

# CLEAN ENERGY TRENDS 2012

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CLEAN EDGE

THE CLEAN-TECH MARKET AUTHORITY



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## CLEAN ENERGY TRENDS 2012

Clean energy, with double-digit growth rates and competition spanning Europe, Asia, and the Americas, has been a dynamic and forward-looking industry for more than a decade. The year 2011, however, will not likely be remembered for this robust growth and global activity, but for the now-infamous Solyndra bankruptcy. The failed company, which represents a potential loss in excess of \$500 million for American taxpayers, has become a rallying cry for many as an example of government gone wrong. For clean-tech critics, Solyndra encapsulates everything bad about government largesse and “proof” that clean tech can’t compete without subsidies and government regulations. Stinging headlines and partisan attacks have left many in the clean-tech community caught off guard, as the industry has become a modern-day whipping boy for all that ails the U.S. economy.

*Venture capital has historically been revered, not reviled, by business leaders and politicians alike*

But these criticisms, offered up in sound bite-sized nuggets delivered more for their impact than accuracy, miss several key points:

1. **The oil, gas, and coal industries still receive massive subsidies.** Mature fossil fuel industries have historically received, and continue to garner, six times as many subsidies as the clean-energy industry globally. While subsidies might make sense for emerging sectors – that’s what subsidies have traditionally been used for – ongoing support for oil and gas industries no longer makes sense. Nor, according to groups like the International Energy Agency and World Bank, are they prudent from an economic, environmental, or energy security perspective.
2. **Venture capital is a risky, high-reward business critical to U.S. innovation.** Venture-backed companies, no matter what the industry, naturally come with a high-risk profile. For every VC-funded home run (think Google, Amazon, and Apple), VCs expect to back many other companies that don’t make it big or fail altogether. You can question whether government should be placing such bets, but there’s no denying that such risk is part of the American capitalist system, and something that’s historically been revered, not reviled, by business leaders and politicians alike.
3. **Nuclear power projects require considerably more in loan guarantees than renewables.** Two new nuclear power plants at the Vogtle complex in Georgia recently received a conditional commitment for an \$8.3 billion loan guarantee from the U.S. government. This loan amount is equivalent to more than 15 Solyndras, and the two plants alone equal nearly a quarter of all recent DOE loan guarantees. This one guarantee, based on its sheer size and the long history of nuclear power plant public opposition, delays, and closures, puts taxpayers at far greater risk than perhaps any other project.
4. **2011 marked a number of developments that point to the significant scale up of clean tech.** Some major developments that went underreported in 2011 include landmark changes in Germany and massive investments by notable investors. Germany, for example, in the aftermath of the Fukushima Daiichi nuclear disaster, announced plans to shutter all of

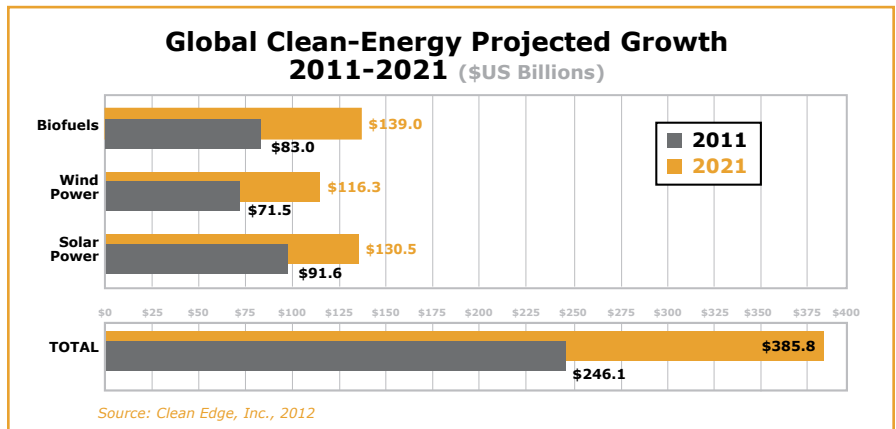
its nuclear plants by 2022 while expanding of renewables, efficiency, and natural gas - embarking on perhaps the most aggressive clean-energy build out seen to date. And a number of noted investors upped their clean-tech investment activities, with Google and Warren Buffett's MidAmerican Energy Holdings investing nearly \$1 billion and \$2 billion respectively in U.S. solar projects.

*Clean tech isn't withering on the vine as some would proclaim, but instead is continuing its rapid expansion*

Clean tech isn't withering on the vine as some would proclaim, but instead is continuing its rapid expansion, witnessed by the growth of green buildings, smart meters, hybrid electric vehicles, distributed and centralized renewables, LED lighting, and a host of other clean-tech breakthroughs that are becoming increasingly ubiquitous. There have been growing pains for many firms, with low-cost manufacturing in China and elsewhere giving U.S. and European manufacturers a not-so-insignificant run for their money, but the industry as a whole has continued to expand throughout the economic downturn of recent years. Combined global revenue for solar PV, wind power, and biofuels, for example, surged by 31 percent over the prior year, growing from \$188.1 billion in 2010 to \$246.1 billion in 2011. The bulk of this expansion came from double-digit growth rates for both wind and solar deployment, along with an increase in pricing for biofuels.

According to our research:

- Biofuels (global production and wholesale pricing of ethanol and biodiesel) reached \$83 billion in 2011, up from \$56.4 billion the prior year, and are projected to grow to \$139 billion by 2021. However, this increase was mostly due to an increase in ethanol and biodiesel prices. The continuing trend of rising bio-fuel prices, up 10 to 20 percent in 2011, is the result of higher



costs for feedstock commodities – mainly sugar for ethanol and rapeseed and other vegetable oils for biodiesel. Between 2010 and 2011, global biofuels sales remained relatively flat, expanding from 27.2 billion gallons to 27.9 billion gallons of ethanol and biodiesel production worldwide.

- Wind power (new installation capital costs) is projected to expand from \$71.5 billion in 2011, up from \$60.5 billion the prior year, to \$116.3 billion in 2021. Last year's global wind power installations equaled 41.6 gigawatts, the largest year for global installations on record. China remained the global leader in new installations for the fourth year in a row, installing more than 40 percent of all global wind turbines, or 18 GW in total. The European Union came in second with nearly 10 GW, followed by the U.S., India, and Canada with approximately 7 GW, 3 GW, and 1.3 GW respectively.

- Solar photovoltaics (including modules, system components, and installation) increased from \$71.2 billion in 2010 to a record \$91.6 billion in 2011. We project the market to continue to expand to \$130.5 billion by 2021. These market numbers, while impressive, do not fully capture the extent of actual industry expansion. While total market revenues were up 29 percent, installations climbed more than 69 percent from 15.6 GW in 2010 to more than 26 GW worldwide last year. This reflects a more than 40 percent decline in crystalline module prices between 2010 and 2011. Between now and 2021 we project that installed costs for PV will continue to decline, falling to nearly one-third of their current levels.

Together, we project these three benchmark technologies, which totaled \$188.1 billion in 2010 and grew 31 percent to \$246.1 billion in 2011, to grow to \$385.8 billion over the next decade.

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
2011	\$91.6	\$71.5	\$83.0

Source: Clean Edge, Inc., 2012

**Renewables:  
Leveraging  
Economies  
of Scale**

As noted above, the scale up of renewables is apparent in the rapidly declining costs and resulting increase in deployment of a host of clean technologies, most notably solar PV. Solar cells, which are mostly made from silicon (the same basic material used in manufacturing computer chips), are now exhibiting economies of scale seen in earlier high-tech revolutions such as personal computers and cell phones. Between 2007 and 2011, solar PV total system costs (including PV modules, balance of system components, and installation) dropped by more than half, with complete systems being installed globally in 2011 at an average \$3.47 a peak watt or 14 to 23 cents per kWh. Contrary to Solyndra’s critics who say the industry isn’t ready for prime time, solar is, in fact, becoming increasingly cost-competitive (making it difficult for high-cost providers like Solyndra to survive). Clean Edge historical data and projections (see table below) show that solar PV is on a steep price decline that is bringing it into cost parity at the retail level (for residential, commercial, and industrial applications), and increasingly competitive at utility scale, far sooner than many had projected.

At the retail level (the customer side of the electric meter), where solar is most competitive, the U.S. shows a dynamic and rapidly changing landscape. In less than a decade, Clean Edge projects that in 13 states (Alaska, California, Connecticut, Delaware, Hawaii, Maine, Maryland, Massachusetts, New

Hampshire, New Mexico, New York, Rhode Island, and Vermont) solar PV will be cost-competitive at the residential level without any subsidy requirements. And solar will become increasingly attractive with a likely explosion in a new breed of power providers (such as solar installers/financiers SolarCity, SunEdison, and SunRun) providing residential, commercial, and industrial customers with a hedge against fluctuating retail electricity rates tied to volatile prices of fossil fuels.

Similar cost breakthroughs have already occurred in much of the wind industry. New wind farms can produce electricity in the 5-8 cents per kWh range, making it competitive today with the cost of fossil fuel electricity generation in many markets.

In 2011, U.S.-based venture capital investments in clean technologies increased from \$5.1 billion in 2010 to \$6.6 billion in 2011, an increase of 30 percent, marking a near-record year according to data provided by the Cleantech Group.

**Total Installed PV System Prices and Costs of Electricity (Global Average)**

Year	System Price (\$/W)	LCOE Range (cents/kWh)
2007	\$7.20	28 - 47
2008	\$7.00	27 - 45
2009	\$5.12	20 - 34
2010	\$4.55	18 - 30
2011	\$3.47	14 - 23
2012*	\$2.69	11 - 19
2013*	\$2.43	10 - 17
2014*	\$2.19	9 - 15
2015*	\$2.02	8 - 14
2016*	\$1.87	7 - 14
2017*	\$1.73	7 - 13
2018*	\$1.60	6 - 12
2019*	\$1.48	6 - 11
2020*	\$1.37	6 - 10
2021*	\$1.28	5 - 10

Source: Clean Edge, Inc., 2012. 2007 through 2011 are actual figures and \*2012 through 2021 are estimates. Figures calculated using Clean Edge cost projections and the NREL Levelized Cost of Energy (LCOE) Calculator. ASSUMPTIONS: Discount rate: 6%; Capacity factor: 16-26%; O&M cost: \$6-\$26/kW.

**U.S. Clean-Tech Venture Investments**

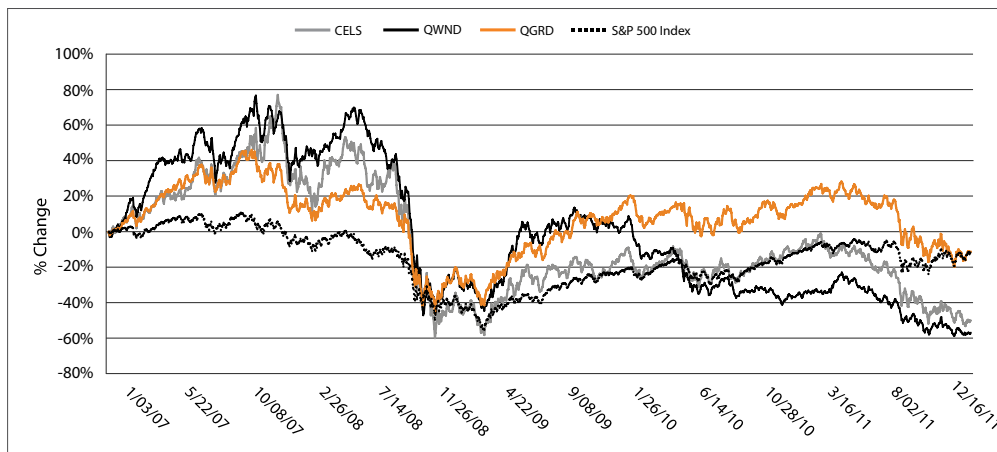
**Clean-Tech Venture Capital Investments in U.S.-Based Companies as Percent of Total 2001-2011**

Year	Total Venture Investments (\$Millions)	Clean-Tech Venture Investments (\$Millions)	Clean-Tech Percentage of Venture Total
2001	\$37,624	\$458	1.2%
2002	\$20,850	\$660	3.2%
2003	\$18,614	\$713	3.8%
2004	\$22,355	\$844	3.8%
2005	\$22,946	\$1,337	5.8%
2006	\$26,594	\$2,814	10.6%
2007	\$30,826	\$3,909	12.7%
2008	\$30,546	\$6,861	22.5%
2009	\$19,746	\$3,814	19.3%
2010	\$23,263	\$5,062	21.8%
2011	\$28,425	\$6,576	23.1%

Source: Cleantech Group and PricewaterhouseCoopers/NVCA data with Clean Edge analysis, 2012. 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 storage, materials, recycling & waste, smart grid, solar, transportation, water & wastewater, and wind.

Last year's \$6.6 billion, while slightly below 2008's record-breaking \$6.9 billion total, represented clean tech's largest percentage of VC activity in the U.S. ever recorded, clocking in at 23.1 percent. At nearly a quarter of total VC activity in the U.S., the clean-tech sector has expanded more rapidly than any other venture category, up from just 1.2 percent of total venture activity a decade earlier.

**NASDAQ® Clean Edge® Stock Index Performance\* (2007-2011)**



*\* 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.*

**NASDAQ®  
Clean Edge®  
Stock Indexes  
Performance**

Another view on the markets comes from tracking the performance of publicly traded clean-energy stocks. Clean Edge, along with NASDAQ®, produces three indexes 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 indexes\* have been extremely volatile, soaring 75, 67, and 34 percent respectively in 2007; falling 64, 54, and 43 percent respectively in 2008; outperforming most market indicators once again in 2009, up 44, 38, and 49 percent respectively, and mixed in 2010, up two percent, down 35 percent, and essentially flat (down 0.4 percent) for the year. 2011 demonstrated the continued decline of most clean-tech indexes, with retail investors perhaps questioning the relative lack of public market exit opportunities and an economic environment with severe government budget shortfalls. CELS, QWND, and QGRD were down 41, 30.4, and 21.6 percent respectively in 2011, against a relatively flat S&P 500. As of February 15, 2012, however, all three indexes were once again outperforming the S&P, with CELS, QWND, and QGRD up 16.7, 7.4, and 13.2 percent for the year compared to the S&P's 6.8 percent, demonstrating once again the sharp rises and falls that we've come to expect from this emerging investment sector.

**Financing the  
Future**

There's little doubt that the future of energy will be cleaner. The shift from carbon-intensive energy sources like wood, coal, and oil to nuclear, and now natural gas and renewables, is well underway. For much of the developed world, and for developing nations leapfrogging the West, the future looks increasingly like it will be built off of a mix of energy efficiency, renewables, the electrification of transport, and lower carbon fuels like natural gas.

In 2011, for example, nearly 70 percent of new electricity capacity in the European Union came from

renewables. Solar PV and wind power accounted for 47 percent and 21 percent of new additions respectively. Add in natural gas, which made up 22 percent of new capacity installations in Europe, and these three sources are proving the energy sources of choice, representing 90 percent of new capacity additions in 2011. By contrast, coal's contribution to new capacity in Europe was just five percent. Globally in 2011, investments in clean-energy projects reached an all-time record of \$260 billion, according to Bloomberg New Energy Finance.

### U.S. Top 10 Disclosed Clean-Tech Venture Deals (2011)

Company	Primary Sector	Total Invested (\$ Millions)	Date
BrightSource Energy	Concentrating Solar Thermal	\$201.0	March 2011
Fisker Automotive	Electric Vehicles	\$190.0	March 2011
Sundrop Fuels	Biomass Gasification	\$175.0	July 2011
Bloom Energy	Fuel Cells	\$150.0	September 2011
OSIsoft	Process Efficiency	\$135.0	January 2011
Fisker Automotive	Electric Vehicles	\$133.3	December 2011
Stion	CIGS Thin Film	\$130.0	December 2011
Boston-Power	Lithium-Ion Batteries	\$125.0	September 2011
Fisker Automotive	Electric Vehicles	\$115.0	June 2011
MiaSolé	CIGS Thin Film	\$106.0	February 2011

Source: Cleantech Group, 2012

But the industry at large, and the nations pursuing cleaner electrons, will need significantly more funding in the coming decade to reach established deployment targets. This build out will require new and innovative financing tools. In our forthcoming book, *Clean Tech Nation: How the U.S. Can Lead in the New Global Economy* (HarperCollins, September 2012) we outline how such financial tools could give the U.S. a leadership edge. We call for the development of new tools that have worked in the past for fossil-fuel infrastructure and real estate, and for leveling the playing field by making such tools available for renewables. In the U.S. such vehicles as master limited partnerships (MLPs) and real-estate investment trusts (REITs) offer up two of the best examples. Relatively simple tax code changes could enable renewables and efficiency measures to leverage the same tools that have enabled the aggressive expansion of oil and gas exploration development in the U.S.

The next few years, we believe, will be clearly defined by those nations that provide the infrastructure for the deployment of innovative and effective financing tools. Just like Google and Warren Buffett, retail investors should be able to tap the relatively steady, reliable, and secure returns that can be offered by these types of clean-energy project investments.

Clean tech is a dynamic and fast-changing industry. Each year we do our best to uncover the key trends that we believe will shape clean-energy markets this year and beyond. Our five major trends for 2012, which are covered in the following pages, are:

- The Few, The Proud, The Green: Military Leads Clean-Energy Deployment
- Japan Moves Toward Cleaner Post-Nuclear Future
- Deep Commercial Building Retrofits Reap Major Efficiency Savings
- Waste-to-Resource Breakthroughs Attract Attention - and Investment
- New Energy Storage Solutions Embolden the Grid

*In 2011 nearly 70 percent of new electricity capacity in the European Union came from renewables*

**Moving Forward:  
Five Trends to  
Watch**



## 1. THE FEW, THE PROUD, THE GREEN: MILITARY LEADS CLEAN-ENERGY DEPLOYMENT

No one knows the costs of fossil-fuel dependence better than members of the armed forces. While securing access to oil in some of the world's most dangerous regions, their missions carry the risk and expense of convoys transporting fuel for their own use. So it makes sense that the U.S. military has emerged as one of the world's biggest champions and funders of clean energy, even if "grunts" and "greens" are rarely thought of together.

On both base and battlefield, the Pentagon – throughout history, no stranger to technology innovation – is deploying unprecedented amounts of clean energy and becoming a critical market opportunity for the clean-tech industry. President Obama's proposed budget for fiscal 2013, even if unlikely to pass Congress, calls for more than doubling Pentagon spending on clean energy and efficiency from its current \$400 million to \$1 billion.

The U.S. Department of Defense is the world's largest single consumer of energy, spending about \$15 billion a year and accounting for a staggering 70 percent of the entire energy use of the U.S. federal government. Every dollar increase in the price of oil adds \$30 million to the Navy's budget alone. So even incremental shifts from fossil fuels to clean energy can have huge market impacts, and the Pentagon has much bigger shifts in mind.

Typifying the new market opportunity for clean-tech players is the Marines Corps' Experimental Forward Operating Base program, an annual event at the Air Ground Combat Center in Twentynine Palms, California, to test commercial vendors' clean-energy and efficiency technologies for battlefield use. Some of these so-called expeditionary technologies, such as solar-charged batteries and small-scale water purification, have been deployed in Afghanistan within eight months of testing, a historically rapid deployment.

"We need to get a grip on the permanent vice that this three-letter word – oil – has had around our necks," says Marines Maj. Gen. Anthony Jackson, a 37-year Corps member who commands seven Marines bases in southern California and

### Profile: SolarCity

#### Location

San Mateo, California  
www.solarcity.com

#### Founded

2006

#### Employees

1,500

#### Technology

SolarCity installs, maintains, and finances commercial and residential rooftop solar PV deployments through 23 operations centers in 11 states. Its five-year SolarStrong project aims to install up to 300 MW of solar on up to 120,000 military housing units across the country, which would double the current amount of residential solar in the U.S.

#### The Buzz

SolarCity has helped transform solar PV installation in the U.S. from a local mom-and-pop business to a nationwide industry that includes competitors such as Sungevity and SunRun. The recent historic drop in solar costs has dramatically helped the solar installation industry and made a project like SolarStrong possible.

#### Brain Trust

CEO Lyndon Rive co-founded SolarCity after launching a series of startups going back to age 17 in his native South Africa. His brother Peter Rive is co-founder, COO, and CTO; both are cousins of SolarCity chairman and Tesla Motors CEO Elon Musk.

#### Bankrollers

Bank of America Merrill Lynch is financing SolarStrong, with an estimated cost of \$1 billion. After a DOE loan guarantee fell through, BofA Merrill and SolarCity were able to come to terms without DOE involvement and announced the deal in November 2011.

#### Our Take

SolarStrong is a great symbol of the U.S. military's commitment to distributed clean power generation and reduced use of fossil fuels. If successful – even if it falls somewhat short of 120,000 rooftops – SolarStrong will bring SolarCity and the entire U.S. rooftop solar industry to an unprecedented new level of size and prominence.

*The U.S. Department of Defense is the world's largest single consumer of energy*

Arizona. "I know the cost of that. I know it up close and personal."

On the operational side, the opportunity is vast. The DoD spends \$4 billion a year powering 2.2 billion square feet of space in 300,000 buildings – three times the amount of real estate operated by Walmart. The Army is leading the way with its NetZero Base program, with the goal of net-zero energy, water, and waste on five U.S. bases by 2020, 25 more by 2025, and all bases by 2050.

Key to achieving these goals is on-site generation, which also reduces the high security risk of dependence on the public grid. In January, SunPower broke ground on a 13.8 MW solar PV array at Naval Air Weapons Station China Lake in California, which will supply 30 percent of the base's power and represents the first 20-year power purchase agreement from a federal government agency. A Siemens unit is building the Army's largest on-site generation project, a 4.5 MW solar PV system at White Sands Missile Range in New Mexico. In early 2012, Skyline Solar won the contract to build solar installations at Edwards Air Force Base in California and the Army's Fort Bliss in Texas. And the military's largest aggregate clean-generation project, SolarStrong, calls for SolarCity (see profile) to install 300 MW of solar PV on 120,000 military housing units across the U.S. in the next five years – the largest residential solar project in U.S. history.

The Air Force – user of about half of all fuels consumed by the military – has mandated 50 percent biofuels use for domestic aviation. The Navy has called for a 50 percent biofuels mix for its ships and aircraft by 2020 – an estimated 336 million gallons of biofuels. In December 2011, the Navy placed the largest biofuels order in U.S. government history, \$12 million for 450,000 gallons of algal and used cooking oil-based fuels from Solazyme and a Tyson Foods-Syntroleum joint venture, Dynamic Fuels.

*Operation Sustainability: U.S. Military Sets Ambitious Environmental Goals*

*Military Deal To Double the U.S.'s Rooftop Solar Installations*

*Obama Budget more than Doubles DoD Funding for Energy Projects to \$1B*

*US Navy Commits \$500M to Biofuels*

*Four California Military Bases Could Produce 7GW of PV, According to Study*

*China Lake Breaks Ground on Navy's Largest Solar Plant*

## Recent Headlines

### Dynamic Fuels

[www.dynamicfuelsllc.com](http://www.dynamicfuelsllc.com)

### SkyBuilt Power

[www.skybuilt.com](http://www.skybuilt.com)

### Skyline Solar

[www.skyline-solar.com](http://www.skyline-solar.com)

### SolarCity

[www.solarcity.com](http://www.solarcity.com)

### Solazyme

[www.solazyme.com](http://www.solazyme.com)

## Select Companies to Watch

## 2. JAPAN MOVES TOWARD CLEANER POST-NUCLEAR FUTURE

One year ago, a magnitude 9.0 earthquake and resulting tsunami devastated Japan, killing more than 15,000 people, damaging or destroying more than 125,000 buildings, and triggering meltdowns in three reactors at Tokyo Electric Power's Fukushima Daiichi nuclear power plant. Although the crippled reactors were brought under control after many harrowing months, the accident's impact on Japan's energy future may be felt for decades to come.

*All but three of the nation's 54 nuclear generators remain shut down*

Before the tragedy in March 2011, Japan received 30 percent of its electricity from nuclear power, with plans to increase nuclear's share to 50 percent by 2030. Now (as of March 2012), all but three of the nation's 54 nuclear generators remain shut down for safety tests, and new Prime Minister Yoshihiko Noda has stated that building any new reactors "will be next to impossible." So Japan, pioneer of many new clean-energy and efficiency technologies in the past, is taking bold steps to change course and steer toward a future powered in much greater measure by renewable energy.

Just before his resignation in August 2011, outgoing Prime Minister Naoto Kan signed a feed-in tariff (FIT) law that will guarantee returns for generators of power from solar PV, wind, small and medium-scale hydropower, geothermal, and biomass. The 15-year FIT takes effect in July 2012 and is intended to help Japan achieve its goal of 20 percent renewable power by 2020; its levels will be reviewed every three years to avoid the type of clean-energy bubble caused by FITs in Spain, Italy, and elsewhere.

The new FIT should further boost Japan's rebounding solar sector. Aided by the falling prices that have bolstered sales worldwide, domestic sales of solar PV in Japan soared 30.7 percent in 2011 to 1,296 MW, passing the gigawatt milestone for the first time, according to the Japan Photovoltaic Energy Association.

Domestic PV manufacturing is expanding with the nation's largest solar facility, Showa Shell Sekiyu-owned Solar Frontier's Kunitomi plant in Miyazaki on the southern island of Kyushu, expected to reach full capacity of 900 MW sometime

### **Profile:** Japan Renewable Energy Foundation

#### **Location**

Tokyo, Japan  
[www.jref.or.jp/en](http://www.jref.or.jp/en)

#### **Founded**

2011

#### **Executive Members**

13

#### **Technology/Mission**

The Japan Renewable Energy Foundation (JREF) is Softbank CEO Masayoshi Son's formal organization to promote funding, development, and deployment of renewables in Japan.

#### **The Buzz**

In the tumultuous 12 months since the Fukushima nuclear disaster, Son and his company have emerged as one of Japan's strongest (and most outspoken) voices for a cleaner energy future. Son has argued that Japan can have 60 percent renewable energy by 2030 and among other plans, has offered to personally help finance solar farms across the country.

#### **Brain Trust**

JREF founder and chairman Son is considered Japan's richest man, with net worth estimated by Forbes at \$8.1 billion. He founded Softbank as a 24-year-old UC-Berkeley grad in 1981 and built it into one of the world's biggest IT and telecom companies. JREF executive board chair Tomas Kåberger left his position as head of the Swedish Energy Agency to run JREF.

#### **Bankrollers**

Son has funded JREF with 1 billion yen (\$12.5 million) from his own coffers.

#### **Our Take**

Son and JREF have big and admirable clean-energy goals, but Japan's political and regulatory realities remain a roadblock. In November 2011, only four of Japan's 35 prefecture governors attended a meeting of Son's Renewable Energy Council of political leaders, casting doubt on Son's ability to realize his ambitious plans. The ability of Son and JREF to overcome Japan's political inertia, the well-entrenched nuclear industry's influence, and the regional utilities' oligopoly will be closely watched.

this year. Kunitomi is the largest thin-film, copper-indium-selenium (CIS) factory in the world. On the deployment front, industrial giants Mitsui and Toshiba are constructing Japan's largest PV solar plant of 50 MW in Aichi Prefecture. Billionaire high-tech tycoon Masayoshi Son wants to finance and build 10 20-MW solar farms around the country. The most ambitious plan of all comes from MEMC Electronic Materials' SunEdison unit, which wants to deploy 1,000 MW of PV across the country in the next five years; it is seeking investors for the project estimated at \$4.6 billion.

Growth of wind power in Japan has slowed in recent years, but the FIT and new sense of urgency has potential to change that. After the earthquake and tsunami, several press reports detailed how wind energy "rode to the rescue" in replacing unavailable nuclear power; none of Japan's wind farms, including the 14-MW Kamisu offshore wind farm in the tsunami zone, had to go offline after the disaster. Offshore wind holds the greatest promise in a small, densely populated island nation. In February 2012, a consortium led by trading giant Marubeni announced plans to install six 2-MW floating wind turbines off the Fukushima coast. If successful, the location could scale up to 80 turbines by 2020.

Japan also has great potential to grow its geothermal power industry. It has 18 geothermal plants (the oldest dating to 1966) with 540 MW total capacity and plenty of expertise, but it's often focused overseas. Three Japanese companies control about 70 percent of the world market for geothermal generating equipment. Japan has a potential 80,000 MW of geothermal capacity, according to the Earth Policy Institute, but much of it is located near hot springs (known as *onsen*) very important to Japanese cultural tradition. Resolving issues like that are among the many challenges Japan faces as it seeks to dramatically re-chart its energy course away from nuclear power in the 21st century.

*Can Japan Do Away with Nuclear Power in its New Energy Master Plan?*

*Japanese Government Passes Feed-in Tariff Bill*

*SunEdison to Build Japan Solar Plants at Cost of \$4.6 Billion*

*Softbank's CEO Wants a Solar-Powered Japan*

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## Recent Headlines

## Select Organizations to Watch

### 3. DEEP COMMERCIAL BUILDING RETROFITS REAP MAJOR EFFICIENCY SAVINGS

Although supply-side energy sources like wind, solar, and biofuels attract the most attention in the clean-tech industry, improvements in efficiency represent perhaps the best opportunity to upgrade our energy system. In most instances, energy-efficiency measures still remain the cheapest source of power, averaging a cost of just 3.5 cents for each kWh saved in the U.S., according to the Edison Foundation's Institute for Electric Efficiency. With buildings responsible for more than a third of energy use worldwide and accounting for up to 80 percent of carbon emissions in large urban environments, retrofitting the built environment has become priority number one for energy-efficiency advocates.

*The most prominent example of a large-scale deep retrofit is New York's iconic Empire State Building*

In the U.S. in particular, commercial buildings – which make up roughly one fifth of the nation's annual energy consumption – have become a primary target. Most of America's commercial buildings were built before 1990 and still use outdated, energy-inefficient technologies and building materials. This presents an opportunity to reduce energy costs by an average of 22 percent with energy-efficiency retrofits, says UCLA's Institute of the Environment and Sustainability. Market researcher Pike Research pegged the U.S. commercial building energy efficiency market at \$5.6 billion in 2011, with expectations of growth to \$20 billion by 2020. To jump-start building energy upgrades, President Obama in December 2011 announced \$4 billion in combined federal and private-sector investment to improve efficiency over the next two years. The commitment is part of the Better Buildings Initiative, an effort to make America's commercial and industrial buildings 20 percent more efficient by 2020.

Simple weatherization and lighting upgrades can provide quick and noticeable energy savings, but the real opportunity lies in "deep" retrofits which take a comprehensive whole-building system approach and can provide energy savings of around 50 percent, if not more. Perhaps the most prominent example of a large-scale deep retrofit is the green renovation of New York City's iconic Empire State Building. This retrofit, when completed in 2013, is projected to cut energy use by 38 percent and save \$4.4 million annually in energy costs, paying for itself in only three years.

#### Profile: Serious Energy

##### Location

Sunnyvale, California  
www.seriousenergy.com

##### Founded

2002 (as Serious Materials)

##### Employees

325

##### Technology

*Serious Energy offers building efficiency products used mainly in retrofits, such as super-insulated windows and architectural glass; the cloud-based Serious Energy Manager building energy management system; and SeriousCapital options to finance retrofit projects.*

##### The Buzz

*Serious Energy is continually expanding into new areas of the building efficiency market. Originally known for its products, the company has aggressively moved into overall energy management and financing. Its retrofit projects include the Empire State Building, the New York Stock Exchange, and UMG Universal Studios. The company is a Better Buildings Initiative participant.*

##### Brain Trust

*Chairman and CEO Kevin Surace is one of clean tech's highest-profile executives, with appearances ranging from the White House to CBS News. The veteran Silicon Valley high tech executive joined the company as CEO in 2002 and was named Inc. magazine's Entrepreneur of the Year in 2009. Claire Broido Johnson, general manager of the company's SeriousCapital financing offerings, is a co-founder of SunEdison and joined Serious in 2011 after a stint at DOE.*

##### Bankrollers

*The venture-backed company's investors include top VC names such as EnerTech Capital, Foundation Capital, New Enterprise Associates, and VantagePoint Partners; it has raised more than \$150 million to date.*

##### Our Take

*With its diversified business of efficiency products, energy management services, and financing, Serious Energy appears well-positioned in this market. It has also proved adept at landing partners such as major commercial developer Grubb & Ellis, which is offering SeriousCapital to its building clients.*

In this collaborative effort by building service provider Johnson Controls, efficient window maker Serious Energy, and other partners including the Rocky Mountain Institute (RMI), notable energy-saving measures include super-insulated refurbishing of the building's 6,514 windows, heat-saving radiator insulation, increased daylighting availability, and improvements to lighting and climate control systems. "Everything that we're doing at the Empire State Building is about business, and bottom line, that's the first and most important thing," Anthony Malkin, president of building supervisor Malkin Holdings, told GreenBiz.com in a 2011 interview. "We're not about paying more to do something qualitatively different, we're about market-ready solutions."

In Denver, the 18-story Byron G. Rogers Federal Office Building is undergoing a similarly deep retrofit. Spearheaded in part by RMI efficiency experts, the project is expected to result in a 70 percent reduction in energy use. A historical facade and disadvantageous orientation present unique challenges to retrofitting the nearly 50-year-old building. To work around these factors, insulation and window work is being done entirely from within the building and engineers from Denver-based engineering consultancy RMH Group have designed a thermal storage system that will capture heat from the sun-facing side of the building to warm the cooler side during winter. Additional energy-saving features include a full transition to LED lighting and solar thermal water heating.

Deep retrofits like these provide a roadmap for building owners elsewhere to pursue their own financially sound renovations. But significant roadblocks stand in the way of a full-fledged retrofit revolution. Most building owners are still put off by upfront costs of retrofits, even if efficiency improvements save money over the near- to mid-term. And while government-led funding efforts can help spur renovation activity, addressing the underlying financing barriers will be the most important step to unleashing the true potential of extensive commercial building retrofits.

*U.S. Commercial Building Energy Efficiency Biz Worth \$5.6 Billion a Year*

*Obama Catalyzes \$4 Billion Worth of Building Energy Upgrades*

*Cost Savings Remain Driving Factor Behind Commercial Retrofits*

*Clinton-Backed Efficiency Program Tackles 30 Million Sq Ft of Commercial Space*

*Albeo Sees 300 Percent Increase in LED Retrofits*

*Chicago Launches Ambitious Retrofit Program to Green City Buildings*

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[www.honeywell.com](http://www.honeywell.com)

**Johnson Controls**

[www.johnsoncontrols.com](http://www.johnsoncontrols.com)

**Rocky Mountain Institute**

[www.rmi.org](http://www.rmi.org)

**Serious Energy**

[www.seriousenergy.com](http://www.seriousenergy.com)

## Select Companies to Watch

## 4. WASTE-TO-RESOURCE BREAKTHROUGHS ATTRACT ATTENTION – AND INVESTMENT

*An army of emerging companies is proving that there is still much room for improvement and innovation*

The practice of turning municipal waste into a valuable resource like electricity is nothing new. The city of Amsterdam, for example, began using steam from waste incinerators to supplement operation of an adjacent power plant all the way back in 1917. Early waste-to-energy facilities were anything but clean, spewing toxic fumes from unchecked garbage incineration. Decades of technology advancements, however, have enabled the capture of harmful gases and increasingly higher conversion efficiencies, making the latest waste recovery methods a more climate-friendly way to generate power than the burning of fossil fuels.

But an army of emerging companies, promising to turn our trash into needed low-carbon fuels, electricity, and specialty chemicals, is proving that there is still much room for improvement and innovation in this space. With municipal waste totaling 435 million metric tons each year in the U.S. alone, and at least two-thirds of the developed world's garbage ending up in landfills and incinerators, the vast opportunity for waste recovery technology has waste-to-resource startups increasingly garnering notable financing rounds, strategic partnerships, and project development support.

A common strategy of many leading technology developers is the gasification of waste – using thermal or chemical methods to convert garbage into synthesis gas, or syngas. This gas can then be combusted to generate electricity or used to produce transportation fuel or specialty chemicals. Plasma gasification, converting trash to gas using extremely high temperatures, is beginning to show particular promise. In collaboration with the U.S. Air Force, Montreal-based PyroGenesis developed a plasma waste-to-energy system that is now in operation at Hurlburt Field on Eglin Air Force Base in Florida, turning onsite waste into electricity. And in Oregon, the Columbia Ridge Landfill is the site of a plasma gasification demonstration plant designed with technology from Bend, Oregon-based InEnTec. At temperatures of about 4,000 to 7,000 °C, plasma gasification allows for the breaking down of materials into elemental gases, with only a small amount of nonhazardous “slag” leftover – a much-preferred end result compared to ash

### Profile: Enerkem

#### Location

Montreal, Quebec, Canada  
www.enerkem.com

#### Founded

2000

#### Employees

130

#### Technology

*Enerkem has developed a thermo-chemical process that converts municipal waste into syngas, then into cellulosic ethanol and other renewable chemicals. The company says its technology allows for lower temperature, pressure, and energy requirements to break down feedstocks, which means lower costs.*

#### The Buzz

*Enerkem has operated a pilot facility since 2003 and a demonstration facility – with an output capacity of 1.3 million gallons per year – since 2009. The company's first commercial facility, currently under construction in Edmonton, Alberta, is projected to have a 10 million gallon capacity when completed in 2013.*

#### Brain Trust

*Esteban Chornet, the company's co-founder and CTO, was an engineer at the U.S. National Renewable Energy Laboratory before leaving to start Enerkem. The company's R&D connection remains strong with its Edmonton plant adjacent to Alberta's Advanced Energy Research Facility.*

#### Bankrollers

*Counting Waste Management and large oil refiner Valero as investors, Enerkem has raised around \$130 million to date. The company also received millions from the U.S. government to support a commercial-scale plant in Mississippi, slated to open in 2014. Enerkem recently filed for an IPO that could raise \$125 million.*

#### Our Take

*Cellulosic ethanol aspirants have endured discouraging reality checks in recent years, but Enerkem's focus on trash as a feedstock may give it the edge it needs, even if its product focus shifts away from fuel to specialty chemicals. Partnerships with Waste Management and Valero – which allow for licensing of Enerkem's equipment – could also provide good inroads to a vast customer base.*

residue from today's waste-to-energy incinerators.

Recognizing the potential for plasma syngas technology, North America's largest recycler and trash handler, Waste Management, recently took an equity stake in InEnTec valued at \$22.5 million. Waste Management is placing bets elsewhere as well, and in the process has become arguably the most important investor in the waste-to-energy sector. Other startups partnering with and receiving investment capital from Waste Management include Agylix, developing technology to turn waste plastic into synthetic crude oil; Harvest Power, working to improve the benefits of composting by accelerating decomposition; and Fulcrum Bioenergy and Enerkem, each developing methods to convert garbage into biofuels; both recently filed to go public. "We don't want to play just in the picking up and delivering," said Waste Management CEO David Steiner in a *Forbes* profile. "We want to own conversion, too. We want to own the technology."

Ultimately, not all emerging waste-to-resource technologies – or the companies behind them – will find success. Some will fail to scale at a commercial level, others will prove prohibitively expensive, and more will stumble in the organizational process. One particularly unique challenge for waste recovery startups is finding the right product to sell. While renewable transportation fuels made from waste offer the largest potential target market, fuels are often the most difficult to produce at an economical price point, as can be seen with high-profile biofuels startups Solazyme and Amyris recently shifting focus away from fuels to more expensive specialty chemicals and cosmetics. But for those companies that can develop a cost-effective technology, establish fruitful partnerships, and find the right products to market, the waste-to-resource business is flush with lucrative opportunities for growth.

*Agilyx Turns Plastics Back to Crude Oil*

*Waste Management Bets on German Trash Tech with Agnion*

*Air Force Steps Ahead with Plasma Waste to Energy*

*Trash-to-Biofuel Developer Enerkem Files for an IPO*

*Harvest Power Secures \$51 Million for Waste-to-Fertilizer*

*Global Waste-to-Energy Market to Reach \$28.8 Billion by 2015*

## Recent Headlines

## Select Companies to Watch

**Agylix**

[www.agilyx.com](http://www.agilyx.com)

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[www.enerkem.com](http://www.enerkem.com)

**InEnTec**

[www.inentec.com](http://www.inentec.com)

**PyroGenesis**

[www.pyrogenesis.com](http://www.pyrogenesis.com)

**Waste Management**

[www.wm.com](http://www.wm.com)



## 5. NEW ENERGY STORAGE SOLUTIONS EMBOLDEN THE GRID

The case for grid energy storage is easy to make. Storing megawatts worth of electricity for several hours at a time strengthens the grid's ability to absorb supply interruptions, which can cost billions when they result in cascading outages. It allows for mass deployment of intermittent renewables, even with some cloudy days and windless nights. And it diminishes the need for costly peak power generation, as electrons could be shifted from inexpensive night hours to times of high demand.

But high technology costs and risk-averse utilities have, until now, kept energy storage from having much of an impact. Existing grid storage is a one-horse race, with pumped hydro facilities – pumping water into elevated reservoirs to be released later to run generators – accounting for 99 percent of the 128 GW of grid storage capacity installed worldwide, according to the Electric Power Research Institute. Recently, however, several high-profile projects and innovative applications have begun to usher in a hopeful new era of grid energy storage.

On the utility side of the meter, the pairing of renewable projects with storage is growing more popular. In China, where an underdeveloped transmission grid makes storage even more important, diversified technology manufacturer BYD and the State Grid Corporation of China have constructed an iron-phosphate battery facility that couples 36 megawatt-hours of available storage capacity with 40 MW peak capacity from nearby wind and solar farms. Project developer AES is pursuing similar systems in the U.S. and abroad, and in late 2011 inaugurated a facility in West Virginia that uses lithium-ion batteries from A123 Systems to provide 32 MW of peak discharge capacity to complement an adjacent 98 MW wind farm. These two projects represent the largest efforts to date that use batteries for grid energy storage. Advanced batteries' quick response times and ease of scalability make a good fit for storing grid electricity, but proven operation in the field is still needed for these technologies to truly establish themselves. At this early stage, setbacks can have major implications – as was seen when a September 2011 fire at a sulfur-sodium battery installation in Joso City, Japan caused Japanese manufacturer

*On the utility side of the meter, the pairing of renewable projects with storage is growing more popular*

### Profile: AES Energy Storage

#### Location

Arlington, Virginia  
www.aesenergystorage.com

#### Founded

2007

#### Employees

27,000 in parent company AES

#### Technology

As a subsidiary of major power company AES, AES Energy Storage owns and operates projects around the world, providing reserve capacity and frequency regulation services. Lithium-ion batteries have been the most prevalent technology for its 72 MW of storage capacity in operation.

#### The Buzz

A 32 MW project in Belington, West Virginia is the company's biggest yet, but bigger deployments are expected. "One way to get people to think about this is in 50-megawatt building blocks, and then about how many are needed," AES president Chris Shelton told Bloomberg in February 2012. "Our proposals are multiples of 100, up to 400 megawatts."

#### Brain Trust

Chris Shelton has served as president of AES Energy Storage since the unit's founding five years ago. A veteran at AES, Shelton also serves as chairman of the Electricity Storage Association. Organizational relationships with firms like A123 Systems, Samsung, and Al-tairnano give AES access to the latest grid storage technologies.

#### Bankrollers

AES Energy Storage's parent company, AES, trades under the ticker symbol AES on the NYSE and had a market cap of more than \$10 billion at the beginning of March 2012.

#### Our Take

AES has shown promise in its ability to get projects up and running, but the true test will be operation on a major scale. With a pipeline of more than 500 MW of projects in development, it won't be long before we find out if the company's energy storage activities are here to stay.

NGK Insulators to halt production of its battery systems.

An expanding pipeline of concentrating solar power (CSP) projects in the works – more than 6 GW in the U.S. alone – gives molten salt storage the chance to make a significant impact in coming years. By diverting CSP steam generation to heat molten salt, plant operators can store energy as heat and create power after the sun has gone down. Most CSP projects planned today don't intend to incorporate storage, but success at installations like SolarReserve's 110 MW Crescent Dunes Solar Energy Project, which could soon power the neon lights of Las Vegas through the night with daytime Nevada sun (at a projected 13.5 cents/kWh), could hasten the adoption of CSP and molten salt storage as an industry standard partnership.

On the customer side of the meter, distributed storage applications can productively shift the grid's energy load. One of the more creative ideas is Ice Energy's approach to commercial air conditioning. The Windsor, Colorado-based company's Ice Bear Energy Storage System draws power from the grid at night, when electricity is cheapest, to make ice. Stored ice is then used during the next day's peak hours of demand to chill refrigerant in the existing HVAC system and deliver cool air to the building. Considering that at least 30 percent of California's peak summer electricity load comes from air conditioning, for example, Ice Energy's approach to energy storage could become a key asset for peak demand management.

Energy storage project costs vary greatly depending on a number of factors like technology type, project size, and characteristics of use. One thing is sure, however. Costs will have to come down dramatically if emerging grid storage technologies are to achieve widespread adoption, especially with the flexibility of today's low-priced, natural gas-fired power.

*ABB, Nissan to Explore a Second Life for EV Batteries: Energy Storage*  
*Energy Storage Market at the Substation Level Expected to Boom*  
*Ice + Sun: A Clean Power, Energy Storage Combo*  
*BrightSource Now Offers Molten Salt Storage for Solar Thermal*  
*Kyocera to Launch Solar With Li-Ion Battery Storage for Homes in Japan*  
*DOE Hub Gets \$120 Million to Build a Better Battery*

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[www.a123systems.com](http://www.a123systems.com)

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[www.aesenergystorage.com](http://www.aesenergystorage.com)

### BYD

[www.byd.com](http://www.byd.com)

### Ice Energy

[www.ice-energy.com](http://www.ice-energy.com)

### SolarReserve

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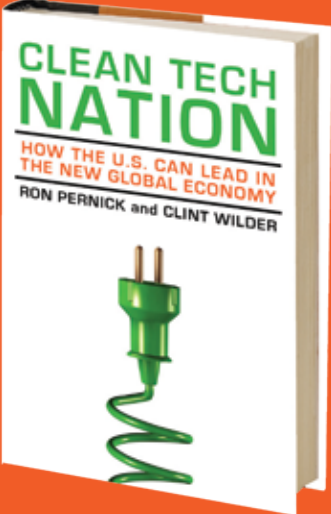


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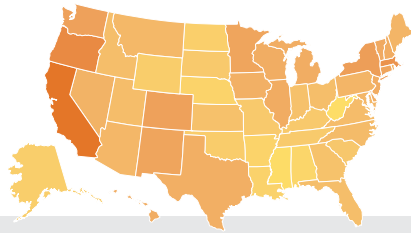
*"The Clean Tech Revolution is one of the few instances in this genre that shows the green movement not in heartstring terms but as economically profitable."*  
—USA Today

*"For years I've been looking for one book to recommend to people who want to get up to speed on what's happening in clean technology. I have finally found it: *The Clean Tech Revolution* by Ron Pernick and Clint Wilder."*  
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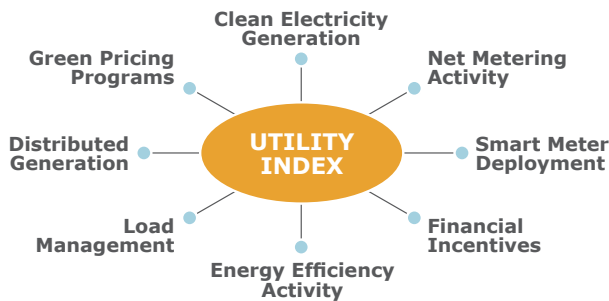
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**Clint Wilder**, senior editor for Clean Edge, is an award-winning technology and business journalist. His book *The Clean Tech Revolution* (with co-author Ron Pernick), has been called "the best clean tech book" by ClimateProgress.org and has been translated into seven languages, including Chinese, Japanese, and Spanish. His new book, *Clean Tech Nation* (co-authored with Pernick) is due out in September 2012. 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.

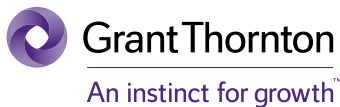
**Trevor Winnie**, senior research analyst, is involved in a range of activities at Clean Edge including helping lead the research effort for the firm's *Leadership Index* advisory service, stock indexes, and other research and consulting work.

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