



CLEAN ENERGY TRENDS 2004

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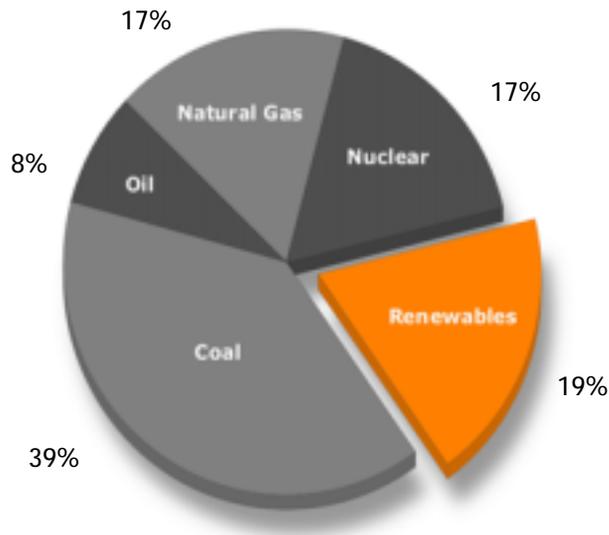
THE CLEAN-TECH MARKET AUTHORITY

INTRODUCTION

For solar, wind, and other non-hydro renewable energy sources to contribute significantly to global electricity supply will require that several key technology, policy, and investment trends be enhanced and expanded

You wouldn't know it from the energy policy debates taking place in the U.S. and other countries, but renewable energy represents the world's second-largest source of electricity. According to the International Energy Agency, clean-energy sources – including hydro, biomass, geothermal, wind, solar, and tidal power – accounted for 19% of global electricity produced in 2000, compared with 39% for coal, 17% each for nuclear and natural gas, and 8% for oil.

Renewables in Electricity Production 2000



But the numbers are deceiving. Hydro power, which in large-scale systems can be less than environmentally benign, accounts for the lion's share – 90% – of renewables' contribution. And solar and wind, while growing significantly each year, accounted for less than 1% of the total.

As usual: another year of good news/bad news for clean energy.

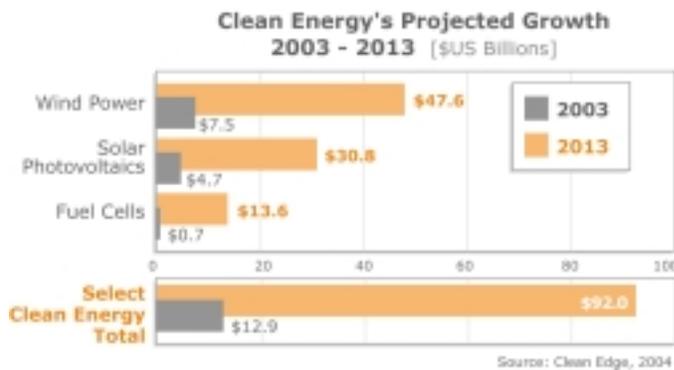
How to change this dynamic? For solar, wind, and other non-hydro renewable energy sources to contribute significantly to global electricity supply will require that several key technology, policy, and investment trends be enhanced and expanded: renewable-energy technology will need to continue its steady improvement; more supportive government policies, such as renewable portfolio standards and tax credits, will need to be implemented; and government, industry, and venture capitalists will need to pump more dollars into the R&D and market-development pipelines. And all of this needs to happen at the right time, in the right markets, in the right order.

Clearly, winning this clean-tech trifecta will be no small feat. But there are some encouraging signs.

STEADY AS SHE GROWS

It's easy to take solace from the growth of renewables over the past few years, though the impressive numbers need some context. Solar and wind power generation capacity have each grown by an average of more than 30% annually over the past five years, growth rates more commonly seen in the high-tech worlds of personal computers and the Internet than the more staid energy sector.

The solar photovoltaics (PV) industry, for example, grew to more than 700 MW of new solar PV manufacturing output in 2003, up from about 500 MW the year before. Wind added more than 7,500 MW of new generation capacity last year; it now accounts for more than 38,000 MW of total installed capacity worldwide, enough electricity to power approximately 19 million average European homes.



But the installed base of both technologies remains relatively small, tempering the impressive growth data. Put in terms of the personal computer industry, it's still only the mid 1980s: the technology is catching on, and prices, performance, and ease of use are improving, but it has yet to reach a critical mass.

That part of the growth curve is yet to come. According to Clean Edge research, solar photo-

voltaics (including modules, system components, and installation) will grow from a \$4.7 billion industry in 2003 to more than \$30.8 billion by 2013. Wind power (new installation capital costs) will expand from \$7.5 billion in 2003 to approximately \$47.6 billion in 2013. And the fuel cell and distributed hydrogen market will grow from a \$700 million industry today (primarily still for research, demonstration, and testing) to \$13.6 billion over the coming decade.

Combined, these three high-growth clean-energy markets have expanded from \$9.5 billion in 2002 to \$12.9 billion today, or a combined annual growth rate of 36%. By 2013, solar PV, wind power, and fuel cells and hydrogen infrastructure will represent a \$92 billion market.

THE GREENING OF POLICY

Renewables' steady growth path is being fueled in large part by government policies around the world at the national, regional, and local levels. Denmark now gets up to 20% of its electricity from wind power on windy days. California, which has been targeting 20% of its electricity supply from non-hydro renewable energy sources by 2017, now aims to achieve that goal by 2010 – at least according to campaign goals espoused last year by now-Gov. Arnold Schwarzenegger. And Japan more than quadrupled its solar PV installations in a five-year period, from 133 MW installed in 1998 to 637 MW installed at the end of 2002.

The U.S. and European governments have committed more than \$2 billion for fuel cell and hydrogen research over the next five years.

THE RISING POWER OF DECLINING COSTS

There's clearly more to come. The U.S. and European governments have committed more than \$2 billion for fuel cell and hydrogen research over the next five years. And renewable portfolio standards in places as diverse as Nevada and Germany are leading to ever-growing megawatts of clean energy. Early this year, California's state treasurer proposed an ambitious effort to commit \$1.5 billion of state pension money for investing in environmental technologies, including clean energy. All of which can play a major role in stoking the growth of clean energy around the world.

And all of which is critical to the success of renewables. Indeed: clean energy simply cannot hit its stride without strong government funding and policy, and few clean-energy markets in the world today are competitive without such public-sector support. When funding dries up, or on-again-off-again policies lead to funding uncertainties (for example, in the U.S. when the production tax credit for wind turbines expire without being renewed), it can create a frustrating and potentially market-crippling "clean-tech cha-cha": two steps forward, one step back. Long-term public commitments are mandatory prerequisites for the robust health of the clean-energy sector.

Much of the growth of wind and solar can be attributed to pure economics: The costs of both have declined by 80% to 90% over the past two decades. According to the U.S. Department of Energy, wind energy has tumbled from around 40 cents per kilowatt-hour (kWh) in 1980 to around 4 cents today. Solar has dropped from more than \$1 per kWh to as low as 18 cents. As a rule of thumb, solar costs drop by 18% for every doubling of manufacturing output, and wind power costs drop by 10% for every doubling of installed capacity.

Indeed, at around 4 cents per kWh, wind power is now one of the cheapest forms of centralized bulk power available (these costs are for electricity generation only and don't include the transmission and distribution charges required to deliver centralized energy to end users). According to some estimates, new nuclear plants deliver energy at a cost as high as three times that of new wind turbines. And wind supplies energy without any of the security risks, waste disposal issues, and radioactive contamination threats associated with nukes.

Solar can't yet make such a favorable price comparison, but today's large-scale systems can clock in at around 10 cents per kWh for direct-user costs, when one considers subsidies and tax credits in places like California. This compares favorably to electricity rates averaging 8 to 12 cents per kWh in the U.S. (and often much higher in Calif.), and rates hovering closer to 20 cents per kWh in such places as Japan and Europe. True, while there is the issue of having to pay the up-front capital costs of the solar modules and related equipment and installation charges (which can be a considerable barrier for many energy buyers), the efficiencies and economics for solar are greatly improving and new forms of financing and subsidy programs bring solar within reach of a growing number of businesses and consumers.

Table 2: Current and Projected PV Costs — 2003-2010

	2003	2004	2005	2006	2007	2008	2009	2010
Installed System Cost (per watt)	\$6.40	\$6.00	\$5.76	\$5.54	\$5.20	\$4.88	\$4.68	\$4.50
Cost per kilowatt-hour	17-29¢	16-27¢	15-26¢	15-25¢	14-24¢	13-22¢	13-21¢	12-20¢
Costs shown are installed prices without subsidies for large-scale, grid-connected industrial systems and low-cost residential systems. Source: Clean Edge, Inc.								

As a rule of thumb, PV modules represent half the cost of a solar system and balance-of-system components and installation represent the remaining half.

As a rule of thumb, PV modules represent half the cost of a solar system and balance-of-system components and installation represent the remaining half. In Japan, Germany, and the U.S., we are seeing installed systems priced as low as \$6 per watt (averaging 17-29 cents per kWh without subsidies). According to Clean Edge projections, pricing closer to \$4.50 per watt (12-20 cents per kWh without subsidies) by the end of the decade is likely based on current improvements and cost reductions. Costs per kWh projections are based on both commercial and residential financing options — and do not include tax credits, subsidies, and other incentives likely available to end users, which can reduce costs significantly.

VENTURE CAPITAL INVESTMENTS

Venture capital investments in energy technologies continued their upswing in 2003 as 2.4% of total venture investing. Overall, venture investments in the U.S. totaled \$18.2 billion in 2003, down from 2002's \$21 billion. However, clean-energy investments remained roughly steady, with \$428 million in 2003 compared with \$435 million in 2002.

Table 3: Clean Energy Private Equity Investments in US Based Companies as Percent of Total

YEAR	TOTAL VENTURE INVESTMENTS (US\$ BILLIONS)	ENERGY TECHNOLOGY INVESTMENTS (US\$ MILLIONS)	ENERGY TECHNOLOGY PERCENTAGE OF VENTURE TOTAL
1999	\$59	\$464	0.8%
2000	\$103	\$1266	1.2%
2001	\$41	\$858	2.1%
2002	\$21	\$435	2.1%
2003	\$18	\$428	2.4%
<i>Compiled by Nth Power, in collaboration with Clean Edge Inc., the Cleantech Venture Network and the PWC/TVE/NVCA MoneyTree Survey</i>			

Total global venture investments in new energy technology companies in 2003 equaled more than half a billion dollars, with approximately \$100 million raised for non-U.S.-based firms. According to Nth Power, nearly half of these deals were for distributed generation and energy storage technology companies, such as Advent Solar,

Anuvu, Avista Labs, Clean Air Partners, Evergreen Solar, Fuel Cell Technologies, Metallic Power, Nanosolar, Powergenix, and Zoxy.

After a significantly down year for clean-energy stocks in 2002, many stocks rebounded, tracking the recovery of the overall market. FuelCell Energy, Hydrogenics, and Plug Power, for example, all recovered from earlier losses and are now trading at or above year-end 2001 prices. Some clean-energy stocks are currently trading at or near their 52-week highs.

The clean-energy industry has also seen some consolidation. General Electric recently announced its intention to acquire the assets of AstroPower, the once high-flying solar firm. While this didn't necessarily create a sunny disposition for AstroPower's beleaguered investors, who saw their stock dive to under \$1, it does indicate the potential that large players like GE see in the emerging solar marketplace. Meanwhile, on the wind-power front, Denmark's Vestas Wind, attempting to remain competitive with behemoths like GE Wind (which acquired the assets of the failing Enron Wind on the cheap in 2002), tendered an offer to acquire its main rival, NEG Micon.

Table 4: Select Clean-Technology Stocks (As of End of Session 2/11/2004)

TICKER	NAME	LAST (\$US)	52-WEEK RANGE (\$US)	MARKET CAP (\$US MILLIONS)
AVA	AVISTA CORP.	18.10	9.80 – 18.70	875.0
BLDP	BALLARD PWR SYS	11.82	8.94 – 15.42	1,369.0
CPST	CAPSTONE TURBINE	2.33	0.71 – 2.57	193.6
ENER	ENERGY CONV DEV	8.18	7.95 – 19.24	201.2
ESLR	EVERGREEN SOLAR	2.24	1.01 – 3.25	26.1
FCEL	FUELCELL ENERGY	13.17	5.00 – 17.79	628.4
HYGS	HYDROGENICS CP	6.15	3.67 – 7.60	326.5
IDA	IDA CORP. INC.	32.05	20.60 – 31.93	1,225
ION	IONICS INC.	27.88	15.70 – 33.25	495.3
ITRI	ITRON INC	20.00	13.00 – 24.16	411.1
MKTY	MECHANICAL TECH	6.30	1.85 – 7.97	174.1
MDTL	MEDIS TECHS	14.10	3.08 – 14.90	345.6
MCEL	MILLENNIUM CELL	2.70	1.45 – 4.00	92.9
PLUG	PLUG POWER INC	9.31	3.85 – 10.65	567.8
SPIR	SPIRE CORP.	4.85	1.78 – 6.38	32.8

Source: Clean Edge, Inc.: www.cleandedge.com/stocks

FIVE TRENDS TO WATCH

How will clean-energy markets develop? Here is how we view the landscape.

1. CLEANER CARS GET TRACTION

The biggest boost for clean energy in the past year may have come not from a company, but from a magazine. When *Motor Trend* named the 2004 Toyota Prius hybrid its “Car of the Year,” it put a high-octane stamp of approval on clean tech – not for its environmental benefits, but for its innovative technology. A month later, the Prius took similar honors at the North American International Auto Show.

Gas-electric hybrids have moved from tree-hugger curiosity to mainstream transport, and 74% of auto industry executives predict that hybrids will increase their overall market share over the next five years, according to a KPMG LLP survey. And unlike last year, when the leading makers of hybrids were caught with their inventories down, manufacturers are wasting no time ramping up production to meet the coming year’s anticipated demand.

Toyota plans to build 130,000 Prius units worldwide in 2004, a 71% increase over its original target, and more units than the Prius sold in seven years combined since its launch in 1997. In the U.S., Toyota plans to ship 47,000 Priuses, a 31% jump from its original projections. Auto industry forecaster J.D. Power and Associates predicts a nearly tenfold increase in total U.S. hybrid sales, to 500,000 units, by 2008.

But who will sell them? Japanese automakers’ lead over their U.S. competitors in the hybrid market is wide and looks to get wider. Honda plans a hybrid Accord, America’s fourth-best-

Profile:

Denso Corp.

Location

Kariya, Japan
www.globaldenso.com/en

Founded

1949 (spun off from Toyota)

Employees

90,000

Technology

Key components for the Toyota Prius hybrid, including engine parts and an air-conditioner compressor that continues running when the gas engine switches off. Denso is also the leader in reduced-emissions diesel components, mainly sold in Europe.

The Buzz

With its technology a key factor in Toyota’s hybrid vehicle success, Denso may be the largest clean-tech firm with a name unknown to auto industry outsiders. It’s the world’s number-three auto parts supplier, is highly profitable, and has a market cap of \$17.2 billion. It’s not just hybrids; Denso is a key player in fuel-cell vehicle components and AC systems that run on CO₂ instead of more environmentally damaging hydrofluorocarbons.

Brain Trust

President and CEO Koichi Fukaya, who says “Denso considers environmental protection in all of its activities.”

Our Take

With a \$1.5 billion annual R&D budget – 8% of sales – Denso will continue to be the leader in clean-tech innovations for auto components. That will help Toyota stay out in front on hybrid and other cleaner technologies, but Denso also has its sights set elsewhere. It aims to double its sales to European vehicle manufacturers in the next five years and has its eyes on the huge potential vehicle market in China.

Japanese automakers' lead over their U.S. competitors in the hybrid market is wide and looks to get wider.

selling car, that it says will have more power than the conventional version. Toyota plans hybrid versions of two popular SUVs, the Highlander and the Lexus RX330. Subaru will roll out a high-performance hybrid sports car, the B9SC.

American automakers' hybrids, in contrast, are still in first gear. Ford's Escape SUV hybrid will finally hit showrooms this summer after two development delays; General Motors' first hybrid, the Saturn Vue SUV, won't be out until 2005. GM vice-chairman of product development Robert Lutz has called the concept of hybrid compacts like the Civic and Accord "an interesting curiosity...that doesn't make sense [with gas prices] at \$1.50 a gallon" – a philosophy that irks some industry observers. "It's another example of the shortsightedness of the U.S. car industry," says Jim Motavalli, author of *Forward Drive: The Race to Build Clean Cars for the Future* (Sierra Club Books, 2000). "If there's another gas crisis, they won't have an answer."

GM is banking on the longer-term promise of hydrogen-powered fuel-cell vehicles (FCVs), targeting 2010 for its first showroom model. But a National Academy of Sciences panel questioned such aggressive timeframes in a 2004 report, predicting a 25-year wait for wide availability of FCVs. Reality is likely somewhere in between.

2003 Top Headlines

Ballard-Powered Fuel Cell Buses Delivered to the City of London

FedEx Unveils Hybrid Truck

Honda Plans to Sell Accord Hybrids in US in 2004

KPMG Survey Finds Major Growth to Come From Hybrid Vehicles

Motor Trend Names Prius 2004 Car of the Year

Seattle's Transit District Buys 235 Hybrid Buses

Toyota To Lift Hybrid Production to 130,000 Units in 2004

U.S. Hybrid Electric Vehicle Sales Projected at 1 Million Annually by 2012

Select Companies to Watch

Ballard Power Systems

www.ballard.com

Denso

www.globaldenso.com/en

Honda

www.hondanews.com

Nuvera Fuel Cells

www.nuvera.com

Toyota

www.toyota.co.jp/en/tech/environment/index.html

2. GREEN POWER BECOMES A PRICE HEDGE

In 2003, a spike in natural gas prices forced many of North America's electric utilities to assess their customers a fuel surcharge. For customers of Austin Energy, the surcharge increased the average bill by \$10.22 a month – but not for everyone. Customers who subscribed to its green-power program, GreenChoice, weren't affected.

Utility customers are starting to feel the benefits of green power where it counts most: the monthly bill. Austin Energy is leading the way among U.S. utilities that offer fixed-rate pricing, a trend expected to grow. Nearly 400 utilities in 35 states offer some form of green-power options, according to the National Renewable Energy Laboratory. With Fed chairman Alan Greenspan and others warning of economic consequences for the U.S. from a possible spike in natural gas prices, the advantage of locking in rates for power, even at a slightly higher initial level, is increasingly attractive.

"The security of long-term contracts for renewables is a positive development," says Lori Bird, senior energy analyst at NREL in Golden, Colo. "Anything that can help reduce the price and offer additional value helps grow the market for green power." An NREL survey of top green power providers found that many have reduced the premium that customers pay for the clean energy option, some by as much as 58%.

The combination of price stability and lower overall costs for green power spells great growth potential. Wind power is the

Profile: **Austin Energy**

Location

Austin, Texas
www.austinenergy.com

Founded

1895 (first hydro plant on the Colorado River)

Employees

1,400

Technology

The GreenChoice power program offers commercial and residential customers a clean-energy mix, mostly wind from Cielo Wind Power's 61-turbine farm on King Mountain near Midland, Tex., with some landfill gas and solar.

The Buzz

The 10th-largest municipal utility in the U.S., Austin Energy is by far the leader among all utilities in green power sales, according to NREL rankings. Austin sells nearly 30 megawatts of green power, more than twice as much as the next two on the list, Sacramento Municipal Utility District and Xcel Energy, which sell about 12 MW each. Austin has committed to 20% renewables by 2020 and a 15% efficiency increase by that date. Perhaps more significantly, the company has pioneered stable pricing, with a 10-year fixed rate offering at a premium of less than 1 cent per kWh over the regular rate – and exempt from fuel charges resulting from natural gas price increases.

Brain Trust

General manager Juan Garza.

Key Customers

Advanced Micro Devices' Austin facility, whose 24 million kWh of renewable energy annually makes it one of the largest industrial buyers of green power in the U.S.; and Concordia University, the first university in the country to receive 100% green power.

Our Take

As volatile natural gas prices continue to make stable green power rates more attractive, the industry will look to Austin Energy as the model of how it's done. Austin, also home to renewable-power retailer Green Mountain Energy, is rapidly emerging as the nation's green power capital – deep in the heart of oil-rich Texas.

The combination of price stability and lower overall costs for green power spells great growth potential.

most common renewable resource for stable pricing, with landfill gas, biomass, and solar contributing a smaller share. Two states, Colorado and Minnesota, have declared wind the least-cost alternative for future power plants. Xcel Energy, Colorado's largest utility and the nation's number-three seller of green power, exempts customers of its Windsource green power program from monthly fuel-cost adjustments, and plans to offer a fixed-rate option. In February 2004, PacifiCorp in Portland, Ore., said it will seek 1,100 megawatts of clean energy over the next seven years.

In Canada, the federal government recently announced that its wind power purchases from producers in Alberta, Saskatchewan, and Prince Edward Island from 1997 to 2002 cost less than standard non-renewable power at retail prices. The Canadian government has committed to a 20% renewable-sourced electricity portfolio by 2006.

There are also price-stabilizing trends in solar power, traditionally a more expensive option. SunEdison, an Arlington, Va.-based startup, is pioneering an approach to solar where it builds the PV array at a customer site and assumes the investment and pay-back risks, while offering the customer a long-term contract with a fixed fee. "Buyers who want solar can now get it in a more fiscally responsible way," says SunEdison CEO Jigar Shah. The company's solar PV powers a Whole Foods Market in Edgewater, N.J., and it has contracts to do the same with other major retailers.

2003 Top Headlines

Austin Energy Drops a Solar Bomb

German Power Prices Drop as Strong Winds Forecast to Boost Supply

L.A. Mayor Proposes Wind Power

National Study Shows Efficiency and Renewables Can Provide Immediate Relief from High Natural Gas Prices

New Berkeley Lab Report Highlights Price Stability Benefits of Renewable Generation

PacifiCorp Seeks Proposals for 1100 Megawatts of Renewables

Pricing Programs Give Consumers Clean Power Choices

Renewable Energy Could Sustain Chinese Growth

Select Companies to Watch

Austin Energy

www.austinenergy.com

Eugene Water & Electric Board

www.eweb.org

Green Mountain Energy

www.greenmountain.com

Sacramento Municipal Utility District

www.smud.com

SunEdison

www.sunedison.com

3. CLEAN ENERGY GOES LOCAL

The shortest, most direct pathway to a renewable energy future in the U.S. may well involve that old environmentalist chestnut: “Think globally, act locally.” Clean-energy advocates, frustrated with the lack of leadership at the national level, are turning to states and cities to implement clean-energy technologies. And state and local governments – as well as the voters that elected them – are responding enthusiastically.

The flagging federal funding for renewables didn’t begin with George W. Bush. For nearly three decades, funding levels have see-sawed along with the political climes. But the current administration’s efforts seem particularly feeble given the increased need to increase U.S. energy security and address climate change. The Bush-Cheney 2001 National Energy Plan called for just 2.8% of U.S. electricity to come from renewables by 2020.

Compare this to California’s new Gov. Arnold Schwarzenegger, who is calling for the state to derive 33% of its power from renewables by 2020 – an order of magnitude above the federal goal.

And so it goes in other states and cities. New York state offsets the cost of solar by up to 70%, and is conducting training programs for solar installers. The Austin, Tex., city council has approved the nation’s most ambitious local solar initiative that would install 100 megawatts of solar power by 2020, powering about 20% of the city’s energy

Profile: **PowerLight Corp.**

Location

Berkeley, Calif.
www.powerlight.com

Founded

1991

Employees

100

Technology

Large-scale solar installations, most using a proprietary product that marries a solar panel with foam insulation. It sits directly atop flat roofs, easing installation, increasing insulation, and reducing roof wear and tear.

The Buzz

It’s hard to find a large-scale local government solar project that isn’t being done by PowerLight. Starting in its California home court, where it has landed nearly every high-profile installation, the PowerLight project map extends across the U.S., including several cities, states, military bases, and universities.

Brain Trust

Founder and CEO Tom Dinwoodie and president Dan Shugar both bring strong backgrounds in energy, engineering, construction, and project management, backed by an enthusiastic corps of professionals.

Bankrollers

The closely-held company has received relatively little outside financing, with most growth coming entirely from revenue, which skyrocketed to \$42 million from \$800,000 in the five years through 2002, putting it on the Inc. 500 list of fastest-growing companies for four straight years (#103 on the 2003 list, with a 1,469% five-year growth).

Our Take

PowerLight has turned the maxim, “Do one thing and do it well” into a potent business strategy. Solar’s mass market will arrive when it becomes plug-and-play, and PowerLight seems to have created a compelling large-scale version of that standardization model that has made it one of the few success stories in the world of solar.

For nearly three decades, funding levels have see-sawed along with the political climes.

needs. Other cities and states have made smaller but still impressive commitments.

It's not just cities and states. College and university systems across the U.S. are similarly making aggressive pledges to solar and other renewables. The Los Angeles Community College District now has one of the cleanest energy policies among academic institutions. It mandates that at least 10% of all new building energy needs be generated on-site with solar power, and up to 15% of energy needs be met by long-term contracts with utility green-power programs. Last November, students at more than 65 colleges and universities across the country participated in a massive National Day of Action calling for Clean Energy Campuses.

Granted, many of these jurisdictions got religion by watching California suffer rolling blackouts during 2000 and 2001. The East Coast/Canadian blackout of August 2003 added additional urgency, and the federal government's slow response further powered the notion that energy security would more likely happen locally than nationally.

But there's a limit to what can be done locally. National leadership is needed to aggregate demand, provide incentives, and send an unequivocal signal that clean energy must be a growing part of our nation's energy mix. Without help from Washington, these local efforts will remain a series of disparate, uncoordinated efforts. The result will be that clean-energy prices remain out of the reach of the mainstream.

2003 Top Headlines

Austin Energy Calls for 100MW of Solar by 2020

Brilliant Ideas: Solar Power Is on the Rise in Central Ohio

Cities Are Driving Forces for Renewable Energy Promotion

Jacksonville International Airport Goes Solar

More Green Power in Pennsylvania Budget

NYSERDA's Power Naturally Program Shines Brightly Over the Empire State

Solar Power Hits Suburbia

Solar Ribbon Cutting Frenzy in Massachusetts

Select Organizations to Watch

Florida Power & Light Co.

www.fpl.com

Los Angeles Department of Water & Power

www.ladwp.com

NYSERDA

www.nyserdera.org

PowerLight

www.powerlight.com

Xcel Energy

www.xcelenergy.com

4. WIND POWER TAKES EUROPE BY STORM

Europe is leading the way when it comes to developing and expanding wind power. A number of factors – including renewable electricity targets, commitments to reduce greenhouse gas emissions, and a host of supportive government policies – are encouraging European countries to take an increasingly active role in developing their wind power resources.

Europe currently accounts for more than 70% of global installed utility-scale wind power, with 28,401 MW of wind power in place at the end of 2003 (compared to just under 6,400 MW in the U.S.) – enough to electrify roughly 14 million typical European households. Europe currently generates about 2% of its electricity from wind, compared with less than one-half percent in the U.S.

On the European continent, three countries account for 80% of all installations: Denmark, Germany, and Spain. Denmark already produces up to 20% of its electricity from wind on windy days. Germany saw its installed wind base more than double over the past three years. And Spain, number three in installed wind capacity worldwide, has seen national companies Gamesa and Iberdrola gain market share – both in Spain and, increasingly, abroad.

Based on current assessments, Europe's wind industry could be supplying up to 10% of total EU electricity demand by 2010. But growth will need to pick up in

Profile:

National Wind Power Ltd.

Location

Reading, U.K.
www.natwindpower.co.uk

Founded

1991

Employees

80

Technology

The U.K.'s largest wind farm developer, NWP generates 160 MW of electricity at 20 sites in England, Scotland, and Wales. NWP also developed and sold six wind farms producing 420 MW in the U.S.

The Buzz

A subsidiary of RWE Innogy, an integrated German energy giant, NWP is at the heart of Britain's push to join Denmark, Germany, and Spain as a world leader in wind power production. In November 2003, NWP opened the U.K.'s first offshore wind farm, a 60 MW installation off North Hoyle, Wales. NWP is big now but aims to get much bigger, inking a huge financial deal in January to fund expansion. Parent RWE sold two-thirds of its interest in the firm for £400 million (US\$730 million) to investors Englefield Capital LLP in the U.K. and First Islamic Investment Bank in Bahrain – the latter being the latest example of an oil industry investor moving into wind power.

Brain Trust

Managing director Alan Moore has held his current post for more than six years. A 35-year veteran of the U.K. power industry, Moore is the current chairman of the British Wind Energy Association.

Our Take

NWP is poised to help its country reach its goal of 15% renewable energy by 2010. The company plans to more than double its current capacity in the next three years, with plans for another offshore wind farm of 100 MW off the coast of North Wales and a new 60 MW onshore farm in Dorset, England. A recent Ernst & Young study called the U.K. the best European country for wind, thanks to ample supply and government support. If the Brits join their counterparts on the continent as preeminent suppliers of wind energy, NWP will be one of the leading companies making it happen.

*Europe currently
accounts for more than
70% of global
installed utility-scale
wind power*

countries beyond the three current leaders. Germany already is seeing a slowdown in new installations.

The U.K. and other countries will have to pick up the slack, and there are indications this is beginning to happen. While it currently has only around 650 MW of installed capacity, Britain has many new megawatts of wind power on the drawing boards. One of the most ambitious plans was announced recently by Shell WindEnergy, with a proposal to build a £1 billion (US\$1.86 billion), 300-turbine, 1,000 MW offshore wind farm, pending successful trials. The project, if built, would provide up to a quarter of London's total electricity needs.

Like the wind industry in other parts of the world, key challenges face Europe's wind industry, including complaints of bird kill and growing NIMBYism. Europe's small geography also means it will be increasingly difficult to find sites for wind farms, with a greater need to explore offshore options. But the growth trend is likely to continue, with serious backing from larger financiers, renewable electricity targets by EU governments, and ongoing technical advances that are bringing down costs.

2003 Top Headlines

Big Boost for Offshore Wind Power in Europe

Denmark's Vestas Closes Tender Stock Offer for Rival

NEG Micon Hikes Capacity in Spain 20 pct

Record Growth for Global Wind Power

RWE Innogy Signs £400 Million Wind Power Deal

Shell Wants London to Be Windy City

U.K. "Best Country" for Wind Power Investment

What's Holding Up Wind Power? U.S. Lags Far Behind Europe

Select Companies to Watch

Enercon

www.enercon.de

Gamesa

www.gamesa.es/home_ingles.htm

National Wind Power

www.natwindpower.co.uk

Shell WindEnergy

www.shell.com/renewables

Vestas

www.vestas.com

5. CHINA HARNESSSES CLEAN ENERGY

Conventional wisdom has had it that Japan would be Asia's global leader in clean energy. Its government has made significant commitments toward building a clean-energy future, and a steady stream of innovations has sprung forth from its many high-tech innovators: Hitachi, Honda, Kyocera, Matsushita, Sharp, Toyota, and others.

But the Land of the Rising Sun could get eclipsed by Asia's biggest emerging superpower. China's central government is embracing clean energy, and its ambitions are large. China already has demonstrated its ability to propagate ideas and technologies quickly, from cars to cell phones. As a result, the nation formerly known as Red China may come to take on a distinctly green sheen.

The move to clean energy is born of China's inability to supply its surging power needs as its economy ramps up. Its car production is up 87% in just one year and the government predicts that the number of private cars will triple between now and 2015. Already, China, which relies on domestic oil for about two-thirds of its needs, has replaced Japan as the world's second-largest oil consumer. And China is set to become the largest emitter of greenhouse gases by 2025.

Transportation is only the beginning. China relies on coal for about three-fourths of its electricity, and demand is surging. Power generation takes a severe toll on China's public health and the environment: Seven of the world's ten most polluted cities are in China and air pollution in some cities is more than ten times the standard proposed by the World Health Organization. Meanwhile, rural

Profile:

GT Solar Technologies

Location

Merrimack, New Hampshire
www.gtsolar.com

Founded

1998 (division of GT Equipment Technologies, founded 1994)

Employees

6, mostly sales/marketing (GT Equipment has 50)

Technology

Integrated turnkey photovoltaic fabrication lines and PV manufacturing equipment for solar wafers, cells and modules.

The Buzz

Parent GT Equipment is one of the leaders in crystal growing furnaces for semiconductors, so an extension into equipment for photovoltaic cells was a natural. The company has leveraged its semiconductor expertise to create fab lines producing crystalline silicon ingots optimized to produce PV wafers, and to create production lines vertically integrated to produce wafers, cells, and modules. China is becoming a major market.

Brain Trust

Keith Matthei, who heads the division, has more than 15 years of experience in the photovoltaic industry and 10 years in the semiconductor equipment industry.

Bankrollers

Wholly owned division of privately held GT Equipment

Our Take

China has big plans for becoming a solar manufacturing powerhouse, and GT Solar is in prime position to be a major player as the country ramps up volume and tries to drive down costs. "They'll have no problem competing against the best in the West in terms of low-cost suppliers," says Matthei.

China is set to become the largest emitter of greenhouse gases by 2025.

China is choking on indoor air pollution, primarily from cook stoves, used for cooking and heating, and fueled by crop residue, woody biomass, or coal. If ever a country was ripe for renewables, it is China.

Recently, China's State Development and Reform Commission revealed it would invest US\$1.2 billion in solar photovoltaic technology and implementation, leading to as much as 300 MW installed by 2005. The government said approximately 10 million, largely impoverished, Chinese will gain access to electricity through these efforts.

As a result, clean-energy companies already are beating a path to China's door. U.S. firms Spire Corp. and GT Solar have shipped turnkey PV module production lines into the country. Kyocera Corp. is launching a module production plant in Tianjin, where it plans to produce 120 MW of PV a year. BP, Shell, and other large players are gearing up sales efforts in China. And it's not just solar. About 400 MW of wind power capacity have been developed in China. By next year, that number should grow to 1,400 MW. Germany's Nordex AG is a major player.

The growth curve could begin to take on hockey-stick proportions. Since 2000, China has considered a renewable portfolio standard. Should a Chinese RPS come to pass, its clean-energy market could explode. China, by its sheer size, could play a key role in bringing the price of clean energy down to earth.

2002 Top Headlines

BP Solar Wins China's Largest On-Grid PV Supply Contract

China's Biggest Solar Power Controlling System Built in Xinjiang

Chinese Government to Boost Solar Investments

Chinese and German Cooperate in Wind Power Project

Chinese Join Up as Solar Power Dream Aims High

Country's Largest Solar Power Station Operational in Xinjiang Pasture

GM Pitches Fuel Cell Vehicles In China

Shanghai Commits to Sustainable Transport Partnership

Select Companies to Watch

GT Solar Technologies

www.gtsolar.com

Kyocera Corp.

global.kyocera.com/prdct/solar/index_module.html

Nordex AG

www.natwindpower.co.uk

Shell Solar

www.shellsolar.com

Spire Solar

www.spiresolar.com

ABOUT CLEAN EDGE

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