

CLEAN ENERGY TRENDS 2013

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CLEAN EDGE

THE CLEAN-TECH MARKET AUTHORITY



THE CLEAN-TECH MARKET AUTHORITY

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CLEAN ENERGY TRENDS 2013

2012 proved to be an unsettling and difficult year for clean energy. High-profile bankruptcies and layoffs plagued many clean-tech companies, overall venture investments retreated in the face of increasingly elusive returns, and the industry was begrudgingly transformed into a partisan wedge issue during the highly contentious U.S. presidential campaign.

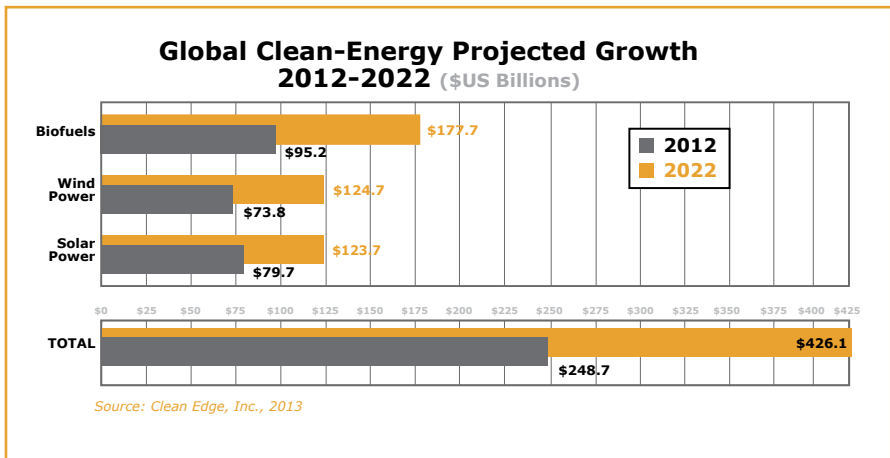
The beginning of 2013 has continued many of these same themes. In the U.S., conservative organizations and politicians continue to attack pro-clean energy policies at both the state and federal level. Numerous groups, most prominently the American Legislative Exchange Council (ALEC), are feeding off election-season rhetoric by ratcheting up efforts to roll back supportive policies such as state-backed renewable portfolio standards (RPS). In Europe, ongoing economic struggles continue to slow demand for a host of clean technologies. Even in China, where economic growth and clean-tech commitments seem to carry on unimpeded, the country's overleveraged solar manufacturers are being forced to crawl back to the government for even larger (and we'd say unsustainable) safety nets.

The fundamental global market drivers for clean technology remain largely intact

The fundamental global market drivers for clean technology, however, remain largely intact. Intensifying resource constraints (everything from freshwater to energy feedstocks) cannot be ignored, especially with a global population now exceeding 7 billion. In the aftermath of unprecedented climate disruption in the U.S. and abroad, resiliency and adaptation are becoming critical business and policy drivers as organizations scramble to meet a literally changing landscape. In the U.S., President Obama has signaled a strong commitment to expanding clean energy and energy efficiency in his second term, calling for a doubling of renewable power by 2020. And increasingly lower prices for clean-tech goods and services are helping wind and solar power reach cost parity in both utility-scale and distributed markets, making the value proposition increasingly attractive. Even amidst the carnage of 2012, clean energy has continued its ascent as a major economic force, with an increasing focus on deploying technologies that are ready and available now.

Indeed, against 2012's not-so-rosy backdrop, solar, wind, and biofuels deployment continued to rise. As a result, combined global revenue for solar PV, wind power, and biofuels grew year-to-year – albeit only slightly – from \$246.1 billion in 2011 to \$248.7 billion in 2012. This

marginal growth doesn't reflect the industry's true expansion, though, as solar PV revenues fell considerably even as installed capacity grew – one of many consequences of fast-declining prices for solar power technologies



- Biofuels (global production and wholesale pricing of ethanol and biodiesel) reached \$95.2 billion in 2012, up from \$83.0 billion the previous year, and are projected to grow to \$177.7 billion by 2022. From 2011 to 2012, global biofuels production expanded from 27.9 billion gallons to 31.4 billion gallons of ethanol and biodiesel. Market size growth over the next decade is expected to be driven by added production, but also by modest price increases.
- Wind power (new installation capital costs) is projected to grow from \$73.8 billion in 2012, up from \$71.5 billion the previous year, to \$124.7 billion in 2022. Global wind capacity expanded by 44.7 gigawatts in 2012, a record year led by more than 13 GW added in both China and the U.S., and an additional 12.4 GW of new capacity in Europe.
- Solar photovoltaics (including modules, system components, and installation) decreased from a record \$91.6 billion in 2011 to \$79.7 billion in 2012 as continued growth in annual capacity additions was not enough to offset falling PV prices. While total market revenues fell 19 percent – the first PV market contraction in *Clean Energy Trends'* 12-year history – global installations expanded to a record of 30.9 GW in 2012, up from 29.6 GW the prior year. Germany remained the top market, adding 7.6 GW in 2012, followed by strong growth in China, Italy, and the U.S., which each added more than 3 GW. By 2022, solar PV revenues are expected to grow to \$123.6 billion.

Together, we project these three sectors will continue to grow over the next decade, nearly doubling from \$248.7 billion in 2012 to \$426.1 billion in 2022.

Global Clean-Energy Market Size 2000-2012

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
2012	\$79.7	\$73.8	\$95.2

Source: Clean Edge, Inc., 2013

BIG, SMART MONEY STEPS IN

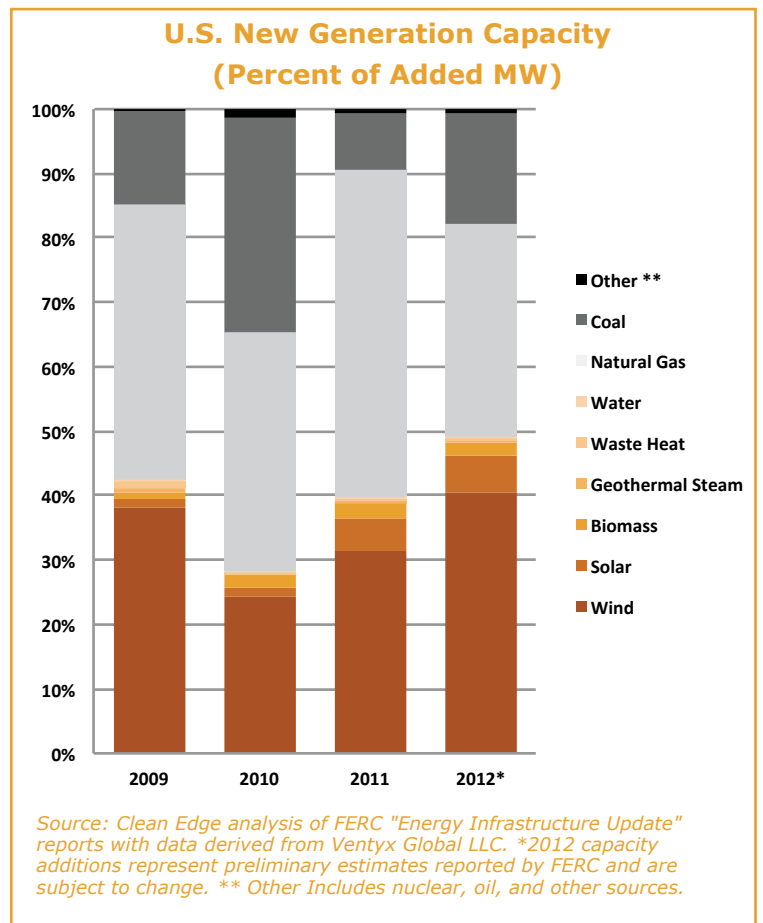
Increased financing from deep-pocketed traditional energy and technology players is also helping to accelerate clean-tech deployment, and simultaneously turning heads. In early 2013, famed investor Warren Buffett's MidAmerican Energy Holdings further expanded its solar portfolio with a \$2 billion acquisition of the Antelope Valley Solar Projects, which will feed 579 MW of electricity to Southern California Edison when construction is completed by SunPower in 2015. Other recent MidAmerican solar project acquisitions include the 550 MW Topaz Solar Farm and a 49 percent stake in the 290 MW Agua Caliente solar power plant. In similar fashion, and announced only a week later, Google's \$200 million equity investment in a Texas wind farm pushed the tech giant's ownership in solar and wind projects to 2 GW, enough to power 500,000 households. (Innovative finance models are also greasing the wheels for distributed solar; see *Distributed Solar Financing Comes of Age* on page 10.)

Wind represented nearly half of all new U.S. generation capacity added in 2012, 41 percent of the total

The transportation market is also seeing significant activity from both relative newcomers and established industry icons. Most notable is Tesla's Model S all-electric sedan, which was named 2013 *Motor Trend* Car of the Year, the first non-internal combustion engine vehicle to win this prestigious performance-based award. While demand for electric cars has been lower than expected by industry participants, EV sales are generally mirroring the growth pattern that hybrids experienced when they first became available to the mass market in the early 2000s. Sales of the Chevy Volt, for example, tripled to more than 23,000 in 2012 in the model's second full year on the market, according to General Motors. (See page 12 for more on how micro-hybrid technology is set to impact fleet-wide fuel efficiency.) The growing popularity of car-sharing programs also presents an interesting scenario for the future of advanced transportation, particularly for personal urban transport. In January 2013, car rental giant Avis Budget Group announced its plan to buy car-sharing pioneer ZipCar for \$500 million, a promising reminder that new ways of thinking can be just as disruptive as new technologies.

GLOBAL ENERGY SHIFT HEATS UP

Although the federal production tax credit for U.S. wind energy projects ultimately got an 11th hour reprieve during Congress' recent fiscal cliff negotiations, the extended period of uncertainty was more than enough to rush developers to beat the year-end deadline. As a result, wind represented nearly half of all new U.S. generation capacity added in 2012 – 41 percent of the total, to be exact – outpacing natural gas's 33 percent share. Including solar, biomass, geothermal, waste heat, and water sources along with



wind, renewables accounted for a record 49 percent of added capacity in the U.S. during 2012. And with coal at just 17 percent of last year’s new capacity, and no new nuclear to speak of, it has really become a renewables and natural gas story for new generation capacity in the U.S.

For the European Union the transition is happening even faster, but in this case solar is in the driver’s seat. In 2012, newly installed solar PV accounted for 37 percent of all added capacity, followed by wind with a 26.5 percent share, and gas at 23 percent. In total, renewable sources represented more than 31 GW of the 44.6 GW of new generation capacity in the EU, roughly 70 percent of all new capacity for the second consecutive year.

In Germany, clean energy already accounts for 25 percent of energy production

Generating capacity is, of course, not the same as actual generation. But even in this regard, clean-energy sources have moved past their days as rounding errors and are playing a significant role in meeting electricity demand in a number of global markets. Wind energy in Denmark blew past a 30 percent share of national electricity use in 2012, and an official target is in place to generate half of all the nation’s power from wind by 2020. In Germany, clean energy already accounts for 25 percent of energy production – led by wind (9.2 percent), biomass (5.7 percent), and solar (5.3 percent) – and the country is aiming for 35 percent from renewables by 2020. In the U.S., nine states were generating more than eight percent of in-state electricity from wind alone by the end of 2011. Iowa’s largest utility, MidAmerican Energy, now gets nearly one-third of its total power from the wind after adding more than 400 MW of wind power capacity in 2012.

On the whole, solar’s role in electricity production remains smaller than wind, but with the rapidly declining costs of solar PV, solar is gaining ground. While only five years ago PV was being installed at roughly \$7 per watt, today projects in Germany can be completed at closer to \$2 per watt. PV system prices remain higher in the U.S., where balance-of-system costs (“soft costs”) have not fallen as fast, but outgoing Energy Secretary Steven Chu is optimistic about where things are heading. “Before maybe the end of this decade, I see wind and solar being cost-competitive without subsidy with new fossil fuel,” Chu explained at a Pew Charitable Trusts event last year. For this to occur, PV costs will have to drop to around \$1 to \$1.50 per watt installed.

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

Year	System Price (\$/W)	LCOE Range (cents/kWh)
2007	\$7.20	24 - 42
2008	\$7.00	23 - 41
2009	\$5.12	17 - 31
2010	\$4.55	15 - 28
2011	\$3.47	12 - 23
2012	\$2.58	9 - 18
2013*	\$2.33	8 - 17
2014*	\$2.10	7 - 15
2015*	\$1.89	6 - 14
2016*	\$1.75	6 - 14
2017*	\$1.61	6 - 13
2018*	\$1.49	5 - 12
2019*	\$1.38	5 - 12
2020*	\$1.27	4 - 11
2021*	\$1.17	4 - 11
2022*	\$1.07	4 - 10

Source: Clean Edge, Inc., 2013. 2007 through 2012 are actual figures and 2013 through 2022 are estimates. Figures calculated using Clean Edge cost projections and the NREL Levelized Cost of Energy (LCOE) Calculator. ASSUMPTIONS: Discount rate: 4%; Capacity factor: 16-26%; O&M cost: \$6-\$60/kW.

The future of energy in the U.S. belongs to a mix of clean energy, improved efficiency, and responsible natural gas development

But as solar and other renewables continue their march down the cost curve, it seems that the goal posts are continually on the move, at least in the U.S., where fracking and horizontal drilling technology to inexpensively tap vast supplies of shale gas has fundamentally shifted the economics of energy. Some argue that America’s cheap natural gas will crowd out clean energy technologies, but we strongly believe this is not the case, as solar and wind have seen repeated record deployment in recent years and state-based RPS keep deployment targets on track. Instead, it appears that the future of energy in the U.S. belongs to a mix of clean energy, improved efficiency, and responsible natural gas resource development – a path recommended in our latest book *Clean Tech Nation: How the U.S. Can Lead in the New Global Economy* (HarperCollins, September 2012). Both private industry and government have active roles in advancing this scenario. Oregon Governor John Kitzhaber’s 10-Year Energy Action Plan, for example, calls for meeting 100 percent of new electric load growth through energy efficiency and conservation. General Electric’s product innovations include new advanced natural gas-fired power plants that can be powered up and down quickly to better partner with variable clean energy sources on the grid.

U.S. Clean-Tech Venture Investments

In 2012, U.S.-based venture capital investments in clean technologies totaled \$5.0 billion, contracting for the first time in three years with a 26 percent drop from \$6.6 billion in 2011, according to data provided by Cleantech Group.

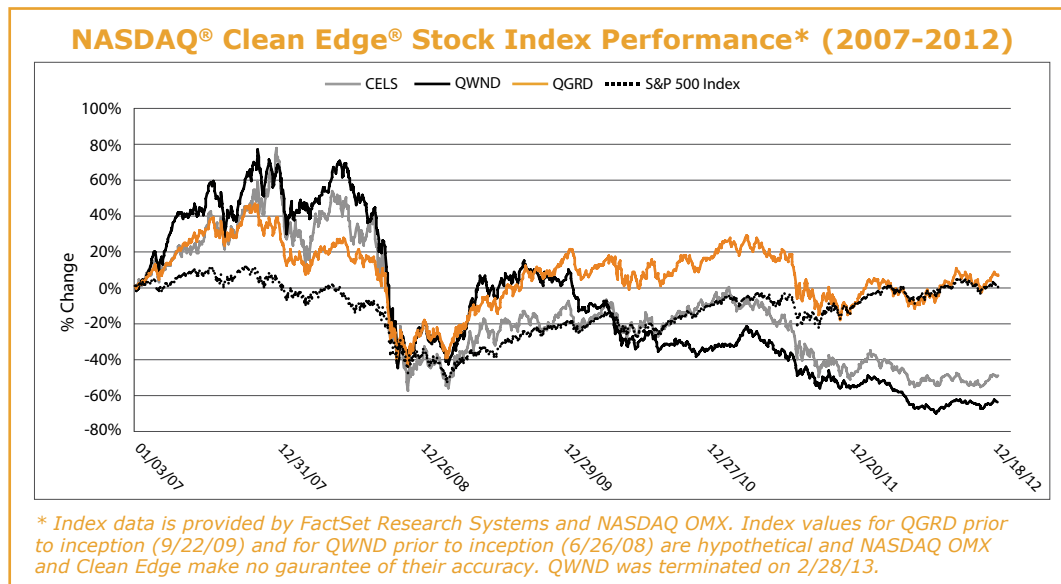
Clean-Tech Venture Capital Investments in U.S.-Based Companies as Percent of Total 2001-2012

Year	Total Venture Investments (\$Millions)	Clean-Tech Venture Investments (\$Millions)	Clean-Tech Percentage of Venture Total
2001	\$40,976	\$458	1.1%
2002	\$22,141	\$660	3.0%
2003	\$19,677	\$707	3.6%
2004	\$23,235	\$878	3.8%
2005	\$23,605	\$1,408	6.0%
2006	\$27,588	\$3,075	11.1%
2007	\$31,883	\$4,034	12.7%
2008	\$29,291	\$6,999	23.4%
2009	\$20,381	\$3,874	19.0%
2010	\$23,315	\$5,343	22.9%
2011	\$29,462	\$6,861	23.3%
2012	\$26,525	\$5,043	19.0%

Source: Cleantech Group and PricewaterhouseCoopers/NVCA data 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.

Clean tech’s decline, however, matched a similar downward trend for total VC investment in the U.S., with clean-tech investments still representing nearly one-fifth of all VC activity in the U.S. during 2012. This share could quite easily shrink in coming years as clean-tech IPOs remain all too rare and mainstream VC firms begin to shift focus back to other areas – particularly to less capital-intensive sectors with shorter business life cycles like software and web-based startups. Worldwide, clean-tech VC investment dropped 33 percent from the 2011 amount to \$6.5 billion in 2012, with U.S.-based companies attracting more than three-quarters of the global total, according to Cleantech Group.

Beyond venture capital, total global clean-energy investments fell 11 percent to \$269 billion, down from \$302 billion in 2011, according to Bloomberg New Energy Finance. But this wasn't entirely negative news for the industry, and it reflects similar findings in our global solar and wind market numbers reported earlier. As BNEF said in a press release, "sharply lower prices of solar and wind technology exert downward pressure on investment volumes, though they allow higher installation levels per dollar of funding." This is backed up by record amounts of installations of both wind and solar worldwide during 2012, even amidst lower investment doled out.



Monitoring clean-tech performance in public financial markets, Clean Edge, along with NASDAQ®, currently produces two indexes* which act as benchmarks for the sector: CELS tracks U.S.-listed clean-energy companies and QGRD looks at smart grid and grid infrastructure companies (QWND, which was discontinued in early 2013, tracked performance of global wind companies). Historically, these indexes have experienced much volatility, climbing as much as 74 percent and falling as much as 64 percent in a single year. During 2012, CELS was down 1.8 percent and QGRD up 18.2 percent for the year. QGRD outperformed the S&P 500 index benchmark, which rose 13.4 percent in 2012.

Clean tech's diversity can sometime make it difficult to identify the sector's trajectory, but as we move beyond the age of hype and hope into an era rooted in accelerated deployment and near-term solutions, several influential trends will emerge. For 2013, our five major trends to watch are:

- Smart Devices and Big Data Empower Customers, Open New Chapter in Energy Efficiency
- Distributed Solar Financing Comes of Age
- Under the EV Radar, Microhybrid Technology Saves Big on Fuel Consumption
- In the U.S. and Overseas, Geothermal Picks up Steam
- Perfectly Natural: Biomimicry Makes its Mark on Clean Tech

**Looking Ahead:
Five Trends to
Watch**

1. SMART DEVICES AND BIG DATA EMPOWER CUSTOMERS, OPEN NEW CHAPTER IN ENERGY EFFICIENCY

Energy efficiency in the built environment often has a major high-tech component, as information about the amount of energy being consumed is critical to decisions and technologies to use less of it. Nowhere is this truer than in the current explosion of data-driven customer energy management technologies – residential “learning thermostats,” sophisticated commercial building energy analysis systems, and much more. This mash-up of clean tech and high tech, under current buzz terms like Big Data, Soft Grid, and CleanWeb, is starting to make a notable dent in energy consumption and create burgeoning opportunities for small startups, large corporate players, and efficiency-minded utilities.

This mash-up of clean tech and high tech is starting to make a notable dent in energy use

Nest Labs, a Silicon Valley startup launched just three years ago by two former Apple iPod and iPhone engineers (see profile), now ships about 45,000 of its Nest thermostats every month. The \$250 Web-connected devices take programmable thermostats to a new level by “learning” from homeowners’ usage patterns, motion sensors, weather forecasts, and other data to adjust heating and air conditioning for maximum savings. And the programming interface is a smart phone app. By this summer, Nest is on track to ship its one millionth device.

Nest may be Silicon Valley’s clean-tech darling of the moment, but it has plenty of high-tech company in the customer energy-saving game. C3 Energy, founded and run by legendary software industry mogul Thomas Siebel, epitomizes Big Data in the building efficiency sector. C3’s software-as-a-service aggregates and analyzes millions of energy-use data points for use by residences, small and large businesses, and especially utilities. C3 has completed a project analyzing data from some 500,000 buildings for PG&E, and has a joint venture with General Electric for grid-scale analytics that Siebel says is trying to solve “petabyte-type problems” (one quadrillion bytes). Global spending on smart building energy management services is projected to grow from \$291 million in 2012 to \$1.1 billion by 2020, according to Boulder, Colorado-based Pike Research.

A more established pioneer is Arlington, Virginia-based

Profile: Nest Labs

Location

Palo Alto, California
www.nest.com

Founded

2010

Employees

140

Technology

Nest is the creator of the market’s leading smart thermostat, selling for \$250. It “learns” the temperatures that a homeowner typically uses and combines them with weather forecasts, motion sensing, and other data to reduce energy consumption.

The Buzz

With its Apple pedigree, big war chest from top VCs, and market momentum, Nest is one of the hottest brands in energy efficiency. The company is shipping about 45,000 thermostats per month, with plans to expand into lighting and alarm systems.

Brain Trust

Both founders come from Apple. CEO Tony Fadell, helped to create the first 18 generations of the iPod and the first three generations of the iPhone. VP of engineering Matt Rogers was responsible for iPod software development.

Bankrollers

Nest’s venture capital backers include Kleiner Perkins Caufield & Byers, Google Ventures, Lightspeed Venture Partners, Venrock, and Generation Investment Management (co-founded by Al Gore). A Series B round of \$80 million, led by Google Ventures, was reported in January.

Our Take

Nest practically epitomizes “the hot startup,” something that clean tech hasn’t seen enough of in recent years. But with giants like Honeywell (which has sued Nest for patent infringement) and Emerson targeting the smart-thermostat space, is Nest’s momentum sustainable? Many top VCs are betting big that it is.

Opower, which delivers utility usage data to consumers so they can compete with their neighbors (or Facebook friends, in a social media app launched last year) for the best energy savings. Since its founding in 2007, Opower estimates its data and analytics have saved customers two terawatt-hours of electricity, the amount used by a city the size of Sacramento. Opower, which sells a smart thermostat from Honeywell, is one of numerous startups partnering with traditional corporate energy management hardware giants. Emerson, Johnson Controls, and Schneider Electric have also combined their thermostats with wireless software from smaller companies, exemplifying the corporate/startup partnership trend growing throughout sectors across the clean-tech industry.

But utilities remain key players. Not always enthusiastically, many are now embracing the empowered-customer trend. In Texas, utility Reliant Energy installs a free Nest thermostat for customers of its Learn & Conserve energy-saving plan, while TXU Energy reported 100,000 downloads of its iPhone and Android smart-phone app for remote thermostat control by the end of 2012. Reliant and TXU are two of seven utilities that have implemented the Green Button, a U.S. Department of Energy initiative for smart meter-enabled customers to track their energy use on their utility's web site; nearly 30 other utilities in 17 states have committed to do the same. Actual consumer use, however, remains spotty; San Diego Gas & Electric, for example, reported 15,000 Green Button downloads from its web site in 12 months, out of its 1.4 million smart-meter customer base.

The web-connected smart thermostat – a leading appliance in the so-called Internet of Things – may be the most promising development for customer energy empowerment. Another potential Nest competitor is an Emerson thermostat set to launch this year with energy analytics software from Bidgely, a startup founded by Sun Microsystems and Microsoft veterans and backed by Khosla Ventures. Such Silicon Valley cachet is making energy efficiency, once derided as unsexy, one of the hottest things in clean tech this year.

TXU Energy Has 100,000 Customers on Smartphone Apps

Smart Building Managed Services Spending to Surpass \$1 Billion by 2020

A Land Grab Emerges over the Connected Thermostat

The Green Button Initiative One Year Later: Got Energy Data?

Nest Lays Defense Against Honeywell Smart Thermostat Lawsuit

How Smart Buildings Become Radically Efficient

Recent Headlines

Select Companies to Watch

Bidgely

www.bidgely.com

C3 Energy

www.c3energy.com

Honeywell

www.honeywell.com

Nest Labs

www.nest.com

Opower

www.opower.com

2. DISTRIBUTED SOLAR FINANCING COMES OF AGE

Third-party ownership or leasing of rooftop solar PV systems in the U.S. – underwritten by financing from the likes of US Bancorp and Goldman Sachs – has gone from a small niche to more than 50 percent of the residential and commercial market in 2012. Along with the falling cost of PV panels, that has fueled the spectacular growth of the market and of leading installer-financiers like SunEdison, SunRun, Sungevity, and market leader SolarCity. Now, in the wake of SolarCity's successful IPO at the end of 2012, even more financing innovations, from crowdfunding to real estate investment trusts (REITs), are poised to bring solar deployment to unprecedented levels.

Mosaic, a much-heralded Oakland, California startup, is bringing crowdfunding to solar financing for the first time. Mosaic (see profile) secured regulatory approval in 2012 to sell pieces of solar project finance to individual investors in California and New York, and its first offering of \$300,000 sold out in 24 hours. As of early 2013, Mosaic had funded 10 small rooftop solar installations (102 kW or less) with \$1.1 million in small-investor dollars, returning yields of 4.5 percent or better. “Our goal is to combine the best elements of crowdfunding with a focus on solar, which has a very positive image with the public,” says Mosaic chief investment officer Greg Rosen.

REITs are used as an investment tool in \$640 billion worth of U.S. property deals, and opening them to solar could bring in thousands of new investors. This is a tax policy change that we call for in our recent book *Clean Tech Nation: How the U.S. Can Lead in the New Global Economy* (HarperCollins, 2012). San Francisco-based Renewable Energy Trust Capital, a solar-focused investment firm headed by former Moody's Investor Service CEO John Bohn, is seeking an Internal Revenue Service ruling to open the REIT structure to solar projects. If it succeeds, solar developers could package residential and commercial solar deployments, in effect, as properties that return a low-risk cash annuity stream to investors. In a similar vein, there are bills in Congress to change the federal tax code to open master limited partnerships (MLPs), which are currently restricted to investors in oil and gas drilling projects, to renewable-energy projects including solar.

Profile: Mosaic

Location

Oakland, California
www.joinmosaic.com

Founded

2011

Employees

17

Technology

Also known as Solar Mosaic, the company offers an online platform for individual investors to collectively fund small to medium-sized solar projects.

The Buzz

Although Mosaic has aggregated just over \$1 million in solar investments to date, its concept of applying the crowdfunding model to solar has huge potential. A 2012 white paper from Bloomberg New Energy Finance estimated that moving one percent of individual retail investments in savings accounts, money markets and U.S. Treasury vehicles into crowdfunding could finance \$90 billion in clean-energy projects.

Brain Trust

Founder & president Billy Parish, 31, was named a Climate Hero by Rolling Stone for founding the global Energy Action Coalition student organization. Founder & CEO Dan Rosen was recognized as one of 30 under 30 in Energy by Forbes in 2012. Mosaic recently hired Howard Solovei from Lending Club as its VP of finance.

Bankrollers

Several independent investors, venture capital firms such as Spring Ventures, and several angels from the Toniic investor network support Mosaic.

Our Take

Investments in Mosaic offer returns around 4 to 5 percent, considerably better than 1.9 percent currently offered by 10-year treasuries. With its initial projects fully funded by 1,000 investors, the company says 10,000 people have signed up to be notified when new projects become available. All eyes are on Mosaic to see if its crowdfunding model is scalable and sustainable, but it is off to a promising start.

Such breakthroughs could open the floodgates to investment streams that are already starting to flow. Overall, solar projects are getting more established as a solid ‘asset class’ that attracts traditional Wall Street financiers who have not previously invested in renewables. An \$85 million project finance fund announced by Sungevity in January, for example, includes \$50 million from Energy Capital Partners, a longstanding investor in oil, gas, and coal projects. As Sungevity, SolarCity and others pioneered the so-called solar utility model for customers to pay monthly fees rather than buy PV systems up front, it has created a consistent, low-risk revenue stream that’s very attractive to large-scale investors. “SolarCity said to the investment world: people always pay their utility bill,” says Terry Grant, a managing director at investment bank Marathon Capital. “If they can act like a utility that happens to be solar, that’s a really good thing.”

Still, wooing top investment dollars into solar projects remains a challenge. Less than five percent of the 6,500 banks and lending institutions in the U.S. are actively involved in financing solar projects, although some big players like Bank of America, Citigroup, US Bancorp, and Wells Fargo have done substantial deals. To further the goal of distributed solar installations as an asset class on a par with large-scale power plants and other capital projects, 16 key industry players recently formed the truSolar Working Group to help reassure large lenders. Led by project developer Distributed Sun and DuPont’s Photovoltaic Solutions unit, the group aims to develop uniform standards for solar project screening, rating and underwriting.

Along with continuing price drops for PV panels, efforts like these continue to transform the U.S. solar sector from its ‘alternative energy’ past into a mainstream industry worthy of investors from Main Street to Wall Street. “We’re no longer geeks selling gear,” says Sungevity co-founder and president Danny Kennedy. “It’s a service business now, and service is about making people – both customers and investors – feel good. We have to sell our industry as that.”

Solar projects are getting more established as a solid asset class

Solar Costs to Fall as REITs Emerge as Source of Funding
Third-party Financing Taking over US Residential PV Market
Solar Mosaic’s Crowdfunding Beats Treasuries With 4.5% Return
Morgan Stanley Backs \$300 Million Residential Solar Lease Facility
Can truSolar Become the Industry’s Kelley Blue Book?
Sungevity Receives \$125 Million for Rooftop Solar Power Systems

Recent Headlines

Clean Power Finance
www.cleanpowerfinance.com

Mosaic
www.joinmosaic.com

Renewable Energy Trust Capital
www.renewabletrust.com

SolarCity
www.solarcity.com

Sungevity
www.sungevity.com

Select Companies to Watch

3. UNDER THE EV RADAR, MICROHYBRID TECHNOLOGY SAVES BIG ON FUEL CONSUMPTION

It's called stop-start. It's also called start-stop, idle-stop-go, idle elimination, microhybrid, mild hybrid, and several other proprietary names. By any label, it's the technology that stops a vehicle's motor during idling, then starts it again—with a battery, not gas—when needed. The technology's roots date back to the 1980s, and it has been available in the European market since 2002. More than 40 percent of new cars sold in Europe and Japan include stop-start, according to AAA. Now it's poised to come to the U.S. in a big way, with a major impact on fleet-wide fuel efficiency.

The Obama administration aggressively updated corporate automotive fleet efficiency (CAFE) standards in August 2012, requiring all new vehicles to get an average of 54.5 mpg by 2025, more than double the 25.3 mpg fleetwide requirement in 2010. Stop-start technology can help automakers increase their average vehicle mileage for a relatively small investment, and Detroit is starting to follow its overseas competitors to help meet the CAFE mandate.

"Microhybrid ICEs will get the most fuel economy without paying a premium," says Thanh Nguyen, technology planning manager for power solutions at battery maker Johnson Controls. Nguyen says that stop-start and microhybrids will get automakers close to CAFE standards for a far smaller technological investment than all-electric vehicles and plug-in hybrids, which have proved costly to develop and have been slow to catch on with mainstream consumers. The stop-start function alone will provide fuel savings (and reduced CO₂ and other emissions) of five to 10 percent; a full microhybrid system, with regenerative braking and an electrically powered air-conditioning compressor, can bring a 15 to 20 percent savings based on a model using European testing procedures. Auto components giant Bosch already lists the benefits of its stop-start system on its web site, claiming fuel savings of up to eight percent. Nguyen estimates that just \$1,000 per vehicle in stop-start and other technology improvements – considerably less than the cost premium for many of today's hybrids – would let the average car get about 48 mpg by 2025.

All hybrid cars sold in the U.S. have stop-start capability already, although they use a different technology than the systems on conventional ICE powertrains. The first non-

More than 40 percent of new cars sold in Europe and Japan include stop-start

Profile: Johnson Controls

Location

Milwaukee
www.johnsoncontrols.com

Founded

1885 by Warren Johnson, inventor of the first electric thermostat

Employees

170,000

Technology

Johnson Controls (JCI) has already released a 12- and 48-volt Micro Hybrid system for stop-start vehicles. The system is now available in Europe, and JCI plans to release it in North America. Initially the system includes separate lead-acid 12-volt and lithium-ion 48-volt batteries, but the second generation will combine both voltages in a single lithium-ion battery pack.

The Buzz

Johnson Controls is currently the leading supplier of stop-start batteries in Europe through its VARTA brand. In Germany, the company's plants in Hannover and Zwickau produce more than 11 million stop-start batteries annually. The company is also adding production facilities capable of making 6.8 million batteries per year in the United States. The company has invested \$100 million to build a stop-start vehicle battery plant in China.

Brain Trust

Ray Shemanski, VP and general manager of OEM and hybrid systems, is beefing up JCI's ties with advanced battery system developers.

Bankrollers

JCI is a longstanding publicly-owned firm, traded on the New York Stock Exchange. With \$42 billion in 2012 revenue and \$6.2 billion in 2012 gross profits, it can develop and operate its stop-start activities out of its own pockets. Revenue from the power systems division was \$5.9 billion in 2012.

Our Take

JCI's scale, legions of engineers, and existing relationships with automakers will make it a key driver of stop-start growth. However, its focus on lead-acid technology could make it vulnerable to advances by firms researching different battery materials and production methods, such as Exide Technologies and Axion Power.

hybrid stop-start systems in the U.S. market were on 2012 high-end vehicles from BMW, Mercedes, and Porsche. For the 2013 model year, Jaguar will join that select group, but stop-start systems will also become available on popularly priced models from Ford, Kia, and possibly others. Even trucks will start to see some systems, with Dodge adding stop-start to its V6-powered Ram 1500 pickup.

But there are some quirks to stop-start that could turn off aggressive drivers. Owners of high-end performance vehicles who want to punch the accelerator and get an instantaneous response can be taken aback. As a result, BMW is currently allowing dealers to de-program stop-start for customers who ask for it. On the other hand, Lamborghini's new 700-horsepower, 12-cylinder Aventador sports car features stop-start using ultracapacitors from Maxwell Technologies. Stop-start acceptance by mainstream Ford and Dodge drivers will be crucial to meeting the U.S. CAFE standards over time.

Lux Research forecasts that more than eight million vehicles, not including hybrids, will be equipped with stop-start technology in North America by 2017 – roughly four times the number of hybrids that are on the road in the U.S. today. Based on automakers' current plans, Johnson Controls has forecast that more than 35 million vehicles with stop-start technology will be produced worldwide by 2015. That's a lot of fuel savings.

The New Thing in Green Tech: Micro-Hybrid Batteries

U.S. Market Ready for Fuel-Saving Stop-Start Technology

The Road Ahead: How We'll Get to 54.5 mpg by 2025

Stop-Start Coming to 8 Million Vehicles in North America by 2017

Johnson Controls Offers Stop-Start Battery System

The CAFE Numbers Game: Making Sense of the New Fuel-Economy Regulations

Recent Headlines

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www.axionpower.com

Bosch

www.bosch-automotivetechology.us

Delphi Automotive

www.delphi.com

Exide Technologies

www.exide.com

Johnson Controls

www.johnsoncontrols.com

Select Companies to Watch

4. IN THE U.S. AND OVERSEAS, GEOTHERMAL PICKS UP STEAM

Overshadowed by wind and solar energy, geothermal is still the only renewable electricity resource besides hydroelectric that provides baseload power. With an average plant uptime of 98 percent, it's actually more reliable than nuclear or coal-fired power plants, both of which require more downtime for maintenance. After a couple of down years, the U.S. geothermal market – the world's largest – bounced back in 2012 and, thanks to positive developments in technology, policy, and capital, is poised to continue the upswing.

The U.S. geothermal industry brought a mere 25 MW of new capacity online in 2010 and 2011 combined, according to the Geothermal Energy Association (GEA). But with the addition of 77 MW of capacity in 2012, the U.S.'s installed cumulative capacity grew to 3,187 MW, more than a quarter of the worldwide total of 11,224 MW. First approved as a renewable energy source eligible for the federal production tax credit (PTC) in 2005, geothermal stands to benefit from the PTC's recent one-year extension and especially its change in project eligibility rules.

In the past, the PTC for wind, geothermal, and some biomass energy had required eligible projects to be in service and producing power by the end of the calendar year when the credit was set to expire. The 2013 credit, approved in the year-end Congressional "fiscal cliff" package, has a more geothermal-friendly threshold: any project that begins construction during the year qualifies. Since geothermal project development times average about seven years, the PTC extension could have a long-range impact on growth. On the state policy front, the three leading geothermal states – California, Nevada, and Hawaii – all have aggressive RPS mandates, and geothermal developers can also earn carbon credits in California's newly-commenced emissions trading system.

In the U.S. and Europe, the industry is increasingly using so-called binary technology that can utilize more moderate and low temperature resources. The technology uses two fluids: moderately heated (below 400°F) geothermal fluid, and a secondary fluid with an even lower boiling point. Heat from the geothermal fluid causes the secondary fluid to flash to vapor, which drives turbines.

Profile: Energy Development Corporation (EDC)

Location

Manila, Philippines
www.energy.com.ph

Founded

1976

Employees

2,580

Technology

EDC's geothermal services include exploration, development, and ongoing operations and maintenance. As a state-sanctioned energy firm, the company has engineers working on improving reservoir management; steamfield commissioning, operations, and maintenance; energy R&D, and project planning and construction.

The Buzz

EDC is the second-largest geothermal company in the world, and the largest in the Philippines by far. It accounts for more than 60 percent of the country's installed geothermal capacity, with plants in Leyte, Negros Oriental, Negros Occidental, Bicol and North Cotabato. EDC took in \$710 million in 2012 revenue.

Brain Trust

Dominic Camu is the Senior Vice-President for power generation at (EDC parent company) Lopez Corporation. He has been head of a General Electric power site in Taiwan. He has 28 years of power plant experience with coal, diesel, waste to energy, combined cycle gas turbines and geothermal power plants.

Bankrollers

EDC stock is publicly traded in the Philippines, and the country has enough funding both to develop in-country and outside of the Philippines. In October 2012, EDC announced it was investing more than \$60 million in geothermal development in Chile and Peru through a joint venture with Alterra.

Our Take

EDC is the private spinoff of a big state-sponsored company. It's tasked with growing the country's power supply. The company's mandate to expand domestically and its nascent push abroad will make it one to watch over the next decade.

With an average plant uptime of 98 percent, geothermal facilities are actually more reliable than nuclear or coal-fired power plants

This is opening up a new range of resources from some unlikely places. Geothermal fluid is a byproduct of many oil and gas wells in the U.S., and 25 billion barrels of it are produced each year. This hot water, long considered an inconvenience and a disposal issue, is now being looked at as a resource, and the Department of Energy's Geothermal Technologies Office is funding research and development of the technology. It enabled the first geothermal project in Louisiana to come online in 2012, and hundreds of gas and oil production sites in the Gulf region could potentially do the same.

Outside the U.S., geothermal is rising rapidly in those countries promoting the power source through national energy policies. The World Bank approved \$300 million in Indonesian geothermal investment in 2012. It considers geothermal the only viable replacement for coal in many East Asian countries, and member countries (the Netherlands, in this case) are making large loans available to make a positive impact on climate change.

East Africa in particular is working to claim more of its geothermal potential. Only about 217 MW of an estimated 15,000 MW of accessible geothermal resources have been developed in Kenya and Ethiopia, but Kenya plans to double geothermal generation by 2020, when it predicts geothermal will provide 30 percent of the country's electricity. By 2030, it aims to have 5,000 MW of geothermal power online.

Indonesia has 27,510 MW in potential geothermal resources; its goal is to quadruple capacity from a current level of 1,200 MW to 5,000 MW by 2025. More than 40 geothermal projects are currently in development there. Elsewhere in Asia, the Philippines aims to grow its operating geothermal capacity from 1,972 MW currently to 3,447 MW by 2025. Energy Development Corporation, the leading Filipino developer (see profile), increased electricity sales by 16 percent in 2012.

Budding Geothermal Markets Light Up East Africa

2013 Geothermal: Last-Minute PTC Revision Sparks a New Hope

Geothermal Stocks Warming Up

California Carbon Auction: Will Geothermal Value Finally Be Recognized?

Another US Loan Guarantee Project Powering Up

J.P. Morgan Buys Stake in Eight Geothermal Power Plants from Ormat

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www.chevron.com/deliveringenergy/geothermal

Energy Development Corporation (EDC)

www.energy.com.ph

Ormat Technologies

www.ormat.com

TAS Energy

www.tas.com/renewable-energy/geothermal

US Geothermal

www.usgeothermal.com

Select Companies to Watch

5. PERFECTLY NATURAL: BIOMIMICRY MAKES ITS MARK ON CLEAN TECH

The concept of biomimicry – using designs found in nature as the template for creating modern industrial products and processes – goes back a while. Scientist Janine Benyus's landmark book *Biomimicry* was published in 2002, and the first modern-day product considered to be inspired by nature, Velcro, was conceived in Switzerland in 1941 – thanks to burrs that stuck to the inventor's pants and dog. But biomimicry is now emerging as a notable design philosophy in the realms of clean tech around the world. Its applications are making more efficient use of energy, water, and materials in everything from bullet trains to personal electronics, and making wind turbine blades and solar technology (both PV and CSP) more productive in generating electricity.

*Sometimes,
nature's lesson is
not for the product
itself, but simply
the way it's installed*

For technologies that generate clean energy from natural sources like the sun and the wind, mimicking nature makes sense. Toronto-based WhalePower has commercialized fan blades with scalloped edges modeled on the fins of humpback whales, 40-ton creatures that can propel themselves out of the sea. The blades move air 25 percent more efficiently than flat blades, and WhalePower is seeking to bring the technology to the wind-turbine industry. In solar power, Australia-based Dyesol has commercialized a sunlight-to-electricity technology called the dye-sensitized solar cell (DSSC). Pioneered by Swiss photochemistry professor Michael Grätzel, the DSSC uses a dye that mimics the photosynthesis process in the chlorophyll of plant leaves, specifically those of the endangered kokia cookie tree from the Hawaiian island of Molokai. The cells are made of titanium dioxide instead of silicon and can produce power in much lower light conditions than conventional PV cells.

Sometimes, nature's lesson is not for the product itself, but simply the way it's installed. Researchers at MIT and Germany's RWTH Aachen University are working with Abengoa's 11-MW PS 10 concentrated solar plant (the world's first solar tower facility) in Spain's Andalusia desert for a more efficient layout of the plant's hundreds of heliostats (mirrors) – based on the design of a sunflower's petals. By mimicking both the layout and the angle of the petals, researchers estimate the plant could produce the same energy with 10 to 20 percent fewer heliostats on the same acreage.

On the energy-efficiency front, biomimicry applications range

Profile: Biomimicry 3.8

Location

Missoula, Montana
www.biomimicry.net

Founded

1998 (as Biomimicry Guild)

Employees

27

Technology

Biomimicry 3.8 is a consulting and professional certification organization for business, scientific, and academic clients, and operator of AskNature.org, a database of biomimicry examples and ideas. The organization's unusual name comes from the 3.8 billion years that life has existed on earth.

The Buzz

From humble beginnings 15 years ago, Biomimicry 3.8 has grown to a highly influential combination of think tank, consultancy, and educator; nearly 100 professionals and specialists worldwide have completed its certification programs. Current and former business clients include Arup, Boeing, GE, HOK Architects, Interface, Procter & Gamble, and Natura, Brazil's largest maker of personal care products. But its biggest impact may be in educating the educators of tomorrow's best biomimicry practitioners.

Brain Trust

Co-founder and Institute board president Janine Benyus almost single-handedly elevated the biomimicry field to world prominence with the 1997 publication of her seminal book Biomimicry. Her fellow co-founders are biologist Dayna Baumeister, who holds the title of Keystone, and CEO Chris Allen, a veteran sustainable business consultant.

Bankrollers

The Institute's sponsors include Autodesk, founding sponsor of the AskNature.org database, and several foundations.

Our Take

From simple online searching of case studies to full-fledged consulting engagements, Biomimicry 3.8 is biomimicry's global focal point. As the field continues to expand within the wide realms of clean tech, the organization will be one of the key resources for biomimicry innovators and entrepreneurs.

from industrial fans and mixers to electronics screens. Pax Scientific in San Rafael, California, whose advisors include Paul Hawken and Amory Lovins, has licensed its impeller and propeller designs to clients like Delphi and NASA Ames Research Center. They're modeled on the spiral design of a type of kelp, for optimum fluid dynamics. Qualcomm's energy-saving (and more readable) Mirasol screen technology for electronic device displays was inspired by the way a butterfly's wings shimmer in bright sunlight. And in the quest for more efficient lighting, what's a better model than the species that creates its own light: fireflies? Researchers from Canada, Belgium, and France have developed an LED coating based on the jagged scales on firefly abdomens, claiming a 55 percent efficiency gain for LEDs.

As biomimicry gains credibility and momentum, at least one city – San Diego – views the field as an emerging sector for economic development. Home to both a vibrant biotech industry and the world-famous San Diego Zoo, the city aims to be a world-class hub for biomimicry research and commercialization. The zoo has hosted three international biomimicry conferences and in 2012 launched the Global Centre for Bioinspiration headed by a former pharmaceutical CEO, Larry Stambaugh. The zoo's mission is not just lab experiments; it commissioned a 2010 study estimating that biomimicry could add \$300 billion to the U.S. economy by 2025 while saving an additional \$50 billion in resource use and pollution cleanup. "We're just starting on the concept of Biomimicry San Diego, to make San Diego a hub," says Jacques Chirazi, the city's clean tech program manager. "Thirty to forty years from now, we need to have a much lower-carbon economy, and biomimicry is a very promising area to help us get there."

Engineers Bring Processes of Nature to Design

More Efficient Concentrated Solar Power Plants Inspired by Sunflowers

The Bullitt Building Follows Nature's Lead in Elegant Efficiency

Amid Wave of Bioinspiration, San Diego Zoo Creates Innovation Center

Scientists Mimic Fireflies to Make Brighter LEDs

Tough, Light and Strong: Lessons from Nature Could Lead to the Creation of New Materials

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www.biomimicry.net

CalTech Center for Bioinspired Engineering

www.bioinspired.caltech.edu

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Whale Power

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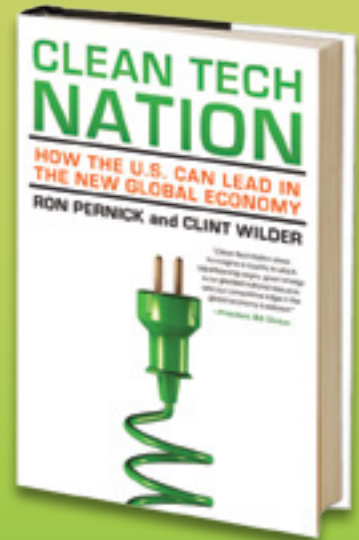
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AUTHORS

Ron Pernick, founder and managing director of Clean Edge, is an accomplished research, publishing, and business development entrepreneur with nearly three decades of high-tech experience. He is the coauthor of two books on clean-tech business and innovation, *Clean Tech Nation* (HarperCollins, 2012) and *The Clean Tech Revolution* (HarperCollins, 2007). At Clean Edge he has coauthored more than two dozen reports on clean technologies, markets, and policies and oversees the firm's research, indexing, and benchmarking services. He consults regularly to companies, government agencies, and investors. He is widely quoted in the media, and is a regular speaker at industry events in the U.S. and abroad.

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Trevor Winnie, senior research analyst for Clean Edge, leads research efforts for the firm's publications including the *State Clean Energy Index*, *U.S. Metro Clean Tech Index*, *NASDAQ Clean Edge stock indexes*, and the *Clean Energy Trends* report series. He also served as a contributor to *Clean Tech Nation* (HarperCollins, 2012).

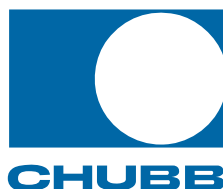
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