CLEAN ENERGY TRENDS 2011

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CLEAN EDGE
THE CLEAN-TECH MARKET AUTHORITY

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CLEAN ENERGY TRENDS 2011

Ten years ago, in April 2001, Clean Edge released *Clean Tech: Profits and Potential*, our first publication. It marked the launch of our research firm and the beginning of a decade-long journey exploring the growth, opportunities, and challenges of the clean-tech sector.

Back then, the concept of clean tech was virtually unknown

Back then, the concept of clean tech was virtually unknown in the mass media, in business circles, and among politicians. At the time, there was one clean-tech institute in India and the United Nations used the term sporadically, but decided, in a move that only a bureaucrat could love, to use the term "environmentally sound technologies" or ESTs, instead. But we thought the term "clean tech" was most apt – reflecting terms used in earlier revolutions such as high tech and biotech – and much more aligned with our own Internet-age proclivities. Needless to say, clean tech and clean energy won out – and have moved broadly into the mainstream vernacular – from Beijing and Washington, D.C. to Rio de Janeiro, Seoul, and across the globe.

As witnessed over the past decade, clean tech has proven to be a significant business opportunity, and its growth rates now rival that of earlier technology revolutions like telephony, computers, and the Internet. According to Clean Edge research, the global market for solar photovoltaics (PV) has expanded from just $2.5 billion in 2000 to $71.2 billion in 2010, for example, representing a compound annual growth rate (CAGR) of 39.8 percent. The global market for wind power, which like solar PV we have tracked every year for the past decade, has similarly expanded from a global market worth $4.0 billion in 2000 to more than $60.5 billion today, for a CAGR of 31.2 percent. And these growth rates are not limited to solar and wind. Other clean-tech sectors, such as hybrid electric vehicles, green buildings, and smart grid, have seen similarly spectacular growth rates.

Ten Years in Clean Tech: At a Glance

	2000	2010
Combined Global Market for Solar PV and Wind	$6.5 billion	$131.6 billion
Average Cost to Install a Solar PV System (Per Peak Watt)	$9	$4.82
Number of Hybrid Electric Vehicles on the Road in U.S.	Less than 10,000	More than 1.4 million
Number of Hybrid Electric Vehicle Models Available Globally	2	30
LEED-Certified Commercial Green Buildings in the World	3	8,138
Number of U.S. States with RPS	4	29
Percentage of Total U.S. Venture Capital Invested in Clean Tech	Less than 1%	More than 23%

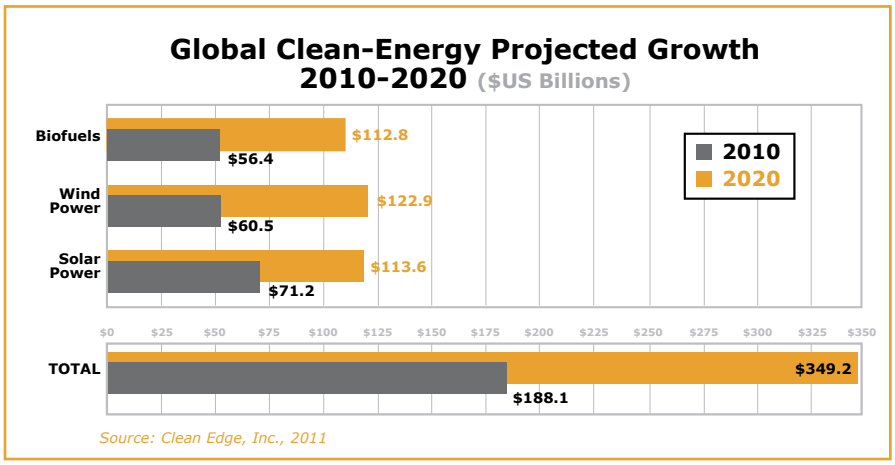
Source: Clean Edge, Inc., 2011

This overall trend for clean-tech markets continued to be one of growth and expansion in 2010. Combined global revenue for solar PV, wind power, and biofuels surged by 30.2 percent over the prior year, growing from $144.5 billion to $188.1 billion. The bulk of this expansion came from a more than doubling in global solar PV installations. For the first time since we began tracking the wind sector, however, we witnessed a slight year-over-year decline in market size.

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According to our research:

- Biofuels (global production and wholesale pricing of ethanol and biodiesel) reached $56.4 billion in 2010 and are projected to grow to $112.8 billion by 2020. In 2010, the biofuels market consisted of more than 27.2 billion gallons of ethanol and biodiesel production worldwide, up from 23.6 billion gallons the prior year.



- Wind power (new installation capital costs) is projected to expand from $60.5 billion in 2010 to $122.9 billion in 2020. Last year's global wind power installations declined slightly to 35.2 GW, down from a record 37.5 GW the prior year. China, the global leader in new installations for the third year in a row, continued to see an increase with total installations of more than 16 GW. The U.S. continued to see significant declines in the face of a tight project finance market, uncertainty around project grants until late in 2010, and the lack of a federal RPS, among other challenges, adding only half as much capacity as the prior year with just 5 GW installed in 2010. Against this backdrop, China surpassed the U.S. for the title of global leader in total cumulative installs for wind power, with a capacity of more than 42 GW.

China surpassed the U.S. for the title of global leader in total cumulative installs for wind

- Solar photovoltaics (including modules, system components, and installation) are projected to grow from a $71.2 billion industry in 2010 to $113.6 billion by 2020. New installations reached more than 15.6 GW worldwide in 2010, a more than doubling from 7.1 GW in 2009. The level of growth and expansion in solar PV was a direct result of PV prices dropping by more than 30 percent in 2009 followed by an additional 10 percent drop in 2010.

Together, we project these three benchmark technologies, which totaled $144.5 billion in 2009 and grew 30.2 percent to $188.1 billion in 2010, to grow to $349.2 billion in the next decade.

A Decade of Unstoppable Growth

When Clean Edge released its growth projections for solar and wind power 10 years ago, many observers, to put it kindly, thought we were being optimistic. We projected that solar power would grow from a global market of $2.5 billion in 2000 to $23.5 billion by 2010 and that wind power would grow from a global market of $4 billion in 2000 to $43.5 billion by 2010. But as we've highlighted above, we were actually quite conservative in our estimates, coming up around 300 percent short in our solar PV estimates and approximately 50 percent short in our wind estimates. Below is a table that shows the actual global market growth for solar and wind for the past 10 years, and for biofuels for the past five years, based on Clean Edge's annual market figures.

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Global Clean-Energy Market Size 2000-2010

Year	Solar PV Global Market Size (in $Billions)	Wind Power Global Market Size (in $Billions)	Biofuels Global Market Size (in $Billions)
2000	$2.5	$4.0	N/A
2001	$3.0	$4.6	N/A
2002	$3.5	$5.5	N/A
2003	$4.7	$7.5	N/A
2004	$7.2	$8.0	N/A
2005	$11.2	$11.8	$15.7
2006	$15.6	$17.9	$20.5
2007	$20.3	$30.1	$25.4
2008	$29.6	$51.4	$34.8
2009	$36.1	$63.5	$44.9
2010	$71.2	$60.5	$56.4

Source: Clean Edge, Inc., 2011

U.S. Clean-Tech Venture Investments

In 2010, U.S.-based venture capital investments in clean technologies increased from $3.6 billion in 2009 to $5.1 billion in 2010, an increase of 42.3 percent, according to data provided by the Cleantech Group.

Clean-Tech Venture Capital Investments in U.S.-Based Companies as Percent of Total 2001-2010

Year	Total Venture Investments ($Millions)	Clean-Tech Venture Investments ($Millions)	Clean-Tech Percentage of Venture Total
2001	$37,624	$458	1.2%
2002	$20,737	$651	3.1%
2003	$18,789	$807	4.3%
2004	$21,699	$760	3.5%
2005	$22,535	$1,158	5.1%
2006	$26,010	$2,685	10.3%
2007	$29,901	$3,761	12.6%
2008	$28,105	$6,120	21.8%
2009	$18,276	$3,553	19.4%
2010	$21,823	$5,055	23.2%

Source: Cleantech Group, 2011, with Clean Edge analysis. Clean-tech venture investment includes seed funding and follow-on rounds prior to private equity activity related to stake acquisitions or buyouts. Investment categories include agriculture, air & environment, energy efficiency, energy generation, energy infrastructure, energy storage, materials, manufacturing/industrial, recycling & waste, transportation, and water & wastewater.

While falling short of 2008's record-breaking $6.1 billion total, 2010's more than $5 billion represented nearly a quarter of all VC activity in the country last year, a new record. In addition, the more than 370 deals in 2010 represents the largest number of financings recorded in a one-year period. Of the 10 largest clean-tech venture deals in 2010, five were for solar, two were for EVs, two were for bio-based materials, and one was for geothermal.

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U.S. Top 10 Disclosed Clean-Tech Venture Deals (2010)

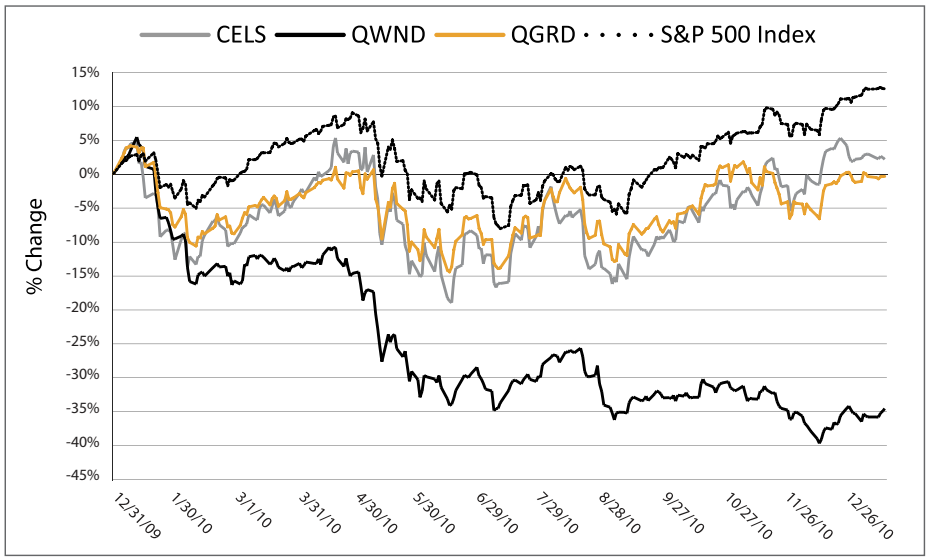
Company	Primary Sector	Total Invested ($ Millions)
Better Place	EV Infrastructure	$350.0
Solyndra	Thin-Film Solar	$175.0
BrightSource Energy	Concentrated Solar Thermal	$171.8
Fisker Automotive	Electric Vehicles	$140.3
Amonix	Concentrated PV	$129.4
Kior	Biomass	$110.0
Abound Solar	Thin-Film Solar	$110.0
Vulcan Power	Geothermal	$108.0
MiaSolé	Thin-Film Solar	$106.0
Elevance Renewable Sciences	Biochemicals	$100.0

Source: Cleantech Group, 2011

NASDAQ® Clean Edge® Stock Indices Performance

Another view on the markets comes from tracking the performance of publicly traded clean-energy stocks. Clean Edge, along with NASDAQ, currently produces three indices which act as transparent and liquid benchmarks for the sector: CELS, which tracks U.S.-listed clean-energy companies; QWND, which tracks global wind power companies; and QGRD, which looks at smart grid and grid infrastructure companies. These Clean Edge indices* soared 75, 67, and 34 percent respectively in 2007; plummeted 64, 54, and 43 percent respectively in 2008 along with the general market; and outperformed most market indicators in 2009, rising 44, 38, and 49 percent respectively. 2010 saw a more mixed performance, with CELS up two percent, QWND down 35 percent, and QGRD essentially flat (down 0.4 percent) for the year. Since 2007, the volatility in the clean-energy sector represents

NASDAQ® Clean Edge® Stock Index Performance* (2010)



** Index data is provided by FactSet Research Systems and NASDAQ OMX. Index values for QGRD prior to inception (9/22/09) and for QWND prior to inception (6/26/08) are hypothetical and NASDAQ OMX and Clean Edge make no guarantee of their accuracy.*

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both the ongoing struggle within the broader financial markets and the real and perceived risks associated with the clean-tech sector. The wind industry in particular took a beating in 2010, as manufacturers were faced with tempered demand and declining revenues. U.S.-listed clean-energy companies fared the best among Clean Edge's three indices, buoyed by fairly strong stock performance of energy-efficiency and power-management companies.

Recent IPOs on Major Global Markets

Company	IPO Date	IPO Raise	Stock Price Close of First Day Trading	Stock Price 2/1/11	Percent Change in Stock Price	Market Cap 2/1/11	Exchange	Sector
Amyris (AMRS)	9/29/2010	$84.8M	$16.50	$32.20	95.15%	$1.41B	NASDAQ	biofuels and biomaterials
China Ming Yang Wind Power Group (MY)	10/1/2010	$350M	$13.25	$9.67	-27.02%	$1.21B	NYSE	wind turbines
Elster Group (ELT)	9/30/2010	$210.6M	$13.80	$15.91	15.29%	$1.04B	NYSE	advanced meters
Enel Green Power (EGPW)	11/4/2010	$3.6B	$2.23	$2.26	1.25%	$11.3B	Milan	renewable energy development
Jinko Solar (JKS)	5/14/2010	$64.2M	$11.01	$27.17	146.78%	$590.43M	NYSE	silicon wafers, solar cells and solar modules
Sensata Technologies (ST)	3/11/2010	$568.8M	$18.50	$32.00	72.97%	$5.52B	NYSE	sensors and controls
Sinovel Wind Group (601558)	1/13/2011	$1.43B	$12.39	$11.11	-10.34%	$11.2B	Shanghai	wind turbines
Tesla Motors (TSLA)	6/29/2010	$226.1M	$23.89	$23.91	0.08%	$2.23B	NASDAQ	electric vehicles

Source: Clean Edge, Inc., 2011

Getting To Cost Parity

As we've written many times before, clean-energy markets will only truly thrive when they reach cost parity with conventional offerings. In March 2011, we released a pricing report for subscribers to our *U.S. Clean Energy Leadership Index* that analyzes current and future costs of distributed solar PV compared with U.S. retail electricity rates, and current and future costs of wind power compared with U.S. wholesale electricity prices. For the first time in history, these clean-energy technologies are reaching cost parity in select markets. And by 2015, we project that distributed solar PV systems will be cost-competitive for residential retail customers in at least 11 states, and for commercial customers in more than six states. By 2020 that number, based on our projections, grows to an astounding 47 states for residential customers and more than 35 states for commercial customers.

Wind is already cost-competitive with fossil fuel-generated electricity in many markets, when considering time to market, siting requirements, and overall costs. That doesn't mean that wind power, like its fossil fuel brethren, doesn't require some subsidies and supportive policies, but it's increasingly becoming a viable option for states and regions looking to bolster their renewable resources. At present, most new wind farms are producing electricity in the 5-8 cents per kWh range, which makes it one of the least expensive options for new generating capacity additions. Since 2007,

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wind power has ranked near and often ahead of natural gas as the leading source of new generating capacity in the U.S.

These projections and market realities bode well for clean energy as an industry. Clean-energy deployments are proving economically viable in a number of key markets. Add in tax credits, low-cost utility financing, and other pricing schemes, and some utilities, like Southern California Edison, are stating that they can deploy solar PV for even less than new natural gas-fired generators at the wholesale level. While such examples are still rare, the tide is turning in favor of renewables, and our research shows there will be many new cost-parity and cost-beating stories to report in the next five years.

Moving Forward

Clean Edge has a full decade of research and projections under its belt. This deep history of data tracking and analysis provides a critical view on where the clean-tech sector has been and where it's headed.

Based on our research and vantage point, what will the world look like a decade from now? While it's difficult to forecast the future with complete accuracy, we expect a host of developments and changes in the next 10 years, including:

- solar and wind resources contributing a combined 20-30 percent, or more, of electricity generation capacity in dozens of U.S. and global markets;
- explosive growth in the electrification of transportation, with millions of grid-connected EVs on the road in the U.S., China, Japan, Europe, and other major markets;
- the eventual death of compact fluorescent light bulbs (CFLs) and the emerging dominance of solid state light-emitting diode (LED) technology (see Trend #1 on page 8);
- a movement to create low-cost, competitive green buildings that produce more energy than they consume; and
- waste streams becoming a common feedstock for new materials and energy production.

Clean energy remains one of the strongest and most vital sectors reshaping the global landscape

As China, India, South Korea, the U.S., Germany, Japan, and other nations compete to win the global clean-tech race, and large-scale clean-energy deployment results in innovation and declining costs, we expect to see continued growth in many clean-tech industries.

Of course, challenges persist. A number of key battles, for example, are brewing within the public and private realm that could have significant impact on the industry. These include everything from budgetary shortages and disputes to supply chain constraints (see Trend #5 on page 16). These and many other vexing issues will demand creative solutions, collaboration among strange bedfellows, and public and corporate leadership, to name just a few. But our assessment, 10 years into tracking this sector, is that clean energy remains one of the strongest and most vital sectors reshaping the global landscape.

On the following pages we look deeper at five of the key trends we believe will shape clean-energy markets in 2011 and beyond.

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1. INCANDESCENT PHASE-OUT LIGHTS THE WAY FOR LOW-COST LEDS

Lighting accounts for roughly one-fifth of all global electricity consumption, yet the lion's share of this energy is emitted not as light but as radiated heat from inefficient bulbs. As efforts to conserve electricity and curb emissions expand across the globe, governments are announcing plans to make traditional incandescent bulbs a thing of the past. Compact fluorescent lights (CFLs) were the initial substitute for incandescent bulbs, but certain characteristics of CFLs – such as mercury content and dimming constraints – will soon cede technology advantage to solid-state light emitting diodes (LEDs).

LEDs are destined to be a replacement for not only incandescent bulbs, but also CFLs

LEDs are moving beyond niche markets and gaining broad-based attention, rapidly approaching a major milestone: the arrival of an affordable LED replacement for the standard 60-watt incandescent bulb. The first companies to achieve this will enjoy an immediate rush of policy-driven demand. National governments in Japan, China, South Korea, the United States, and the EU have already announced bans on production or sales of inefficient bulbs, necessitating massive retrofit efforts across the globe. This presents a major market opportunity. In the U.S. alone, it's estimated that 425 million 60-watt incandescent bulbs are sold each year.

With the stakes that high, emerging startups, along with major lighting industry names like Philips Electronics, Osram Sylvania, and Panasonic, are aggressively developing replacement bulb products. In May 2010, Florida-based Lighting Science Group began providing a 40-watt replacement LED bulb for Home Depot's EcoSmart line at a retail price of $20. Netherlands-based Lemnis Lighting currently offers its Pharox 300, a 6-watt, dimmable, 60-watt equivalent LED bulb, for $25. And retailing at $40, Philips' AmbientLED 12.5-watt bulb recently became the first 60-watt equivalent LED to qualify for EPA's Energy Star label.

Typical LED bulbs last at least 25,000 hours, compared to averages of 1,000 hours for incandescent bulbs and 10,000 hours for CFLs. LED lifetime costs (including costs for bulb purchase and electricity consumption) are already well below that for incandescents and are fast approaching CFLs. But consumers are more concerned with the upfront costs. With

Profile: Lemnis Lighting

Location

Barneveld, The Netherlands
www.lemnislighting.com

Founded

2005

Employees

50

Technology

Lemnis Lighting is an LED lighting technology developer and marketer. The company's products, manufactured at six sites worldwide, target both indoor and outdoor applications. The Pharox LED lamp, the company's flagship indoor lighting product, is available for $25 and is intended as a replacement for incandescent and CFL bulbs.

The Buzz

Lemnis received the World Economic Forum's Technology Pioneer Award in 2009, and has produced and sold more than three million Pharox lamps worldwide. The company reports a current pipeline of more than 100 million units to be delivered in 2011-2013.

Brain Trust

Lemnis Lighting spun out of Tendris, a Dutch clean-tech incubator, with Warner Philips (great-grandson of Philips Electronics founder Anton Philips) as a cofounder. The company has a relatively small internal team, but has partnered with other groups for manufacturing and industry collaboration.

Bankrollers

In March of 2010, Lemnis raised $35.7 million in a fourth round of funding. This investment valued the company at $170 million. To date, Lemnis has been funded by Tendris and an assortment of angel investors.

Our Take

The light bulb is a quintessential example of commoditized technology, and consumers are not accustomed to caring about anything more than its purchase price. Lemnis should do well if it can be a leader in achieving the $10 price point for a quality, high-lumens LED bulb. The company's commitment to online sales means that success may depend just as much on marketing ingenuity as technological innovation.

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CFLs retailing for less than $3, LEDs must achieve cost reductions to become a widespread consumer choice. “Big chunks of the market are going to start shifting at $15,” says Lemnis cofounder and CEO Warner Philips, “and we think that the [entire] mass market is going to shift at below $10. That’s really the critical psychological price point for consumers.” Philips, who happens to be the great-grandson of Philips Electronics founder Anton Philips, expects to see LEDs competing at these prices in the next 12 to 36 months.

LEDs must also compete with CFLs on performance. The typical 60-watt incandescent bulb produces about 800 lumens (the standard measure of light intensity), a level matched by 60-watt equivalent CFLs. LED bulbs, however, produce just 300-500 lumens on average, and very few 60-watt equivalent LED products exceed 700 lumens. The U.S. Department of Energy’s L-Prize, a competition for development of advanced solid-state lighting technology, requires that a 60-watt equivalent bulb deliver at least 900 lumens without using more than 10 watts.

Even with these challenges, LEDs enjoy some significant advantages over CFLs. They allow for dimming control, enjoy vastly extended lifetimes, contain no mercury – and save an estimated 80 percent of energy over incandescent equivalents. With price declines accelerating and technology fast improving, LEDs are destined to be a replacement for not only incandescent bulbs, but also CFLs.

LED technology must continue to improve, but for some large-scale lighting purchasers, LEDs already make the grade. In late 2010, for example, Starbucks finished replacing incandescent and halogen lighting with LEDs in more than 7,000 stores worldwide. If commercial LED campaigns like this gain momentum, LEDs’ time to shine may come sooner than expected.

Recent Headlines

GE Closes Last U.S. Incandescent Light Bulb Plant

LED Bulbs Set to Take Over Global Market

LED Lighting Features Strongly in Philips’ Strategic Vision

Survey: Consumers Warming to Efficient Lighting

Starbucks to Cut Energy Consumption by 80% with LED Lighting

Home Depot Teams Up With Philips, Cree on LED Bulbs

Select Companies to Watch

Cree
www.cree.com

Lemnis Lighting
www.lemnislighting.com

Lighting Science Group
www.lsgc.com

Osram Sylvania
www.sylvania.com

Philips Electronics
www.philips.com

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2. NATURAL GAS ADVANCES AS A POWERFUL PARTNER FOR WIND AND SOLAR ENERGY

The move to include natural gas in clean-energy mandates, epitomized by President Obama's recent call for 80 percent clean energy (including natural gas and nuclear) by 2035, has provoked considerable debate. Most U.S. states don't currently include natural gas in their top-tier clean-energy requirements, and only one, Ohio, includes nuclear. But no matter how you define the landscape, natural gas will be integral to 21st century electricity. If the pairing of gas with renewables proves successful, it could also play a major role in fueling a clean-energy future.

Pairing gas with renewables could play a major role in fueling a clean-energy future

Natural gas is the cleanest burning fossil fuel (far cleaner than coal), it's highly flexible, and can be used with a range of generating technologies including steam turbines, reciprocating engines, and combined cycle plants. Rapid fire-up, fire-down qualities also make gas a perfect complement to intermittently available solar and wind. Although prices have been notoriously volatile in the past, recent advancements in drilling technologies have brought vast amounts of previously unrecoverable reserves into play, leading many to believe that an extended era of dependably inexpensive natural gas has arrived.

The integration of natural gas and renewable energy offers an opportunity to transition smoothly away from dirty energy sources. One key trend in pairing natural gas with renewables has been the development of solar-gas hybrid systems, such as Florida Power & Light's Martin Next Generation Solar Energy Center, which recently connected a 75 MW concentrated solar power (CSP) plant to the largest natural gas plant in the U.S. (3.8 GW). Other hybrid plants in development include an NV Energy project in Nevada and two separate projects in California led by Inland Energy. Along with tackling renewables' intermittency issues, hybrid plants are an enticing idea because the sharing of existing infrastructure, such as turbines and transmission lines, promises to reduce upfront capital costs.

Integrated solar combined cycle (ISCC) plants, which increase steam generation by adding solar heat to gas-turbine waste heat, are another example of the mixing of solar and gas.

Profile: NextEra Energy

Location

Juno Beach, Florida
www.nexteraenergy.com

Founded

NextEra Energy has two principal subsidiaries: NextEra Energy Resources, a clean-energy producer, and Florida Power and Light (FPL), a rate regulated electric utility. The company was originally founded in 1925 as FPL.

Employees

More than 15,000

Technology

NextEra subsidiary FPL's newly built Martin Next Generation Solar Energy Center is the first industrial-scale solar retrofit of a conventional power plant. The hybrid plant's 75 MW CSP station will generate electricity when solar resources are available, allowing for less gas use and diminished emissions for the largest gas-fired facility in the U.S.

The Buzz

NextEra estimates the $476 million project price tag is a 20 percent discount compared to a typical CSP plant. The company also anticipates fuel savings of $178 million over 30 years.

Brain Trust

Lewis Hay, CEO of NextEra, originally joined the company as CFO in 1999, taking over as CEO in 2001. Hay also serves as vice chairman of the Edison Electric Institute, an association of investor-owned electric companies. He is joined by Armando Olivera, CEO of FPL, and Mitch Davidson, CEO of NextEra Energy Resources.

Bankrollers

NextEra Energy trades under the ticker symbol NEE on the NYSE and had a market cap of more than $22 billion at the beginning of March 2011.

Our Take

NextEra has a track record of augmenting intermittent renewables with gas, but it remains to be seen if anticipated cost savings for the Martin Plant will be realized. If targets are reached, look for the pipeline of gas-solar retrofits to grow.

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Ain-Ben-Mathar, Morocco, recently became home to the world's first operating ISCC plant with its 470 MW project (20 MW from solar). In Yazd, Iran, a 478 MW solar-gas plant (17 MW from solar) is under construction, with final commissioning expected in mid-2011. Similar projects are also in development in Egypt and Algeria.

Pairing wind with gas is also in the works. U.S.-based energy developer Altresco aims to combine wind and gas at the plant level by integrating wind turbines and gas generators in a micro-grid. PG&E's recently commissioned natural gas-fired Colusa Generating Station near Maxwell, California is designed to reduce power when renewables become available. And in North Dakota, the planned 2,000 MW Hartland Wind Farm will "firm" output with roughly 500 MW of natural gas capacity.

Despite the potential for clean tech to benefit from natural gas, environmental risks from gas drilling are a very real concern. Indeed, the threat of drinking water and soil contamination, blowouts, and other concerns have caused some to ban the practice of hydraulic fracturing, or fracking, altogether. New York, rich in shale gas reserves, has issued a temporary moratorium on fracking until investigators comprehensively review the practice. Some environmental groups such as the Sierra Club and Worldwatch Institute have cautiously supported the marriage of natural gas and renewables as a bridge to a clean-energy future, but only if it is done in an environmentally sensitive, responsible, and fully transparent way.

President Obama's expansive view of clean energy may not fit everyone's view of a clean-tech future. But definitions aside, natural gas provides many advantages over coal and nuclear. With proper regulation and oversight, the combination of natural gas and renewable energy sources could serve as a useful bridge to a clean-energy economy.

Recent Headlines

Does the Future of Power Belong to Natural Gas?

Egypt's First Solar-Thermal Plant Goes into Operation in Kuraymat

The Newest Hybrid Model

New Natural Gas Plant to Aid in Integrating Energy From Solar, Wind

Integrating Solar: CSP and Gas Turbine Hybrids

New York Governor Halts Gas "Fracking" until July 2011

Select Companies to Watch

Abengoa Solar
www.abengoasolar.com

Altresco
www.altresco.com

NextEra Energy
www.nexteraenergy.com

Hybrid Wind Turbines
www.hybridturbines.com

NV Energy
www.nvenergy.com

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3. CLEANER AVIATION FUELS ARE POISED FOR TAKEOFF

As the global economy recovers and nations like China and India continue their ascension, commercial aviation – and its resulting CO2 emissions – is poised for significant growth. Boeing, for example, expects the number of commercial planes to double by 2030, with more than 4,300 new aircraft in China alone. Without any mitigation efforts, CO2 emissions from aviation – about two percent of global emissions today and 13 percent of the world's emissions from transportation fuels – are expected to quadruple by 2050. So the aviation industry, driven by both government mandates and business incentives, has a number of efforts underway to run leaner and cleaner – with next-generation biofuels getting the most attention.

Airlines have a compelling reason to become less susceptible to rising petroleum prices

Starting in January 2012, the European Union's airline emissions cap will go into effect, requiring all carriers flying to and within Europe to cut CO2 by two percent from 2005 levels and an additional three percent in 2013. And with fuel costs accounting for about 30 percent of their operating expenses – roughly $150 billion a year – commercial airlines have compelling economic reason to become less susceptible to rising petroleum prices. The International Air Transport Association, with 230 member airlines in 140 countries, estimates that 15 percent of all jet fuel is expected to be bio-derived by 2020, and 50 percent by 2040.

A large number of major carriers around the world, including Lufthansa, Virgin Atlantic, Qantas, and Alaska Airlines, have launched biofuels initiatives and/or run test flights. The industry is almost universally committed to next-generation, sustainable (i.e. not corn or soy-based) fuels; the Sustainable Aviation Fuel Users Group, comprising 20 airlines and four aircraft makers, has pledged to use only fuels from non-food feedstocks. As a result, many of the leading players in next-gen biofuels, among them Amyris, ClearFuels, Sapphire Energy, Solazyme, and Solena Fuels, have made aviation fuel a major focus, often in partnerships with airlines and manufacturers.

Solena Fuels has joint-venture plans for the world's first two commercial biofuels refineries, in the U.K. with British Airways and in Australia with Qantas. Both will convert wood and agricultural waste to jet fuel. Oil giants are playing too. In February 2011, BP's aviation division launched plans for the world's largest aviation biodiesel-from-jatropha plant in

Profile: Solazyme

Location

South San Francisco, California
www.solazyme.com

Founded

2003

Employees

100

Technology

Using a process that it claims avoids 95 percent of CO2 emissions in comparison to fossil fuels, Solazyme produces military grade A-1 jet fuel. The company produces oil and other biomaterials using microalgae that feeds on a variety of biomass waste.

The Buzz

Solazyme has attracted the attention of high-profile partners and customers such as the U.S. Navy and Qantas Airlines. It delivered the largest shipment to date of algal aviation fuel - 20,000 gallons - to the Navy in September 2010 and is contracted to produce 150,000 gallons for the Department of Defense in 2011. Biofuels Digest magazine named Solazyme its company of the year in 2010.

Brain Trust

Solazyme founders Jonathan Wolfson and Harrison Dillon first planned to start a biofuels company as college classmates at Emory University. Wolfson has worked as an investment banker at Morgan Stanley and received the Clinton Global Initiative's Green Leap award in 2009. Dillon has a Ph.D in genetics and is a listed inventor on 30 patents and patent applications for Solazyme's technology.

Bankrollers

Solazyme has received more than $146 million in funding from investors including Braemar Energy Ventures, Chevron Technology Ventures, Sir Richard Branson, the U.S. DOE, Lightspeed Venture Partners, Morgan Stanley, Unilever, VantagePoint Venture Partners, and Zygote Ventures.

Our Take

With rising oil prices spurring even more interest in aviation biofuels, Solazyme is poised to grow substantially in the coming years. The company has a slew of powerful backers who are eager to see it succeed, with a widely rumored IPO in the offing in 2011. The aviation biofuels sector remains challenging and risky, but Solazyme will clearly be in the forefront among suppliers.

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Brazil in partnership with Airbus, Brazil's TAM Airlines, and Brasil EcoDiesel.

Also in Brazil, Amyris is working with Embraer, GE Aviation, and Brazilian airline Azul to perfect its synthetic jet fuel called No Compromise. Solazyme, which produced the first algae-based jet fuel in 2008, delivered 20,000 gallons of it to the U.S. Navy in September 2010. Some airlines are forming their own ventures; KLM is a founding partner of Netherlands-based SkyNRG, whose biokerosene fuel blend powered the first military helicopter biofueled test flight, a Royal Dutch Air Force Boeing Apache AH-64D, in June 2010.

The military, particularly the U.S. Navy and Air Force, is a key booster of biofuels. Under eco- and security-minded Secretary Ray Mabus, the Navy has mandated that all its aircraft (and ships) be powered by a 50-50 bio/petrol blend by 2020. As the largest fuel purchaser in the world, the Pentagon "will play an absolutely game-changing role in this space," says Suzanne Hunt, senior advisor at the Carbon War Room, a Washington, D.C. group founded by Virgin chairman Richard Branson to support market-based emissions reduction. "The military takes the issues of fuel security and climate security very seriously." One of the Navy's key fighter jets, the F/A-18, had a successful test flight powered by camelina-based fuel in April 2010.

Military and civilian aviation biofuels efforts, however, face considerable challenges. In January 2011, the Navy strongly refuted a RAND Corp. study claiming that biofuels were too far from commercial viability for significant military use in the next decade. And aviation's technical requirements mean a long and potentially expensive development, test, and certification process for any alternatives to traditional petroleum. But a major global industry that's clearly serious about carbon reduction could become the key market-demand boost that next-gen biofuels need.

Recent Headlines

Aviation Industry Sets its Sights on Biofuel as the Next Jetsetter

FAA Awards $125 Million for Clean Tech Aviatic Research

Solazyme Delivers Algae Jet Fuel to U.S. Navy

Qantas to Build Commercial Jet Biofuel Plant

Washington State Agency Proposes Biomass Jet Fuel Project

Navy Denounces Report Critical of its Biofuel Goals

Select Organizations to Watch

Boeing
www.boeing.com

Solazyme
www.solazyme.com

Solena Fuels
www.solenafuels.com

Sustainable Aviation Fuel Users Group
www.safug.org

Virgin Atlantic
www.virgin-atlantic.com/en/us/allaboutus/environment/biofuel.jsp

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4. LOW-COST GREEN BUILDING BRINGS RELIEF – AND SUSTAINABILITY – AROUND THE WORLD

Although green building has made impressive strides in its cost-competitiveness with conventional design and construction, it's certainly not the first option one thinks of for extremely low-cost building in developing nations and disaster recovery areas. But a flurry of innovation in design approaches, construction materials, and other facets of architecture is fueling a wave of affordable, sustainable, and energy-saving construction in places as diverse as New Orleans, Haiti, Pakistan, and Kenya.

For rebuilding after disasters, the focus is shifting from temporary shelter to sustainable construction

Focusing on locally sourced and recycled materials, rainwater collection, natural ventilation and lighting, and small-scale solar and wind, international architects are creating low-cost and sustainable homes, schools, and other facilities. Governments can often be a big driver; Kenya, for example, began requiring solar power in all new homes in June 2010. And breakthrough concepts like homes for less than $7,500, though still nascent, are gaining momentum with backing from some of the world's leading tech innovators.

A major driver of this trend is online open-source collaboration, with green-minded architects and others sharing ideas and doing collaborative design. Open Architecture Network, launched by San Francisco-based non-profit Architecture for Humanity (AFH), includes some 3,400 designs used by more than 7,000 collaborators worldwide.

AFH has affiliated chapters in 25 countries and its average construction cost of a two-bedroom green home is $7,500. "In the developing world sustainable design generally doesn't cost more, because there's little or no existing infrastructure in place," says AFH co-founder and CEO Cameron Sinclair. Collaborative efforts are driving costs even lower. "The $300 house," an August 2010 *Harvard Business Review* challenge by Dartmouth business school professor Vijay Govindarajan, sparked a torrent of ideas from innovators like Bill Gross, whose Idealab incubator has hatched companies like eSolar, Energy Innovations, and NetZero. No one has hit the (deployable) $300 target home yet, but Idealab comes close with WorldHaus, a $2,500 housing kit that the company plans to make available

Profile: Architecture for Humanity

Location

San Francisco, California
www.architectureforhumanity.org

Founded

1999

Employees

20

Technology

Architecture for Humanity (AFH) specializes in sustainable design, construction, and development services in developing countries and disaster-stricken areas. AFH also developed the Open Architecture Network, using global open-source collaboration to develop sustainable, accessible, and locally appropriate designs.

The Buzz

AFH's Open Architecture Network was launched in 2006 using the Creative Commons license, making its designs free for use. The network has since expanded to include more than 7,000 participants and 3,400 designs. In 2010, AFH launched its affiliate network, which now numbers 70 affiliate chapters in 25 countries, including 1,250 design teams.

Brain Trust

AFH was founded in 1999 by Cameron Sinclair (then 26 years old) and Kate Stohr, starting with only $700 and a laptop. Sinclair became interested in humanitarian design at the Bartlett School of Architecture at the University of London. He received the 2006 TED prize, which led to the development of the Open Architecture Network.

Bankrollers

AFH is a non-profit charitable organization, with corporate sponsors including Advanced Micro Devices, Adobe, IBM, Google, Herman Miller, and Sun Microsystems.

Our Take

AFH has grown from a small operation to a global network of professionals, collaborating on sustainable and efficient-by-design buildings. We see AFH as a leading innovator in both low-cost green architecture and the open-source technology tools that are advancing it.

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this year in India, Kenya, and South Africa.

For rebuilding after disasters, the focus is shifting from temporary shelter to sustainable construction that also helps rebuild the local economy. In earthquake recovery efforts in Pakistan, British aid group Article 25 emphasizes local sourcing and the training of local citizens in sustainable building techniques. In Pakistan, "locals are transforming a relief-stage solution into a permanent one," Article 25's CEO and director of projects Robin Cross wrote in *The Guardian*. Recovery efforts like the U.S. Green Building Council's Project Haiti take a similar, longer-term approach.

In the U.S., actor Brad Pitt's Make it Right Foundation has completed about 50 of a planned 150 LEED Platinum homes in New Orleans' Lower Ninth Ward. Another non-profit, Global Green USA, is contributing to the city's green rebuild with the Holy Cross Project, a single-family and apartment village funded by the Home Depot Foundation and intended as a model of affordable green housing for the nation. Global Green also helps New Orleans residents rebuild existing homes with more energy efficiency through its Build it Back Green program.

Whether in disaster recovery or international development, clearly this emerging trend faces huge challenges: logistics, funding, local politics and corruption, conflicts between NGOs, and the often prevailing mentality of quick-and-dirty solutions. But there will always be demand for low-cost building design, particularly with an expected rise in climate-related disasters – and thousands of global innovators are proving that cheaper can be cleaner too.

Recent Headlines

USGBC Community Works to Rescue and Rebuild Haiti

Kenya Requires Solar Panels in New Homes

Bill Gross Designs a $2500 House

Sustainability Experts Say Green Construction Needs to Be Affordable

Rwanda Works to Power Up with Clean Energy

The $300 House: The Design Challenge

Select Organizations to Watch

Architecture for Humanity
www.architectureforhumanity.org

Article 25
www.article25.org

Global Green USA
www.globalgreen.org

Make It Right
www.makeitrightnola.org

WorldHaus
www.worldhaus.com

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5. INNOVATION PROVIDES ALTERNATIVES TO RARE EARTHS

Rare-earth intensive industries are putting stress on an untested supply chain

As clean tech becomes more ubiquitous in the global economy, its emerging industries will increasingly be forced to manage dependence on often immature material supply chains. Raw materials like lithium in advanced batteries, indium, gallium, and tellurium in thin-film PV cells, and rare-earth metals (17 elements listed near the bottom of the periodic table) present in a wide variety of newer products are all essential to clean technologies. While not scarce in existence, they are now in unprecedented demand and highly vulnerable to supply risks. But a range of emerging advanced material and nanotech innovations are beginning to create viable alternatives.

The U.S. Department of Energy recently estimated that clean-energy products now account for roughly 20 percent of global consumption of "critical materials," which it defined as a set of rare earths, along with lithium, cobalt, indium, gallium, and tellurium. Rare-earth metals are of particular concern because more than 95 percent of the world's supply is currently produced in China. These materials play an important role in a variety of clean-tech applications including hybrid and electric-drive vehicles, large wind turbines, and high-efficiency lighting. And the current distribution imbalance affects far more than just clean tech. Rare earths are also integral to powering electronic devices including hard drives, smart phones, and weapons guidance systems.

The scaling up of clean tech and other rare-earth intensive industries is putting stress on an untested supply chain. Combine fast-paced industry expansion with China's aggressive slashing of rare-earth export quotas – by 72 percent in the last half of 2010 and 11 percent for the first six months of 2011 – and you have a recipe for trouble. Efforts are underway to establish a more geographically diverse supply network, but it will take years before a new army of upstart mining companies like Colorado-based Molycorp and Australia's Lynas can significantly impact global supply dynamics.

With roots in environmental stewardship, clean tech is no stranger to resource sensitivity. For this reason, industry participants are beginning to manage rare-earth supply risk through a familiar tactic: technological innovation.

Profile: GE Global Research

Location

Niskayuna, New York
ge.geglobalresearch.com

Founded

1900

Employees

2,800 researchers

Technology

GE Global Research, a subsidiary of General Electric, is an industrial research organization, based in the U.S. with a presence in India, China, and Germany. The group currently specializes in developing technological innovations in a variety of areas, including molecular imaging, energy conversion, nanotechnology, and advanced propulsion.

The Buzz

ARPA-E recently awarded GE Global Research a grant to develop nanocomposites for use in permanent magnets, which are critical components in an array of technologies like smart phones, electric vehicles, and large wind turbines. The aim is to create permanent magnets that require fewer rare-earth metals without sacrificing power performance.

Brain Trust

Although not openly collaborating with any universities on permanent magnet research, Global Research has a rich collection of researchers, with more than 1,000 Ph.Ds on staff.

Bankrollers

In September 2010, ARPA-E announced $2.2 million in funding for GE's work on a two-year project entitled 'Transformational Nanostructured Permanent Magnets'. Global Research's annual budget is around $600 million.

Our Take

GE's clean-tech manufacturing established direct exposure to rare earths in wind turbines in 2009 through its acquisition of ScanWind, a developer of gearless drive-trains that utilize rare earths. While GE would prefer that technological innovation come from inside the company, such as those efforts being pursued by GE Global Research, any advancement in rare-earth resource management will have industry-wide benefits to supply chain stability.

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Permanent magnets, for example, essential to converting electrical energy into mechanical energy, have traditionally required a rare-earth metal like neodymium to enable the lightweight, high-power electric motors used in clean-tech vehicles such as Toyota's Prius, Chevy's Volt, and Nissan's LEAF. Technology from Tesla Motors presents a potential alternative. Toyota's all-electric 2012 Rav4 will use Tesla's rare-earth-free induction motor technology currently used in its Roadster model. Elsewhere, Japanese technology developer Hitachi and auto parts supplier Aisin Seiki are among companies designing electric motors that use ferrite magnets in place of rare earths.

In the longer term, nanotechnology could provide breakthroughs. The University of Delaware and GE Global Research are both being funded by DOE's Advanced Research Projects Agency–Energy (ARPA-E) to explore how nanocomposites can increase energy density in permanent magnets while reducing the use of rare earths. Successful advances here could lower product costs while easing pressures on fragile material supply chains.

Movement away from rare earths does risk simply trading one material dependency for another. Take advanced batteries for transportation. While today's mass market hybrids use rare earth-reliant nickel metal hydride (NiMH) batteries, an increase in vehicle electrification will spike demand for next generation lithium-ion batteries, quickly testing the responsiveness of lithium supply. Recycling efforts and new mining development can help ease supply risks, but both of these strategies have their limitations – whether in scale or rapidity. The most promising solutions, as highlighted above, will be advanced material innovations that help make the use of rare earths in clean-tech products rare indeed.

Recent Headlines

Commodities Surge as China Slashes Rare Earth Exports

U.S. Rare Earth Access at Risk, Supply Diversity Needed

Rare Earth Mining in the United States Gets a Second Chance

As Hybrid Cars Gobble Rare Metals, Shortage Looms

New Magnets Could Solve Our Rare-Earth Problems

China Bans Rare Earth Exports to Japan Amid Tension

Select Companies to Watch

Hitachi
www.hitachi.com

Toyota
www.toyota.com

Aisin Seiki
www.aisin.com

Tesla Motors
www.teslamotors.com

GE Global Research
ge.geglobalresearch.com

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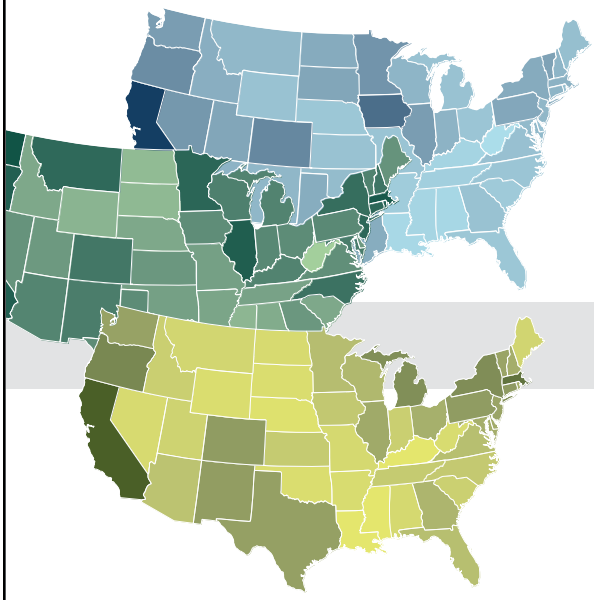
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Ron Pernick, co-founder and managing director of Clean Edge, is an accomplished market research, publishing, and business development entrepreneur with more than two decades of high-tech experience. He is also co-author of the highly acclaimed business book *The Clean Tech Revolution* (HarperCollins). Ron has coauthored more than two dozen reports at Clean Edge and oversees the company's many projects and initiatives. He speaks regularly at industry conferences and is widely quoted in the media.

Clint Wilder, senior editor for Clean Edge, is an award-winning technology and business journalist. His book *The Clean Tech Revolution* (with co-author Ron Pernick), has been called "the best clean tech book" by ClimateProgress.org and has been translated into seven languages, including Chinese, Japanese, and Spanish. Wilder is a frequent speaker at industry events and business schools, and writes a blog on clean tech for the Green section of The Huffington Post.

Trevor Winnie, senior research analyst, is involved in a range of activities at Clean Edge including helping lead the research effort for the firm's *U.S. Clean Energy Leadership Index* advisory service, stock indices, and other research and consulting work.

Sean Sosnovec, research and marketing associate, provides research assistance on the firm's *U.S. Clean-Energy Leadership Index*, stock indices, and other publications and reports.

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