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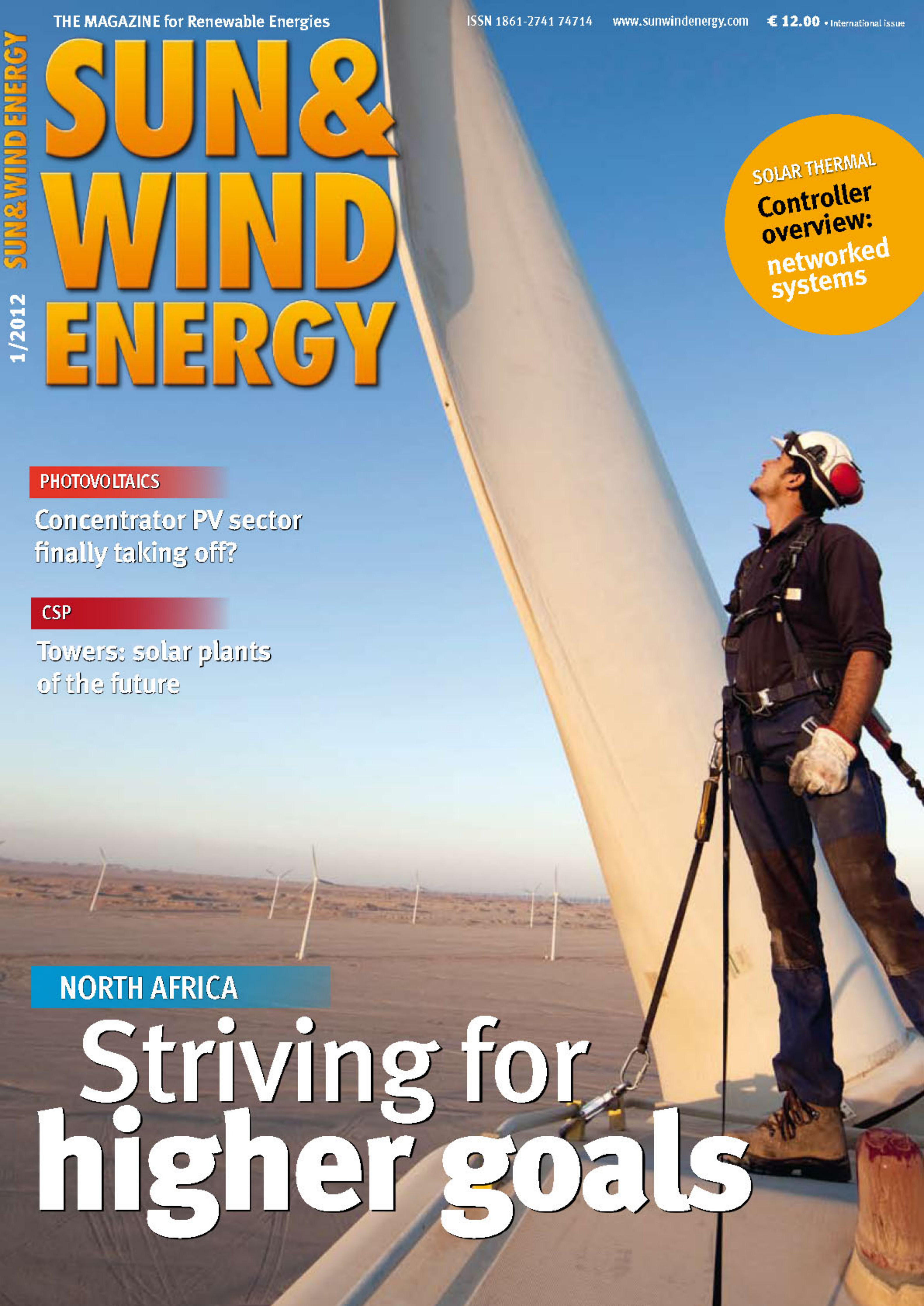

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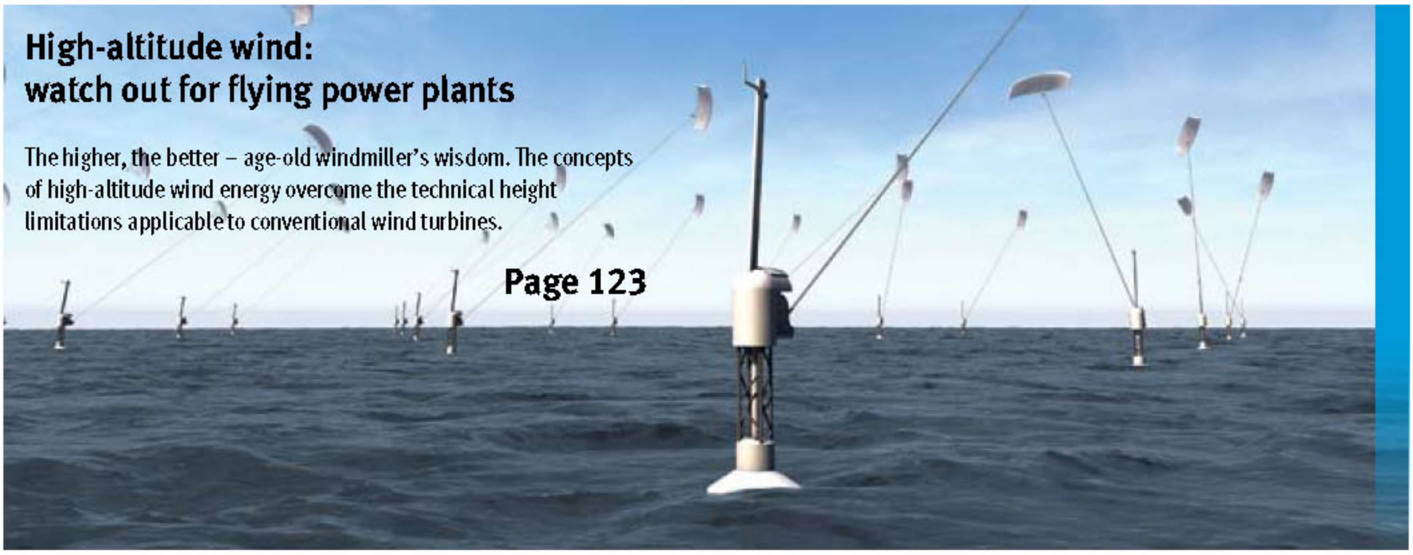

High-altitude wind: watch out for flying power plants

The higher, the better – age-old windmiller's wisdom. The concepts of high-altitude wind energy overcome the technical height limitations applicable to conventional wind turbines.

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Graphic: SkySails

Photo: Solar Frontier

Country Special Japan: more renewables, less nuclear power

Nothing is as it used to be in Japan after the Fukushima nuclear accidents. The Japanese government is therefore ambitious to put a stronger focus on regenerative energies. New feed-in tariffs are already under way.

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Photo: Linddana

Wood chipping: robust technology for long-term use

Wood is in demand as an energy source. In Europe, its use is increasing steadily. Manufacturers of specialized machinery are meeting the new demand by introducing new harvesters and chippers.

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Watch out for flying power plants!

The higher, the better – age-old windmiller's wisdom. The concepts of high-altitude wind energy overcome the technical height limitations applicable to conventional wind turbines.

There is no shortage of bold ideas in the world of wind energy: gigantic framework constructions standing in water depths of 50 metres or more, for example. Or 160-metre high lattice towers topped by multi-MW turbines. The technical systems gathered together in a study drawn up by consultants GL Garrad Hassan, however, eclipse them all. High-altitude wind energy and airborne wind energy are the technologies which are intended to harvest the power of the wind at hub heights far beyond anything known to date. And when we say high, then we mean really high: the figures discussed range from 300 metres to heights well into the troposphere, several kilometres above the Earth's surface.

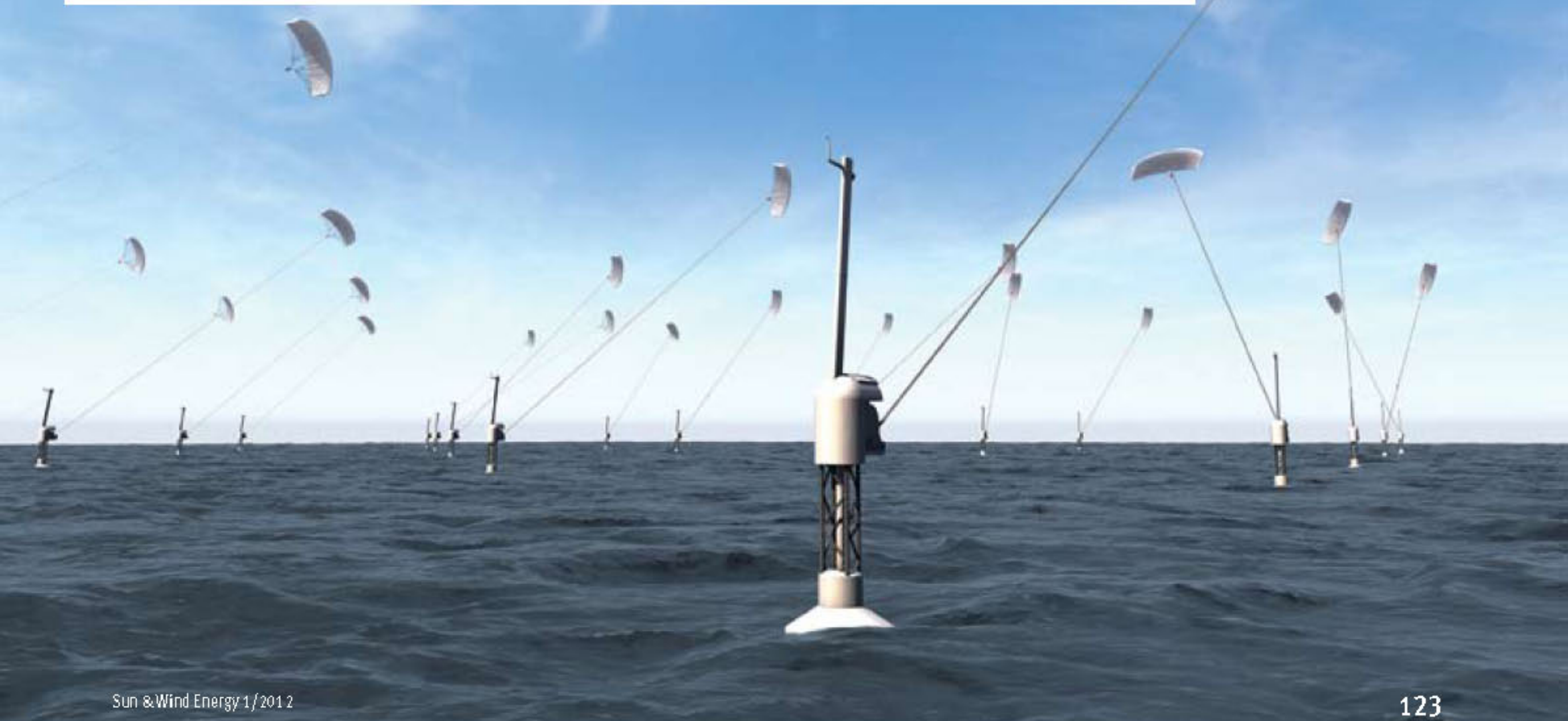
Is that all just computer fantasy? "The time for mere visions is over," says Peter Frohböse, one of the experts involved with such – at first sight – exotic applications at GL Garrad Hassan. "We are now starting serious research projects." The first companies are looking for investors to help the most promising solutions through to the prototype phase.

Forcing down production costs

The study names two principal motives for the development of airborne wind technologies. Firstly: onshore wind energy occupies considerable areas of land, preferably in the vicinity of the load centres. As the study authors point out, this space demand is one of the biggest limiting factors for onshore projects. The alternatives are offshore turbines ... or else airborne solutions. What cannot be done on land must take either to the water or to the skies.

The second motive: offshore wind is especially complex and expensive in greater depths of water. That results in higher production costs than for onshore turbines or conventional power plants. The current calculations of the airborne technology companies, on the other hand, claim that the production costs could be forced down to 5 to 6 €-ct/kWh, which according to Frohböse would enable them to be competitive with written-off conventional power plants. If we believe the researchers from the Italian company Kite Gen, even costs of just 3 €-ct/kWh are feasible if their concept is scaled up to the maximum possible dimension.

Such tantalising prospects can be attributed above all to the favourable wind conditions at great heights. Consequently, the authors of the study paid particular attention to the meteorological aspects of the airborne technology. The discussed concepts refer to heights exceeding 300 metres, with a main focus on altitudes beyond 2,000 metres. That is naturally far above the realms of classic wind energy use.



The North German company SkySails has developed an offshore concept with buoy-like floating platforms which are anchored on the sea bed. The wind energy is harvested by kites flying figures of eight. As the kite rises to a height of 800 metres, the tethering line is unwound and drives the generator on the platform.

Graphic: SkySails

The kite-driven power plant from Kite Gen achieves an output of up to 3 MW – here a prototype which went into operation in 2011.
Photo: Kite Gen

Wind without turbulence

Against the above background, it was difficult to obtain reliable data for assessment of the different approaches. And the few data which were available had to be interpreted with extreme caution.

The atmosphere is engaged in continuous dynamic and thermal interaction with the Earth's surface, with constant exchanges of energy, impulses and mass. That results in turbulence, which in turn detracts from the yield of a wind turbine to a greater or lesser extent, depending on the height. From a certain height, which may vary according to region, local ground topology and time of the day, however, such disturbance ceases. Meteorologists here speak of the atmospheric boundary layer, which typically lies at an altitude between one and two kilometres during the daytime.

The area above this boundary is the coveted layer of the atmosphere for wind energy engineers, as it is no longer subject to turbulent air movements. Taking tolerances and safety margins into account, they pinpoint heights of 2,000 metres and more. Studies of the energy density distribution suggest a peak wind energy capacity at around 9,000 to 10,000 metres. Consequently, there are at least two high-altitude concepts targeting such heights for the longer term, namely those of Joby Energy and Sky WindPower.

Generator on the ground or in the air

Joby Energy is one of over 20 high-altitude companies at various stages of development around the world. "The basic starting point is always the same", says Frohböse. "The wind above 300 metres is to be used for power generation." It is relatively certain that the wind is both stronger and more constant at such heights. There are two fundamental solutions for the harvesting of this energy potential. In one case, the generator and other electrical components are installed as a ground station, and only the aerodynamic modules are actually in the air. The charm of this idea, as Frohböse explains, is that "all you need for each extra metre of height is an extra metre of cable".

The alternative: all the power-generating equipment is accommodated together with the aerodynamic components – at the top of the system. The only connections to the ground are here the tether and the power transmission. One major benefit of a flying turbine is that the complicated mechanical energy and power transmission to the ground can be eliminated. On the other hand, an airborne turbine needs some kind of buoyancy system to lift it into the air and to keep it there. This would consume a certain proportion of the energy obtained – a clear cost disadvantage.

Another point for discussion is the power transmission cable, which would have to be several kilometres long and would be correspondingly heavy, not to mention the power losses. The anchor cables must also not be forgotten. For weight reasons, therefore, all airborne systems integrate the power and anchor cables into a single link. Sky WindPower has chosen insulated aluminium cable with a kevlar sheath – definitely not a cheap solution. Frohböse: "The airborne solutions must use new materials, so as to be sufficiently light. A conventional cable would already mean several hundred kilograms of additional weight to be lifted."

Wing with propellers

One typical representative of this system is the Makani Airborne Wind Turbine. It comprises a wing similar to the wing of an aircraft, with propellers mounted on its leading edge. At take-off, the power link is effective in the reverse direction: mains power drives the propellers to bring the system to its operating height of at least 300 metres. The Makani AWT is then released to fly in circles like a kite, and the propellers are switched to generator mode. "The idea is to simulate the circular motion of a conventional wind rotor, but without the whole turbine structure", says Corwin Hardham, CEO of Makani Power. Where a conventional 1 MW turbine would tip the scales at around 100 t, he continues, the Makani system weighs only one-tenth of that for the same nominal output.

One "major problem" which Makani Power is yet to solve, however, is the noise produced by the system. At full power, the Makani wing circles at a speed of over 220 km/h – and the propellers are then turning at almost 400 km/h.

Kite with carousel

Noise and the far-from-trivial task of keeping the drive units and the heavy power cable in the air are probably the main reasons why kite-based concepts dominate. Eight of the 22 projects rely on a kite to drive the generator via its tether lines and a winch drum. The high-altitude kite here follows either a circular or figure-of-eight flight path.

One example is the carousel concept of the Italian company Kite Gen. An autopilot system controls the kite such that the carousel-like generator begins to rotate. The relative position of the airfoil determines the sequence of power supply and power generation phases. It goes without saying that power generation phases predominate. According to the developers, enormous nominal outputs can be achieved with just a single system. In the jumbo variant, the "Kite Gen Carousel" would sweep the equivalent of a ground area 1,600 m in diameter, reaching a nominal output of 1,000 MW. And as if that were not already enough: with around 5,000 full-load hours per year, the carousel would outshine even the most favourably located offshore turbine system.

Despite the overall low investment costs, it remains important to consider the costs for maintenance, says Frohböse. As an engineer, he recognises that this point demands a differentiated perspective – especially where the kites are to rise to altitudes of several kilometres: "The cables could prove to be a problem. The kilometre-long tether must be constantly wound and unwound. That could bring high outlay for maintenance. And the same can be said about the kite itself."

Commercial applications already in 2020?

The critical discussions which unfold with regard to the high-altitude technology are addressed above all to the space requirements for these concepts. "Most of these concepts will encounter difficulties in densely populated regions", says Frohböse. The ground-based systems like the carousel generator are especially expansive. "With a kite solution, the ratio of area to installed capacity is a least as high as for conventional wind energy. In fact, the space requirements for a kite system are probably even higher." That would be a real hindrance to the marketability of high-altitude technologies. According to the authors of the study, greater land use would impact the acceptance. The restrictions for air traffic are another factor.

But as in other cases, it is always possible to turn to the oceans if there are too many problems on land. "There is real market potential if the sector concentrates on offshore applications", the authors write. They see possibilities for the high-altitude technologies to the east of Japan, in the Northern Pacific, off the east coast of North America and to the west of the British Isles. These are all regions with wind conditions which are particularly interesting for conventional wind energy. The problem is the water depth, which exceeds the capabilities of conventional foundation structures. High-altitude applications could thus serve to complement conventional technologies. The desert regions of Northern Africa and Asia are similarly worth consideration: Desertec with high-altitude wind instead of solar?

The future development is very much dependent on the operational availability of the high-altitude systems. The sector radiates cheerful optimism in this respect, and modesty is certainly not a typical character trait in the high-altitude community. Some representatives are convinced that the first commercial applications could already be delivering their enormous yield by 2020. Frohböse is a little more restrained in his forecasts: "It is true that the technology is no longer a mere vision à la Jules Verne. But as far as 2020 is concerned, we should perhaps be limiting our expectations to a number of serious prototypes."

Jörn Iken

A totally different concept: Makani uses a kind of airplane. Here, the wing is being carried into position for an autonomous power generation test flight in California in June 2011.

Photo: Makani Power