

CLEAN ENERGY TRENDS 2005

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MARCH 2005

CLEAN EDGE

THE CLEAN-TECH MARKET AUTHORITY

INTRODUCTION

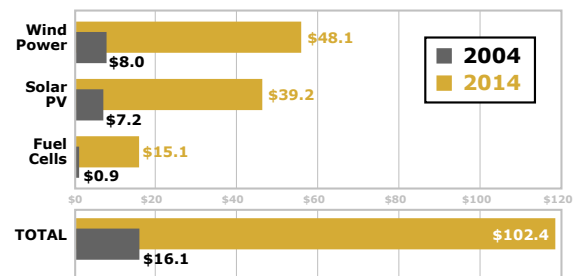
When historians look back to assess the history of clean energy, the first half of the 21st century's first decade will likely be viewed as the point at which the industry began its hockey-stick growth spurt. Which is not to say that it's all smooth skating. Like the hockey rink itself, the business of developing next-generation solar, wind, hydrogen, and other technologies can be both slippery and high-risk.

The industry has entered a critical phase encountered by all major tech booms. As individual technologies mature, there is an inevitable churning of players: mergers, acquisitions, divestments, bankruptcies, and – always – new market entrants. The result is a constant rising and falling of prospects for companies, and even entire sectors, that is variously fascinating (if you're an outside viewer) or frightening (if you're an inside participant). But it's never dull.

Some of this is due to technology breakthroughs – some real, some potential – that continue unabated. But it may be the far less scientific world of politics that leads the way. Last year demonstrated just how non-ideological the race to develop clean-energy sources can be. Republican governors Schwarzenegger of California and Pataki of New York both launched aggressive clean-energy initiatives, and China unveiled plans that could result in up to 100 gigawatts of new renewables by 2020. Meanwhile, Germany's generous feed-in tariffs made solar photovoltaics (PV) so popular that it led to module shortages around the world.

All of which bodes well for clean energy's continued growth. According to Clean Edge research, markets for solar PV (modules, system components, and installation) will grow from \$7.2 billion in 2004 (compared to \$4.7 billion in 2003) to \$39.2 billion by 2014. New wind power installations are projected to expand from \$8 billion in 2004 (about the same as 2003) to \$48.1 billion in 2014. And fuel cells and distributed hydrogen are projected to grow from \$900 million (primarily for research contracts and demonstration and test units) to \$15.1 billion over the next decade.

Clean Energy Projected Growth 2004-2014 (\$US Billions)



Source: Clean Edge, 2005

\$100 Billion Market by 2014

Select Business Developments of 2004

- Endesa, a leading Spanish utility, said it would invest roughly US\$2.5 billion over the next five years to increase its renewable energy capacity in Europe — a whopping 32% of Endesa's planned investment in new capacity through 2009.
- FPL Energy, a clean-energy provider, continued to gain dominance in the U.S. wind energy market, generating a quarter of its electricity supply from the wind.
- GE acquired Astropower, which it expects to grow into a \$1 billion business by the end of the decade. This follows the company's purchase of Enron Wind in 2002; GE quickly turned that into an annual \$1 billion business.
- Sharp Electronics, the world's leading manufacturer of solar PV modules (accounting for about a third of total global output in 2004) reached an estimated \$1 billion dollars in total PV sales.
- Toyota shipped approximately 130,000 Prius hybrid-electric vehicles and announced plans to ramp up global production to around 180,000 in 2005. Toyota says it plans to open a Prius production facility in the U.S. in 2006.

Already, these three clean-energy markets have expanded from \$9.5 billion in 2002 to just over \$16 billion in 2004. By 2014, they will grow another sixfold, to more than \$100 billion.

Select Clean-Technology Stocks

(As of End of Session 3/8/2005)

Ticker	Name	Last (\$US)	52-Week Range (\$US)	Market Cap (\$US Millions)
AVA	AVISTA CORP	18.15	15.35 - 19.43	879.8
BLDP	BALLARD POWER SYS	5.73	5.14 - 12.05	680.6
CPST	CAPSTONE TURBINE	1.72	.42 - 3.52	145.4B
ENER	ENERGY CONV DEVIC	22.31	6.75 - 23.45	696.5
ESLR	EVERGREEN SOLAR	6.95	1.92 - 7.60	330.4
FCEL	FUELCELL ENERGY	11.30	7.16 - 20.30	544.3
HYGS	HYDROGENICS CORP	4.61	3.19 - 6.27	297.7
IDA	IDACORP INC HLDG	29.13	25.30 - 32.95	1,113.0
ITRI	ITRON INC	27.50	15.93 - 28.199	581.6
MKTY	MECHANICAL TECHNO	4.75	2.92 - 6.88	138.9
MDTL	MEDIS TECH LTD	20.31	8.50 - 21.60	533.9
MCEL	MILLENNIUM CELL	2.35	0.80 - 3.43	91.0
PLUG	PLUG POWER INC	7.49	4.62 - 10.24	548.6
SPIR	SPIRE CORP	5.70	3.45 - 7.95	39.0

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

For all the positive developments and encouraging signs, pure-play clean-energy stocks showed mixed results in 2004. While a number trade at or near their 52-week highs, many continue to be saddled with delayed product releases, limited earnings, and similar issues facing emerging companies. Some investors are turning instead to larger players with clean-energy initiatives, such as GE, Sharp, and Toyota. But for those with an appetite for risk, and the potentially high returns that come with it, many clean-energy stocks still offer significant potential. As one sign of investor interest, the first clean-energy index began trading

on AMEX as an exchange-traded fund in early 2005.

Venture Capital Investments

Venture capital (VC) investments in energy technologies increased last year from \$509 million in 2003 to \$520 million in 2004. As a percent of total VC investments, energy tech declined from 2.8% in 2003 to 2.6% in 2004. This was due to an overall increase in total U.S. VC activity, increasing from \$18 billion in 2003 to \$20 billion in 2004. (See page 3 for more on VC investments.)

Clean Energy Private Equity Investments in U.S.-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	\$458	0.8%
2000	\$103	\$1,265	1.2%
2001	\$41	\$919	2.2%
2002	\$21	\$539	2.6%
2003	\$18	\$509	2.8%
2004	\$20	\$520	2.6%

Source: Clean Edge, Inc. and Nth Power

As an asset class, clean energy and clean tech continued to post gains last year. Several traditional venture firms have recently begun investing in the space, along with more established energy funds. And some new funds, such as Chrysalix Energy II and Expansion Capital II, recently achieved initial closings. With pension funds and other institutional money also eyeing the clean-energy arena, the relative trickle of money entering this space is expected to become a steady stream.

ENERGY-TECH INVESTMENTS

A Calm Surface Hides Shifting Currents

by Rodrigo Prudencio, *Principal, Nth Power*

High oil and natural gas prices, turmoil in the Middle East, a growing push by state governments to require renewable portfolio standards, and increasing concern about power outages: These headlines have the ingredients for a growing interest in the energy-tech sector.

Despite the seemingly perfect storm of headlines, however, energy tech's share of total venture capital (VC) investing fell slightly to 2.6%. Venture capital investments in energy tech increased by about 2% from \$509 million in 2003 to \$520 million in 2004, but this trailed overall venture capital investments which grew by 10% in 2004 to \$20.4 billion from last year's \$18 billion.

This still represents historically high levels for the energy-tech space, which represented less than 1% of total venture deals prior to 2000. But recent trends make clear that in an environment of resurgent venture capital investment, energy-tech deals are going to have to fight for their share of attention from investors.

Nth Power, which has been tracking and analyzing energy-tech venture data for more than a decade, sees some interesting trends in its 2004 findings.

Investors Get More Selective . . . But More Committed. The number of deals completed by VCs in the energy-tech sector has bounced around over the last several years. In 2004, investors closed 69 deals, a 14% drop from a busier 2003, which saw 80 deals completed.

Investors, however, were not stingy. After three consecutive years of declining averages, energy-tech dollars per deal grew more than 18% to \$7.5 million. This is due to a number of factors. To begin with, patience and selectivity have resulted in larger investments in more mature companies. VCs are pouring more capital into companies as they see the prospects improving for financial returns in the energy-tech sector. And last, the growing number of VCs participating in energy-tech deals has led to deal competition and higher investments in the most promising companies.

Subsector Trends. Nth Power divides the energy-tech investment opportunity into four categories: Energy Intelligence, Distributed Energy, Power Reliability, and Related Services. In general, these categories do a good job of classifying the universe of deals in the clean-energy sector. A number of deals, such as advanced materials that have broad energy applications, fall outside of these categories and are classified as Other.

After three consecutive years of declining averages, energy-tech dollars per deal grew more than 18% to \$7.5 million.

A continued trend towards more investments in Distributed Energy and Power Reliability, and away from Energy Intelligence, characterized the distribution of funding in 2004. Leading the way for Distributed Energy investment was the strong interest in fuel cell and solar deals. Small-scale fuel cells, in particular, generated the most activity. This may be because investors see more pull for fuel cells for their longevity in consumer electronics than for their zero-emissions characteristic in larger applications. Polyfuel and Ultracell were two of the most visible deals in this category.

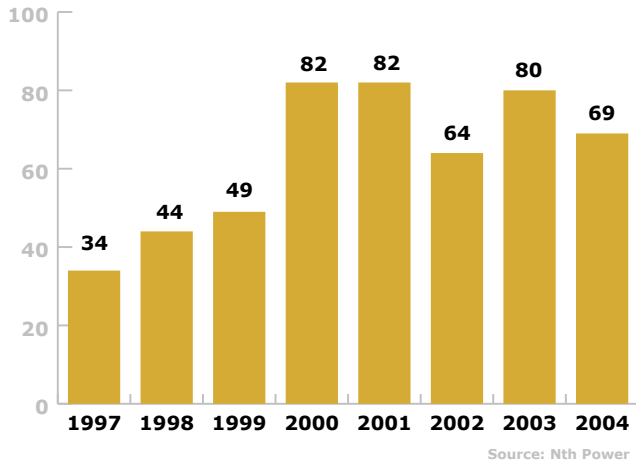
Strong demand in the overall market for solar photovoltaics buoyed solar deals during

2004. As a result, newcomers such as Konarka, Miasolé, and Nanosolar, were able to tap into venture dollars, while more established players, such as Evergreen Solar, raised private capital through what is known as “private investment in a public equity” or PIPE.

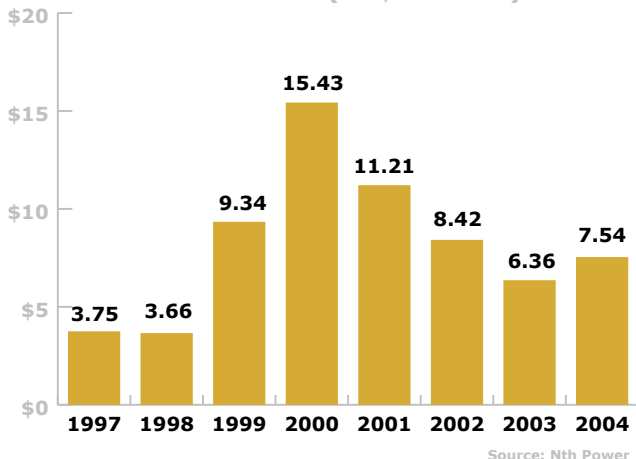
Power Reliability deals also have grown over the last few years. Leading the way are battery deals that address mobile computing, medical devices, and other “unplugged” applications. Power sources for wireless networks and myriad new sensor applications are other drivers.

While investments in Distributed Energy and Power Reliability grew in 2004, investments in Energy Intelligence deals declined rather sharply from 2003. Nth Power does not believe that this reflects disenchantment with Energy Intelligence technologies, such as sensors, advanced metering, energy management devices, and grid optimization applications. Rather, it’s that the Energy Intelligence companies that survived the tech market crash after 2001 are on solid footing, with dominant market positions and little need to raise capital.

Number of U.S. Energy VC Deals Per Year 1997-2004



Average U.S. Investment Per Energy VC Deal 1997-2004 (US\$ Millions)



Venture Capital Dips into Public Markets.

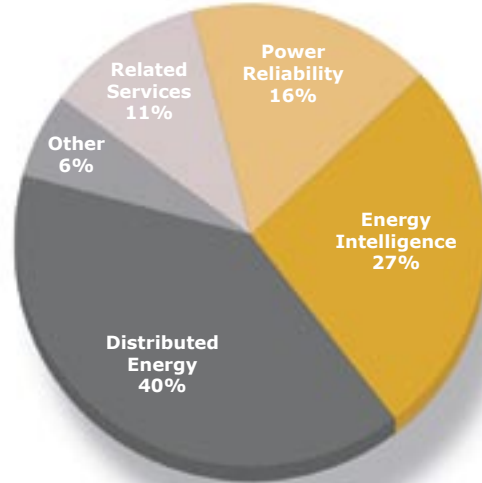
The public markets continue to be receptive to promising energy-tech companies. In Europe, several energy-tech companies successfully completed public offerings on the London Stock Exchange’s AIM. And in the U.S., companies such as Evergreen Solar, MTI Fuel Cells, and SatCON all raised capital from private-investor structured deals. These PIPE investments totaled more than \$30 million.

Investors were also busy finding energy-tech deals outside of the U.S. This comes as no surprise given China’s enormous energy appetite and Europe and

Japan's favorable renewables policies. Some of the most visible private equity deals completed overseas in 2004 were fuel cell companies Pemeas (Germany) and ITM Power (UK), battery technology companies Atraverda (UK) and Pionics (Japan), and solar cell manufacturer Q-Cells (Germany).

Such developments are telltale signs of a welcome warm-up for venture capital-backed companies that have been waiting for their opportunity to harvest returns and invest them in other high-potential investments.

**U.S.-Based Venture Investments
2004, by Subsector**



Source: Nth Power

FIVE TRENDS TO WATCH

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

1. FUELS FROM BIOMASS GROW LIKE A WEED

While solar, wind, and hydrogen seem to be capturing the headlines and hype, biofuels are gaining traction.

Biomass term refers to any of three types of fuels: biogas, biodiesel, and ethanol. Not long ago, interest in biofuels came principally from home hobbyists and green activists. But no longer. According to the U.S. Department of Energy, biodiesel is America's fastest-growing alternative fuel and is experiencing even greater growth in Europe.

U.S. biodiesel sales are expected to quadruple in 2005 over a year earlier to 125 million gallons.

And who are the customers? The U.S. Army, Navy, Air Force, and Marines all use B20, a mixture of 20% biodiesel and 80% diesel. U.S. cities are joining in. The snow plows in Minneapolis-St. Paul run on a blend of diesel and biofuel made from soybeans. Bangor, Maine, burns biodiesel in its buses, fire trucks, and heavy equipment.

U.S. biodiesel sales are expected to quadruple in 2005 over a year earlier to 125 million gallons. One reason: an excise tax credit went into effect, with a two-year tax credit that trims 20 cents per gallon off biodiesel's retail price, giving it near price-parity with conventional diesel.

But Europe could be the real driving force. The EU plans to increase the share of biofuels used in road transport to 2% by the end of the year, with a further target of 5.75% by 2010. Europe is bristling with biofuel investments. Germany's industry is cranking at full capacity. France recently unveiled plans to nearly triple biofuel output within three years. Spain says it will make bioethanol competitive with conventional fuels.

Profile: **World Energy Alternatives LLC**

Location

Chelsea, Massachusetts
www.worldenergy.net

Founded

1998

Employees

40

Technology

Supplies biodiesel to fleets, including the U.S. military, school bus fleets, various state transportation departments, and public utilities.

The Buzz

Perhaps no one is happier about \$50-a-barrel oil prices than World Energy, the largest U.S. supplier of biodiesel, which is sitting pretty as oil prices — and biofuel markets — reach new highs. With customers in 42 U.S. states and recent inroads into Europe, World Energy is set to double the 50% annual growth it has enjoyed since its founding.

Brain Trust

CEO Gene Gebolys, whose interest in energy harks back to an 8th grade science project, founded World Energy in 1998 after spinning out of another firm. In 2004, the company was purchased by fuel wholesaler Gulf Oil, a move designed to infuse the capital needed to accelerate growth.

Key Customers

Power Alabama, Entergy, Harvard University, Kodak, the U.S. Postal Service, and lots of state and local agencies. Supplies 90% of biodiesel bought by the U.S. military, the nation's largest biodiesel customer.

Our Take

With its diverse product line, high-profile customers, and well-oiled sales machine, World Energy dwarfs nearly all of its competitors, mostly local mom-and-pops. As biofuels become a growing part of the world's energy appetite, World Energy is set for potentially high-octane growth.

And in an ironic twist, UK biodiesel developer D1 Oils launched a joint venture to produce biofuels in Saudi Arabia, using jatropha, a non-edible plant producing oil for blending with diesel.

The biofuel boom also can be seen in the lab, where biotech firms – like U.S.-based Genencor and Denmark’s Novozymes – are working to better extract fuels from organic waste. Novozyme reported last year that technology advances had cut the cost of the enzyme part of the biomass-to-ethanol conversion process from more than US\$5 to less than 30¢ per gallon of ethanol.

Not everyone loves biofuels – at least not all biofuels. For example, fuels derived from corn promote large-scale monocropped farms, which are undesirable ecologically. And then there’s the net-energy analysis – how much energy it takes to make a gallon of biofuels, compared to the energy it yields. The bottom line: Producing biofuels from corn requires 131,000 BTUs per gallon, which has an energy value of 77,000 BTUs.

None of which seems to be slowing the biofuel bandwagon. It may not be the ideal alternative to Saudi crude, but it shows great promise as domestic energy that requires tilling, not drilling. That keeps both the drivers – and the farmers – happy.

Genencor Making Progress in the Conversion of Biomass to Ethanol

New Biodiesel Stations to Open in Colorado and New Mexico

Bioenergy To Ease Poverty In Developing Countries

APS Biomass Plant Comes on Line

Novozymes Exceeds Milestone in Biomass-to-Ethanol Project

New Facility Offers First Nationwide Access to Biodiesel Blend

Groundbreaking Takes Place for B20 Pump Near Pentagon

Chrysler to Fuel Jeep Liberties with B5 Biodiesel

2004 Top Headlines

Abengoa Bioenergy
www.abengoabioenergy.com

Blue Sun Biodiesel
www.gobluesun.com

D1 Oils plc
www.d1plc.com

Peter Cremer North America
www.petercremerna.com

World Energy Alternatives
www.worldenergy.net

Select Companies to Watch

2. ENERGY EFFICIENCY BECOMES BIG BUSINESS

Efficiency is back in the spotlight with greater prominence than at any time since the 1970s Arab oil embargo. A wide array of providers are bringing 21st-century innovations to bear, helping companies, utilities, and governments make impressive strides in energy saving.

The nonpartisan American Council for an Energy-Efficient Economy has called for \$7 billion in federal and state spending over the next five years on efficiency R&D programs.

The nonpartisan American Council for an Energy-Efficient Economy has called for \$7 billion in federal and state spending over the next five years on efficiency R&D programs. Eighteen states currently spend a collective \$1 billion annually on such programs, with California, Connecticut, Maryland, and New Jersey promulgating new efficiency standards in just the past year; at least six more states are expected to do the same in 2005.

In industry, many efficiency efforts are underway. General Electric's Global Research unit is six months into a three-year, \$6 million federal project to dramatically increase the efficiency of industrial electric motors, which gobble up 65% of the electricity annually used by American manufacturers – and nearly a quarter of all U.S. electricity consumption. GE Global Research is working with Rensselaer Polytechnic Institute and Sensicast Systems, a provider of networking software that optimizes the transfer of data from wireless sensors. If the project succeeds, GE says such wireless sensor networks could eventually save 120 trillion BTUs per year in industrial energy use.

The humble light bulb represents a key application for big energy-saving potential with new breakthroughs in light-emitting diode (LED) technology. A new Optimized Digital Lighting bulb from Lighting Science Group Corp. replaces a 15-watt fluorescent bulb or a 65-watt incandescent bulb with just 5.6 watts of consumption.

Profile: **Encorp**

Location

Windsor, Colo.
www.encorp.com

Founded

1994

Employees

75

Technology

Energy-management equipment, including a digital device the size of a laptop that manages on-site generation. Encorp embeds other efficiency devices and software in generators made by big OEMs like Caterpillar, Cummins-Onan, and Waukesha.

The Buzz

Established and well-connected, Encorp has financial and business momentum in the fast-growing efficiency sectors of combined heat and power (CHP), distributed generation, and the digital management of both. Customers include big utilities, independent power producers, manufacturers, hospitals, municipalities, and the micro-grid at Fort Bragg, N.C. Important partnerships with the U.S. EPA for CHP and NREL for management of distributed generation help, too.

Brain Trust

Acting CEO David Johnson, formerly Encorp's CFO, took the helm in March 2005. CTO Mike Cruse is a 20-years-plus veteran of embedded systems design, network communications, and software development, including intelligent building automation systems, facility-systems integration, remote monitoring and control, and demand-side energy management.

Bankrollers

A blue-chip roster of VCs, including Angeleno Group, Arete Corp., Nth Power, OPG Ventures, Perseus, Rustic Canyon Partners, and Siemens Venture Capital. The company completed a \$7.11 million funding round in 2004.

Our Take

Encorp's markets are solid and growing, and the company has stated a goal of 100% growth for 2005. A year into its second decade, Encorp is now past the growing-pain stage, well-funded, and riding the wave of energy-efficiency management and CHP generation.

City governments across the U.S. are saving energy, and money, by replacing incandescent traffic signals with LED bulbs. Syracuse, N.Y., Arlington and Dallas, Tex., and Elk Grove, Calif., are among the most recent to do so.

Globally, 37 countries use some sort of energy-efficiency labeling system for appliances and electronic gear. Joining them this year is China, the world's fastest-growing energy user, which will start labeling air conditioners and refrigerators with a goal of saving 18 billion kilowatt-hours of electricity by 2010 and 87 billion kilowatt-hours by 2020. In the next phase, the China National Institute of Standardization will extend efficiency labels to television sets, irons, and electric fans.

The opportunities are rich. The Rocky Mountain Institute points out that in industrial settings, "there are abundant opportunities to save 70% to 90% of the energy and cost for lighting, fan, and pump systems; 50% for electric motors; and 60% in areas such as heating, cooling, office equipment, and appliances." In general, say experts, up to 75% of the electricity used in the U.S. today could be saved with efficiency measures that cost less than the electricity itself.

GE-Led Motor-Efficiency Project to Save 120 Trillion BTUs

Fuel Efficiency Stimulates Use of Lightweight Materials in Automobile Industry

Mitsubishi Electric Achieves Energy Efficiency of 83% with Co-Generation System

ACEEE Testifies on Efficiency's Role in Restoring U.S Economy Health

New RMI Book Shows Businesses How to Mobilize and Profit from the End of Oil

Fortune Proposes Plan to Free America from Dependency on Oil

New LED Bulb Promises to Slash Lighting Costs by 80%

Marriage of Carbon Nanotubes, LEDs Shows Unexpectedly Bright Prospects

2004 Top Headlines

American Process Inc.

www.apweb.com

Encorp

www.encorp.com

GE Global Research

www.research.ge.com

Lighting Science Group Corp.

www.pxgp.com

Sensicast Systems

www.sensicast.com

Select Companies to Watch

3. CONCENTRATING SOLAR POWER HEATS UP

You may be surprised to learn that the U.S. derives about as much solar electricity from concentrated solar power as from photovoltaics.

Solar photovoltaics garners the lion's share of attention among solar technologies. But another technology is also deserving of consideration: concentrating solar power (CSP) for large-scale power generation. CSP plants use the sun's heat to make steam to spin electricity-producing turbines using any one of several technologies.

You may be surprised to learn that the U.S. derives about as much solar electricity from CSP as from PV. Case in point: Nine solar thermal power plants in California's Mojave Desert produce around 350 MW of power, slightly more than the 340 MW from all PV installations in the U.S. as of the end of last year. But while PV has been expanding by 40% or so annually for the past three years, the CSP market has been at a virtual standstill for more than a decade.

Things are starting to heat up. Governments and utilities are seeking ways to stabilize pricing. And while solar (including both PV and CSP) requires more up-front capital than most conventional energy sources, its payoff comes over time in the form of predictable pricing (since the price of sunlight never wavers).

Earlier this year, a coalition of western states joined with the U.S. Department of Energy and the National Renewable Energy Laboratory (NREL) to propose large-scale expansion of CSP. The plan is for 1,000 MW of CSP facilities to be built across the western U.S. The first wave already is taking shape in Nevada, where a 50 MW plant is scheduled for construction. DOE's goal is to cut in half the price of electricity generated from CSP, to just 7 cents a kilowatt-hour. That would make CSP competitive with many traditional electrical generation technologies.

The U.S. isn't the only hotbed for CSP. Spain is

Profile:

FPL Energy

Location

Juno Beach, Florida
www.fplenergy.com

Founded

Founded as ESI Energy in 1985.
Established as FPL Energy in 1998.

Employees

1,800

Technology

Largest owner and operator of solar technology in the United States. Owns and operates, along with other partners, 90% of the 350 MW of CSP in the Mojave Desert.

The Buzz

FPL Energy has proven to be one of the most aggressive clean-energy developers in the U.S. Not only does it generate nearly half of all wind power assets in the nation, but with its recent acquisition of additional CSP plants in the Mojave, it now controls more than 90% of the nation's concentrating solar power assets.

Brain Trust

Jim Robo, president, formerly headed up corporate development and strategy for FPL Group and served as chief executive officer of a division of GE Capital.

Our Take

CSP, which has been dormant for more than a decade, could be in for a significant recovery with a player like FPL and its investment partners stepping in. The company recently doubled its CSP holdings along with partner Carlyle/Riverstone (a \$1.1 billion private equity fund better known for its investments in coal, oil, and natural gas). This most recent investment could signal a growing appetite for central solar power development in coming years.

planning two 50 MW plants with molten salt storage, which enables them to provide energy even when the sun isn't shining by releasing stored electricity. The Middle East – which is rich in both oil and sunlight – could become another CSP Mecca. Israel currently is seeking proposals for the first 100 MW of a planned 500 MW of CSP. And there are similar plans on the drawing boards in Algeria, Egypt, and Morocco.

CSP also could play a role in the transition to a hydrogen economy. Sandia National Labs, the University of Nevada, and General Atomics are looking into producing hydrogen from water using CSP as an energy source. And several others are exploring the opportunity of combining CSP's high-temperature capabilities to produce hydrogen.

High up-front costs and the availability of reliable grid networks to transmit power remain two hurdles for CSP's ramp-up. It will require supportive national and regional policy and committed (and patient) capital to expand these markets. But as utilities seek reliable, low-cost, fossil-free sources of energy to meet renewable-energy mandates and central station power needs, CSP's prospects could shine brightly.

Western States to Expand Use of Concentrating Solar Power
ECOSTAR Project Produces Roadmap for Lowering Costs of Solar Power
Sandia and Stirling Energy Systems to Co-Develop Concentrated Solar Power Plant Technology
Arizona Solar Trough Plant To Produce Electricity for 12 Cents/kWh
DOE Supports States' Efforts to Install 1000 MW of Concentrating Solar Power Systems
Investment Alliance Signed to Take Solar Tower Development to China
Government to Help Install Concentrating Solar Power in the West
A Rebirth of Solar Concentrating Power System

2004 Top Headlines

FPL Energy
www.fplenergy.com

Nexant
www.nexant.com

Solar Millennium
www.solarmillennium.de

Solargenix
www.solargenix.com

Solel
www.solel.com

Select Companies to Watch

4. THE HYDROGEN INFRASTRUCTURE BEGINS TO EMERGE

It doesn't seem that long ago that the idea of a "hydrogen infrastructure" – trucks, pipelines, and onsite systems to fuel the new generation of fuel cells for vehicles and buildings – seemed like – well, a pipe dream. The cost, according to ABI Research, is \$2 billion between now and 2012 in the U.S. alone. What companies would step up to the challenge?

Oil companies, utilities, car makers, industrial gas producers, and a slew of pure-play tech start-ups are seeking their piece of this potential global bonanza.

As the infrastructure begins to take shape, the answer is: just about everybody. Oil companies, utilities, car makers, industrial gas producers, and a slew of pure-play tech start-ups are seeking their piece of this potential global bonanza.

As with any fast-scaling technology, there are signs of consolidation. Canada's Hydrogenics purchased Stuart Energy, its neighbor in Mississauga, Ontario. Ballard Power Systems shed its interest in German-based Ballard AG, part of a collaborative agreement with Ford and Daimler-Chrysler. The move was seen as a retrenchment for Ballard, and as a sign of ups and downs to come for the hydrogen sector.

Still, there's plenty of expansion. Mitsubishi recently launched a Vancouver-based spin-off to make hydrogen fuel-production systems; Shell opened its first hydrogen station in North America; Praxair opened two hydrogen plants in Texas; and Ford and BP announced plans for fueling stations in three cities.

And that's just stateside. Across the pond, the price tag for a European hydrogen infrastructure has been pegged by consultancy e4tech at EUR 3.5 billion (US \$4.7 billion) by 2020. That would create a network of 2,800 filling stations serving 6.1 million vehicles.

The challenges remain significant. Fuel cells remain an embryonic industry, with a mind-

Profile:

Proton Energy Systems

Location

Wallingford, Connecticut
www.protonenergy.com

Founded

1996

Employees

70

Technology

Makes onsite hydrogen generators for industrial use; and regenerative PEM fuel cell systems, which can capture, store, and release electrical energy.

The Buzz

In late 2003, Proton purchased Northern Power, a power systems designer and builder, and created a new holding company, Distributed Energy Systems, of which Proton is a part. Distributed Energy ranked 473 on the 2004 Deloitte Technology Fast 500, a ranking of the fastest-growing companies in North America.

Brain Trust

An impressive cast of industry veterans, headed by Distributed Energy Systems board chair Robert Shaw, a pioneer in renewable-energy investing, and its president and CEO, Walter (Chip) Schroeder. Mark Murray, a veteran of industrial sales and marketing, signed on last fall as president of Proton.

Key Customers

U.S. Energy Department, U.S. Navy, Evergreen Solar, Pinnacle West.

Our Take

Proton's on a roll — it had record revenue of \$11.4 million in the 4th quarter of 2004, and margins of 12% — not bad for a technology sector just gaining traction. It's not all smooth sailing, though: Proton lost a major GE distribution contract last year that sent its stock price plummeting. But the alliance with Northern Power represents a clean-energy powerhouse, offering not just key components of a hydrogen infrastructure, but the means to get them installed and integrated in the field. That puts Proton at the nucleus of the emerging hydrogen economy.

numbing array of technologies competing for prominence. Who wins, and who doesn't, will determine what the hydrogen infrastructure will look like. Among the still-unanswered questions: What are the potential hydrogen fuel sources? How will hydrogen be transported to fueling stations? What are the best storage technologies? How much hydrogen will be required? How many fueling stations will be needed? It seems that after a half-decade or so of trying, that answers to such questions should be forthcoming. But so far, all that's available are best guesses. That's a challenge to companies, both established and start-ups, seeking to make capital-intensive bets in what the hydrogen future will look like.

As with other clean technologies, political leadership is coming – in the U.S. as well as in Europe and Asia. In California, for example, Gov. Arnold Schwarzenegger has launched the Hydrogen Highway Network initiative to “support and catalyze a rapid transition to clean hydrogen transportation economy” in the state. Schwarzenegger envisions a network of 150 to 200 fueling stations by 2010.

It's a bold move, filled with uncertainty. But the governor is certain his state can help create the standards that determine how hydrogen will be delivered, and by whom.

DTE Energy Dedicates Hydrogen Technology Park

Hydrogen to Fuel China's Automobiles in the Future

Canadian Group Tests Production of Hydrogen from Water Using Solar Energy

Mitsubishi Corporation Establishes Spinoff Hydrogen Venture in Vancouver, B.C.

Shell Unveils New Concept to Support the Development of Hydrogen Markets

Ford & BP To Build U.S.-Based Hydrogen Fleets & Fueling Stations

Schwarzenegger Seeks to Boost Hydrogen-Fueled Cars

Proton Energy Systems Provides On-Site Hydrogen Generator

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BC Hydro
www.bchydro.com

ChevronTexaco Technology Ventures
www.chevrontexaco.com/technologyventures

General Hydrogen
www.generallhydrogen.com

Praxair
www.praxair.com

Proton Energy Systems
www.protonenergy.com

Select Companies to Watch

5. GREEN BUILDING CONSTRUCTS A SOLID FOUNDATION

Green building is arguably the most exciting and significant development in construction in the past three decades, thanks in large part to LEED (Leadership in Energy and Environmental Design), a building standard launched by the U.S. Green Building Council (USGBC). LEED consists of 69 criteria to be met by builders in six areas, including energy use and emissions, water use, materials and resource use, and sustainability of the building site. LEED buildings use an average of 30% less energy than other structures of comparable size.

The growth of green building is having a bandwagon effect on manufacturers of everything from compact fluorescent light bulbs and water-saving appliances to new bio-based and recycled building products.

More than 170 buildings comprising 5% of all new commercial construction in the U.S. have earned LEED certification since 1998, and more than 1,750 more in the U.S. are in the pipeline. LEED buildings house every human activity there is, from the Pentagon Athletic Center and the Detroit Lions' football training facility to elementary schools, a Steelcase wood furniture factory, and the David L. Lawrence Convention Center in Pittsburgh, Pa. – the world's largest LEED project at 1.5 million square feet. A LEED standard for residential construction is forthcoming.

The growth of green building is having a bandwagon effect on manufacturers of everything from compact fluorescent light bulbs and water-saving appliances to new bio-based and recycled building products. Durra Building Systems in Whitewright, Tex., for example, makes construction materials from wheat straw that replace traditional drywall and roofing. Its products are now in Hilton hotels, IMAX theaters, and three Australian airports.

New York City's Freedom Tower, arguably the world's most-watched construction project, will drive significant further interest in green build-

Profile:

Turner Construction Co.

Location

Dallas, Texas
www.turnerconstruction.com/
greenbuildings

Founded

1902

Employees

5,000

Technology

"Gray water" systems that reduce use by half by recycling sink and shower water; floor-by-floor HVAC systems that save energy and increase air purity; recycled building materials with at least 20% post-consumer or 40% post-industrial content; low VOC paint and coatings; incorporated solar PV power in many projects.

The Buzz

Turner first identified green building as a growth market segment in 1995; now the U.S.'s largest commercial construction firm has completed nearly 100 green buildings worth close to \$8 billion. High-profile projects include Pittsburgh's Lawrence Convention Center, currently the world's largest LEED structure, and The Solaire, Manhattan's first green luxury residential high-rise.

Brain Trust

CEO Tom Leppert laid out a multi-point plan last fall for Turner's green leadership, including recycling construction waste on all projects and doubling its LEED-certified engineers to 150, both by the end of this year. Spearheading the efforts is senior VP of sustainable construction Rod Wille, a 37-year Turner veteran.

Key Customers

Alcoa, Emory University, Genzyme, Reebok, Toyota.

Our Take

Turner is not only leading by example, but is also helping show other firms that green building is a worthy investment. In a Bayer Consulting study commissioned by Turner last year, about 75% of green building owners, developers, architects, and engineers said their buildings generated a higher ROI than others. That's the kind of bottom-line data point that propels an industry forward.

ing. Its proposed design includes a revolutionary “wind farm” 60 floors up in the sky – up to 30 vertical-axis turbines on a cabled truss section that will generate 20% of the tower’s electricity from wind coming off the Hudson River. (Another World Trade Center building, to be finished in late 2005, will be the first LEED-certified office building in the Big Apple.) Further uptown, The Durst Organization broke ground last year on a 54-story Bank of America tower, which aims to be the first LEED Platinum skyscraper. It will include a 4.6 megawatt co-generation plant, an anaerobic digester to turn food waste into electricity, 50% recycled building materials, and 50% reduced water consumption from recycling and capturing rain water.

A driving force in green building is the bottom line. In a 2004 survey of building owners, developers, engineers, and architects commissioned by Turner Construction, 80% said lower energy and operations outlays recoup any additional costs of green building. And the added costs aren’t much, if any: a recent study by construction cost management consultancy Davis Langdon found “no significant difference” in the cost of buildings constructed with the intent to seek LEED certification. That should pretty much nail the business case for building green.

NAHB Drives Green Building With New Model Guidelines
GE Energy PV Systems Installed in First Zero-Energy Community
Kubota Wins Order for Japan’s Largest Solar Home Development
NowHouse Showcases Latest Advancements in Environmentally Friendly Homebuilding
California Proposes Initiative to Achieve Solar Homes Goal
California Firm Has Wind-Energy Vision for Freedom Tower
EcoCottages Provide Instant Off-Grid Housing Solution
SolarWorks Helps New Jersey Medical Center ‘Go Green’

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Holcim Ltd.
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Turner Construction
www.turnerconstruction.com/greenbuildings

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