

## **Sunrise For Renewable Energy?**

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A spectacular sea snake has been spotted slithering around Scotland's northern waters. Though it is fiery red in colour, and some 100 metres in length, the writhing beastie has not sent the locals of Orkney running for the hills. That is because it is actually an innovative new device designed to produce electricity by capturing energy from the ocean's waves. Pelamis, manufactured by Ocean Power Delivery, a British firm, is at the vanguard of the next energy revolution. Or at least that is what proponents of renewable energy would have you believe. Orkney is home to the European Union's main marine-energy test centre, and local politicians and academics like to boast that Scotland, ideally suited to wave and wind-power projects, will become "the Saudi Arabia of renewable energy".

If such claims sound a bit over the top, they are entirely in keeping with the euphoria now sweeping through the renewable-energy sector. Money is pouring in as venture-capital firms, including many not previously interested in renewable energy, throw money at renewables. BP and Royal Dutch/Shell, two oil giants, have big renewables divisions. GE has unveiled "Eco-magination", an initiative focused on clean energy. High oil prices, environmental concerns, a desire for greater energy security and improved technologies "are combining to create the best investing environment ever for renewable power", observed Terry Pratt, a credit analyst at Standard & Poor's, in a report published in October. The International Energy Agency (IEA), a quasi-governmental agency not known for excessive greenery, forecasts that over \$1 trillion will be invested in non-hydro renewable technologies worldwide by 2030. By then, the IEA predicts, such technologies will triple their share of the world's power generation to 6%. In some regions, such as western Europe and California, the share could top 20%.

Yet such predictions are met with scepticism by those who remember what happened after the oil shocks of the 1970s. Back then, high oil prices and concerns over scarcity led many firms to bet heavily on alternative-energy technologies. Most of them lost those bets when oil and gas prices fell in the late 1980s. One of the biggest losers was Exxon. Its current boss, Lee Raymond, has vowed not to spend another penny of his shareholders' money on renewables, which he calls "a complete waste of money".

The chief drawback of renewables is their cost compared with conventional energy sources. The cost of generating electricity from wind turbines is at least 5 cents per kilowatt hour (kWh), for example. Solar or wave power cost at least 18 or 20 cents per kWh. The cost of electricity from conventional sources, in contrast, is typically much lower--as little as 3 to 5 cents per kWh. Barring some dramatic breakthrough, renewable sources cannot, on the face of it, possibly compete.

### **Changing The Rules**

But look beyond the headline figures and a different picture emerges. Renewable energy has regulatory, commercial and technological trends on its side, all of which are working to close the cost gap with conventional sources. Taken together, they promise a far more sustainable, market-driven basis for investment in renewables than yesterday's faith in high oil prices--and suggest that renewable energy's cheerleaders could be on to something after all.

First, consider regulatory and policy trends. Critics have long complained that renewables have survived only because of government subsidies. They are right--but every form of energy is subsidised. America's huge Energy Act, signed into law by President Bush in August, hands most of its \$80 billion or so of largesse not to wind or solar, but to well-entrenched industries such as oil, coal and nuclear. Germany and Spain handed out cash to their coal industries even as they subsidised windmills.

Yet many governments, striving to reduce carbon emissions, are now embracing policies that promise more enduring and politically palatable support for renewable energy than subsidies: "externalities" pricing. In some countries, especially in Europe, action has come in the form of direct taxes on carbon emissions--which, of course, greatly benefit renewable energy. Japan is phasing out its solar subsidies altogether next year. Tax is a four-letter word in America, so policymakers there have instead adopted a mix of regulations, rather than a carbon tax, to boost clean energy. These include such measures as tax credits and "renewable portfolio standards" that require a certain proportion of energy production within a particular state to come from renewables.

Second, these policy measures are being accompanied by the arrival of innovative business models built around renewables. A good example is Actus Lend Lease, an American firm, which is developing the world's largest solar-powered residential community in Hawaii to provide housing for American soldiers. "This is a business decision--there is no subsidy," says Chris Sherwood of Actus. Lenders were worried about the volatility of electricity prices, since Hawaii generates most of its electricity by burning imported oil, and the community's residents will pay a fixed rent, including utility bills, that is set by the army and adjusted only once a year. A sudden spike in the electricity price might have meant that the firm running the project would have been unable to make its debt repayments. Solar panels, in contrast, produce electricity at a known price for the lifetime of the panels. Reducing the uncertainty over energy costs, says Mr Sherwood, made it possible for the developers to borrow more.

Similarly, Sun Edison, an American start-up backed by Goldman Sachs and BP, has devised a clever new business model that overcomes a number of the real-world obstacles that have hitherto stymied renewable-energy projects. Simply put, it offers big retailers (such as Whole Foods and Staples) long-term, fixed-price electricity contracts in return for being able to set up solar panels on their rooftops. The retailers benefit from stable power prices, but do not have to buy or run the panels themselves; Goldman Sachs, which finances the panels, benefits from the associated tax credits and other offsets; BP sells more solar panels; and solar power has a better chance of taking off. Meanwhile, other ventures are looking to wind energy for a hedge. Several firms are putting together hybrid financial products that combine the output of wind farms in America's mid-west with that of natural gas-fired plants--thus hedging the volatility of both.

Pricing schemes that favour renewable energy are also being made possible by the arrival of new technologies such as "smart" meters, which allow for hour-by-hour variation in power prices. These make it possible for utilities to charge much more for power during the sweltering midday peak than early in the morning or late at night. Since solar panels produce their greatest power output in the middle of the day--just when prices are at their peak under a variable-pricing regime--Tim Woodward of Nth Power, a venture-capital firm specialising in energy, thinks smart meters with this type of "time of use" or "critical peak" pricing will make solar power far more attractive. "We see a groundswell toward this," he says. Several American states, led by California, are moving towards variable pricing, and the Energy Act encourages utilities to adopt it. Enel, Italy's national energy company, is rolling out smart meters to 30m customers across the

country, and there are plans to make smart meters mandatory across the European Union, whenever a meter is installed or replaced.

### **Boxing Clever**

In the mean time, GridPoint, an American firm, is selling a "black box" at retailers such as Home Depot that its boss, Peter Corsell, claims will "solve the last-mile problem of the stupid grid". Usually, solar panels need a complex tangle of wires, inverters, batteries and other equipment to be installed to make them work. His firm replaces that with a "plug and play" device that also provides backup power. It even uses predictive software and an internet connection to juggle weather forecasts and utility pricing plans to decide when to sell power back on to the grid.

All of this is making renewables more attractive, even without advances in the generating technologies themselves. But those technologies are not standing still either. Wind energy is now a commercially viable business, without subsidies, in a number of places around the world. (The crucial factor is the "wind potential" of the site; even the best sites for wind turbines produce power only 30-40% of the time, and the average across all of Germany's wind turbines, for example, is just 11%.) Of course, government helped the industry get to this point. Denmark, for example, is home to world-class turbine manufacturers, such as NEG Micron and Vestas, thanks to early state aid. And tax credits and other subsidies help wind operators in Germany and elsewhere.

The key to wind's success in becoming commercially viable has been technologies that have allowed turbine size to grow from an average of 10 metres in diameter in the mid-1970s to over 80 metres today. To build and run such monstrous turbines, companies have devised new composites for the blades, variable-pitch blades that catch the slightest of breezes, variable-speed drive motors and other advances. A doubling of wind speed means about an eight-fold gain in a windmill's energy output, so making windmills taller makes sense, as winds tend to be stronger and more stable higher off the ground. Of course, there are practical limits: make a turbine too big and you cannot deliver it to a field or a windy mountain-top. But offshore, where turbines can be moved by ship, that is not a constraint. Experts expect offshore wind to take off dramatically, especially in Europe, which has both plenty of wind and lots of protesters who object to land-based turbines. Robert Kleiburg of Shell muses that the industry may need to rethink turbine design for offshore environments, however.

The prospects are also good for improvements in solar power. Ever since Bell Labs patented its design for a photovoltaic cell in 1954, crystalline silicon--the same stuff that is used to make computer chips--has been the dominant technology for such cells, thanks to its high reliability and conversion efficiency (at least compared with rival technologies). Silicon-based systems typically convert about 15% of the sun's energy into useful electricity. That may seem low, but since the fuel is free, the efficiency of conversion matters less than the overall cost per kilowatt of power delivered.

Alas, silicon photovoltaic cells are now victims of their own success. The solar industry has sucked up so much crystalline silicon that there is a global shortage, and prices have shot up. But crisis breeds invention. "In the old days, we'd get the garbage after the IT industry got the good stuff," says Rhone Resch of America's Solar Industries Association. But now half a dozen silicon-wafer plants are going up around the world dedicated solely to providing silicon for solar energy. "This is a watershed for the silicon industry," says Christopher O'Brien of Sharp Solar.

One firm hoping to capitalise on the silicon shortage is Evergreen Solar. It uses conventional crystalline silicon, but in an unusually frugal fashion. From crucibles of molten silicon, ribbons of

the stuff are continuously pulled out. This "string-pulling" uses 30% less silicon than the usual sawing-and-etching method does, with further improvements in sight. But others are betting on a rival technology: thin films. Rather than etch wafers, various firms are creating solar panels on rolls of stainless steel (ECD Ovonic), plate glass (GE's Astropower division), and other materials amenable to continuous manufacturing processes. That means costs can be greatly reduced once full-scale plants are built and perfected, which would compensate for thin films' lower conversion efficiency.

"I'm betting against silicon," says Arno Penzias, a Nobel-winning scientist who is now with NEA, a venture-capital firm. Instead, he favours a flavour of thin-film solar technology known as "CIGS"--a sandwich of thin layers of copper, indium and gallium selenide pioneered at America's National Renewable Energy Laboratory (NREL). His firm invests in HelioVolt, which is trying to commercialise this technology; the firm claims that it can already achieve efficiencies close to those of silicon in the laboratory but using just one-hundredth the material. Billy Stanbery, HelioVolt's boss, thinks this technology could allow solar panels to be built into roofing materials, rather than installed on top. Shell's solar division, which is developing a thin film similar to CIGS, thinks it could reduce the cost of solar panels by more than 50% by 2012.

Another promising, but tricky, approach is organic solar panels. Konarka, whose founder won a Nobel prize for pioneering organic solar cells, is leading the charge in this area--but even one insider admits that commercialisation of its optical organic PV cells "is a long way off". Other researchers are applying nanotechnology and molecular chemistry to solar power, with the aim of mimicking photosynthesis. Most pundits think that is a long way off too. But a paper published by a team from the NREL in May raises a tantalising possibility: it found that tiny nanocrystals known as "quantum dots" could, in theory, make possible solar cells with around 70% efficiency. So the future for solar power could be bright indeed.

### **Follow The Money**

But what is most striking is that figures compiled by Shell Renewables in April 2004, when the oil price stood at \$40 a barrel--it is currently closer to \$60--found that wind turbines and solar panels could close the cost gap with conventional energy sources. Provided they are large enough and are sited in suitable locations, the most efficient modern wind turbines can produce electricity at a wholesale price (the price at which electricity producers buy and sell power on the grid) competitive with non-renewable sources.

Solar panels cannot produce power at such low cost, but comparing their cost-per-kWh with wholesale prices is arguably not the most relevant comparison. That is because in general, solar panels are used not by electricity producers selling power to the grid at wholesale prices, but by consumers who use solar power to supplement or replace power bought from utility companies at retail prices (typically 8 to 20 cents per kWh). So solar power need only match these higher retail prices in order for homeowners and businesses to start to consider it as a viable alternative. And it turns out that the most efficient of today's solar panels do indeed match the retail price of electricity in some parts of the world with high retail prices, such as Japan (which is now phasing out its solar subsidies).

Renewables' growing competitiveness is not, in short, simply the result of sky-high oil prices. And that explains why Wall Street is at last getting interested. Not long ago, America's renewable-energy industry held a finance conference in New York at the Waldorf Astoria hotel. Brian Daly, a financier with the Trust Company of the West, stood up to make a presentation in the bejewelled grand ballroom. He observed: "When I made my first presentations in this industry, there were ten guys with ponytails and I had to flip charts myself." Now, he observed,

the Waldorf ballroom was packed with besuited bankers--and his slides appeared on a high-tech screen.

If you still need persuading that something big and exciting is happening in renewable energy, head back to the frothy waters of the North Sea off Scotland. There, you will find the energy equivalent of beating swords into ploughshares: the planting of windmills on oil platforms. Talisman, an independent oil company, has decided to put up two windmills on top of one of its gas platforms. Building stable platforms accounts for around a third of the cost of offshore wind farms. But the oil and gas industry in the North Sea, now in decline, has plenty of platforms sitting around.

A Talisman official explains that, for the moment, the energy will be used only to power the platform's operations, but in future it may serve as a generating station, and send power ashore. "This will be the greenest platform in the world," he says. If even hardened oilmen can look to the winds for inspiration, perhaps the time really has come for renewable energy after all.