ADVANCED ENERGY ECONOMY

ADVANCED ENERGY NOW 2014 MARKET REPORT

Global and U.S. Markets by Revenue 2011-2013 and Key Trends in Advanced Energy Growth

Prepared by Navigant Research

February 2014

About Advanced Energy Economy

Advanced Energy Economy is a national association of businesses and business leaders who are making the global energy system more secure, clean and affordable. Advanced energy encompasses a broad range of products and services that constitute the best available technologies for meeting energy needs today and tomorrow. AEE's mission is to transform public policy to enable rapid growth of advanced energy businesses. AEE and its State Partner organizations are active in 22 states across the country, representing roughly 1,000 companies and organizations in the advanced energy industry. Visit Advanced Energy Economy online at: www.aee.net.

About Navigant Research

Navigant Research, the dedicated research arm of Navigant, provides market research and benchmarking services for rapidly changing and often highly regulated industries. In the energy sector, Navigant Research focuses on in-depth analysis and reporting about global clean technology markets. The team's research methodology combines supply-side industry analysis, end-user primary research and demand assessment, and deep examination of technology trends to provide a comprehensive view of the Smart Energy, Smart Utilities, Smart Transportation, and Smart Buildings sectors. Additional information about Navigant Research can be found at www.navigantresearch.com.

Advanced Energy Now 2014 Market Report

ADVANCED ENERGY ECONOMY
the business voice of advanced energy

EXECUTIVE SUMMARY

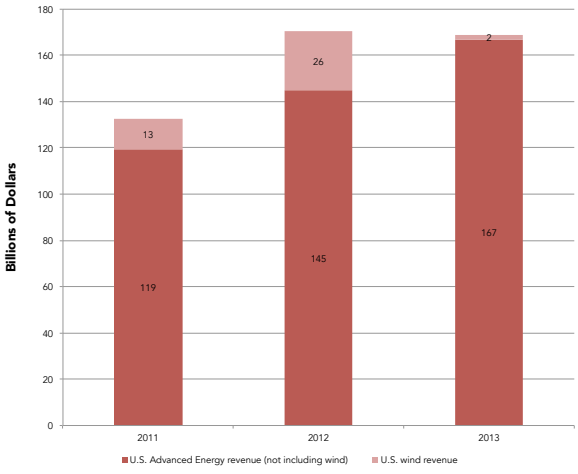
The Advanced Energy Now 2014 Market Report is the first annual report of market size, by revenue, of the advanced energy industry, worldwide and in the United States. As defined by Advanced Energy Economy (AEE), a national association of business leaders with the goal of making the global energy system more secure, clean, and affordable, advanced energy is a broad range of technologies, products, and services that constitute the best available technologies for meeting energy needs today and tomorrow.

Prepared for AEE by Navigant Research, Advanced Energy Now 2014 draws on more than 60 previously published Navigant Research studies on specific industry categories. The results presented in Advanced Energy Now 2014 must be viewed, however, as a conservative assessment of advanced energy market size. Some subsegments and product categories have not been independently studied by Navigant Research, leading the size of some segments to be significantly understated. Also, Navigant Research has utilized strict definitions within product categories, in order to distinguish advanced energy from conventional energy products. Finally, U.S. market revenue counts only domestic sales of products and services and does not include revenue from exports, understating the economic scope of the U.S. advanced energy industry.

Summary Findings

For 2013, advanced energy reached $1.13 trillion in estimated global revenue, a 7% increase year-over-year driven by growth in six of the seven segments. Fluctuation in the worldwide total for advanced energy was largely driven by a peak year for large hydro projects in 2011 followed by a large decline in 2012, then slow growth in 2013.

U.S. Advanced Energy Growth



(Source: Navigant Research)

In the United States, the advanced energy market was an estimated $168.9 billion in 2013, 15% of the global advanced energy market, up from 11% in 2011. Excluding wind, U.S. advanced energy revenue grew 18% from 2011 to 2012 and 14% from 2012 to 2013. Wind energy suffered a severe, $23 billion revenue downward swing between 2012 and 2013, due to policy uncertainty around the federal Production Tax Credit (PTC). The effect of wind's downturn is that U.S. advanced energy revenue declined 2% overall in 2013, following a 26% increase from 2011 to 2012.

Globally, after a decline in investment in large-scale hydropower in 2012 from a peak in 2011 (due to a reduction in orders from China and elsewhere) and slight decline in nuclear power, the Electricity Generation segment rebounded in 2013 with nearly 6% growth driven by hydro, solar, and biomass. Revenue from advanced vehicles (led by clean diesel autos in Europe) allowed Transportation to bounce back (up 6%) in 2013 from a slight dip (down 3%) in 2012, driven by strong growth in hybrid and plug-in hybrid vehicles. Conversely, there has been steady growth in advanced Fuel Production (up 34% from 2011 to 2013), led by ethanol, compressed and liquefied natural gas for transportation (CNG and LNG), and bio-oils associated with development of cellulosic biofuels. The Buildings segment showed similar two-year growth globally (up 27%), led by advanced lighting. Significant growth in revenue from industrial applications of Combined Heat and Power (CHP) accounted for much of the 26% growth in the Industry segment from 2011 to 2013.

In the United States, the advanced energy market story is of a particularly strong 2012, followed by continued robust growth for most segments and product categories in 2013, with one notable exception – wind power.

U.S. advanced energy revenue grew just over 25% overall from 2011 to 2012. While overall U.S. revenue was down slightly from 2012 to 2013, that's because growth in most subsegments was masked by a $23 billion drop in wind energy investment from a banner year to a near freeze (just $2 billion estimated for 2013), due to policy uncertainty around the federal Production Tax Credit (PTC). Excluding wind, the advanced energy market in the United States grew 14% from 2012 to 2013, with significant gains in Transportation (hybrid, electric, and natural gas vehicles), Buildings (lighting, CHP for commercial and institutional buildings), and Industry (CHP in industrial applications).

The United States remains a world leader (34% of global revenue) in the production of advanced fuels – principally in biofuels and synthetic diesel and gasoline – as revenue in Fuel Production grew steadily, up 17% from 2011 to 2013. Similarly, revenue from advanced Building products and technologies increased 11% from 2011 to 2012 and 12% from 2012 to 2013, for two-year growth of 24%. But the most dramatic growth came in Transportation, where revenue from advanced vehicles more than doubled over the two-year period. Hybrid vehicles led the way in revenue, rising from $7.2 billion in 2011 to $11 billion in 2012 and an estimated $14 billion in 2013. The fastest growth came in plug-in electric vehicles (from $707 million in 2011 to an estimated $3.6 billion in 2013) and natural gas trucks and buses ($102 million to $530 million).

It is in U.S. Electricity Generation that disparities in advanced energy progress between 2012 and 2013 are most apparent, with a 52% increase in 2012 followed by an estimated drop of 29% in 2013. Wind energy accounts for much of this roller-coaster pattern. Revenue from wind installations hit a peak of $25 billion in 2012 – a record year for wind – then dropped precipitously, to an estimated $2 billion in 2013. This $23 billion fall-off is largely attributable to the on-again, off-again fate of the federal PTC.

In Electricity Generation there was a dramatic growth story, however: solar photovoltaic (PV) energy. Solar PV revenue grew steadily over this two-year period, up 27% from 2011 to 2012, and 54% from 2012 to 2013. Two-year growth, from $8.2 billion to $16.2 billion, was 97%. This revenue growth is even more impressive given the continued declines in total installed prices for PV over that period. In 2013, the United States accounted for an estimated 18% of global revenue for solar PV, a doubling of its global market share from 2011.

FOREWORD

Advanced Energy Economy (AEE) is the pragmatic voice of business leaders who are working every day to make the energy we use secure, clean, and affordable. AEE also represents a dynamic industry: the advanced energy industry includes corporations with global impact, growth companies, and start-ups. All these companies are delivering energy technologies, products, and services across our country and around the world.

Advanced Energy Now 2014 Market Report is our annual report on the size, growth, and significant trends in the advanced energy market. It tracks developments since publication of Economic Impacts of Advanced Energy in 2013, which was also produced for AEE by Navigant, a leading market research firm in our industry. That study quantified for the first time advanced energy revenue and U.S. GDP impact along with federal, state, and local tax revenue from advanced energy companies.

Advanced energy is a thriving industry made up of a wide variety of businesses. For this report, revenue has been tracked and compiled from seven broad industry segments and 41 sub-segments, representing more than 80 distinct products and services addressing both energy supply and demand. It is a comprehensive accounting of the advanced energy marketplace. But as compelling as these data are, they represent only the tip of the iceberg of economic opportunity for this country represented by advanced energy.

Just as information and communication technology transformed the way we live and work, advanced energy is transforming the way we power our devices and our economy. Applying 21st century technology to our mid-20th century electricity and transportation systems will create wealth, jobs, and prosperity not only in advanced energy but also across the economy.

Advanced energy is a $1 trillion global market and a U.S. market of nearly $170 billion. Advanced energy is here today and growing for tomorrow. At AEE, we are committed to bringing together business leaders to help accelerate its progress.

Graham Richard
CEO, Advanced Energy Economy

INTRODUCTION AND METHODOLOGY

The Advanced Energy Now 2014 Market Report is the first annual report of market size, by revenue, of the advanced energy industry, worldwide and in the United States.

As defined by Advanced Energy Economy, a national association of business leaders with the goal of making the global energy system more secure, clean, and affordable, advanced energy is a broad range of technologies, products, and services that constitute the best available technologies for meeting energy needs today and tomorrow. Defined in this way, advanced energy is not static but dynamic, as innovation and competition produce better energy technologies, products, and services over time. Today, electric and plug-in hybrid cars, natural gas-fueled trucks, high-performance buildings, energy-saving industrial processes, high capacity wind turbines, onsite and utility-scale solar power, and advanced nuclear power plants are all examples of advanced energy, as they diversify energy sources, reduce health and environmental costs to communities, and use energy resources more productively. Advanced energy represents an opportunity for U.S. companies and workers not only to serve the domestic market but to export goods and services into the global energy markets.

Advanced energy consists of seven broad industry segments and 41 subsegments, each of which contains multiple product categories. The segments and subsegments of advanced energy are enumerated in the figure below:

Transportation	Fuel Production	Fuel Delivery	Buildings
• Propulsion Systems • Vehicle Design and Materials • Frieght Logistics • Land-use and Infastructure Design • Enabling Information Technology	• Ethanol and Butanol • Biodiesal • Biogas • Synthetic Diesel and Gasoline • Bio-oil • Compressed Natural Gas and Liquefied Natural Gas • Hydrogen	• Fueling Stations • Fuel Transportation Infastructure	• Building Design • Building Envelope • Heating, Venilation, and Air Conditioning (HVAC) • District Energy, Combined Heat and Power (CHP), and Combined Colling Heating and Power (CCHP) • Water Heating • Lighting • Applicance and Electronic Equipment • Enabling IT

Industry	Electricity Generation	Electricity Delivery and Management
• Manufacturing Machinery and Process Equipment • Industrial Combined Heat and Power	• Hyrdropower • Gas Turbines • Solar • Wind • Geothermal • Marine • Waste • Biomass • Nuclear • Fuel Cells and Other Distributed Generation	• Transmission • Distribution • Advanced Metering Infastructure • Microgrids • Electric Vehicle Charging Infastructure • Energy Storage • Enabling Information and Communication Technology

Sizing Advanced Energy Markets

The first attempt to quantify the size of the global and U.S. advanced energy markets was Economic Impacts of Advanced Energy, prepared by Pike Research (now Navigant Research) and published in January 2013. Economic Impacts of Advanced Energy presented revenue data across the 41 subsegments of advanced energy for 2011, and estimates for 2012. Advanced Energy Now 2014 includes 2011 revenue, updated 2012 revenue, and estimated revenue for 2013 to provide both a snapshot of market size at the present time and growth trends over three years.

Advanced Energy Now 2014 draws on more than 60 previously published Navigant Research studies on specific industry categories for the most comprehensive assessment of advanced energy markets to date. As in Economic Impacts of Advanced Energy, however, the results presented in Advanced Energy Now 2014 must be viewed as a conservative assessment of advanced energy market size. Though this is the most comprehensive study yet performed, it is not exhaustive, due to the nature of available data, and it is purposely conservative in methodology:

- Identified subsegments or product categories that have not been independently studied by Navigant Research are not included, leading the size of some segments to be significantly understated.

- The market revenue for most subsegments is based on the total installed cost of the technology. However, some subsegments only measure vendor revenue from equipment sales excluding revenue from installation and other services, and other subsegments exclude revenue from multiyear projects still in development.

- The focus of the market data is primarily on new investments, capital improvements, and the sale of products and services – not, for example, the sale of electricity generated by installed technologies in the Electricity Generation segment. Sales of advanced fuels such as ethanol and biodiesel, however, are included in the Fuel Production segment.

- In some product categories, such as Hydropower, Nuclear, and Gas Turbines, projects can take between two and 10 years to complete, making tracking of annual capital investment difficult. For this analysis, the full total installed plant cost was assigned to the year in which orders were placed for the main components (e.g., turbines, reactor, generator equipment).

- Operations and maintenance revenue is not included, nor is refurbishment revenue, which can be substantial for certain subsegments.

- U.S. market revenue counts only domestic sales of advanced energy products and services and does not include revenue from exports, understating the economic scope of the U.S. advanced energy industry.

It should also be noted that Navigant Research has utilized strict definitions within product categories, in order to distinguish advanced energy from conventional energy products. For instance, in the Buildings segment, not all HVAC installations are counted, only HVAC installations associated with energy-specific commercial retrofits, new HVAC systems that exceed local code compliance, ground-source heat pumps, and systems deployed in high-efficiency homes. The parameters for advanced water heating are even more restrictive: this category includes only residential water heating as specifically used in high-efficiency homes. For more detailed information on individual subsegments and product categories, see Economic Impacts of Advanced Energy or go to www.advancedenergynow.net.

It is the goal of Advanced Energy Now market reports to include new data as they become available each year, in order to better characterize the true scope of advanced energy markets. Thus Advanced Energy Now 2014 quantifies several product categories that were not included in Economic Impacts of Advanced Energy. The new categories quantified this year are: Electric Bicycles (Propulsion Systems) and Smart Parking (Enabling IT) in Transportation; Compressed/Liquefied Natural Gas for Transportation in Fuel Production; Smart Glass (Building Envelope) in Buildings; Natural Gas Generator Sets for back-up power (Fuel Cells and Other Distributed Generation) in Electricity Generation; and Smart Street Lighting (Enabling IT) in Electricity Delivery and Management. Revenue from these new categories is included in subsegment, segment, and overall totals only for the years there are data available. For that reason, care must be taken in comparing results from different years.

In Advanced Energy Now 2014, all growth rates between years (2011 to 2012; 2012 to 2013; 2011 to 2013) are calculated using only those product categories for which market data are available for both years being compared.

Overview and Summary Findings

For 2013, advanced energy reached $1.13 trillion in estimated global revenue, a 7% increase year-over-year driven by growth in six of the seven segments. Fluctuation in the worldwide total for advanced energy was largely driven by a peak year for large hydro projects in 2011 followed by a large decline in 2012, then slow growth in 2013.

In the United States, the advanced energy market was an estimated $168.9 billion in 2013, 15% of the global advanced energy market, up from 11% in 2011. Excluding wind, U.S. advanced energy revenue grew 18% from 2011 to 2012 and 14% from 2012 to 2013. Wind energy suffered a severe, $23 billion revenue downward swing between 2012 and 2013, due to policy uncertainty around the federal Production Tax Credit (PTC). The effect of wind's downturn is that U.S. advanced energy revenue declined 2% overall in 2013, following a 26% increase from 2011 to 2012.

Globally, after a decline in investment in large-scale hydropower in 2012 from a peak in 2011 (due to a reduction in orders from China and elsewhere) and slight decline in nuclear power, the Electricity Generation segment rebounded in 2013 with nearly 6% growth driven by hydro, solar, and biomass. (See Table 1) Revenue from advanced vehicles (led by clean diesel autos in Europe) allowed Transportation to bounce back (up 6%) in 2013 from a slight dip (down 3%) in 2012, driven by strong growth in hybrid and plug-in hybrid vehicles. Conversely, there has been steady growth in advanced Fuel Production (up 34% from 2011 to 2013), led by ethanol, compressed and liquefied natural gas for transportation (CNG and LNG), and bio-oils associated with development of cellulosic biofuels. The Buildings segment showed similar two-year growth (up 27%), led by advanced lighting. Significant growth in revenue from industrial applications of Combined Heat and Power (CHP) accounted for much of the 26% growth in the Industry segment from 2011 to 2013.

Global Advanced Energy Market

Segment	2011 Global Revenue (millions)	2012 Global Revenue (millions)	2013 Global Revenue (millions) (estimated)
Transportation	$325,914	$315,865	$343,577
Fuel Production	110,667	138,644	148,404
Fuel Delivery	2,207	1,926	2,606
Buildings	117,981	133,710	150,272
Industry	30,576	33,325	38,495
Electricity Generation	532,342	359,802	384,194
Electricity Delivery and Management	34,735	65,022	63,649
Global Total	**$1,154,422**	**$1,048,294**	**$1,131,197**

Table 1 (Source: Navigant Research)

In the United States, the advanced energy market story is of a particularly strong 2012, followed by continued robust growth for most segments and product categories in 2013, with one notable exception – wind power.

U.S. advanced energy revenue grew just over 25% overall from 2011 to 2012. (See Table 2) While overall U.S. revenue was down slightly from 2012 to 2013, that's because growth in most subsegments was masked by a $23 billion drop in wind energy investment from a banner year to a near freeze (just $2 billion estimated for 2013), due to policy uncertainty around the on-again, off-again Production Tax Credit (PTC). Excluding wind, the advanced energy market in the United States grew 14% from 2012 to 2013, with significant gains in Transportation (hybrid, electric, and natural gas vehicles), Buildings (lighting, CHP for commercial and institutional buildings), and Industry (CHP in industrial applications).

The United States remains a world leader (34% of global revenue) in the production of advanced fuels – principally in biofuels and synthetic diesel and gasoline – as revenue in Fuel Production grew steadily, up 17% from 2011 to 2013. Similarly, revenue from advanced Building products and technologies increased 11% from 2011 to 2012 and 12% from 2012 to 2013, for two-year growth of 24%. But the most dramatic growth came in Transportation, where revenue from advanced vehicles more than doubled over the two-year period. Hybrid vehicles led the way in revenue, rising from $7.2 billion in 2011 to $11 billion in 2012 and an estimated $14 billion in 2013. The fastest growth came in plug-in electric vehicles (from $707 million in 2011 to an estimated $3.6 billion in 2013) and natural gas trucks and buses ($102 million to $530 million). Though still relatively small compared to the total vehicle market, this growth is indicative of larger trends occurring in the U.S. vehicle fleet.

It is in U.S. Electricity Generation that disparities in advanced energy progress between 2012 and 2013 are most apparent, with a 52% increase in 2012 followed by an estimated drop of 29% in 2013. Wind energy accounts for much of this roller-coaster pattern. Revenue from wind installations hit a peak of $25 billion in 2012 – a record year for wind – then dropped precipitously, to an estimated $2 billion in 2013. (See Figure 1)

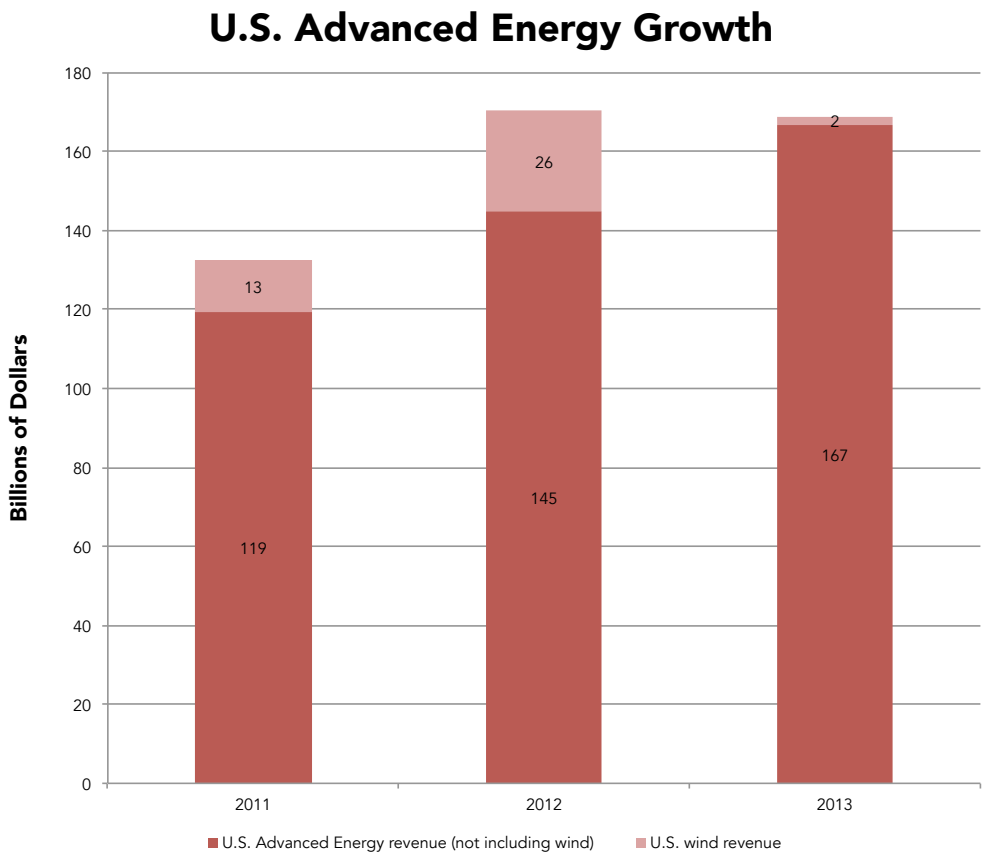


Figure 1 (Source: Navigant Research)

This $23 billion fall-off is largely attributable to the on-again, off-again fate of the aforementioned federal PTC. With the scheduled expiration of the PTC at the end of 2012, projects were hurried to completion before the end of the year in order to qualify for the tax benefit. Shortly after it expired in early 2013, the PTC was given a one-year extension. While the PTC expired again at the end of 2013, the latest extension changed qualification for the tax benefit from project completion to "commenced construction," with important implications for the market. Projects that broke ground or incurred certain levels of expenses by December 31, 2013, qualify for the tax credit, resulting in a robust pipeline of projects – totaling 12 GW of capacity, just under the 13 GW installed in 2012 – that will hit the market when they are completed in 2014 or 2015.

In Electricity Generation there was a dramatic growth story, however: solar photovoltaic (PV) energy. Solar PV revenue grew steadily over this two-year period, up 27% from 2011 to 2012, and 54% from 2012 to 2013. Two-year growth, from $8.2 billion to $16.2 billion, was 97%. This revenue growth is even more impressive given the continued declines in total installed prices for PV over that period. In 2013, the United States accounted for an estimated 18% of global revenue for solar PV, which is a doubling of its global market share from 2011.

US Advanced Energy Market

Segment	2011 US Revenue (millions)	2012 US Revenue (millions)	2013 US Revenue (millions) (estimated)
Transportation	$11,709	$18,045	$24,113
Fuel Production	43,164	47,337	50,957
Fuel Delivery	227	378	252
Buildings	35,271	39,229	43,966
Industry	4,202	5,452	6,733
Electricity Generation	29,829	45,385	31,273
Electricity Delivery and Management	7,990	14,385	11,605
US Total	**$132,392**	**$170,212**	**$168,899**

Table 2 (Source: Navigant Research)

The remainder of this report consists of overviews of the seven industry segments that make up advanced energy and analysis of key market trends in each segment.

Transportation

In 2013, Transportation remained the second largest advanced energy technology segment by global market size, with estimated revenues of $343.6 billion, accounting for more than 30% of the overall total. Although Transportation revenue dropped slightly from 2011 to 2012, strong growth in Hybrid Electric, Plug-in Electric, and Natural Gas Vehicle sales led to an estimated year-on-year increase of 6% in 2013.

With an estimated $239.5 billion in revenue in 2013, Clean Diesel Vehicles is the largest product globally. Europe continues to be the leading market for clean diesel vehicles, though sales in the United States have grown from $3.3 billion in 2011 to an estimated $5.1 billion in 2013. Hybrid Electric Vehicles are the second largest product subsegment, and it is growing rapidly, up 70% over 2011, with estimated revenues of $53.2 billion in 2013. Light Duty Natural Gas Vehicles continued to have moderate growth with an estimated $30.5 billion in revenue in 2013, up 6% over 2012 after growth of just 1% the year before.

The most dramatic growth came in Plug-in Electric Vehicles, up from a small global base of $1.9 billion in 2011 to $6.9 billion in 2013, representing 271% growth. The United States grew its share of plug-in vehicle revenues from less than 40% worldwide to nearly 50% over the same period, with revenue up from $706.6 million to $3.6 billion, averaging 125% annual growth, or 400% over two years.

Growing just as dramatically were Natural Gas Trucks and Buses, which nearly tripled in revenue, to $5 billion globally, compared to $1.8 billion in 2011. Fuel Cell Vehicles was the smallest product category, at an estimated $950,000 in revenues in 2013, and it was the only product category that saw a decrease in revenues compared to 2012.

Transportation	2011 Global Revenue (millions)	2012 Global Revenue (millions)	2013 Global Revenue (millions) (estimated)
Propulsion Systems	$325,914	$315,865	$343,517
Enabling Information Technology	$0	$0	$60
Transportation Subtoal	**$325,914**	**$315,865**	**$343,577**
	2011 US Revenue (millions)	**2012 US Revenue (millions)**	**2013 US Revenue (millions) (estimated)**
Propulsion Systems	$11,709	$18,045	$24,082
Enabling Information Technology	$0	$0	$31
Transportation Subtoal	**$11,709**	**$18,045**	**$24,113**

Table 3 (Source: Navigant Research)

The remainder of this section takes a closer look at these new vehicles, which highlight both the shift away from petroleum but also progress in using petroleum fuels more efficiently and with fewer emissions.

Electric Vehicle Growth Strong Globally and Domestically

The fast-growing market for vehicles with electric drives – which includes hybrids (HEVs) and plug-in electric vehicles (PEVs), both hybrid and all-electric – has become an important part of the global automotive industry, and it is likely to only grow in importance in the future. The United States and Japan are the largest markets for hybrids, with sales expected to surpass 500,000 and 900,000 vehicles in 2013, respectively. Outside of these markets, HEV sales are marginal – especially in Europe, where HEV technologies compete against fuel efficient diesel technologies. The latter technologies have become the market leader among light duty vehicles in Europe.

Looking beyond HEVs, government incentives have boosted early adoption of plug-in electric vehicles (PEVs), but favorable economics and superior vehicle performance suggest there is room for rapid growth. (See Figure 2) Initial purchase price premiums for PEVs over conventional gas- and diesel-powered internal combustion engine (ICE) vehicles remain high. But operational cost savings due to lower fuel and maintenance costs mean that, when considered over the life of the vehicle, PEVs are cost-competitive with, if not advantageous over, conventional ICE vehicles. Electric motors are as much as three times more efficient than ICEs, which makes electricity as a fuel far cheaper per mile traveled than gasoline or diesel. Electricity costs are also historically stable compared to volatile gasoline and diesel prices, which adds to the incentive for drivers.

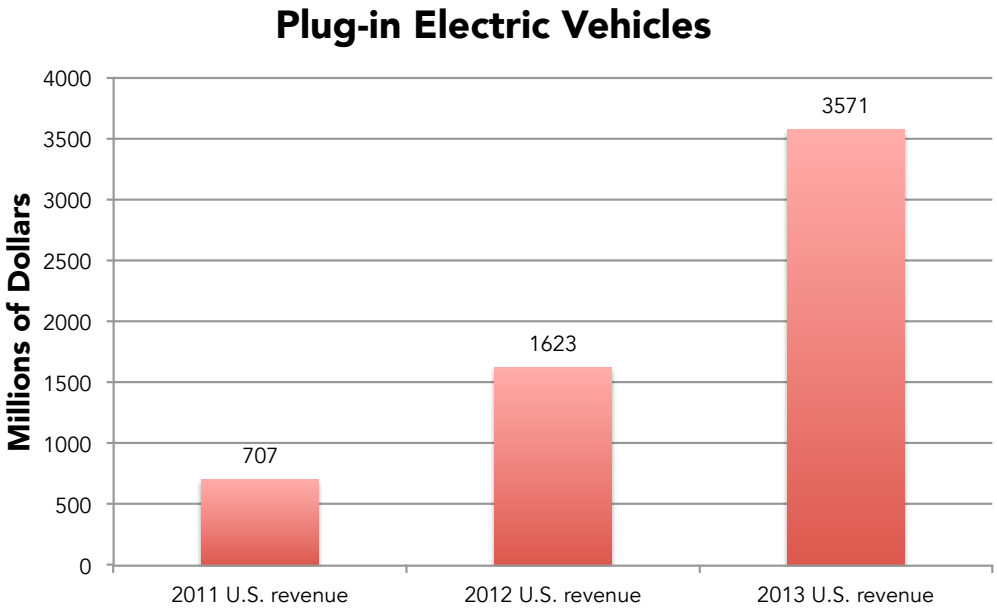


Figure 2 (Source: Navigant Research)

Additional value streams are emerging from innovations in PEV technologies that allow PEV owners to utilize battery power not only for driving, but also potentially for emergency backup power and grid balancing. Test fleets are currently examining the revenue potential of vehicle-to-grid (V2G) services, while electricity providers are looking into ways to shift PEV charging to off-peak hours through demand response (DR) programs. Developments in both areas promise to further lower the total operating costs of PEVs, strengthening the business case of PEV technologies for fleets and individual owners.

A recent analysis by Navigant Research, which shows the geographic diversity of electric vehicle adoption in North America, projects that California, New York, Washington, and Florida will lead the way in PEV sales in the United States. By 2022, Hawaii is expected to have the highest concentration of annual PEV sales (in share of overall vehicle sales in the state), followed by California and Oregon. Los Angeles, New York City, and San Francisco are anticipated to have the largest sales of PEVs through the forecast period of any metropolitan areas in the United States. In Canada, the provinces of Ontario, Quebec, and British Columbia will account for 97% of Canadian PEV sales by 2022 (they also account for 75% of the Canadian population). The cities of Toronto, Montreal, and Vancouver will lead Canadian PEV sales. Navigant Research forecasts annual PEV sales alone will reach approximately 467,000 vehicles in the United States and 80,000 in Canada by 2022 – slightly faster than HEV sales grew in their first decade.

Clean Diesel Still King Globally, Growing in the United States

Diesel cars have undergone a major transformation over the past 20 years as both the European Union (EU) and North America have implemented stringent light-duty vehicle emissions regulations covering diesel vehicles and diesel fuel. A clean diesel vehicle is classified as one that meets the limits for nitrogen oxide (NOx) or particulate matter (PM) emissions set by the U.S. Environmental Protection Agency's (EPA) Tier 2 standards or the EU's Euro 5 standards. Each of these standards mandates a dramatic reduction from previous emissions levels. For example, the U.S. Tier 2 standards reduce NOx levels by over 50% and the PM levels by 90% from the Tier 1 standards.

The global market for clean diesel vehicles in 2013 is an estimated $239.5 billion, down from $262.2 billion in 2011, due primarily to weak economic conditions in Western Europe, the world's largest market for clean diesel cars. Demand is primarily driven by diesel cars' superior fuel economy over gasoline. Diesel fuel is also taxed less than gasoline in many European countries, giving diesel cars an even greater operating cost advantage. Western Europe will continue to constitute the majority of clean diesel vehicle sales during the next five years, particularly in the light-duty segment, even as it experiences slower growth over this period, with other fuel-efficient alternatives to diesel becoming available.

In the United States, the diesel market has begun to surge, growing 55% between 2011 and 2013, to an estimated $5.1 billion. There are currently fewer than 20 clean diesel vehicle models sold in this country, but they are selling strongly. With new federal fuel efficiency standards requiring a fleet average of 54.5 mpg by 2025, the United States should see continued demand for all fuel-efficient technologies, including diesel and hybrid.

Natural Gas Trucks and Buses Rev Up

As the cost of oil climbs and emissions from large diesel and gasoline engines garner more scrutiny, consumers, fleets, and governments are looking for alternatives that lower costs and emissions. At the same time, natural gas has become a significantly more cost-competitive vehicle fuel than a decade ago. The result is a growing market for Natural Gas Vehicles (NGVs). Global revenue from all NGV sales has increased from $30.7 billion in 2011 to $35.5 billion in 2013. While light-duty NGVs account for an estimated 86% of the global NGV market, with $30.5 billion in 2013, medium- and heavy-duty vehicles (trucks and buses) have grown the fastest. In 2013, revenue from NGV trucks and buses jumped to an estimated $5 billion, up 172% over 2011. In the United States, the market for NGV trucks and buses grew to an estimated $530 million in 2013, representing more than 400% growth over two years. Revenue from sales of light duty NGVs nearly doubled, from $460 million to $807 million. (See Figure 3)

NGV sales are driven by multiple forces in the global market: economic benefit, availability of vehicles, environmental benefit, government influence, and refueling infrastructure. In addition to being increasingly competitive overall, NGVs have also found some niche markets, including refuse trucks, day cab trucks, and transit buses. These vehicles use a lot of fuel in close proximity to fueling stations, making alternative fuels practical and payback periods relatively short.

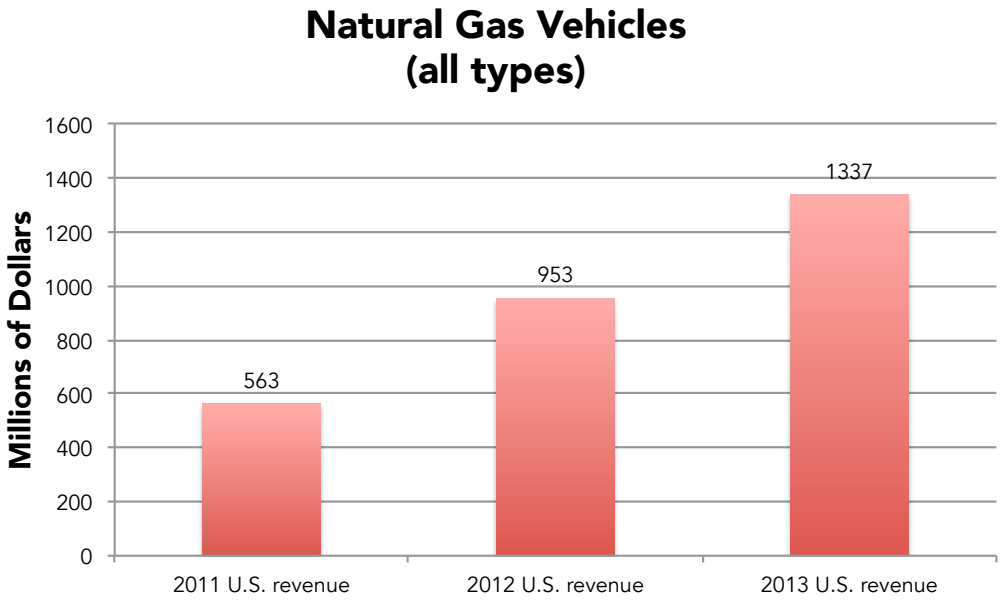


Figure 3 (Source: Navigant Research)

The economics of medium- and heavy-duty NGVs benefit from rapid recovery of vehicle purchase-price premiums compared to diesel vehicles because of the significant price differential between diesel fuel and natural gas. As a result, the payback period for heavy-duty trucks can be as short as 1.5 years in North America. On average, the price of compressed natural gas (CNG) is about 36% less than diesel at current prices. Liquefied natural gas (LNG) tends to be a bit more expensive, and is more variable, than CNG. The higher initial costs for NGVs are largely driven by storage tanks for the CNG or LNG, which typically account for between 53% and 76% of total vehicle incremental costs.

Demand for natural gas trucks and buses is uneven, though North America and Asia Pacific stand out as regions with strong growth. In North America, where natural gas costs are low, the vehicle market has grown faster than refueling station development. In Asia Pacific, China and developing markets are looking to natural gas to help solve environmental woes in large cities. Navigant Research forecasts that the total number of heavy-duty NGVs on the road across the world will reach nearly 1.9 million trucks and a similar 1.8 million buses by 2022.

Fuel Production

Fuel Production was the third largest advanced energy technology segment in 2013, with an estimated $148.4 billion in global revenue, accounting for 14% of the overall total. (See Table 4.1) Fuel Production continued to see strong year-on-year growth at 7% over 2012, and the segment has increased 34% since 2011. Ethanol and Butanol, including both sales of fuel and investment in refinery infrastructure, continued to be the leading source of revenue in the segment with a combined $81.4 billion in revenue. A new addition to this year's report, sales of Compressed Natural Gas and Liquefied Natural Gas for transportation, contributed estimated revenue of $37.7 billion in 2013, up 20% from 2012 and 64% from 2011. Biodiesel sales and new biodiesel refinery infrastructure grew to $24.2 billion in 2013, a 35% increase compared to 2011. A combined 32.6 billion gallons of biodiesel and ethanol were produced globally in 2013, compared to 29.3 billion gallons in 2011.

The U.S. Fuel Production segment reached $51 billion in 2013, up 8% from 2012, and 18% from 2011. (See Table 4.2) Sales of ethanol in the United States reached an estimated 14.1 billion gallons representing $41.5 billion in revenue in 2013. Biodiesel sales and biorefinery infrastructure were the next largest sources of revenue with a combined $4.6 billion; new biodiesel refinery infrastructure capacity of 200 million gallons was added in 2013, four times the 2011 total, and biodiesel production increased 30% during this time. Bio-methane, Bio-oil, and Synthetic Diesel and Gasoline reached a combined estimated $2.7 billion in revenue from fuel sales and infrastructure investment in 2013, representing a 600% increase compared to 2011.

Fuel Production	2011 Global Revenue (millions)	2012 Global Revenue (millions)	2013 Global Revenue (millions) (estimated)
Compressed Natural Gas and Liquefied Natural Gas	$23,018	$31,486	$37,654
Ethanol and Butanol	$68,140	$84,240	$81,408
Bio-diesel	$17,882	$20,432	$24,192
Synthetic Diesel and Gasoline	$1,580	$1,938	$4,280
Bio-oil	$1	$500	$805
Bio-methane	$47	$48	$65
Hydrogen	**$0**	**$0**	$0
Fuel Production Subtotal	**$110,667**	**$138,644**	**$148,404**

Table 4.1 (Source: Navigant Research)

Fuel Production	2011 US Revenue (millions)	2012 US Revenue (millions)	2013 US Revenue (millions) (estimated)
Compressed Natural Gas and Liquefied Natural Gas	$504	$581	$883
Ethanol and Butanol	$39,140	$41,730	$42,722
Bio-diesel	$3,135	$4,231	$4,638
Synthetic Diesel and Gasoline	$372	$438	$2,694
Bio-oil	$1	$345	$1
Bio-methane	$12	$12	$18
Hydrogen	$0	$0	$0
Fuel Production Subtotal	**$43,164**	**$47,337**	**$50,957**

Table 4.2 (Source: Navigant Research)

Despite being a major advanced energy segment, the biofuels market is shifting, driven by policy, market, and technology changes. We look at three of these developments below, focusing on the largest biofuels market – the United States.

US Revises Renewable Fuel Standard

The United States is the leading producer of biofuels (including conventional ethanol, conventional biodiesel and advanced biofuels), accounting for nearly 57% of global sales, followed by Brazil (27%), China, France, Germany, and Argentina. (See Figure 4) The revised Renewable Fuel Standard (RFS2) is the policy driving biofuels production in the United States today, requiring fuel blenders to incorporate an increasing volume of biofuels into their transportation fuel sales over time.

This requirement for increased utilization of biofuels, however, has clashed with a trend toward lower fuel consumption, driven in part by rising Corporate Average Fuel Economy (CAFE) standards. The rise of the Prius and Tesla's recent success are harbingers of an emerging fleet of next-generation vehicles that will further trim petroleum fuel consumption. At the same time, generally higher pump prices, as well as demographic shifts, have resulted in consumers driving less. As a result, certain limits for accommodating mandated levels of ethanol and biodiesel production are being reached.

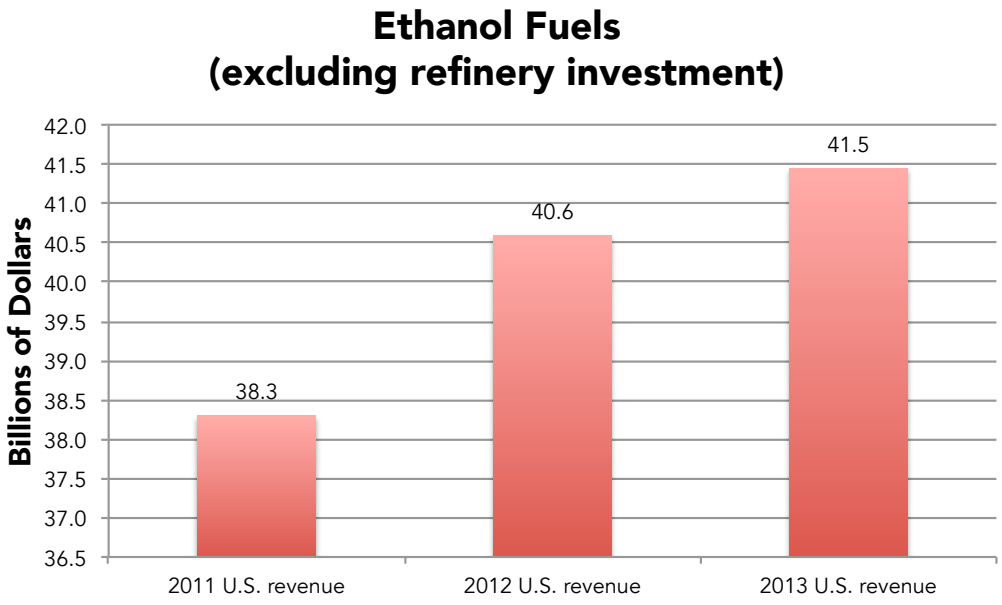


Figure 4 (Source: Navigant Research)

Conventional biofuels are used primarily in blends with petroleum-based fuels (ethanol with gasoline and biodiesel with petroleum diesel). Ethanol has essentially reached a "blend wall" of 10% ethanol in gasoline (E10) at current levels of production. Assuming that total fuel use continues to decline, ethanol blending will need to decline in parallel, unless alternative end-market demand emerges. One option is flex-fuel vehicles (FFVs) – used widely in Brazil – which can burn ethanol-gasoline mixtures with up to 85% ethanol (E85). Several million such vehicles are on the road today in the United States, but the fuel is not widely available and distribution infrastructure to the consumer remains limited. The EPA has approved blends of up to 15% ethanol (E15) for all gasoline vehicles (not just FFVs) manufactured in 2001 or later, but uncertainty around E15's impact on engine hardware and stakeholder resistance has led to limited adoption to date.

Offering either E85, E15, or both, alongside existing fuels will require investments in fuel delivery infrastructure, and possibly replacing existing fuels (e.g., midgrade gasoline) at many existing fueling stations. Station owners will be reluctant to do so until they are sure that the market for these fuels exists. At the same time, biofuels that have no blending limits with petroleum fuels are not yet widely available.

While both E85 and E15 use would increase the addressable market for ethanol producers, this will take time. As a result, in late 2013, the Environmental Protection Agency (EPA) proposed revisions to biofuel volume obligations under RFS2 for 2014.[1] With a proposed reduction of an estimated 3 billion gallons – a volume roughly equal to 20% of current nationwide biofuels production – the agency is seeking to reduce the total biofuel requirements for conventional ethanol below the legislated targets for the first time. The EPA has adjusted annual volumes for advanced biofuels in prior years, due to the slower-than-expected development and limited availability of these non-food-crop-based fuels.

1. The RFS2 gives this authority to the EPA, which is responsible for setting specific targets for different fuel types covered by the RFS2.

Bio-based Products Provide a Stepping Stone to Advanced Biofuel Production

At the core of biofuel ambitions over the next decade is the commercialization of conversion technologies for everything from agricultural waste to algae. While conventional biofuels like ethanol and biodiesel derived from commodity crops (corn and soybeans) are widely commercialized, advanced biofuels are still clawing their way to commercial relevance – and price parity – with petroleum-based fuels. First-of-kind biorefineries for advanced biofuels have come online in recent years with dozens more currently under construction, but development has been slow, expensive, and arduous. Navigant Research forecasts that just 9 billion gallons of advanced biofuel will be produced globally by 2020, a far cry from the targets set by current mandates. However, bio-based chemicals and products other than fuels offer shorter runways to revenue for emerging producers.

In the low-margin, high-volume business of fuel production, profitability is predicated on reaching economies of scale, which in the case of biofuels, require hundreds of millions of dollars in capital investment per production facility. By comparison, bio-products offer lucrative opportunities in high-margin, low-volume markets – food supplements, feed, pharmaceuticals, chemicals, polymers, and paper – while requiring less production capacity to be built initially.

Algae players are a key constituent in this group and are chasing high-value omega-3 fatty acid production. Selling at more than $2,000 a ton, omega-3s are a widely consumed nutritional supplement, with bio-based pathways offering alternatives to increasingly expensive omega-3 retail products derived from seafood sources. By comparison, biofuels are slightly more expensive than incumbent petroleum-based fuels, selling on average for $200 to $500 per ton.

The process for making bio-based products is largely similar to those for making advanced biofuels. By creating a near-term revenue stream while advanced biofuels march toward competitive scale, bio-based products and materials provide a key stepping stone to greater advanced biofuels production.

Aviation Biofuels Are Flying

Unlike the incumbent conventional biofuels industry, the aviation industry is marching toward commercializing a number of advanced biofuel products that can be dropped into existing aviation infrastructure.[2] The industry is aiming to offset 6% of global petroleum consumption by 2020. Boeing and Airbus have spearheaded a number of test flights and initiatives aimed at developing aviation biofuel supply chains around the world. More than 30 commercial carriers have flown more than 1,500 flights with a blend of biofuels since 2008.

In sugarcane-rich Brazil, bargain airline GOL Linhas Aereas Intelligentes recently announced a partnership with Boeing and Amyris, an emerging player in the advanced bio-based economy, to use sustainable aviation biofuel on 200 flights during the World Cup in 2014 and in 20% of flights during the Rio Olympics in 2016. The partnership aims to speed the research, development, and approval of aviation biofuels using sugarcane as a primary feedstock. GE Aviation, meanwhile, has signed an agreement to purchase synthetic biofuel derived from cellulosic biomass, natural gas, and water electrolysis-generated feedstock from the Washington, D.C.-based D'Arcinoff Group for testing in jet engines. LanzaTech has moved aggressively to secure front-end partnerships with industrial producers in China and India, using flue gas from facilities like steel mills and fermenting it into chemicals and fuels. Building on an aviation biofuels supply agreement with Virgin Atlantic, LanzaTech recently announced that it is the first to have its jet biofuel certified by the independent Roundtable on Sustainable Biomass (RSB).

2. Ethanol and biodiesel are not suitable blendstocks for commercial aviation fuels.

As with many advanced energy segments, the U.S. Department of Defense (DOD) is playing a key role in financing and building capacity. The DOD is the largest end-use consumer of oil in the world, and in recent years the military has made a series of commitments to integrate advanced biofuels into their operations. The U.S. Navy is aiming to deploy a permanent green strike force in 2016. In March 2013, the DOD issued three contracts totaling $16 million, matched by $17 million in private investment by the biofuel companies (Emerald Biofuels, Natures BioReserve, and Fulcrum Biofuels) for advanced biorefinery construction. The goal is for these refineries to be capable of delivering 150 million gallons of drop-in biofuels for use in fighter jets and destroyers at a cost of less than $4 per gallon.

Strategic partnerships across the aviation biofuels value chain highlight the range of pathways to commercialization that are being explored globally. In January, Boeing announced a potential breakthrough opportunity with Etihad Airways and Masdar Institute in Abu Dhabi to develop halophyte (plants that tolerate water with high salinity) farms for widescale production of sustainable aviation biofuels. This follows Boeing's December 2013 announcement to pursue certification for the use of synthetic diesel (also known as renewable diesel) in commercial aviation. Although synthetic diesel contributed to just 2.7% of the total gallons of biofuels produced worldwide, it made up more than 95% of the advanced biofuel pool in 2013.

Aviation biofuel supply chain integrator companies like SkyNRG seek to condense the upstream, midstream, and downstream components of liquid fuel production into "bioports," or regional production hubs that produce aviation biofuel and synthetic diesel. The company pairs available feedstocks with conversion technology solutions at sites like Schiphol Airport and the Port of Rotterdam in the Netherlands and Brisbane Airport in Australia. This model takes advantage of concentrated demand and expanding integration of advanced energy at airports worldwide. Unlike ground transportation, there is no Tesla for the commercial aviation industry at the moment. However, higher oil prices and the difficulty of refining aviation fuels from increasingly heavy oils are leading to increasing interest from commercial airlines and the airport operators serving them. The emergence of supply chain integrators is a sign of a maturing industry poised for rapid growth.

Fuel Delivery

Fuel Delivery is the smallest of the Advanced Energy industry segments globally with an estimated $2.6 billion in revenue in 2013, an increase of 35% over 2012. Fueling Stations and Fuel Transportation Infrastructure currently make up the Fuel Delivery segment, with revenue available just for Fueling Stations.

Revenue from Fueling Stations comes from natural gas vehicle (NGV) fueling stations serving cars, light duty trucks, transit buses and medium- and heavy-duty trucks – primarily with Compressed Natural Gas (CNG) – as well as fueling stations for commercial vehicles, including heavy-duty trucks, transit buses and other fleets – primarily with Liquefied Natural Gas (LNG), though there are regional variations.

Until recently, CNG fueling stations accounted for the vast majority of revenue in the Fuel Delivery segment. But the market for fueling stations serving commercial vehicles has taken off, jumping from $71.3 million in 2012 to an estimated $1.3 billion in 2013. Fueling stations for Hydrogen, which has yet to establish itself as a commercial transport fuel, are also included in the Fueling Stations subsegment, with 2013 estimated revenues from station construction reaching $31.9 million, down 34% from 2011.

The United States accounted for nearly 10% of revenue within the global Fuel Delivery market, with $252 million, an increase of 11% from 2011. CNG fueling stations for cars and light duty trucks is still the largest source of U.S. revenue, with an estimated $157 million, but as is true globally, growth has been fastest among fleets. Revenue from fueling stations that service medium and heavy duty trucks and buses has surged, from a relatively small base of $10.9 million in 2011 and $16 million in 2012 to an estimated $85.9 million in 2013, an increase of 684% over two years. U.S. investment in Hydrogen Fueling Stations, on the other hand, has waned in the past year, down to an estimated $9.7 million in revenue in 2013, compared to $24.3 million in 2011 and after a modest increase, to $26.8 million, in 2012.

Fuel Delivery	2011 Global Revenue (millions)	2012 Global Revenue (millions)	2013 Global Revenue (millions) (estimated)
Fueling Stations	$2,207	$1,926	$2,606
Fuel Delivery Subtotal	**$2,207**	**$1,926**	**$2,606**
	2011 US Revenue (millions)	**2012 US Revenue (millions)**	**2013 US Revenue (millions) (estimated)**
Fueling Stations	$227	$378	$252
Fuel Delivery Subtotal	**$227**	**$378**	**$252**

Table 5 (Source: Navigant Research)

Natural Gas Station Investment Fueled by Low Fuel Costs

As governments and companies around the world look at ways to reduce the financial and environmental costs of transportation, natural gas, which emits less carbon dioxide than petroleum fuels, is getting increasing attention as a transportation fuel. Greater use of natural gas vehicles (NGVs) depends on the availability of the fuel, whether that fuel is CNG or LNG. With lower-cost natural gas now available, investment in refueling infrastructure is undergoing robust growth as companies look to capitalize on the newfound interest in these fuels. (See Figure 5)

CNG is used for a variety of vehicles, including cars and light-duty trucks, as well as medium- and heavy-duty trucks and transit buses, which do not range far from fueling stations. LNG is generally used for vehicles that travel longer distances, such as long-haul trucks. The reason for differing applications is that, while LNG holds more energy by volume than CNG, the fueling infrastructure for LNG is significantly more expensive, driven by its higher storage tank costs.

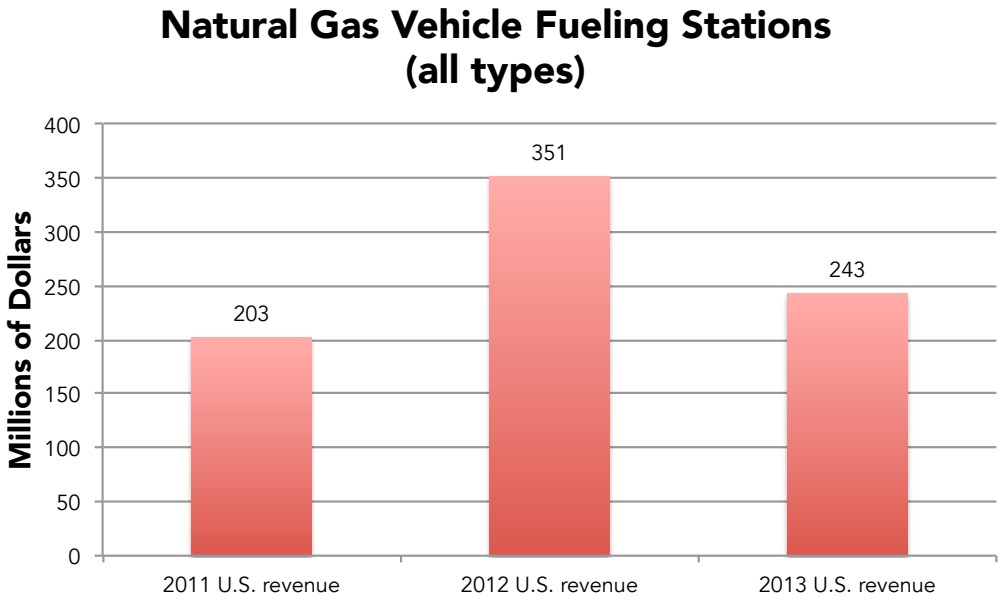


Figure 5 (Source: Navigant Research)

The cost of NGV fueling infrastructure (both CNG and LNG) remains higher than for petroleum fuels today. While CNG stations have a robust supply chain of component manufacturers, the need for pipelines to supply the fuel from the natural gas grid can make the siting of new stations challenging. Regardless of distribution challenges, the lower retail price of both CNG and LNG relative to gasoline and diesel is increasing demand for both the vehicles and the fueling stations for servicing them.

Future investment in NGV infrastructure is expected to be strongest in the United States, where it is driven largely by private industry. Navigant Research is anticipating a large number of new stations coming online by 2016, when the number of NGV fueling stations worldwide will approach 35,000. The United States is expected to have 42% of all new stations built between 2013 and 2016 (1,110 stations). Western Europe will add an increasing number of stations each year in an effort to build NGV corridors, but growth in some countries could be tempered by a focus on electric vehicle infrastructure. Asia Pacific has the greatest number of NGV stations currently, with investment focused in China, Japan, and India. Eastern Europe and Latin America's NGV station development is more sporadic, with little government investment.

NGV fueling stations are designed and constructed by a variety of firms. While energy companies, such as Clean Energy Fuels and Royal Dutch Shell, are most likely to offer end-to-end development and construction (using subcontractors typically), CNG design and engineering firms and manufacturers of equipment (such as compressor manufacturer ANGI Energy) can all provide design and construction services.

Public-Private Partnerships Seek to Solve Fuel Cell Conundrum

Fuel cell vehicles (FCVs) range from scooters to fork lifts to light-duty vehicles to trucks and buses. Makers of FCVs are focused on reducing costs and establishing refueling infrastructure in order to prepare for commercial introduction of passenger car models in the 2015-2017 timeframe. Industry-government partnerships in Europe, Japan, the United States, and South Korea are moving forward on infrastructure rollout plans. However, given that it takes 18 months to three years to build a hydrogen station, there will likely be sparse fueling station coverage by 2015 – which may cause automakers to slow their commercial vehicle rollouts. This is the classic chicken-and-egg conundrum faced by all advanced transportation industries, including electric vehicles, natural gas vehicles, and, to a lesser extent, biofuels. As the least commercially developed advanced transportation industry, however, with a few hundred fuel cell vehicles (FCVs) reportedly leased or demoed in 2013, hydrogen fuel infrastructure has been particularly slow to emerge. In 2013, only 13 new hydrogen fueling stations were built, compared to 18 in 2012, and 20 in 2011, with half of those built in the United States. Not surprisingly, hydrogen fueling stations are primarily the result of government supported research and/or demonstration projects. Nevertheless, public-private partnerships are emerging as the next phase of hydrogen fueling infrastructure deployment.

In R&D as well as deployment, the center of gravity for FCVs has shifted from the United States to Western Europe. Germany, the United Kingdom, and the Nordic countries, which have less geography to cover than the United States, are forging ahead with plans to deploy hydrogen fueling stations. Japan and South Korea, where there is a strong vehicle manufacturing presence, are also key markets for these vehicles and their fueling stations. In the United States, California is funding hydrogen station build-out and will be the first U.S. market for FCVs.

Launched in 2009, Germany's H2Mobility is a key global initiative that brings together automotive companies and infrastructure companies (with government support) so that infrastructure and car commitments can proceed hand-in-hand. H2Mobility was created shortly after a set of automakers signed a letter of intent to begin making commercial FCVs available in 2015. The signatories included Daimler, GM, Honda, Hyundai, and Toyota. This program has since become a model for other efforts, most notably one in the United Kingdom, where government, automakers, and hydrogen companies signed a memorandum of understanding (MOU) committing to work together to support the rollout of FCVs from 2015 to 2030. The U.K. initiative found that, based on a consumer preference assessment, FCVs could generate sales of 10,000 vehicles per year by 2020. In order to meet this demand, the United Kingdom would require 65 stations by 2015. The South Korean government has a target of 43 hydrogen stations in place by the end of 2015, and 168 by 2020.

In June 2012, the German federal government signed a letter of intent with Air Liquide, Air Products, Daimler, Linde, and Total Deutschland to develop a network of at least 50 public filling stations throughout Germany by 2015. The effort will require public and private investment of over €40 million ($52 million). The aim is to have 400 stations by 2020 and 1,000 stations by 2030.

The Nordic countries, which include Denmark, Norway, Sweden, Iceland, and Finland, have all adopted policies or public-private programs to promote fuel cell and infrastructure deployment. The Scandinavian Hydrogen Highway Partnership (SHHP) has a goal of building a complete network of stations connecting all of Scandinavia by 2015. This network would consist of 15 primary stations and 30 satellite stations. In 2012, Toyota, Nissan, Honda, and Hyundai signed an MOU to deploy FCVs and hydrogen infrastructure in Denmark, Iceland, Norway, and Sweden between 2014 and 2017.

While the U.S. Department of Energy (DOE) is not directly funding hydrogen infrastructure deployment, it has launched a cooperative effort, called H2USA, to build hydrogen infrastructure that can support FCV rollouts. As it is, the United States will be challenged in attempting any significant hydrogen rollout in the short term other than in California, where the state offers a variety of tax breaks for zero emission vehicles and has provided funding for hydrogen fueling stations in the past.

Buildings

Buildings is the fourth largest advanced energy segment globally with an estimated $150.3 billion in revenue in 2013, representing an increase of 12% since 2012 and 27% since 2011. (See Table 6.1) Heating, Ventilation, and Air Conditioning (HVAC) remained the largest subsegment in 2013 with $54.7 billion in revenue, followed by Lighting with $52.8 billion. Growth in both of these subsegments was the result of increased activity in commercial building retrofits. The Building Envelope subsegment grew to an estimated $15.2 billion in revenue, followed by Building Design with $14.9 billion. Within that subsegment, Zero Energy Buildings grew 51% in 2013, making it one of the fastest growing product categories in Buildings.

Smart Glass was a new product category added to the Building Envelope subsegment for 2013, with estimated global revenue of $88 million. Enabling Information Technology (IT), defined as IT that can be used to better manage a building's energy use, reached an estimated $6.5 billion in revenue in 2013. The United States accounted for an estimated 57% of the global Enabling IT market in 2013 at $3.7 billion, with strong growth in Demand Response services (69% over 2013, to $2 billion in U.S. revenue). The global market for District Energy and Combined Cooling, Heating, and Power (CCHP) increased 35% compared to 2011, to an estimated $3 billion in 2013 revenue, with the United States representing nearly 40% of that total at $1.2 billion in revenue, up 29% over 2012. Water Heating (defined as sales of energy efficient water heating technology in the residential market) and Appliances and Electronic Equipment were the two smallest subsegments with an estimated $1.8 billion and $1.4 billion in revenues, respectively in 2013, but with the latter growing 128% over 2012.

Overall, U.S. Buildings segment revenue grew 12% year-over-year, to an estimated $43.9 billion in 2013, and 25% over 2011. (See Table 6.2)

Buildings	2011 Global Revenue (millions)	2012 Global Revenue (millions)	2013 Global Revenue (millions) (estimated)
Building Design	$11,537	$13,039	$14,878
Building Envelope	$13,017	$14,006	$15,242
Heating, Ventilation, and Air Conditioning (HVAC)	$44,383	$49,613	$54,673
District Energy and Combined Cooling, Heating, and Power (CCHP)	$2,229	$2,787	$3,023
Water Heating	$1,467	$1,612	$1,773
Lighting	$41,329	$47,212	$52,770
Appliances and Electronic Equipment	$266	$613	$1,412
Enabling Information Technology	$3,752	$4,829	$6,500
Buildings Subtotal	**$117,981**	**$133,710**	**$150,272**

Table 6.1 (Source: Navigant Research)

Buildings	2011 US Revenue (millions)	2012 US Revenue (millions)	2013 US Revenue (millions) (estimated)
Building Design	$2,819	$3,128	$3,525
Building Envelope	$8,720	$9,645	$10,762
Heating, Ventilation, and Air Conditioning (HVAC)	$10,522	$11,532	$12,616
District Energy and Combined Cooling, Heating, and Power (CCHP)	$814	$925	$1,189
Water Heating	$1,133	$1,197	$1,268
Lighting	$9,139	$9,992	$10,701
Appliances and Electronic Equipment	$105	$148	$208
Enabling Information Technology	$2,020	$2,663	$3,697
Buildings Subtotal	**$35,271**	**$39,229**	**$43,966**

Table 6.2 (Source: Navigant Research)

Below, we highlight three significant trends in advanced energy for Buildings:

- Building Energy Management Systems
- LED Lighting
- Demand Response

Building Energy Management Systems Take Off

Innovation in the area of Building Energy Management Systems (BEMS) during the past five years – in particular moving data to the cloud – has made it easier for energy managers to track, analyze, and compare important building energy data. One of the primary benefits of this is the ability to integrate more readily into existing workflow procedures for tracking energy and sync up with a building's automation system to track building-related energy data in real time.

As a result, the global market for BEMS has grown almost 25% from just under $1.9 billion in 2011, to an estimated $2.4 billion in 2013. Growth in the U.S. market over this period was 27%, from $737.2 million in 2011 to an estimated $935.4 million in 2013. (See Figure 6) Navigant Research forecasts that BEMS will grow to an annual market of $5.6 billion globally in 2020. The market will be concentrated in North America and Europe, though the Asia Pacific market is growing at the fastest pace.

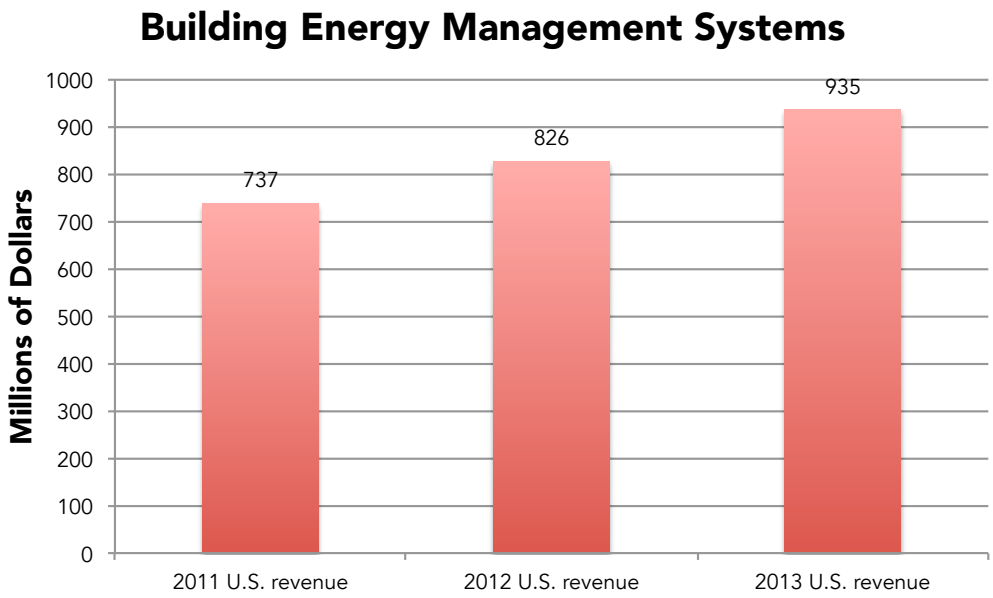


Figure 6 (Source: Navigant Research)

The BEMS technology landscape is still evolving, but the roles that various players will take in the long term are starting to solidify. The building industry incumbents, such as Johnson Controls, Schneider Electric, and Siemens, have been acquiring companies that provide broad data integration capabilities, as well as specialized firms that offer capabilities such as demand response. At the same time, BEMS startups (though many of them could hardly be called startups at this point, given the number of Fortune 500 companies that have signed up for their systems) are releasing regular updates to their offerings, with each new iteration providing more comprehensive functionality, easier-to-use front ends, and scalability.

The trend of competitors jointly investing in new companies has continued to develop in the BEMS market in the last year. Schneider Electric and the venture capital arm of Siemens joined forces in a $9 million investment round for BuildingIQ in January 2013. Then, in June, Johnson Controls invested in Optimum Energy through a venture capital advisory relationship with Navitas Capital, with the round totaling $12.2 million (and compounded by additional funding from Edison Energy in August). These investments are setting the stage for a new dynamic in which incumbents aim to foster innovation by investing in startups while allowing them to maintain their autonomy, rather than acquiring them and fitting them into the incumbents' existing offers and strategies.

While the market is growing quickly, there is still a big learning curve for much of the building industry when it comes to BEMS. The offering, as a whole, is very new to many customers. Given the rapid pace of technology advancements over the last few years, many BEMS vendors are shifting their focus from new technology development to marketing and packaging their products in ways that appeal to customers. For some, that means offering outsourced energy management services that can be paid for through operating expenses; for others, it means going through utility channels. Either way, the near-term challenge in the BEMS market is driving revenue rather than innovation.

LEDs Light Up the Lighting Industry

In recent years, LED-based lighting products have begun to compete successfully with rival technologies on the characteristics of light quality, efficacy, dimmability, and almost every other metric except price. But now, with LED prices falling rapidly and new designs for LEDs continuing to emerge from lighting labs around the world that push quality and efficacy ever higher, LED adoption rates are accelerating. LEDs are expected to be the dominant lighting technology over the next decade, with LED lighting products (including lamps and luminaires) in commercial building markets forecast to grow from $2.7 billion in 2013 to more than $25 billion in 2021.

In the coming years, prices are expected to fall to a point where savings from electricity consumption provide sufficiently short paybacks that customers will begin moving to this technology en masse. This shift will be most dramatic in the share of lamps sold for retrofit projects, where older lighting is often replaced specifically to improve efficiency. Navigant Research forecasts that the share of lamps sold to retrofit projects worldwide that are LED-based will grow from just 5% in 2013 to 40% by 2017 and 63% by 2021. Such growth will largely eliminate inefficient technologies like incandescent and halogen. LEDs will also take a significant portion of the market from the previously leading T8 and T5 fluorescent lamps.

The single largest driver globally for the adoption of LED lighting may be China's 12th Five-Year Plan (2011-2015), which sets aggressive goals for energy efficiency. China's National Development and Reform Commission, the agency responsible for implementing the efficiency goals, has stipulated that the proportion of LED lights sold in the country will top 20% by 2015. That would make China the largest consumer of LED lighting in the world.

Laws or standards that drive out incandescent lamps are also accelerating the shift in the lighting market in other countries. This inefficient technology is being phased out in much of Europe, China, and the United States by legislation that either outright bans the sale of these lamps or requires minimum efficacies that standard incandescent lamps cannot achieve. Initially, these laws are driving up the market share of compact fluorescent lamps (CFLs) and, in some cases, halogen lights that have been redesigned to meet the new standards. Eventually, the laws will be just one more factor pushing consumers toward LEDs.

The impending tidal wave of LED lighting technologies amounts to a significant disruption for the lighting industry. Lighting companies with exposure in traditional lighting technologies have been scrambling to ensure that they will not be left behind. All of the major lighting companies have developed or acquired LED offerings and now highlight LEDs prominently in their product lineups.

Positioning to take advantage of LED sales, however, will not be enough to maintain growth for the big lighting companies. Due to the much longer lifespan of LED lamps (typically 25,000 to 50,000 hours), Navigant Research forecasts that overall revenue from lamp sales will actually decrease in the coming decade – even as a greater proportion of sales are generated by more expensive LED lamps. In anticipation, companies are broadening their offerings by expanding from lamps to lighting controls and lighting services. Just as the tech giants (e.g., Hewlett-Packard and IBM) of decades past had to make the shift from hardware to software/services, today's lighting giants are becoming providers of complete lighting solutions rather than just the manufacturers of the physical elements that emit light.

Demand Response Provides Relief to the Grid, Expands to New Markets

Today more than 10.3 million sites (residential, commercial, and industrial) around the world are involved in demand response (DR) programs, generating revenue of nearly $3 billion worldwide in 2013, $2 billion in the United States alone, with both U.S. and global markets growing nearly 70% in the past year. (See Figure 7)

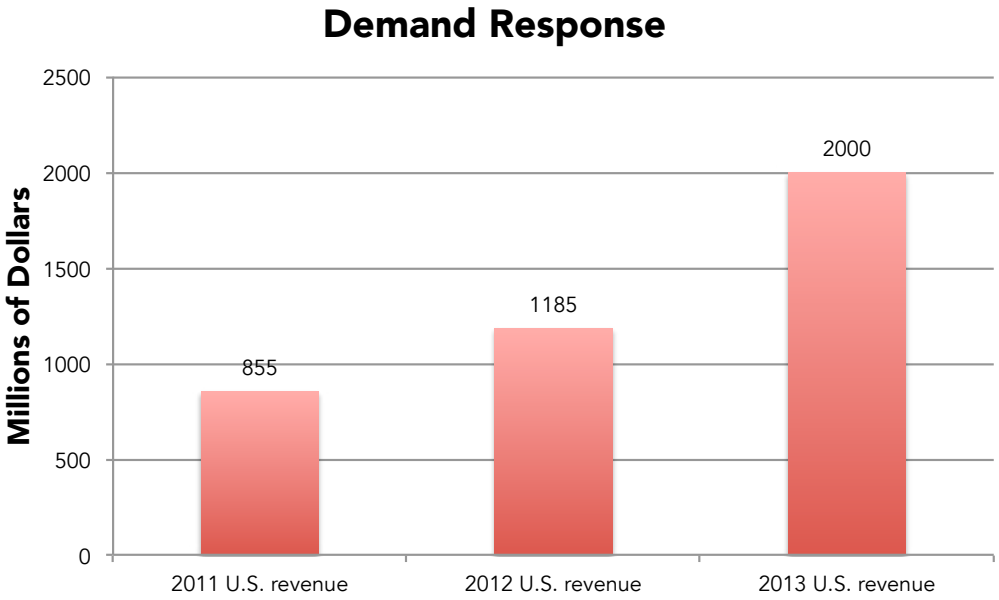


Figure 7 (Source: Navigant Research)

DR programs provide financial compensation to customers who contribute to energy load reduction during times of peak demand when grid capacity is strained and electricity is the most expensive. Customized for each facility, DR energy reduction measures can include turning down (or off) lighting, air conditioning, pumps, and other non-essential equipment. In some regions, facilities may participate in DR by switching to backup generation, thereby reducing demand on the grid. DR programs and services are increasingly targeting commercial buildings, which, on a global basis, consume 23% of all electricity. Power consumption of commercial buildings has, at various points, exceeded 50% of peak loads in the United States.

Building owners and operators are increasingly interested in DR as a source of revenue, and utilities are now tailoring their DR services for the commercial sector. To date, the majority of the commercial customers engaging in DR programs have been large businesses and institutions. Now, utilities, grid operators, and DR service providers are turning their attention to underserved small and medium-sized commercial business and institutional customers, which account for a significant number of facilities and sites that can contribute a considerable amount of DR during a peak event. Global revenue for DR in the commercial sector alone is forecast to grow from $278 million in 2012 to over $712 million in 2018.

DR resources made significant contributions to balancing supply and demand during system emergencies for several U.S. Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs) in the summer of 2013. Heat waves in the eastern United States in the third week of July and in mid-September drove demand for electricity to record levels in some areas. The New York ISO activated DR every day for a full work week in July downstate and for two days in a row for the entire state. In the PJM ISO (which primarily serves mid-Atlantic states) during that same week, resources were dispatched for several days in multiple zones, mostly in its Eastern territory.

The advent of Automated Demand Response (ADR), which will ultimately enable real-time optimization of advanced HVAC, lighting, water heating, and other systems, looks especially promising, especially in Asia Pacific, which will most likely leapfrog directly to ADR as the market accelerates. Japan is turning to DR in light of its dearth of natural resources for electricity and the crisis in the country's nuclear industry following Fukushima. In Europe, the need to integrate variable resources like wind and solar power will drive utilities to implement ADR programs.

Navigant Research forecasts that global load curtailment from all DR resources will grow from 55,638 MW in 2013 to 155,479 MW in 2020.

Industry

Industry is the sixth largest Advanced Energy segment globally, with an estimated $38.5 billion in 2013 revenue. Industry is comprised of two subsegments quantified here, Industrial Combined Heat and Power (CHP), with 2013 revenue of $27.2 billion (up 19% from 2012, 31% from 2011), and Manufacturing Machinery and Process Equipment, with global revenue (reported this year for the first time) of $11.3 billion (up 8% from 2012, 16% from 2011). Industrial Energy Management Systems is the only product category quantified within Manufacturing Machinery and Process Equipment.

U.S. revenue in advanced energy for Industry increased nearly 60% over two years to an estimated $6.7 billion in 2013, compared to $5.5 billion in 2012 and $4.2 billion in 2011. Industrial CHP revenue in the United States grew to $3.1 billion in 2013, compared to $1 billion in 2011, an increase of 200% over two years. U.S. Manufacturing Machinery and Process Equipment (consisting entirely of Industrial Energy Management Systems) grew steadily at 7% annually, or 15% over two years, to $3.7 billion in 2013, up from $3.4 billion in 2012 and $3.2 billion in 2011.

Industry	2011 Global Revenue (millions)	2012 Global Revenue (millions)	2013 Global Revenue (millions) (estimated)
Manufacturing Machinery and Process Equipment	$9,773	$10,513	$11,340
Combined Heat and Power	$20,803	$22,812	$27,155
Industry Subtotal	**$30,576**	**$33,325**	**$38,495**
	2011 US Revenue (millions)	**2012 US Revenue (millions)**	**2013 US Revenue (millions) (estimated)**
Manufacturing Machinery and Process Equipment	$3,184	$3,414	$3,669
Combined Heat and Power	$1,018	$2,038	$3,064
Industry Subtotal	**$4,202**	**$5,452**	**$6,733**

Table 7 (Source: Navigant Research)

Industrial CHP Gets Federal Nod and Gains Traction

Combined Heat and Power (CHP), or cogeneration, achieves greater levels of overall efficiency by simultaneously generating electricity and useful heat. It allows facility owners to reduce their fuel expenses while also cutting emissions. Approximately 82 gigawatts (GW) of CHP capacity was in operation across the country by mid-2011.[3] The United States currently accounts for one-quarter of CHP capacity installed globally. Industrial CHP currently represents more than 75 GW of electric capacity, or 7% of the country's total installed electric generating capacity. Refineries processing petroleum and manufacturing chemicals account for nearly 40 GW.

3. According to the U.S. CHP database, maintained by ICF International on behalf of Oak Ridge National Lab (ORNL) and the Department of Energy (DOE).

Although comprised of a relatively broad base of CHP deployments across a number of applications and industries, the U.S. CHP industry has room to grow as measured against leading markets like Denmark, the Netherlands, and Finland. Installed CHP capacity accounts for more than 30% of total generation capacity in these countries, compared with 7% in the United States. Federal agencies and CHP supporters estimate that CHP could make up 20% of U.S. electric generating capacity if fully utilized.

In August 2012, President Obama issued an executive order that called for 40 GW of new CHP capacity to be deployed in the industrial sector, representing an increase of 50% over the current installed base. Although non-binding, the order seeks to stimulate $40 billion to $50 billion in new capital investment. Meanwhile, a surge in natural gas production, along with lower prices, is expanding the field of potentially viable projects. More than 65% of CHP capacity operating within the country uses natural gas as a primary fuel source.

Today, 23 states recognize CHP in one form or another as part of their Renewable Portfolio Standards (RPS) or Energy Efficiency Resource Standards. A number of states, including California, New York, Massachusetts, New Jersey, and North Carolina, have specific incentive programs for CHP.

In the oil- and gas-rich state of Texas, CHP has thrived despite low electricity rates and narrow spark spreads (the difference between the delivered electricity price and the total cost to self-generate electricity, a widely used measure of CHP viability). The state accounts for 17 GW of installed CHP, or 21% of total U.S. capacity. Texas is home to 5% of the world's refining capacity, and facilities that produce commodity products and which have high around-the-clock thermal loads (typically steam) are the best candidates for CHP. Bills signed into law by Texas Governor Rick Perry supporting CHP technology in mid-2013 also removed regulatory barriers, improving the business climate for CHP facilities in Texas.

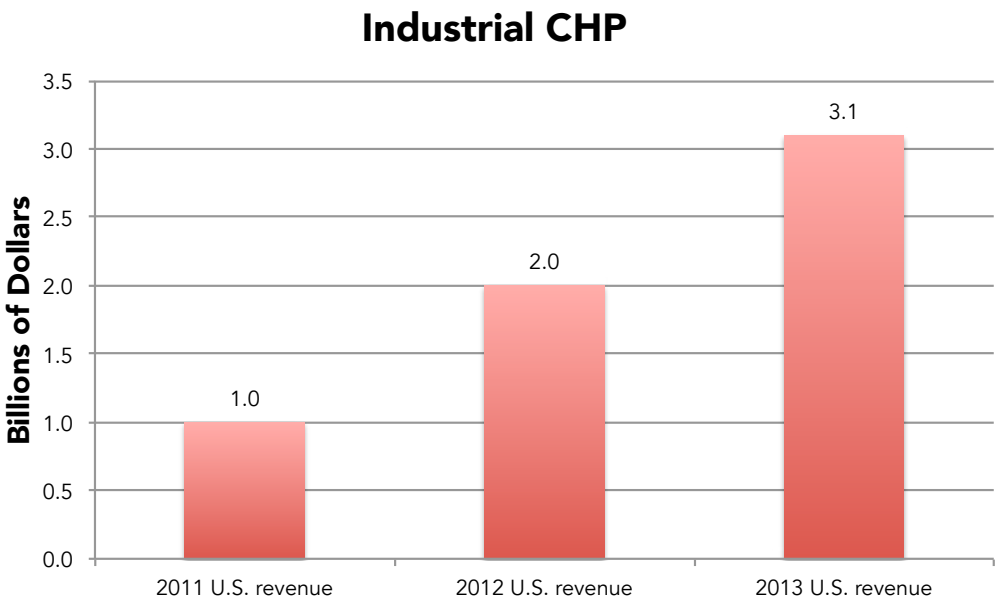


Figure 8 (Source: Navigant Research)

For the United States as a whole, the trend toward more distributed generation, and electricity grids capable of supporting and integrating related technologies, is opening up opportunities CHP to expand power generation capacity while reducing demand-side pressure on the grid. After declining dramatically in the first decade of the 21st century, from an average 2,700 MW installed annually between 2000 and 2004 to 207 MW a year from 2005 to 2010, the CHP market appears to be picking up. (See Figure 8) Industrial CHP revenue doubled between 2011 and 2012, from $1 billion to $2 billion, then increased another 50%, to an estimated $3.1 billion, in 2013, for growth of 201% over two years.

Industrial Energy Management Systems Improve Efficiency and Profits

Industrial companies that have high energy use can benefit immensely from understanding and managing energy consumption within their facilities and throughout the entire enterprise. The implementation of an industrial energy management system (IEMS), which is composed of both software applications and onsite services, has become critical to manufacturing's financial performance. IEMS involves the monitoring and measurement of a wide variety of energy-related inputs. These include electricity, gas and other fuel sources, water, steam, and compressed air, among others. An IEMS provides the capability to bring information and knowledge of all aspects of energy-related matters into the present, where cost-effective tactics can be employed before high charges or inefficient usage occur.

In the United States, revenue from deployment of Industrial Energy Management Systems grew steadily at 7% annually, or 15% over two years, from 2011 to 2013, reaching an estimated $3.7 billion in 2013, up from $3.4 billion in 2012 and $3.2 billion in 2011. (See Figure 9)

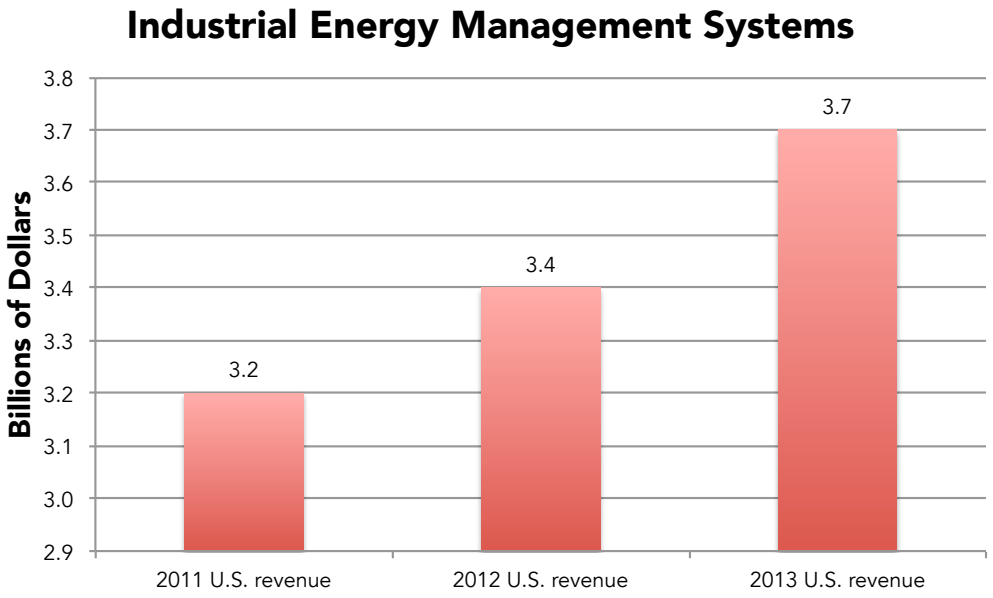


Figure 9 (Source: Navigant Research)

According to the U.S. Energy Information Administration (EIA), four industrial sectors – petroleum refining, chemicals, paper, and metals – use the bulk of energy consumed in the United States, accounting for about 75% of all industrial energy consumption.

Technology, processing capabilities, software applications, and business intelligence insights are progressing quickly in the IEMS market as vendors apply the latest innovations and advancements from other markets and application areas to the industrial sector. This aspect of the market is highly competitive, as vendors feel pressure to be on the leading edge of technology and data analytics.

Companies such as Schneider Electric, Siemens, Invensys, and Rockwell Automation have been leading players in this market for a long time. The landscape is shifting, though, and large IT companies like SAP and IBM are gaining market share with their capacity to handle large data sets and their experience with enterprise-level business analytics. Other smaller niche companies are also participating in the IEMS market with unique product and service offerings. However, these companies generally require partnering relationships with the larger, more established vendors in order to access the market. In general, partnering is prevalent as complete, best-in-class solutions are difficult to accomplish within the context of a single company. Although many regions of the world, including North America and Europe, are still recovering from the effects of the global recession, making industrial companies cautious about investment – including investment in IEMS – annual global IEMS revenue is forecast to grow from $11.3 billion in 2013 to $22.5 billion in 2020. The North American market is expected to be the largest global region for IEMS revenues, but only by a slim margin over Europe, followed by Asia Pacific, led by China.

Electricity Generation

In 2013, Electricity Generation remained the largest advanced energy segment by global market size with estimated revenues of $384.2 billion, accounting for 34% of the overall total. (See Table 8) While this represents an increase of 5% compared to 2012 (not counting Natural Gas Generation Sets for backup generation, which are quantified for the first time in 2013), the 2013 total is down 29% from 2011, when governments around the world were spending billions on energy infrastructure as part of economic stimulus programs.

Continuing as the leading source of revenue in the Electricity Generation segment, worldwide orders for hydropower plants rose by nearly 17% in 2013, to an estimated $106.8 billion, though even that was down from $257 billion in 2011. China and India are the key markets for hydropower, with several large hydropower projects coming online over the coming decade. Hydropower is followed by Solar with an estimated $96.8 billion in revenue, up 10% from 2012, and Wind with an estimated $67.7 billion. Nuclear orders have continued to slow globally, with revenues dropping from $53.4 billion in 2011 to $45.7 billion in 2013. Nuclear orders continue to be delayed and cancelled in Western Europe, North America and other markets. China remains the most significant market for nuclear orders over the coming decade and has invested heavily in domestic uranium mining operations.

In the United States, Electricity Generation reached an estimated $31.3 billion in 2013 revenues, down 31% from 2012 but up 5% over 2011. Gas Turbines, Natural Gas Combined Cycle, and Hydropower all suffered from reduced orders in 2013, and Wind revenue fell precipitously, from $25.5 billion in 2012 to $2.1 billion in 2013 – though 2014 and 2015 are expected to be closer to 2012 levels. Meanwhile, there was strong growth in revenue in these Electricity Generation subsegments: Solar (up 65% over 2012 to $19.5 billion), Waste (up 90%, to $550 million), Geothermal (up 15%, to $833 million), and Biomass (up 50%, to $900 million), and Fuel Cells and Other Distributed Generation (up 57% to $142.7 million, plus an additional $1.9 billion in revenue from Natural Gas Generator Sets for backup power in 2013 for a total of $2 billion).

Electricity Generation	2011 Global Revenue (millions)	2012 Global Revenue (millions)	2013 Global Revenue (millions) (estimated)
Solar	$96,193	$87,672	$96,828
Wind	$67,069	$82,111	$67,685
Geothermal	$666	$1,730	$1,470
Hydro	$256,984	$91,260	$106,756
Marine	$300	$140	$0
Waste	$4,700	$2,750	$5,910
Biomass	$10,500	$7,200	$14,700
Nuclear	$53,433	$47,944	$45,672
Gas Turbines	$41,742	$37,986	$38,403
Fuel Cells and Other Distributed Generation	$755	$1,009	$6,770
Electricity Generation Subtotal	**$532,342**	**$359,802**	**$384,194**
	2011 US Revenue (millions)	**2012 US Revenue (millions)**	**2013 US Revenue (millions) (estimated)**
Solar	$8,246	$11,850	$19,519
Wind	$12,993	$25,461	$2,060
Geothermal	$118	$723	$833
Hydro	$1,203	$943	$845
Marine	$30	$0	$0
Waste	$640	$290	$550
Biomass	$300	$600	$900
Nuclear	$0	$0	$0
Gas Turbines	$6,117	$5,428	$4,553
Fuel Cells and Other Distributed Generation	$182	$91	$2,013
Electricity Generation Subtotal	**$29,829**	**$45,385**	**$31,273**

Table 8 (Source: Navigant Research)

Below, we look more closely at the major trends in advanced Electricity Generation, namely the impact of natural gas, the dramatic growth of solar, and the rollercoaster in U.S. wind energy.

Natural Gas Disrupts U.S. Power Markets, But Causes No Equipment Boom

The boom in natural gas has dramatically changed the nature of electricity on the U.S. power grid today. The increased supply of natural gas from hydraulic fracturing is resulting in prices low enough to displace existing and proposed coal and nuclear power generation for the foreseeable future (and also accelerating demand for natural gas vehicles; see Transportation). Utilities across the country, including Duke, Dominion, and American Electric Power, are planning to retire or offload coal plants and make up the difference with natural gas. Over time, the role of natural gas has shifted from producing power during times of peak demand to providing baseload power.

For the most part, the existing natural gas generating capacity built during the past 20 years is running at higher utilization, effectively absorbing the new gas supply. This explains, in part, why the natural gas boom has not led to a commensurate uptick in orders for new gas turbine or combined cycle plants. The other major factors are slow economic growth and flat or declining electricity use, with energy efficiency and, to an extent, solar PV and wind power offsetting fossil fuel generation. Overall, U.S. orders of combined cycle plants have declined in the past two years, dropping from $4.7 billion in revenue in 2011 to an estimated $3.7 billion in 2013, while orders for simple cycle gas turbines dropped 14% from 2012 to $811.7 million estimated in 2013. (See Figure 10)

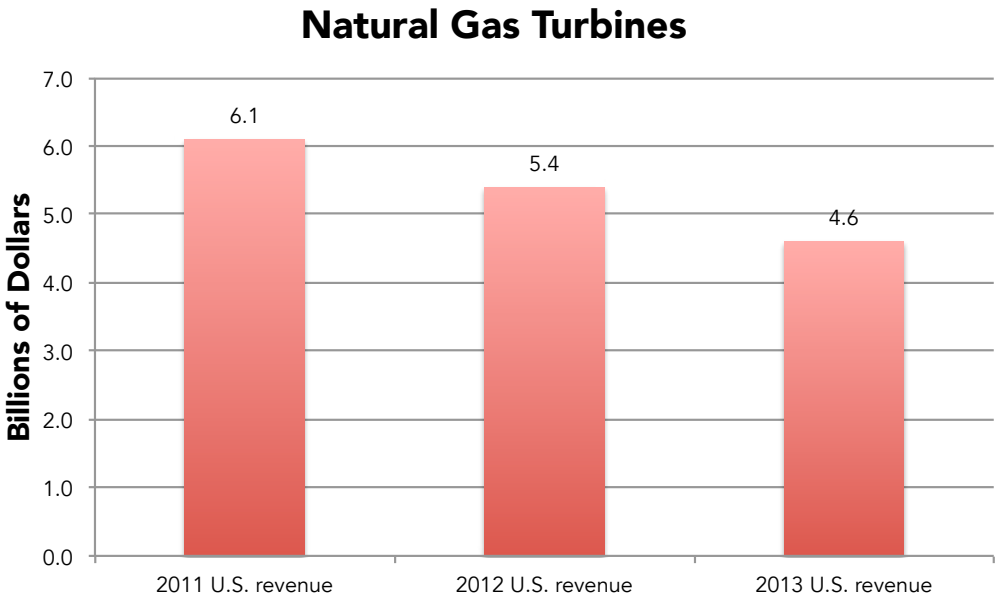


Figure 10 (Source: Navigant Research)

By contrast, electricity demand growth is picking up in the Far East, Middle East and Africa. Simple cycle gas turbines are generally the lowest cost technology for adding capacity in these markets and increasing availability of natural gas has helped to support adoption. As a result, orders for these gas turbines have increased 36% globally compared to 2012, to $7.5 billion. Meanwhile, combined cycle sales have declined over the past two years, from $34.7 billion in 2011 to $30.8 billion in 2013.

As a sign of things to come, however, GE has developed high efficiency combined cycle power plants capable of ramping up and down quickly – reportedly from 750 MW down to 100 MW and then back up again at a rate of 100 MW per minute. This will be important for increasing grid flexibility, particularly in regions with high penetration of renewables. GE has reported large orders of these units for 2015 delivery in Japan, Saudi Arabia, the United States (notably Colorado), and other locations.

United States Becomes a Leading Market for Solar PV

As a result of growth in the past year, the United States has become the third largest market in the world for Solar PV. U.S. installations totaled an estimated 4.5 GW in 2013, representing $16.2 billion in revenue – a nearly 100% increase over 2011. (See Figure 11) Module manufacturers have driven down costs and scaled up production. Between 2010 and 2012, global solar PV module manufacturing capacity nearly doubled from 36 GW to 65 GW, depressing module prices and profitability, thus leading to extensive bankruptcies, mergers and acquisitions, and even international trade disputes. But lower prices also spurred sales and deployment of this technology as it became more affordable compared to alternatives.

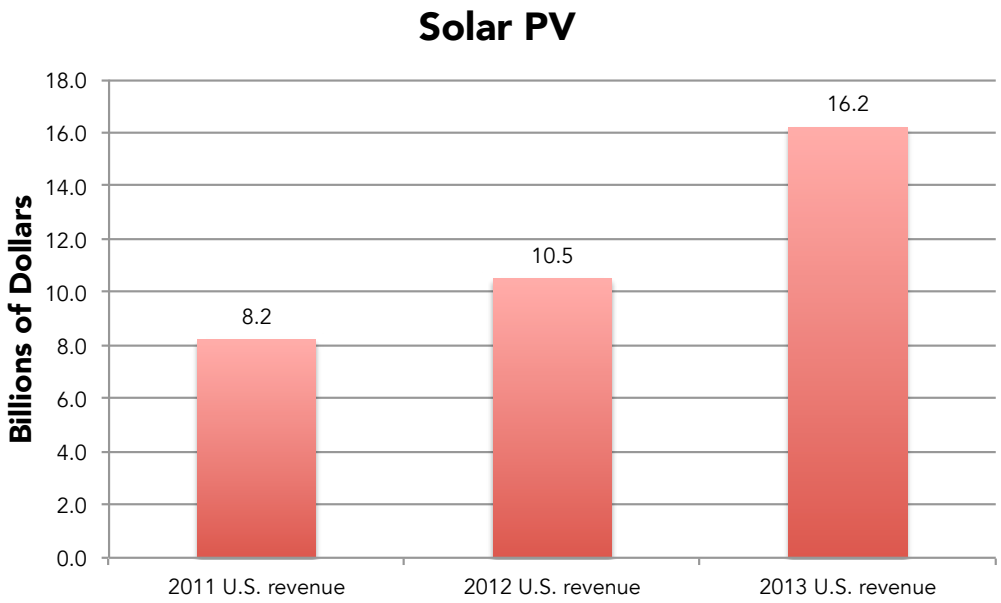


Figure 11 (Source: Navigant Research)

In the United States, renewable portfolio standards, many with specific requirements for solar, are the main policy tool driving the deployment of utility-scale solar PV. This includes the largest solar PV plant in the world (currently at 250 MW), Agua Caliente in Yuma Arizona, which will reach 290 MW at full capacity in 2014, owned by NRG Energy and MidAmerican, and built by First Solar. While no federal renewable portfolio standard or solar PV-specific target exists, the federal 30% Investment Tax Credit (ITC) is available through 2016 and plays a major role in PV competitiveness. Accelerated deprecation was also available through the end of 2013, but has since returned to its normal five year schedule. When coupled with the 29 states, Washington D.C., and two territories that have renewable portfolio standards, especially those with solar carve-outs, there are a number of attractive regional PV markets. States with aggressive goals in which solar PV is expected to play a key role include Hawaii (40% renewable energy by 2030), California (33% by 2020), and New York (29% renewable energy by 2015). North Carolina and Georgia are two new markets that are seeing strong growth as well.

There is surging demand for distributed solar PV on residential rooftops and on or nearby commercial buildings. With state and federal incentives, these systems are cost effective in many markets, and as the supply chain continues to mature, distributed PV is approaching grid price parity, even without incentives, in some parts of the country. The growth of solar leases and residential power purchase agreement (PPA) options, under which solar PV can installed for little to no money down, has led to a more than doubling of the annual US distributed solar market since 2011. Companies such as SolarCity, Sungevity, SunRun, and others have become household names in a growing number of states as the majority of residential solar customers now elect to lease their systems instead of owning.

With the closure of numerous Chinese module manufacturing plants, supply and demand were brought more into balance in 2013. This balance is set to further improve over the next three years, adding stability to the market. In the United States in particular, soft costs, such as customer acquisition and permitting, are now increasingly the focus for reducing the installed cost of solar PV. Navigant Research forecasts revenue from global solar PV installations to reach a cumulative total of $840 billion between 2014 and 2020, with the United States accounting for more 14% of that total.

Wind Sees a Boom in China, Wild Swings in the United States

The global market for wind power in 2013 was an estimated $67.7 billion, down 18% compared to 2012 ($82.1 billion), but up slightly from 2011 when revenue reached $67 billion. At an estimated 15 GW of new installed capacity, China represented nearly 40% of all new wind installed globally last year. For comparison, all of Europe installed an estimated 12 GW. China's 2013 total is down from a high of approximately 19 GW in 2010, though not all of these installations are connected to the grid. The National Development Reform Committee's wind power development roadmap calls for wind to account for 17% of China's total electricity production by 2050. In order to reach this target, 200 GW of wind power will need to be installed by 2020, 400 GW by 2030, and 1,000 GW by 2050. There are considerable opportunities for installations in low wind speed, low temperature and high altitude areas throughout the country. China's "Big 5" state-owned power producers have developed the vast majority of the country's wind power to date and benefit from having the global manufacturing hub in their backyard. Goldwind, United Power, and Minyang have gained in global market share in 2013 as a result of reduced orders from perennial wind turbine market leaders Vestas and GE.

In the United States, the January 2013, one-year extension of the production tax credit (PTC) and investment tax credit (ITC) came too late to prevent a significant slowdown following the record year of 2012, when 13.1 GW was installed, representing $25.5 billion in revenues. 2013 installed capacity fell more than 90% to 1.1 GW representing only $2 billion in revenue. (See Figure 12)

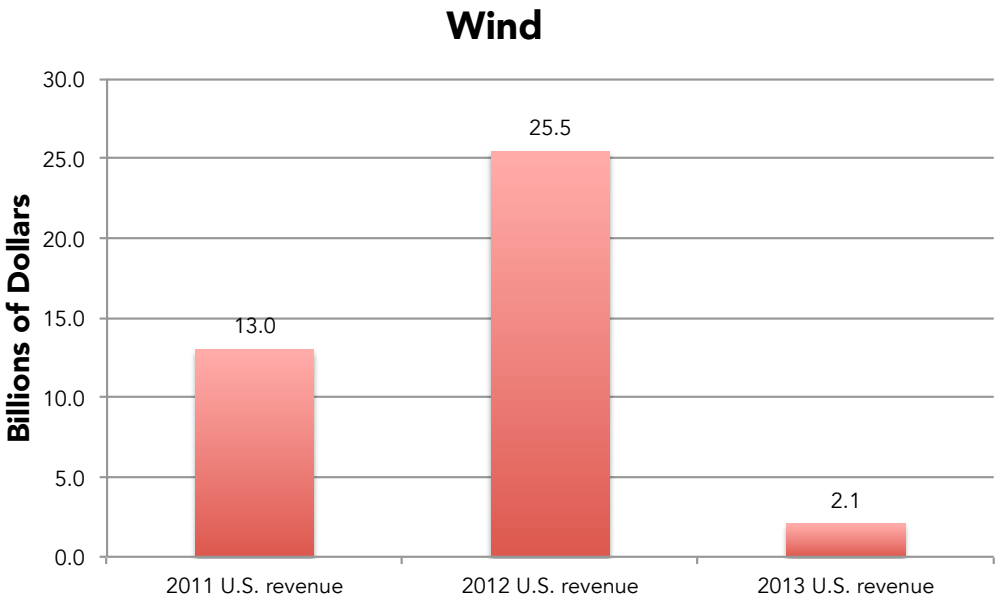


Figure 12 (Source: Navigant Research)

Still, the wording of the 2013 extension of the PTC and ITC changed the terms of eligibility, requiring either construction to begin or 5 percent of project costs to be incurred by the end of 2013, rather than requiring the installation to be operational. As a result, some 12 GW of wind orders are now in the works and will show revenue in 2014 and 2015. Vestas, for example, took in orders for up to 1.7 GW in the second half of 2013, mostly for projects in Texas and Oklahoma. In late December 2013, Siemens secured 468 MW in orders for Cape Wind, the first offshore wind project planned for the United States, off the Massachusetts coast. Despite this revived pipeline, without further extension of the PTC/ITC, or some other alternative, the U.S. wind market could once again dwindle.

Electricity Delivery and Management

Electricity Delivery and Management is the fifth largest Advanced Energy segment globally with an estimated $63.6 billion in revenue in 2013. (See Table 9.1) Enabling Information and Communication Technology (ICT) was the largest subsegment with revenue of $29.3 billion (up 4% from 2012). Smart Street Lighting was a new product category quantified under the Enabling ICT subsegment and, at $17.8 billion in 2013, accounted for 60% of the subsegment total. Transmission moved down to the second largest subsegment with an estimated $13.8 billion in revenue in 2013, followed by Distribution ($8 billion) and Advanced Metering Infrastructure ($7.4 billion). In 2013, Microgrids, Energy Storage, and Charging Infrastructure all saw strong growth, although from smaller bases, with an estimated $3.7 billion, $727 million, and $567 million in revenue respectively.

Excluding the new Smart Street Lighting product category, Electricity Delivery and Management revenue was down 3% in 2013. The United States accounted for a significant portion of this decline, with revenues down 27% from 2012. (See Table 9.2) The U.S. total, estimated at $11.6 billion in 2013, includes $3.9 million from Smart Street Lighting, systems that manage street lights remotely to detect burned out lamps, adjust to weather and traffic conditions, and flash in case of emergency, among other functions. (See Table 9.2) Transmission infrastructure investment, which boomed under the federal economic stimulus program has been on a falloff thereafter. In 2013, U.S. Transmission revenue was down nearly 50% compared to 2011, primarily as a result of High Voltage Direct Transmission Systems (HVDC) dropping from a peak of $1.9 billion in 2012 to an estimated $330 million in 2013. The same is true for Smart Meters and Advanced Metering Infrastructure. Revenue in this category fell to $996 million, a drop of 30% from the $1.4 billion it achieved in both 2011 and 2012. Despite the contraction of the U.S. Electricity Delivery and Management segment overall, three of the seven subsegments experienced strong growth from 2011 to 2013: Distribution ($1.6 billion, 47% growth over two years), Microgrids ($755 million, 92% growth), and Charging Infrastructure ($102 million, 278% growth).

Electricity Delivery & Management	2011 Global Revenue (millions)	2012 Global Revenue (millions)	2013 Global Revenue (millions) (estimated)
Transmission	$9,808	$17,894	$13,839
Distribution	$5,998	$7,383	$8,021
Advanced Metering Infrastructure (AMI)	$6,776	$7,409	$7,392
Microgrids	$2,560	$3,124	$3,829
Charging Infrastructure	$127	$355	$567
Energy Storage	$117	$791	$727
Enabling Information and Communication Technology	$9,351	$28,066	$29,275
Electricity Delivery & Management Subtotal	**$34,735**	**$65,022**	**$63,649**

Table 9.1 (Source: Navigant Research)

Electricity Delivery & Management	2011 Global Revenue (millions)	2012 Global Revenue (millions)	2013 Global Revenue (millions) (estimated)
Transmission	$1,147	$2,133	$576
Distribution	$1,064	$1,322	$1,566
Advanced Metering Infrastructure (AMI)	$1,949	$2,228	$1,785
Microgrids	$394	$556	$755
Charging Infrastructure	$27	$92	$102
Energy Storage	$81	$360	$158
Enabling Information and Communication Technology	$3,328	$7,694	$6,664
Electricity Delivery & Management Subtotal	**$7,990**	**$14,385**	**$11,605**

Table 9.2 (Source: Navigant Research)

Along with energy storage, we review key developments in two of these fast-growing technology areas. Although revenue in these categories is still relatively small, each of these three technologies has the potential for significant growth as power sources become more diversified and energy is used and managed in new ways.

Energy Storage Looks to Fill Gaps

Variable electricity generation sources such as wind and solar photovoltaics (PV) continue to reach higher penetration levels on the grid, with an estimated 73 GW added globally in 2013 alone. In October 2013, Germany hit a momentary peak of nearly 60% generation from wind and solar. That same month in Denmark, wind production supplied 122% of the country's power needs; spread across 2013, there were more than 90 hours in 2013 when wind produced more than 100% of Denmark's power needs. High penetration of these power sources is not limited to Europe. In one day in May 2013, wind power represented 60% of Xcel Energy's load in Colorado between 1 a.m. and 2 a.m. The challenge now is to better align variable electricity production with demand throughout the day, creating a tremendous market opportunity for energy storage.

Energy storage systems (ESS) are gaining the most traction in the major markets for renewables – including Germany, Japan, and the United States – which have enacted rules or legislation specifically to encourage the adoption of ESS for the purpose of integrating variable energy sources into the grid. Market incentives come in various forms, including outright subsidies for ESS adoption, reforms that change how variable generation is compensated, and adjustments to connection requirements for variable power plants.

Within energy storage, many technologies are looking to compete for market share for wind and solar integration, such as compressed air energy storage (CAES), hydrogen, and various advanced battery technologies, including advanced lead-acid, lithium ion, flow, sodium sulfur, sodium metal halide, and liquid metal. Another technology is pumped storage, in which water is pumped to a reservoir during off-peak hours then allowed to flow and generate electricity during times of peak demand. The technology is mature but is feasible only in sites where reservoirs can be built. Each storage option offers something unique in terms of operating and performance profiles, and many face questions about scalability. But already energy storage has grown from roughly $100 million in global revenue in 2011 to over $700 million in 2012 and 2013.

Alternatives to energy storage, including demand response (DR) and fast-starting natural gas-fired generation, offer some advantages – such as requiring less capital investment or greater market familiarity – but ESS have the advantage of more technical flexibility, particularly at the residential level where retail electricity rates are highest. This is why Germany has adjusted its feed-in tariff to prioritize on-site consumption, and Japan has incentives for energy storage. In California, the three largest investor-owned utilities – Pacific Gas & Electric, San Diego Gas & Electric, and Southern California Edison – are now required to secure a combined 1.3 GW of energy storage by 2020. While the majority of this target will be met through larger installations supporting the transmission and distribution systems, 200 MW of customer-sited storage is required across the three utilities. Companies are already offering energy service models in residential and commercial markets that include ESS, often in conjunction with solar PV. Overall, the ESS market for solar PV and wind alone is expected to reach 5.5 GW by 2023, representing $10.3 billion in revenue.

Like all new technologies, price continues to be a challenge, particularly for advanced batteries, but the future is bright. Other technologies, such as solar PV and wind were also once prohibitive, but we have witnessed steady improvements in price, driven by both technology innovation and industry scale, and there is every reason to expect similar developments with advanced batteries.

Microgrids Catch On

Microgrids, as the name implies, are small versions of our large electricity networks. Normally, grid-tied microgrids operate in parallel to main larger grid, i.e., they are interconnected and synchronized. But they also have the ability to disconnect and run independently ("islanded") to provide 24/7 energy services regardless of the status of any larger utility grid network. Depending on the connected generation sources, they may simultaneously reduce air emissions and fuel price volatility. Microgrids may also be designed to operate solely as grid independent systems, such as in rural areas not served by the larger grid (e.g., village power in Alaska and in developing countries).

Interest and investment in microgrids has grown, particularly during the past five years in response to the increase in extreme weather events, the higher penetration levels of distributed generation, and in some cases, declining quality of power service from the grid (especially in developing countries). In the United States, one of the most established forms of microgrid – CHP-based systems on college campuses – proved their value in Superstorm Sandy, as NYU and Princeton both stayed warm and lit while the grid around them went dark. More sophisticated forms of microgrid, in which portions of the power grid reconfigure themselves automatically to isolate outages and reroute power, are now being piloted at military bases. Still other microgrids that are aggregating diverse sets of both distributed renewable and fossil assets are fully operation on a commercial basis in California, including the 42 MW University of California-San Diego microgrid, San Diego Gas & Electric's 4 MW Borrego Springs microgrid, and the Santa Rita Jail 3.6 MW microgrid in Alameda County.

Microgrid installations at military bases, universities, remote communities in Alaska and Hawaii, and other applications will keep the United States in its leadership position in terms of microgrid deployment out to 2020, when the annual market is forecast to reach $20 billion. From 2011 to 2013, U.S. microgrid revenue grew from $399 million to $755 million. (See Figure 13) At the same time, the prospect of remote microgrids is gaining traction as a way to finance rural electrification in the developing world as well as in especially remote regions of developed countries.

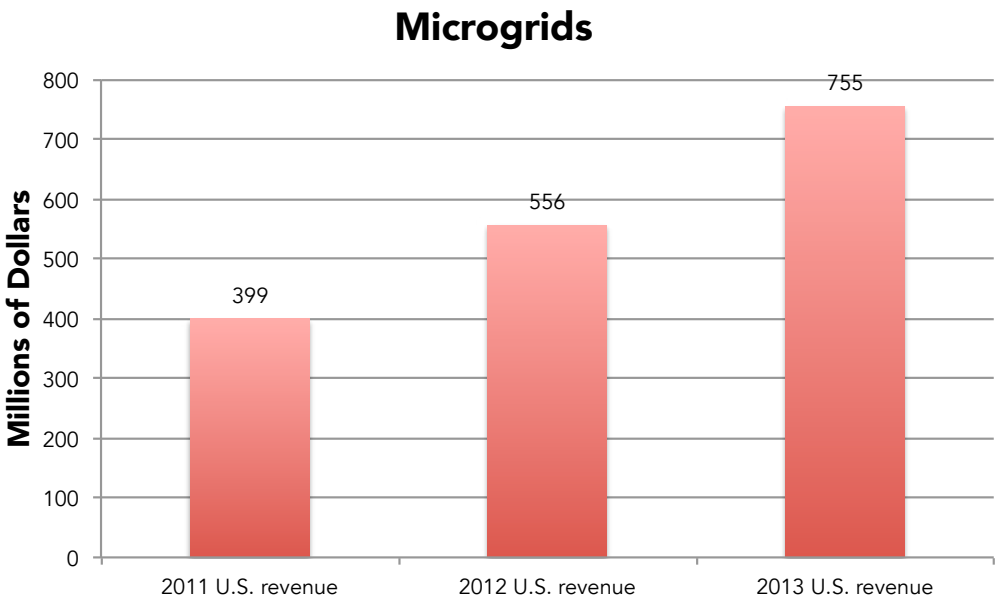


Figure 13 (Source: Navigant Research)

One of the current market leaders for remote microgrids is India, which has deregulated all remote microgrids under 1 MW. India is a hotbed for pay-as-you-go business models focused on off-grid small solar PV systems, some of which qualify as microgrids. It leads the top 10 non-U.S. countries in remote microgrid capacity in 2013, with an estimated 7 MW online. This capacity is forecast to grow to 54 MW by 2020 at a CAGR of 33.9%.

China has been investigating microgrids for the past three or four years, and the 12th Five-Year Plan for energy production, produced by the Energy Bureau, sets a target of 30 microgrid installations of 1 MW or larger by 2015. China is expected to be ranked as the top non-U.S. microgrid market by 2020. Three of the top five markets (China, Australia, and India) will be led by remote off-grid systems.

One of the sleeper markets for microgrids not currently in the top 10 is South Africa, which is largely served by the national utility Eskom. Eskom provides the country with 95% of its power and supplies 45% of the entire African continent's power. At present, an unspecified number of remote microgrids that incorporate solar PV, wind, diesel, and energy storage have been installed. Ranging in size from 6 kW to 200 kW, these systems serve farms and entire off-grid communities. A typical community of 100 homes would need a remote microgrid of 100 kW to meet its most basic needs for lighting, entertainment, and refrigeration. The best near-term market segment for microgrids in South Africa, though, is not communities but the numerous remote platinum, gold, and coal mines that dot the country – and where projects in the design stage range from 30-50 MW.

Electric Vehicle Charging Infrastructure Presents Challenge and Opportunity for Utilities

The Electric Vehicle Supply Equipment (EVSE) market has seen 347% growth globally since 2011 with estimated revenue of $567 billion in 2013. The U.S. market for charging infrastructure grew at an impressive, though slightly slower, pace of nearly 280% during this time, and represented 18% of the global 2013 EVSE market with an estimated $102 billion in revenue. (See Figure 14) Government programs have continued to support deployment, and companies have competed to bring less expensive or better featured products to market. Residential charging equipment is directly driven by the increase in Plug-in Electric Vehicle (PEV) sales, as many drivers purchase a charger for exclusive use at home. Commercial charging, which includes workplace, public and private chargers, is also tied to PEV growth, both actual and anticipated.

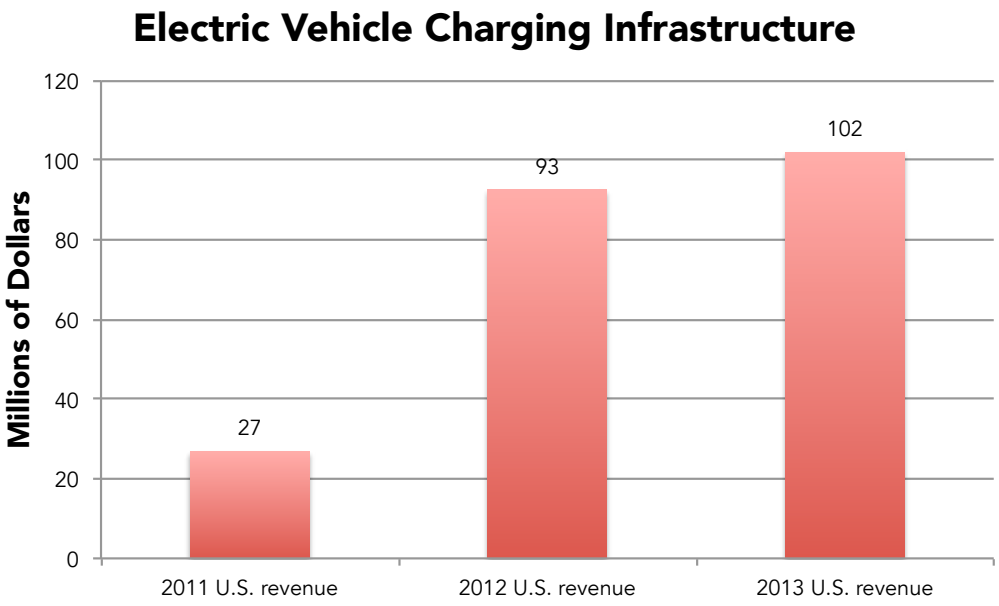


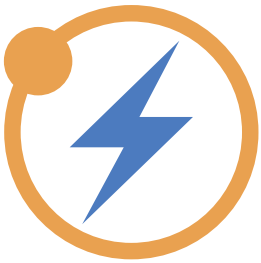
Figure 14 (Source: Navigant Research)

More than 435,000 PEVs will be sold globally in 2013, and growth is expected to continue at a steady pace. The EVSE market is growing steadily in response, both in the residential charger and commercial charger market. As the market matures, some of its early challenges are dissipating. For example, in the first year of PEV introductions, there were some growing pains regarding compatibility of charging units with various PEV models.

Utilities stand to gain additional revenue from increasing rates of PEV adoption, as drivers charge up with electricity instead of fill up at the gas pump. While utilities look forward to that growth, the planning process for it is not straightforward, as utilities face competing demands as regulated entities.

In North America, utilities in most cases have not owned or operated charging stations. States are beginning to decouple EV charging from utility regulation, and some utilities are developing business models for their own networks. In Texas, NRG Energy has developed the eVgo network in Houston and the Dallas/Fort Worth area, and begun developing eVgo networks in California and Washington, D.C., as well. Also in Texas, Austin Energy has created the Plug-in EVerywhere network in that city, while the municipally owned utility in San Antonio, CPS Energy, has also installed a network of charging stations. On the commercial side, California-based ChargePoint has created a network of 15,000 charging stations in the United States, Europe, and Australia.

Overall, Navigant Research expects global sales of EVSE to grow from around 442,000 units in 2013 to 4.3 million in 2022, a compound annual growth rate (CAGR) of 28.8%. Revenue from the sales of EVSE is expected to grow from $567 million in 2013 to $5.8 billion in 2022 at a CAGR of 29%.



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