

# CLEAN ENERGY TRENDS 2014

BY RON PERNICK  
AND CLINT WILDER  
AND JAMES BELCHER

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THE CLEAN-TECH MARKET AUTHORITY



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**CLEAN ENERGY TRENDS 2014**

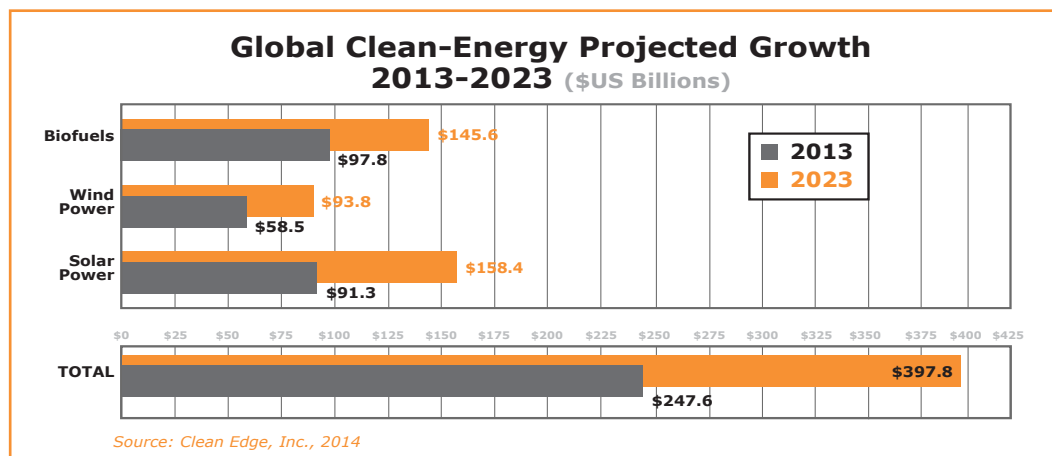


## CLEAN ENERGY TRENDS 2014

Over the past 12 months, the global clean-energy picture has been a classic good news-bad news story, with dazzling growth, success stories, and soaring stock prices in some sectors – most notably solar PV deployment – but downward trends and policy and finance hurdles in others. As the industry continues to mature and makes its presence felt among decades-old, fossil-fuel energy sources, it faces a host of new challenges and opportunities. Among these are a transition away from early-stage venture capital investments to corporate and later-stage project financing sources; the shift away from nuclear power in Germany, Japan, California, and elsewhere; and pushback from some utilities and regulators who perceive distributed generation as a significant threat to long-established business models.

### A RECORD YEAR FOR SOLAR DEPLOYMENT

The year 2013 also marked a significant tipping point in the history of clean energy: for the first time since Clean Edge began tracking global markets in 2000, the world installed more new solar photovoltaic generating capacity, 36.5 gigawatts, than wind power (35.5 GW). Record levels of new solar deployment in China, Japan, and the U.S., combined with a down year in the wind industry, enabled this unprecedented crossover. Although total global wind power capacity remains nearly 2½ times the size of solar, projected double-digit growth rates in solar throughout the next decade mean that wind will not stay No. 1 indefinitely. With the installed cost of solar expected to fall around seven percent annually, Clean Edge projects that by 2021, global cumulative installed solar PV capacity will reach 715.8 GW, surpassing wind power's projected 697.3 GW in that year. Nearly 100 GW of new solar capacity is already under development worldwide, according to researcher NPD Solarbuzz.



The global solar market's continued double-digit growth of 18 percent, plus a modest uptick in biofuels, was not enough to overcome the wind industry's lackluster performance. As a result, combined global revenue for solar PV, wind power, and biofuels declined slightly to \$247.6 billion from \$248.7 billion in 2012.

- Solar photovoltaics (including modules, system components, and installation) grew to \$91.3 billion from \$79.7 billion in 2012, with a record 36.5 GW installed globally. In contrast to 2011 and 2012, when PV panel costs plummeted more than 20 percent in both years, prices stabilized last year, dropping just three percent to \$2.50 per watt installed (less than one-third

the cost 10 years earlier.) The industry's boom year in installations translated into strong revenue gains as well. Although prices will continue to drop an estimated seven percent per year over the next decade, to \$1.21 per watt by 2023 (see chart on page 4), double-digit annual growth in capacity will fuel strong revenue growth to \$158.4 billion in 2023.

The U.S. installed an estimated 4.2 GW of new solar PV in 2013, deploying more than Germany (an estimated 3.3 GW) for the first time in more than a decade. China installed an eye-popping 12 GW of solar in 2013, according to Bloomberg New Energy Finance – roughly as much as total cumulative solar PV installations in the U.S., and nearly triple the 4.5 GW deployed in China the year before. Prior to 2013, no nation had ever added more than 8 GW in a single year. And Japan, continuing its aggressive renewables push as it struggles to replace most of its nuclear power, also installed a record amount of new solar PV capacity in 2013, approximately 7 GW.

- Wind power (new installation capital costs) fell to \$58.5 billion from \$73.8 billion in 2012. The industry added 35.5 GW of new capacity in 2013, well below the previous year's record 44.7 GW and its weakest performance since 2008. Indeed, the global wind industry slowed in every major market except China, which installed an astounding 45.4 percent (16.1 GW) of the world's new capacity in 2013, according to the Global Wind Energy Council; the U.S. saw just over one new gigawatt of wind come online. That extended China's lead as the world's largest wind market with 91.4 GW cumulative installed capacity at the end of the year, well ahead of 61.1 GW in the U.S. and 34.3 GW in Germany. But we project modest growth to return in 2014 and to continue over the next decade, with the industry expanding to \$93.8 billion in 2023.
- Biofuels (global production and wholesale pricing of ethanol and biodiesel) rose slightly, from \$95.2 billion in 2012 to \$97.8 billion in 2013. Global biofuels production held steady at around 31 billion combined gallons. We project that the global markets for both ethanol and biodiesel will grow an average 4.5 percent annually over the next decade, reaching a combined \$145.6 billion in 2023, with biodiesel prices falling and ethanol pricing remaining fairly stable.

We project that these combined clean-energy sectors will continue to grow over the next 10 years, expanding from \$247.6 billion in 2013 to \$397.9 billion in 2023.

Clean energy's mixed-signals theme continued into early 2014, as the industry experienced a range of high-profile successes and setbacks. A highly controversial *60 Minutes* segment called "The Cleantech Crash," airing on the first Sunday in January, started the year by rehashing old themes of clean tech as a government boondoggle and venture capital investment disaster. The piece galvanized a significant clean-tech industry backlash against what was viewed as an inaccurate hit piece, most notably by VC icon Vinod Khosla, who featured prominently in the broadcast. Yet one week later, Google announced the acquisition of smart thermostat maker Nest Labs for \$3.2 billion, a "moonshot" bet by Google that, with Nest's help, it can design, develop, and deploy ever-smarter hardware for homes and businesses. Another highly-anticipated IPO candidate, energy-efficiency data provider Opower, filed for

its offering in February. And in March, the world's largest auto maker, Toyota, launched the first-ever green bond (more than \$1 billion) to fund auto loans for hybrids, plug-in EVs, and other clean vehicles in the U.S.

### Total Installed PV System Prices (Global Average)

Year	Global Average System Price (\$/W)
2007	\$7.20
2008	\$7.00
2009	\$5.12
2010	\$4.55
2011	\$3.47
2012	\$2.58
2013	\$2.50
2014*	\$2.33
2015*	\$2.16
2016*	\$2.01
2017*	\$1.87
2017*	\$1.74
2019*	\$1.62
2020*	\$1.51
2021*	\$1.40
2022*	\$1.30
2023*	\$1.21

Source: Clean Edge, Inc., 2014. 2007 through 2013 are actual figures and 2014 through 2023 are estimates

The expansion of clean energy occurs in a bigger-picture context that finds many of the world's largest energy-using nations struggling with choices for their energy future. At Clean Edge, we continue to believe that the energy story in the developed world will be the growth of natural gas, renewables, and efficiency, with coal-fired and nuclear power plants on the wane. But reality is more muddled.

In Germany, for example, Chancellor Angela Merkel's plan to shutter all of the nation's nuclear plants by 2022 has caused a small resurgence in coal-fired power. Although Germany leads the world's large economies with 23 percent of its energy from renewables, critics say its push for a non-nuclear future has yielded high electricity rates and increased CO2 emissions. The Japanese public overwhelmingly opposes re-starting that country's nuclear

### Global Clean-Energy Market Size 2000-2013

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
2013	\$91.3	\$58.5	\$97.8

Source: Clean Edge, Inc., 2014

power plants in the wake of the 2011 Fukushima nuclear disaster, but many national leaders, including Prime Minister Shinzo Abe and recently-elected Tokyo governor Yoichi Masuzoe, are pro-nuclear.

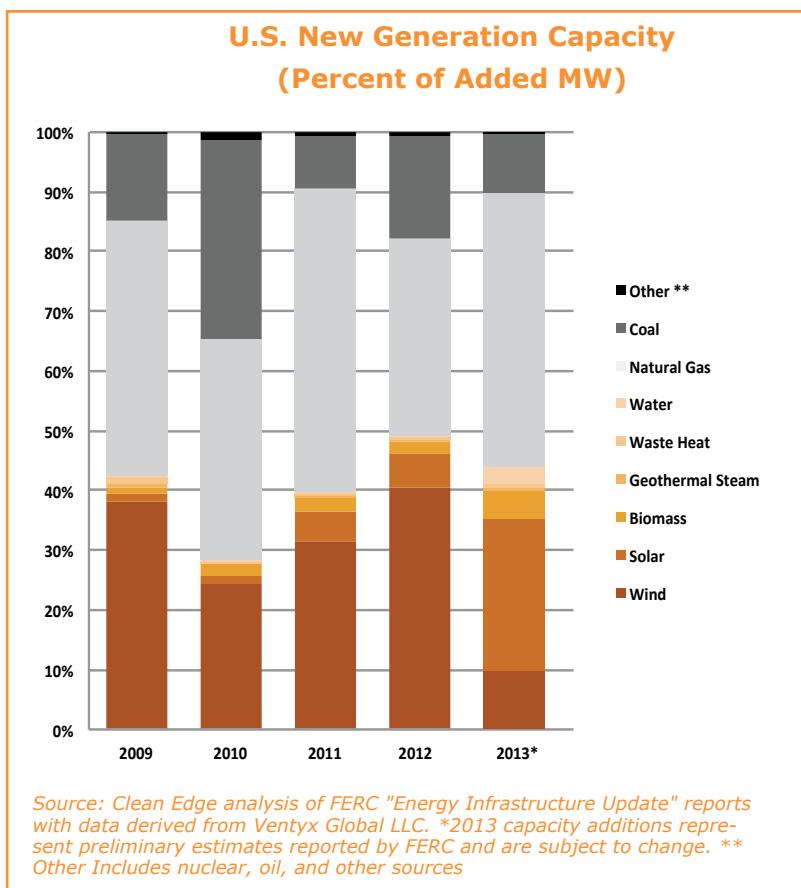
In the U.S., non-hydro renewables (solar, wind, biomass, and geothermal) accounted for 41 percent of new generation capacity added in 2013, more than triple the contribution of coal, oil, and nuclear combined. (And although they are short-term statistical anomalies, it's worth noting that renewables made up 100 percent of capacity added in November 2013 and 99 percent in January 2014). But renewables' contribution last year was down from 51 percent in 2012. Wind power's drop from 42 percent in 2012 to just 10 percent in 2013 (trailing solar for the first time) was one factor, but the biggest reason was the boom year in new natural gas capacity, which dwarfed all other energy sources at 47 percent of new capacity.

The Obama administration continues to tout an 'all of the above' energy mix, and in early 2014 approved a \$6.5 billion Department of Energy loan guarantee to Southern Company's Georgia Power utility to build two additional reactors at its Plant Vogtle site near Waynesboro, Georgia – the first new nuclear reactors in the U.S. in 30 years. Total loan guarantees for the project are \$8.3 billion. By contrast, the largest DOE loan guarantee to a clean-

energy company, under the program widely criticized by *60 Minutes* and others as a boondoggle – was \$1.6 billion to NRG for the 392 MW Ivanpah concentrated solar power plant, which in February began delivering electricity to the grid.

Nonetheless, the global “nuclear renaissance” predicted before the 2011 Fukushima disaster in Japan is now highly unlikely, and coal, accounting for only 10 percent of new generation capacity in the U.S. last year, is generally on the wane in the developed world. Natural gas continues to pose the biggest competition for renewables, although the potential for pairing natural gas-fired plants with solar and wind farms remains high, especially as large-scale battery storage technology advances and drops in price.

*The Japanese public overwhelmingly opposes re-starting that country's nuclear power plants*



## VC, OVERALL INVESTMENT FALLS

2013 saw the continued decline of venture capital as a source of clean-tech funding. For the second consecutive year since their peak of \$7.5 billion of 2011, VC investments in U.S.-based clean-tech companies fell. In 2013, such investments slipped to less than \$4.4 billion, the lowest total since 2009, according to data tracked annually by Cleantech Group. Even more notably, clean-tech investments as a percentage of all U.S. VC dollars fell from 21.4 percent in 2012 to just 14.9 percent, the lowest level since before the late 2000s clean-tech boom—2007, to be precise.

**Clean-Tech Venture Capital Investments in  
U.S.-Based Companies as Percent of Total 2001-2013**

Year	Total Venture Investments (\$Millions)	Clean-Tech Venture Investments (\$Millions)	Clean-Tech Percentage of Venture Total
2001	\$40,952	\$458	1.1%
2002	\$22,177	\$660	3.0%
2003	\$19,620	\$707	3.6%
2004	\$23,209	\$893	3.8%
2005	\$23,524	\$1,411	6.0%
2006	\$27,515	\$3,053	11.1%
2007	\$31,952	\$4,098	12.8%
2008	\$29,949	\$6,857	22.9%
2009	\$20,265	\$4,182	20.6%
2010	\$23,360	\$5,682	24.3%
2011	\$29,710	\$7,491	25.2%
2012	\$27,323	\$5,839	21.4%
2013	\$29,365	\$4,367	14.9%

*Source: Cleantech Group and PricewaterhouseCoopers/NVCA data with Clean Edge analysis, 2014. Clean-tech venture investment includes seed funding and follow-on rounds prior to private equity activity related to stake acquisitions or buyouts*

While that VC boom was mainly fueled by solar and biofuels startups, the top VC deals of 2013 comprised a much more diverse range of clean-tech sectors. Seven different sectors were represented among the 10 largest deals disclosed. Two of the top 10 recipients (Uber's \$258 million round, the year's largest, and Lyft's \$60 million) were from the transportation sector, but as ride-sharing services they also represent the emerging growth sector of Web-based clean tech business models known as cleanweb (See *Internet-Enabled Clean-Tech Startups Define a New Sector* on page 16.)

Beyond venture capital, total global clean-energy investments fell for the second straight year, according to Bloomberg New Energy Finance. Global investments in 2013 were \$254 billion, down from \$286.2 billion the previous year and well below the peak of \$317.9 billion in 2011. China saw its first year-to-year decline (of 3.8 percent) in more than a decade, while U.S. investment levels dropped 8.4 percent. But the big story was in Europe, where lower feed-in tariffs and other subsidies caused a plunge of 41 percent, to \$57.8 billion from \$97.8 billion in 2012. Japan, by contrast, enjoyed a clean-energy investment increase of 55 percent to \$35.4 billion, the vast majority of it funding the nation's post-Fukushima solar energy boom.

Picking up some (though far from all) of the VC financing slack is the continued rise of large corporations and financial firms around the world investing in clean tech. Google's multi-billion dollar acqui-

**U.S. Top 10 Disclosed Clean-Tech Venture Deals (2013)**

Company	Primary Sector	Total Invested (\$ Millions)	Date
Uber	Transportation	\$258	August 2013
Intrexon	Biofuels & Biochemicals	\$150	May 2013
Bloom Energy	Fuel Cells & Hydrogen	\$150	May 2013
Skyonic	Air	\$128	June 2013
eRecyclingCorps	Recycling & Waste	\$105	October 2013
Telogis	Transportation	\$93	October 2013
Nest	Energy Efficiency	\$80	January 2013
rePlanet	Recycling & Waste	\$67	December 2013
Blu Homes	Energy Efficiency	\$65	June 2013
Lyft	Transportation	\$60	May 2013

Source: Cleantech Group, 2014

sition of Nest is the most prominent example, but other large deals struck in 2013 included Goldman Sachs' \$500 million fund to finance SolarCity PV installations and Wells Fargo's pledge to invest \$100 million in tax equity financing in SunEdison projects. Joint ventures and other partnerships between corporates and smaller clean-tech players, such as Softbank's 50-50 joint venture in Japan with fuel cell developer Bloom Energy, continue to be on the upswing. General Electric, Schneider Electric, Johnson Controls, Siemens, and ABB are among the large global firms leveraging smaller clean-tech partners. Even some large U.S. utilities, such as Duke Energy, Edison International, and NextEra Energy Resources are pairing up with or acquiring solar and other players in distributed generation (see *Enlightened Utilities Begin to Embrace Distributed Energy Assets* on page 10).

"Corporates are getting more comfortable stepping in at early stages to help get these clean-tech companies to the scale they need to succeed," says Kerry Cebul, a principal in the advisory group at Cleantech Group. Another key trend helping to pick up the clean-tech financing slack is the emergence of so-called "yieldcos" – registered, non-traded LLCs established specifically for private-equity investments in clean-energy projects. Two examples, Pattern Energy and NRG Yield, both issued successful IPOs during 2013.

On another industry financial barometer, the performance of clean-tech companies in public equity markets, 2013 was a banner year. Clean Edge, along with NASDAQ, produces two indexes that act as benchmarks for the clean-tech sector: CELS tracks U.S.-listed clean-energy companies and QGRD is comprised of smart grid and grid infrastructure firms. CELS, fueled by the stocks of Tesla Motors and SolarCity among others, soared 89 percent for the year, by far its best performance to date and well ahead of the S&P 500's gain of 30 percent. QGRD gained 24 percent, its best year since 2009.

For the first time, we have expanded the scope of this annual *Clean Energy Trends* report to track the global growth of green buildings and electric and hybrid vehicles. In the past decade, green buildings, as measured by the number of structures certified by the U.S. Green Building Council's Leadership in Energy & Environmental Design (LEED) standard, have seen a phenomenal growth trajectory. In 2003, less than 50 buildings worldwide received LEED certification; last year, 4,617 did, an 8.6 percent increase over the number in 2012—and these numbers exclude single-family residences. Since 2000, the number of LEED-certified green buildings worldwide has seen an impressive compound annual

**CELS (the NASDAQ Clean Edge Green Energy Index) soared 89 percent for the year**

**EVS, HYBRIDS, & GREEN BUILDINGS ON THE RISE**



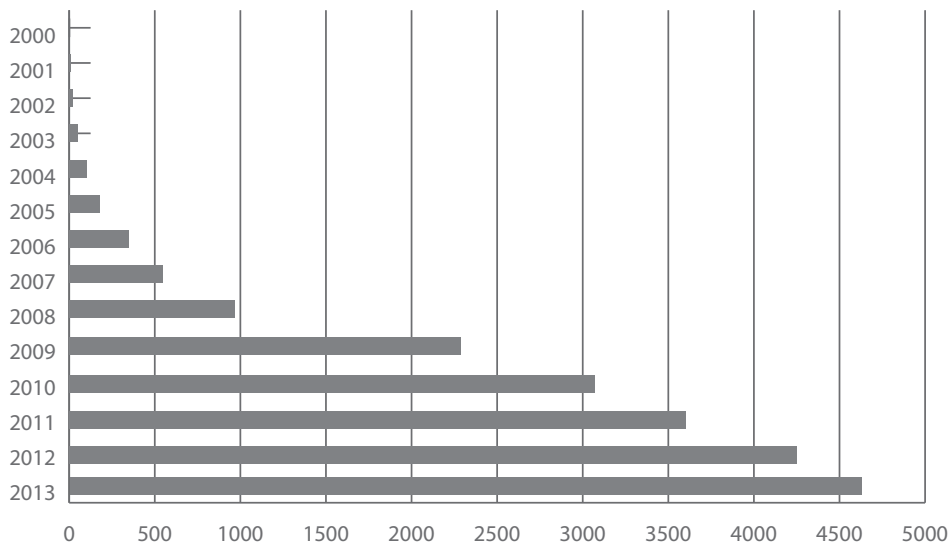
### NASDAQ® Clean Edge® Stock Index Performance\* (2007-2013)

Year	CELS	QGRD	S&P 500 Index
2007	67%	35%	4%
2008	-64%	-43%	-38%
2009	44%	51%	23%
2010	2%	-1%	13%
2011	-41%	-22%	0%
2012	-2%	18%	13%
2013	89%	24%	30%

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

growth rate (CAGR) of 68.9 percent. This critical energy and resource efficiency sector continues to advance. Net zero buildings, which go beyond the highest (Platinum) level of LEED certification to generate as much or more energy than they use, have moved from pipe dream to reality at notable scale around the world (see *Net Zero Energy Buildings Gain Ground* on page 14).

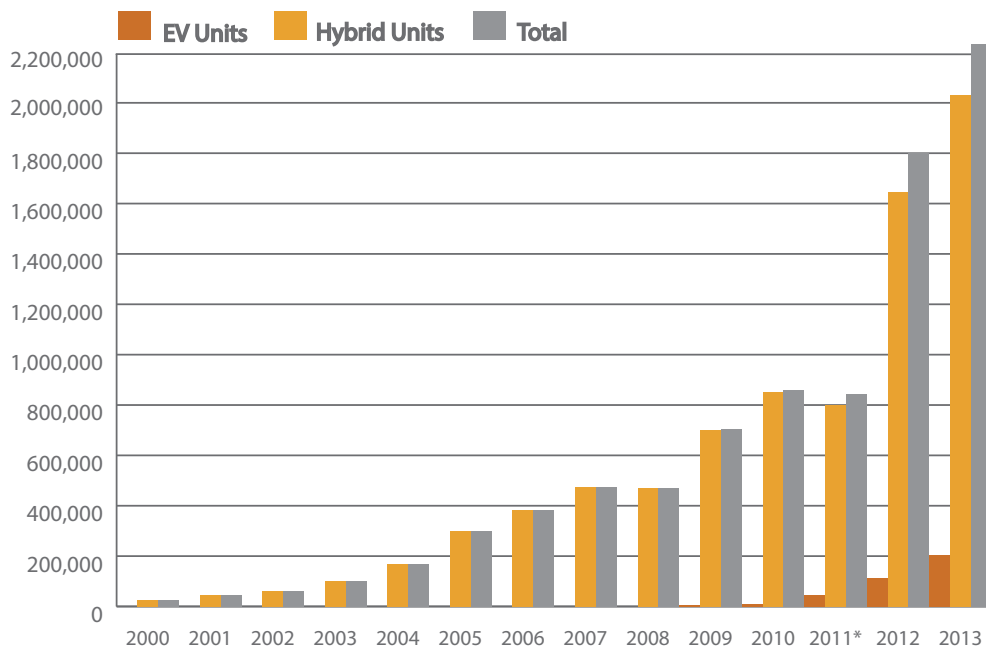
### Global LEED-Certified Projects 2000-2013



Source: U.S. Green Building Council, with Clean Edge analysis, 2014

The electrification of vehicles, a global megatrend highlighted in our 2012 book *Clean Tech Nation*, continued at a rapid pace in 2013. Global sales of hybrid and electric vehicles (EVs) jumped 26.4 percent to 2.3 million cars. Annual sales have more than doubled since 2010 (a slight drop in 2011 was an anomaly due to the earthquake and tsunami in Japan, which shut down and curtailed production at Toyota, Nissan, and other leading hybrid and EV manufacturers for several months). Since 2000, hybrids and EVs combined have experienced a CAGR of more than 38 percent. With the U.S. market requiring vehicles to get an average of 54.5 miles per gallon by 2025 and growing demand for cleaner vehicles in China, we expect these strong global growth trends to continue.

### Global EV and Hybrid Vehicle Sales 2000-2013



Source: Manufacturers' counts, Frost & Sullivan, International Energy Agency, J.D. Power & Associates, LMC Automotive, and Polk, with Clean Edge analysis, 2014

\*2011 sales were affected by the earthquake and tsunami in Japan, which suspended production for multiple months

Note: Hybrids are gas/electric drivetrain vehicles, and include such models as the Toyota Prius. EVs include all battery and plug-in drivetrain vehicles, including models such as Nissan's LEAF and Tesla's Model S

Each year, we select the most important trends to watch in the diverse and maturing clean-tech industry. In 2014, our five major trends to watch are:

- *Enlightened Utilities Begin To Embrace Distributed Energy Assets*
- *Cities Lead Climate Charge by Focusing on Regional Carbon Reduction*
- *Net Zero Energy Buildings Gain Ground*
- *Internet-Enabled Clean-Tech Startups Define a New Sector*
- *Vertical Farming Sprouts in Cities Around the World*

### LOOKING AHEAD: FIVE TRENDS TO WATCH

## 1. ENLIGHTENED UTILITIES BEGIN TO EMBRACE DISTRIBUTED ENERGY ASSETS

The growth of rooftop solar PV and other distributed generation (DG) and energy storage assets is challenging the traditional utility centralized generation business model as never before. The U.S. utility trade group Edison Electric Institute, in a widely cited 2013 report called *Disruptive Challenges*, warned of a “death spiral” where utilities add fixed charges to make up for lost revenue from DG, incentivizing even more customers to generate their own power.

This has caused many large utilities to fight regulatory battles in about a dozen U.S. states as they attempt to reduce the credits that rooftop solar customers get for the electrons that their PV panels (and other distributed assets) return to the grid, a policy known as net metering. In the most contentious battle to date, Arizona regulators in November 2013 approved a 70 cents-per-kilowatt system capacity charge for rooftop solar users, or roughly \$5 per residential system per month. Local utility Arizona Public Service had sought a much higher tariff that could have penalized solar system owners with charges closer to \$50 per month.

But some forward-looking utilities, if not fully embracing a distributed energy future, are making investments, forming partnerships, and acknowledging that the threat of DG might also be a business opportunity. In 2013, for example, \$12 billion utility holding company Edison International acquired SoCore Energy, a Chicago-based rooftop solar developer focused on retailers like IKEA and Walgreens. NextEra Energy Resources, the wholesale generation unit of Florida Power & Light parent NextEra Energy, bought Smart Energy Capital and its portfolio of government and academic solar PV customers in the Northeast. Edison, Duke Energy, and two other unnamed utilities made investments in Clean Power Finance (CPF), a San Francisco-based provider of software and services to spur financing of residential solar. Exelon-owned Constellation offers a solar leasing program for homeowners in six Northeast states, partially through a partnership with residential developer Astrum Solar in Annapolis, Maryland. And New York utility PSEG Long Island is paying local developers to install solar on homes in parts of its service territory.

**Utilities are fighting regulatory battles against rooftop solar in about a dozen states**

### Profile: Edison International

#### Location

Rosemead, California  
www.edison.com

#### Founded

1894

#### Employees

16,600

#### Technology

Utility holding company Edison International, through its subsidiaries, generates and distributes electric power. Its most significant holding is Southern California Edison (SCE), an investor-owned utility and one of the country's largest utility companies. SCE services an approximately 50,000 square-mile area of southern California for a population of nearly 14 million people, and currently sources 19.9 percent of its power from renewable sources.

#### The Buzz

Serving the Southern California market that's considered ground zero for the U.S. solar industry, Edison – through unregulated subsidiary Edison Energy – is arguably the leader among large utilities in beginning to embrace distributed solar. Its 2013 acquisition of SoCore Energy and investment in Clean Power Finance are exemplary; expect to see more moves like these. It also invested in Optimum Energy, a provider of efficiency technologies for large commercial HVAC systems.

#### Brain Trust

Theodore F. (Ted) Craver Jr. was elected chairman, president, and CEO in 2008. Before joining Edison in 1996, Craver was executive vice president and corporate treasurer of First Interstate Bancorp. Another key exec is senior VP of strategic planning Bert Valdman, formerly with Puget Sound Energy.

#### Bankrollers

Edison International is a publicly-traded company (NYSE: EIX) with 2013 revenue of \$12.6 billion and net income of \$1.2 billion.

#### Our Take

Edison, along with Duke Energy and NextEra, are the big players to date among U.S. utilities dipping their toes into the business opportunities of distributed solar and storage. They'll be closely watched by both the utility and solar industries.



“Some utilities are starting to say, ‘Why don’t I make money in distributed generation, the way I do in all other areas?’” says Nat Kreamer, CEO of CPF. At the Solar Power International trade show in October 2013, CPF hosted a dinner for senior executives of large utilities interested in distributed solar. “That would not have happened even 12 months earlier,” says Kreamer.

The trend extends far beyond U.S. borders. In Germany, still the world’s largest market for distributed solar PV, utilities are starting to transform their business models to accommodate more solar and distributed resources. RWE, Germany’s second largest utility, is overhauling its entire business strategy, noting that DG will be “the only growth segment in the European power generation market” for the foreseeable future. In Japan, not only does the DG portion of the post-Fukushima push for solar growth (seven new GW in 2013) create a challenge for centralized utilities, it also represents a growing evolution of tech and finance models for distributed assets: the country already has some 30,000 homeowners who use fuel cells like Panasonic’s Ene-Farm to generate power on site.

Customer-sited battery technology is considered to be where solar was around ten years ago – still expensive, but gaining early adopters. Emerging suppliers of “intelligent storage” batteries that can be quickly ramped up and down – like Stem and Demand Energy Networks – can help utilities with grid management and stability, but their customers would like to be compensated for providing those services to the grid. And SolarCity has entered the distributed storage business as well, offering its commercial solar PV customers a Tesla Motors-made battery system called DemandLogic.

As DG and distributed storage continue to grow, energy regulators will need to adapt as much as the utilities they regulate. “They will have to transition from being rate setters for monopolies’ rate bases,” says former Federal Energy Regulatory Commission chairman Jon Wellinghoff, now a partner at the law firm Stoel Rives. “They’ll (need to) be setting rules for competitive markets.”

*Solar Switch Forces Utilities to Shift Priorities*

*Why Are Some Big Utilities Embracing Small-Scale Solar Power?*

*Japanese Energy Giants Rush Into Storage as Solar Booms*

*Why Edison Wants A Piece Of The Rooftop Solar Business*

*Under Threat, Germany’s Second-Biggest Utility Says It Will Create a New ‘Prosumer Business Model’*

*SolarCity Taps Tesla Battery Tech for New Energy Storage Biz*

**Clean Power Finance**

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

**Constellation**

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

**Edison International**

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

**PSEG Long Island**

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

**RWE**

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

## Recent Headlines

## Select Companies to Watch

## 2. CITIES LEAD CLIMATE CHARGE BY FOCUSING ON REGIONAL CARBON REDUCTION

With little progress on meaningful global climate pacts and often frustratingly slow action at the national level, the world's cities are increasingly taking center stage in the fight to reduce carbon emissions. And for good reason. Many of the world's largest metro areas, from New York to Mumbai, are coastal and particularly vulnerable to the very real impacts of carbon emissions – making climate change a very real and present danger. In addition, policy changes are often easier at the municipal level; cities tend to control building codes and land use rules, holding the keys to encouraging mass transit and compact development.

While many overarching energy policies are made at the federal level in the U.S., some cities and regional utilities have been taking a more active role in updating their energy infrastructures, especially in the aftermath of devastating storms like Hurricane Katrina in 2005 and Superstorm Sandy in 2012. The report *A Stronger, More Resilient New York*, published as part of that city's post-Sandy Special Initiative for Rebuilding and Resiliency, launched 23 initiatives specific to electric utilities. The initiatives include regulatory overhauls to support long-term capital improvements, including scaling up distributed generation and microgrids. "The City will take steps to diversify and improve the sources of the city's power supply," the report notes, "and to do so in a way that will connect the city directly to new, low-carbon generation sources, which address some of the causes of climate change."

Seattle has taken its longtime climate leadership a step further, announcing a plan for the entire city to reach net zero emissions by 2050, focusing on road transportation, energy use in buildings, and waste. It plans to use congestion pricing to fund some of the changes, and its two major pension funds are divesting from fossil fuel investments. Seattle ranked ninth among U.S. metro areas in Clean Edge's 2013 *Clean Tech Leadership Index*, placing No. 5 in the green buildings and advanced transportation categories.

Outside of North America, a number of cities have focused on similarly aggressive emissions reductions. Copenhagen, which aims to be fully carbon neutral by 2025, plans for half of its

### Profile: C40

#### Location

London  
www.c40.org

#### Founded

2005

#### Member Countries

63

#### Executive Team

30

#### Technology/Mission

*C40 is a network of the world's largest cities working to reduce greenhouse gas emissions. Members receive tools to help them benchmark their efforts and pool best practices to reduce carbon emissions.*

#### The Buzz

*Marquee-name mayors, philanthropists, and thought leaders give C40 the clout to do its job. Getting cities to disclose emissions data and detail on their anti-carbon efforts is a key to progress, and the group's cachet, funding, and research encourage participation.*

#### Brain Trust

*Rio de Janeiro Mayor Eduardo Paes is the current C40 chair—a position held previously for two years by former New York Mayor Michael Bloomberg, now president of the C40 Board of Directors. Working closely with the Clinton Foundation's Climate Initiative, and counting mayors of 11 of the world's largest cities as members of its steering committee, the group does not lack for big thinkers.*

#### Bankrollers

*C40 is backed by some of the philanthropic world's heaviest hitters, including the Clinton Climate Initiative, the World Bank, and Bloomberg Philanthropies—which itself is contributing \$10 million from 2014 through 2016.*

#### Our Take

*Participation in the group has been great initial publicity for C40 members, but ongoing detailed reporting on carbon emissions and their sources is part of helping fight climate change in a measurable way. Exchanging best practices publicly can benefit all cities and help build the political will needed to make progress on carbon reduction.*

*Cities and regional utilities are updating their energy infrastructures, especially in the aftermath of devastating storms*



total energy consumption to come from wind by 2020, up from 30 percent in 2012, according to the Danish Wind Industry Association. The city is converting a centralized citywide oil and coal-based heating system to one fueled by biomass from straw and wood pellets, along with combined heat and power generation.

More than 400 German municipalities, including Berlin, Frankfurt, and Hamburg, have joined forces under the umbrella of Klima Buendnis (Climate Alliance), a Europe-wide organization with more than 1,600 city, municipality, and district regions. The German members have committed to reduce CO2 emissions by 10 percent each year and to cut 1990 per-capita CO2 levels in half by 2030. To do so in a measurable way, the alliance offers tools for CO2 monitoring, and guidelines on developing climate change policies. Berlin's Energy Saving Partnership, started in 1996 in partnership with the Climate Alliance, has invested more than 60 million euros (about \$82 million) in energy efficiency and building retrofits, yielding a 26 percent drop in building energy consumption, reducing CO2 emissions by nearly 600,000 tons from 1996 to 2012.

In Australia, the city of Sydney found that public lighting drove a third of its municipal operations' total electricity use. Over the next few years, it will replace 6,450 more lights with LEDs, reducing GHG emissions by 70 percent and saving US\$800,000 per year on electricity. One of Sao Paulo, Brazil's biggest GHG problems has come from trash disposal from its 10 million residents, with decaying waste in landfills generating methane and other gases. The city installed thermoelectric power plants to harness this fuel, cutting emissions and supplying seven percent of the city's power.

"As innovators and practitioners," says former New York City Mayor Michael Bloomberg, "our cities are at the forefront of this issue – arguably the greatest challenge of our time."

*Cities Lead in Crafting Carbon-Neutral Environs*

*Copenhagen's Ambitious Push To Be Carbon Neutral by 2025*

*Eyes on Germany: Municipal Climate Change Efforts and North-South Climate City Partnerships*

*Can Cities Solve Climate Change?*

*Grants To Make Buses More Environmentally Efficient*

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## Organizations To Watch

### 3. NET ZERO ENERGY BUILDINGS GAIN GROUND

In 2006, the Cascadia Green Building Council in the Pacific Northwest launched the Living Building Challenge, creating a formal goal for worldwide architects and designers to create structures that generate as much or more energy than they consume, along with other sustainability attributes. Eight years later, net zero energy buildings are increasingly becoming a reality across the globe. The growing needs for emissions reduction and climate resilience are driving the trend, while falling costs of on-site generation (especially solar PV), ultra-efficient HVAC systems, LED lighting, and electrochromic glass (which saves energy by changing shading properties) are making the net zero energy goal more realistic and affordable. And new policy mandates in places such as California and Europe are expected to help drive unprecedented growth in the next two decades.

Within the past two years, the opening of several high-profile buildings has raised awareness and helped prove the net zero energy concept, even at relatively large scale. The John W. Olver Transit Center in Greenfield, Massachusetts is a bus terminal and office complex completely powered by 22 geothermal wells, a 98-kilowatt solar array, and a wood pellet-fired boiler. The six-story Bullitt Center in Seattle, considered “the greenest commercial building in the world,” achieves net zero in water use (by collecting the region’s ample rainfall) and waste (with composting toilets) as well as energy. Salt Lake City’s Public Safety Building houses the city’s police and fire departments in a 174,000 square foot facility that uses solar PV, solar hot water, and LED lighting to achieve a perfect Energy Star rating of 100. The headquarters of solar supplier SunCarrier Omega in Bhopal, India, the nation’s first net zero building, is 100 percent powered by the company’s tracking solar PV arrays, small wind turbines, and battery storage.

Net zero goes a step beyond even the greenest green buildings by monitoring a building’s actual use. To qualify for net zero certification from the International Living Future Institute (now Cascadia’s parent organization), a structure must use the same or less energy than it generates over a one-year period. “The focus is on performance – how you operate the buildings is enormously important,” says Denis Hayes, president and CEO of the Bullitt Foundation. “A well-operated LEED Silver building is much better than a poorly-operated LEED Platinum one.”

*The opening of several high-profile buildings has raised awareness and helped prove the net zero energy concept*

#### Profile: Arup

##### Location

London  
www.arup.com

##### Founded

1946

##### Employees

Nearly 11,000

##### Technology

Arup is a multi-national building design with a portfolio of more than 20 zero-net energy or deep energy efficiency projects to its credit worldwide.

##### The Buzz

With its ambitious projects around the world and a willingness to take on risks that other companies aren’t, Arup is seen as the go-to firm for executing on sustainable and innovative designs. Projects have included the John W. Olver Transit Center in Massachusetts, the first zero net energy transit center in the U.S., and Northern Arizona University’s applied R&D facility that uses 89% less energy than a typical building of its size. Arup’s solar-powered design for a net zero sports stadium in Qatar, site of the 2022 World Cup, will keep the stadium at 73 degrees when it’s 111 outside, even with the retractable roof open.

##### Brain Trust

Group board chairman Philip Dilley, along with 13 directors across the globe, operate from a set of core values that maintain the sustainability vision established by late founder Ove Arup long before the term was invented.

##### Bankrollers

Arup has 90 offices in 38 countries. Although not publicly traded, the firm makes its finances public and had \$1.69 billion in revenue in fiscal 2013 with a profit of \$33.5 million.

##### Our Take

Arup has long been at the leading edge of architecture and design trends. Its size and global reputation for sustainability innovation make the firm well positioned to lead as net zero energy buildings gain momentum in the coming years.





Although skeptics may contend that examples of net zero buildings are isolated, that will change dramatically in coming years. The European Union has mandated that all new public buildings must achieve “nearly zero” energy status by the end of 2018, and that all other new buildings achieve the same status by the end of 2020. Strong mandates in 17 Asia-Pacific nations will increase that region’s share of global near-zero buildings to 39 percent by 2017, according to Lux Research, with most growth in India, China, South Korea, Japan, and Australia.

In California, the sweeping new building code mandates known as Title 24 take effect this year; they require net zero status for all new residential construction by 2020 and for all new commercial buildings by 2030. In the 2013 Energy Efficiency Indicator survey conducted by The Institute for Building Efficiency (an initiative of Johnson Controls), more than 70 percent of 3,000 worldwide building decision-makers said they intend to achieve zero, near zero, or positive energy status for at least one of their buildings in the future. In addition, the U.S. Navy and Marines are aiming to have half of their U.S. bases and other facilities achieve net zero energy status by 2020; several U.S. Army bases share the same goal.

Beyond individual buildings, some locations are aiming to achieve net zero energy communities. The largest in the U.S. is the West Village area on the campus of the University of California-Davis, a closely watched \$300 million project hoping to serve as a model for similar efforts worldwide. Another large net zero district initiative is FortZED in Fort Collins, Colorado (population 140,000), encompassing the city’s downtown and the campus of Colorado State University.

*“World’s Greenest Office Building” Makes Net Zero Look Easy*

*Auckland Business Goes Net Zero Energy*

*Net Zero Energy Buildings Attract ‘Knowledge Workers’*

*The Packard Foundation Achieves Net Zero Energy Building Certification*

*Walgreens Opens First Net Zero Retail Store*

*Building Code Revision Launches California Toward Zero Net Energy Buildings*

## Recent Headlines

### Arup

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

### FortZED

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

### International Living Future Institute

[www.living-future.org](http://www.living-future.org)

### New Building Institute

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

### Terrapin Bright Green

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

## Organizations to Watch



## 4. INTERNET-ENABLED CLEAN-TECH STARTUPS DEFINE A NEW SECTOR

In our 2012 book *Clean Tech Nation*, Clean Edge managing director Ron Pernick and senior editor Clint Wilder named Connectivity as one of the “Six C’s” driving clean tech forward (along with Costs, Capital, Competition, Consumers, and Climate). Now, clean-tech business models enabled by Internet, wireless, and cloud-based technologies are growing rapidly, creating the emerging and increasingly well-funded industry sector known as cleanweb.

Definitions of the sector vary, but most use web-based systems or apps to save energy, deploy renewables, and use resources more efficiently. Cleanweb is often linked with what’s known as the share economy, where consumers connect online to share car rides, home repair equipment, or other products and services, disrupting traditional purchase or rental models and saving resources. Other definitions of cleanweb encompass “big data” companies such as C3 Energy and Opower, whose massive databases on consumer electricity usage help power homes and businesses more efficiently, and Optimotive, a Spain-based provider of online programs that monitor energy use in industrial processes and water treatment plants. It also encompasses companies like Mosaic and Clean Power Finance that are using the web to unleash funding for solar installations and efficiency projects.

As in many online businesses, barriers to entry are relatively low, and new business concepts in this sector sprout almost daily. Would-be entrepreneurs at cleanweb “hackathons” in places like Berkeley, San Francisco, Boston, and New York compete to create the best new concepts. The Cleanweb Initiative, an online network where many of the same folks share ideas and collaborate, has thousands of members worldwide.

But the cleanweb sector is more than just a grassroots effort, and is becoming serious business, attracting major funding and thousands of customers. Cleanweb treads on VC’s historically familiar high-tech turf of software and the web. “It’s less capital-intensive, leverages technologies that VCs are very familiar with, and can create value very quickly,” says Nicholas Eisenberger, managing partner of Pure Energy Partners, a

### Profile: Lyft

#### Location

San Francisco  
www.lyft.com

#### Founded

2012

#### Employees

180

#### Technology

Lyft is a peer-to-peer ridesharing program that uses mobile devices to facilitate connecting riders needing a ride and drivers with a car to share.

#### The Buzz

Since its launch in 2012, Lyft has provided more than a million rides. The company has quickly expanded from San Francisco and is now in 22 U.S. cities with plans to continue expansion domestically and overseas. So far, Lyft has outpaced a slew of competitors, including Sidecar and Uber, in both customers and funding.

#### Brain Trust

Lyft is the brainchild of CEO Logan Green and President John Zimmer, finalists in BusinessWeek’s 2009 list of U.S. Entrepreneurs Ages 25 and Under. Lyft grew out of Zimride, a ridesharing service for college students started by the pair in 2007 after a mutual friend introduced them on – where else? – Facebook. Zimmer found that 80 percent of seats in cars on U.S. roads are empty.

#### Bankrollers

The company has raised more than \$150 million in venture funding from Andreessen Horowitz, Founders Fund, Google Ventures, Mayfield Fund, K9 Ventures, Floodgate, and others.

#### Our Take

In the cleanweb/share economy world where some models can seem a bit flighty, Lyft is helping legitimize the sector with an expanding business and even more impressive VC funding. Its cutesy branding – pink mustaches on the front of its drivers’ cars – belies a savvy business culture and growth trajectory worth keeping an eye on. But the biggest hurdle for Lyft and its competitors may be local opposition from the taxi industry and public officials. Cities such as Las Vegas, Miami and St. Louis have banned rideshare services, while others like Seattle have severely restricted them. Industry disruption can be messy.

*Cleanweb is often linked with what’s known as the share economy, where consumers connect online*



leading funder in the sector. “I’m not suggesting that all clean-tech venture capital should migrate to cleanweb, but it helps traditional VCs to see the opportunities in resource efficiency – and also helps clean-tech investors to see the power of the IT tools that are out there.”

Prominent cleanweb players to date include Lyft, a San Francisco-based ridesharing service with more than \$80 million in venture funding (see profile); other ridesharing providers Sidecar, also in San Francisco, and Washington, D.C.-based Ridescout; and WegoWise, a Boston-based startup whose online benchmarking platform compares a building’s water, electricity, and gas usage (the ‘WEG’ in the name) to data it’s collected on 10,000 structures. Sidecar CEO Sunil Paul is credited with coining the term cleanweb. In addition to these pure plays, sometimes a joint venture yields a cleanweb business model. HonestBuildings, a free online network connecting players in the real estate business, now offers real-time, online energy monitoring for buildings thanks to a partnership with energy performance software provider Lucid. Noesis Energy provides a similar online marketplace for building efficiency vendors seeking new projects.

In some cases, cleanweb companies are increasing the efficiency of clean-tech industries themselves. So-called soft costs, including customer acquisition, account for 64 percent of residential solar installation expenses and 52 to 57 percent of commercial PV system costs, the National Renewable Energy Laboratory reported in late 2013. New York-based startup SolarList provides its door-to-door sales force of college students with an app that lets homeowners assess the costs and paybacks of solar on their roofs, then sells these qualified leads to installers. Mosaic streamlines solar financing by enabling crowdfunding via the web; in just over a year, it has raised more than \$6 million from more than 2,000 individual investors. “Catalyzing clean tech is a major component of cleanweb,” says Eisenberger.

*Cleanweb Companies Attract Big Data and Big Money*

*Turbocharging Efficiency with the Internet*

*Cleanweb Investment Shows No Signs of Slowing Down*

*Cleanweb or Deep Tech: Diverging Paths for Energy Startups*

*Lyft Lands \$60 Million*

*Cleanweb: Is IT the Secret to a New Energy Future?*

## Recent Headlines

### The Cleanweb Initiative

[www.cleanweb.co](http://www.cleanweb.co)

### Lyft

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

### Mosaic

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

### SideCar

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

### WegoWise

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

## Organizations to Watch

## 5. VERTICAL FARMING SPROUTS IN CITIES AROUND THE WORLD

The earth's population is projected to reach 9 billion by mid-century, and its people will need 69 percent more calories in 2050 than they did in 2006, according to an analysis of United Nations data by non-profit environmental group World Resources Institute. To meet this demand, the world needs higher crop yields of more calorically-dense, nutritious food. Food security, safety, climate impacts, and resource scarcity problems persist as well: Japan, for example, currently imports 75 percent of its food, while the Middle East deals with water scarcity. So agricultural researchers are working to produce more calories with less land, energy and water, ideally closer to the urban centers where population growth is most prevalent.

Part of the solution lies in vertical farming. The idea is to grow fruits and vegetables in state-of-the-art buildings, on racks and multiple stories, rather than on traditional farmland – all within city limits. Vertical farming technologies include hydroponics (growing food in a solution instead of soil); aeroponics (growing food in an air or mist environment); aquaponics (raising aquatic animals with plants, each feeding the other), energy-efficient lighting, living building facades, green roofs, and more. This combination of techniques and technologies makes vertical farming more resource-efficient than conventional agriculture, and vertical farms in city buildings are close to where the food is consumed, saving further on fuel and transport emissions.

Depending on crop and technique, vertical farming yields four to ten times as much as traditional farming methods in terms of pounds of crops – using less water and energy per square meter, according to Dan Albert of Seattle-based urban farm Farmbox Greens. Crops also can be stacked in vertical racks, and grown 24/7 year-round in climate-controlled environments. New York-based AeroFarms claims its technology yields 22 crop turns a year, compared with conventional farms' two or three. SkyGreens, located in Singapore, uses hydraulically-driven vertical systems to ensure tropical vegetables get consistent sunlight exposure in its greenhouses. Kyoto, Japan-based Nuvege uses vertical farming to pack 271,000 square feet of growing space into a 31,000 square foot building. The dense planting arrangement makes watering go further, yielding a 50 to 70 percent reduction in water consumption compared with traditional agriculture. The company produces 7.6 million heads (760 tons) of lettuce per year, and says the controlled

**Vertical farming technologies include hydroponics, aeroponics, and aquaponics**

### Profile: FarmedHere

#### Location

Chicago  
www.farmedhere.com

#### Founded

2009

#### Employees

200

#### Technology

A local produce grower in Chicago, FarmedHere uses two vertical farming methods: an aquaponic system for herbs and tilapia fish, and an aeroponic system from AeroFarms for leafy greens. The growing cycle for the greens is 18 days, compared with more than 60 in conventional agriculture.

#### The Buzz

Winner of a 2013 Chicago Innovation Award in the up-and-comer category for startups, FarmedHere produces more than a million pounds of greens each year. Its products include basil, arugula, and mixed greens, and are in more than 60 stores in the city, including Mariano's, Whole Foods Market, Fresh Farms, and Green Grocer.

#### Brain Trust

CEO Jolanta Hardej is a former mortgage financier who switched industries after the financial meltdown of 2008. In an interview with Japan Aquaponics magazine, Hardej said that before her career switch, the only gardening she knew anything about was her grandmother's backyard plot in Poland. Her brokerage experience gave her access to progressive-minded investors, and she started with an experimental, small-scale facility.

#### Bankrollers

National organic food powerhouse Whole Foods loaned FarmedHere \$100,000 to expand its organic aquaculture operation into a previously abandoned 90,000 sq. ft. building, adding 150,000 sq. ft. of growing space.

#### Our Take

FarmedHere uses multiple vertical farming methods to produce food sold across Chicago. Its Whole Foods backing gives it a distribution network and a certain scale, which has proved a struggle for some of its peers. While some vertical farming remains on a hobbyist scale, FarmedHere is a viable commercial enterprise.

environment lets it manage crop nutritional value more effectively.

Energy for lighting is one of vertical farming's greatest expenses, making it a financial challenge if not carefully and properly designed. Lighting researchers, notably Philips, are creating ever more efficient red- and blue-spectrum LEDs to feed plants. Other researchers are testing sensors that provide data to optimize crop yields and nutrient density, or decrease energy and water use. Vertical farmers also are experimenting with a variety of non-traditional growing spaces: retrofitted warehouses, basements, sub-basements - even restaurant closets or under grocery stores.

When judging farming for the nutrient-rich foods that will help feed the population boom, success depends on producing calories efficiently. Vertical farming success may also be measured in terms of kWh per grams of fresh produce weight. "The real question is, at what point are you comparable to conventional agriculture?" asks Caleb Harper of MIT's CityFarm project, which is modeling energy use in both conventional and vertically-farmed produce, and sharing the data with global stakeholders to increase production. Vertical farmers also are working on sustainability as they increase yields, sourcing nutrients such as nitrogen, phosphorous, calcium, and potassium from the waste products of chicken and yogurt producers.

Vertical farming is still a tiny niche compared to conventional ag, and often focused on high-end boutique produce. But that's a common characteristic of early-stage technologies, such as early biotech concentrating on expensive pharmaceuticals. This emerging sector's systems, technologies, techniques, and goals are sparking breakthroughs in resource efficiency that may not only improve vertical farming, but traditional agriculture as well. "Everyone has a tiny farmer inside of them," says Harper. "They want to grow food - it's innate, but it's really complex."

*Does It Really Stack Up?*

*Five Examples of Creative Urban Agriculture from Around the World*

*Newark, NJ: Farming Mecca?*

*Singapore's Vertical Farms*

*Urban Farming in London's World War II Bomb Shelters*

*Vertical Indoor Farms Are Growing in the U.S*

## Recent Headlines

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

**FarmedHere**

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

**MIT CityFARM**

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

**Nuvege**

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**AUTHORS**

**Ron Pernick,** managing director of Clean Edge, is an author, analyst, and entrepreneur with three decades of high-tech and clean-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, NGOs, and investors. He is widely quoted in the media, and is a regular speaker at industry events in the U.S. and abroad.

**Clint Wilder,** senior editor for Clean Edge, plays a key role in the production of the firm's research and publications. He also co-authored both *The Clean Tech Revolution* (HarperCollins, 2007) and *Clean Tech Nation* (HarperCollins, 2012). Wilder has covered the high-tech and clean-tech industries as a business journalist for more than two decades and is a frequent speaker and panelist at industry events in the U.S. and overseas. He is also a blogger for the Green section of The Huffington Post, a facilitator in the Energy and Climate Change track of the Clinton Global Initiative, and a founding member of the Clean Economy Network.

**James Belcher,** senior analyst at Clean Edge, covers a range of clean technology areas. He analyzes clean-tech markets, contributes to Clean Edge reports and consulting projects, and helps maintain the firm's stock index products (CELS and QGRD). James' past experience includes work with eMarketer, Inc., Webtrends, and Find/SVP, Inc. (now ORC International) covering technology and digital marketing. He has a BA in Humanities with a concentration in English from Florida State University.

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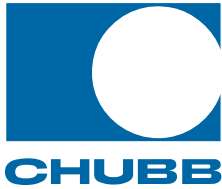
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