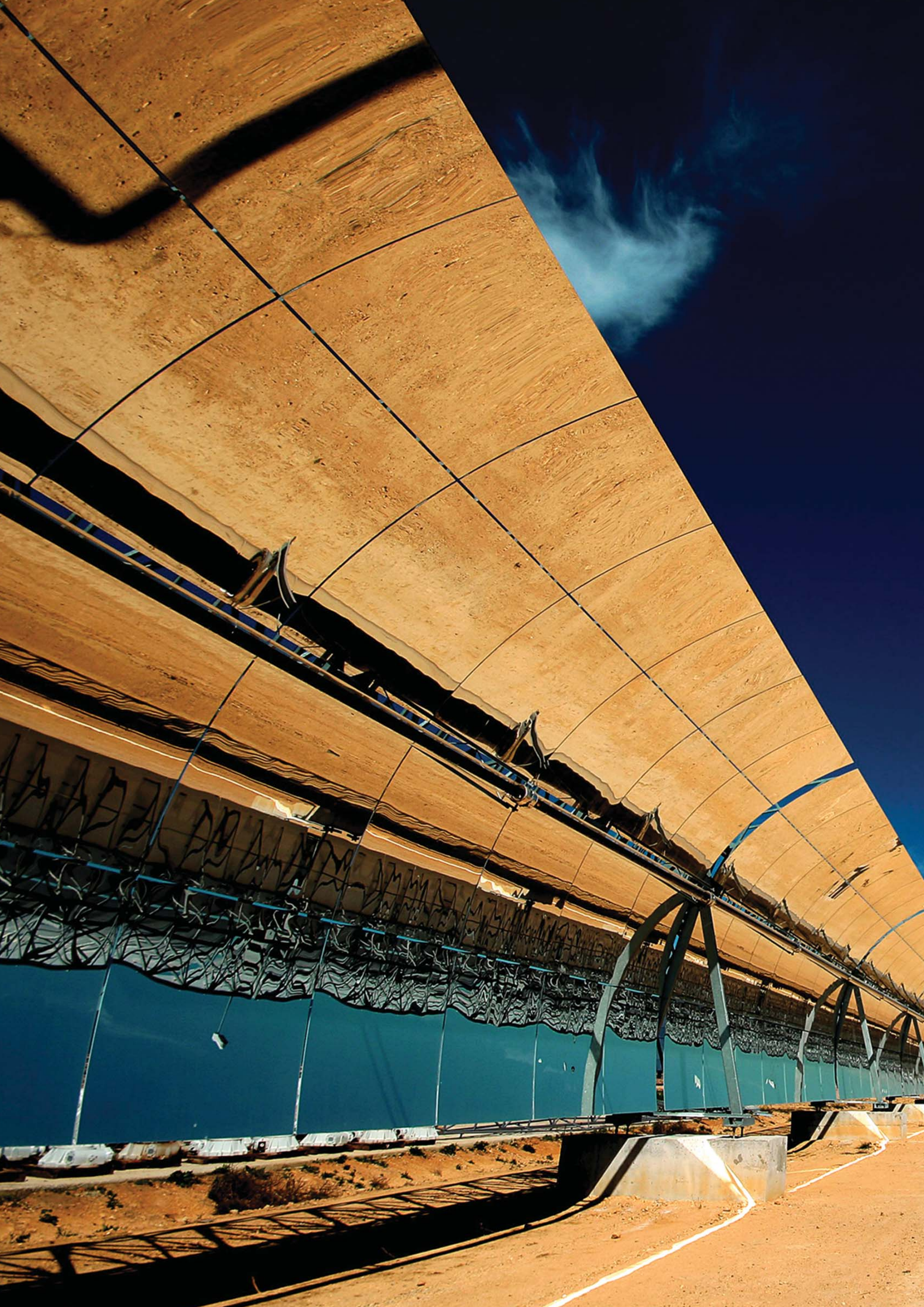
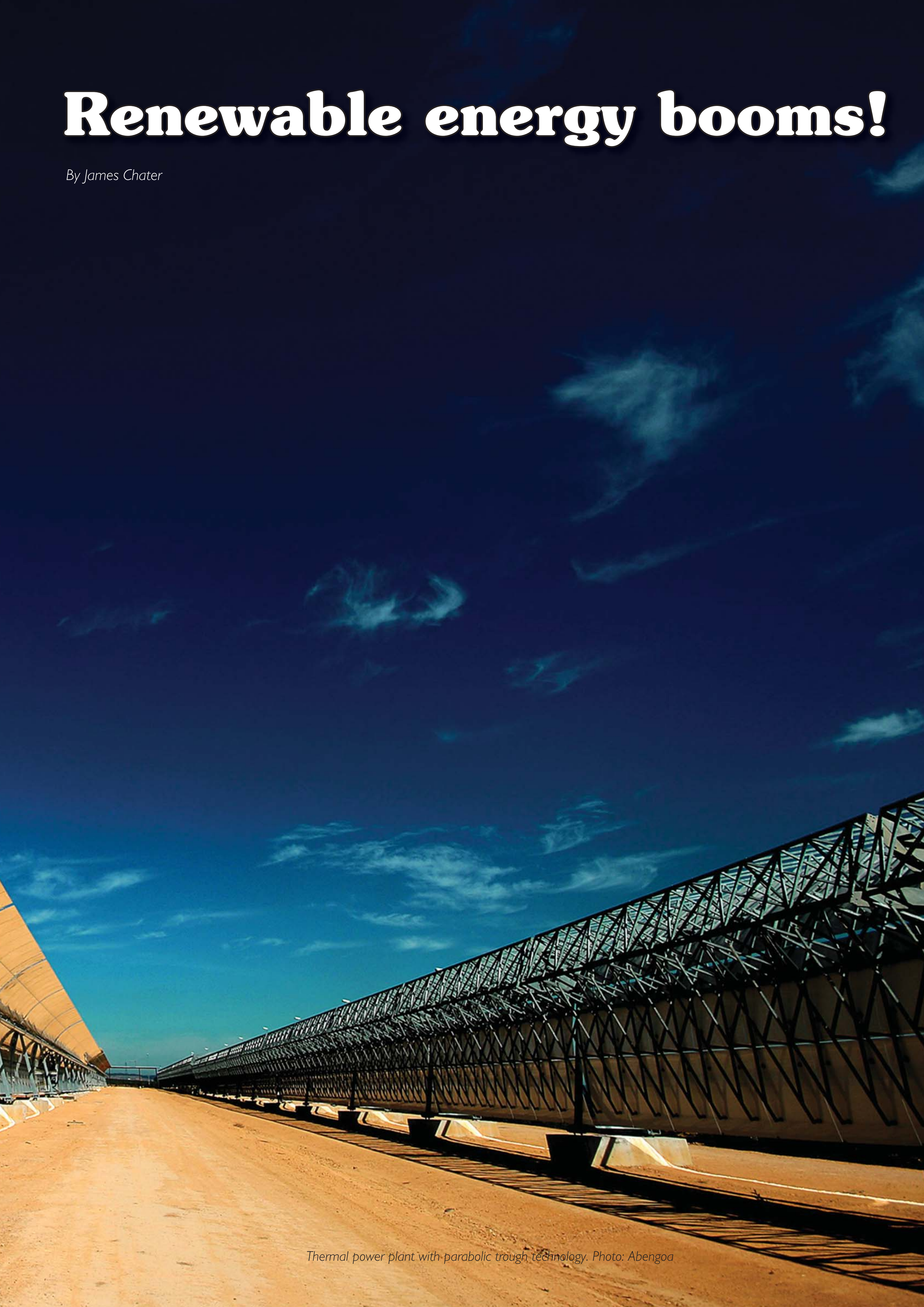


Renewable energy booms!

By James Chater



Thermal power plant with parabolic trough technology. Photo: Abengoa

***Keywords*: Ball Valves • CSP • Materials • Water**

The next few years will be crucial for renewable energy. Solar power is progressing at an exponential rate, and wind and tidal are not far behind. Progress is being driven by not only by government intervention but also by innovation leading to falling prices. Several technological breakthroughs are occurring, and this will continue. This article surveys solar and tidal power (no disrespect meant to wind, hydro, geothermal, biofuels or biomass) and finds plenty of resourcefulness and creativity. All in all, an exciting time for suppliers of equipment and materials to green energy projects.

Background

Two recent warnings from energy think-tanks are worth setting side by side. First, the IAE has warned that world needs USD 48 trillion in investment to meet its energy needs up to 2035. Second, Carbon Tracker and the LSE have stated that known fossil fuel reserves already far exceed the carbon budget to avoid global warming of 2°C, and that a fossil fuel bubble is developing as companies pursue unburnable carbon. If we accept these two premises, it is clear that the future lies with zero-carbon energy sources.

And the future is already here. Depending on such variables as solar power or wind power at any given moment, renewables can already generate power cheaper that fossil fuels or nuclear. This is especially true of solar power, where innovation and increasing economies of scale are causing prices to plummet. And in terms of speed of installation, solar is beating nuclear hands down. In 2013, the world saw an additional capacity of 17 GW of solar power installed, the equivalent of 17 nuclear power plants! We have reached the point where increased installation rates and falling prices are feeding off one another.

PV plant by Isofon in Morocco.

True, governments are skewing the playing field with tax breaks, loan guarantees, subsidies and feed-in tariffs. This is nowhere truer than in Germany, where traditional utilities (E.ON, RWE) are losing out. A telling sign of the times is that the French oil and gas giant Total just bought SunPower for USD 1.4 billion.

Renewables by region

Germany, with its *Energiewende* (energy turning), is the undisputed world leader in renewable energy. The German government is aiming for 80% renewables by 2050, and with solar power able to satisfy as much as 40% of peak demand, it looks so far as if this goal will be achieved. In the process, it is massively reducing its greenhouse gas emissions.

Not to be outdone by its neighbour, Denmark has set a target for 100% renewables by 2050, to include not only power generation but also heating and transport. For 2020 the target is to generate 35% of electricity from renewables.

Spain and Portugal are not far behind. Although Portugal generates surprisingly little solar power, its wind resources are abundant and increasing. For a few hours in 2011, the country's electricity supply was fuelled entirely by renewables! Spain generates a large amount of its electricity from wind and solar power and is a world leader in Concentrated Solar Power (CSP).

In comparison with these European countries, many would accuse the United States of having dragged its feet. Nevertheless, US carbon pollution is down, and on 25 June 2013 President Obama announced a plan to cut carbon emissions. Public land has been released for solar and wind projects, agencies have been ordered to increase their share of renewables consumption, electric cars are to be increased, and training in the solar power job sector is to be financed.

Kaplan turbine at the workshop in Heidenheim, Germany. Photo: Voith

The United States is not the only country seeking to transform its energy policies. North of the US border, British Columbia has passed the BC Green Energy Plan in order to achieve a 100% carbon-neutral power grid. In China solar power is increasing so fast that it is expected to overtake coal as early as 2016. Even Saudi Arabia has espoused solar: last year, it launched a plan to install 41 GW of solar capacity to serve more than 30% of the country's electricity supply by 2032. As yet there are few installations, but with the country's oil reserves fast dwindling, this is likely to change. Saudi Aramco is investing in several small projects.

In Europe, North Africa and the Middle East, several wind and solar projects are in the offing thanks to the work of the Desertec Foundation. For the time being, Desertec is focusing on creating the conditions for developing renewable projects in Morocco and Tunisia. It

Did you know?

- Renewable energy capacity grew 8% in 2011, producing 20.3% of electricity.
- In 2000, the world had 1.4 GW of installed solar capacity. By the end of 2013 this had grown to 40.7GW, up 2,752%.
- Germany has 75% of installed solar capacity world-wide.
- A solar panel cost USD 60 per watt in the mid 1970s. Today the cost is USD 1.50 per watt.
- Solar installations are growing by 65% per year.
- IKEA has started selling solar panels in its UK stores.

has been estimated that the world's deserts receive as much energy from the sun in six hours as the world requires in one year.

Limitations

The benefits of renewables are obvious, but what about the shortcomings? The main one is probably the bottleneck caused by limited supply of super-conductive materials (supermagnets) such as neodymium and other rare earths. Another is the skills shortage: as house owners have learnt to their cost, not everyone who claims to be able to fit solar panels correctly and safely can actually do so!

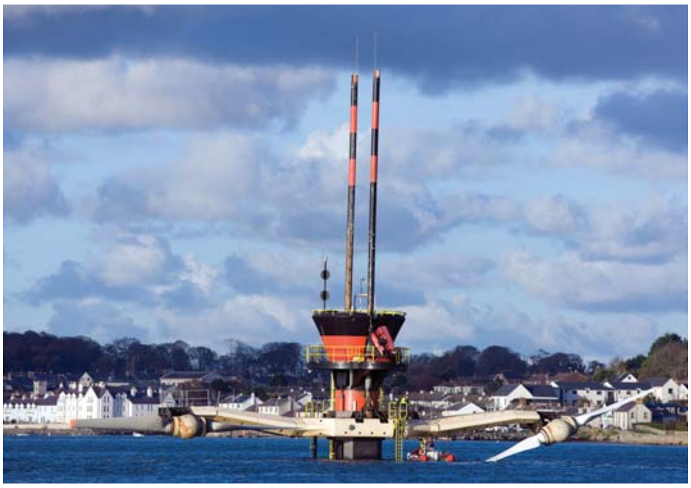
Power-to-gas unit, Falkenhagen, Germany. Photo: E.ON

Another challenge is storage. Renewables are often viewed as a "top-up" energy source because the sun does not shine nor the wind blow all the time; therefore we still need more traditional sources of energy. However, the industry is gradually turning the tables on this argument. CSP solar plants allow storage of solar heat for up to 15 hours. E.ON is engaged on a project, P2G (power-to-gas), that uses wind or solar power to transform water into hydrogen via electrolysis; this hydrogen is then injected into the gas network. Another way to capture energy is to store it as heat. The British firm Isentropic is developing PHES (pumped-heat electricity storage), an ingenious technology which not only stores energy as heat but exploits the temperature difference between two chambers to generate more electricity.
Another challenge is posed by the fluctuations in power load resulting from the intermittent nature of solar, wind and tidal (Variable Renewable Energy or VRE). Fluctuations of 5-10% are relatively easy to absorb; anything higher, and the grid system would need to be transformed. Grid integration remains a major challenge that is only just beginning to be addressed.


Gemasolar plant, owned by Torresol Energy. Photo © Torresol Energy Investments, S.A. Heliosdtats (turning mirrors) reflect the suns rays onto a receiver on the tower.

Solar

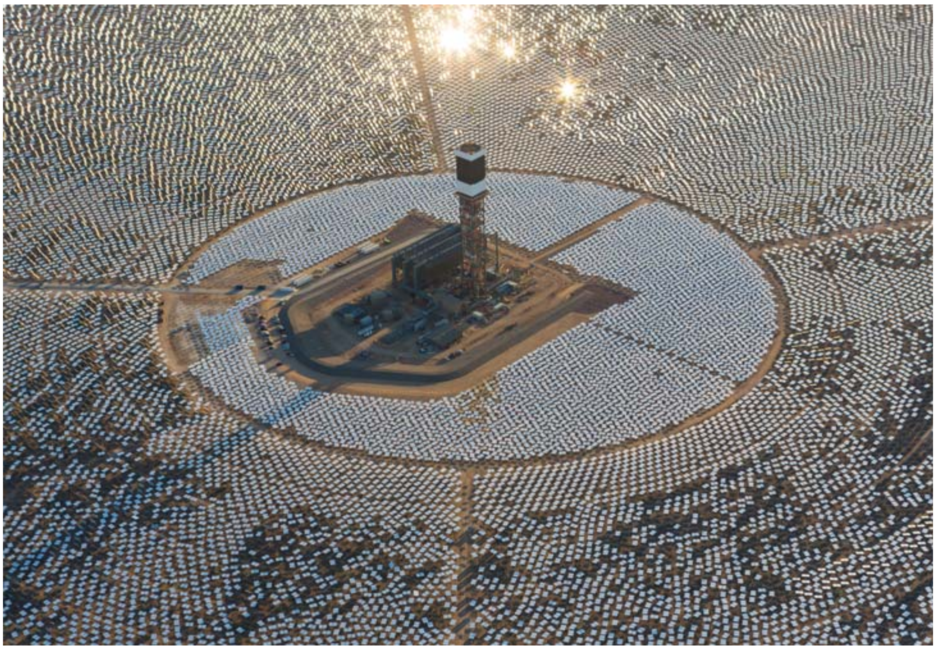
Solar power falls into three main types: water heating/cooling, photovoltaic (solar panels) and CSP.
Of these water heating is by far the largest sector, and China is the largest user. It provides ample opportunities for supplies of 300- and 400-series stainless steels and of duplex grades. Weather proofing and the possibility of achieving thin gauges for aesthetic reasons are two factors that often influence the choice of stainless steel. Stainless steel is used for inner and outer shell of water tanks in direct thermosiphon systems; in the heat exchangers of indirect pressurized systems; for absorbers that transfer thermal energy to the fluid; for glazed cushion absorbers; for the frames; for the cushion absorbers of unglazed roofing panels.
Photovoltaic is a smaller sector, but fast-growing: between 2009 and 2011 the sector almost doubled in size. In PV panels, fasteners are usually made of stainless steel, even when the frames are made of another material. Types 304 and 316L are used on the substrata that support the cells, on fasteners, and on the joints with which the panels are welded together.



The SeaGen installation in the strait of Strangford Lough, Northern Ireland, uses tidal forces to generate electrcity with the aid of two axial-flow turbines with a combined capacity of 1.2 MW. Two underwater rotors attached to a tower structure drive the marine current turbine. The twin rotors turn with the tidal current and optimally track the flow thanks to their 180-degree-pitch blades. Photo: Siemens

In CSP, mirrors or lenses concentrate the sun's rays. The concentrated light is converted into heat, which drives a turbine to produce electricity. The medium used to transfer and store the heat is molten salt. Heat can be stored for up to 15 hours without any solar feed, allowing a solar plant to run both day and night. Examples include Crescent Dunes, Nevada, and Gemasolar, near Seville. The medium of molten salt requires control valves, solenoid valves of special materials to withstand the high temperatures and steam.
The solar sector is bristling with innovation. For instance, NREL has invented a black silicon that can be used to coat solar cells to increase the absorption of sunlight. Another idea is to instal solar panels in public spaces such as roads, pavements, car parks and playgrounds. Additional features could include heating elements to melt snow and ice, LEDs to make road lines and signage, and an attached cable corridor.

Solar energy is synergistic with other industries such as water treatment. Desalination projects are often fueled by solar power. A sophisticated example is Qatar's Sahara Forest Project, which exploits sea water to produce electricity and grow crops. Saltwater cools the greenhouses, while steam-driven turbines desalinate the water used to irrigate crops. Electricity is produced by a CSP plant.



The Invanpah solar energy installation in the Mojave desert, California, said to be the largest in the world, became operational in early 2014. Photo: NRG Solar

Ocean energy

Energy from waves and tidal/ocean currents is at an earlier phase of development than wind or solar. The potential is vast and still relatively untapped. Ways of harnessing the oceans' energy include wave energy conversion; tidal lagoons and barrages that capture the energy of rising and falling tides; and turbines that capture the kinetic energy of tidal currents.

Tidal energy has an advantage not shared by wind, wave power or solar: it is predictable and consistent. Also the turbines used have smaller rotors than those used in wind. They can therefore be bunched closer together, resulting in a smaller environmental footprint.

The seas off the UK boast many of the best sites in the world for tidal energy. The UK's tidal power resource probably exceeds 10GW, about half of Europe's tidal energy capacity. It is thought that Pentland Firth, near the Orkney Islands, could one day provide half of Scotland's electricity. It is here that the European Marine Energy Center (EMEC) testing facility is located. Among the participants are Ireland's OpenHydro, the UK's Tidal Generation and Atlantis Resources. The UK also has one tidal lagoon, at Swansea Bay, Wales, and more are envisaged.

Ocean energy provides plenty of scope for innovation. For instance, energy is now being generated by the collision of seawater and freshwater. In osmotic power, the energy is derived from the difference in salt concentration between seawater and river water. The two types of water are funneled into separate membranes divided by a semi-permeable membrane. The salt molecules in the seawater then pull the freshwater through the membrane. Pressure builds, driving a turbine. Statkraft's osmotic power plant in Tofte, Norway, has been running since 2009. Progress has been held up because no membrane had been specifically designed for the application. Now, however, French researchers have invented nanotube membranes made of boron nitride that are thousands of times more efficient because their surface structure can create stronger electrical charges.

Material selection in ocean energy will be driven by the corrosive action of seawater and by the need to keep components free of biological fouling. It is therefore likely that large amounts of stainless steel valves will be used as well as check valves to rectify the flow.

Statkraft's osmotic power prototype at Tofte in Hurum, Norway.

Sources

Our thanks to Nigel Ward of the Nickel Institute for providing us with copies of Gary Coates, "Emerging demand for nickel in renewable energy" and Richard Matheson, "Emerging markets for nickel and stainless steel in the 21st century". Other sources include: www.madehow.com/Volume-1/Wind-Turbine.html; "Stainless steel in solar energy use" (published by the ISSF); "Pumping heat", The Economist, 7 June 2014, p. 5; Wikipedia.