What if airborne wind farms became a widespread reality?

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High Energy

UNCERTAINTIES

Systems, Technology

MEGATREND (Most significant)

Energy Boundaries

TRENDS

Cross-Sectoral Partnerships
Net Zero
New Materials

TECHNOLOGIES

Advanced Connectivity
Energy Transformation
Internet of Things (IoT)

SECTORS IMPACTED

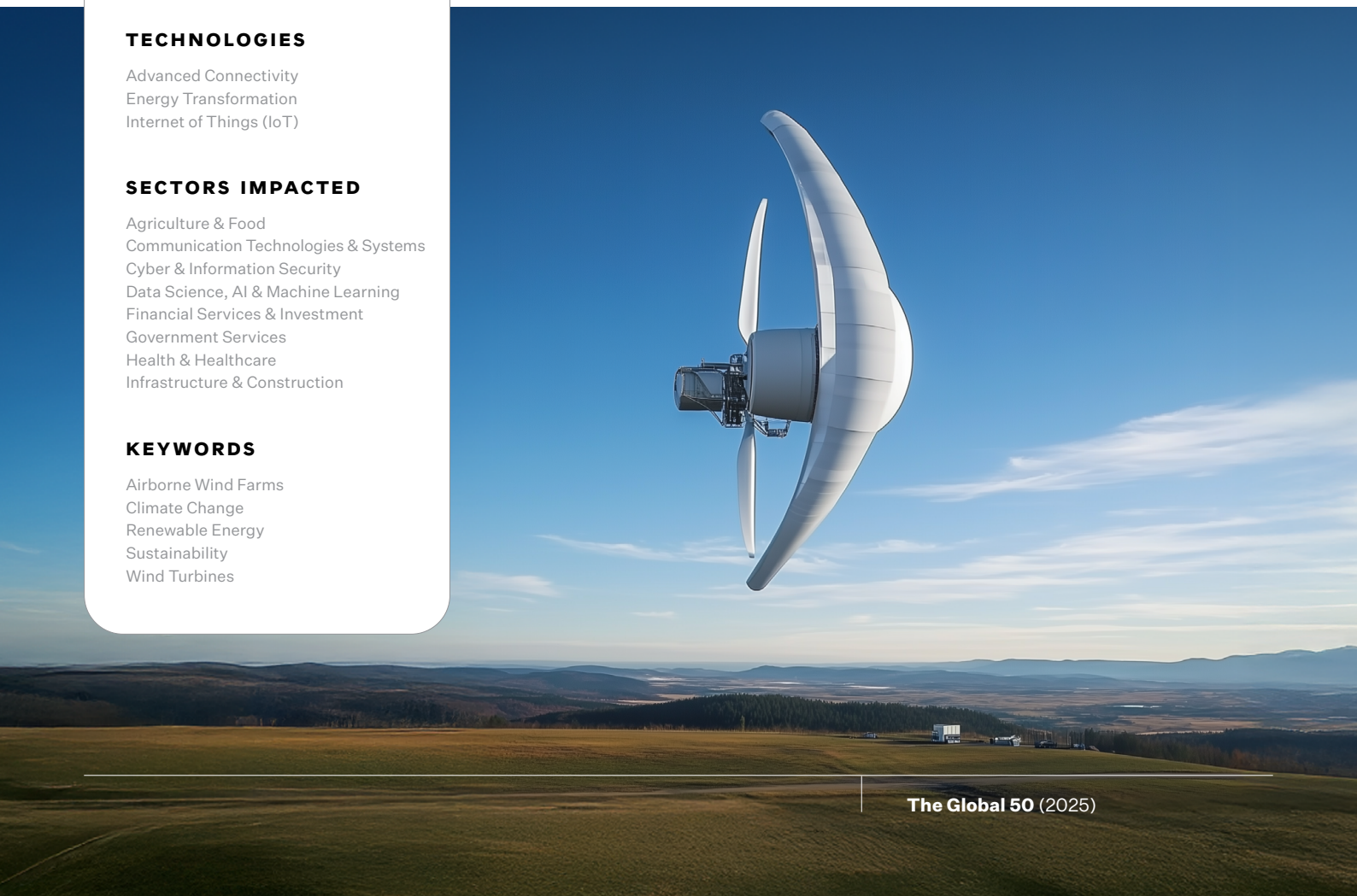
Agriculture & Food
Communication Technologies & Systems
Cyber & Information Security
Data Science, AI & Machine Learning
Financial Services & Investment
Government Services
Health & Healthcare
Infrastructure & Construction

KEYWORDS

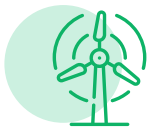
Airborne Wind Farms
Climate Change
Renewable Energy
Sustainability
Wind Turbines

Within Reach | **Transitional** | Visionary

Next-generation airborne wind turbines, durable and resilient to high winds, provide a new form of urban and remote energy generation by capturing energy from high-altitude winds to power future cities.



WHY IT MATTERS TODAY



Technological advances in wind turbine design and 3D printing offer solutions to unlock

80%

more wind energy potential, addressing **challenges posed by shifting weather patterns and urbanisation**

There are increasing global demands for renewable energy, but global renewable energy growth is not expected to meet the 28th United Nations Climate Change Conference (COP28) goal of tripling global renewable energy capacity by 2030.[762] Electricity generation from wind grew by 265 TWh (14%) in 2022, reaching 2,100 TWh.[763] To meet the goal of multiplying this capacity by three and a half times by 2030, consistent annual capacity additions of 14-17% will be required.[764]

Shifting weather patterns are changing the viability of wind energy. Currently, 93% of global wind capacity is onshore,[765] but an expected decline in wind resources in the northern hemisphere – due to climate shifts[766] – is pushing certain regions that had invested in onshore wind farms to reassess their sustainability and viability.[767] Technological advances (e.g. in blade design, materials, and system optimisation) and advanced manufacturing (including 3D printing) are expected to unlock an estimated 80% more wind energy potential this decade[768] and to increase the energy capture per turbine.[769]

Rapid urbanisation and limited acceptance are reducing options for traditional wind turbines onshore. Roughly 56% of the world's population (4.4 billion people) currently live in cities, and this number is expected to more than double by 2050, with almost 70% living in cities.[770] Traditional wind turbines are not suitable for urban environments, as urban areas do not have enough space for these large structures and people often mount strong resistance because of concerns regarding noise and appearance.[771] Moreover, urban environments do not provide the winds required for efficient energy harvesting.[772] Integrating wind turbines into high-rise buildings – as has been done, for example, in the 240-metre-high Bahrain World Trade Center, where turbines are designed to provide 11–15% of the tower's energy needs[773,774] – allows the capture of stronger winds at higher altitudes within the urban environment.

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THE OPPORTUNITY

BENEFITS

Energy capture from stronger, more consistent winds; provision of energy in remote and urban areas.

RISKS

Dependence on consistent wind conditions; bird strikes; interruptions to air traffic; high cost to build and maintain.

Breakthroughs in engineering, materials science, and nature-inspired designs enable a new generation of airborne wind turbines that are durable and more resilient to high winds. These advanced designs capture energy from stronger, steadier winds at altitudes between 300 and 10,000 m[775] in remote, off-grid,[776] challenging terrain,[777] and even urban environments.

As systems, airborne wind farms convert wind energy into electricity either at ground level or in the air.[778] Biomimetics inspires innovations that enhance turbine blades, while advanced machine intelligence enables more efficient, safer designs that reduce bird strikes and prevent damage or safety incidents from malfunctions,[779] potentially scaling the system to more than 1 MW.[780]

Towers such as Burj Khalifa in Dubai (828 m),[781] Merdeka 118 in Kuala Lumpur (679 m),[782] and the One World Trade Center in New York (541 m)[783] could integrate these wind turbines into their structural designs, bringing wind energy generation into urban environments.

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