel alternatives.¹⁹

Overall, research shows that increasing the share of renewable energy in a country's energy system can strengthen economic growth, and potentially benefit international competitiveness. By investing in renewable energy, any country has the potential to reverse a pattern in which expensive fossil-based energy is imported while generating relatively few domestic jobs.²⁰ In the longer term, any country could instead strengthen its position as a net exporter of green energy.²¹ At the same time, greater reliance on renewable energy could provide national companies with a significant competitive advantage. Countries with a high share of renewable energy can reduce current-account deficits and potentially increase GDP.²² Consequently, if a country is able to produce a larger share of its own energy from low-cost, clean sources, this could improve the international competitiveness of national businesses while strengthening GDP. Such developments would benefit both the private sector and public finances.

Vestas deploys wind energy more effectively than anyone else

- +207GW installed wind capacity across 88 countries (more than anyone else)
- +165GW under service (the largest fleet in the world)
 - As a supplier that strengthens energy security, Vestas can support a stronger business case, and protect consumers from additional costs associated with energy security risks.
 - Evidence from energy infrastructure finance shows that cyber and supply-chain risks are increasingly treated as valuation factors by investors and lenders. Consequently, a turbine supplier assessed as a cybersecurity or national-security risk may increase regulatory uncertainty, operational costs, financing costs, and asset-life risks reducing the long-term economic value of the project.²³
- These additional costs may also increase the project's levelized cost of electricity and, depending on market and regulatory arrangements, may ultimately be passed on as additional cost to electricity consumers.²⁴

Sustainable

Decarbonisation is critical to address the climate crisis

Despite political pushback in some countries, roughly two-thirds of the world's nations still maintain a net-zero objective, covering approximately three-quarters of the global GDP and global greenhouse gas emissions.²⁵ Evidence shows that climate change is not only raising average temperatures; it's also increasing the likelihood and severity of heatwaves, extreme rainfall and flooding, and conditions that drive major wildfires around the world.

Europe is currently the fastest-warming continent, with land temperatures rising roughly twice as fast as the global average, and heatwaves becoming longer, more frequent and more intense.²⁶

[25. Net Zero Tracker | Welcome](#) [26. Extreme weather: floods, droughts and heatwaves | In-depth topics | European Environment Agency \(EEA\)](#)



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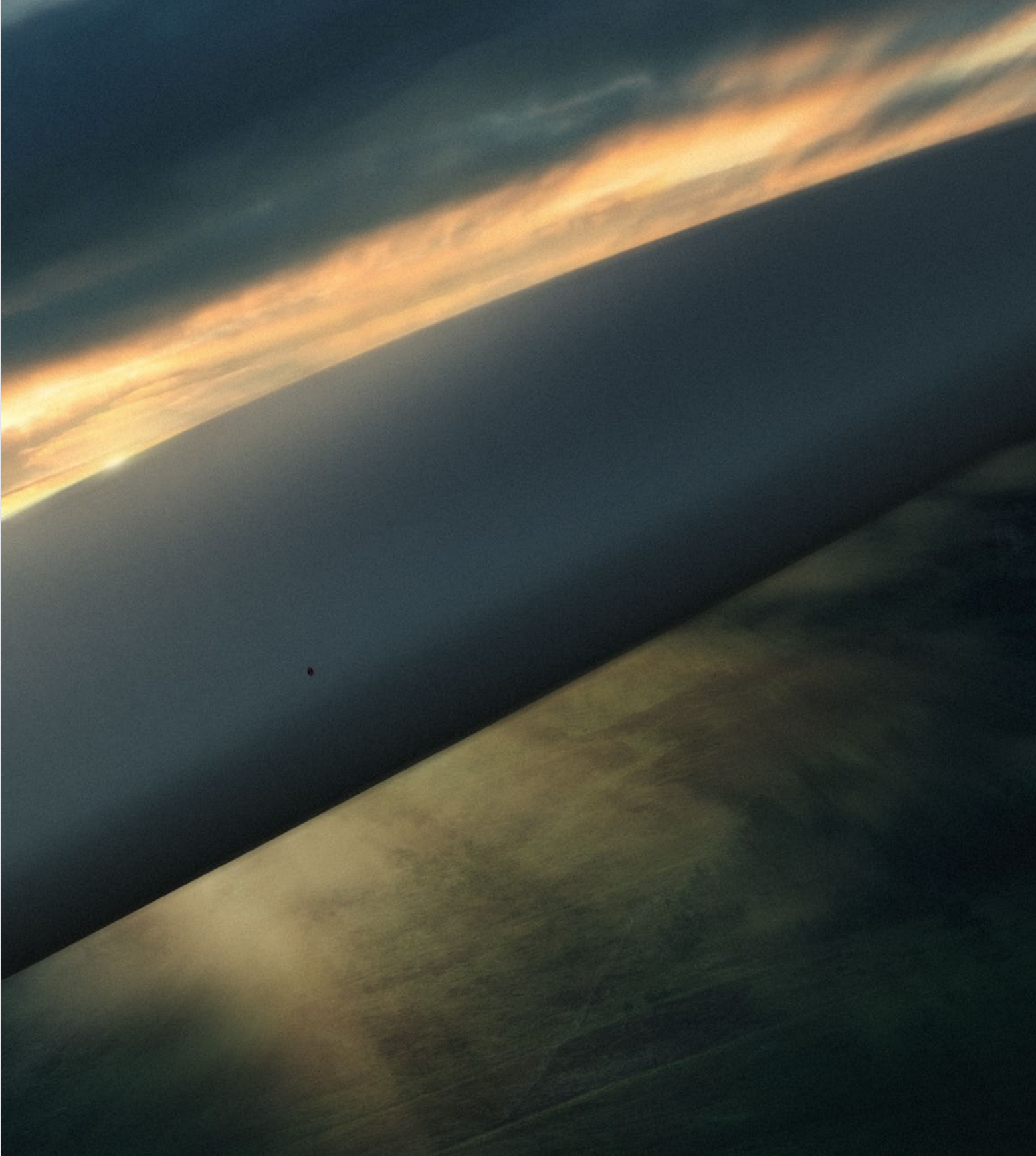
Decarbonising the energy system is critical to slow down global warming, and requires a rapid expansion of renewable energy sources. Wind energy is one of the most effective technologies for reducing greenhouse gas emissions from the energy sector while supporting the transition to a low-carbon economy.

Vestas advances sustainability across the wind energy value chain
Climate: The installed Vestas turbine fleet had the capacity to avoid 245 million tonnes of GHG emissions annually at the end of 2025. We focus on a science-based decarbonisation of our operations and supply chain, aiming to reduce GHG emissions from our own operations by 50% and supply-chain emissions per MWh generated by 45% by 2030.

245M tonnes
GHG emissions potentially avoided annually

Circularity: We aim to produce zero-waste wind turbines by 2040. We have already achieved an approximate 97% recyclability rate of the entire wind turbine and, through enhanced material handling and process optimisation, achieved a 69% recycling rate of our manufacturing waste in 2025. Circularity is more than waste reduction. By recovering and reusing valuable materials, it can strengthen industrial resilience, improve resource security and reduce exposure to future material constraints.

Social: We aim to be the safest, most inclusive, and socially responsible company in the energy industry. Our priorities include protecting the safety and wellbeing of employees and local communities, conducting social due diligence in line with international standards, and building a diverse and inclusive workforce. In 2025, we achieved a Total Recordable Injury Rate (TRIR) of 2.7, covered 20% of in-scope projects through our social due diligence processes, and women represented 25% of our corporate leadership.



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