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Energy Technology Revolution (ETR)

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ETR Document Outline and Hyperlinks

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Two global technology revolutions are occurring today— the Energy Technology Revolution (ETR) and the Network Technology Revolution (NTR). Jobenomics addresses the NTR in a separate document (see http://jobenomicsblog.com/network-technology-revolution/).

The objective of this ETR report is to help decision-makers and opinion-leaders focus on the strategic value of the ETR with emphasis on the economics of business and job creation—the mission of Jobenomics.

This report addresses emerging ETR technologies, processes, systems and markets that can (1) provide affordable clean energy solutions, (2) achieve the climate change goal of limiting greenhouse emissions to a global temperature increase of 2°C over 2005 levels, and (3) improve national economies via implementing highly-scalable business initiatives that will create millions of new middle-class jobs.

Energy Technology Revolution Executive Summary

No one really knows how big the U.S. energy super-sector is in terms of economic impact and employment. Jobenomics estimates $1.2 trillion per year and 12 million Americans. Future U.S. energy employment will be determined by the churn of new businesses replacing old businesses, retrofitting/replacing old equipment, and exports of American goods and services. The ETR deals with a mix of traditional and emerging technologies, processes and systems that will create **tens of millions** of new jobs. Countries that have a national ETR strategy will claim the bulk of these jobs.

- Germany, China, India and California have aggressive ETR strategies. They are the ones to watch.
- U.S. energy consumption has largely peaked. However, global energy consumption is forecast to grow 33% by 2030—more than double the total U.S. consumption today. Export potential is huge.
- Cumulative global energy investment over the next two decades is projected to be $48 trillion which will not meet the climate change goal of limiting long-term temperature increase to 2°C. Instead, these investments (if realized) point to a 3.6°C increase. An additional $18 trillion is needed.
- Fiscally-driven government incentive programs have value. Politically-driven programs do not. Only the private sector has the wherewithal to fund the $18 trillion needed to meet the 2°C objective.
- Combatting climate change solely with renewable energy will not work. To achieve climate change goals, a balance of renewables, cleaner fossil fuels, nuclear and energy efficiency is needed.
- While U.S. renewable energy consumption is projected to grow significantly, it will supply only 9% of total U.S. energy needs in 2030 compared to 7% in 2013. Under current conditions, the U.S. renewable energy mix will not change much from 2013 to 2030: biomass/biofuel's share was 40% in 2013 and is projected to be 38% in 2030, followed by hydro 28% to 25%, wind 18% to 21%, wood 7% to 3%, municipal waste 5% to 4%, geothermal 2% to 5%, and solar 1% to 3%.
- A dozen sustainability issues (from hostile electric utilities, to low investor returns, to politicization and over expectations, to competing technologies and storage) challenge successful deployment of renewable technologies. Most challenges can be overcome expeditiously with technology

maturation and consensus-building. However, declining demand and over capacity will be more difficult. Growth of U.S. electricity demand has slowed in each decade since the 1950s. In 2017, U.S. electrical generation is projected to enter a 15-year depression that will depress utility-grade electricity generation projects. This depression is likely to have a major negative impact on the high-flying renewable energy industry. Reasons include: (1) many federal and state incentive programs are scheduled to expire or drop-down after December 2016, (2) existing electricity generation sources provide adequate capacity to meet slow electrical demand growth and satisfy renewable requirements under current state standards, and (3) competing technologies, especially natural gas, will claim the majority of new electricity generation additions.

- There are essentially three energetic architectures: (1) large, centralized, utility-grade designs, (2) medium-size utility-grade and grid-connected distributed generation designs, and (3) small-scale off-grid dispersed generation designs. If the U.S. utility-grade market drops precipitously as forecast, architectures (2) and (3) will offer the best way forward for the American energy industry. However, the U.S. government cannot account for (3), which will hinder policy and decision making.
- Net-zero communities could significantly reduce the $2.0 trillion needed by 2030 to modernize and protect the aging U.S. electrical grid that loses as much electrical energy as it delivers.

The U.S. fossil fuel versus renewable energy debate is politicized, acerbic and wrongheaded. The U.S. is the only country with the disposition and resources to lead the global community against the potential ravages of greenhouse gas emissions. The United Nations' goal of limiting global temperature growth to a 2°C increase is highly doubtful without the U.S. fully engaged from a systems-of-systems energy super-sector perspective. From a Jobenomics perspective, a combination of renewables, cleaner fossil fuels, nuclear, energy efficiency, and other ETR advancements is needed as outlined along the following lines.

- **Solar** power is the smallest but fastest growing energy sector in the U.S. and internationally. There are essentially four solar technologies: solar photovoltaic, concentrated solar power, solar thermal heating and cooling, and solar mobile. 2016 will be a peak year with 3.87GW of added U.S. solar capability. From 2017 to 2030, solar is projected to add only 1.43GW. On the other hand, small-scale **solar photovoltaics** (much of which is not accounted for in government projections) are likely to grow significantly, as the solar industry works out transition issues caused by the introduction of newer technology before older technologies are out of warranty. Over the last five years, solar photovoltaics (PV) employment has grown by 86% adding 80,000 new workers with an additional 36,000 anticipated in 2015. Today, out of 150 million U.S. homes and businesses, 600,000 now have gone solar, which leaves 99.6% of U.S. homes and businesses still available for solar energy service companies (ESCOs). ESCOs are making dispersed solar generation increasingly affordable to individual homeowners and small businesses due to lower installation costs, lower operational costs, smarter information and network technologies, and innovative leasing, subscription and net-metering services. Large-scale **concentrating solar power** (CSP) directs heat from the sun via mirrors to generate power. 19 countries have CSP projects that are operational or under development. The CSP industry should not be viewed as a large jobs producer but an industry that will mature over time. More than 30,000 **solar heating and cooling systems** (SHC) are being installed annually in the U.S., employing more than 5,000 Americans. 78 million SHC are operational worldwide. **Solar mobile** is a phrase that Jobenomics uses for portable and transportable solar applications that have the potential to create new industries (from aerospace to wearables), thousands of new businesses and millions of new jobs. *Jobenomics U.S. business and jobs creation outlook: very poor for concentrated solar, poor for large-scale utility-grade projects, excellent for small-scale residential and commercial PV, excellent for solar mobile, excellent export potential.*

- **Onshore wind** power generates 177 terawatt-hours today, but has the potential for producing 38,553TWh, enough to electrify America many times over. The total U.S. wind industry currently sustains about 85,000 jobs. In 2013, the U.S. and China were running neck-and-neck as leading wind power nations. 2015 is projected to be a great year for the U.S. with 10.7GW of new capacity. However, after 2016, the U.S. onshore wind power market is projected to drop precipitously, entering a 15-year depression, due to declining federal subsidies, ample generation capacity and slow demand growth. From 2016 to 2030, wind is projected to add only 10.6GW, collectively less than 2015 alone. As a result, a recent Wall Street publication rated the U.S. wind turbine installation industry as the third fastest dying U.S. industry. In comparison, China plans a 300% capacity increase by 2020 (85% onshore and 15% offshore). Europe has 66 **offshore wind** farms operational today. By 2030, the U.S. projects only one. With the decline in utility-grade projects, "small wind" may the future for the U.S. wind industry. There are four main market areas for small wind generation: residential, agricultural, government/institutional and industrial/commercial. In 2013, residential had the largest number of projects (40%) but the smallest amount of capacity (3%), followed by agriculture (26% projects, 7% capacity), government/institutional (14% projects, 37% capacity) and industrial/commercial (20% projects, 53% capacity). *Jobenomics U.S. business and jobs creation outlook: poor for large-scale utility-grade projects, poor for U.S. offshore projects, good for residential distributed and dispersed generation development projects, excellent export potential.*
- **Biomass** and **biofuels** comprise the largest segment of renewables but are likely to decline significantly if the U.S. Renewable Fuel Standard (RFS) is repealed as expected after the 2016 elections. Corn-based ethanol is a $30 billion/year industry that is supported largely by federal government RFS mandates. Non-food-based cellulosic biofuels are not economical without the RFS. On the other hand, **biogas** and **wood** have upside potential. 60% of Sweden's natural gas vehicles use biogas. Ideal locations for U.S. biogas plants include 17,000 waste water facilities, 8,000 farms and 1,750 landfills. Wood and mulch are increasingly being used as a heating feedstock, not only for home but for waste-to-energy plants. 12 million U.S. homes use wood biomass for heating. The U.S. is now the largest wood pellet exporter accounting for $500 million in trade. *Jobenomics U.S. business and jobs creation outlook: poor for biofuels, good for biogas, and good for wood.*
- **Hydroelectric** is the most proven energy efficient energy source with significant upside potential internationally and domestically for distributed and dispersed power generation. Hydroelectrics include proven **hydropower** technology (conventional hydro, pumped storage, micro-hydro, run-of-river and high-head/low-head) and developing **hydrokinetic ocean** technologies (tidal, wave, current, and gradient power). The regular nature of river and tidal currents provides an advantage for hydropower compared to wind and solar. Since water is 835 times denser than air, hydroelectrics is an untapped, powerful, clean, renewable energy source. While there is limited potential for large-scale U.S. conventional hydro developments, there is significant U.S. potential for energy efficient upgrades to current facilities, adding power generation capability to a portion of 80,000 U.S. non-powered dams utilizing new low-impact designs and technologies, developing a percentage of the 5,400 identified sites for small hydro plants, and developing a percentage of the 130,000 identified low-head micro-hydropower sites for both power generation and community storage. Oceans have unmatched hydrokinetic potential via tidal, wave, current, and gradient power. South Korea's Incheon Tidal Power Station will be operational in 2017 and is expected to generate 2.4 trillion watt hours of electricity annually—the amount equivalent to 3.5 million barrels of crude oil. Russia is designing a tidal power plant 10 times bigger than Incheon. *Jobenomics U.S. business and jobs creation outlook: poor for large-scale domestic projects, excellent for distributed and dispersed applications, excellent for international ocean hydrokinetic joint endeavors.*

- **Geothermal** has the lowest life-cycle emission of any renewable technology besides hydropower. While initial capital costs are high, overall life-cycle costs are significantly lower than many competing technologies. Geothermal energy consumption is expected to more than triple in the U.S. by 2030, largely due to the advent of new enhanced geothermal system (EGS) technology. EGS consists of engineered underground reservoirs that are drilled into hot rock formations to produce energy from geothermal resources that are otherwise not economical due to lack of water and/or permeability. EGS offers the prospect of geothermal energy across the entire U.S. and a potential 40-fold increase over current geothermal systems. Due to its small footprint, geothermal facilities can be located in downtown areas of major metropolitan areas where power density (the amount of power that can be generated in a given area) is an issue for other renewable technologies like wind and solar. As part of Salton Sea Restoration and Renewable Energy Initiative, California has announced plans to promote development of a 1.7GW geothermal facility that will double U.S. nameplate geothermal capacity. The Salton Sea project is also significant as a potential source of precious metal extraction including lithium, zinc and manganese. Lithium is used in batteries and crucial to the emerging electric vehicle industry. Near-term geothermal potential could support 75,000 new U.S. jobs, not including an additional 90,000 construction and manufacturing jobs. Globally, there are over 700 geothermal projects in 76 countries in development, proving excellent export potential for U.S. geothermal technology. The geothermal market also includes **geothermal heat pumps** (GHPs). GHPs are typically used in off-grid residential and commercial applications and are popular in the green-building movement, net-zero buildings and other forms of high efficiency sustainable building practices that are becoming mainstream concepts for new eco-friendly communities. *Jobenomics U.S. business and jobs creation outlook: good for all geothermal sectors.*
- **Municipal waste** is the least understood renewable technology from an energy conservation, emissions mitigation and jobs creation perspective. If the U.S. recycling rate is increased from 33% today to 75% by 2030, 515 million tons of CO_2 would be saved—equal to closing 72 coal power plants or taking 50 million cars off the road. The municipal waste and recycling industry reached an all-time high of 383,300 jobs in 2014. An additional 2.3 million new American jobs could be created if the U.S. could achieve a 75% recycling rate. Municipal solid waste recycling converts organic waste into energy and inorganic waste into commodities. The U.S. has 86 **waste-to-energy** (WtE) plants. While there are no new large ($200+ million) waste-to-energy projects on the horizon, there is a burgeoning industry of micro-WtE plants and advanced technology **material recovery facilities** (MRFs). Micro-WtE plants use waste to generate on-site electricity and heat for businesses and remote operations (e.g., deployed military units). MRFs currently make major energy conservation contributions in single stream recycling of discarded paper, plastics, cans and glass. For example, recycling aluminum cans saves 95% of the energy required to make the same can from its virgin bauxite material. Advanced technology MRFs, already in operation in Europe and recently in China, reclaim valuable raw minerals (plastics), common metals (copper, aluminum, ferrous) and precious metals (gold, platinum, silver) in discarded consumer electronics and appliances. In 2014, China became the leading urban mining nation by establishing a number of major ($1 billion level) urban mining centers with super-MRFs that reclaim raw materials, metals and minerals from every conceivable type of manufactured item that contains reclaimable raw materials. Urban mining is defined as a process of reclaiming raw materials and metals from products, buildings and waste from towns, cities and metropolitan areas. The goal of urban mining is to monetize urban waste streams including municipal solid waste, construction and demolition material, electronic waste, and tires and rubber products. A mid-sized American community typically landfills or exports approximately $30 million dollars' worth of high-value minerals and metals that could be used to

fund local projects and create jobs. *Jobenomics U.S. business and jobs creation outlook: excellent if a national urban mining initiative is advanced.*

- **Nuclear** power is projected to grow substantially over the next decade. The U.S. nuclear power industry is the largest in the world, with 100 operating commercial nuclear fission reactors at 62 locations in 31 states, with 99GW capacity that is projected to grow slightly to 102GW by 2030, a 3% increase. 56 countries operate nuclear reactors commercially, in research facilities, or in military applications. About 80% of global nuclear capacity is in OECD countries, but non-OECD countries are set to account for the bulk of future nuclear growth. Over 45 countries that currently do not have nuclear power have started nuclear programs or are actively embarking on starting a nuclear power program. China has 22 operational nuclear power reactors, 26 under construction and hundreds more about to start construction or planned. By 2030, China's planned capacity is forecasted to be 150GW—790% increase over the 18GW today. By 2050, China has announced a goal of 400GW— a 2100% increase. China's nuclear program got a big jump start from American nuclear technology transfer (largely a one-way effort with non-proliferation and climate change caveats) including sale of state-of-the-art reactors, components and materials, as well as next generation technology such as **thorium-fuel reactors**. **Small modular reactors** (ranging from tens to a few hundred megawatts) are gaining traction in Canada, the United States and Russia. Lockheed Martin, a U.S. defense contractor, claims that they may be able to field a **nuclear fusion reactor** within a decade. Their program is called, "Compact Fusion." If successful, Compact Fusion would be a ground-breaking ETR advancement. *Jobenomics U.S. business and jobs creation outlook: stable for the domestic U.S. and outstanding if Compact Fusion is successful, excellent for export potential for U.S. nuclear technology and services.*
- **Coal** supplies approximately one-fifth of total U.S. energy consumption needs. U.S. coal consumption will increase 8% and world consumption by 34% by 2030. Over the last five years, U.S. coal exports have increased from 1 billion to 1.4 billion short tons, a 40% increase. Modern "ultra-supercritical" coal-fired power plants are much cleaner than older dirtier models that represent 75% of the world's operational plants. Older plants burn coal more inefficiently at lower temperatures than modern plants that use powdered coal laced with additives that absorb toxic emissions. Coal and natural gas cogeneration power plants are much cleaner and cheaper to operate. Another way to make coal cleaner is to gasify it. Integrated Gasification Combined Cycle (IGCC) systems are being introduced to convert synthetic gas into electrical power. Another exciting coal-to-gas technology involves underground coal gasification that turns unworked underground coal (in-situ) into an easily extractable gas. While still in the research phase, producing hydrogen from coal has significant potential. Of the seven technologies that can produce hydrogen, coal gasification with sequestration is forecast to be the dominant method by 2035. This could be extremely important consideration to the coal industry if hydrogen-powered vehicles and stationary hydrogen fuel cells become commonplace. Notwithstanding these achievements and opportunities, the U.S. coal outlook is poor due to four factors: harsh new Administration air quality standards that are being contested at the Supreme Court, low natural gas prices, increasingly competitive renewable energy technologies, and plummeting investor and market confidence—the Dow Jones U.S. Coal Index is down 85% since 2011. In 2015, the Obama Administration cancelled America's leading clean air initiative, called FutureGen, and is aggressively pursuing carbon cap-and-trade and emission restrictions targeted at coal-fired power plants. This is both unfortunate and politically-driven. Most of the world relies on coal as a primary energy source. If the U.S. abandons the notion of clean or cleaner coal, the rest of the world may do so, as well. *Jobenomics U.S. business and jobs creation outlook: domestic poor, U.S. coal employment has dropped 60% in the last three decades, exports good, at least in the near-term.*

- **Oil** and **natural ga**s industry is a booming business that will continue to be outstanding in the foreseeable future with exports replacing decreasing U.S. demand. U.S. oil production growth in 2014 was the largest in more than 100 years. U.S. petroleum product exports increased for the 13th consecutive year with 2014 being a record year. To a large degree, the oil and natural gas boom is due to horizontal drilling and hydraulic fracturing that has provided access to large volumes of oil and natural gas that were previously uneconomic to produce from low permeability (tight) shale and sandstone geological formations. Over the past decade, dry shale gas production has grown from 2.8 billion cubic feet per day (Bcf/d) to 40.6 Bcf/d, a growth rate of 1258%, and tight oil production has grown from 0.4 million barrels per day (bbl/d) to 4.6 million bbl/d, a growth rate of 1129%. The U.S. has approximately 610 trillion cubic feet (40 years' worth at current production rates) of technically recoverable shale natural gas resources (ranked fourth after China, Argentina and Algeria) and 59 billion barrels (35 years' worth) of technically recoverable tight oil resources (ranked second after Russia). In 1990, shale gas provided only 1% of U.S. natural gas production; by 2013 it was over 39%, and by 2040, 53% of America's natural gas supply will come from shale gas. According to the American Petroleum Institute, as of 2011, the oil and natural gas industry supported 9.8 million full-time and part-time U.S. jobs and 8% of the U.S. economy. Due to excess natural gas supplies, new export industries could be created, including **liquefied natural gas** (LNG), **gas-to-liquid** (GTL), and **shipbuilding** that could potentially employ several million new workers. However, the unconventional oil and gas industry may have an Achilles heel in spite of its overall strength. This weakness is called "induced seismicity," also known as man-made earthquakes. Legal and regulatory challenges against induced seismicity could cripple the unconventional oil and gas industry, especially in communities that advocate anti-fossil fuel policies. The unconventional oil and gas industry also faces challenges with capitalization due to dropping oil prices. Despite these challenges, the industry, especially the gas sector, looks bright—perhaps extremely bright if **methane hydrate** production comes to fruition. *Jobenomics U.S. business and jobs creation outlook: good for oil (excellent if Congress lifts the crude oil export ban), excellent for natural gas, excellent for liquid natural gas export, poor for U.S produced LNG shipbuilding.*

- **Net-zero** communities consist of decentralized micro-grids that eliminate or reduce the need for centralized, vulnerable and expensive utility-grade grid energy and services. Burlington, Vermont, the state's largest city, is the first U.S. net-zero community that produces "100%" of their residential electrical power needs from renewables. Several dozen other U.S. communities are planning to be net-zero. A "net-zero building" is a building that produces and consumes equal amounts of energy. Since there are 132 million residential units versus 5 million commercial/industrial buildings, the residential sector is the likely place to focus on a national net-zero initiative. 132,802,859 U.S. households spend approximately $800 billion/year on energy-related expenditures. If 5% of these expenditures were allocated to net-zero technologies and services, approximately 800,000 direct middle-class ($50,000/year) jobs could be created. *Jobenomics U.S. business and jobs creation outlook: good in a business-as-usual scenario, outstanding if a national net-zero initiative is created.*

- **Alternative fuels** and **advanced vehicles** have the potential to transform and disrupt the transportation sector and national economics. Worldwide, the automotive industry supports over 50 million jobs. In 2014, the U.S. motor vehicle industry directly employed 1,553,000 Americans, with a total direct/indirect/induced employment of 7,250,000 jobs. There are six primary alternative fuels (biodiesel, electric, propane, natural gas, hydrogen and ethanol), and six emerging fuels (biobutanol, drop-in biofuels, methanol, P-Series fuels, renewable natural gas and Fischer-Tropsch xTL fuels). Advanced vehicles include biodiesel vehicles, hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), all-electric vehicles (EVs), flexible fuel vehicles (FFVs), natural gas vehicles, propane vehicles, and fuel cell electric vehicles (FCEVs). The key to making electric vehicles more marketable involves better batteries. Advanced battery development is one of the most important technological battlegrounds of the next two decades. Every advanced economy has a national advanced battery program. **Advanced batteries** will boost national economies, perhaps rivaling the economic impact of the personal computer. Global **electric vehicle** has gone multi-modal totaling 235 million EV-two-wheelers, 665,000 EV-cars (up from 180,000 in two years) and 46,000 EV-buses. **Hydrogen-powered transportation** has truly revolutionary potential as well as a major disruptive effect on the petroleum-based internal combustion engine industry. Hydrogen **fuel cells** also have the potential to provide energy efficient and environmentally clean electrical power in stationary and portable power applications. A major technological breakthrough in alternative fuels and advanced vehicles has huge implications for national economies. *Jobenomics U.S. business and jobs creation outlook: to be determined, a 2nd place finish could result in the loss of millions of jobs.*

- **Energy services** are the most stable high-growth sector within the energy super-sector.

  Energy efficiency moved from the "hidden fuel" to the "first fuel" exceeding any supply-side fuel. Energy efficiency employs almost 1 million Americans and is expected to add another 1.3 million by 2030. Energy efficiency and energy conservation are needed in combination to reduce consumption and emissions. Energy efficiency means using energy more effectively and is often associated with a technological change. **Energy conservation** means using less energy and usually requires a behavioral change. Without energy conservation, energy efficiency is likely to lead to a "Jevons paradox " that postulates that resource savings often leads to increased consumption of that resource, which further leads to economic expansion and further energy consumption. This is especially true in rapidly growing emerging economies.

  Energy-as-a-Service (EaaS) service models are modelled after cloud computing service models (i.e., Software-as-a-Service, Platform-as-a-Service, and Infrastructure-as-a-Service) and will soon emerge as a substantial energy sector industry with the ultimate potential of creating millions of jobs. It will also enable intelligent and micro-energy applications in tomorrow's "Internet of Things" world. When it comes to fruition, the EaaS will function as intelligence middle layer to manage large and complex energy assets in an interactive, integrated and seamless way. EaaS providers will strategically position (and consequently reposition) their clients within a dynamically changing energy ecosystem, by offering integrated, secure, low-cost, and portable service solutions in both centralized and decentralized energy environments.

  Energy assurance involves providing a steady supply of clean affordable fuels without major disruption. **Energy security** involves ecosystem protection including people, sources, infrastructure, and information systems. Due to increasing terrorist, criminal and cyber threats, energy assurance and energy security service**s** are burgeoning markets. General Keith Alexander (former Director of the US National Security Agency) says "the greatest risk (from terrorists) is a catastrophic attack on the energy infrastructure" including high-tech attacks on refineries, power stations and the electric grid. The U.S. private security market boomed after 9/11. Today, there are nearly 2 million full-time security jobs. Many more are needed, especially for energy security services. In regard to energy assurance, the crisis in Ukraine has created an energy assurance crisis in Europe which is dependent on Russian natural gas and petroleum. Blockage of any of the six major maritime oil trade route chokepoints, as well as disruption of 1.5 million miles of U.S. pipelines would have global repercussions. Energy security and energy assurance businesses and job opportunities depend a lot on international events, crises and conflicts and how proactive governments plan to be.

Disaster preparedness and recovery services expect growth, considering the "catastrophic" consequences of not achieving UNFCC climate change goals and man-made disasters. Each year organizations like the American Red Cross respond to 70,000 natural and man-made disasters in the United States. The world will likely witness more extreme weather events as global temperatures rise. Superstorm Sandy caused an estimated $50 billion worth of damage resulting in approximately 750,000 insurance claims and a $48 billion federal government recovery effort. The threat of man-made disasters in the US is also increasing. 9/11 was just a start. Cyber warfare and biological warfare portend catastrophic-level consequences. *Jobenomics U.S. business and jobs creation outlook: excellent if government and industry are proactive.*

- **Exotic and yet unknown technologies** Exotic technologies, such as energy harvesting, spray-on solar cells, gravity motors, cold fusion and vortex technologies, are in development. The Department of Energy has started down this path with its Advanced Research Projects Agency-Energy (ARPA-E), which is modelled after the highly successful Department of Defense's Defense Advanced Research Projects Agency (DARPA). Whether any of these exotic technologies will result in a major energy breakthrough is unknown. Perhaps the next profound discovery won't happen in a high-tech laboratory but in a remote third-world village where a highly scalable energy invention is yet to be disseminated worldwide.

This report concludes with two recommendations. First, U.S. government needs to institute a labor force statistical system dedicated to the energy workforce and an Energy Industry Classification Standard like the one used by investors and the S&P 500. Second, the 2016 Presidential elections offer an ideal opportunity to debate new energy architectures and America's role in leading the world in the Energy Technology Revolution, not only to clean up our planet, but to enhance national economies via the production of clean fuels and the creation of millions of new businesses and tens of millions of new jobs.

The Energy Technology Revolution (ETR)

A revolution is occurring in the energy sector. ETR technologies, processes and systems are changing the energy mix with exciting technical breakthroughs on the horizon. Motivated by global climate change and emerging economies, the appetite for clean and affordable energy has never been higher. Like the Military Technology Revolution (MTR) did in the post-WWII era, and the Information Technology Revolution (ITR) did in the 1990s, the Energy Technology Revolution (ETR) will produce tens of millions of new jobs globally in the next several decades. These jobs will be produced with a lot of churn. Existing energy companies will become more efficient, requiring fewer workers. New technologies will create new markets and employment opportunities. Brilliantly innovative and creatively destructive systems will transform societies. Countries that have a national ETR strategy will claim the bulk of these new jobs.

So how big is the U.S. energy sector in terms of jobs and the economy? No one knows. None of the federal government's thirteen statistical agencies track comprehensive energy super-sector employment and economic statistics. Jobenomics guesstimates the size of the U.S. energy super-sector to be approximately 12 million employees[1]. If properly managed, this super-sector's future is so bright that is conceivable that the U.S. could double these numbers within the foreseeable future by simply (1) exporting energy, technology, processes and systems, and (2) moving from a centralized supply-driven architecture to a more decentralized demand-driven architecture that generates power at the point-of-consumption, whether it is a residence, a vehicle or a portable device. The churn of replacing or retrofitting retiring businesses with newer, cheaper and cleaner equipment will also produce a newer high-tech workforce that will replace the existing workforce.

The ETR is likely to change energy scarcity to energy abundance. No one saw the renaissance in the natural gas industry a decade ago due to the combination of horizontal drilling and hydraulic fracturing (fracking). Fracking is unlocking hydrocarbons buried deep underground in the continental U.S. and soon will do so around the world. A decade from now, hydrogen could replace gasoline, and renewables could replace coal. Equally possible, coal would be cooked rather than burned to produce clean methane and net-zero buildings could be energy self-sufficient. Gasification technology is unleashing clean-burning synthetic gases from garbage, human and animal waste and biomass. Energy efficiency has moved from the "hidden fuel" to the "first fuel," exceeding output from any other fuel sources.

What happened to the news industry during the ITR is representative of what Jobenomics envisions for the energy industry during the ETR. Several decades ago, news was dominated by three national broadcast TV channels, dozens of syndicated radio networks and hundreds of major metropolitan newspapers. Today, the U.S. has hundreds of broadcast and cable TV channels, thousands of radio stations that have multiple news feeds, plus millions of Internet bloggers and social media newscasters, which has decimated newspaper circulation that has hit its lowest level in seven decades. The number of listeners is relatively the same yesteryear as today, but America has created an order of magnitude more businesses and jobs reporting the news. The ETR will allow America to do the same in the energy industry.

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[1] According to the Department of Energy's Energy Information Administration (EIA), U.S. energy expenditures were $1.2 trillion in 2011 (the latest data available). $1.2 trillion equates to 8.3% of U.S. gross domestic product ($14.5 trillion in 2011). As a percent of today's U.S. labor force (140 million), 8.3% equates to approximately 12 million Americans.

Renewable energy sources, micro-grids, net-zero communities, advanced vehicles, alternative fuels, energy storage devices and smart networks will allow energy generation to occur closer to the consumer. Generating power close to the point-of-consumption eliminates cost, complexity, interdependencies and inefficiencies associated with transmission and distribution over 3 million miles of power lines in America. Like distributed computing (i.e., PCs) and distributed telephony (i.e., mobile phones), distributed generation shifts control to the consumer. It is also likely that on-site power generation will create an order of magnitude more businesses and jobs, much in the same way the PCs and smartphones and personal digital assistants currently provide.

Energy Consumption

Countries report on energy supply, energy generation and energy consumption. At the end of the day, the driving factor is how much energy is consumed, at what price economically and environmentally, and how many people it serves and supports. Total primary energy consumption includes the consumption of petroleum, natural gas, coal, nuclear electrical power and renewable energy. Using the latest comparable data[2], China was the leading energy user consuming 104 quadrillion Btu followed by the U.S. (97 quads), Russia (30 quads), India (23 quads), Japan (21 quads), Germany (13 quads), Canada (13 quads), Brazil (12 quads), South Korea (11 quads) and France (11 quads). From 2008 to 2011, China's energy usage increased 31% whereas U.S. consumption dropped 2%.

Global Energy Consumption Growth Forecast

Type Fuel	2013	2030	Growth Rate	Consumption	
	Quadrillion Btu		2013-2030	2013	2030
Petroleum and Other Liquids	181	211	**16%**	**84%**	**80%**
Natural Gas	121	163	**34%**		
Coal	155	208	**34%**		
Nuclear	27	50	**85%**	**5%**	**7%**
Renewables (All)	62	98	**58%**	**11%**	**13%**
Total	**547**	**729**	**33%**	**100%**	

Source: EIA International Energy Outlook 2013

According to the EIA's International Energy Outlook 2013 (latest comparable data release)[3], global energy consumption is forecast to increase by 33% from 2013 to 2030, from 547 quadrillion Btu to 729 quadrillion Btu—a growth of 182 quads; that is more than twice the energy that the U.S. consumes annually. Note: this Jobenomics Energy Technology Revolution report uses 2013 as the baseline year in order to better compare and analyze data from various U.S. and international reports and agencies.

Almost all of this growth is in emerging economies (non-OECD[4]) like China, India and the Middle East. Nuclear is forecast as the fastest growing supplier due to a massive nuclear power effort in China. Renewables come second with 58%, followed by coal (34%), natural gas (34%) and petroleum (16%). By 2030, fossil fuels (petroleum, gas, coal) will still remain the primary energy source with 80% market share (581 quads out of a total of 729 quads), down only slightly from 84% in 2013 (458 quads out of 547 quads).

According to EIA Annual Energy Outlook 2015[5], total U.S. energy consumption by sector and source equaled 98.3 quadrillion Btu (quads) in 2014, up slightly from 97.14 quads in 2013.

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[2] EIA, International Energy Statistics: Total Primary Energy Consumption, 30 April 2013, http://www.eia.gov/tools/faqs/faq.cfm?id=87&t=1

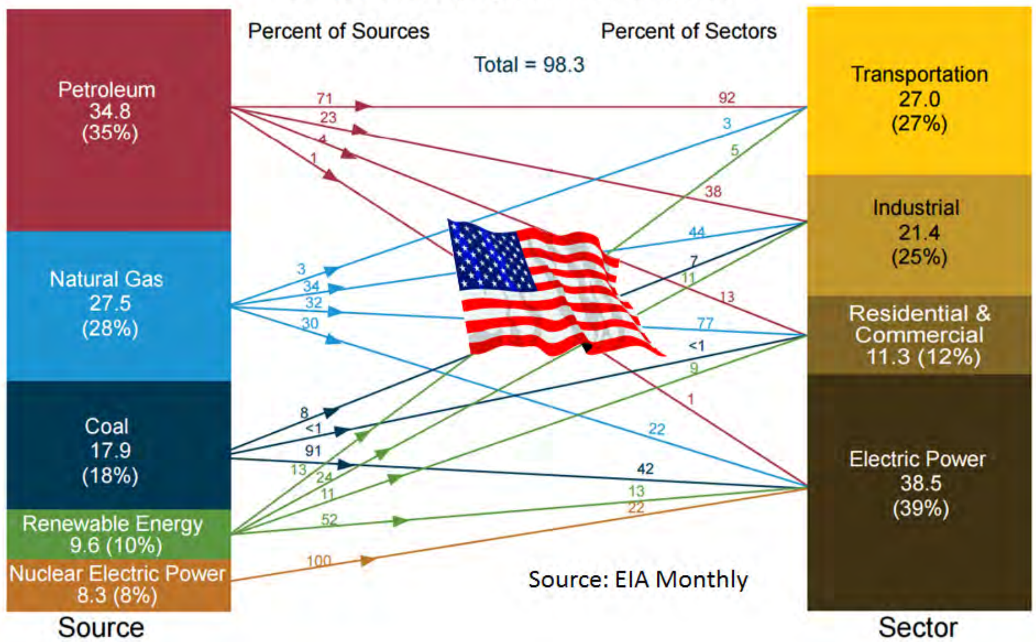
[3] EIA, International Energy Outlook 2013, http://www.eia.gov/forecasts/archive/ieo13/world.cfm

[4] Organization for Economic Cooperation and Development (OECD) is a forum where the governments of 34 democracies and 70 non-member countries work to promote economic growth, prosperity and sustainable development.

[5] EIA, Annual Energy Outlook 2015, Energy Consumption by Sector and Source, Table A2, 14 April 2015, http://www.eia.gov/forecasts/aeo/

Primary Energy Consumption by Source and Sector

United States, Quadrillion Btu, 2014



By source, 35% of America's energy consumption comes from petroleum, 28% natural gas, 18% coal, 10% renewable energy (including 5% biofuels and wood) and 8% nuclear. Stated in another way, 87% comes from carbon-based (petroleum, gas, coal and biomass) fuels, 8% nuclear and 5% non-biomass renewables. By sector, electrical power is the largest (39%), followed by transportation (27%), industrial (25%) and residential/commercial (12%)[6].

US Energy Consumption Growth Forecast

Total Energy Consumption All Sectors

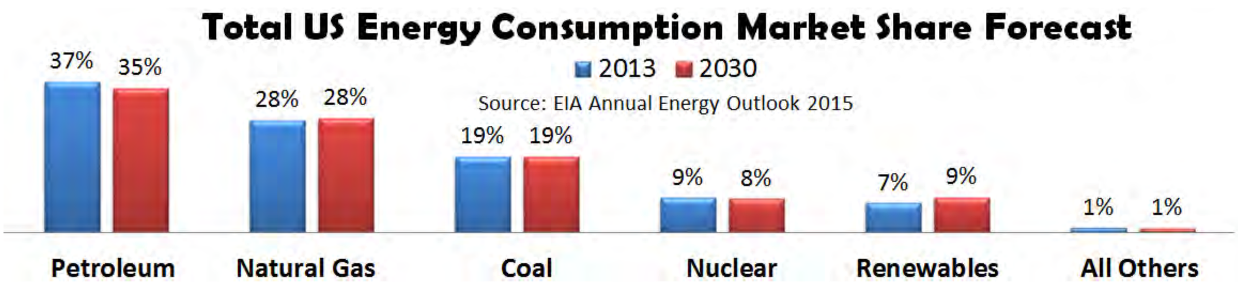
Consumption	2013	2030	Growth
	Quadrillion Btu		Rate
Petroleum and Other Liquids	35.9	36.5	2%
Natural Gas	26.9	28.8	7%
Coal	18.0	19.2	6%
Nuclear	8.3	8.5	2%
Renewables	7.0	8.8	27%
All Others	1.1	1.1	0%
Total	**97.1**	**102.9**	**6%**

Source: EIA Annual Energy Outlook 2015

According to EIA projections[7], domestic consumption of all U.S. energy sources is forecast to increase by only 6% from 97.1 quads in 2013 to 102.9 quads[8] in 2030. Petroleum and petroleum liquids, such as ethanol, are forecast by the EIA to decrease by 2% by 2030 due to energy efficiency and higher vehicle fuel standards (i.e., more miles per gallon). In the fossil fuel category, natural gas is the biggest gainer (7%), followed by coal (6%). Nuclear is forecast to

[6] EIA, Total Energy, Monthly Energy Review, Primary Energy Consumption 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/flow/css_2014_energy.pdf
[7] EIA, Annual Energy Outlook 2015, Energy Consumption by Sector and Source, Table A2, 14 April 2015, http://www.eia.gov/forecasts/aeo/
[8] Note: All EIA Forecasts are based on EIA's Reference Case, as opposed to Hi and Low scenarios

grow by 2%. Renewables (including hydropower) is forecast to grow by 27%, albeit from a low base of 7.0 quads. For a better apples-to-apples fuels comparison, the total U.S. energy consumption market share forecast is presented below.



Other than a 2% decrease in petroleum being replaced by a 2% increase in renewables, the market will remain rather static between 2013 and 2030. This data is rather surprising due to concerns about harmful effects of fossil fuel greenhouse gas emissions vis-à-vis the benefits of renewable energy on climate change. Note: renewable energy supply and consumption forecasts are addressed in detail in the Renewable Energy Sources section of this report.

If renewables only grow by 2% of the total energy mix in the next 25 years, the United Nations' goal of limiting global temperature growth to a 2°C increase is highly doubtful without the U.S. leading the way. In addition to renewables, the U.S. will have to emphasize energy efficiency, energy conservation, cleaner fossil fuels, and other ETR leading-edge advancements, like advanced batteries, storage systems and hydrogen power.

It is important to note that, adjusted for per capita usage, U.S. consumption is projected to decrease[9] indicating that American energy consumption has peaked, due mainly to advances in appliance energy efficiency, increase in vehicle efficiency standards and the shift in production from cooler to warmer regions. From 2013 to 2030, U.S. energy use per capita and per dollar of gross domestic product is projected to decline 6% and 30% respectively[10]. Population increase will largely make up for this decline, thereby raising consumption from 97.1 quads in 2013 to 102.9 quads in 2030.

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[9] EIA, Market Trends: U.S. energy demand, In the United States, average energy use per person declines from 2012 to 2040, http://www.eia.gov/forecasts/aeo/MT_energydemand.cfm

[10] EIA, Annual Energy Outlook 2015, Market Trends: U.S. energy demand, In the United States, average energy use per person declines from 2012 to 2040, http://www.eia.gov/forecasts/aeo/MT_energydemand.cfm#declines

Climate Change

The controversy regarding climate change is a catalyst for the ETR. Controversy provides political and emotional "energy" to adopt new ETR technologies, processes and systems that will create a better, cleaner and cheaper energy ecosystem. To climate change activists who believe in impending catastrophic consequences, the ETR is a call-to-action for creatively destructive technologies that can upend the world's dependence on fossil fuel. To fiscally-conservative fossil fuel supporters, the ETR offers solutions for economic revival and jobs creation in a manner that reduces pollution without destroying businesses.

Then global warming, now climate change, is becoming more of a call-to-arms, than a call-to-action, which is damaging a movement whose ultimate aim is to heal an injured planet and preserve a way of life, albeit with some significant changes. Much of the climate change mantra has evolved to sloganeering, such as "80 by 50," (80% reduction of greenhouse emission from 2005 levels by 2050 via renewable energy) and "100% RE" (renewable energy).

Organizations like the Global 100% RE Alliance[11] are gaining traction in communities across America and the world, promulgating the position that any reference to fossil fuels or cleaner fossil fuel solutions is emphatically unacceptable. Approximately 100 U.S. cities have signed a compact with the Carbon*n* Climate Registry (cCR)[12], an international movement in 44 countries dedicated to the achievement of transparency and accountability of climate change actions (and access to global climate change funds).

From a Jobenomics perspective, climate change may be at the point of becoming so polarized, politicalized and acerbic that change may no longer be achievable. Consequently, this report may be deemed irrelevant to many since it seeks an orthogonal position (perpendicular to the doctrines of the right and left) based on a combination of renewable energy optimism and fossil fuel pragmatism. In the end, the American consumer will choose energy solutions based on best value, which will be determined by a combination of economic and social good.

Climate change policy is best articulated by the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC is currently the only international climate policy organization that has achieved broad international support from 195 nations. According to the United Nations, to prevent a 2°C increase in temperature that could cause "catastrophic" damage to our planet, global emissions must peak by 2025 and fall by half of current levels by 2050.

From an ETR solutions perspective, it is important to understand global emissions. According to the U.S. Environmental Protection Agency (EPA) [13], global emissions can be tracked by gas, by source and country.

- By gas, the four main greenhouse gas (GHG) emissions are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (like chlorofluorocarbons [CFCs] and hydrofluorocarbons [HFCs] that have been linked to depletion of the ozone layer). Carbon dioxide accounts for 77% and methane 14% of all U.S. GHG emissions from human activities, mainly via combustion of carbon-based fuels. Human nitrous oxide emissions account for 8%, primarily from agricultural soil

[11] Global 100% RE Alliance is a global initiative that advocates 100% renewable energy, http://go100re.net/
[12] Carbon*n* Climate Registry (cCR), http://carbonn.org/
[13] EPA, Global Emissions by Gas, http://www.epa.gov/climatechange/ghgemissions/global.html

amendments using nitrogen-based fertilizers. The remaining 1% of GHG emissions comes from fluorinated gases (CFCs and HFCs) from man-made refrigerants and propellants.

These percentages can be misleading since the Global Warming Potential (known as GWP) is different for each gas. The 100-year time-horizon GWPs relative to CO_2 are CO_2 = 1, CH_4 = 25, N_2O = 298, CFC-11 = 4,750, HFC-23 = 14,800[14]. Over long periods of time, CH_4 traps up to 25 times more atmospheric radiation than CO_2. The chemical hydroflourocarbon-23 (HFC-23), used in China and India for air conditioning and refrigeration, is nearly 15,000 times more damaging to the climate than carbon dioxide. Fortunately, this HFC climate time bomb has been defused, but not until the refrigerant companies made billions of dollars in windfall profits from the sale of carbon credits, maximized through manipulation of HFC production levels. In other words, these unscrupulous companies produced the toxic chemicals in order to destroy them for the carbon credits that were sold to other companies.

- By source, global industry emits 45% of all GHGs with global electrical and heat generation industries contributing 26% and other industries 19%. Land use is the second largest at 31% with deforestation and land clearing contributing 17% and agriculture 14%. Fossil fuel burning air, land and sea vehicle emissions account for 13% in the transportation sector. Fossil fuel burning (including wood and charcoal) in residential and commercial buildings accounts for 8%. Waste and waste water treatment plants and incinerators account for the final 3%.
- By country, China is the leading emitter of CO_2 at 23%, followed by the U.S. at 19%, EU-27 13%, India 6%, Russia 6%, Japan 4%, Canada 28% and the rest of the world 28%. Deforestation in South America, Asia and Africa are not included and could amount to as much as 16% of the global CO_2 emissions.

CO_2 emissions are used as the general standard for measuring emissions. Over the last six decades, global CO_2 emissions from fossil fuels have increased 700% and are increasing exponentially in the developing world. From 1990 to 2012, China and India increased CO_2 emissions by 233% and 110% respectively[15]. Developed world reductions (U.S. -17% and EU -19% over the same period) are helping to offset global increases, but not at a rate that will mitigate worrisome consequences of toxic emissions in the atmosphere.

Most developing nations, including China, cling to the idea of "common but differentiated responsibilities" that places the burden on developed nations. From a developing country point-of-view, rich countries, especially those in the West, are mostly responsible for climate challenges due to their historic development and use of GHG-producing fossil fuels. By use of these toxic substances, the West has created a moral hazard (taking a risk that others will eventually inherit) that they should rectify on behalf of the rest of the world. Consequently, it is important that the ETR understand this emerging economy perspective, and focus ETR's technologies, processes and systems on specific national and regional needs.

Over half of global emissions come from developing countries, requiring them to be active participants. A core principle of the ETR concept is to assist developing countries to achieve their climate change

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[14] Greenhouse Gas Protocol, Global Warming Potential, http://www.ghgprotocol.org/files/ghgp/tools/Global-Warming-Potential-Values.pdf

[15] European Commission Joint Research Center, *Trends In Global CO_2 Emissions: 2013 Report*, Table A1.2, http://edgar.jrc.ec.europa.eu/news_docs/pbl-2013-trends-in-global-co2-emissions-2013-report-1148.pdf

contributions (known as Intended Nationally Determined Contributions, or INDCs). Other than major developing countries like China, Brazil and OPEC countries, most developing countries do not have the financial resources to either mitigate emissions or adapt to the impacts of climate change.

- Regarding INDC financing, rich nations have pledged to fund the Green Climate Fund with a target budget of $100 billion per year by 2020. The Fund will support developing countries with high impact efforts to mitigate GHG emissions and to adapt to the impacts of climate change. As of December 2014, total pledges from 27 countries amounted to only $10 billion.

  President Obama's 2016 Budget proposed $1.29 billion in spending on international climate programs, with only $500 million allocated to the Green Climate Fund in FY2016. Consequently, the U.S. government, and any other government in the developed world, is unlikely to meet the Green Climate Fund $100 billion/year challenge.

- Regarding INDC mitigation, on 11 November 2014, President Obama announced[16] a new U.S. target to cut net greenhouse gas emissions 26% to 28% below 2005 levels by 2025. At the same time, President Xi Jinping announced Chinese targets to limit peak CO_2 emissions by 2030 and to increase renewable/nuclear energy to around 20% by 2030. Obama's ambitious new U.S. goal doubles the pace of domestic carbon pollution reduction by 2025 with an ultimate goal of 80% reductions by 2050. Xi's ambitious new goal will require China to deploy approximately 1,000GW of new nuclear, wind and solar power by 2030—more than all existing Chinese coal-fired power plants produce today and close to total current U.S. electricity generation capacity. These announcements are intended to encourage other nations to do the same with their INDCs.

  The backbone of President Obama's 26% to 28% reduction pledge is contained in his Clean Power Plan (CPP)[17] that was written by the EPA and is currently in interagency review. The CPP sets unique CO_2 emission rates in each state. States would determine how to achieve these rates through a combination of improvements at individual power plants, shifting generation from coal to cleaner natural gas, investing in new renewable energy or through energy efficiency programs. The CPP also sets extremely strict performance standards for newly built plants.

Impact of Clean Power Plan

Source: EIA Analysis of Impacts of the CPP

ELECTRIC GENERATION CAPACITY	Gigawatts (GW)			% Change	
	2013	2030		2030	
	Actual	AEO2015	CPP	AEO2015	CPP
Coal	304	260	209	**-14%**	**-31%**
Natural Gas/Oil	470	519	518	10%	10%
Renewables	167	226	372	**35%**	**123%**
Nuclear/Other	124	128	127	3%	2%
Total GW	*1065*	*1133*	*1226*		

[16] White House, Office of the Press Secretary, Fact Sheet: U.S.-China Joint Announcement on Climate Change and Clean Energy Cooperation, http://www.whitehouse.gov/the-press-office/2014/11/11/fact-sheet-us-china-joint-announcement-climate-change-and-clean-energy-c

[17] EPA, Clean Power Plan, http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule

A recent analysis[18] of the impact of Administration's Clean Power Plan by the EIA evaluated the differences between EIA's 2015 Annual Energy Outlook (AEO2015) Reference Case and various Clean Power Plan scenarios (CPP base policy, CPP base policy extended from 2030 to 2040, CPP with new nuclear, CPP with new biomass CO_2 models, CPP with high economic growth, and CPP with high oil and gas resources). The CPP base policy is shown above. In percentage terms, the CPP doubles the reduction of coal-fired plants (a decrease from -14% to -31%) and triples renewable energy electric generation capacity (an increase from 35% to 123%) over AEO2015 2030 projections. Oil, gas, nuclear and other energy sources are projected to grow about the same amount in both the AEO and CPP calculations. The analysis states that the CPP will cause retail electricity prices to increase by an average of 3% to 7% with some regions experiencing as much as a 15% price increase over the next decade. The EIA also projects that gains in energy efficiency and "price-induced conservation" will eventually moderate higher electricity prices[19].

Proponents say the CPP will result in significant health benefits by reducing greenhouse gases and preventing thousands of premature deaths. Opponents argue that the CPP will shutter a majority of older power plants and make new coal and natural plans unaffordable, thereby causing an enormous energy price increases for American citizens who can least afford it.

The final Clean Power Plan is expected in August 2015. However, fierce opposition by Congress, coal industry and states is likely to postpone or derail the CPP entirely. A group of 14 states and coal companies sued the EPA over the legality of the rules in the D.C. Circuit Court of Appeals. It is important to note that the Administration believes that it has legal precedence (see Massachusetts v. EPA[20]) under the authority of the Clean Air Act[21] to overrule states if their pollutants endanger public health and welfare, and impose a federal plan to enforce necessary reductions. In response, the anti-CPP community is preparing to respond with their own studies and expert witnesses that the economic consequences of the CPP will cause even a graver threat to health and welfare.

- Regarding INDC adaption, developing countries are likely to bear the brunt of adverse effects of climate change because they are the least likely to have the capacity to adapt. Adaptive capacity involves the ability for a nation to properly respond to any environmental change that causes major societal and economic disruptions. For example, adaptive ETR solutions will be needed for water harvesting and preservation, land and crop management, seawall and storm surge flood barriers, emergency medical services, infrastructure protection, continuity of critical operations, crisis and crime management, energy assurance and security, and the like. These adaptive challenges require time, expertise and money to mitigate.

[18] EIA, Analysis of the Impacts of the Clean Power Plan, May 2015, Table 3 Summary results for AEO2015 Reference case and Clean Power Plan cases, selected years, Page 23, http://www.eia.gov/analysis/requests/powerplants/cleanplan/pdf/powerplant.pdf

[19] EIA, Today in Energy, 11 June 2015, Efficiency moderates effects of higher electricity prices under proposed Clean Power Plan, http://www.eia.gov/todayinenergy/detail.cfm?id=21612

[20] Center for Climate Change and Energy Solutions, Clean Air Act Cases, http://www.c2es.org/federal/courts/clean-air-act-cases

[21] Clean Air Act, 42 U.S.C. §§7401 et seq. (2013), §7411(d), section 111(d).

Fortunately, ETR technology, processes and systems already exist to meet many of these challenges, but lack a system-of-systems approach and common cause to achieve resolution. The issue is deploying these solutions to the right place at the right time. Well-planned and well-resourced early adaptation actions save money and lives later.

In December 2014, Lima Climate Conference delegates resolved to list INDCs on the UNFCCC website to improve rich-state backing for poor-state solutions. These INDCs will essentially serve as Requests for Proposals from the developing world. As of April 2015, seven INDCs (U.S., Switzerland, Norway, Latvia, Mexico, Gabon and Russia) have been posted on the UNFCCC website[22].

The Obama Administration submitted the U.S. INDC on 31 March 2015. The U.S. INDC states that "the United States intends to achieve an economy-wide target of reducing its greenhouse gas emissions by 26%-28% below its 2005 level in 2025 and to make best efforts to reduce its emissions by 28%." According to the White House Fact Sheet[23], "The U.S. target will roughly double the pace of carbon pollution reduction in the United States from 1.2 percent per year on average during the 2005-2020 period to 2.3-2.8 percent per year on average between 2020 and 2025." The U.S. target covers all greenhouse gases (CO_2, methane, etc.) across all sectors. The Administration's INDC submission was not coordinated with the U.S. Congress, which has reacted negatively. The Administration believes that these ambitious goals can be done with existing legal authority and, therefore, Congressional approval is not needed.

While INDC financing, mitigation and adaption goals are laudable, reality rests in execution. The Jobenomics ETR concept deals with executing the best existing and emerging energy technologies, processes and systems to solve global adaption and mitigation challenges in the most cost-effective manner producing the maximum amount of green jobs. These climate change challenges will not likely be solved by silver-bullet solutions but rather a system-of-systems approach to a dynamic and ever-changing ecosystem. The ETR concept offers a platform that provides a framework for a future energy ecosystem and a neutral starting place for consensus-building.

The international community began dealing with climate change consensus-building as far back as 1992 at the Rio Earth Summit. In 1994, the UNFCCC began operation and conducted regularly scheduled meetings leading up to the 1997 Kyoto (Japan) Protocol. The Kyoto Protocol recognized the damaging effects of GHGs and that rich nations, which had already benefited from industrialization, would take the lead in reducing emissions. The Kyoto Protocol was signed in 1997 with a binding effect from 2005 to 2012. Kyoto Protocol aimed for a 5% cut in global carbon emissions. What transpired over the 2005 to 2012 period was a 58% increase.

The latest conference was held in Lima, Peru in December 2014. The goal of the Lima conference was to develop an outline of a legally-binding and universal agreement on climate change that would be signed by all 195 member nations at the Paris Conference in December 2015.

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[22] United Nations Framework Convention on Climate Change (UNFCCC), http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx

[23] The White House, FACT SHEET: U.S. Reports its 2025 Emissions Target to the UNFCCC, 31 March 2015, https://www.whitehouse.gov/the-press-office/2015/03/31/fact-sheet-us-reports-its-2025-emissions-target-unfccc

The Paris Conference is officially known as the 21st yearly session of the Conference of the Parties (COP 21) to the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and the 11th session of the Meeting of the Parties (CMP 11) to the 1997 Kyoto Protocol. INDCs, climate financing, mitigation and adaption are key elements of the universal agreement that will replace the failed Kyoto Protocol. The "legally-binding" agreement will be designed to set national standards with a collective goal of limiting GHG emissions to a global temperature increase of 2°C above 2005 levels with a binding effect beginning in 2020.

Energy Investment

Energy investment is essential to energy economics and employment. Without adequate investment, a more affordable, secure, cleaner and sustainable energy ecosystem will not materialize. According to the International Energy Agency[24], investment in the global energy supply has increased from $700 billion in 2000, to $1.6 trillion in 2013 and will soon rise to $2 trillion dollars per year.

The cumulative global energy investment over the next two decades (2014 to 2035) is projected to be $48 trillion, of which $40 trillion will be for energy supply and $8 trillion for energy efficiency. Most of the $40 trillion cumulative energy supply investment will be used to compensate for depleted oil and gas fields, replacing or retrofitting electric power plants, and upgrading aging transmission lines and pipelines.

Electrical power generation will dominate energy supply investment with $16.37 trillion, followed by oil at $13.67 trillion and gas at $8.77 trillion. Of the $8 trillion cumulative energy efficiency investment, 62% will be transportation related (mainly automotive), 29% for buildings (mainly residential) and 9% for industry. Energy efficiency investments are forecast to quadruple from $130 billion in 2013 to $550 billion per year in 2035.

The U.S. and China are the largest single country energy investors with cumulative total investments equaling $7.34 trillion and $7.31 trillion respectively, or collectively 30% of the global total. Russia is the next largest spender with $2.73 trillion, followed by India with $2.44 trillion. The entire European Union will invest $5.38 trillion, of which $3.2 trillion will be on supply and $2.2 trillion on energy efficiency.

These investments are not enough to meet the climate change goal of limiting long-term temperature increase to 2°C. Instead, these investments (if realized) point to a 3.6°C increase. Substantial policy changes and investment strategies would be needed to meet the 2°C objective.

According to IEA estimates[25], an <u>additional</u> global investment of $900 billion <u>per year</u> (largely in renewable sources and energy efficiency) for the next twenty years is needed to give the world a 50% chance of avoiding potentially calamitous effects of climate change. As a percent of world GDP, the U.S. share would be about $180 billion per year, which is a highly improbable figure. The International Renewable Energy Agency (IRENA) estimates the U.S. share for renewable energy alone is $40 billion per year, which is also improbable.

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[24] International Energy Agency (IEA), World Energy Investment Outlook 2014 Report, http://www.iea.org/publications/freepublications/publication/weio2014.pdf

[25] IEA WEIO2014, http://www.iea.org/publications/freepublications/publication/weio2014.pdf, page 14, estimates that cumulative global investment must increase $18T from 2014 to 2035 ($40T to $53T in energy and $8T to $13T in energy efficiency) in order to set the world on a 2°C emissions path. $18T/20 years=$900B/year.

According to Bloomberg New Energy Finance[26], global investment (from both government and private sector) in clean energy in 2014 was $310 billion, which represents 19% of the $1.6 trillion total energy investment reported by the International Energy Agency. A decade earlier, global clean energy investment was only $60 billion. The all-time record of $317.5 billion was attained in 2011. In 2014, China led with $89.5 billion (29% of the $310 billion total), followed by the U.S. with $51.8 billion (17%), Japan with $41.3 billion (13%) and Canada with $9 billion (3%). $310 billion is less than one-third of the investment needed to meet the UNFCCC climate change goal of limiting the long-term temperature increase to 2°C.

According to the White House[27], President Obama and the Democrat-controlled Congress invested $20 billion per year in clean energy technologies as part of the post-Great Recession recovery program (American Recovery and Reinvestment Act of 2009). President Obama's 2016 Budget proposed $1.29 billion in spending on international climate programs, including $500 million for the Green Climate Fund that will be the first installment of a pledged $3 billion spread over four years. The budget also proposes approximately $12 billion for federally-funded INDC U.S. financing. $7.4 billion is proposed for U.S. clean energy technology (advanced vehicles, energy-efficient vehicles and carbon capture and storage), $4 billion for states to improve coal-fired power plants, $400 million to assess climate change flood risks, $100 million permitting renewable energy projects on federal lands and waters, and $89 million to combat drought. While the U.S. Congress supported a similar budget proposal under President Bush, the political environment in Washington is more contentious today. Senior members of the Republican-controlled Congress have pledged to block any or all proposed funding to "unelected UN bureaucrats."

Without U.S. leadership and a significant commitment of U.S. funds, the UNFCCC 2015 Paris Conference is unlikely to produce the type of required government protocols and investments to meet the 2°C objective. So, is all this government climate change activity in vain? Jobenomics believes the answer is no. Governments have the responsibility to set policy and stimulate new initiatives via both incentive and disincentive programs. Fiscally-driven government incentive and disincentive programs have significant value to jump-start initiatives. Politically-driven incentive and disincentive programs are usually counterproductive and discourage the very people who have the means to finance major climate change initiatives.

Given policy-making deadlocks and the on-and-off nature of federal tax credits, Washington is not capable of leading or incentivizing a major climate program. On the other hand, state, county and municipal government incentive programs show promise. These programs include green energy funds, green banks and bonds. According to a recent Brookings-Rockefeller Report[28], since 1998, state clean energy funds have invested over $3.4 billion in state dollars to support renewable energy markets while leveraging another $12.5 billion in federal and private sector investment. States are also creating "green" banks that leverage limited public-sector funds with private-sector capital to provide low-cost

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[26] Bloomberg New Energy Finance, Rebound in clean energy investment in 2014 beats expectations, 9 January 2015 Press Release, http://about.bnef.com/services/renewable-energy/

[27] White House, Office of the Press Secretary, Fact Sheet: U.S.-China Joint Announcement on Climate Change and Clean Energy Cooperation, http://www.whitehouse.gov/the-press-office/2014/11/11/fact-sheet-us-china-joint-announcement-climate-change-and-clean-energy-c

[28] Brookings-Rockefeller Project on State and Metropolitan Innovation, April 2014, http://www.brookings.edu/~/media/research/files/reports/2014/04/clean%20energy%20bonds/cleanenergyfunds.pdf

and long-term loans to clean energy projects and green industries. New York launched a $1 billion green bank in 2013 with many other states to follow. Finally, the trillion dollar tax-exempt state and municipal bond market has funded U.S. infrastructure projects for decades. Tax-exempt general obligation bonds (bonds most often issued to cover operating expenses supported by the taxing power of the state, county or municipality) and revenue bonds (bonds most often issued to fund infrastructure projects supported by the income generated by those projects) are attractive to private sector investors.

From a Jobenomics perspective, successful fiscally-driven state, county and municipal government programs are the only way that the U.S. will be able to fulfill climate change commitments. The key to success is via leveraging limited government funds to attract large private sector investments that are applied to a pipeline of high-priority projects and industries. The federal government could play a valuable role in identifying best-practices and promulgating these best-practices across the 50,000 state, county and municipal agencies and authorities.

If presented with lucrative ETR business opportunities, the global private sector has the wherewithal to provide the annual $900 billion investment capital to meet the 2°C objective. To prove this assertion, one must merely look at the magnitude of recent market capitalization (value) growth and the value of the energy super-sector in relation to world GDP.

Since the Great Recession, market capitalization[29] of all U.S. listed companies has been increasing $1.75 trillion per year and market capitalization of the world's top 100 companies by $1.3 trillion per year. A major ETR breakthrough, such as hydrogen fuel cells or advanced battery technology, could attract investment debt and equity financing approaching $1 trillion per year in the transportation industry alone in order to retool the $3 trillion/year automotive industry. It is estimated that energy expenditures equate to approximately 10% of world gross domestic product, which equates to an $8 trillion per year industry. As addressed in this report, the ETR could incentivize this $8 trillion/year industry to "retool" to meet energy and environmental needs. If the private sector is presented with viable ETR opportunities with reasonable risk and financial returns, it has the financial means to respond. Leading investment institutions are beginning to respond to renewable investment opportunities. In 2012, Goldman Sachs announced[30] that it planned to invest $40 billion over the next decade in renewable/alternative energy sources including: solar, wind, hydro, biofuels, biomass conversion, energy efficiency, energy storage, green transportation, efficient materials, LED lighting and transmission. Goldman has also pledged to reduce its own net carbon emissions to zero by 2020.

From an international investment (and employment) point of view, the EY (formerly Ernst & Young) 2015 Renewable Energy Country Attractiveness Index[31] rates the top 40 countries that provide the most attractive overall investment environment. The attractiveness rating is determined by a combination of macro stability, ease of doing business, prioritization of renewables, bankability of renewables and project attractiveness. Wind (onshore, offshore), solar (photovoltaics and concentrated solar), biomass, geothermal, hydro and marine technologies are all rated and are addressed later in this document. The

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[29] World Bank, Market capitalization of listed companies, U.S., http://data.worldbank.org/indicator/CM.MKT.LCAP.CD

[30] Reuters, Goldman sets $40 bln clean energy investment plan, 23 May 2012, http://www.reuters.com/article/2012/05/23/goldman-green-idUSL1E8GMDPR20120523

[31] EY, Renewable Energy Country Attractiveness Index (RECAI), March 2015, Page 14, http://www.ey.com/UK/en/Industries/Cleantech/Renewable-Energy-Country-Attractiveness-Index

top 10 countries for overall renewable energy investment are China, U.S., Germany, Japan, India, Canada, France, United Kingdom, Brazil and Australia.

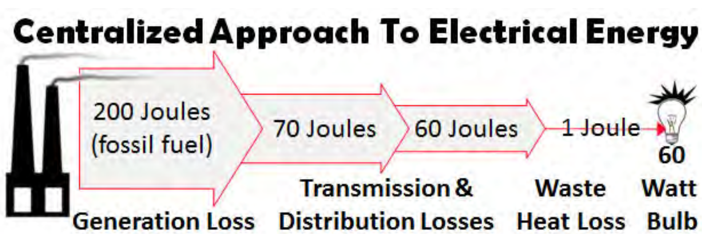
Demand-Side Energetics

Energetics (also called energy economics) is the study of energy conversion or energy transformation. Examples of energy conversion include transformation of electricity→light, fuel→kinetic energy, water power→mechanical power, and biomass→heat. For millennia, the focus of energy conversion has been on the supply-side of the energy ledger—the side closest to the producer or supplier. The future is on the demand-side—the side closest to the consumer or point-of-consumption.

There are essentially three energetic architectures: (1) large, centralized, utility-grade designs, (2) medium-size utility-grade and grid-connected distributed generation designs, and (3) small-scale, off-grid distributed and dispersed generation designs. Utility-scale and distributed generation designs are supply-side oriented, whereas dispersed generation focuses on demand-side energetics at the point-of-consumption.

The EIA defines distributed generation as being connected to the electrical grid and intended to directly offset retail sales. The EIA defines dispersed generation as being off-grid and often used for remote applications where grid-connected electricity is cost-prohibitive[32]. Jobenomics asserts that EIA's dispersed generation definition is too limited since it implies that dispersed generation is a niche technology used for high-cost remote applications rather than mainstream residential and small business applications. Furthermore, Jobenomics believes that America should strive to be demand-driven where every building and every community is energy sufficient—able to produce and store the energy it needs—at the point-of-consumption.

Today's supply-side architectures are inefficient, given existing and emerging ETR technologies, processes and systems. America produces and distributes electricity, heat and transportation fuels primarily by a centralized supply-side approach. America's supply-side energetics model was originally created to deliver energy from principal sources of energy, such as coal mines, oil refineries, rivers, dams and ports. This energy was then delivered over long distances to population and industrial centers. Substantial losses occur across the entire energy value chain, whether it is in production or generation, during distribution over 5 million miles of pipelines and electrical grids, or in inefficient burning or waste heat loss at the point-of-consumption.



The EIA calculates[33] that two-thirds of the energy used for producing U.S. electrical power is lost in generation and distribution. As shown, less than 1% of the total energy consumed is ultimately

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[32] EIA, Modeling distributed generation in the buildings sectors, August 2013, http://www.eia.gov/forecasts/aeo/nems/2013/buildings/

[33] EIA, Today In Energy, Energy Perspectives, 18 December 2012, http://www.eia.gov/todayinenergy/detail.cfm?id=9250

converted into light energy. The other 99% is wasted across the supply chain. On average, 200 joules of energy are needed to deliver 1 joule of power (1 joule = 1 watt second), the amount needed to illuminate a 60 watt incandescent light bulb.

Electricity Related Losses By Sector, 2015 Forecast

Source: EIA Annual Energy Outlook 2015

Quadrillion Btu	Commercial	Residential	Industrial	Transportation	Grand Total
Delivered Energy	8.77	10.90	25.23	27.13	**72.03**
Electricity Related Losses	**9.50**	**9.80**	**6.76**	**0.06**	**26.11**
Total	18.27	20.70	31.98	27.18	**98.15**
Losses % of Total	**52%**	**47%**	**21%**	**0.2%**	**27%**

The U.S. energy consumption in 2015 is projected to be 97.83 quadrillion Btu across all sectors from all sources[34]. Of the 97.83 quads, 27% will be electricity related losses. About half of the energy that commercial and residential consumers purchase is lost (52% and 47% respectively). While inherently inefficient, supply-side industries are making strides in energy efficiency.

The most efficient electrical power generation plants are hydro and tidal power plants with 90% power efficiencies (i.e., the amount of potential or kinetic power turned into electricity). Coal- and oil-fired plants are 40% efficient. The most inefficient are solar and geothermal plants with 15% to 20% efficiencies.

At the generation side of the supply chain, cogeneration technologies have double the energy efficiencies of combined heat and power plants[35]. Cogeneration involves the recovery of otherwise-wasted thermal energy to produce electricity or heat.

At the consumer side of the supply chain, fluorescent lamps and light emitting diodes (LEDs) have significantly enhanced energy efficiencies. Building on the previous example, by replacing the 60 watt incandescent light bulb with a 15 watt fluorescent lamp, energy generation is reduced from 200 to 50 joules, which results in energy efficiency increase of 75%. Replacing fluorescent lamps with LED bulbs increases energy efficiency by additional 30%. LEDs last five times longer than fluorescent lamps, which last eight times longer than incandescent bulbs. While these represent supply-side success stories, supply-side energetics have reached the point of diminishing returns.

Demand-side energetic architectures offer much higher potential for energy efficiency by producing energy on-site. If residences and businesses could produce and store energy on-site, there would be little need for outside electrical supply and expensive utility-grade electrical grids. The problem with on-site power generation has been the high cost of dispersed generation equipment. However, this is changing. Dispersed generation is becoming increasingly affordable to individual homeowners and small businesses due to lower installation costs, lower operational costs, smarter information and network technologies, and innovative leasing, subscription and net-metering services. A 2013 study by the

[34] EIA, Annual Energy Outlook 2015, Energy Consumption by Sector and Source, Table A2, 14 April 2015, http://www.eia.gov/forecasts/aeo/

[35] EPA, Combined Heat and Power Partnership Efficiency Benefits, http://www.epa.gov/chp/basic/efficiency.html

Center on American Progress[36] reports that the bulk of rooftop solar installations are from middle-class homeowners with median incomes ranging from $40,000 to $90,000.

Dispersed electrical generation is not a new concept. In fact, it is often the dominant way of doing business in many parts of world that are dependent on diesel-powered generators as opposed to 24/7 electrical power supplied by utilities. In the United States, there are approximately 12 million residential electrical generators: 9 million used for emergency or backup power and 3 million for primary power. From an environmental perspective, most of the 9 million emergency generators are noisy and dirty and limited to 200 hours per year. The 3 million primary power generators are generally more expensive due to cleaner burning fuels (propane), better fuel efficiencies and more interconnectivity to household systems. As renewable energy costs decrease, the likelihood of mass deployment of residential dispersed electric and heat generation will increase.

Few American policy-makers realize that gains in demand-side energy efficiency has produced far greater gains in energy conservation and greenhouse gas mitigation than all renewable energy advances combined. The IEA's inaugural 2013 Energy Efficiency Report[37] states that energy efficiency savings from 11 developed economies[38] are equivalent to one-quarter of all petroleum products consumed annually by the U.S. transportation sector.

Energy efficiency has moved from the "hidden fuel" to the "first fuel," exceeding output from any other supply-side fuel sources. In 2010, this new first fuel reduced total fuel consumption in the 11 IEA member countries by an estimated 65%. By reducing demand at the point-of-consumption, energy efficiency enables energy conservation, reduces pressure energy infrastructure, augments energy assurance and security, and improves health and wellness via mitigation of toxic emissions.

For the ETR to be truly transformative, policy-makers must focus on the demand-side of the equation. As addressed later in this report, a majority of 150 million U.S. homes and small businesses could be energy efficient or energy independent within a few decades. In addition, a distributed/dispersed, point-of-consumption, intelligent architecture that integrates multi-sources of indigenously-produced energy (wind, solar, biomass, geothermal, hydro and/or natural gas) could produce many millions of net new jobs nationally and tens of millions internationally. If underwritten by government loans and guarantees, like the government does for mortgages, demand-side energetics is likely to attract significant private sector investor interest.

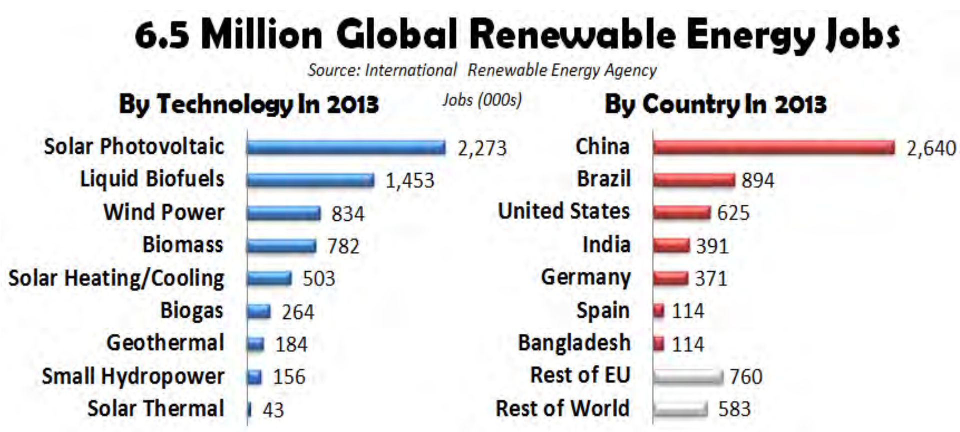
[36] Center for American Progress, Solar Power to the People: The Rise of Rooftop Solar Among the Middle Class, 21 October 2013, https://cdn.americanprogress.org/wp-content/uploads/2013/10/RooftopSolarv2.pdf
[37] IEA, Energy Efficiency Unit (EEU), Energy Efficiency Market Report 2013, http://www.iea.org/publications/freepublications/publication/EEMR2013_free.pdf
[38] United States, United Kingdom, Germany, France, Italy, Denmark, Finland, Netherlands, Sweden, Japan and Australia.

ETR Employment Outlook in the Renewables Sector

Solar, Wind, Hydro, Geothermal, Biomass, Municipal Waste,
Carbon-Based Renewables (Ethanol, Cellulosic Biofuels, Biogas/RNG)

Renewable Energy Employment Outlook.

The Washington DC-based Environmental and Energy Study Institute[39] estimates the number of U.S. jobs in the renewable energy sector to be between 900,000 and 1,100,000 employees. Their assessment includes direct, indirect and induced labor in the following renewable energy industries: biofuels, hydropower, wind, biodiesel, geothermal, biomass, fuel cells, waste-to-energy, and wave and ocean power. According to the EIA's Annual Energy Outlook 2014, renewable energy consumption is forecast to increase 46% between 2013 and 2030, which would translate to approximately 500,000 new American jobs. Jobenomics believes that these new job estimates are low if distributed generation and storage systems reach their potential within the period.



The International Renewable Energy Agency[40] reports that global renewable energy employment provided 6.5 million jobs in 2013. China is the largest employer with 2.64 million or 41% of the worldwide employment total, followed by Brazil (894,000), U.S. (625,000), India (391,000), Germany (371,000), Spain (114,000) and Bangladesh (114,000). By technology, solar photovoltaic dominated the field, employing 2.27 million or 35% of the worldwide employment total, followed by biofuels (1.45 million), wind (834,000), biomass (782,000), solar heating/cooling (503,000), biogas (264,000), geothermal (184,000), small hydropower (156,000), and solar thermal (43,000). Combined solar represents 43% of total employment versus combined bio with 38%.

From a global perspective, IEA reports[41] that renewable energy sources reached 22% in global electrical generation, on par with natural gas and one-third the amount of coal. In the transportation sector,

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[39] Environmental and Energy Study Institute, *Jobs in Renewable Energy and Energy Efficiency*, http://www.nacubo.org/Documents/BusinessPolicyAreas/FactSheetGreenJobs061113.pdf
[40] International Renewable Energy Agency, Renewable Energy and Jobs, Annual Review 2014, http://www.irena.org/Publications/rejobs-annual-review-2014.pdf
[41] International Energy Agency (IEA) Medium-Term Renewable Energy Market Report 2014, http://www.iea.org/Textbase/npsum/MTrenew2014sum.pdf

biofuels will make modest headway but will still be a minority renewable energy supplier versus petroleum. Renewable sources of heat account for only 8% of the heat total and have not grown significantly over the last five years, despite the need for small-scale distributed generation.

While worldwide renewable electric power generation is projected to grow approximately 8% by 2020 (about half of the total contributed by China), as a percentage of the total energy mix, renewable energy is forecast to be flat. As a result, the anticipated contribution of renewable energy to mitigating the damaging effects of greenhouse gases and limiting temperate rise to the 2°C climate change goal will not be realized under current or likely policy and market scenarios. To achieve climate change goals, all eyes will be watching Germany, China, India and California as precursors to the UNFCCC's Paris Climate Change Conference in December 2015.

Germany's *Energiewende* (German for energy transition) is a national initiative to transition Germany from fossil and nuclear fuels to renewable energy. By 2022, Germany plans to be completely out of nuclear energy and will be highly dependent on wind and solar energy. Germany also plans to raise renewable energy's share from approximately 25% today to 80% by 2050. This aggressive national initiative is designed to dramatically reshape Germany's energy portfolio to be dominated by renewable energy, energy efficiency and sustainable development.

Energiewende will not be easy. German citizens are concerned about *Energiewende*'s hefty tax increases for renewable subsides and much higher surcharges on electricity bills. German energy providers, who invested heavily in traditional technologies before the renewable energy craze took hold, are suing the government for what they consider hostile energy policies. The largest German utility, E.ON, has been forced to break itself up into essentially good and bad technology companies. The "bad utilities" company is focused on shuttering fossil fuel and nuclear businesses, while the "good utilities" company is focused on growing renewable suppliers and developing new service businesses, such as smart metering, distributed generation management, consumption analytics and energy management. It will be fascinating to watch *Energiewende* reposition the German energy sector from a centralized model to a more decentralized, distributed model. Lessons learned will be especially valuable for policy-makers in democratically-elected Western economies.

China is the renewable energy model for centrally-planned economies. China's Communist Party is committed to a massive nuclear and renewables effort that will generate more energy than produced by the entire U.S. energy sector (including coal and oil). A recent Chinese study[42] shows that it's technologically and economically feasible for most of China's energy to come from renewables by 2050, with renewables accounting for over 60% of China's total energy consumption and over 85% of total electricity consumption – signifying a true revolution of energy production and consumption. This study analyzes how China can gradually phase out fossil energy, especially coal, from its leading role in China's energy development, and give low-carbon green electricity a prime role to play.

Chinese leadership is also committed to being the global provider of renewable energy products and services. The International Renewable Energy Association predicts that China will invest $145 billion

[42] Wang Zhongying, director of the China National Renewable Energy Center and deputy director general of the Energy Research Institute at China's National Development and Reform Commission, China 2050 High Renewable Energy Penetration Scenario and Roadmap Study, http://www.scribd.com/doc/262478415/China-2050-High-Renewable-Energy-Penetration-Scenario-and-Roadmap-Study

each year to add this new generating capacity. Today, China is the largest user and manufacturer of solar panels and wind turbines in the world. They are also developing the largest hydropower infrastructure in the world. China recently completed the world's largest hydroelectric dam with an installed capacity of 22,500MW. This dam, called Three Gorges Dam, can deliver incredible 100 trillion watt hours per year. The dam also evicted 1.3 million Chinese peasants by fiat from the regime in Beijing.

Even with massive new building programs, China will still add a new coal-fired power plant every week to satisfy the power demands of a rapidly growing middle class. According to China's Health and Environmental Protection Ministers, up to 500,000 Chinese prematurely die[43] every year due to killer smog produced in large part by dirty Chinese coal-fired power plants. Chinese leadership knows that China has to break its dependency on coal, but coal is the only readily available and reliable source of energy. As a result, China is investing heavily on "clean coal" technologies and carbon capture, utilization and storage.

India's Prime Minister Modi is banking on renewables to fight climate change, rather than committing to emission cuts that would adversely affect the poor (India still has 280 million people living without power) and disrupt a growing middle-class economy. India's 2015-2016 Budget[44] commits $400 million to expanding renewable energy from today's installed capacity of 33.8GW to 170GW by 2022, including expansion of solar from 3.3GW to 100GW, wind from 22GW to 60GW, and a $50 billion investment in transmission and distribution systems.

According to the Minister for Power, Coal and New & Renewable Energy, Piyush Goyal[45], India is seeking the proper "combination of solar with wind, hydro or waste-to-energy, so that they can provide 24/7 power to all homes, businesses and industries across the country by 2019."

India is also seeking significant investment funds and ETR technology, processes and systems from the international community as well as creating a National University for Renewable Energy. Electric and hybrid vehicles are receiving special attention and limited funding from the India government. Regarding fossil fuels, India is doubling the tax on domestically produced and imported coals. The revenue collected from this tax will be allocated to the National Clean Energy Fund to finance renewable energy projects. India's 2015/16 Budget also calls for developing one hundred smart cities with integrated policies for sustainable development, and establishing a National Air Quality Index and a National Air Quality Scheme.

California has its own version of *Energiewende*. According to California's governor[46], "California has the most far-reaching environmental laws of any state and the most integrated policy to deal with climate change of any political jurisdiction in the Western Hemisphere." In his 2015 Inaugural Address, Governor Brown announced three ambitious new 2030 goals: increase from 33% to 50% electricity

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[43] The Telegraph, China's 'airpocalypse' kills 350,000 to 500,000 each year, http://www.telegraph.co.uk/news/worldnews/ asia/china/10555816/Chinas-airpocalypse-kills-350000-to-500000-each-year.html
[44] Government of India, Budget 2015-16, http://pib.nic.in/budget2015/ecosurveyRel.aspx#
[45] EY, Renewable Energy Country Attractiveness Index, Minister Goyal Interview, Page 6, March 2015, http://www.ey.com/Publication/vwLUAssets/Renewable_Energy_Country_Attractiveness_Index_43/$FILE/RECAI%2043_March%202015.pdf
[46] Office of Governor Brown, Inaugural Address, 5 January 2015, http://gov.ca.gov/news.php?id=18828

derived from renewable sources; reduce automotive petroleum by up to 50%, and increase building efficiency and clean heating fuels by 100%. In addition, California envisions more distributed power, expanded rooftop solar, micro-grids, an energy imbalance market, battery storage, integrated information technology and electrical distribution, and millions of electric and low-carbon vehicles.

Other than climate change reasons, California's mandates were issued to spur stagnating investment in renewables, advanced vehicles and energy efficiency. For example, California's major utility companies were on track to meet the 33% goal and showed little interest in signing new power purchase agreements with expensive renewable energy companies. The new mandates were implemented by executive order by the Governor and enforced by the California Public Utilities Commission. In addition to the Governor's executive orders, President Obama has committed by executive order 22 million acres of federal land in the California desert to support large utility-grade wind and solar energy projects in order to generate 20 gigawatts of electricity, enough to power 6 million homes. While environmentalists praise such executive actions, many free-market economists fear that these projects will become a California state albatross due to numerous renewable energy sustainability challenges.

Before addressing renewable energy sustainability challenges, it is important to congratulate California for the risks they have taken and the successes that they have achieved. Jobenomics feels it is premature to call California a success story, but they have certainly defied their critics. They had some big failures that have clearly been eclipsed by their achievements. California leads the nation, and most of the world, in virtually every renewable energy category in both power generation and transportation. California is well on the way to paying back over $30 billion worth of federal loans while attracting over $20 billion worth of private sector investment. Their progress has been remarkable. In 2008, California's renewable energy constituted 12% of their energy mix. In 2015, it is 25%. By 2020, it will be 33% if signed contracts are exercised. Also by 2020, the world will know if California's renewable energy sector is competitive in an open market without undue government support. If it is, they will clearly be an outright success story. If they achieve their 50% goal by 2030, they will change the world.

Renewable Energy Sustainability Challenges.

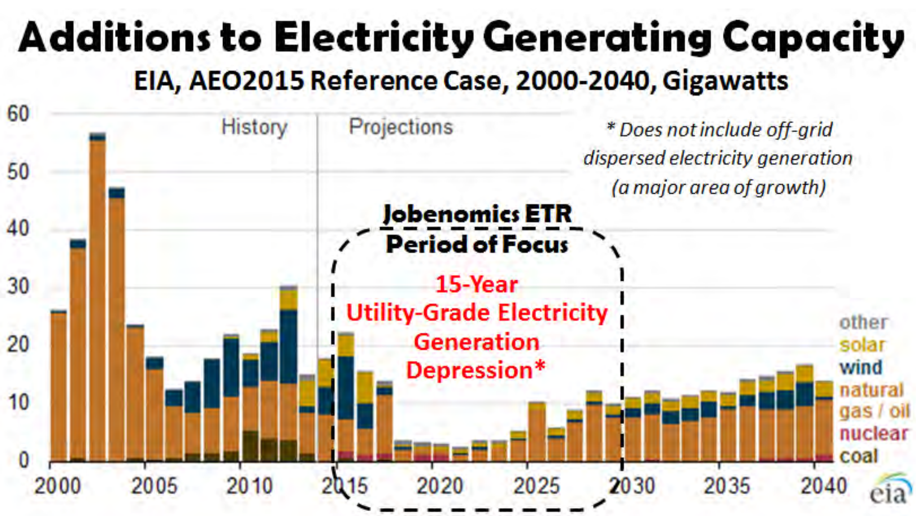
Sustainability is the paramount issue facing the renewable energy sector. From a Jobenomics perspective, the most pressing challenges to renewable energy sustainability involve *Electrical Demand/Depression, Electrical Utilities, Government Aid, Ecological Taxation, Private Sector Investors, Correct Methodology, Over-Optimistic Expectations, Grid-Scale Storage, Distributed Generation and Dispersed Generation, Next-Generation Renewable Technology,* and *Power Density.* The issue is not if renewables can overcome these challenges, but when and to what degree.

Electrical Demand/Depression.

According to the EIA[47], growth of U.S. electricity demand (including retail sales and direct use) has slowed in each decade since the 1950s and is projected to be low for the next decade and a half as rising demand for electric services is offset by efficiency gains from new appliance standards and investments in energy efficient equipment.

In 2013, the U.S. generated about 4,058 billion kilowatt hours of electricity from the following sources: #1 coal 39%, #2 natural gas 27%, #3 nuclear 19%, #4 hydropower 7%, #5 wind 4.13%, #6 biomass 1.48%, #7 petroleum 1%, #8 other gases < 1%, #9 geothermal 0.41% and #10 solar 0.23%[48].

From 2013 through 2016, the majority (52%) of new electrical capacity is likely to consist of renewables that can take advantage of federal tax incentives and state renewable fuel standards. After 2016, the electrical power generation market is projected to enter a 15-year depression that will affect all sources, especially utility-grade wind and solar power projects.



In 2017, U.S. electrical generation is projected to enter a 15-year depression (as shown above) that will depress all large-scale projects[49]. These projections do not include electrical generating capacity for

[47] EIA, Annual Energy Outlook 2014, Electricity Demand, Page MT-16, http://www.eia.gov/forecasts/aeo/
[48] EIA, What is U.S. electricity generation by energy source?, http://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3

small-scale projects that are not connected to the grid (e.g., dispersed wind, solar and natural gas residential systems). The U.S. power generation market will change for two major reasons: (1) many of the federal and state incentives are scheduled to expire or drop-down, and (2) existing sources provide adequate capacity to meet slow electrical demand growth and satisfy renewable requirements under state standards. Of the two reasons, the second reason is by far the most serious.

According the EIA AEO2014 Reference Case, "Annual capacity additions drop significantly after 2016 and remain below 9GW/year until 2023, while existing capacity is adequate to meet relatively slow demand growth in most regions and satisfy renewable requirements under state standards"[50]. As amended by the AEO2015 Reference Case, "Capacity additions through 2017, much of which are under construction, average about 17GW per year and about half are nonhydro renewable plants (mainly wind and solar) prompted by federal tax incentives and renewable portfolio standards. From 2018 to 2024, projected capacity additions average less than 4GW per year, as earlier planned additions are sufficient to meet most growth in electricity demand. From 2025 to 2040, average annual capacity additions—primarily natural gas-fired and renewable technologies—average 12GW per year. By comparison, annual additions from 2000 to 2013 averaged 26GW per year"[51]. The underlined figures highlight the fact that EIA forecasts dropped over 50% in the span of one year (from 9GW/year in the AEO2014 report to 4GW/year in the AEO2015 report).

EIA's AEO 2014/2015 Reference case projections assume trends that are consistent with historical and current market behavior, technological and demographic changes, and current laws and regulations. EIA also has a number of other "cases" that incorporate significant changes to the reference case, such as the Administration's Clean Power Plan that accelerates early retirement of older fossil fuel power plants to make way for renewable energy, high economic growth scenarios, and high oil and gas resource scenarios. Unless stated otherwise, Jobenomics uses the AEO Reference Case in this report because of (1) the challenges of getting the Clean Power Plan enacted, (2) the likelihood of a continued slow growth economy, and (3) the sustainability of fossil fuel energy, especially natural gas, as the dominant U.S. energy resource for the foreseeable future.

Competition for large-scale, supply-side electrical power generation will be intense, especially against natural gas, which is highly-competitive in terms of both cost per Btu and the cost of retrofitting or replacing retiring coal-fired power plants. For large-scale projects, renewables are more capital-intensive and have higher construction costs than natural gas. In addition, the boom in shale gas production is dropping gas prices, which makes natural gas even more competitive.

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[49] EIA, Today in Energy, Projected electric capacity additions are below recent historical levels, 11 May 2015, http://www.eia.gov/todayinenergy/detail.cfm?id=21172&src=email

[50] EIA, Annual Energy Outlook 2015, Market Trends: Electricity demand, Additions to power plant capacity slow after 2016 but accelerate beyond 2023, AEO2014 Reference Case (Figure MT-32, 7 May 2014), http://www.eia.gov/forecasts/AEO/MT_electric.cfm

[51] EIA, Today in Energy, Projected electric capacity additions are below recent historical levels, 11 May 2015, http://www.eia.gov/todayinenergy/detail.cfm?id=21172&src=email

2013 to 2040 Cumulative Additions to Electricity Generation Capacity By Fuel

Source: EIA Annual Energy Outlook 2015, Figure 35, Reference Case, Gigawatts

Natural Gas/ Oil	Coal	Wind	Solar	Other Renewable	Nuclear	Other	*Total*
167.17	1.05	49.22	47.96	11.83	8.97	0.97	*287.18*
58.2%	0.4%	17.1%	16.7%	4.1%	3.1%	0.3%	*1.00*

Fossil Fuel 59% (Natural Gas/ Oil, Coal) **Renewable Fuels 38%** (Wind, Solar, Other Renewable)

EIA data indicates that fossil fuels (mainly natural gas) will capture 59% of capacity additions from 2015 to 2040. All renewables will capture 38%, with wind accounting for 17.1% and solar 16.7%[52].

Scheduled 2015 Capacity Additions & Retirements

Electrical Generating Companies		Net Change (MW)		Percent
Additions	Wind	17,957	9,811	70%
	Solar		2,235	
	Other renewables		471	
	Nuclear		1,122	30%
	Gas		4,318	
Retirements	Petroleum	(13,722)	(800)	6%
	Coal		(12,922)	94%
	Net Additional Capacity	***4,235***	*Source: EIA*	

Unlike emerging economies, electrical generation in the United States is becoming a zero-sum game. Using 2015 as an example[53] (shown), 17,957MW of new capability will come online, but 13,722MW will retire (94% coal). In other words, only 4,235MW is new capacity and 13,722 is replacement capacity. 70% of the scheduled 2015 additions involve renewable energy that has a significant competitive advantage due to unfulfilled state renewable standards and generous government incentives. The addition of Tennessee Valley Authority's Watts Bar 2 nuclear facility in 2015 can be considered an anomaly since is the first new U.S. nuclear reactor to come online in 20 years.

Unless current federal incentives are extended and state standards are revised to further restrict fossil and nuclear fuels, grid-scale opportunities for renewable energy will be limited. Even if federal incentives were extended, the market still has to deal with increasing energy efficient and dwindling demand. Consequently, from a Jobenomics perspective, renewable energy supporters must change focus from grid-scale to off-grid distributed and dispersed generation applications before the floor drops out of the utility-grade electrical power generation market.

Electrical Utilities.

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[52] EIA, Annual Energy Outlook 2015, Figure 35. Cumulative additions to electricity generation capacity by fuel in six cases, 2013-40 (gigawatts), Page 26, http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf & http://www.eia.gov/forecasts/aeo/section_elecgeneration.cfm

[53] EIA, Today In Energy, 10 March 2015, http://www.eia.gov/todayinenergy/detail.cfm?id=20292&src=email

One of the biggest challenges to the renewable energy industry may not come from the fossil fuel industry, but from electrical utilities.

Someone has to pay for America's gargantuan electrical power infrastructure. The U.S. electrical grid is the world's largest commercial monolith, annually distributing $366 billion worth of electricity over 3 million miles of power lines from 7,000 power plants that are owned by 3,300 utility companies who employ 500,000 people who service 159,000,000 American customers[54,55]. Unfortunately, this monolith is aging, requiring tens of billions of dollars to maintain annually and investments of up to $2.0 trillion[56] by 2030 to modernize and protect. According to a recent analysis[57] of federal energy records, about once every four days, part of the nation's power grid is struck by a cyber or physical attack. A 2014 testimony[58] by Admiral Rogers (NSA Director) to Congress revealed the possibility of a major Chinese or Russian cyberattack against the U.S. power grid, which could cause cascading regional blackouts lasting days to months—with major economic damage and loss of life.

A sizeable percentage of the consumer's electrical bills are for infrastructure maintenance and security costs. Consumers who elect to get off the electrical grid by producing their own electricity will shift these costs to other consumers. This is not acceptable to electrical utility owners who are making a major legislative push to have renewable energy users pay their fair share to maintain grid integrity and pay for necessary upgrades.

Over the past several years, utility companies in more than three dozen states across the country have attacked rooftop solar to protect their monopolies. Rooftop solar companies argue that electrical utilities are monopolies that are trying to drive the renewable energy industry out of business. The showdown in Arizona (the U.S.'s top state for solar energy) between the largest utility, Arizona Public Service, and a national advocacy group called TUSK (Tell Utilities Solar won't be Killed) is likely to be a bellwether contest to be adjudicated by state legislators and regulators. According to former Congressman and TUSK's Chairman Barry Goldwater Jr.[59], "We can't let solar energy - and all its advantages and benefits it provides us - be pushed aside by monopolies wanting to limit energy choice." TUSK is also launching advocacy initiatives in nine other states.

For the near-term, the advantage favors the Goliaths as opposed to fledgling renewable energy companies. However, this may change. Small advocacy groups in unlikely areas like West Virginia, the 42nd worst state for sunshine, have stymied "anti-solar" attempts by West Virginia's two largest electric utilities. These two utilities first tried to amend the State's alternative energy standard to eliminate solar net-metering. Next came solar leasing. Now they are lobbying the West Virginia legislature to institute a rooftop solar fee structure.

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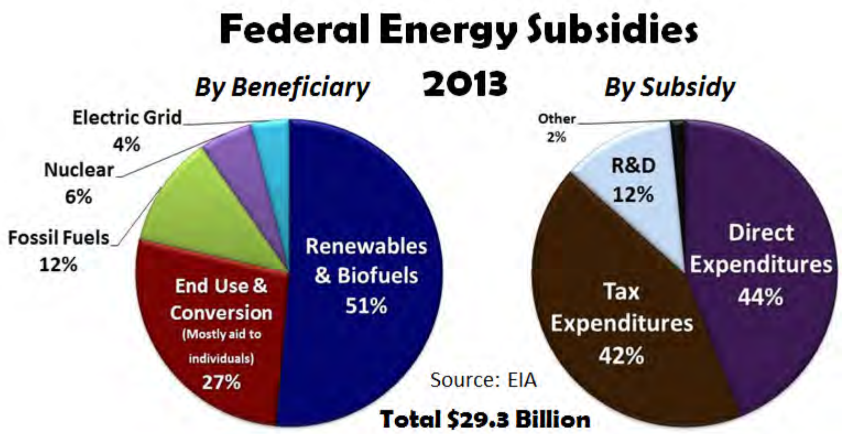
[54] American Public Power Association, 2014-2015 Annual Directory & Statistical Report, U.S. Electric Utility Industry Statistics, http://www.publicpower.org/files/PDFs/USElectricUtilityIndustryStatistics.pdf
[55] Edison Electric Institute, Electricity 101, http://www.eei.org/electricity101/pages/value.aspx
[56] U.S. Quadrennial Energy Review, Summary For Policymakers, Aging Infrastructure and Changing Requirements, Page S-4, http://energy.gov/sites/prod/files/2015/04/f22/QER%20Summary%20final_1.pdf
[57] USA Today, 27 March 2015, http://www.usatoday.com/story/news/2015/03/24/power-grid-physical-and-cyber-attacks-concern-security-experts/24892471/
[58] C-Span, 20 November 2014, Cyber Threats, http://www.c-span.org/video/?322853-1/hearing-cybersecurity-threats
[59] TUSK, Tell Utilities Solar won't be Killed, http://dontkillsolar.com/tusk/

Eventually, a compromise will be reached between centralized on-grid utility companies and decentralized off-grid renewable energy companies. Jobenomics forecasts that utility companies will eventually become more like the German E.ON electric utility and create new revenue streams based on becoming or acquiring renewable energy suppliers, and energy services including net-metering, energy efficiency, energy management and energy solutions.

Government Aid.

A major sustainability challenge will occur when government aid ends, forcing the renewable energy industry to operate without subsidies in a highly competitive and saturated energy market.

Federal, state and local governments provide a long list of standards, policies, subsidies, incentives, disincentives, loans and grants to help renewable energy and energy efficiency. A comprehensive list of government programs can be accessed at DSIRE[60]. Established in 1995, DSIRE is operated by the North Carolina Clean Energy Technology Center at NC State University, and is funded by the Department of Energy.



According to the EIA, there are over 70 federal domestic energy assistance programs[61]. In FY2013, federal government total energy subsides were $29.3 billion, down 23% from a high of $38.0B in FY2010. By beneficiary, renewables were the largest with 51% of the total in FY2013. Within the renewable category, wind received $5.9B, followed by solar $5.3B, biofuels (ethanol) $1.8B and others $2.0B. End Use & Conversion received 27% that was mainly aid for individuals, including the Low Income Home Energy Assistance Program and the oil to natural gas Conversion Program. Fossil fuels were 6% ($1.1B for coal and $2.3B for natural gas and petroleum liquids), nuclear 6% and electrical grid 4%. By subsidy, Direct Expenditures (cash outlays to producers or consumers) were the largest with 44%, followed by Tax Expenditures (largely production and investment tax credits), R&D 12% and all others 2%.

Just the threat of reduced government subsidies can torpedo a fledging renewable energy sector as happened to U.S. wind power in 2013. Wind power achieved a record 13.8GW in utility-grade wind

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[60] DoE, DSIRE, http://www.dsireusa.org/

[61] EIA, Analysis & Projections, Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2013, 12 March 2015 release date, http://www.eia.gov/analysis/requests/subsidy/?src=email

development in 2012 and then plummeted to 0.6GW in 2013 (a 96% drop) due to regulatory uncertainty regarding the Production Tax Credit (PTC).[62] Congress subsequently renewed the PTC and renewed growth transpired in 2014 due to the reinstatement of production-based credits.

The PTC (a 10-year production-based credit equal to up to $22/MW hour deduction for renewables) is only one of the many U.S. federal government incentive programs. The other two major federal tax incentive programs are Investment Tax Credit (credit equal to 30% of eligible capital expenditures) and Modified Accelerated Cost Recovery System (accelerated depreciation of tangible property). In addition to federal tax incentives, the DoE offers loan guarantee programs and grants. State and local governments offer tax incentives and regulatory advantages such as mandatory renewable portfolio standards (RPS) that set specific annual amounts for renewable electricity consumption, and renewable fuel standard (RFS) for the amount of synthetic fuel that will be blended in gasoline.

Jobenomics believes that these government subsidies are absolutely necessary to launch vitally important renewable technologies. On the other hand, subsidies can create a perception that these technologies can stand on their own well before they mature, and a misperception that renewables can prematurely replace traditional technologies when they cannot.

Ecological Taxation.

Ecological (interactions between organisms and their environment) taxation is akin to a government subsidy but is a more aggressive approach to pressuring communities to adopt environmentally-friendly methods and standards.

Ecological taxation (ecotax) can reward or punish. On the reward side, ecotax credits and abatements can be offered to compliant individuals and businesses. On the punishment side, ecotax-related fees, duties, assessments, penalties and garnishments can be exacted on the non-compliant. Carbon credits are a version of an ecotax since they penalize fossil fuel plants that produce CO_2 and reward renewable energy producers.

The international carbon credit system was ratified in conjunction with the Kyoto Protocol in 1997, with a goal to stop the increase of CO_2 emissions. Carbon credits consist of tradable certificates or permits (equal to one ton of CO_2 emission equivalents) that are awarded to entities (countries and companies) that reduce their GHGs below quota. These credits can then be sold to entities that don't meet their quotas or traded on the world's carbon markets.

Emission trading is also a form of ecotax that is commonly referred to as a cap-and-trade emissions trading system. Different forms of cap-and-trade systems have been instituted in the United States to control toxic emissions, such as Acid Rain (caused by emissions of sulfur dioxide and nitrogen oxide that react with the atmosphere to produce acids), but a U.S. cap-and-trade system to address global climate change has yet to be instituted. Such a system would greatly benefit renewable energy sustainability but would penalize fossil fuel sources.

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[62] Bloomberg New Energy Finance, Sustainable Energy In America 2014 Factbook, Figure 45: U.S. wind build, 2004-13, Page 37, http://about.bnef.com/white-papers/sustainable-energy-in-america-2014-factbook/

There is strong support from climate change and renewable energy supporters for ecological taxation in order to rapidly transition from fossil and nuclear fuels. Without a compelling ecological event, Jobenomics predicts that ecotaxes in general and a U.S. cap-and-trade system in particular, will not be forthcoming due to strong fossil fuel support from U.S. price-conscious consumers and fiscally-conservative policy-makers. Notwithstanding, the Paris 2015 Agreement will require the Obama Administration to submit the United States Intended Nationally Determined Contributions (INDCs), which will likely include a commitment to an international cap-and-trade system. It is likely that the Republican-controlled Congress will not ratify such an agreement. It is also likely that American public ire will rise on both sides of this issue.

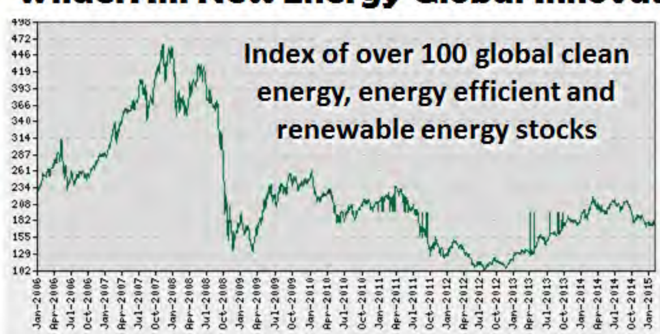
Private Sector Investors.

The principle source of renewable energy funding does not come from government, but from private sector investors who have experienced a very bumpy ride with renewable energy.

The leading index for renewable energy-related investment portfolios is called the WilderHill New Energy Global Innovation Index (NEX). The NEX is an index (portfolio) of over 100 international stocks mainly from the U.S., China and Europe. According to WilderHill[63], the NEX "is comprised of companies worldwide whose innovative technologies and services focus on generation and use of cleaner energy, conservation and efficiency, and advancing renewable energy generally. Included are companies whose lower-carbon approaches are relevant to climate change, and whose technologies help reduce emissions relative to traditional fossil fuel use."

Since its inception in 2006, the NEX has lost clean energy investors a total of 15.4%. A major drop occurred during the 2008-09 Recession. Discounting the ravages of the Great Recession, the renewable energy market continues to be lackluster compared to other markets that have doubled the value of their investor's portfolios.

WilderHill New Energy Global Innovation Index (NEX)



Annual NEX Performance	
Year	Performance
2006	33.0%
2007	59.0%
2008	-60.6%
2009	40.9%
2010	-13.9%
2011	-39.6%
2012	-4.2%
2013	53.9%
2014	-3.3%
2007-2014	-15.4%

The ride for renewable energy investors can be characterized as volatile, with huge upswings in four up-years, followed by persistent downturns in five down-years. 2014 started out positive, but the threat of truncated government subsidies and falling oil prices caused the NEX to retreat 16.5% in the last six months of the year, ending with a loss of 3.3%. Like the NEX, the S&P Global Clean Energy Index[64]

[63] WilderHill New Energy Global Innovation Index, http://www.nexindex.com/

[64] S&P Global Clean Energy Index, 1 Feb 2014, http://us.spindices.com/indices/equity/sp-global-clean-energy-index

reports similar results with a 5-year return of -12.5%. The S&P Global Clean Energy Index provides exposure on 30 companies around the world that are involved in clean energy production, equipment and technology.

Unless more stability and lucrative investment opportunities are afforded by the renewable energy industry, private sector investment will be tepid. Given the volatility and weak returns offered by renewable and clean energy stocks, private sector investors may even get out of this market if another global economic downturn occurs as it did in 2008. The renewable energy industry will not be sustainable until this volatility subsides and renewable energy stocks maintain a steady upward vector that is attractive to private-sector investors.

Master Limited Partnerships (MLPs) are widely used in the fossil fuel industry and are a way to lower financing costs for renewable energy projects and attract private sector investment.

MLPs were established by Congress in 1980 to raise capital from small investors by offering them a limited partnership in emerging energy companies. MLPs are limited by U.S. federal law to only apply to enterprises that engage in energy, real estate, investment/financial and other businesses. The vast majority (82%) are involved with energy-related fossil fuel businesses.

The main advantage of an MLP over a corporation is that MLPs do not pay corporate-level income taxes. Small investors usually own 98% of the MLP and 2% is owned by the managing partners (albeit they get paid handsomely for managing the operation). MLPs trade on public exchanges (NYSE, NASDAQ, etc.) or over-the-counter markets and pass the majority of their income down to their shareholders who are paid by quarterly distributions. These distributions are eagerly sought by dividend-hungry small investors. The major downside to MLPs is that these small investors are the least able to weather economic downturns in various sectors of the energy industry (such as the gathering and processing sector that has lost 40% of its value when crude oil dropped from $100 per barrel to $50 per barrel in 2014).

Largely due to the hydraulic fracturing (fracking) shale industry, energy-related MLPs have grown dramatically in the last decade. There are about 125 U.S. MLPs with $600 billion invested. The Yorkville MLP Infrastructure Universe Index[65] (YINFU) consists of the entire universe of energy-related MLPs in the following business segments: natural gas pipelines (35.2%), gathering and processing (23.5%), refined product pipelines (13.6%), crude oil pipelines (12.3%) and general partners (15.4%). The YINFU reports that the 10-year total returns for MLP investors was 15.0% compared to 7.9% for the S&P 500 and 2.0% for 10-year U.S. Treasury yields. Total MLP market capitalization has grown from $2 billion in 1994 to $438 billion as of 27 February 2015.

In 2013, a bipartisan group of U.S. legislators introduced the Master Limited Partnerships (MLP) Parity Act, a bill that would give renewable energy projects the same access to lower-cost capital that has been available to the fossil fuel industry for decades. The Senate and House bills expanded the definition of MLPs to include new ETR-related categories including wind, solar, biomass, marine, hydropower, biodiesel, energy efficient buildings, fuel cells, combined heat and power, carbon capture and storage, and electricity storage.

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[65] Yorkville Capital Management, http://www.yorkvillecapital.com/yorkville-mlp-infrastructure-universe-index.aspx

Unfortunately, these bills died in Congress due to the ideological divide that exists in Washington. On the left, climate change advocates wanted many of fossil fuel MLP categories to be eliminated. On the right, pro-fossil fuel advocates argued for the elimination of the hefty production and investment tax credits that are critical to fledgling renewable solar and wind industries. To date, Congress has not been able to forge forward on a plan for MLPs for renewable energy. As part of President Obama's Fiscal Year 2016 Revenue Proposal[66], he proposed to eliminate fossil fuels MLPs as part of the Administration's policy of reducing GHG emissions, supporting renewable energy and reducing reliance on fossil fuels.

Jobenomics believes that the MLP Parity Act for both fossil and renewable fuels should be enacted. The market will ultimately decide on winners and losers—not the government. With all the publicity and economic potential of renewables, small investors will likely flock en masse to clean energy MLP opportunities.

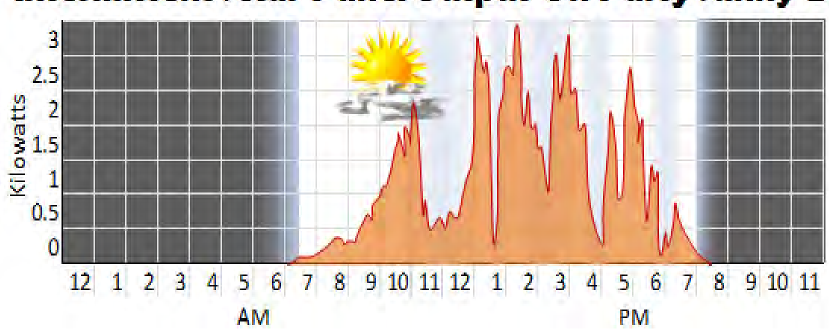
Correct Methodology.

Correct methodology must be used in order to attract the amount of private sector investment needed to commercialize clean and environmentally-friendly technologies.

Methodology involves an organized, documented and verifiable set of procedures and guidelines across the renewable energy life cycle, from analysis to design to implementation to operation to termination. Some of the key methodologies needed to advance renewable energy technologies involve intermittency, pricing, costing and dispatchability—the four areas most often understated by renewable energy supporters and often renewable energy's Achilles heel.

Intermittency. An intermittent energy source is a source characterized by output that is dependent on the natural variability of the source rather than the requirements of consumers. Solar and wind energy are examples of intermittent energy sources since they are only available when the sun is shining or when the wind is blowing.

Intermittent Solar Panel Output On Party Sunny Day



[66] Ernst & Young, Master limited partnership alert, February 2015, http://www.ey.com/Publication/vwLUAssets/EY-master-limited-partnership-alert/$FILE/EY-master-limited-partnership-alert.pdf

As shown, solar intermittency varies by time of day, weather conditions and locale. The top U.S. sunshine states[67] are Arizona with 3,806 hours of sunshine per year, followed by Nevada with 3,646 hours, Colorado 3,204 hours, California 3,055 hours, Idaho 2,993 hours and Georgia 2,986. Florida, nicknamed "The Sunshine State" is 7th with 2,927 hours. The worst sunshine state is Alaska with 2,061 hours, followed by Washington with 2,170 hours, New York 2,120, Ohio 2,183, Vermont 2,295 and Michigan 2,392. While Alaska has 2,061 hours of sunshine, it is considered extremely intermittent since it has limited amounts of sunshine during the winter months when electricity is needed the most and vast amounts during the summer when electricity is needed the least.

Pricing. Electricity pricing is not homogeneous. EIA's Electric Power Monthly Report[68] shows that residential customers pay more than commercial, industrial, or transportation end-users. For example, Michigan's average of all sectors was $0.11kWh (11 cents) with residential pricing $0.15kWh, commercial $0.11kWh, industrial $0.08kWh and transportation $0.12kWh. Prices vary widely by state with Hawaii being the highest at $0.34kWh and Washington being the lowest at $0.07kWh. Internationally, the U.S. national average is $0.12kWh compared to the highly subsidized rate in India of $0.08kWh and Germany's $0.35kWh. Germany's national rate is almost three times as high as the U.S. and is likely to go much higher with Germany's Energiewende initiative.

Costing. Levelized costs of electricity (LCOE) calculations are used as a measure of the overall competiveness of different technologies. LCOE calculations generally represent electricity costs of a projected duty cycle, such as a month or year. More mature calculations include end-to-end system factors including subsidies, credits, R&D, capital expenditures, financing costs, operations and maintenance costs, and utilization rates. Less mature calculations, often used for marketing purposes, focus on a much more limited set of factors. Wind and solar have no fuel costs and limited operational manpower expenditures, which afford these technologies significant advantages when items like government subsidies and capital expenses are not included.

Dispatchability. Dispatchable power refers to electricity that can be dispatched or adjusted from producers of electrical energy to meet the rapidly changing demands of downstream electrical grid operators and end-users. Operators throttle up or down electrical generators to adjust for supply and demand, to balance loads or to supplement other suppliers in response to outages or intermittent power spikes. Wholesale electricity prices reach extremely high levels for a relatively small number of hours. Only power plants that can supply power during those hours can monetize high prices that are charged during peak demand[69].

The only types of renewable energy that are currently dispatchable are biofuel, biomass, hydro with a reservoir and concentrated solar with thermal storage. Intermittent solar photovoltaic and wind power will not be dispatchable until a cost effective means of grid-scale storage becomes available. The energy supplier that can react to changing conditions and provide "dispatchable" power at the lowest price will

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[67] Average Annual Sunshine by State, http://www.currentresults.com/Weather/US/average-annual-state-sunshine.php

[68] EIA, Electric Power Monthly, http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

[69] Forbes, Energy, *Levelized Cost Of Electricity: Renewable Energy's Ticking Time Bomb?,* 29 Nov 2014, http://www.forbes.com/sites/williampentland/2014/11/29/levelized-cost-of-electricity-renewable-energys-ticking-time-bomb/

rule the marketplace because they can charge premium prices for power (often many times the ordinary price) when it is needed the most.

Over-Optimistic Expectations.

Over-optimistic expectations are damaging implementation of renewable energy technologies, processes and technology. Even the most ardent renewable energy supporters are coming to the conclusion that trying to combat climate change solely with renewable technologies simply will not work in the foreseeable future.

After years of research and development, the Google Renewable Energy Cheaper than Coal (RE<C) team concluded[70] that renewable energy technologies will not save the planet, and a fundamentally new approach is needed to address climate change challenges.

In 2007, Google started a major investment program to drive down the cost of renewable energy in order to help solve the world's climate and energy problems. One of their major initiatives was called Renewable Energy Cheaper than Coal (RE<C) to show that renewable energy could be produced more cheaply than coal-fired power plants. After significant investment, RE<C was shut down. The reason was that even the most advanced renewable energy technologies could not come close to matching the 4 to 6 cents per kilowatt hour[71] price that average coal and natural gas plants are charging.

The RE<C team also concluded a wholesale adoption of renewable energy would not result in significant reductions of carbon dioxide emissions. This does not mean that Google and their environmental engineers want to give up on renewables. On the contrary, they believe that the U.S. needs to dedicate more R&D to proven (hydro, wind, solar photovoltaics and nuclear), next-generation (thin-film solar PV and next-generation nuclear fission reactors) and "crazy" technologies (cheap fusion) using a 70%/20%/10% formula.

Grid-Scale Storage.

Grid-scale storage is essential to the ultimate success of intermittent energy sources like solar, wind and tidal power.

There are essentially three types of electrical energy storage systems: portable (laptops, battery operated appliances, etc.), transportable (electric and fuel cell vehicles) and stationary (dispersed, distributed and grid-scale).

Grid-scale storage, also called large-scale energy storage or grid energy storage, refers to systems that can store large amounts of electricity for later use in an electrical power grid. There are currently over a

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[70] IEEE Spectrum, Today's renewable energy technologies won't save us. So what will?, by Ross Koningstein & David Fork, 18 Nov 2014, http://spectrum.ieee.org/energy/renewables/what-it-would-really-take-to-reverse-climate-change

[71] Note: 1 Gigawatt (GW) = 1,000 megawatts (MW), 1 MW = 1,000 kilowatts (kW), 1 kW = 1,000 watts (W). When comparing watts to watt hours, watts are the amount of power used at one time and watt hours (Wh) are the amount of energy used over time. For example, a 100 W light bulb consumes 200 Wh of energy over two hours (100 W x 2 hours = 200 Wh).

dozen grid-scale storage systems that convert electricity into potential-kinetic, chemical or electromagnetic energy. Potential-kinetic is most often associated with pumped-hydroelectric storage. Chemical is most often associated with batteries. Electromagnetic is associated with superconducting magnetic energy storage.

Today, pumped-hydroelectric storage provides over 95% of the world's grid-scale storage capacity and 98% of America's grid-scale storage capacity[72]. Using excess production electricity, pumped hydro systems draw water from lower level reservoirs and store its (potential) energy in higher reservoirs. When the energy is needed, the water is released (kinetic energy) through turbines to produce electricity for the grid. Mountainous Japan is the leading nation with pumped hydro, accounting for 10% of Japan's electrical generating capacity. Pumped hydro has been used in the U.S. since the 1920s. Today, the United States has 40 pumped hydro plants that provide 22GW, or 2%, of U.S. capacity[73].

Nonhydro storage has doubled the U.S. electric power sector capacity from 160MW to nearly 350MW over the past five years, largely due to battery, flywheel and compressed air storage systems.

- Batteries are discussed in detail in the advanced battery section.

- Flywheel energy storage works by accelerating a rotating mechanical device (flywheel) to a very high speed to produce and store rotational energy. Europe's first grid-connected hybrid flywheel system was announced by the Irish government in March 2015[74]. Irish company Schwungrad Energie Limited is installing a 20MW flywheel energy storage system that houses a flywheel inside a giant vacuum-sealed container suspended by magnets. Magnets substantially reduce friction, enabling the system to store energy with up to 85% to 90% efficiency[75]. Schwungrad Energie is collaborating with U.S.-based Beacon Power that specializes in utility-grade flywheel energy storage systems. The first system is expected to launch commercially in 2017 in Rhode, County Offaly, Ireland.

- Compressed air storage systems (CAES) can be used to store large amounts of power for weeks at less than the cost of other storage systems, with the exception of pumped hydro, due to scale. CAES often fill man-made underground caverns that also can be used for natural gas storage. Air storage systems return about 60% of the power used to fill caverns. When released, the air pressure turns turbines to produce electricity. Due to scale, CAES store hundreds of megawatt hours of electricity for weeks at a time. In less than a decade, annual investment in compressed air will be almost $5 billion, according to Navigant Research. That will support more than 11GW of installed capacity and help renewable power developers match demand with supply.

Other nonhydro grid-scale storage technologies in development include batteries (sodium sulfur, lithium ion), flow batteries (allow storage of the active materials external to the battery), hydrogen fuel cells (convert water into hydrogen), gravity (a variation of pumped hydro using underground reservoirs),

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[72] EIA, Today in Energy, Nonhydro electricity storage increasing as new policies are implemented, 3 April 2015, http://www.eia.gov/todayinenergy/detail.cfm?id=20652&src=email
[73] Energy Storage Association, http://energystorage.org/energy-storage/technologies/pumped-hydroelectric-storage
[74] Government of Ireland, Department of Jobs, Enterprise and Innovation, First Hybrid-Flywheel Energy Storage Plant in Europe announced in Midlands, 26 March 2015, http://www.djei.ie/press/2015/20150326.htm
[75] Schwungrad Energie Limited, http://schwungrad-energie.com/

compressed air (a variation of pumped hydro using air rather than water), molten salt (currently being used in concentrated solar plants), ice (used in some air conditioning systems), high temperature solid oxide fuel cells (produce electricity from a ceramic electrolyte), flywheels (rapidly spinning disks that retain potential energy), super-capacitors (non-chemical electric devices with high discharge capacity), superconducting magnets (store energy in cooled superconducting coils) and syngas (using excess electricity to convert biomass into storable synthetic methane-related gases or propane-related liquids).

Distributed Generation and Dispersed Generation.

Distributed and dispersed generation technologies generate electricity near the particular load they are intended to serve—at the point-of-consumption. Generating power at the point-of-consumption eliminates cost, complexity, interdependencies and inefficiencies associated with transmission and distribution. Like distributed computing and distributed telephony, distributed/dispersed generation shifts control to the consumer.

Distributed generation generally entails using many medium-sized solar, wind, or natural gas generators that provide power to local (as opposed to long-distance) consumers in cities, towns, universities, industrial parks and government buildings. These medium-sized generations can be used on-grid or off-grid.

Dispersed generation refers to small generating units that serve individual homes or businesses. These units (fossil fuel turbines, fuel cells, small wind and solar PV generators) are small enough to fit in garages and are usually off-grid unless connected to net-metering systems. Dispersed generation includes micro-units that are embedded components of other systems from electronic devices, water heaters, traffic cameras, cell towers and even electric cars. These micro-units are almost always off-grid.

The off-grid nature of distributed and dispersed generation makes it difficult to account for its contribution in the energy sector. Consequently most off-grid electrical generation is not included in EIA's and IEA's statistics and forecasts. For example, residential solar photovoltaic power that is not connected to a net-metering system is not counted in the energy picture. Solar thermal that is used in water heaters and to heat swimming pools provide significant amounts of energy, and are also not included in energy consumption or energy conservation calculations.

Jobenomics envisions a future where most of the energy produced will be off-grid. Individual residences and businesses will not need to be connected to a grid if they can produce enough indigenous energy. Future electric cars are being designed to produce and store energy for their owners, whether they are on the road or in their homes. Wearable technology might even be generated by a person's body heat or movement. In an Internet-of-Things world, milliwatts (mW, one thousandth of a watt) will be a more important measure of energy consumption than megawatts (MW). Consequently, the value of small and micro-renewable technology in ever-increasing distributed and dispersed renewable energy generation applications is likely to be extremely understated given today's statistical methodologies.

Next-Generation Renewable Technology.

If better is the enemy of good, then 2nd generation technology is the enemy of 1st generation. This is particularly true for renewable technologies such as solar.

Solar power inefficiency is a major reason to be cautious of current solar power systems that will mature over time. 1st generation silicon solar panels and 2nd generation solar thin-film technologies are restrained by the Shockley-Queisser limit of 34% power efficiency (the amount of sunlight power turned into electricity), whereas 3rd generation multi-layer solar cells may be able to approach efficiencies near 86%. Consequently, next-generation solar systems are likely to be much more efficient and significantly cheaper than current 1st generation solar panels.

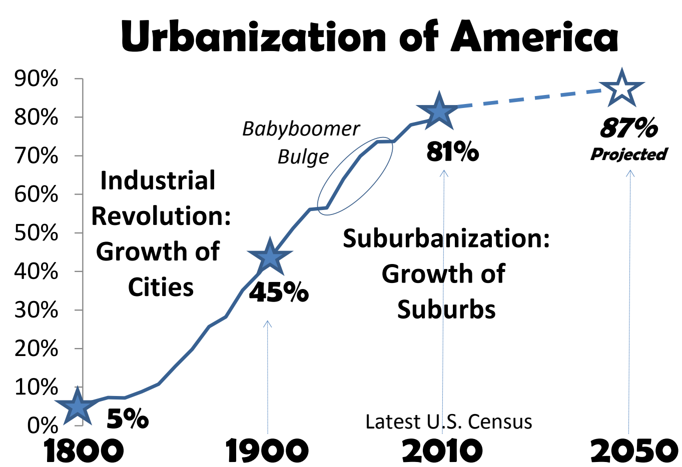
Even with substantial government incentives and subsidies, home and small business owners have reason to be circumspect about investing tens of thousands of dollars in a system that could be obsolete in a few years. To overcome this issue, energy-service companies offer leasing arrangements and subscription services that feature upgrades to 1st generation systems when more efficient technologies become available.

Power Density.

The final challenge worthy of serious consideration for renewable energy involves power density. Power density is the amount of power that can be generated in a given area (square foot, square meter, square mile). Centralized fossil fuel and nuclear power plants have small footprints, whereas the most popular forms of renewable energy have substantially larger footprints. Power density often becomes a major issue for renewable energy in crowded metropolitan, agricultural and industrial areas where available land is limited and costly.

Urbanization presents a major challenge to many forms of renewable energy, such as wind and solar power, which requires extensive space relative to the energy it produces. Solar PV farms produce as much as 20 watts per square meter ($20W/m^2$) in sunny California and Nevada deserts but only $5W/m^2$ in many East Coast localities[76]. Wind power and conventional ethanol are estimated to have average power densities of only $2W/m^2$. By comparison, conventional fossil fuel power plants can have power densities as high as $1{,}000W/m^2$. Consequently, most renewables require significantly more space than conventional power generation.

Today, 81% of Americans live in urban areas, up from 5% in 1800 and 45% in 1900. By 2050, U.S. urbanization is projected to grow to 87%. Increasing numbers of Americans are moving from rural areas to small urban clusters (population 2,500 to 50,000) to urban areas (50,000+) to mega-cities like New York, Los Angeles and Chicago[77]. By 2030, it is projected that 53 U.S. urban areas will have more than 1,000,000 people, up from 41 in 2010 and 12 cities in 1950.



[76] The Energy Collective, The Future of Energy: Why Power Density Matters, Robert Wilson, 8 August 2014, http://theenergycollective.com/robertwilson190/257481/why-power-density-matters
[77] U.S. Census Bureau, Geography, 2010 Census Urban and Rural Classification and Urban Area Criteria, http://www.census.gov/geo/reference/ua/urban-rural-2010.html

Other parts of the world are urbanizing along a similar path as America, but at a much faster rate. 46% of the world's population now lives in urban areas, up from 30% in 1950. While 16% may not seem like a significant increase, the world's urban population has grown from 746 million in 1950 to 3.9 billion in 2014. By 2050, 66% of this planet's residents will live in urban areas. India is projected to add 404 million urban dwellers, followed by China with 292 million and Nigeria with 212 million.

The Tokyo-Yokohama metropolis is the world's metropolitan area (also called agglomerate) with 38 million inhabitants, followed by Delhi with 25 million, Shanghai with 23 million and Mexico City, Mumbai and São Paulo, each with 21 million inhabitants. The top U.S. metropolitan areas are New York-Newark with 19 million, followed by Los Angeles-Long Beach-Santa Ana with 12 million, Chicago with 9 million, Miami with 5.8 million, Dallas-Fort Worth with 5.6 million, Philadelphia with 5.6 million, Houston with 5.5 million and Atlanta with 5.0 million inhabitants. By 2030, the world is projected to have 41 mega-cities with more than 10 million inhabitants, 63 cities between 5 and 10 million and 558 cities with 1 to 5 million people[78].

Population density is directly proportional to power density. Power density is a formidable issue for mega-cities that are constrained by available land that is needed for living, working and nourishment. The most density populated city in the world with a population of over a million is Manila, Philippines with a population density of 111,000 people per square mile. The most density populated city in the world with a population of over 10 million is Delhi, India with a population density of 66,000 people per square mile.

Japan is committed to being a world leader in renewable and innovative energy solutions in the world's most density populated nation. The Tokyo-Yokohama metropolis has a population density of 11,330 people per square mile, which makes it an important place to watch from a power density perspective. The population of central Tokyo is 13 million with a population density of approximately 17,000 inhabitants per square mile.

Driven by power density constraints and the curtailing of nuclear power due to the Fukushima nuclear accident, Japan has launched major initiatives in clean fossil fuel and renewable energy projects. As an example of a clean fossil fuel initiative, Japan has plans to install residential fuel cells in 10% of all households by 2030.

While the Japanese are exploiting every available surface area for renewable energy projects, there is simply not enough land to meet the energy needs of their large metropolitan areas. Consequently, the Japanese are pursuing subsurface geothermal and offshore solar, wind and hydrokinetics programs that are addressed throughout this report.

Japan has approximately 72GW of approved renewable energy projects, of which 96% are solar according to ministry data. In order to emphasize the importance that Japan places on urban power density issues, Jobenomics offers a glimpse at several unique Japanese solar energy programs that feature quasi-offshore and onshore floating solar farms as potential solutions to meeting metropolitan renewable energy demands.

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[78] United Nations, World Urbanization Prospects, 2014 Revision, Department of Economic and Social Affairs, Page 13 and 27, http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf

Operational since 2013, 70MW Kyocera Kagoshima Nanatsujima Mega Solar Power Plant is Japan's largest utility-scale solar power plant that was built in a protected harbor (shown) in Kagoshima City, located on the southwestern most Japanese island of Kyushu. This quasi-offshore solar farm consists of 290,000 solar panels covering 1,270,000 square meters (314 acres or 0.5 square miles) and was built upon a landfill site at a cost of $276 million using a total of 78,000 workers over a construction period of 14 months[79]. It took 5,400 cement trucks to haul 50,000 tons of concrete for the solar panel foundations. This plant provides power for 22,000 average Japanese households in Kagoshima City (population 600,000 with a population density of 2,868 inhabitants per square mile)[80].

Using lessons learned from the Nanatsujima Mega Solar Power Plant, Japan's electronics giant Kyocera designed and built two onshore floating solar power plants became operational in 2014. These two farms float on two large ponds in Osaka (Japan's second largest metropolis with a population of 19 million people that encompasses 3 million residents in Osaka City that has a population density of 31,000 per square mile and 1.3 million households) and generate 2.9MW of electricity, enough to power 1,000 households.

Kyocera is now building the world's largest floating solar plant on the Yamakura Dam reservoir in a Tokyo suburb. This plant consists of 50,000 Kyocera solar modules floating over 180,000 square meters (45 acres or.07 square miles) of water[81]. The Yamakura floating solar plant will be capable of generating 13.4MW, enough for approximately 4,700 homes. According to the Tokyo Metropolitan Government, the city of Tokyo has 6.7 million households, so 4,700 won't make much of a dent. As shown in the picture, there are no other onshore bodies of water the size of Yamakura Dam reservoir.

The New York-New Jersey-Connecticut metropolis (population of 20 million) has a density of 4,600 people per square mile[82]. New York City (population 8 million in five boroughs) has a population density of 26,400 per square mile (Manhattan's population is 1.5 million with a population density of

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[79] Solar Power Plant Business, Japan's Largest Solar Plant Withstands Ash, Salt, Strong Wind, 1 December 2013, http://techon.nikkeibp.co.jp/english/NEWS_EN/20131201/319700/?ST=msbe&P=1
[80] Kyocera, News Release, Kyocera Starts Operation of 70MW Solar Power Plant, the Largest in Japan, http://global.kyocera.com/news/2013/1101_nnms.html
[81] Kyocera, News Release, Kyocera and Century Tokyo Leasing to Develop 13.4MW Floating Solar Power Plant on Reservoir in Chiba Prefecture, Japan 22 December 2014, http://global.kyocera.com/news/2014/1205_dfsp.html and News Release, Kyocera TCL Solar Inaugurates Floating Mega Solar Power Plants in Hyogo Prefecture, Japan, 20 April 2015, http://global.kyocera.com/news/2015/0401_tome.html
[82] NewGeography, World Urban Areas Population And Density: A 2012 Update, http://www.newgeography.com/content/002808-world-urban-areas-population-and-density-a-2012-update

69,000)[83]. New York City has peak loads of over 11,000 megawatts of electricity[84]. At $5W/m^2$ (1MW = 1,000,000W) a solar farm would have to be approximately 8.6 square miles (11,000MW x 1,000,000W ÷ $5W/m^2$ = 2.2 billion m^2 or 8.6 square miles) or ¼ the size of Manhattan (33.8 square miles). California's 24,000MW (installed capacity) Westlands Solar Park will encompass 37.5 square miles. An MIT Professor of Mechanical Engineering[85] calculates that 4,000 5MW wind turbines could furnish enough electricity for New York City. This wind farm would require an area 40 by 40 miles. If these solar and wind parks were put on land (as opposed to offshore), system installation costs would have to include $1,538 per square foot in Manhattan or $424 per square foot real estate costs in the outlying boroughs of New York[86].

Power density is certainly not a show-stopper by any measure for renewable energy, but it is an important consideration in estimating installation costs and area requirements. Many areas in America consist of highly populated metropolitan corridors surrounded by productive agricultural and industrial regions where power density is an issue. Consequently, renewable energy technologies like geothermal, hydroelectric and fuel cells may take precedence over other forms of renewable energy that have larger footprints. Until these technologies mature or next generation solar with significantly higher efficiencies and smaller footprints evolve, cleaner fossil fuel and nuclear power will have to suffice in areas restrained by power density considerations.

[83] Wikipedia, Demographics of New York City, http://en.wikipedia.org/wiki/Demographics_of_New_York_City
[84] NYC.gov, A Stronger, More Resilient New York report, Utilities, Electrical System, Page 108, http://www.nyc.gov/html/sirr/downloads/pdf/final_report/Ch_6_Utilities_FINAL_singles.pdf
[85] Massachusetts Institute of Technology (MIT) School of Engineering, by Paul Sclavounos, Professor of Mechanical Engineering and Naval Architecture, How Many Wind Turbines Would It Take To Power All Of New York City?, 30 March 2010, http://engineering.mit.edu/ask/how-many-wind-turbines-would-it-take-power-all-new-york-city
[86] Business Insider, Here's How Much Real Estate A Million Dollars Buys You In Every Major US City, 11 March 2014, http://www.businessinsider.com/us-city-real-estate-price-chart-2014-3

Renewable Energy Sources.

According to EIA's Annual Energy Outlook 2015 Energy Consumption by Sector and Source [87], renewable energy sources (excluding ethanol, net electricity imports, and non-marketed renewable energy sources[88]) supplied 7.2% of America's energy needs (6.96 quadrillion Btu out of total energy consumption of 97.14 quads) in 2013, and will grow to 8.6% by 2030.

The International Renewable Energy Agency[89] (IRENA) Remap 2030[90] report forecasts that the renewable energy share in the U.S. energy mix will increase from 7.5% in 2010 (2.5% renewable power, 1.6% liquid biofuels and 3.4% biomass used for heating in industry and buildings) to 10% by 2030 under a business-as-usual scenario. To achieve President Obama's 27% INDC 2025 goal, IRENA estimates that the United States would have to increase renewable energy investment by $38 billion per year.

US Renewable Energy Consumption Growth Forecast

Total Energy Consumption All Sectors

Consumption	2013	2030	Growth
	Quadrillion Btu		Rate
Wood	0.58	0.38	-35%
Biomass, Biofuels	3.57	4.25	19%
Hydroelectric	2.54	2.80	10%
Geothermal	0.16	0.50	220%
Municipal Waste	0.42	0.46	10%
Solar	0.08	0.34	306%
Wind	1.59	2.32	45%
Total	**8.95**	**11.05**	**23%**

Source: EIA Annual Energy Outlook 2015

As shown, U.S. renewable energy consumption of all sectors (industrial, transportation, commercial and residential) and all sources (including ethanol) is projected to increase by 23% from 2013 to 2030, from 8.95 quadrillion Btu to 11.05 quads[91]. While the supply of U.S. ethanol is forecast to remain level (1.07 quads in 2013 and 1.08 quads in 2030), Jobenomics predicts that the Congressionally-mandated Renewable Fuel Standard will be repealed during this period, likely pushing corn-based ethanol largely out of the market. If this happens, the adjusted renewable energy consumption for 2030 could be as low as 10.42 quads, which would reduce the overall growth rate from 23% down to 16%.

Solar (306%) and geothermal (220%) are projected to be the fastest growing sectors, albeit from a low base. Biomass/biofuels (including ethanol), hydroelectric (the use of dams that release water to generate electricity via turbines) and wind power are projected to dominate renewable energy

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[87] EIA, Annual Energy Outlook 2015, Energy Consumption by Sector and Source, Table A2, 14 April 2015, http://www.eia.gov/forecasts/aeo/

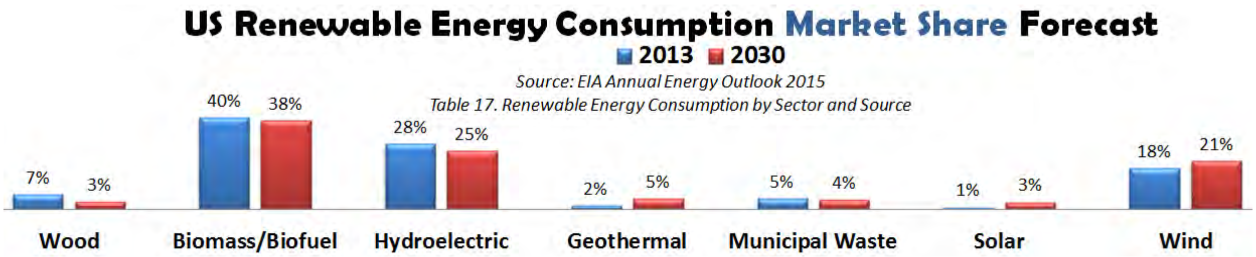
[88] EIA forecasts do not include non-marketed renewable energy sources including off-grid residential systems (distributed and dispersed electrical generation solar hot water heaters, solar photovoltaics and wind generators) and commercial systems (solar thermal, solar photovoltaic and wind), which Jobenomics predicts will be major near-term energy contributors as addressed in detail in this document.

[89] IRENA was formed in 2009 and is headquartered in Abu Dhabi, UAE. As of May 2015, IRENA has 172 member states, including 32 states that have started the formal process of joining.

[90] International Renewable Energy Agency (IRENA), Renewable Energy Roadmap 2030, Renewable Energy Prospects: United States of America, January 2015, http://www.irena.org/remap/IRENA_REmap_USA_report_2015.pdf

[91] EIA, AEO2015, Table 17, Renewable Energy Consumption by Sector and Source, http://www.eia.gov/forecasts/aeo/tables_ref.cfm

consumption both in 2013 and 2030. Solar and geothermal will grow at much greater rates, but collectively will not match bio, hydro or wind power within the next fifteen years. While listed by the EIA as potential sources, offshore wind and biogenic municipal waste are forecast to make minimal contributions for the foreseeable future.



As addressed earlier, the percentage of renewables in the overall energy consumption mix will not dramatically change from 2013 to 2030 (7.2% to 8.6% respectively). The same is true within the renewable energy sector as shown above.

In 2013, biomass/biofuels (including ethanol) dominated U.S. renewable energy consumption mix with 40% of the market, followed by hydroelectric with 28%, wind with 18%, wood 7%, municipal waste (disposition of landfill gas and sewage sludge) 5%, geothermal 2%, and solar (thermal and photovoltaic) 1%. Solar (from 1% to 3%), geothermal (from 2% to 5%) and wind (from 18% to 21%) sectors are expected to increase by 2030, while all other sectors are expected to decrease. Again, it is important to point out that these projections do not include off-grid distributed and dispersed electric and heat generation. For example, the use of wood pellets for heating is increasing significantly domestically and internationally. As discussed in more detail later, the U.S. wood pellet industry is now the world's largest exporter, recently displacing Canada.

One must conclude from these data that (1) the renewable energy sector will not be a major energy provider by 2030 if less than 10% of the energy consumed is by renewables, (2) the ambitious climate change goals set forth by Presidents Obama and Xi Jinping will have to be solved through cleaner fossil and nuclear fuels in addition to renewables, and (3) off-grid distributed and dispersed renewable energy accounting methodologies will be needed to give the United States a more accurate picture of how energy is consumed and the real contribution of renewable energy at the point-of-consumption. Furthermore, Jobenomics believes that the renewable power sector consumption and employment could be significantly understated, if a number of ETR breakthroughs and export opportunities occur as discussed in the following sections, starting with hydroelectric and hydrokinetic power, which has significant unrealized domestic and international potential as a baseload (24/7) source of renewable power.

Biomass/Biofuel/Wood Employment Outlook.

EIA forecasts that biomass/biofuel renewables will **decrease** its share in the U.S. renewable market mix from 40% in 2013 to 38% by 2030, and will **increase** its domestic consumption from 3.75 quadrillion Btu in 2013 to 4.25 quads in 2030 for a net growth of 19%[92]. EIA forecasts that wood renewables will

[92] EIA, AEO2015, Table 17, Renewable Energy Consumption by Sector and Source, http://www.eia.gov/forecasts/aeo/tables_ref.cfm

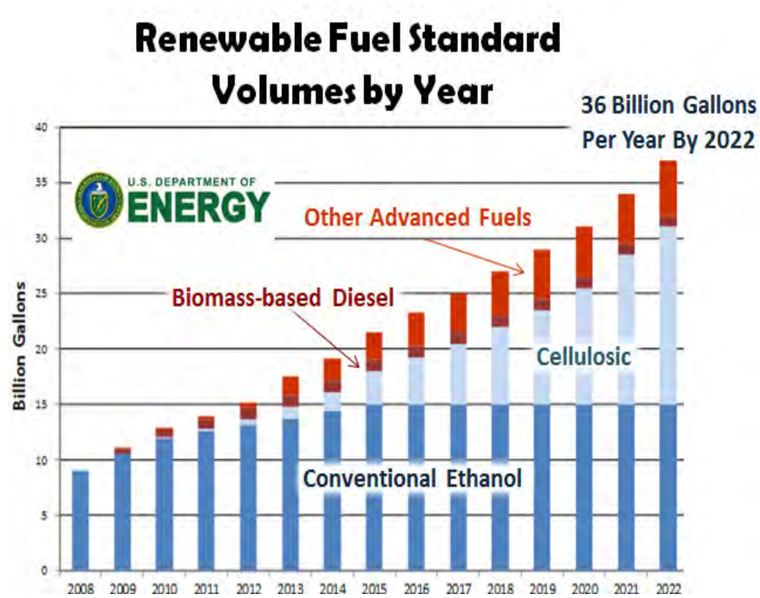
decrease its share in the United States renewable market mix from 7% in 2013 to 3% by 2030, and will **decrease** its domestic consumption from 0.58 quadrillion Btu in 2013 to 0.38 quads in 2030 for a net loss of 34%[93]. Again it is important to note that EIA does not report on off-grid consumption, nor is the export potential included in these figures.

From an international investment (and employment) point of view, the Renewable Energy Country Attractiveness Index[94] rates the top 40 countries that provide the most attractive overall investment environment. The top 10 countries for **biomass** are: China, United States, Japan, Brazil, United Kingdom, Finland, Sweden, Germany, France and Netherlands.

Biomass is biological material derived from living, or recently living, plant or animal-based organic matter. One of the primary differences between fossil fuels and biomass involves time. Over the millennia, fossil fuels (coal, oil and natural gas) absorbed CO_2 that is released en masse during burning. While biomass-related fuels (ethanol, cellulosic, etc.) release CO_2 during burning, they can reabsorb CO_2 by replanting. Since biomass feedstock can be harvested and regrown, it is considered a renewable fuel source.

Biomass is used to produce biofuels including ethanol (made from corn and other food products and agricultural waste), biodiesel (made from vegetable oils and fats), algal fuels (derived from algae), biogas (made from methane from landfills, waste treatment plants, and animal manure) and solid biomass (wood, sawdust and crop waste that is used directly or processed into briquettes or charcoal).

Biofuels are most useful in liquid or gas form because they are easier to transport. Not all biofuels are created equal. Algal biofuels (still R&D) have much higher oil/energy content than corn, as corn has to wood.



The Energy Policy Act of 2005 (and expanded by the Energy Independence and Security Act of 2007) authorized loan guarantees for innovative technologies that avoid greenhouse gases (GHGs) and created the federal Renewable Fuel Standard (RFS)[95] that mandates the amount of biofuels that must be blended with gasoline each year, escalating from 9 billion gallons in 2008 to 36 billion gallons by 2022.

RFS categories consist of conventional ethanol, cellulosic fuels, biomass-based diesel and other advanced renewable

[93] Ibid
[94] EY, Renewable Energy Country Attractiveness Index (RECAI), March 2015, Page 14, http://www.ey.com/Publication/vwLUAssets/Renewable_Energy_Country_Attractiveness_Index_43/$FILE/RECAI%2043_March%202015.pdf
[95] DoE, Alternative Fuels Data Center, Renewable Fuel Standard, http://www.afdc.energy.gov/laws/RFS.html

fuels. Any unused quotas can be allocated to other categories. Each fuel category in the RFS must emit lower levels of GHGs relative to the petroleum it replaces. Conventional ethanol must reduce GHGs by 20%, whereas cellulosic fuels are held to a much higher standard of 60% lower GHG emissions than the petroleum baseline it replaces. Biomass-based diesel and other advanced renewable fuels are held to a 50% lower emission standard.

Biofuels created from fossil fuels (ancient deceased plant- or animal-based organic matter) are not included in the RFS and are accounted as "carbon-based renewables" in the oil and gas sector. Alternative fuels, like propane and hydrogen, are not included in the RFS. Biomass in the form of wood is also not included in the RFS since it does not reduce GHG emissions compared to the fuel it replaces.

The EPA administers the RFS program and establishes the volume requirements for each category. The EPA tracks compliance through the Renewable Identification Number (RIN) system, which assigns an RIN to each gallon of renewable fuel. Entities regulated by RFS include oil refiners, blenders, and gasoline and diesel importers. Entities can fulfill obligations by meeting required volumes or purchasing RINs from parties that exceed their requirements. Failure to meet requirements results in significant fines[96].

On 29 May 2015, EPA released blending goals for 2014 through 2016 using a middle-of-the-road approach to appease pro-ethanol (farmers and ethanol producers) and anti-ethanol (a mixture of oil industry, refiners, motor-vehicle organizations, pro-food and green energy activists) groups in the run up to the 2016 presidential elections.

Revised RFS Standards for 2014, 2015 and 2016

Source: EPA Billions of Gallons	2014		2015		2016		
	Original RFS Mandate	**Proposed EPA Goal**	**Original RFS Mandate**	**Proposed EPA Goal**	**Original RFS Mandate**	**Proposed EPA Goal**	*EPA % Increase 2014 -16*
Cellulosic biofuel	1.75	0.03	3.00	0.11	4.25	0.21	*524%*
Biomass-based diesel	≥1.00	1.63	≥1.00	1.70	≥1.00	1.80	*10%*
Advanced biofuel	3.75	2.68	5.50	2.90	7.25	3.40	*27%*
Renewable Fuel	18.15	15.93	20.50	16.30	22.25	17.40	*9%*

The EPA[97] retroactively set its overdue 2014 requirements at the actual level of production of 15.93 billion gallons of biofuel, which was below the 18.15 billion gallons original Renewable Fuel Standard mandate. In 2015, the EPA set the goal at 16.30 billion gallons, down from the congressionally mandated amount of 20.50 billion gallons. In 2016, the EPA set the goal at 17.40 billion gallons, down from the congressionally mandated amount of 22.25 billion gallons. The EPA also proposes to repeal the 2011 Cellulosic Biofuel mandate since the industry only producing 2% of the volume required by the original mandate. Also on 29 May 2015, the US Department of Agriculture announced a plan to spend $100 million on ethanol infrastructure to aid farmers and deliver higher ethanol bends to consumers. This money is largely earmarked for new service station blender pumps that can deliver E85 to flex-fuel vehicles. Flexible fuel vehicles (FFVs) are designed to run on gasoline or gasoline-

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[96] EPA, Renewable Fuel Standard (RFS), http://www.epa.gov/otaq/fuels/renewablefuels/index.htm
[97] EPA, Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass Based Diesel Volume for 2017, 29 May 2015, http://www.epa.gov/otaq/fuels/renewablefuels/documents/rfs-2014-2016-standards-nprm.pdf

ethanol blends of up to 85% ethanol (E85) as opposed to the current 90% gasoline/10% ethanol blends.

From a Jobenomics perspective, the RFS was borne in an era when energy independence was paramount. Today, the United States has become an energy exporter. The federal RFS may have outlived its usefulness and can be replaced by renewable fuel standards that are mandated by the states. Moreover, the RFS has attracted a lot of negative attention for being too politicized and too narrowly focused.

Conventional Ethanol Employment Outlook. Conventional ethanol (fuel derived from food-based starch feed stocks such as corn, sorghum and wheat) constitutes the majority of mandated renewable fuels. In 2014, there was more biomass capacity (mainly ethanol) retired (89MW) than installed (30MW), taking cumulative capacity down to 8.4GW[98].

In 2013, the production of 13.3 billion gallons of ethanol supported 86,504 direct jobs and 300,277 indirect and induced jobs for a total of 386,781 jobs[99].

Conventional ethanol is a $30 billion per year industry in the United States, consisting of 210 plants in 28 states with nameplate capacity of 14.9 billion gallons and an annual operating capacity of 13.8 billion gallons. Ethanol industry operating costs were approximately $36 billion, of which $29 billion were for 4.8 billion bushels of corn that represented 82% of the total operating costs[100]. In 2014, U.S. fuel ethanol production reached 14.3 billion gallons of ethanol fuel, the highest level ever, and represents 9.8% of the volumetric share of the total U.S. motor gasoline supply, also the highest level ever. The growth in U.S. fuel ethanol production has now outpaced growth in corn consumed as feedstock[101].

The U.S. ethanol industry depends largely on government mandate and the rising cost of gasoline—both of which are on the decline. In 2015, mandated conventional ethanol volumes will level off at approximately 15 billion gallons per year, partially due to rising global food prices (albeit the United States has had several years of bumper corn harvests) and the worldwide perception that America cares more about its transportation needs than world hunger.

15 billion gallons of corn-based ethanol is enough to feed 600,000,000 people[102]. According to the United Nations World Food Programme, 850,000,000 people worldwide, or one in nine people on earth, do not have enough food to lead a healthy active life[103]. In addition, for the first time ever, in 2014, over

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[98] Bloomberg New Energy Finance, 2015 Factbook Sustainable Energy in America, Page 63, February 2015, http://www.bcse.org/images/2015%20Sustainable%20Energy%20in%20America%20Factbook.pdf

[99] Renewable Fuels Association, 2014 Ethanol Industry Outlook, Page 8, http://www.ethanolrfa.org/page/-/rfa-association-site/Resource%20Center/2014%20Ethanol%20Industry%20Outlook.pdf?nocdn=1

[100] ABF Economics, Contribution of the Ethanol Industry to the Economy of the US, 17 February 2014, http://ethanolrfa.org/page/-/rfa-association-site/studies/ABF_Ethanol_Economic_Impact_US_2013.pdf?nocdn=1

[101] EIA, Today in Energy, Corn ethanol yields continue to improve, 13 May 2015, http://www.eia.gov/todayinenergy/detail.cfm?id=21212&src=email

[102] 25 gallons of ethanol has enough calories to feed 1 person per year. Therefore, 15 billion gallons could feed 600 million people. Also, 8 bushels of corn feeds 1 person per year. Therefore, 5 billion bushels of corn equals to 625 million people. A detailed 2012 study (http://necsi.edu/research/social/foodprices/foodforfuel/foodforfuel.pdf), adjusted to 2015 figures, yields a result of 613 million people.

[103] United Nations World Food Programme, Hunger Statistics, http://www.wfp.org/hunger/stats

50% of the entire U.S. corn crop was used in ethanol production, which contributed to much higher prices for food and animal feed stock. In 2005, before the RFS was enacted, the average cost per bushel of U.S. corn was $2.00. In 2012, corn peaked at $6.89 per bushel[104]. The season-average 2015/16 farm price is currently projected at $3.50 per bushel[105].

There are a growing number of policy-makers who want to repeal the law entirely or remove ethanol mandates derived from corn. Congress' reluctance to pass a Farm Bill and authorize tax credit extensions for renewable biofuels has made investors nervous, limiting the number of new ethanol projects. In January 2015, the U.S. Senate introduced the Corn Ethanol Mandate Elimination Act of 2015 that modifies the RFS program away from corn-produced ethanol and towards development of advanced, environmentally-friendly biofuels like biodiesel, cellulosic ethanol and other revolutionary alternative fuels that are not currently covered by the RFS.

Ethanol not only reduces oil-based supplies but it costs oil companies $1.4 billion per year on RIN blending credits—paper credits used to meet quotas for blending ethanol with gasoline. As a result of major lobbying campaigns by oil, refining, livestock, poultry, and food industries, the EPA is considering lowering the conventional ethanol standard in 2015, dealing a blow to this farm-based renewables industry.

Ethanol producers do not seem to be too worried about lower federal biofuels volumes due to excess capacity, falling gas prices, and exports. U.S. gasoline consumption is about 135 billion gallons a year. At 10% blending rates, domestic ethanol would be 13.5 billion gallons, which is 10% below the 15 billion gallon mandate. Lower gas prices might help drive ethanol demand higher since Americans are likely to drive more miles or buy bigger gas-guzzling vehicles. The growing demand for ethanol exports is not covered under the RFS mandates and would compensate for some of the domestic shortfall.

According to the EIA[106], over the last 5 years, U.S. ethanol exports averaged 750 million gallons per year, or 5% of the 15 billion gallon mandate. 2014 represented the fifth consecutive year for net U.S. ethanol exports. The United States exported 826 million gallons (an increase of 33% over 2013 and second to an all-time high of 1.2 billion gallons in 2011) and imported 73 million gallons (a decrease of more than 81% from 2013). In 2014, the U.S. exported ethanol to 37 countries, with Canada buying 360 million gallons (41%), followed by Brazil, United Arab Emirates and Philippines purchasing more than 50 million gallons each. Like the United States, Canada and Brazil also have ethanol blending mandates that continue to generate demand for U.S. ethanol exports. The key drivers for ethanol exports are the finalized levels of RFS targets, future corn crop yields, and ethanol producer profitability.

According to the Renewable Fuels Association[107], in 2013, the production of 13.3 billion gallons of ethanol supported 86,504 direct jobs in renewable biofuel production and agriculture in the United

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[104] U.S. Department of Agriculture, Economic Research Service, Feed Grains Database, Corn, http://www.ers.usda.gov/data-products/feed-grains-database/feed-grains-custom-query.aspx#ResultsPanel
[105] U.S. Department of Agriculture, World Agriculture Supply and Demand Estimates, Monthly Report: Coarse Grains, 12 May 2015, http://www.usda.gov/oce/commodity/wasde/latest.pdf
[106] EIA, Today in Energy, U.S. ethanol exports in 2014 reach highest level since 2011, 26 March 2015, http://www.eia.gov/todayinenergy/detail.cfm?id=20532&src=email
[107] Renewable Fuels Association, Ethanol Facts, http://www.ethanolrfa.org/pages/ethanol-facts-economy & Ibid 52

States, as well as 300,277 indirect and induced jobs for a total of 386,781 jobs. Agriculture contributed 59,822 direct and 242,348 direct/indirect/induced jobs or 69% and 63% respectively of the total.

Jobenomics assesses the overall U.S. employment potential of the ethanol industry as relatively stable for three reasons, even if the ethanol industry received a major policy shock regarding the RFS. First, layoffs would be limited since most of the jobs are associated with agricultural corn production, a commodity that could be sold elsewhere. Second, ethanol is an easily transportable fuel that is suited for a rapidly growing export market. Finally, many ethanol producers are major agribusinesses and refiners that could shift employees to other sectors.

Jobenomics also forecasts that the RFS for ethanol will not be revised until after 2017 due to the politics of agribusiness. At the 2015 Iowa Ag Summit, Republican presidential candidates, Jeb Bush and Scott Walker pledged support for the federal ethanol mandate, thereby shifting from previous positions that were critical of the mandate. The Democrat frontrunner, Hillary Clinton, has also reversed her long standing RFS opposition and now supports a "mend it but don't end it" position on the ethanol mandate. Iowa is not only a leading agribusiness state but it is a bellwether state for presidential elections.

Cellulosic Biofuels Employment Outlook. Cellulosic biofuels are created from non-food renewable feed stocks like wood mulch, grasses and inedible parts of plants, such as corn stalks.

Yard waste, urban wood waste, wood mill mulch, farm waste and organic solid waste are good sources of cellulosic feedstock as long as the feedstock is viewed as waste material. Once waste material is perceived to have value, the price goes up which adds to the cost of biofuel, which in turn makes it less attractive versus the marginally more expensive gasoline. While plentiful, these sources of feedstock may prove to be inaccessible or too expensive to service a cellulosic mandate of 16 billion gallons per year by 2022. The mandate for 2015 is an optimistic 3 billion gallons of cellulosic fuel, when the reality is that the industry is struggling to produce more than 100 million gallons.

The prognosis for cellulosic fuel would be much greater if a sustainable and inexpensive source of feedstock is found. Switchgrass, camelina and jathropha hold some promise since they are perennial plants that grow unattended. However, to make feedstock supplies reliable, an agricultural initiative would have to be promulgated in order for farmers to embrace these crops. The organic fraction of municipal solid waste (MSW) and algal fuel are also interesting alternatives. Jobenomics is working with a number of organizations to monetize high-value waste streams such as municipal solid waste (MSW), construction and demolition (C&D) material, electric waste and used tires. Each of these waste streams has a high percentage of carbon-based material (such as organic waste, wood, plastic and rubber) that can be converted into bio-oils or syngas to be processed into drop-in biofuels. Drop-in biofuels are similar to fossil fuels and can be used directly in existing infrastructure and pipelines, unlike conventional ethanol that has to be blended.

The Jobenomics employment outlook for the cellulosic fuel industry is poor. For this industry to grow, investors would have to make bold assumptions that: (1) the RFS standard will stay in place until 2022, (2) a reliable source of affordable feedstock will be found, and (3) gas prices will appreciate substantially in order to make the cost of cellulosic fuel competitive against the cost of gasoline. It is unlikely that these preconditions would mature enough to enable cellulosic biofuels to compete against other ETR technologies.

Biogas or Renewable Natural Gas (RNG) Employment Outlook. Biogas systems capture methane from organic waste streams (human, livestock, food and municipal solid waste) that would otherwise escape into the atmosphere.

Biogas is produced when bacteria decompose organic waste anaerobically—without the presence of oxygen—into a gas mixture composed of about 60% methane and 40% carbon dioxide. This methane-laden gas is used to create energy (electricity, heat, fuel) and other byproducts such as fertilizers, plastics and chemical feedstock. In addition, biogas production reduces water contamination, odor pollution and climate-change methane emissions. Since methane has a GHG heating factor 20 times higher than carbon dioxide, combustion of biogas eliminates 20 times less toxic emissions.

As discussed in the Alternative Fuel-Hydrogen section of this report, biogas can play a major role in producing BioHydrogen ($BioH_2$) used to power hydrogen fuel cells, hydrogen-based vehicles and a hydrogen-based economy. Bacteriological digestion/fermentation of organic waste holds the promise of biological production of $BioH_2$. Unlike fossil fuel (natural gas) processes that currently produce 95% of America's hydrogen supplies, $BioH_2$ produces virtually no greenhouse gases.

Biogas is also called renewable natural gas (RNG) or biomethane, which is a clean and low-carbon natural gas alternative made from organic waste including landfills, wastewater treatment plants, commercial food waste facilities and livestock centers. The major difference between natural gas and RNG is that RNG is not made from fossil fuels.

According to NGVA Europe[108], about 60% of the gas used in Sweden's 38,500 natural gas vehicles is RNG. In Germany, 25% of the public compressed natural gas stations dispense 100% RNG. In the United States, RNG vehicles are becoming more common but are yet in their infancy. RNG is also used for electric power generation and in-home use. From a greenhouse gas perspective, renewable gas has tremendous benefits since methane from animal waste and other biomass sources that would have otherwise entered the atmosphere are instead combusted as renewable fuel.

Also known as digester gas, RNG is the gaseous product of anaerobic digestion of organic matter[109]. Anaerobic digesters can range in size from a large refrigerator to the size of small building. Ideal locations for American RNG plants include 17,000 U.S. wastewater facilities, 8,000 U.S. farms and dairies, 1,750 landfills, and cities that collectively discard 66.5 million tons of food waste each year. According to the Joint Biogas Opportunities Roadmap[110], the United States currently has more than 2,000 sites producing biogas and, with the proper support, more than 11,000 additional biogas systems could be soon deployed.

As strange as it may seem, livestock (cattle, buffalo, sheep, goats, camels, horses, pigs, and poultry) emit almost as much methane as oil and gas producers[111] and account for almost half of all human-caused

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[108] Natural & bio Gas Vehicle Association (NGVA) Europe, http://www.ngvaeurope.eu/worldwide-ngv-statistics
[109] DoE, Renewable Natural Gas (Biomethane), http://www.afdc.energy.gov/fuels/emerging_biogas.html
[110] U.S. Department of Agriculture, *Biogas Opportunities Roadmap*, August 2014, http://www.usda.gov/oce/reports/energy/Biogas_Opportunities_Roadmap_8-1-14.pdf
[111] Climate Central, Measuring Cow & Pig Emissions Goes to New Heights, 19 July 2014, http://www.climatecentral.org/news/livestock-methane-emissions-satellite-co2-17749

GHGs. Livestock emissions deserve a harder look from a climate change and renewable energy perspective.

The EPA's AgSTAR program reports that about 8,000 U.S. farms could support biogas recovery systems, providing about 1,500MW of energy and reducing emissions of global warming pollution by about 34 million metric tons of CO_2 equivalents—the equivalent of taking 6.5 million cars off the road[112]. Today, there are only 200 U.S. farms using biogas digesters compared to 4,500 German farms that produce only ¼ of the animal waste produced by U.S. farms[113]. A simple agricultural plant costs as low as $3,500 per electrical kW installed with a typical 5 to 7 year payback period without subsidies or leasing.

According to the U.N. Food and Agriculture Organization[114], 109 million metric tons of pigs were produced worldwide in 2012, followed by 93 million metric tons of chickens and 63 million metric tons of cattle. United States, China and Brazil are the largest chicken and cattle producers. From an ETR perspective, while cows emit more methane, pigs and chickens seem to be better suited for methane capture than their bovine table partners since they are raised in a more confined environment as shown. Worldwide, 1.3 billion pigs are slaughtered each year.

China produced more pigs than the rest of the world combined, with the United States in a distant second place. The Chinese, who have an insatiable appetite for all things porcine, consume 500 million pigs per year[115]. According to the International Institute of Social Studies in The Hague, feeding this massive porcine population requires almost half of the world's feed crops. As a result, the Chinese are importing vast amounts of corn and soy as well as buying foreign farms to the tune of millions of acres, including farms in the United States, Canada, Brazil and Argentina.

The 2013 acquisition of Smithfield Foods (the largest U.S. pork producer in 26 states and 12 countries) by Shuanghui (China's largest pork producer) offers the international community a unique way to participate in porcine biogas capture and conversion. Given that the world's porcine population is two billion strong, and that each pound of pork requires six pounds of feed, the amount of GHGs generated by respiration and fecal matter is huge—much of which can be captured in confined spaces in typical pig farms. Solid waste could be processed via anaerobic digesters and other human-waste processing systems, and respiration gases could be collected and compressed in the same manner as landfill gases are.

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[112] EPA, USDA-EPA Collaboration to Advance the Deployment of Anaerobic Digesters at US Livestock Facilities, http://www.epa.gov/agstar/documents/usda_iaa.pdf

[113] Global Intelligence Alliance, How to Profit from Biogas Market Developments, June 2010, http://www.globalintelligence.com/insights/all/how-to-profit-from-biogas-market-developments

[114] U.N. Food and Agriculture Organization, FAOSTAT 2012, http://faostat.fao.org/site/339/default.aspx

[115] The Economist, Swine in China: Empire of the pig, China's insatiable appetite for pork is a symbol of the country's rise. It is also a danger to the world, 20 December 2014, Page 67

The Coalition for Renewable Gas[116] estimates that transforming organic waste into RNG would create 70,000 new American jobs. The American Gas Foundation[117] is more optimistic, estimating that developing renewable natural gas can create up to a total of 257,000 direct, indirect and induced new jobs.

As part of the 2014 U.S. Farm Bill, the U.S. Department of Agriculture is making more than $280 million available to eligible farmers and rural small businesses through the Rural Energy for America Program for energy efficiency and renewable energy projects, including biomass using anaerobic digesters. The maximum grant amount is $500,000 and the maximum loan amount is $25 million per applicant[118]. Rather than spending $25 million on one major project, $25 million could fund over 7,000 rural biogas recovery systems at $3,500 each.

Jobenomics agrees with the Joint Biogas Opportunities Roadmap that 11,000 additional biogas systems could be implemented (1) relatively easily, quickly and cheaply, (2) thereby creating over a hundred thousand new American jobs (3) while simultaneously making significant reductions in toxic methane emissions (4) without any major changes or disruptions to the U.S. energy infrastructure.

Wood Employment Outlook. From 2005 to 2012, the United States experienced a 32% increase in the number of homes (from 1.9 to 2.5 million) that use wood biomass as the primary heating fuel[119]. Another 9 million American households use wood biomass as a secondary form of heating. Since these are off-grid dispersed generation gains, they are not reported in the EIA Annual Energy Outlook reports that are largely oriented to utility-grade electrical, heat and transportation energy consumption and generation. According to the EIA[120], the United States is the largest wood pellet exporter in the world with approximately 73% delivered to the United Kingdom, 12% to Belgium and 7% to the Netherlands for the purpose of utility-grade electrical generation in order to be compliant with the EU's 2020 Climate and Energy Plan. The EU considers wood pellets a renewable biomass feedstock. A renewables obligation credit program (a U.K. renewable energy incentive program[121]) has motivated many coal-fired power plants to retrofit using wood pellets or other forms of biomass as co-firing agents. The United States exported 4.4 million tons in 2014, a 40% increase over 2013, eclipsing Canada, the former wood pellet leader. U.S. wood pellet exports accounted for more than $500 million of trade in 2014.

Hydroelectric & Hydrokinetic Power Employment Outlook.

EIA forecasts that conventional hydroelectric power (hydropower) will **decrease** its share in the United States renewable market mix from 28% in 2013 to 25% by 2030, and will **increase** its domestic

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[116] The Coalition for Renewable Gas, http://www.rngcoalition.com/infographic/
[117] American Gas Foundation, The Potential for Renewable Gas, September 2011, http://www.gasfoundation.org/ResearchStudies/agf-renewable-gas-assessment-report-110901.pdf
[118] USDA, Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Loans & Grants, http://www.rd.usda.gov/programs-services/rural-energy-america-program-renewable-energy-systems-energy-efficiency
[119] EIA, Today in Energy, Increase in wood as main source of household heating most notable in the Northeast, 17 March 2014, http://www.eia.gov/todayinenergy/detail.cfm?id=15431
[120] EIA, Today in Energy, 22 April 2015, UK's renewable energy targets drive increases in U.S. wood pellet exports, http://www.eia.gov/todayinenergy/detail.cfm?id=20912&src=email
[121] GOV.UK, The Renewables Obligation, https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/the-renewables-obligation-ro

consumption from 2.54 quadrillion Btu in 2013 to 2.80 quadrillion Btu in 2030 for a net growth of 10%[122]. EIA does not forecast high-head/low-head hydro or hydrokinetic power generation during this period.

From an international investment (and employment) point of view, the EY (formerly Ernst & Young) March 2015 Renewable Energy Country Attractiveness Index[123] rates the top 40 countries that provide the most attractive overall investment environment. The top 10 countries for **hydropower** are: China, Brazil, United States, Japan, Canada, India, Peru, Norway, Turkey, and Germany. The top 10 countries for hydrokinetics (marine power) are: Ireland, United Kingdom, South Korea, Philippines, France, Canada, Portugal, Norway, United States and Japan.

Conventional Hydropower. Hydropower is derived from the energy of moving water. Hydropower has been exploited for centuries, starting with water wheels that produced mechanical power to grind wheat into flour.

Hydropower is currently the second largest source, after biomass, of renewable electrical power generation in the United States. According the National Hydropower Association (NHA), the U.S. hydropower industry currently employs up to 300,000 employees and has significant room for expansion if policy-makers level the playing field for this proven and reliable renewable baseload technology.

A recent NHA study[124] examined the U.S. hydropower industry's potential under a business-as-usual scenario, where national policies mandate a 10% renewables generation goal, and an accelerated scenario with a 25% mandate. The 10% business-as-usual scenario generated 23GW of new capacity along with 480,000 new direct, indirect and induced jobs. The 25% accelerated scenario generated 60GW of new capacity along with 1,400,000 new direct, indirect and induced jobs. The NHA study only examined proven hydropower technology (conventional hydro, hydrokinetic, pumped storage, micro-hydro and run-of-river) and developing technologies (wave, ocean current and tidal in-stream conversion). Jobenomics believes that there is significant additional employment potential in off-grid high- and low-head hydro.

Based on a recent Navigant Consulting and American Council on Renewable Energy study, the NHA reports[125] that the LCOE (levelized cost of energy) of hydropower offers the lowest cost of electricity across all major fossil fuel and renewable energy sources. Since water is 835 times denser than air, hydrokinetics is an untapped, powerful, clean, renewable energy source. The energy contained in a 12-mph water flow is equivalent to that contained in an air mass moving at about 110 mph. The regular nature of river and tidal currents provides an advantage for hydropower as compared to the variability of wind and solar power. Furthermore, high-head and low-head hydropower are excellent complements to wind and solar distributed generation architectures.

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[122] EIA, AEO2015, Table 17, Renewable Energy Consumption by Sector and Source, http://www.eia.gov/forecasts/aeo/tables_ref.cfm

[123] EY, Renewable Energy Country Attractiveness Index (RECAI), March 2015, Page 14, http://www.ey.com/Publication/vwLUAssets/Renewable_Energy_Country_Attractiveness_Index_43/$FILE/RECAI%2043_March%202015.pdf

[124] National Hydropower Association, Job Creation, http://www.hydro.org/why-hydro/job-creation/

[125] National Hydropower Association, Hydropower is Affordable, http://www.hydro.org/why-hydro/affordable/

On the other hand, hydropower production depends on water availability that can vary significantly from year to year, especially in periods of drought. Conventional hydro run-of-river plants are subject to changes in river flows. To make water more consistently available, dams and reservoirs are used for major conventional hydroelectric generators and pumped storage plants. Pumped storage plants can function as energy generators when stored energy is released to the grid.

The world's first hydroelectric power plant began operation in 1882 on the Fox River in Appleton, Wisconsin. To get more power out of flowing river water, Americans built dams to capture greater and more stable forms of kinetic and potential energy. In 1933, the Tennessee Valley Authority (TVA) was established to provide hydroelectric power and manage flood control and soil conservation programs. Today, the Grand Coulee Dam on Washington's Columbia River is the largest hydroelectric power producer in America, and the world's six largest, with a total generating capacity of 6,809MW. The United States is ranked as the world's second largest user of hydropower with 101GW of installed capacity, following China's 282GW.

Jobenomics believes that hydropower should receive more attention as a major contributor to the U.S. renewable energy portfolio. While there is limited potential for new large-scale U.S. conventional hydro developments, there is significant U.S. potential for energy efficient upgrades to current facilities, adding power generation capability to non-powered dams, developing a percentage of the 5,400 identified sites for small hydro plants, and developing a percentage of the 130,000 identified low-head micro-hydropower sites.

The DoE's New Stream-reach Development Assessment[126] found over 12GW of hydropower potential at the existing 80,000 U.S. non-powered dams, most of which could incorporate small downstream run-of-river hydropower facilities utilizing new low-impact designs and technologies for both power generation and community storage.

Run-of-River Hydropower. In recent years, run-of-river (RoR) hydropower projects have emerged as a viable, low-impact alternative to existing large-scale projects. The difference between RoR hydropower and conventional storage hydropower is the absence of a dam and reservoir. Run-of-river relies on coursing rivers to generate electricity, as opposed to stored water. RoR facilities use running water to produce electricity by diverting river flow through turbines that spin generators and then return water back to the river downstream. The largest RoR dam in the United States is the Chief Joseph Dam on the Columbia River near Bridgeport, Washington, with an installed capacity of 2,620MW and an annual generation of 9,780GWh.

RoR applications also use low-head hydro turbines that are attached to bridge abutments or pilings. Using existing bridge infrastructure minimizes costs and environmental disruptions. Bridges are usually close to electrical transmission lines and provide relatively easy access in case of fouling (clearing debris). Low-head hydropower systems can produce up to 100kW of electricity. In addition, RoR systems complement solar and wind systems since RoR plants generally exhibit high annual capacity factors (the proportion of time a year that a power facility is actually generating electricity) exceeding 50%.

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[126] Oak Ridge National Laboratory, New Stream-Reach Development Resource Assessment, http://nhaap.ornl.gov/nsd

Apple built a run-of-river micro-hydro system that harnesses the power of water that's been flowing through local irrigation canals to power their data center in Prineville, Oregon. These micro-hydro projects will generate 12 million kilowatt-hours of renewable energy a year. To supplement this micro-hydro generation, Apple purchases local wind energy to power the entire data center[127].

High-head and Low-head Hydropower. Using the engineering principle of "hydraulic head" (the force of the liquid column proportional to its height), low-head hydro power systems produce electrical and mechanical energy by converting the potential and kinetic energy possessed by a body of water (rivers, streams, lakes, canals, tidal pools, etc.).

Hydraulic head systems have three classes: high-head/high-power, high-head/low-power, and low-head/low-power. High power refers to greater than 1MW, low power refers to less than 1 MW, high-head refers to drops greater than 30 feet, and low-head refers to less than 30 ft. Unlike hydroelectric systems that require expensive dams, high-head and low-head hydro power systems have more modest financing, construction and operational requirements. High-head systems are usually utility-grade whereas low-head are used for small-grade distributed generation applications close to the point-of-consumption.

High-head and low-head systems typically direct water through a narrow channel to a propeller/turbine that turns an alternator that produces electricity.

- For drops exceeding 15 feet, water is diverted to a screened catch box (to eliminate debris), channeled into pipeline (called a penstock that is usually made of PVC plastic) and fed downhill to increase pressure (1 psi for every 2.5 foot drop). Pressurized water is then routed to nozzles that spin a turbine, turning an alternator to create electricity. Electrical output depends on the amount of diverted water, degree of drop and the number of turbines used.

- For drops of only several feet, such as streams, low-head micro-hydro (micro-hydro refers to power potential of less than 100kW) power systems can produce enough electricity to power a modest dwelling with low wattage. Instead of a penstock, the water is channeled into a slightly declined waterway that funnels the water into a vertical tube (often less than 6 feet tall). The channeled water flows down the vertical tube across a propeller that drives an alternator that produces several kilowatts of electricity. Primitive low-head micro-hydro power systems used in third-world applications cost as little as $100.

The Idaho National Laboratory reviewed U.S. water energy resources and concluded that there are potentially 130,000 low-head micro-hydro power sites that could each produce more than 10kWh per year. In addition, there are approximately 5,400 sites that could potentially be developed as small hydro plants having a total hydropower potential of approximately 18,000MW[128].

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[127] Apple, Environmental Responsibility Report, 2015 Progress Report Covering FY2014, http://images.apple.com/environment/pdf/Apple_Environmental_Responsibility_Report_2015.pdf
[128] DoE, Idaho National Laboratory, Feasibility Assessment of the Water Energy Resources of the United States for New Low Power and Small Hydro Classes of Hydroelectric Plants, January 2006, http://hydropower.inl.gov/resourceassessment/pdfs/main_report_appendix_a_final.pdf

Jobenomics tends to agree more with the National Hydropower Association than the EIA on the future of U.S. hydropower. Hydropower needs to play a much larger role in the United States energy portfolio and export strategy. Global hydroelectric plants could be made much more energy efficient, power generation capability could be added to non-powered dams, and high-head/low-head systems would be a significant addition to decentralized distributed generation architectures.

Ocean Hydrokinetic Power. Due to their sheer size and continuous power, oceans have the greatest hydrokinetics energy production potential. The ultimate goal for ocean hydrokinetic planners is to create massive offshore wave parks and marine current turbine arrays, similar to onshore wind farms, which convert wave and ocean current energy into electricity. Large wave parks and tidal/marine power plants are often preferable to large onshore plants that result in societal and ecological disruption of flooded land.

Oceans capture energy from waves, marine currents, temperature and salinity gradients, and tides.

Wave Power. Wave energy is a form of stored wind energy since waves are generated mostly by wind.

Wave power technologies are now in various stages of research, development and deployment in Europe, Australia and the United States. Hydrokinetic wave technologies include (1) long floating structures that generate electricity by riding the waves, (2) floating reservoirs that catch breaking waves to generate low-head pressure, (3) tethered floating buoys that act like mechanical pumps, and (4) near-shore anchored oscillating water columns that function as water pistons to power turbines that generate electricity.

The world's first wave farm opened in Portugal in 2008 with a total installed capacity of 2.25MW, but was shut down several months after opening due to technical and program management issues.

Perhaps the most interesting wave project, 15 years under development and testing, is Carnegie Wave Energy's CETO project[129] that is scheduled for a 25MW wave park in 2018 off the shores of Australia's stormy west coast. CETO, named after a Greek sea goddess, is different from other wave devices since it is submerged about 10 feet under the surface where is safer from the ravages of breaking waves, harsh storms and ships. One CETO version consists of submerged buoys that drive seabed pumps, delivering high pressure water onshore via a subsea pipe to turbines that generate electricity. The high-pressure water can also be used to supply a reverse osmosis desalination plant. Another version uses a cable instead of a subsea pipe to deliver onboard generated electricity from underwater foam-filled steel buoys that are each 69 feet in diameter.

Marine Current Power. Hydrokinetic marine current technologies harness the kinetic energy associated with subsurface marine and tidal currents.

Hydrokinetic rotating devices are similar to horizontal and vertical axis wind turbines. As an illustration, the Japanese are developing large-scale marine energy farms that use a power generation system similar to an underwater kite anchored to the ocean floor that "flies" in the current [130].

[129] Carnegie Wave Energy, CETO Technology, http://www.carnegiewave.com/ceto-technology/ceto-overview.html
[130] Wall Street Journal, Japan Real Time, Japan Looks to Ocean for Renewable Energy, 18 February 2015, http://blogs.wsj.com/japanrealtime/2015/02/18/japan-looks-to-ocean-for-renewable-energy/

In the United States, the Gulf Stream, Florida Straits Current, California Current and Aleutian Passages offer significant marine current potential. The Gulf Stream alone is estimated to have 21,000 times more hydrokinetic energy than Niagara Falls. Due to its proximity to large population centers (e.g., Miami) and relatively consistent high speeds and flows, the Florida Straits was chosen by the U.S. Bureau of Ocean Energy Management[131] for the first U.S. government lease, issued in June 2014, for hydrokinetic marine current testing.

Temperature Gradient Power. Hydrokinetic temperature gradient technologies exploit differences in water temperature. Temperature gradients between warm sea surface and cold deep water can be harnessed using different ocean thermal energy conversion (OTEC) processes. OTEC is a renewable energy technology that harnesses the solar energy absorbed by the oceans (the world's largest solar panel) to generate electric power in tropical regions where the year-round ocean temperature differential is around 36°F.

In 2013, Lockheed Martin (United States)[132] signed a contract to design a 10MW OTEC power plant—the world's largest OTEC project—that will supply 100% of the power requirements for a green Reignwood Group (China) resort off the coast of southern China. The agreement lays the foundation for the development of other American-Chinese OTEC plants, ranging in size from 10MW to 100MW, worth several billion dollars.

Salinity Gradient Power. Salinity gradient, also called osmotic power, technologies are often located at the mouths of rivers, where freshwater mixes with saltwater. The energy associated with the salinity gradients is harnessed using reverse osmosis and conversion technologies. The world's first salinity gradient power generation plant was opened in 2009 in Norway with a designed capacity of 10kW. In 2013, Norway ceased operations after determining that other renewable technologies are more competitive[133].

Tidal Power. Hydrokinetic tidal power draws on the predictable changes in gravitational energy produced by earth-moon-sun orbital forces. Examples of tidal turbines include (1) horizontal-axis turbines that convert kinetic energy of fast-moving water currents, (2) tidal barrages that use the potential energy in the hydraulic head created by rising and falling tides, (3) tidal lagoons that use retaining walls embedded with turbines, and (4) dynamic tidal power seawalls that protrude perpendicularly from coastal shores and exploit tidal pressure differentials on each side of the wall. Tidal power plants have been operational for 50 years.

The 240MW Rance Tidal Power Station was the first operational hydrokinetic tidal power plant, commissioned in 1966 on the estuary in Brittany, France. From 1968 to 2009, five more small (1.2MW

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[131] U.S. Bureau of Ocean Energy Management, Renewable Energy on the Outer Continental Shelf, http://www.boem.gov/BOEM-Overview-Renewable-Energy/

[132] Lockheed Martin, Lockheed Martin and Reignwood Group Sign Contract To Develop Ocean Thermal Energy Conversion Power Plant, http://www.lockheedmartin.com/us/news/press-releases/2013/october/131030-mst-otec-lockheed-martin-and-reignwood-group-sign-contract-to-develop-ocean-thermal-energy-conversion-power-plant.html

[133] Statkraft, Statkraft halts osmotic power investments, http://www.statkraft.com/media/news/News-archive/2013/Statkraft-halts-osmotic-power-investments/

to 20MW) tidal power stations started operations in Canada, China, Russia, South Korea and England. In 2011, South Korea commenced operation of the 254MW Sihwa Lake Tidal Power Station that is currently the world's largest tidal facility. Based on its experience with the Sihwa station, South Korea is building a 1,320MW, $3.4 billion, Incheon Tidal Power Station[134] that has forty-four 30MW water turbines. The state-run Korea Hydro & Nuclear Power's Incheon Tidal Power Station is slated to become operational in 2017 and is expected to generate 2.4 trillion watt hours of electricity annually—the amount equivalent to 3.5 million barrels of crude oil.

Not to be outdone by South Korea, Russia is designing an 11,400MW Mezenskaya Tidal Power Plant[135] on the coast of the White Sea in Eastern Russia. Mezenskaya will use several hundred floating concrete blocks with bottom water conduits that were tested and developed at Russia's experimental Kislogubskaya tidal power plant. Mezenskaya estimates that it will generate as much as 38.9 trillion megawatt hours per year.

Compared to Russia and South Korea, American hydrokinetic and inland marine power projects are in their infancy. As of April 2014, the U.S. Federal Energy Regulatory Commission (FERC)[136] has licensed 1 inland and 3 tidal projects with an estimated 2.45MW of power. These projects are located in New York, Maine, Washington State and Alaska. FERC has also issued preliminary permits, pre-filing permits and pre-filing licenses for 4 wave, 3 tidal and 4 inland marine and hydrokinetic projects with an estimated 130MW of installed capability. These projects are located in Massachusetts, New York, California, Oregon, Michigan and Alaska.

The first U.S. commercially licensed tidal energy project is Verdant Power's Roosevelt Island Tidal Energy (RITE) Project[137]. 30 turbines are being installed in the tidal strait that connects the Long Island Sound with the Atlantic Ocean in the New York Harbor. These horizontal-axis turbines convert the kinetic energy of fast-moving (> 1 m/s) water currents into clean renewable electricity.

RITE is scheduled to be operational in late 2015 and will use the flow of the river and tides to generate 1,050kW of electricity, enough to power 9,500 New York homes. In addition to New York, in March 2014, the U.S. Trade and Development Agency awarded Verdant Power a grant to perform a feasibility study on the exportation of their technology downstream of a major hydropower plant near Adana, Turkey[138]. If ultimately installed, the Adana project will provide an anticipated $32.5 million in opportunities for U.S. manufacturing and services.

According to Verdant Power[139], hydrokinetic energy, both bidirectional (tidal) and unidirectional (river and manmade channels), could provide at least 12 GW of installed capacity for the United States by

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[134] The Korea Times, Incheon to House Largest Tidal Power Plant, 20 January 2010, http://www.koreatimes.co.kr/www/news/biz/2010/01/123_59412.html
[135] Russia Renewable Energy Information Portal, Mezenskaya Tidal Power Plant, http://russiagogreen.ru/en/res/detail.php?ID=1497
[136] Federal Energy Regulatory Commission, Hydrokinetic Projects, 4 December 2014, http://www.ferc.gov/industries/hydropower/gen-info/licensing/hydrokinetics.asp
[137] DoE, Energy.gov, http://energy.gov/articles/turbines-nyc-east-river-will-provide-power-9500-residents
[138] Verdant Power, USTDA Provides Funding for Verdant Power Feasibility Study in Turkey, March 2014, http://www.verdantpower.com/verdant---ustda.html
[139] Power Magazine, New York City Backs Tidal Power, by Angela Neville, Page 4, 1 May 2011, http://www.powermag.com/new-york-city-backs-tidal-power/?pagenum=4

2020. For each GW, 1,500 direct jobs could be created, for a total of 18,000 direct jobs by 2020 and an additional 72,000 indirect and induced jobs. Verdant anticipates U.S. installed capacity to reach 60GW.

Wind Power Employment Outlook.

EIA forecasts that onshore wind power will **increase** its share in the United States renewable market mix from 18% in 2013 to 21% by 2030, and domestic consumption will **increase** from 1.59 quadrillion Btu in 2013 to 2.32 quadrillion Btu in 2030 for a net growth of 46%[140]. EIA forecasts very minimal offshore wind power generation during this time period (0.03 quads)[141].

From an international investment (and employment) point of view, the Renewable Energy Country Attractiveness Index[142] rates the top 40 countries that provide the most attractive overall investment environment. The top 10 countries for **onshore wind** power are: China, United States, Germany, Canada, Brazil, India, Ireland, United Kingdom, France and Sweden. The top 10 countries for **offshore wind** power are: United Kingdom, China, Germany, Belgium, Netherlands, Denmark, France, United States, Japan and Finland.

Wind power, or wind energy, describes the process where wind turbines are used to convert the kinetic energy in wind into mechanical power that is converted into electricity by a generator. Wind turbines can be broken down into two types: horizontal and vertical axis wind turbines. Wind turbines come in various sizes: utility-grade 1.5MW to 7.5MW (very large machines with rotors over 250 feet used in large wind farms for producing electricity for the grid), large commercial and industrial 500kW to 1.5MW (smaller machines with rotors less than 200 feet used in small wind farms to produce power for local grids), commercial onsite 50kW to 250kW (campuses and large facilities), small commercial-scale onsite 10kW to 50kW (small businesses, farms), residential-scale <10kW (homes) and very small 1kW systems for remote locations and cell phone towers.

In 2013, the United States and China were running neck-and-neck as leading wind power nations. China has more installed capacity than the United States, 90GW versus 60GW respectively, but the United States produces more than China, 167 terawatt-hours versus 138TWh respectively[143]. In 2014, electricity produced from U.S. wind power amounted to 178TWh; it will be 231TWh by 2020, a 30% increase[144]. According to the National Renewable Energy Laboratory, the United States has the potential for producing 38,553 terawatt-hours[145] of onshore wind power, which is enough to electrify

[140] EIA, AEO2015, Table 17, Renewable Energy Consumption by Sector and Source, http://www.eia.gov/forecasts/aeo/tables_ref.cfm

[141] EIA, Annual Energy Outlook 2015, Table 16 Renewable Energy Generating Capacity and Generation, http://www.eia.gov/forecasts/aeo/

[142] EY, Renewable Energy Country Attractiveness Index (RECAI), March 2015, Page 14, http://www.ey.com/Publication/vwLUAssets/Renewable_Energy_Country_Attractiveness_Index_43/$FILE/RECAI%2043_March%202015.pdf

[143] American Wind Energy Association, A Pleasant Surprise: USA, Not China, Is #1 In Wind Energy, 1 November 2014, http://aweablog.org/blog/post/a-pleasant-surprise-usa-not-china-is-1-in-wind-energy

[144] EIA, Annual Energy Outlook 2015, Table 16, Renewable Energy Generating Capacity and Generation, http://www.eia.gov/forecasts/aeo/data.cfm?filter=renewable#renewable

[145] DoE, WINDExchange, http://apps2.eere.energy.gov/wind/windexchange/filter_detail.asp?itemid=2542

America many times over. By 2020, China plans a 300% increase its total wind production capacity to 390TWh (85% onshore and 15% offshore)[146].

In comparison to China, the United States wind industry outlook appears to be on a different track. A recent Wall Street publication rated the United States' wind turbine installation industry as the third fastest dying U.S. industry, citing the fact that revenue in the wind turbine installation industry fell at an annualized rate of 16.4% in the five years through 2014, and it is projected by IBISWorld to slump by an annualized 7.3% over the next four years[147].

Wind industry attracts $25 billion per year in private investment, which sustains about 85,000 U.S. jobs, according to the American Wind Energy Association[148]. Jobenomics foresees employment losses in large-scale U.S. utility-grade wind projects, but growth in small-scale U.S. and international distributed and dispersed generation projects. Jobenomics also forecasts employment growth in large-scale international onshore and offshore wind energy projects, especially in authoritarian-based economies that can direct and fund large state-run projects. However, competition for large-scale international projects will be intense with preference given to indigenous production and participation.

As opposed to the weak American outlook, the international outlook for wind power is excellent. According to the IEA Wind Energy Technology Roadmap[149], since 2008, wind power deployment has more than doubled, approaching 300GW of cumulative installed capacity providing 2.5% of global electricity demand. Denmark, Portugal and Spain are the leading wind power countries in terms of wind power as a percentage of total electricity demand, with 30%, 20% and 18% respectively.

Global onshore wind power generation costs range from $60MWh to $130MWh, which makes wind power competitive in many areas around the world. The IEA roadmap targets a 15% to 18% share of global electricity from wind power by 2050.

Onshore Wind Employment Outlook. EIA's wind data from 2005 to 2030[150] shows a bumpy ride for utility-grade wind turbine producers and installers.

After steady growth from 2005 to 2009, the Great Recession dropped new wind energy production by 50% in 2010. By 2012, the market recovered, only to drop by 96% to 1.11GW of new capacity as shown in 2013 due to the expiration of the production tax credit (PTC). Even though the PTC was quickly reinstated, in 2014, wind power only added 4.80GW of capacity. In 2015, the wind energy market is forecast to deliver a record 10.70GW, including a record amount of wind energy produced on U.S. federal government land.

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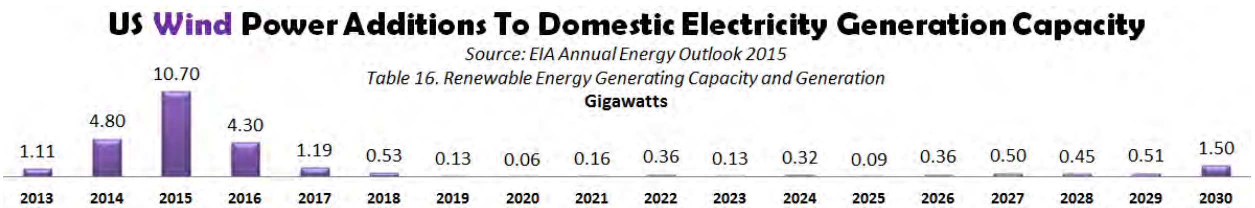
[146] IEA Wind 2013 Annual Report, Section 18 CWEA, Table 1 Key National Statistics 2013: China, Page 77, http://www.ieawind.org/annual_reports_PDF/2013/2013%20AR_small_090114.pdf
[147] 24/7 Wall St., Newsletter, The 10 Dying (and 10 Thriving) U.S. Industries, 16 December 2014, http://247wallst.com/special-report/2014/12/16/the-10-dying-and-10-thriving-u-s-industries/2/
[148] American Wind Energy Association, Infographics, retrieved 1 March 2015, http://www.awea.org/MediaCenter/content.aspx?ItemNumber=6661&RDtoken=62686&userID=
[149] IEA, Wind Energy Technology Roadmap-2013, http://www.iea.org/publications/freepublications/publication/Wind_2013_Roadmap.pdf
[150] EIA, Annual Energy Outlook 2015, Table 16 Renewable Energy Generating Capacity and Generation, http://www.eia.gov/forecasts/aeo/

The U.S. Department of Interior's Bureau of Land Management (BLM) manages 20.6 million acres of public lands with wind potential. The BLM has authorized 40 wind energy development projects, with a total approved capacity of 5.6GW, with 4.7GW authorized since the beginning of the Obama Administration (a statistic highlighted by the BLM). In 2015, the BLM anticipates that a record 4.1GW of new capacity will come online via wind energy plants located on federal land in California, Arizona, Oregon, Wyoming and Nevada[151]. The massive Chokecherry and Sierra Madre Wind Energy Project in Carbon County, Wyoming, consists of 1,000 wind turbines that will generate 3GW of electricity, enough to power 1,000,000 homes[152]. According to the BLM, "The Chokecherry and Sierra Madre Wind project is one of the projects that will help achieve the Administration and Interior initiative to make a rapid and responsible move to large-scale production of renewable energy."



After 2015, the utility-grade wind energy market rapidly bottoms out. From 2016 to 2030, wind is projected to add only 10.58GW, which is less over the 15-year period than in 2015 alone[153]. During the entire decade of the 2020s, only 2.9GW additional wind power will be added, which will devastate the U.S. wind industry, if EIA's 2015 AEO Reference Case projections transpire. The Obama Administration and EPA's proposed Clean Power Plan would significantly increase wind power additions during this time period by accelerating the retirement of older coal and natural gas plants[154]. However, Jobenomics doubts that the Clean Power Plan will be enacted by Congress.

According to the EIA, annual capacity additions will drop significantly after 2016 and will remain low through 2030. The primary reason for this depression is that existing electrical generation capacity is adequate to meet relatively slow demand growth in most regions and satisfy renewable requirements under state standards. Unless states dramatically change their renewable energy standards, as recently mandated by the Governor of California, large-scale wind energy projects will be at risk. EIA data indicates that fossil fuels (mainly natural gas) will capture 59% of capacity additions from 2015 to 2040. All renewables will capture 38%, with wind accounting for 17.1%[155] of the utility-grade market.

[151] Department of Interior, Bureau of Land Management (BLM), Renewable Energy: Wind, http://www.blm.gov/style/medialib/blm/wo/MINERALS__REALTY__AND_RESOURCE_PROTECTION_/energy/solar_and_wind.Par.38552.File.dat/fact_Wind.pdf, http://www.blm.gov/wo/st/en/prog/energy/wind_energy.html

[152] BLM, Chokecherry and Sierra Madre Wind Energy Project, http://www.blm.gov/style/medialib/blm/wo/MINERALS__REALTY__AND_RESOURCE_PROTECTION_/energy/priority_projects.Par.93933.File.dat/fact_ChokeCherrySierraMadreWind.pdf

[153] EIA, Annual Energy Outlook 2015, Table 16, http://www.eia.gov/forecasts/aeo/tables_ref.cfm

[154] EIA, Today in Energy, 5 June 2015, Proposed Clean Power Plan would accelerate renewable additions and coal plant retirements, http://www.eia.gov/todayinenergy/detail.cfm?id=21532&src=email

[155] EIA, Annual Energy Outlook 2015, Figure 35. Cumulative additions to electricity generation capacity by fuel in six cases, 2013-40 (gigawatts), Page 26, http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf & http://www.eia.gov/forecasts/aeo/section_elecgeneration.cfm

Even though prospects for large-scale U.S. wind projects look bleak, small-scale U.S. and international projects hold promise. From a Jobenomics perspective, the challenge for wind power is focused on distributed and dispersed generation initiatives. Distributed and dispersed power generation delivers power at the point-of-consumption, eliminating cost and inefficiencies associated with most utility-grade providers.

There are four main market areas for distributed and dispersed wind generation: residential, agricultural, government/institutional (military bases, schools, municipal facilities, etc.) and industrial/commercial. According to the DoE's recent Distributed Wind Market Report [156], in 2013, residential had the largest number of projects (40%) but the smallest amount of capacity (3%) since low-powered turbines (referred to as "small wind") were installed in America. Agriculture had 26% of all projects and delivered 7% of total installed capacity. The government/institutional sector had 14% of all projects and delivered 37% of total installed capacity. The industrial/ commercial sector had 20% of all projects and delivered 53% of total capacity.

In 2013, 12 states accounted for 80% of domestic wind-generated electricity for a total of approximately 65,000GWh of power[157]. Texas was the top producer with 36,000GWh, followed by Iowa with 15,000GWh, followed by California, Oklahoma, Illinois, Kansas, Minnesota, Oregon, Colorado, Washington, North Dakota, and Wyoming.

The best resources lie in the Midwest stretching from Texas to North Dakota due to a more consistent average wind speed. Since there are no fuel or other variable costs associated with wind power generation, a wind plant's capacity factor—a measure of the plant's generation as a percentage of its maximum generating capacity—is very closely related to the available wind resource.

Over the last decade, 104,000 total wind turbines were deployed in the United States, of which 69% were ≤100kW projects, 30% were >100kW projects installed on wind farms, and 1% were large, >100kW distributed projects.

Domestic U.S. wind power manufacturing has decreased the imported share of wind equipment (i.e., blades, towers, generators, gearboxes, and wind-powered generating sets), declining from an estimated 80% in 2007 to 30% in 2013[158], which is good news for American manufacturing employment. Correspondingly, small wind U.S. exports increased from 8MW in 2012 to 13.6MW in 2013, which equates to a 70% increase, also very good news. U.S. small wind turbines were exported to more than 50 countries including Italy, United Kingdom, Germany, Greece, China, Japan, Korea, Mexico, and Nigeria. 76% of U.S. manufacturers' new small wind sales are now international sales.

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[156] DoE, 2013 Distributed Wind Market Report, August 2014, http://energy.gov/sites/prod/files/2014/09/f18/2013%20Distributed%20Wind%20Market%20Report.pdf

[157] EIA, Today In Energy, Twelve states produced 80% of U.S. wind power in 2013, 15 Apr 2014, http://www.eia.gov/todayinenergy/detail.cfm?id=15851 [

[158] EIA, 2013 Wind Technologies Report, Despite challenges, a growing percentage of the equipment used in U.S. wind
power projects has been sourced domestically since 2006-2007, Page 21, http://energy.gov/sites/prod/files/2014/08/f18/2013%20Wind%20Technologies%20Market%20Report_1.pdf

As discussed in the solar section, 600,000 American homes and businesses (out of a total of 150 million) have gone solar, which is sufficient to attract enough investors and suppliers for a national initiative that could create 640,000 direct jobs. The same potential exists for manufactures and installers if they can make small-wind turbines more aesthetic and more affordable.

A typical home uses 1,000 to 2,000kWh per month that could be handled by a 10kW unit. Unfortunately, typical 10kW vertical wind units require 100 foot tall towers with 25 foot diameter rotors that cost upwards of $60,000 to install, which makes residential wind power unattractive aesthetically and economically. Given the fact that the U.S. distributed manufacturing is comprised of 100s of companies with facilities in 34 states, an innovative, low-cost, attractive, small-wind rooftop system (example shown[159]) with local storage and grid-metering could be available soon either by direct purchase or a leasing arrangement.

Notwithstanding the dour EIA outlook for utility-grade wind power, Jobenomics forecasts that the ultimate potential for American wind power is very promising if an affordable home-based system can be deployed. One must remember that the EIA forecasts do not include off-grid electrical production by distributed and dispersed generators that are the future of the wind industry.

Jobenomics believes that American ETR wind technologies, processes and system companies will join with other dispersed ETR (solar and inland hydro) companies to exploit this opportunity to electrify America with clean renewable technology.

Offshore Wind Employment Outlook. The EIA lists offshore wind as part of the renewables portfolio, and it forecasts the potential for offshore wind generation in the next decade for U.S. consumers. The near-term employment outlook for U.S. offshore wind is limited due the fact that America is late to the game and struggling with policy and environmental issues.

Offshore winds are attractive as a power source since they are typically stronger and steadier than onshore winds. Offshore wind turbines, however, are costlier, take longer to build, and are challenging to maintain.

The Europeans are currently the offshore wind leaders. 66 European offshore wind farms are operational. The United Kingdom has the largest installed capacity at 3,653MW, followed by Denmark with 1,271MW, Germany 903MW, the Netherlands 228MW, and Finland, Ireland, Norway and Portugal with a combined total of 55MW[160]. According to Bloomberg New Energy Finance[161], "there were no fewer than seven European billion-dollar offshore wind projects reaching the 'final investment decision' stage, including the $3.8 billion, 600MW Gemini array off the Netherlands (the largest non-hydro renewable energy project on record in terms of dollars committed), the $2.6 billion, 402MW Dudgeon

[159] Supa-Flo VAWT, Rooftop Mounted Wind Turbine Ventilator, http://rooftopwind.biz/html/supa_flo_wec.html
[160] IEA Wind 2013 Annual Report, Table 2 National Statistics of the IEA Wind Member Countries 2013, http://www.ieawind.org/annual_reports_PDF/2013/2013%20AR_small_090114.pdf
[161] Bloomberg New Energy Finance, Rebound in clean energy investment in 2014 beats expectations, 9 January 2015, http://about.bnef.com/press-releases/rebound-clean-energy-investment-2014-beats-expectations/

project in U.K. waters, and the $1.7 billion, 350MW Wikinger undertaking in the German area of the Baltic Sea."

China is aggressively pursuing offshore wind power. China has installed offshore wind power capacity of only 670MW but has aggressive plans for 5,000MW (5GW) by the end of 2015 and 30,000MW (30GW) of offshore capacity by 2020, which will be very difficult to achieve given the short timelines. However, in 2013, China designed, built and deployed several integrated jack-up installation vessels, each capable of transporting, lifting and installing ten offshore turbines in Chinese and international waters, which the Chinese believe will help them achieve their ambitious offshore wind power goals. In addition, the Chinese government is offering cost-plus contracts (feed-in tariffs) to Chinese renewable energy companies to take the offshore plunge to construct 44 projects in 2015 and 2016.

Japan and South Korea have limited offshore wind projects. Offshore wind projects are slated for Kenya and Canada.

Fourteen years in the making and touted as "America's first offshore wind farm," Cape Wind[162] is currently in its $2.6 billion financing and final commercial contracting stage, anticipating a construction start in 2015. Cape Wind is a 24 square mile project located in the Nantucket Sound off ofMassachusetts. 130 wind turbines with an installed capability of 468MW will generate an average of 170MW of electricity, enough to supply 75% of the energy needs of Cape Cod and the islands of Martha's Vineyard and Nantucket. However, objections from influential seafront real estate owners, Indian tribes, local fishermen, politicians (including the Kennedy family and new Republican governor), and termination of power purchase agreements from local electrical utilities have put Cape Wind on hold, perhaps permanently.

In 2011, the Department of Energy awarded $26.5 million for 19 offshore wind technology projects[163]. Eight projects were for advanced modeling and simulation tools, four projects for innovative rotor and control systems designs, and seven projects for conceptual designs.

Of the seven conceptual design projects, three were selected in May 2014 to advance to the demonstration phase[164]. Dominion Virginia Power will install two 6MW direct-drive wind turbines 26 miles off the coast of Virginia Beach, Virginia, using a domestically-produced twisted jacket foundation (easier to manufacture and install than traditional foundations) with a hurricane-resilient design. Fishermen's Energy of New Jersey will install up to 6 wind turbines with a total capacity of at least 20MW three miles off the coast of Atlantic City, New Jersey that will be used as an at-sea laboratory. Principle Power will install a wind farm with a capacity of up to 30 megawatts of electricity approximately 18 miles off the coast of Coos Bay, Oregon, using a domestically-developed semi-submersible floating foundation.

Considering the fact that 80% of U.S. electrical demand comes from coastal states, Jobenomics considers offshore wind a critical, but underdeveloped, element of the U.S. renewable energy portfolio. As such,

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[162] Cape Wind, http://www.capewind.org/faqs/cape-wind-basics
[163] Energy.gov, Offshore Wind Technology Development Projects, http://energy.gov/eere/wind/offshore-wind-technology-development-projects
[164] Energy.gov, Offshore Wind Advanced Technology Demonstration Projects, http://energy.gov/eere/wind/offshore-wind-advanced-technology-demonstration-projects

the United States should endeavor to accelerate research and development, mitigate market barriers, and pursue teaming agreements with leading international firms regarding offshore wind and other renewable ocean technologies.

Solar Energy Employment Outlook.

EIA forecasts that solar energy will **increase** its share in the United States renewable market mix from 1% in 2013 to 3% by 2030, and domestic consumption will **increase** from 0.08 quadrillion Btu in 2013 to 0.34 quads in 2030 for a net growth of 306%—the highest growth rate in any energy category[165].

The U.S. solar industry employment is growing at over 20% per year, or 20 times the national average job growth rate. In 2015, the solar industry is projected to add 36,000 new workers, representing a 21% growth rate. Over the last five years, solar employment has grown by 86%, adding over 80,000 new workers. According to The Solar Foundation (TSF)[166], the U.S. solar industry employed 173,807 in 2014. Of the 173,807 direct employees, 56% were involved with installation services, 19% with manufacturing, 12% with sales & distribution, 9% with project development and 4% other services.

From an international investment (and employment) point of view, the Renewable Energy Country Attractiveness Index[167] rates the top 40 countries that provide the most attractive overall investment environment. The top 10 countries for **solar photovoltaics** are: China, United States, Japan, Germany, India, Chile, Australia, France, South Africa and United Kingdom. The top 10 countries for **concentrated solar power** are: United States, Chile, China, South Africa, India, Australia, Morocco, Israel, Brazil and Spain.

EIA touts the fact that solar is second only to natural gas in electrical production. IEA reports that with the right policy-making, solar could become the world's largest source of electricity by 2050. Many publications[168] rate solar as the #1 thriving U.S. industry with an annualized growth rate of 70% between 2009 and 2014—faster than any other U.S. industry. Leading government analytical agencies agree. Bloomberg[169] reports that 4.6GW of solar PV was built in the United States in 2013 and 6.3GW in 2014 (27% growth), of which the majority was utility-grade. Bloomberg estimates solar PV build in 2015 at 8.5GW (26% growth) and in 2016 at 10.8GW (21% growth).

Even the U.S. federal government is involved in the solar craze. The U.S. Department of Interior's Bureau of Land Management (BLM) manages more than 19 million acres of public lands with excellent solar energy potential in six states: California, Nevada, Arizona, New Mexico, Colorado and Utah. Since

[165] EIA, AEO2015, Table 17, Renewable Energy Consumption by Sector and Source, http://www.eia.gov/forecasts/aeo/tables_ref.cfm

[166] The Solar Foundation, National Solar Jobs Census 2014, http://www.thesolarfoundation.org/press-release-solar-industry-creating-jobs-nearly-20-times-faster-than-overall-u-s-economy/

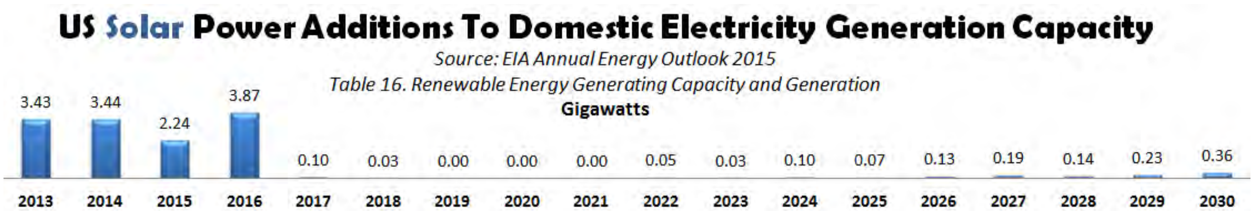
[167] EY, Renewable Energy Country Attractiveness Index (RECAI), March 2015, Page 14, http://www.ey.com/Publication/vwLUAssets/Renewable_Energy_Country_Attractiveness_Index_43/$FILE/RECAI%2043_March%202015.pdf

[168] 24/7 Wall St., Newsletter, The 10 Dying (and 10 Thriving) U.S. Industries, By Alexander Hess and Thomas Frohlich, 16 December 2014, http://247wallst.com/special-report/2014/12/16/the-10-dying-and-10-thriving-u-s-industries/2/

[169] Bloomberg New Energy Finance, H1 2015 North American PV Outlook: Wide-Open Throttle, 17 February 2015, http://about.bnef.com/landing-pages/h1-2015-north-american-pv-outlook-wide-open-throttle/

the Obama Administration took office in 2009, the BLM has approved 29 utility-grade solar energy projects with a total approved capacity of over 8.5GW. In addition, the BLM currently has some 70 pending solar energy applications. In 2015 and 2016, the BLM anticipates that 4.7GW of new capacity will come on line via solar energy plants located on federal land[170].

Despite all this good news, Jobenomics is not optimistic for the long-term health of the solar industry due to the fact that a 15-year depression is scheduled to hit the U.S. utility-grade solar market. Before the utility-grade U.S. market collapses, the U.S. solar industry needs to shift its emphasis from large-scale U.S. projects to small-scale distributed and dispersed generation domestic projects, and emerging international efforts and initiatives.



This chart[171] shows EIA projections for large utility-grade solar projects. According to the EIA, 2013 to 2016 will be good years, and, after 2016, not so good. From 2017 to 2030, solar is projected to add only 1.43GW, about one-third of that in 2016 alone. During the entire decade of the 2020s, only 0.9GW additional will be added, which will devastate the U.S. utility-grade solar power industry[172]. The Obama Administration and EPA's proposed Clean Power Plan would significantly increase solar power additions during this time period by accelerating the retirement of older coal and natural gas plants[173]. However, Jobenomics doubts that the Clean Power Plan will be enacted by Congress.

According to the EIA, annual capacity additions will drop significantly after 2016 and remain low through 2030. The primary reason for this depression is that existing electrical generation capacity is adequate to meet relatively slow demand growth in most regions and satisfy renewable requirements under state standards. Unless states dramatically change their renewable energy standards, as recently mandated by the Governor of California, large-scale wind energy projects will be at risk. EIA data indicates that fossil fuels (mainly natural gas) will capture 59% of capacity additions from 2015 to 2040. All renewables will capture 38%, with solar accounting for 16.7%[174] of the utility-grade market.

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[170] Department of Interior, Bureau of Land Management, Solar Energy & Renewable Energy Projects Approved Since the Beginning of Calendar Year 2009, http://www.blm.gov/wo/st/en/prog/energy/solar_energy.html, http://www.blm.gov/wo/st/en/prog/energy/renewable_energy/Renewable_Energy_Projects_Approved_to_Date.html

[171] EIA, Annual Energy Outlook 2015, Table 16, Renewable Energy Generating Capacity and Generation, http://www.eia.gov/forecasts/aeo/

[172] EIA, Annual Energy Outlook 2015, Table 16, http://www.eia.gov/forecasts/aeo/tables_ref.cfm

[173] EIA, Today in Energy, 5 June 2015, Proposed Clean Power Plan would accelerate renewable additions and coal plant retirements, http://www.eia.gov/todayinenergy/detail.cfm?id=21532&src=email

[174] EIA, Annual Energy Outlook 2015, Figure 35. Cumulative additions to electricity generation capacity by fuel in six cases, 2013-40 (gigawatts), Page 26, http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf & http://www.eia.gov/forecasts/aeo/section_elecgeneration.cfm

To make matters worse, in December 2016, the federal 30% Investment Tax Credit is scheduled to drop from 30% to 10% for commercial solar projects and from 30% to 0% for residential solar projects. According to a TFS survey[175], 62% of all U.S. solar companies expect to lay off employees or subcontractors once the federal ITC drop-down takes effect, causing another major challenge to the high-flying solar industry.

The Solar Energy Industries Association (SEIA) agrees in part with EIA's outlook. According to the 2014 SEIA/GTM Research U.S. Solar Market Insight™ report[176], 2014 was the best year ever (up 30%) for solar with 2015 projected to be even better (up 31%). Beyond 2015, SEIA states that the trajectory of solar industry growth will depend on (1) continuance of the residential solar boom that is being threatened by more than 20 ongoing proceedings regarding rate structures revisions, (2) revival of commercial solar that has slumped recently due to a variety of reasons, from tight economics to difficulty in financing small commercial installations, and (3) fruition of scheduled new 14GW utility-grade solar capacity in 2015/2016 and the fate of the solar industry after the 2017 ITC expiration.

According to SEIA, only slightly more than half (29) of all U.S. states have some type of renewable energy standard (RES), renewable portfolio standard (RPS), or renewable power goal in place[177]. Of these 29 states, 16 have solar mandates. DoE's NC Clean Energy Technology Center reports, as of Q4 2014, that 64 separate policy and regulatory activities related to distributed solar PV and rate design, are underway in 33 states and the District of Columbia[178]. 28 of the 64 are related to net metering policy, 18 are related to increases in fixed customer charges, and 10 involve states initiating or continuing studies into the value of distributed solar PV. The remainder involve solar-only fixed or demand charges and creation of utility-owned solar PV programs.

In addition to resolving these rate structure issues, for solar to keep up its spectacular growth it needs to (1), prioritize small-scale residential and commercial distributed and dispersed generation projects, (2) encourage temporary extensions to federal and state government incentive programs that step down at the end of 2016[179], (3) look to international opportunities, such as India's new renewable power initiative that funds a massive solar power expansion from a current installed capacity of 3.3GW today to 100GW by 2022[180,181], and (4) exploit revolutionary new solar mobile applications—all of which are addressed next.

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[175] The Solar Foundation, National Solar Jobs Census 2014, http://www.thesolarfoundation.org/factsheet-national-solar-jobs-census-2014/

[176] Solar Energy Industries Association (SEIA)/GTM Research, Solar Market Insight Report 2014 Q4, http://www.seia.org/research-resources/solar-market-insight-report-2014-q4

[177] SEIA, http://www.seia.org/policy/renewable-energy-deployment/renewable-energy-standards

[178] NC Clean Energy Technology Center, The 50 States of Solar, February 2015, http://nccleantech.ncsu.edu/wp-content/uploads/The-50-States-of-Solar_FINAL.pdf

[179] The federal Investment Tax Credit is scheduled to step down at the end of 2016 and many state subsidies are expiring in lieu of increased retail rates, tariffs, fee and net-metering schemes that will shift the renewable energy subsidy burden from government to consumers.

[180] Government of India, Budget 2015-16, http://pib.nic.in/budget2015/ecosurveyRel.aspx#

[181] India is also seeking $200 billion of U.S. investment in renewable power. U.S.-based SunEdison and First Solar plan to build more than 20GW of solar capacity in India by 2022.

From a Jobenomics perspective, there are essentially four major solar energy technologies: solar photovoltaic, concentrated solar power, solar thermal heating and cooling, and solar mobile (portable and transportable solar applications).

Solar Photovoltaic (PV) Employment Outlook. Solar photovoltaic (PV) devices use semiconducting materials to convert sunlight directly into electricity. Today's solar PV devices cannot store energy and are effective only when the sun shines.

There are currently two solar PV technologies in production: crystalline silicon and thin film. Almost 90% of the world's photovoltaics today are based on some variation of crystalline silicon. Crystalline solar panels are the most commonly used silicon for residential and small-scale applications. Crystalline panels are more expensive than thin film but are space-efficient and long-lasting. Thin-film solar cells are less expensive since they are mass produced, whereas crystalline panel production is more labor intensive. In comparison to crystalline silicon panels that are hard, opaque and heavy, thin-film technology is flexible, lightweight and translucent, which makes it ideal for customized applications.

A combination of solar photovoltaics and concentrating solar technologies may also be available soon. This technology is called concentrating photovoltaic (CPV) that operate at a much higher efficiency than either crystalline silicon or thin film. CPVs use optic technology to concentrate sunlight in order to gain as much as 50% more energy from the sun than the standard solar panel. Two other promising technologies are CIGS (Copper, Indium, Gallium and Selenide) and GaAs (Gallium-Arsenide) that also offer high efficiency. In addition, they have unique properties that can be incorporated in building materials and fabrics, including applications like solar-powered roadways. The first solar PV roadway is in R&D in the Netherlands[182].

Solar PV technology is evolving to the point that it can be embedded in roof shingles, or peel and stick thin-film solar cells, thereby allowing buildings and structures to be easily retrofitted without the cost of cumbersome mounting mechanisms. With net-metering, every building owner would constitute a micro-business that provides supplemental or emergency power to the grid as needed. Millions of renewable power micro-businesses would embody a "virtual grid" that could alleviate America's trillion-dollar national grid modernization headache.

There are essentially three types of solar PV generation systems: utility-grade, distributed generation and dispersed generation plants. Utility-scale solar PV systems utilize massive PV arrays (often thousands of ground-mounted solar panels) to generate electricity for the grid. American utility-grade solar PV power plants generated 12,303GWh in 2014, compared to 6,048GWh in 2013. 12,303GWh is enough to meet the electricity needs of 1,500,000 homes (out of approximately 130 million) and represents less than half of one-percent of America's electric generation. Distributed generation refers to electricity that is produced for local communities and large organizations. Distributed generation systems can either be connected to the grid or operate as stand-alone systems. Dispersed generation refers to electricity that is produced at the point-of-consumption. Dispersed generation systems are usually off-grid micro-systems that generate electricity from residential and small business rooftop or ground-mounted systems. Both distributed and dispersed generation systems can incorporate net-metering devices that allow excess energy to be sold to utility-grade enterprises. The total amount of

[182] SolaRoad, http://www.solaroad.nl/en/

distributed and dispersed electrical generation in the United States is unknown since EIA cannot account for off-grid production without some form of reporting, net-metering or smart building technology.

According to SEIA, there are 10,053 operational major solar PV projects with another 3,522 under construction and 25,741 under development in the United States[183]. 56% of these projects are located in California. Arizona, Nevada, North Carolina, Texas, Utah and Florida are also planning significant solar PV development efforts. The largest solar park in development is the 2.4GW Westlands Solar Park[184] that encompasses 24,000 acres (37.5 square miles) in California's western Fresno and Kings Counties. Westlands is slated to come online in 2015 with an initial capability of 0.2GW that will be expanded to 2.4GW by 2025.

Declining solar PV prices (down 80% since 2008 and 33% since 2011) are partly responsible for high growth rates. However, federal government subsidies (tax and investment credits, grants and guaranteed loans) provide the greatest incentive to continued growth. Many states also provide generous subsidies. For example, New York State offers credits equal to 25% of qualified solar energy system equipment expenditures, limited to $5,000[185]. Just as important, the installed price has dropped consistently over the last decade and is projected to become even more affordable.

According to a recent DoE Lawrence Berkeley National Laboratory report[186], residential installed solar PV prices have dropped "precipitously" over the last fifteen years from a high of $12/W to $4.70/W for systems ≤10kW, $4.30/W for systems 10-100kW in size and $3.90/W for systems >100kW. So, how much does a solar installation cost? According to a survey of 45,000 American homes in 2011[187], the average cost of installing solar PV in the United States was $17,056. The lowest state was Louisiana at $3,552 and the highest state was South Dakota at $38,428. Now in 2015, solar PV prices should be 33% lower. On the other hand, state subsidies may now be much higher. The bottom line is that rooftop solar is affordable with payback time averaging 11 years and lifetime cost savings of $20,800 according to the 2011 survey.

Over the last decade, the solar PV manufacturing industry experienced intense international competition that has caused numerous bankruptcies, and many job losses in the United States' manufacturing sector. The highly publicized Solyndra failure in 2011 is one such example that resulted in the loss of 1,900 jobs and caused a black-eye for the renewable energy industry. From 2007 to 2012, Western-made solar panel modules dropped from 43% to 14% of the world total with most of the manufacturing total being assumed by Asian companies (mainly Chinese that produced 64% of all solar PV modules in 2012). Many experts believe that U.S. solar PV manufacturing may experience a renaissance due to next generation solar PV technologies, automation and increasing foreign labor costs.

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[183] SEIA, Major Solar Projects in the United States: Operating, Under Construction, or Under Development, 23 February 2015, http://www.seia.org/research-resources/major-solar-projects-list
[184] Westlands Solar Park, http://www.westlandssolarpark.com/
[185] The New York Department of Taxation and Finance, Solar Energy System Equipment Credit, http://www.tax.ny.gov/pit/credits/solar_energy_system_equipment_credit.htm
[186] DoE, Lawrence Berkeley National Laboratory, Tracking the Sun VII, An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2013, September 2014, http://emp.lbl.gov/sites/all/files/lbnl-6858e.pdf
[187] Energy Analytics & Clean Power Research, U.S. homeowner solar estimate tool results, 2011, http://costofsolar.com/management/uploads/2013/06/How-Much-Does-Solar-Power-Cost.png

What the United States has lost in manufacturing, it more than gained in service industries that provide project management, business development, financing, leasing, installation and removal/roof repair[188] services. In many ways, it is more profitable to be in the solar service sector than the manufacturing sector since global manufacturing capability exceeds global demand.

The solar PV industry is the largest global renewable energy employer and fastest growing industry in the renewable energy sector. SolarCity (NASDAQ:SCTY), SunPower (NASDAQ:SPWR), Vivint Solar (NYSE:VSLR), and General Electric (NYSE: GE) are the four major U.S. solar PV service providers.

SolarCity is the U.S. market leader with 36% market share and 6,000 employees in 15 states—mainly in the West, Southwest and Texas (high sunshine states) and the Northeast (states that offer generous solar PV subsidies)[189]. SolarCity is teamed with Tesla to incorporate lithium ion battery packs with their solar PV systems, thereby moving solar PV closer to being a baseload energy source that can provide consistent energy regardless of weather and time of day. It is interesting to note that the Solyndra facility is reportedly[190] being leased by SolarCity to house a new R&D center and its Silevo division that is involved in panel manufacturing. SolarCity's ultimate goal is to be an energy service provider to virtually every American home and business.

Energy service companies, called ESCOs, specialize in monetizing gains in energy efficiency. ESCOs perform the role of consultants and project managers to integrate a project's design, finance, installation and operational functions. Using the value of projected savings, ESCOs can also sell energy to customers with little or no capital outlay via various arrangements, such as energy saving contracts that guarantee power savings; performance-based power purchase agreements that specify costs per kWh; installation and maintenance agreements that specify levels of service; and financing services that provide leasing, loans or direct purchase agreements. U.S. ESCO industry revenues grew from $2 billion in 2000, to $6 billion in 2013 and are projected to be as high as $15 billion by 2020[191]. Traditionally, most ESCO revenues come from government and large commercial contracts, but, lately, the small residential and business market segment is growing briskly.

The majority of U.S. homes are suitable for rooftop or ground mounted solar PV installations. Homeowners who live in condominiums or multi-family homes may not be suitable candidates. In addition, some buildings are not ideally suited for rooftop solar or have enough space for ground mounts. The ideal rooftop is one that has sufficient surface area on a sturdy, relatively new, unshaded and uncluttered roof that faces south, with a pitch angle of 30° to 45°. Flat roofs can incorporate an angled mount positioned to face the sun. For non-ideal rooftops, solar panels can still provide brilliant results.

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[188] Removal and replacement of solar panels can cost about $4,000-$6,000, an important consideration for aging or damaged roofs. Roofs and solar panels have approximately the same 20-25 year lifespan, therefore it is an important consideration that a new rooftop solar system be placed on a relatively new roof.
[189] SolarCity, http://www.solarcity.com/company/about
[190] Silicon Valley Business Journal, SolarCity leases former Solyndra facility to house Silevo panel division, 13 Feb 2015, http://www.bizjournals.com/sanjose/news/2015/02/13/solarcity-leases-former-solyndra-facility-to-house.html?page=all
[191] DoE, Berkeley Lab, September 2013, http://emp.lbl.gov/sites/all/files/lbnl-6300e-ppt.pdf

If rooftops are not viable, homeowners and renters can join the growing "community solar garden" or "shared solar" movement where grid-connected collectives share energy using "virtual net-metering."[192] A Boston-based startup called CloudSolar is offering a solution similar to community solar gardens, but the panels are located remotely on a distant farm or other piece of land. CloudSolar lets clients purchase a solar panel and share in the revenues (up to 80%) sold to local utilities[193].

Today, out of 150 million U.S. homes and businesses, 600,000[194] now have gone solar. This number of customers indicates that homeowners and business owners are open to solar. More importantly, this leaves 99.6% of U.S. homes and businesses still available for solarization—a virtually untouched market with lots of expansion room. If only 5% of America's 132,802,859 housing units[195] were solarized, Jobenomics estimates that approximately 2.5 million new jobs would be created. The math is relatively straight forward: 132,802,859 American homes x 5% = 6,640,143 residential installations x 7 days per installation = 46,481,001 man-days x 5 people per installation = 232,405,003 total man-days ÷ 365 days per year = 636,726 direct man-years (full time jobs). Assuming a typical 1:3 ratio for service businesses, 636,726 jobs would lead to an additional 1,910,000 indirect/induced jobs for a total of 2.5 million.

It is unlikely that solar PV installation will lend itself to do-it-yourselfers. However, the solar installation business requires only modest technical skills and capital investment, which makes solar PV installation an ideal startup business opportunity. According the SEIA, all the major solar companies are scrambling to hire local solar installation and maintenance subcontractors.

With proper government and private sector support, new solar installation businesses could be mass-produced across the nation. A mass-produced small business initiative could have huge consequences beyond job creation. It would provide incentive and hope for the shrinking middle-class and struggling inner-city denizens. It would also serve as a model for mass-producing other fledging small business initiatives.

Jobenomics predicts that the solar PV industry will continue to grow at a rate between 10% and 20%—even with the impending reduction in utility-grade generation business opportunities. Jobenomics endorses the SolarCity plan for dispersed solar PV generation systems for every U.S. home and small business—as long as this includes planned obsolescence as part of the strategy. No one wants a long-term solar PV system or contract if something better is introduced to render older models obsolete before the end of their warranted lifespan.

Concentrating Solar Power Employment Outlook. Concentrating solar power (CSP) directs heat from the sun via mirrors to a collector reaching temperatures of 750°F or higher, to drive traditional steam turbines or engines that create electricity. CSP is ideal for large scale operations that can collect and store heat, which allows for dispatchability of solar electricity.

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[192] Solar Gardens Institute, Solar Gardens Community Power, http://www.solargardens.org
[193] TechCrunch, CloudSolar Helps Renewable Energy Fans Who Can't Install Their Own Solar Panels, 28 March 2015, http://techcrunch.com/2015/03/26/cloudsolar/
[194] Solar Energy Industry Association, Solar Energy Facts: Q3 2014, http://www.seia.org/sites/default/files/Q3%202014%20SMI%20Fact%20Sheet.pdf
[195] U.S. Census Bureau, Quick Facts, Housing Units 2013, http://quickfacts.census.gov/qfd/states/00000.html

According to the National Renewable Energy Laboratory[196], 19 countries have CSP projects that are operational, under construction or under development. In the United States, California has 8 projects, followed by Nevada and Arizona with three each, and Colorado, Florida, Hawaii and Utah with one each.

There are four general CSP technologies: Parabolic Trough Systems (line-focus systems using curved mirrors to focus sunlight on a receiver), Linear Fresnel Reflector Systems (line-focus systems using flat mirrors to focus sunlight on a receiver), Power Tower Systems (point-focus systems using heliostats to focus sunlight on a tower-mounted receiver) and Dish/Engine Systems (point-focus systems using curved mirrors to focus sunlight on a receiver).

Spain and Australia are the leading countries in concentrating solar power production, with the United States gaining with several large CSP power plants that came online in 2013/2014. Three more U.S. large plants are scheduled to come online in 2015/2016. All five plants received substantial loans from the Department of Energy's Loan Guarantee Program. Arizona's $2 billion Solana project received $1.45 billion and California's $2.2 billion Ivanpah project received $1.45 billion worth of government loan guarantees, which nervous investors are now trying to convert to government grants.

The Solana (280MW) and Ivanpah (392MW) plants are much larger than the small (10MW) U.S. concentrating solar power demonstration plants that entered service as far back as 1985, or Spain's largest plant (20MW). Solana uses parabolic mirrored troughs to collect sunlight and a molten salt thermal storage system that allows six hours of operations on stored energy. Operational in 2013, Solana generates enough power to supply 70,000 homes in Phoenix, Arizona, under a 30-year power purchase agreement with the Arizona Public Service utility. Ivanpah uses a field of movable mirrors (heliostats) focusing light on three 459-foot central towers. Operational in 2014, Ivanpah is the largest solar thermal power tower system in the world operating under a 25-year power purchase agreement. Ivanpah does not have a thermal storage capability. Each plant is estimated to reduce CO_2 emissions by more than 400,000 tons annually.

Ivanpah, the world's largest CSP plant, employed 2,600 people at the peak of construction and now supports 65 permanent jobs[197]. Consequently, the CSP industry should not be viewed as a large jobs producer, but an industry that will mature over time.

Solar Thermal Heating and Cooling Employment Outlook. Solar heating & cooling (SHC) technologies collect the thermal energy from the sun to provide hot water, space heating and cooling to homes and small businesses. It is also used extensively to heat swimming pools.

Solar thermal uses roof-mounted solar collectors to heat cold water and transport the heated water back to the hot water tank. An automatic control system enables conventional water heaters to provide supplemental hot water as needed. Solar energy can also be used to generate cool air. There are two kinds of solar cooling systems: desiccant systems and absorption chiller systems that use a process similar to a refrigerator without a compressor. Worldwide, around 75% of all solar thermal systems installed are thermosiphon systems and 25% are pumped solar heating systems. Despite the lofty term, thermosiphon systems are basic systems that use a solar collector to heat water that, via

[196] National Renewable Energy Laboratory, Concentrating Solar Power Projects, http://www.nrel.gov/csp/solarpaces/
[197] BrightSource Energy, Ivanpah Project Facts, http://www.brightsourceenergy.com

natural convection, passively circulates to the hot water tank. In pumped solar heating, a circulating pump moves the heat transfer fluid between the tank and the collector.

According to the Solar Energy Industry Association[198], more than 30,000 solar heating and cooling systems (SHC) are being installed annually in the United States, employing more than 5,000 Americans. The Solar Energy Industry Association SHC Roadmap predicts 50,000 U.S. SHC jobs by 2050, which represents a growth rate of approximately 7% per year. Using these calculations and 1:3 direct to indirect/induced labor ratio, by 2020, the SHC industry should have 7,000 direct and 21,000 indirect/induced jobs for a total of 27,000 jobs.

Also according to SEIA, residential solar water heating systems typically are $6,000 to $10,000, while commercial and industrial systems range from $20,000 to $1,000,000. Depending on application, location, and financial incentives, the payback period can be as little as 4 to 8 years. Over 9 million residential water heaters are replaced annually, creating an excellent opportunity to incorporate solar water heating at a low incremental cost. Roughly 80% of the existing SHC market volume is in the small residential sector.

From an international SHC perspective, the IEA Solar Heating and Cooling Programme Report states that 78 million SHC were operational worldwide in 2012, with 78% being used for domestic hot water preparation in single-family houses[199]. China and Europe accounted for 83% of total worldwide installed capacity and 92% of the new SHC collector installations in 2012. The top country for installed capacity in 2012 was China with 180GW, compared to 16GW in the United States. The IEA report estimated total capacity of solar thermal collectors in operation worldwide by the end of 2013 to be 330GW installed capacity, which is higher than wind power at 318GW, solar PV at 138GW, geothermal at 12GW and ocean tidal power at 11GW. Worldwide, the number of jobs in the fields of production, installation and maintenance of SHC systems is estimated at 460,000.

From a Jobenomics perspective, SHC is an underserved American renewable energy market that has significant economic and employment potential. An integrated solar HC/PV/storage system with net-metering would have significant appeal to both the United States and the international marketplace.

Solar Mobile Employment Outlook. Solar mobile is a phrase that Jobenomics uses for portable and transportable solar applications that have the potential to create new industries, thousands of new businesses and millions of new jobs.

In 2012, the solar powered boat Planet Solar was the first boat to sail around the world powered only by solar panels. As such, solar maritime has the potential to revolutionize

198 Solar Energy Industry Association, Solar Heating & Cooling: Energy for a Secure Future, 2013, http://www.seia.org/sites/default/files/resources/SEIA%20SHC%20Roadmap-Final-9.30.pdf

199 Solar Heating and Cooling Programme (SHC) of the International Energy Agency (IEA), Solar Heat Worldwide 2012, published June 2014, http://www.iea-shc.org/data/sites/1/publications/Solar-Heat-Worldwide-2014.pdf

the $122 billion/year U.S. recreational boating industry that employs 338,000 jobs in 35,000 businesses[200].

Realizing the potential of the solar-powered unmanned aerial systems market (UAS), Google recently added Titan Aerospace's solar-powered Solara UAS into Google's product mix. Solara will theoretically fly for up to five years without needing to land, cruising more than 12 miles high[201]. Solara is intended to fill in the gaps of Google's Project Loon's constellation of solar-powered unmanned balloon-satellites that will travel on the edge of space delivering Internet service to the two-thirds of the world's population does not yet have access[202].

Not to be outdone by Google, Facebook started Internet.org[203] to bring together technology leaders, nonprofits and local communities to connect the parts of the world that doesn't have internet access. In March 2015, Facebook performed the maiden flight of its long-range experimental V-shaped solar-powered UAS, codenamed Aquila. Aquila has the wingspan of a Boeing 767, but weighs less than a small car, and can stay aloft for three months at a time. 1,000 Aquila drones will use high-speed data lasers to reach 5 billion internet users, including those in the world's most remote regions.

Other countries are also pursuing long-range, solar-powered UAS. A Swiss long-range experimental solar-powered aircraft named Solar Impulse 2 began it's around the world flight on 9 March 2015 from Abu Dhabi, UAE. The Abu Dhabi government's clean-energy company is a key sponsor of the flight, which purpose includes making the world "confront the Conference on Climate Change of the United Nations, which will define the new Kyoto protocol in December 2015 in Paris.[204]"

Solar Impulse 2 is a 5,070 pound, single seat aircraft with a wingspan larger than a Boeing 747. The best speed for this solar-powered aircraft is 28 mph and it will take 25 flight days to accomplish its mission with multiple stops along the route. 17,000 solar cells built into the wing provide power to four electrical motors and lithium batteries that will power the aircraft at night. The plane will reach an altitude of around 28,000 feet during daylight and dip at night to around 5,000 feet when flying over the Pacific and Atlantic oceans, which will take 5 days and nights each for the solo pilot.

Solara, Aquila and Solar Impulse will provide valuable information to the rapidly growing unmanned aircraft system (UAS) market that is projected to add 103,000 jobs over the next decade[205].

Solar cars have been in development for years and are getting ready for prime-time. 120,000 electrical vehicles (EVs) were sold in the United States in 2014, a 23% increase from 2013, and a 128% jump from 2012[206]. While a totally solar powered EV is not likely in the near-term, solar technology can contribute

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[200] National Marine Manufacturers Association, NMMA releases new U.S. economic impact report at American Boating Congress, 8-9 May 2013, http://www.nmma.org/article.aspx?id=18350
[201] SlashGear, http://www.slashgear.com/titan-aerospace-these-are-the-drones-google-just-bought-14325163/
[202] Google, Project Loon, http://www.google.com/loon/
[203] Internet.org by Facebook, http://internet.org/about
[204] SolarImpulse, http://www.solarimpulse.com/
[205] AUSI, The Economic Impact of Unmanned Aircraft Systems Integration in the United States, March 2013, https://higherlogicdownload.s3.amazonaws.com/AUVSI/958c920a-7f9b-4ad2-9807-f9a4e95d1ef1/UploadedImages/New_Economic%20Report%202013%20Full.pdf
[206] Inside EVs, Monthly Plug-In Sales Scoreboard, http://insideevs.com/monthly-plug-in-sales-scorecard/

to extending the range of an EV, thereby relieving some customer range anxiety and making EVs more marketable.

The final category of mobile solar is solar-powered consumer products ranging from modules, to battery packs, to solar powered outer wear. Portable solar modules are typically compact, lightweight, flexible or foldable, rugged and highly efficient. Tommy Hilfiger's $400 solar-powered jacket[207] (shown) features a removable solar pack that charges a battery to keep mobile devices working while on the go. Researchers are working on nanotechnology (nano-electronics, nano-coatings, nano-composites, nano-fluids, nano-catalysts, nanocarbons and nano-electrodes) to increase solar efficiencies and to reduce size. Researchers are also working on wireless electricity[208] that could soon be as common as Wi-Fi. Wireless energy coupled with stationary or transportable solar power could power wireless buildings or charge portable wireless devices without the need for chargers, charging stations or batteries.

As stated previously, 1st generation silicon solar panels and 2nd generation thin film solar are restricted by the Shockley-Queisser limit of 34% power efficiency, whereas 3rd generation multi-layer solar cells may be able to approach efficiencies near 86%. 86% solar efficiencies combined with micro- and nanotechnologies could provide an endless stream of new consumer electronics, transportation, medical, military and residential/commercial applications—and jobs.

Geothermal Employment Outlook.

EIA forecasts that geothermal energy will **increase** its share in the United States' renewable market mix in the electric power generation sector from 2% in 2013 to 5% by 2030 (the same percentages as the highly touted solar), and domestic consumption will **increase** from 0.16 quadrillion Btu in 2013 to 0.50 quads in 2030 for a net growth of 212% [209]. Off-grid geothermal is not included in these figures.

According to the Geothermal Energy Association (GEA)[210], the total number of jobs supported by the geothermal industry in 2010 was 13,100 direct, indirect, and induced employees. According to a report by the Western Governors Association (WGA)[211], development of near-term geothermal potential of 5.6GW of geothermal energy could result in 23,949 direct jobs and 75,000 total indirect and induced jobs. In addition, 90,000 construction and manufacturing jobs could be created. Since the WGA report, U.S. geothermal power grew from 2.9GW to 3.5GW in 2014 with an additional 1.25GW of geothermal under development[212].

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[207] Tommy Hilfiger, Solar Power Jacket, http://usa.tommy.com/shop/en/thb2cus/7655931
[208] WiTricity, http://witricity.com/technology/the-witricity-story/ and CNN Video, http://www.cnn.com/2014/03/14/tech/innovation/wireless-electricity/
[209] EIA, AEO2015, Table 17, Renewable Energy Consumption by Sector and Source, http://www.eia.gov/forecasts/aeo/tables_ref.cfm
[210] Geothermal Energy Association (GEA), Green Jobs Through Geothermal Energy, October 2010, Page 6, http://www.geo-energy.org/pdf/reports/GreenJobs_Through_Geothermal_Energy_Final_Oct2010.pdf
[211] Geothermal Energy Association, How many jobs will be supported by the geothermal industry in the future? http://geo-energy.org/geo_basics_employement.aspx
[212] Geothermal Energy Association (GEA), Annual U.S. & Global Geothermal Power Production Report (February 2015), Page 12, http://geo-energy.org/reports.aspx

While initial capital costs are high, overall life-cycle costs are significantly lower than many competing technologies. Geothermal plants have no fuel costs, and minimal maintenance or ancillary costs. Once a plant is operating it can generate electricity for 30 years or longer—24/7/365.

From an international investment (and employment) point of view, the Renewable Energy Country Attractiveness Index[213] rates the top 40 countries that provide the most attractive overall investment environment. The top 10 countries for **geothermal energy** are United States, Indonesia, Japan, Kenya, Philippines, Turkey, Italy, Germany, Mexico and Chile.

Geothermal (geo=earth + thermal=heat) energy derives its clean and sustainable power from the heat of the earth. Geothermal energy is brought to the surface by extracting hot water that is circulating around subsurface hot rocks, or by pumping cold water into the hot rocks and returning the heated water to the surface, to drive steam turbines to produce electricity, or used directly for heating and cooling. Low- to moderate-temperature geothermal reservoirs (68°F to 302°F) provide direct heat for residential, industrial and commercial uses. Today, U.S. geothermal plants are located only in western states where surface (hot springs) or subsurface geothermal activity is readily accessible. Many of the best locations for geothermal are found in the Pacific's "ring of fire," an active volcanic area with hot magma close to the earth's surface.

Deep underground geothermal power is now being developed using enhanced geothermal systems (EGS). EGS are engineered underground reservoirs created to produce energy from geothermal resources that are otherwise not economical due to lack of water and/or permeability[214]. The EGS process is relatively straightforward. Two deep wells (up to 5 miles deep) are drilled to access extremely hot underground rock formations. The rock formations are hydraulically fractured to enhance water flow between the wells. Once complete, water is pumped down the injection well, circulated through the extremely hot fractured rocks, and drawn up the production well to the earth's surface. Heat exchangers extract heat from the water and turbines generate electricity and heat.

EGS offers the prospect of geothermal energy across the entire United States and a potential 40-fold increase over current U.S. geothermal power generating capacity. Geothermal plants have much smaller footprints than wind and solar, which is a useful attribute when power density (the amount of power that can be generated in a given area) is an issue. When EGS becomes a reality, large geothermal plants could be potentially located in downtown areas of major metropolitan areas.

The international geothermal power market is growing steadily at a sustained rate of 4 to 5%. As of the end of 2013[215], worldwide geothermal power plant capacity was 12GW of installed (nameplate) capacity, 12GW of planned capacity, and 30GW capacity under development. The United States' portion of the global total is 3,442MW installed, 978MW planned and 3,100MW under development, which equates to 29%, 8% and 10% of the world's total, respectively. At 3,442MW, the United States is the world's largest producer of geothermal power, followed by the Philippines with 1,904MW, Indonesia

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[213] EY, Renewable Energy Country Attractiveness Index, March 2015, http://www.ey.com/Publication/vwLUAssets/Renewable_Energy_Country_Attractiveness_Index_43/$FILE/RECAI%2043_March%202015.pdf

[214] Energy.gov, Enhanced Geothermal Systems, http://energy.gov/eere/geothermal/enhanced-geothermal-systems-0

[215] Ibid 147

with 1,333MW and Mexico with 1,005MW. Within the next decade, the Philippines or Indonesia could tie the United States in nameplate geothermal capacity. Iceland's geothermal power plants not only generate 30% of the nation's electricity but also provide nearly 90% of heating needs.

Geothermal power generation is produced in the western United States, Alaska and Hawaii. According to the DoE[216], California is the leading state with current installed capacity of 2,711MW and planned capacity of 607MW, followed by Nevada (current 566MW, planned 176MW), Utah (73MW/20MW), Hawaii (38MW/0MW), Oregon (33MW/61MW), Idaho (16MW/63MW), New Mexico (4MW/0MW), Alaska (0.73MW/25MW), Colorado (0MW/20MW), Arizona (0MW/5MW), North Dakota (0MW/0.82MW), and Montana (TBD).

Almost 700 geothermal projects are under development in 76 countries. The United States has the largest number of planned projects at 124. New initiatives in the western United States promise substantial increases in geothermal power over the next decade. California's Imperial Irrigation District announced plans to promote development of up to 1,700MW of new geothermal generation as part of Salton Sea Restoration and Renewable Energy Initiative[217] that will double U.S. nameplate geothermal capacity. Not only will this geothermal energy provide enough electricity to power more than one million homes, it can be produced with minimal impact on landscape and habitat. The Salton Sea project is also significant as a potential source of precious metal extraction including lithium, zinc and manganese. Lithium is used in batteries that are crucial to the emerging electric vehicle industry.

The future of American geothermal development is unclear. According to GEA's 2015 Power Production Report, since 2005, the United States built over 38 geothermal power projects adding 700MW capacity. However, this positive trend may stall due to limited demand for new power, Congressional uncertainty about the federal investment and production tax credits, and "unbalanced mechanisms for valuing baseload power and integration costs in California." California comprises 855MW, or 67%, of the total planned U.S. geothermal capability additions of 1,275MW.

While the GEA is pleased about California Governor Brown's new 50% renewable goal, geothermal can only be competitive if California decision-makers "will add the appropriate costs to intermittent power sources due to their variable deliverability, so baseload renewables like geothermal and biomass power can compete for PPAs with Investor Owned Utilities on a more accurate comparison of the full cost for power." In other words, solar and wind power are given an unfair competitive advantage using current LCOE methodology. Baseload renewables are power plants that can generate dependable (24/7) power to consistently meet demand regardless of weather conditions.

The future of international geothermal is much clearer. In 2014, 21 new geothermal power plants came on line with over 600MW of new capability for a total of 12.8GW in January 2015. By 2020, the global community could add as much as 4.8GW of additional geothermal capability, a five-year increase of 38%. On the other hand, compared to other renewable resources such as solar and wind, identifying new geothermal resources requires expensive geological analysis, upfront drilling and higher levels of uncertainty. Consequently, many nations are defaulting to intermittent sources of renewable power that do not require as much speculation.

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[216] DoE, National Renewable Energy Laboratory, Geothermal Maps, http://www.nrel.gov/gis/geothermal.html
[217] Imperial Irrigation District, Salton Sea Restoration and Renewable Energy Initiative, http://www.iid.com/index.aspx?page=663

Geothermal Heat Pumps (GHPs), also known as ground source heat pumps, ground source heat exchangers or GeoExhange, are off-grid geothermal sources typically used in residential and commercial applications. Being off-grid, GHPs are not included in many projections and are often overlooked from a policy perspective.

Geothermal heat pumps have been in use since the late 1940s. There are approximately 50,000 being installed each year for heating and cooling throughout the United States in residential, commercial and government buildings[218].

Like air-source heat pumps that capture heat from outdoor air, ground source heat pumps are electrically powered systems that use relatively constant 50° to 60°F temperatures just below the earth's surface to provide heating, cooling and hot water. Ground source heat pumps can be closed or open loop systems installed in horizontal trenches, vertical boreholes or submerged in water. Closed loop systems circulate water or antifreeze to collect ground heat in winter and reverse to pull heat from buildings for cooling. Open loop systems often pump water from underground aquifers across heat exchangers and recycle the water back into the aquifer.

GHPs cost more than traditional heating and cooling systems but are less expensive to operate. These systems are popular in the green-building movement. Net-zero homes and other forms of high efficiency sustainable building practices are becoming mainstream concepts for new eco-friendly communities. A recent McGraw Hill Construction study[219] finds that 73% of single-family homebuilders say consumers will pay more for green homes. By 2016, the study forecasts green single-family homes alone will represent 26% to 33% of the housing market, translating to a $100 billion opportunity. In 2013, two-thirds of all single-family and multifamily builders and developers offered renewables, with solar photovoltaic and ground source heat exchangers being the most widely-used technologies.

Through December 31, 2016, homeowners who install ENERGY STAR certified geothermal heat pumps are eligible for a 30% federal tax credit[220]. In addition, a number of states (CT, DE, IA, ID, IN, MD, MO, MT, ND, NM, OK, PA[221]) have supplemental credits and energy efficiency mortgage programs.

From an employment outlook, GHPs compete with conventional systems installed by HVAC contractors. Consequently, employment growth in GHPs would be offset by reductions in competing systems. From an environmental aspect, a typical 3-ton residential GHP system produces an average of about one pound less CO_2 per hour of use than a conventional system, which is a significant environmental savings.

Municipal Waste Employment Outlook.

EIA forecasts that energy made from municipal waste will **decrease** its share in the U.S. renewable market mix in the electric power generation sector from 5% in 2013 to 4% by 2030, and domestic consumption will **increase** from 0.42 quadrillion Btu in 2013 to 0.46 quads in 2030[222].

[218] Energy.gov, Geothermal Heat Pumps, http://energy.gov/energysaver/articles/geothermal-heat-pumps
[219] McGraw Hill Construction's Dodge Construction Market Forecast, Green Multifamily and Single Family Homes SmartMarket Report (2014), http://analyticsstore.construction.com/2014GreenHomesSMR?sourcekey=PRESREL
[220] ENERGY Star, http://www.energystar.gov/products/certified-products/detail/heat-pumps-geothermal
[221] DoE, DSIRE, http://www.dsireusa.org/

Jobenomics disagrees with EIA's municipal waste, more commonly known as municipal solid waste (MSW), outlook and believes that MSW-related projects have huge economic and employment potential beyond electrical power generation, which is the focus of EIA's 2015 Outlook report.

While there are no new major U.S. waste-to-energy plants on the horizon, there is a burgeoning industry of small and deployable waste-to-energy plants that will operate largely off-grid, and material recovery facilities (MRFs) that will make major contributions to energy conversation as well as avoidance of GHG production associated with traditional mining of virgin materials and metals. MRFs are generally associated with single-stream recycling of cans, paper, glass and plastics. Advanced technology MRFs reclaim high-value metals from electronic waste and other valuable waste streams, like tires.

MSW waste-to-energy and material recovery facilities are able to do as much for energy conservation[223] and mitigating GHG emissions as any other renewable technology. The following reports validate this assertion:

- According to the EPA[224], material recovery (recycling) is an enormous energy saver. For example, recycling aluminum cans saves 95% of the energy required to make the same can from its virgin source bauxite. By recycling just 1 ton of aluminum cans, Americans conserve more than 207 million Btu, the equivalent of 1,665 gallons of gasoline. Recycling of other materials produces similar energy savings: copper 90%, plastics 87% and steel 68%. Recycling of steel conserves 2,500 pounds of iron ore, 1,400 pounds of coal and 120 pounds of limestone[225]. From an economic savings perspective, why spend ten-years on permitting and $1 billion dollars digging for bauxite, copper or iron, when modern MRFs can reclaim raw materials from discarded or obsolete manufactured products at a fraction of the cost?

- According to the EPA[226], Americans recycled and composted almost 87 million tons of MSW (out of 251 million tons, or 35%) in 2012, which saved more than 1.1 quadrillion Btu of energy—the amount of energy consumed by 10 million households in a year or the annual GHG emissions for 33 million cars.

- The Natural Resources Defense Council[227], a U.S. environmental action group with 1.4 million members, calculates that if the recycling rate were increased from 33% today to 75% by 2030, 515 million tons of CO_2 would be saved—equal to closing 72 coal power plants or taking 50 million cars off the road.

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222 EIA, AEO2015, Table 17, Renewable Energy Consumption by Sector and Source, http://www.eia.gov/forecasts/aeo/tables_ref.cfm

223 Energy conservation refers to any behavior resulting in not using energy, while energy efficiency is a technological approach to using less energy—both are needed to satisfy global energy demand and reduction of GHG emissions.

224 EPA, How does recycling save energy?, http://waste.supportportal.com/link/portal/23002/23023/Article/17257/How-does-recycling-save-energy

225 Institute of Scrap Recycling Industries, Inc. (ISRI), About the Scrap Recycling Industry, http://www.isri.org/docs/default-source/recycling-industry/fact-sheet---recycling.pdf?sfvrsn=10

226 EPA, Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2012, Page 4, http://www.epa.gov/solidwaste/nonhaz/municipal/pubs/2012_msw_fs.pdf

227 Natural Resources Defense Council, More Jobs, Less Pollution: Growing the Recycling Economy in the United States, Key Findings, Page 1, http://docs.nrdc.org/globalwarming/files/glo_11111401a.pdf

Since recycling is such an enormous energy saver, why don't American policy-makers place more emphasis on this energy-producing, energy-conserving and jobs-creating sector? Perhaps the reason is that most policy-makers view MSW as garbage that needs to be eliminated, rather than a commodity that needs to be monetized. Another possible reason is that policy-makers generally do not perceive MSW disposal as an important element of the U.S. energy ecosystem. The final possible reason is that few policy-makers see the economic and employment potential that Jobenomics sees in exploiting the latent value of municipal waste commodities. By converting MSW to energy or reclaiming raw materials (as is done in Europe) millions of new middle-class jobs and small businesses could be created.

The waste management and remediation services category (NAICS 562) includes solid waste collection; hazardous waste collection; other waste collection; hazardous waste treatment and disposal; solid waste landfill; solid waste combustors and incinerators; other nonhazardous waste treatment and disposal; remediation services; materials recovery facilities; and all other waste management services. In regard to employment potential, the National Waste & Recycling Association[228] reports that U.S. employment in the municipal waste and recycling industry reached an all-time high of 383,300 in 2014. The Natural Resources Defense Council calculates that an additional 2.3 million new American jobs could be created if the United States could achieve a 75% recycling rate for municipal solid waste and for construction and demolition (C&D) debris[229].

Waste-to-Energy (WtE). Jobenomics is working with several waste-to-energy (WtE) companies to monetize waste streams by converting MSW and C&D material to electrical power.

MSW and C&D waste streams contain combustible and non-combustible materials. Combustibles are those items that have sufficient caloric value (Btu) that can be converted to electrical power via waste-to-energy systems. If insufficient, additional Btu can be added by the injection of petroleum-based fuels, tires or plastics, all of which have high Btu content.

Americans generate approximately 251 million tons of MSW per year (2012 data). MSW, often called household trash, is used to produce energy at waste-to-energy plants using organic materials like paper, cardboard, food waste, grass clippings, leaves, mulch, wood and other non-biomass combustible materials like plastics and rubber. According to the EIA[230], 86 WtE-related plants (including refuse derived fuel and mass burn plants) employ around 7,000 workers who process about 30 million tons of MSW, or 12% of the total amount of MSW. In the United States, most WtE facilities range from 500 to 3,000 tons per day.

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[228] National Waste & Recycling Association, National Waste, Recycling Industry Saw Nine Monthly Employment Gains in 2014, https://wasterecycling.org/blog/national-waste-recycling-industry-saw-nine-monthly-employment-gains-in-2014/

[229] Natural Resources Defense Council, More Jobs, Less Pollution: Growing the Recycling Economy in the United States, Key Findings, Page 1, http://docs.nrdc.org/globalwarming/files/glo_11111401a.pdf

[230] EIA, Waste-to-Energy (Municipal Solid Waste), http://www.eia.gov/EnergyExplained/?page=biomass_waste_to_energy

According to Bloomberg New Energy Finance[231], no new asset financing (investment) is projected for major WtE plants in the near future. Construction and commissioning for a WtE plant typically takes up to four years after financing has been secured. A typical WtE plant costs approximately $200+ million to build. 2012 was the last year that a substantial amount of financing ($275M) was raised for a new American WtE plant, largely due the expiration of the Production Tax Credit. Selling MSW to landfills (average $37 per ton) is often a much cheaper option than building a WtE plant. However, cost is not the only factor.

Compared to a typical landfill[232], a WtE plant is more environmentally-friendly for a number of reasons. First, for every megawatt of electricity generated by a WtE plant, a megawatt from a fossil fuel plant is avoided, creating a net GHG emission savings. Second, WtE plants separate non-combustible materials that are recycled, which is more environmentally-friendly than mining virgin materials. Third, WtE plants burn methane-producing compounds, as opposed to landfills that are the third largest producers of human-made methane, accounting for 18% of total CH_4 emissions in 2013, following animal enteric fermentation that accounted for 25.9% and natural gas production and distribution that accounted for 24.7% [233]. Using the EPA's Decision Support Tool, a 1,500 ton per day WtE plant in Saugus, Massachusetts, determined that it avoided approximately 270,000 tons of CO_2 equivalents per year compared to landfilling[234]. Finally, WtE plants reduce the need for landfills—many of which are reaching capacity. Over the last three decades, the number of U.S. landfills dropped by 75% to fewer than 2,000 today, with new landfills being increasingly harder to open due to NIMBY (Not-In-My-Back-Yard) and more stringent EPA regulations.

To deal with the limited landfill issue, policy-makers have turned to recycling and composting to reduce the volume of MSW headed for landfills. Since recycling and composting account for only 87 million tons (65.3 tons for recycling and 21.3 tons for composing) out of 250.9 million tons of MSW, 163.9 million tons remains available for disposition. Of the 163.9 tons, 29.3 are combusted with energy recovery[235] leaving 135 million tons, or 54% of the original total, for landfilling[236].

Compared to the United States, many countries in Europe (Germany, the Netherlands, Sweden, Belgium, Austria and Denmark) have largely banned the practice of landfilling. These European policy-makers mandate that MSW has to be processed rather than landfilled. If U.S. policy-makers included MSW in mandated national and state renewable energy standards, this underappreciated and often overlooked major GHG contributor would not be as much a threat to climate change as it is today.

[231] Bloomberg New Energy Finance, 2015 Factbook Sustainable Energy in America, Page 63, February 2015, http://www.bcse.org/images/2015%20Sustainable%20Energy%20in%20America%20Factbook.pdf
[232] Note: Landfills are usually zoned for MSW, C&D or inert (earth and earth-like) waste.
[233] EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013, 15 April 2015, Page ES-13, http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Main-Text.pdf
[234] Energy Recovery Council, Waste-to-Energy Reduces Greenhouse Gas Emissions, http://energyrecoverycouncil.org/waste-energy-reduces-greenhouse-gas-emissions-a2966
[235] Includes combustion of MSW in mass burn or refuse-derived fuel form, and combustion with energy recovery of source separated materials in MSW (e.g., wood pallets, tire-derived fuel).
[236] EPA, Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2012; Page 9, retrieved 14 March 2015, http://www.epa.gov/osw/nonhaz/municipal/pubs/2012_msw_fs.pdf

The EPA considers MSW as a renewable energy source[237]. MSW not only renews itself each year, but is exploding worldwide. The globe is not prepared to handle the environmental challenges caused by MSW's toxic emissions into the atmosphere, ground and waterways. According to The World Bank[238], a decade ago, 2.9 billion people generated 0.64 kg of MSW per person per day for a total of 0.68 billion tons per year. Today, 3 billion people generate 1.2 kg/capita/day for a total of 1.3 billion tons per year (an increase of 91%). By 2025, 4.3 billion people are expected to generate 1.42 kg of MSW for a total of 2.2 billion tons per year (an additional increase of 69%). Globally, solid waste management costs will increase from today's annual $205.4 billion to about $375.5 billion in 2025 (an increase of 83%). Cost increases will be even more severe in low income countries that will suffer increases of over 500%. As a result of this exponential growth, ETR solutions are essential to manage environmental challenges posed by this evergrowing renewable waste steam.

If the United States mandated MSW, virtually every community in the United States would have a WtE, a single-stream recycling MRF and an advanced technology MRF for high-value waste streams. Every community would have these systems because reliable sources of MSW organic and non-organic feedstock would be made available to sustain highly-profitable WtE and MRF operations that would attract tens of billions of dollars of private sector investment[239].

Raw MSW and C&D waste streams are not ideal for WtE operations until the non-combustible, non-organic (metals, glass, rocks, etc.) fractions are removed. Today, pre-processing systems are available to sort large quantities of raw MSW and C&D. Once the combustible material is segregated, the organic material is shredded and blended to produce a consistent material for burning in WtE plants and Refuse-Derived Fuel (RDF) systems. RDF is often used in cement kilns, coal-fired power plants and industrial facilities.

There are four types of WtE technologies: incineration, pyrolysis, plasma and gasification.

- **Incineration** (mass burn) has been used for centuries and is still the most common technology used to dispose of MSW and generate electricity. Incineration is generally considered to be the dirtiest technology, but modern incineration plants are much cleaner.

- **Pyrolysis** plants combust waste material in an oxygen-free environment to produce carbon black, a material used in paints and toner cartridges, oil/tar and synthetic gas (syngas). Pyrolysis is becoming an increasingly popular technology, but produces lots of ash and is often expensive.

- **Plasma**, which is essentially lightning in a bottle, is the most modern technology, but is yet unproven for wide-scale deployment. Due to plasma's ultra-high temperatures (2000°C), plasma is ideally suited for eliminating toxic and nuclear waste.

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[237] EPA, Frequent Questions about Energy Recovery from Waste, Is municipal solid waste considered a renewable resource?, http://www.epa.gov/waste/nonhaz/municipal/wte/faq.htm#2

[238] The World Bank, What a Waste: A Global Review of Solid Waste Management, Annex J, MSW Generation by Country, http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTURBANDEVELOPMENT/0,,contentMDK:23172887~pagePK:210058~piPK:210062~theSitePK:337178,00.html

[239] eCyclingUSA, A new approach to urban mining, materials reclamation and jobs creation, http://ecyclingusa.com/

- **Gasification** is considered to be the cleanest and most cost effective technology. Gasification plants usually consist of high-efficiency combined power and heat (CHP) plants, that recover thermal energy from organic MSW sources to produce syngas, that is used generate steam in highly efficient boilers, that powers turbines, that produce electricity. The syngas can also be used directly as a gas (after reforming) for turbines, a chemical feedstock, or processed into a liquid fuel.

Gasifiers come in various sizes. Small and medium-sized gasifiers generally use a fixed-bed system to support combustion. Small downdraft fixed-bed gasifiers generally produce between 1kW and 1MW of power. Small gasifiers usually require low ash, wood or blended RDF pellets as feedstock. Medium updraft fixed-bed gasifiers produce between 1MW and 10MW of power. Deployable small and medium sized gasifiers are being developed by the U.S. military and have numerous commercial applications for larger organizations (industries, universities, shopping malls, hospitals, etc.) that generate solid waste and have need for supplemental power. Large gasifiers use fluidized-bed systems that inject air or steam through the feedstock to enhance combustion of large quantities of material. Large gasifiers can produce up to 200MW of power.

Next-generation gasifiers include pure oxygen and hydrogen (hydrogasification) that replace blown air in order to increase efficiencies and destroy organic syngas contaminants, thereby creating a much purer syngas that can be used directly in turbine generators. However, the cost of pure oxygen and hydrogen is currently too high to be cost effective. Plasma and high-energy microwaves are also in development.

From a Jobenomics perspective, government renewable energy standards should include some form of MSW mandates. MSW mandates would greatly reduce GHG emissions and incentivize municipalities to consider implementing modern WtE technology, which in turn would create many thousands of new jobs.

Material Recovery Facilities (MRFs). One of the Jobenomics strategic initiatives involves urban mining. Urban mining is defined as a process of reclaiming raw materials and metals from products, buildings and waste from towns, cities and metropolitan areas. The goal of urban mining is to monetize urban waste streams including municipal solid waste (MSW), construction & demolition material (C&D), electronic waste (appliances, commuters/peripherals, and other electronic items) and tires (car and truck tires, and other rubber products).

Every community in America should look to urban mining to (1) monetize waste streams, (2) reduce landfilling and exporting, and (3) create new businesses and jobs. Jobenomics helped create eCyclingUSA[240] to bring advanced technology MRFs to America in order to help municipalities create revenue streams from discarded electronic waste streams.

In 2014, China became the leading urban mining nation by establishing a number of major ($1 billion level) urban mining centers with super-MRFs that reclaim raw materials, metals and minerals from every conceivable type of manufactured item or system that contains reclaimable raw materials.

The Chinese put a premium on processing electronic waste that contains precious metals (gold, platinum, silver, palladium, etc.), common metals (copper, iron, tin, lead, zinc, titanium, etc.) and high-value plastics (e.g., ABS). A ton of motherboards (printed circuit boards)/CPUs (central processing units) contain over $1,000,000 worth of precious metals—much of which can be reclaimed.

The material recovery industry is generally referred to as the "scrap" industry. According to the Institute of Scrap Recycling Industries [241], the scrap recycling industry employs 137,970 Americans—the vast majority of whom recycle scrap manually. Jobenomics believes that this employment number is a very conservative number compared to its ultimate potential if government renewable energy standards mandated recycling goals to include both organic and non-organic (scrap) fractions. As discussed later in more detail, government mandates are important to provide a reliable and consistent source of feedstock for processing operations and investment.

Scrap goes far beyond MSW and includes electronic waste, consumer products, appliances, scientific and medical equipment, furniture, utensils, hardware, equipment, containers, rubber products, tires, cars, trucks, planes, trains, ships, bridges, ports, piers, stadiums, buildings, as well as any other unused, obsolete or discarded product or material. E-waste also includes peripherals. Personal computer e-waste peripherals include printers, monitors, keyboards, mice, etc. E-waste associated with demolished buildings includes wiring, lamps, HVAC systems, water heaters, ducting, lighting, refrigerators, stoves, dishwashers, etc. Natural disasters, like Hurricane Sandy, generate massive amounts of e-waste that could be processed to generate funds for reconstruction.

Compared to organic MSW material, scrap has (1) much higher monetary value, (2) much greater contribution to mitigation of GHG emissions and energy conservation of virgin metals and minerals, and (3) much higher employment potential if affordable advanced technology MRFs were located in several hundred U.S. communities.

In Europe where waste processing is mandated, MRFs usually operate at full capacity (3 shifts per day) using feedstock generated by as little as 300,000 people. The United States has a population of over 300,000,000 that could mathematically support 1,000 such MRFs. Americans cast off significantly more scrap items than the rest of the world.

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240 eCyclingUSA, www.eCyclingUSA.com, note: the author of this report is also the CEO of eCyclingUSA
241 Institute of Scrap Recycling Industries, Inc. (ISRI), Economic Impact Study U.S.-Based Scrap Recycling Industry (2013), http://www.isri.org/docs/default-source/recycling-analysis-(reports-studies)/economic-impact-study-u-s-based-scrap-recycling-industry-2013.pdf?sfvrsn=8

The World Bank[242] calculates that Americans cast off 5.7 pounds of MSW per capita per year, versus 4.4 in Europe (average of Germany, United Kingdom and France), 3.8 pounds in Japan, 2.2 pounds in China and Brazil, and 0.7 pounds in India. By 2025, Americans are projected to decrease MSW generation by 11%, Europeans and Japanese are projected to remain at the same level, and developing countries to increase substantially: India 106%, China 68% and Brazil 55%. Given the developing world's growing middle-class, waste will be as big an economic and employment opportunity as it is an environmental hazard.

Germany, the Netherlands, Sweden, Belgium, Austria and Denmark have largely phased out landfilling[243] in order to meet the EU's 2008 Waste Framework Directive, which requires recycling of at least 50% of household waste by 2020. Compliance with this mandate by these countries has led to the development of advanced technology MRFs to process, segregate and reclaim valuable raw materials.

The average cost of an advanced technology MRF is between $10M and $20M, as compared to the $200M average for a WtE plant. At full capacity, MRFs employ up to 200 direct and 300 indirect/induced personnel. 1,000 advanced technology MRFs could therefore employ 500,000 Americans. In the near term, 100 MRFs are clearly achievable, producing 50,000 jobs and providing a revenue stream for cash-starved municipalities.

The highest value scrap is electronic waste (e-waste) or Waste Electrical and Electronic Equipment, WEEE, the nomenclature of the European Commission. The U.S. EPA uses a narrow definition of e-waste that includes computer-related devices, televisions, hard copy devices and mobile devices. Europe's WEEE definition is much broader and covers any end-of-life electrical and electronic equipment that has a plug or battery.

E-waste contains precious metals and other highly valuable materials. Metal deposits in e-waste are up to 30 to 50 times richer than ore extracted from mines. For example, one ton of gold ore yields about 5 grams of gold, but one ton of phone circuitry yields about 150 grams, 30 times as much[244]. A ton of cellphones (6,000 units) yields approximately $15,000 in precious metals. Computers and servers are also a source for precious metals. Due to the advent of cloud computing and mobile devices, over 310 million U.S. personal computers are ready for end-of-life management. An average PC weighs 20 pounds, so 310 million PCs represents 6 billion pounds of feedstock. It is probably safe to say that every PC has three times its weight in peripherals, generating a total of 24 billion pounds, or 12 million tons of feedstock—enough to keep 375 five-ton per hour MRFs operating three shifts per day.

E-waste also includes hazardous (toxic, corrosive, flammable or reactive) substances that are a risk to human health and the environment. According to the International Environmental Technology

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[242] The World Bank, What a Waste: A Global Review of Solid Waste Management, Annex J, MSW Generation by Country, http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTURBANDEVELOPMENT/0,,contentMDK:23172887~pagePK:210058~piPK:210062~theSitePK:337178,00.html

[243] EurActiv, Landfills continue to rule despite EU recycling target, http://www.euractiv.com/sustainability/landfills-continue-rule-despite-news-518229

[244] The Diplomat, The Potential of Urban Mining, http://thediplomat.com/2013/11/the-potential-of-urban-mining/

Center[245], 50 million tons of e-waste is produced globally each year, of which only 15% to 20% is recycled and the rest is landfilled or incinerated. Most of the toxic heavy metals in landfills are from e-waste—the United States' ratio is 70%—that include substances like lead, mercury, cadmium and beryllium, as well as hazardous chemicals and polluting plastics.

According to the EPA, e-waste is the fastest growing waste stream in America, but only 25% is collected for recycling[246] with the remainder landfilled. Of the recycled 25%, it is estimated that four-fifths are exported to foreign recyclers (many in third world countries often with child laborers working in toxic e-waste dumps) and one-fifth is recycled domestically in the United States. The EPA admits that reliable data on exports is not available.

These pictures were taken by a Jobenomics team member in mid-2014 during a visit to a Chinese urban mining center. These pictures show Chinese workers removing discarded U.S. printed circuit boards (PCBs) and central processing units (CPUs) from 40-foot containers (stacked seven containers high and many containers wide) that were recently shipped from California.

PCBs and CPUs are highly valuable and should be processed in America as opposed to exporting. Using advanced technology MRFs similar to ones that are operational across China and Europe, every American community (city, country or region) with populations greater than 300,000 could be earning $30 million per year by processing its indigenous e-waste, as well as creating up to 500 direct and indirect jobs. From an environmental perspective, the good news is that China is shutting down its notorious toxic e-waste dumps, limiting e-waste imports to only pre-possessed items and developing state-of-the-art urban mining centers that process the full range of organic and non-organic materials. These actions will make a significant energy conservation contribution to the climate change equation, as well as significantly reducing environmental disruption and pollution associated with surface and sub-surface mining.

According to the U.S. EPA, developing nations will soon be discarding more e-waste than the developed world. In the last two decades, China has increased computer usage from 10 million computer users in 1997 to over 400 million internet users today. China is the largest producer of electronic equipment. According to the International Business Times[247], in 2011, China produced 90% of the world's personal computers, 80% of all air conditioners, 80% of all energy-saving lamps, 74% of all solar cells and 70.6% of all mobile phones. Given the relatively short life-spans of consumer electronics, it is no wonder China is putting urban mining in high gear.

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[245] UNEP, International Environmental Technology Center, Policy Brief on E-waste: What, When and How, http://www.unep.org/ietc/Portals/136/Other%20documents/PolicyBriefs/13052013_E-Waste%20Policy%20brief.pdf
[246] EPA, General Information on E-Waste, http://www.epa.gov/osw/conserve/materials/ecycling/faq.htm#recycled
[247] International Business Times, China Manufacturing: 10 Things The Chinese Make More Of Than Anyone Else In The World [Infographic], August 2013, http://www.ibtimes.com/china-manufacturing-10-things-chinese-make-more-anyone-else-world-infographic-1369727

On a more sinister note, a Senate Armed Services Committee[248] report stated that "much of the material used to make counterfeit electronic parts is electronic waste, or e-waste, shipped from the United States and the rest of the world to China." While national security is a major concern, these counterfeits find their way into products across a wide range of American industries, including telecommunications, healthcare, transportation, and consumer electronics. Consequently, e-waste end-of-life management impacts not only energy conservation, economics, environment and employment issues, but security as well.

Over the last several years, Jobenomics conducted dozens of meetings with U.S. mayors regarding how to monetize e-waste streams and use the revenue for jobs creation. Virtually all of the city managers (mayors, city councils, solid waste managers) were unaware that they were foregoing such a lucrative source of revenue. City managers were very interested in how Europeans were monetizing their waste streams and Jobenomics/eCyclingUSA's efforts to bring advanced technology MRFs to America.

Over 100 state-of-the-art e-waste MRFs are in operation in Europe. Advanced technology MRFs can shred electronics and appliances to the pellet or powder level, and then collate the raw materials by type (copper, aluminum, iron and plastics) and color. A typical system can process an appliance as large as a refrigerator in one minute in a closed environment to prevent any leakage, like CFCs, into the environment. U.S. designed equipment can accommodate e-waste as large as two-door refrigerators (American refrigerators are larger than European). These large capacity machines can also accommodate similar sized equipment like computer racks, medical equipment and vending machines. The United States is in the process of transitioning from coin-operated vending machines to high-tech machines that accept credit cards and mobile payments, and feature digital screens, video cameras, and smartphone charging stations. As many as 5 million American vending machines are now obsolete and ready for e-waste end-of-life management.

Many city managers were unaware that their policies encouraged exporting their electronic waste overseas. Many solid waste managers acknowledged that they use companies to handpick high-value electronic waste items for shipment overseas using the same 40 foot containers (now empty) that brought foreign electronics into the United States. These solid waste managers and their bosses were pleased that they received payment for these handpicked items up to $10 per ton. They were not so pleased when they were informed that advanced technology MRFs can generate revenues up to $1,165 per ton.

248 Electronics TakeBack Coalition, Commentary: E-Waste Export Policy Key to Stopping Electronics Counterfeits and Protecting Military Readiness, 26 September 2014, http://www.electronicstakeback.com/2014/09/29/commentary-e-waste-export-policy-key-to-stopping-electronics-counterfeits-and-protecting-military-readiness/

With a $25 million, 10 ton/hour, advanced technology e-waste MRF, a medium-sized city could generate $73 million annual revenue with $30 million annual profits after the first year of operation. Average payback period for an advanced technology e-waste MRF is typically less than three years, which is significantly shorter than most renewable energy technologies.

A basic understanding of how the $73 million revenue figure is calculated is important to understanding why e-waste is such a highly valuable commodity. The calculation is based on a feedstock mix of computers, consumer electronics, and small and large appliances. Metal and material content figures are generally well established by the scrap industry. The dollar value for metals, plastics, glass and PCBs are updated daily on multiple e-commerce websites, such as Scrap Register[249], Scrap Monster[250] and Alibaba[251]—the world's largest e-commerce site that is owned and operated by the Chinese, the largest commodity-buyers in the world.

$ Value of e-Waste Raw Materials

Feedstock: Computers, Consumer Electronics, Small and Large Applicances

Metal/Material	% of e-Waste	$s per Metric Ton*	$/Ton (2204 pounds)	Total $/Year (10t/hr x 20hr/d x 330d/yr)
Iron/Steel (Fe)	20%	$ 327	$ 65.40	$ 4,316,400
Copper (Cu)	5%	$ 6,149	$ 307.45	$ 20,291,700
Aluminum (Al)	20%	$ 1,741	$ 348.20	$ 22,981,200
ABS Plastics	10%	$ 1,580	$ 158.00	$ 10,428,000
Other Plastics/Foam	40%	$ 125	$ 50.00	$ 3,300,000
Computer Components**	5%	**$ 3,537**	$ 176.87	$ 11,673,486
Source: Jobenomics, eCyclingUSA	100%	$ 13,459	$ 1,106	**$ 72,990,786**

*Scrap Prices Feb 2015

**Unprocessed Computer Components	% of e-Waste	$s per Pound*	$/Ton (2204 pounds)
Central Processing Units	1%	$ 26.00	$ 573.04
Memory Chips	1%	$ 10.00	$ 220.40
Cell Phones	3%	$ 5.50	$ 363.66
Laptops	20%	$ 0.80	$ 352.64
Hard Drives	20%	$ 0.90	$ 396.72
Mother Boards	15%	$ 3.50	$ 1,157.10
Medium Grade Boards	10%	$ 0.88	$ 193.95
Low Grade Boards	5%	$ 0.15	$ 16.53
#2 Copper Wiring	5%	$ 1.07	$ 117.91
Power Supplies	20%	$ 0.33	$ 145.46
Source: Jobenomics, eCyclingUSA	100%	$ 49.13	**$ 3,537**

As calculated above, the value per metric ton of the feedstock mix is $1,106. On a yearly basis, a 10 tons/hour MRF, operating 20 hours a day for 330 days per year, would produce $72,990,786 worth of

[249] Scrap Register, http://www.scrapregister.com/scrap-prices/united-states/260
[250] Scrap Monster, http://www.scrapmonster.com/scrap-prices
[251] Alibaba, http://www.alibaba.com/Metallurgy-Chemicals-Rubber_Plastics_m6

revenue. After expenses, it would yield approximately an EBIDTA (Earnings Before Interest, Depreciation, Taxes, and Amortization) of 40%, or $30 million profit per year. Note: this calculation does not include tipping fees, grants, tax abatements, or carbon credits which would enhance revenue and profitability. It also does not include advanced computer component processing systems that are in development. For example, used copper wiring sells for $1.07 per pound, but would yield $2.54 if processed for the pure copper, a 138% increase.

It is important to note that the commodity prices listed on the chart represent clean or highly pure fractions, which can be sustainably achieved by MRFs that have advanced technologies, such as optical sorters and infrared scanners. Commodity prices are highly sensitive to purity—the higher the purity, the higher the profit. For example, 99% pure copper sells close to the spot price of copper of $6,149 per ton, whereas 80% pure copper (called dirty copper that contains other heavy metals like brass) only reaps around $3,000 per ton.

There are also ways to increase profitability by increasing the amount of items that contain precious metals (computers, servers and cellphones) in the mix. As of February 2015, e-waste components sold as high as $26 per pound. This is a partial price list: CPU processors $26.00/pound, memory chips $10.00/pound, cell phones $5.50/pound, motherboards $3.50/pound, hard drives $0.90/pound, medium grade printed circuit boards @ $0.88/pound, and low grade printed circuit boards $0.15/pound. An average personal computer has 6 pounds of these high value components.

Turnkey advanced technology e-waste MRFs can be operational within a year, profitable during the first year, and debt free (pay-back to investors) within two years thereafter. The two major investment issues involve the availability of feedstock, which could largely be solved by government mandates, and commodity prices, which have recently dropped by around 25% but are expected to increase to all-time highs. As the world's growing middle class demands more electrically-powered gadgets and the Internet-of-Things connects more electronics to things than people, commodity prices are likely to rise.

In 2014, approximately 350 million computers were sold globally, of which 137 million were PCs. Worldwide, 2 billion PCs currently in operation will be soon ready for end-of-life management[252]. By 2018, PC production will drop 12% to 121 million. On the other hand, 1.2 billion smartphones and 1.1 billion tablets, phablets (a smartphone having a screen which is between the size of a typical smartphone and a tablet) and other portables are projected for production, up from near-zero in 2012[253]. Until Americans stop exporting or landfilling 95% of this e-waste, we will miss out on a huge economic and employment opportunity. If U.S. policy-makers would enact some form of e-waste mandates, these mandates would generate sufficient investor interest to construct advanced technology e-waste MRFs across America. Due to urban mining properties compared to virgin mining, the material recovery industry offers a potential energy conservation contribution that is unmatched by any other single technology.

[252] Worldometers, Forrester Research, http://www.worldometers.info/computers/
[253] International Data Corporation Worldwide Quarterly Smart Connected Device Tracker, 3 September 2014, http://www.idc.com/getdoc.jsp?containerId=prUS25077914

ETR Employment Outlook in Alternative Fuels and Advanced Vehicles

Alternative Fuels, Advanced Vehicles, Advanced Batteries, Fuel Cells, Electric Vehicles, Hydrogen Vehicles

Recent breakthroughs in alternative fuels and advanced vehicles will transform the U.S. transportation sector and national economy. More than a dozen alternative fuels are in production or under development for use in alternative fuel vehicles and advanced technology vehicles. Alternative fuels and advanced vehicles will significantly reduce petroleum use and harmful GHG emissions.

Alternative Fuels.

According to the Department of Energy (DoE)[254], there are six primary alternative fuels (biodiesel, electric, propane, natural gas, hydrogen and ethanol), and six emerging fuels (biobutanol, drop-in biofuels, methanol, P-Series fuels, renewable natural gas and Fischer-Tropsch xTL fuels).

- Biodiesel is a renewable fuel that can be manufactured from vegetable oils, animal fats, or recycled cooking grease for use in diesel vehicles.
- Electricity can be used to power plug-in electric vehicles, which are increasingly available. Hybrids use electricity to boost efficiency.
- Propane is a readily available gaseous fuel that has been widely used globally for decades.
- Natural gas is a domestically abundant gaseous fuel that can have significant fuel cost advantages over gasoline and diesel fuel.
- Hydrogen is a potentially emissions-free alternative fuel that can be produced from domestic resources for use in fuel cell vehicles.
- Ethanol is a renewable fuel made from plant materials; it is blended with gasoline.
- Biobutanol is an alcohol produced from the same feedstock as ethanol including corn, sugar beets, and other biomass feedstock.
- Drop-in biofuels are hydrocarbon fuels substantially similar to gasoline, diesel or jet fuels, which are made from biomass feedstock including crop residues, woody biomass, dedicated energy crops and algae.
- Methanol, or wood alcohol, was used in automobiles in the 1990s. Today, research institutions are evaluating natural gas-derived methanol as a feedstock for transportation fuels and fuel cell vehicles.
- P-Series fuels are blends of natural gas liquids, ethanol and a biomass co-solvent.
- Renewable natural gas (RNG or biomethane) is a vehicle fuel produced from biogas, which is the gaseous product of anaerobic digestion of organic material.
- Fischer-Tropsch xTL Fuels are synthetic transportation fuels produced through a Fischer-Tropsch process using carbon-based feedstock to produce gasoline, diesel, ethanol, and methanol.

[254] U.S. Department of Energy, Alternative Fuels Data Center, http://www.afdc.energy.gov/fuels/

Advanced Vehicles.

According to the Department of Energy (DoE)[255], advanced vehicles include biodiesel vehicles, hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), all-electric vehicles (EVs), flexible fuel vehicles (FFVs), natural gas vehicles, propane vehicles, and fuel cell electric vehicles (FCEVs).

- Biodiesel vehicles use biodiesel blends, like B20 (20% biodiesel and 80% conventional diesel), without engine modification.
- Hybrid electric vehicles (HEVs) use electricity as primary fuel or to improve the efficiency of conventional vehicle designs. Sales of hybrids and plug-in electric vehicles totaled nearly 450,000 vehicles in 2014, down 8.8% from 2013. HEVs represent 2.75% of U.S. passenger vehicle sales. Top U.S. selling models in 2014 were Toyota Prius Liftback (27.2% market share), Toyota Prius c (9.0%), Toyota Camry Hybrid (8.7%), Ford Fusion Hybrid (7.8%), Toyota Prius v (6.8%), Hyundai Sonata (4.7%), Ford C-Max Hybrid (4.2%), Lexus CT200h (3.9%), Toyota Avalon Hybrid (3.8%), and Lexus ES 300h (3.3%)[256]. Japanese hybrid cars dominated U.S. sales with 63% of the market.
- Total global sales of plug-in hybrid electric vehicles (PHEVs) and all-electric vehicles (EVs) amounted to 320,000 units in 2014, an 80% rate of growth and on pace to exceed 500,000 in 2015[257]. In the United States, plug-in electrical car sales reached 118,500 cars in 2014, a 27% gain over 2013 and the third annual increase[258]. The best-selling U.S. models are the Nissan Leaf, Chevrolet Volt, Tesla Model S and BMW i3.
- Over 17 million U.S. flexible fuel vehicles (FFVs) have an internal combustion engine and are capable of operating on gasoline or E85 (a gasoline-ethanol blend containing 51% to 83% ethanol, depending on geography and season), or a mixture of the two[259].
- Natural gas and propane powers about 250,000 U.S. vehicles, mostly in private fleets such as police cars, shuttles, and school buses.
- Hydrogen powered fuel cell electric vehicles (FCEVs), in early stage deployment, are more efficient than conventional internal combustion engine vehicles and emit no harmful emissions.

Advanced Batteries.

The key to making PEVs more marketable involves better batteries. Advanced battery development is one of the most important technological battlegrounds of the next two decades.

Every advanced economy has a national advanced battery program. Advanced batteries will boost national economies, perhaps rivaling the economic impact of the personal computer. Advanced

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[255] Ibid 38
[256] Wikipedia, Hybrid electric vehicles in the United States, US Top 10 Selling Hybrid Models by Market Share in 2014, http://en.wikipedia.org/wiki/Hybrid_electric_vehicles_in_the_United_States
[257] Greentechgrid, The Future of the Electric Car, 1 April 2015, http://www.greentechmedia.com/articles/read/the-future-of-the-electric-car
[258] Green Car Reports, FINAL UPDATE: Plug-In Electric Car Sales Continue Rise In 2014, To 118,500, 3 February 2015, http://www.greencarreports.com/news/1096120_plug-in-electric-car-sales-continue-rise-in-2014-100000-plus-delivered-this-year
[259] DoE, Alternative Fuels Data Center, Flexible Fuel Vehicles, http://www.afdc.energy.gov/vehicles/flexible_fuel.html

batteries will not only speed the development of affordable electric cars, but will reduce the dependence on petroleum and enhance a cleaner environment.

The ultimate goal for advanced batteries is to meet or beat gasoline's internal combustion engine watt-hour standard. Today's lithium-ion batteries are limited by the laws of physics to only one-quarter of gasoline's watt-hour standard. Consequently, another battery technology is needed or potentially a replacement for either gasoline (such as hydrogen fuel cells) or the internal combustion engine itself.

During the past few years, several models of plug-in electric vehicles (PEVs), including battery electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs) have been introduced in the light-duty vehicle market. PEVs are limited by driving range, which is related to battery capacity, and can usually travel between 60 and 200 miles before recharging. Therefore, charging infrastructure is crucial to the success of these kinds of vehicles. To address this issue, states have established plans to promote the development of infrastructure through financial incentives for the building of new public and private recharging facilities.

Excluding private stations, there are 9,313 electric charging stations across the United States. California has the most with 2,062, followed by Texas with 571[260]. The rate at which charging adds range to a vehicle depends on the vehicle, battery type, and type of electric vehicle supply equipment. The charging time can range from 15 minutes to 20 hours or more. The lowest level charging equipment (AC Level 1) will charge 2 to 5 miles of range per hour via a 120 volt AC plug—most often associated with home charging stations. The highest level charging equipment (DC Level 2) will charge 50 to 70 miles of range per hour. Even at the fastest charge rate of 70 miles of range per hour, it takes a motorist 4 hours to achieve a 280 mile range, although Tesla's Supercharger stations claim to be able to charge Tesla's Model S in a matter of minutes, instead of hours[261].

Today, the answer to long charging times is hybrid combustion-electric vehicles. With an advanced battery breakthrough, all electric vehicles will likely become the favored choice of vehicle owners. Advancements in solar thin-film automotive applications and inductive charging (wireless charging via electromagnetic fields) could also advance the popularity of all-electric vehicles.

Jobenomics expects that lithium batteries (lithium-sulfur, lithium-ion, and lithium-ferrophosphate) will deliver the most viable near-term storage systems in both the transportation and electric power generation sectors.

- Tesla Motors[262], in partnership with Panasonic, is building a $5 billion lithium ion battery "Gigafactory" in Nevada that is slated to be operational by 2017. By 2020, the Gigafactory is projected to produce as many lithium ion batteries as the world produced in 2014. The Gigafactory will supply 500,000 Tesla cars per year and employ approximately 6,500 people.

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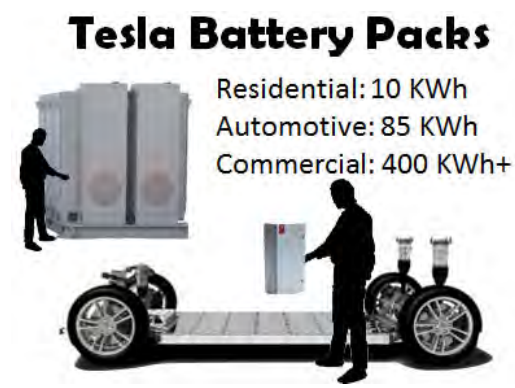
[260] EIA, Electric Vehicle Charging Station Locations, http://www.afdc.energy.gov/fuels/electricity_locations.html
[261] Tesla, Supercharger, http://www.teslamotors.com/supercharger
[262] Tesla Motors, Gigafactory, http://www.teslamotors.com/sites/default/files/blog_attachments/gigafactory.pdf

Tesla is also building the world's largest supercharging grid that currently has 148 operational stations in the United States, 121 in Europe and 48 in Asia—all currently offering free fuel to Tesla vehicle owners. Tesla plans to double the number of stations over the next two years.

In addition to cars, Tesla has announced plans to create stationary storage Li-ion batteries for homes and businesses, a move the company claims could change the "entire energy infrastructure of the world." The resident battery pack, called Powerwall, allows homeowners to store energy for later usage or sell to the grid via a proprietary net-metering system. Powerwalls retail for $3,500 for a 10kWh system that can run an entire home, or $3,000 for a 7kWh system. Powerwalls are small enough (3' x 4' x 6", starting weight 220 pounds) to be mounted on a wall—a sturdy wall. Installation costs are projected to double the price, which may put the cost of the system out of reach for many homeowners. Tesla claims that residential battery packs will save consumers 25% on their electricity bills by using electricity more efficiently. The Powerwall comes with a 10 year warranty.



Powerpack is a commercial battery pack for industrial or business use. Powerpacks are designed to scale from 100kWh to 10MWh to infinity. A number of large retail companies have signed on to use Powerpacks.

The Powerwall and Powerpack and will be built in Tesla's Gigafactory in Nevada, which still is under construction. Elon Musk, Tesla's CEO, has stated his goal is to sell 15GWh of stationary storage by 2020. If 7.5GWh were for 10kWh Powerwalls and 7.5GWh were for 10MWh Powerpacks, Tesla would have to sell 750,000 Powerwalls and 750 Powerpacks.

- Lithium-sulfur batteries are in development with a promise of doubling or tripling energy per kilogram over lithium-ion batteries. The best known lithium-sulfur batteries in development produce 500kWh per kilogram, compared to lithium-ion batteries that can produce a maximum of 200kWh per kilogram. Reportedly[263], Nissan is close to production of a lithium-sulfur battery for their LEAF electrical vehicle.

- Alevo[264] opened a $1 billion grid-scale, lithium-ferrophosphate factory in a former North Carolina cigarette factory in October 2014. Alevo classes itself a first-of-its-kind Energy Service Provider that uses innovative battery technology and smart data analytics to reduce wasted energy via "time-shifting" for better delivery to the grid when and where needed.

[263] The Economist, Battery Technology, A whiff of brimstone, Adding sulfur to electrical batteries may quintuple their performance, January 3rd 2015 edition, page 66
[264] Alevo, http://alevo.com/

Alevo plans to use its GridBank containers, "the world's first utility-grade battery," to store renewable energy and energy produced by coal-fired power plants. Coal-fired power stations can substantially reduce GHG emissions through efficiencies gained, which will enable these plants to be compliant with tough new EPA Clean Power standards in order to continue burning fossil fuels.

Electric Vehicles.

According IEA Global EV Outlook 2015[265], an update of a seven-year effort with 16 member governments, annual EV-car sales exceeded 300,000 (up from 45,000 per year in 2011), EV and charging infrastructure deployment increased, battery costs and energy density improved, and vehicle electrification has gone multi-modal totaling 235 million EV-two-wheelers, 665,000 EV-cars (up from 180,000 in two years) and 46,000 EV-buses. In 2014, Norway's market share of EVs exceeded 12% of all vehicles, followed by the Netherlands with 4% and Sweden with 2%. As a ppercentage of total EV-cars, the United States has the lead with 39% of the global total with 275,100 EVs, followed by Japan with 16% with 108,248 EV-cars, and China with 12% with 83,198 EV-cars. However, China has the lead on EV charging stations, with 30,000 compared to America's 21,814 and Japan's 11,511.

According to the first-ever U.S. Quadrennial Energy Review[266], in 2013, there were about 70,000 battery-electric vehicles and 104,000 plug-in hybrid electric vehicles—small numbers compared to the approximately 226 million registered vehicles in the United States. Total U.S. sales of plug-in electric vehicles (PEVs) represent about 0.7% of new vehicle sales in 2014 (up from 0.6% in 2013 and 0.4% in 2012). California is home to almost half of all of American PEVs. About 5 out of every 1,000 registered California vehicles are PEVs.

China is coming on strong for electrical vehicles. Favoring electrical vehicles over hydrogen-powered vehicles, China has launched a national campaign to develop an indigenous electric vehicle industry and encourage foreign companies to joint venture as well as import their foreign EVs. It is estimated that 40 EV models will be on sale in China this year, double the amount of several years ago. A major reason for the Chinese EV campaign is to comply with Beijing's aggressive new pollution standards and national initiative to put up to 5 million new-energy vehicles on the road by 2020. Many China watchers think that these goals are too aggressive and the foreign EV automakers are cooperating with the regime more for market access than marketing EVs.

Fuel Cells.

Advancements in fuel cells hold great promise. According to a 2014 report from Navigant Research[267], the global revenue for stationary fuel cells is projected to grow from $1.4 billion in 2013 to $40 billion in 2022. More conservative forecasts predict that the fuel cell market will double in the next five years.

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[265] IEA Global EV Outlook 2015, Key Takeaways, http://www.iea.org/evi/Global-EV-Outlook-2015-Update_1page.pdf
[266] Quadrennial Energy Review, Chapter 3, Implications of Electric Vehicle Penetration for the Grid, Page 3-15, http://energy.gov/sites/prod/files/2015/04/f22/QER%20ch3%20final_0.pdf
[267] Navigant Research, Stationary Fuel Cells Will Reach $40 Billion in Annual Revenue by 2022, 10 March 2014, http://www.navigantresearch.com/newsroom/stationary-fuel-cells-will-reach-40-billion-in-annual-revenue-by-2022

While industry revenue may be growing, the fuel cell industry is still very much in the process of formation and rationalization. As an industry, few companies are profitable and highly dependent on government assistance. The good news is that government assistance to fuel cell development is growing internationally. For example, the Dubai Carbon Center of Excellence (DCCE) [268] was established to incubate growing niche markets, like fuel cell technology. Backed by the Emirates National Oil Company and other major funding organizations, DCCE is developing 300MW of fuel cells for the United Arab Emirates—a country with 9 million residents.

A fuel cell works like a battery, using energy from the electrochemical reaction between hydrogen and oxygen without combustion—a highly efficient and ultra clean power generation system that generates both electricity and heat with water as its principal byproduct. Fuel cells are different from batteries in that they require a continuous source of energy to sustain the chemical reaction. Fuel cells run on hydrogen, the simplest element and most plentiful gas in the universe.

In nature, hydrogen does not exist on its own and has to be extracted from hydrogen-containing sources. 95% of U.S. hydrogen is currently produced from natural gas. However, numerous emerging technologies (gasification, renewable electrolysis, renewable liquid reforming, high-temperature thermochemical water-splitting, biological and photoelectrochemical[269]) are growing in popularity. According to a report to Congress[270], coal gasification is projected to eventually replace natural gas reforming as the principal source of hydrogen production.

Also according to DoE[271], "distributed production may be the most viable approach for introducing hydrogen in the near term in part because the initial demand for hydrogen will be low. Two distributed hydrogen production technologies that may offer potential for development and commercialization are (1) reforming natural gas or liquid fuels, including renewable liquids, such as ethanol and bio-oil, and (2) small-scale water electrolysis." Distributed and dispersed electricity generation is highly endorsed in this report.

NASA was the first organization to commercialize the use of fuel cells to generate power for satellites and space capsules. Today, fuel cells are used for primary and backup power for buildings and vehicles, including forklifts, buses, boats and ships. As of 2015, fuel cell automobiles have been introduced for commercial lease and sale in the United States.

The six main electrolytes used in fuel cells are proton exchange membrane fuel cells (PEMFC), direct methanol fuel cells (DMFC), phosphoric acid fuel cells (PAFC), molten carbonate fuel cells (MCFC), alkaline fuel cells (AFC) and solid oxide fuel cells (SOFC). Many of these electrolytes use expensive precious materials that make fuel cells costly, uncompetitive and useful for niche applications, such as NASA space. Solid oxide fuel cells (SOFCs) offer significant potential by incorporating low-cost ceramic materials that operate at high temperatures (800°C) that, in turn, produce high electrical efficiencies.

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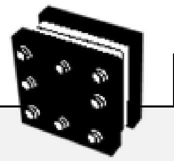
[268] Dubai Carbon, http://www.dcce.ae/page/About-Us.html
[269] US Department of Energy, Alternative Fuels Data Center, Hydrogen Production and Distribution. http://www.afdc.energy.gov/fuels/hydrogen_production.html
[270] DoE, Effects of a Transition to a Hydrogen Economy on Employment in the United States Report to Congress, July 2008, Table 2.5 -2.7, http://www.hydrogen.energy.gov/pdfs/epact1820_employment_study.pdf
[271] DoE, Energy.gov, Central Versus Distributed Hydrogen Production, http://energy.gov/eere/fuelcells/central-versus-distributed-hydrogen-production

On the other hand, alkaline fuel cells (AFC) operate at low temperatures (65°C) that can use more readily available low-cost metals and plastics[272].



Fuel Cell Applications

	Portable	Stationary	Transport
Definition	Units that are built into, or charge products that are designed to be moved, including auxiliary power units (APU)	Units that provide electricity (and sometimes heat) but are not designed to be moved	Units that provide propulsive power or range extension to a vehicle
Power Range	1W to 20kW	0.5kW to 400kW	1kW to 100kW
Applications	• Non-motive APU (campers, boats, lighting) • Military applications (soldier-borne power, generators) • Portable products (torches, chargers), personal electronics	• Large stationary power • Large combined heat and power (CHP) • Small stationary micro-CHP • Uninterruptible power supplies (UPS)	• Materials handling vehicles (forklifts) • Fuel cell electric vehicles (FCEV) • Trucks and buses

Source: E4tech, The Fuel Cell Industry Review 2014

According to the 2014 Fuel Cell Industry Review[273], the fuel cell industry can be characterized by three major applications: portable, stationary and transport. Portable fuel cells encompass those designed to be moved. Stationary power fuel cells are designed to provide power to a fixed location. Transport fuel cells provide either primary propulsion or range-extending capability for vehicles.

Energy efficiency of a fuel cell is generally between 40% and 60%, or up to 85% efficient in cogeneration if waste heat is captured for use. Consequently, many legacy fuel cell manufacturers offer combined heat and power (CHP) products that take advantage of wasted heat to improve economics.

Technical challenges include the high cost of producing, shipping and dispensing hydrogen fuel, and the high costs of materials used in fuel cell production. Notwithstanding these challenges, successful development of fuel cells is paramount to hydrogen-powered transportation and hydrogen-based economies.

Fuel cell power plants are now entering the commercial marketplace as evidenced by these examples:

- Japanese development and implementation of a residential fuel cell, called "ENE-FARM" was introduced in 2009. ENE-FARM technology is a subset of the broader micro combined heat and power, or micro-CHP, co-generation sector. ENE-FARM uses natural gas to extract hydrogen from water, which in turn, produces heat and electricity. In total, 100,000 Ene-Farm micro-CHP units have now been installed throughout Japan with 2,500,000 units are planned by 2030. Within the

[272] Note: The Dubai Center is using AFC technology from AFC Energy (http://www.afcenergy.com/default.aspx)
[273] E4tech, The Fuel Cell Industry Review 2014, http://www.fuelcells.org/pdfs/TheFuelCellIndustryReview2014.pdf

next few years, Tokyo Gas[274] plans to install over 300,000 units in Tokyo households and apartment buildings. Similar programs are underway in Europe and Asia.

- Intelligent Energy (IE)[275] is a London-based energy technology business that develops advanced hydrogen fuel cell technologies for consumer electronics (<100W), distributed power and generation (1kW to 20kW), and automotive (1kW to multiples of 100kW). IE's hydrogen consumer electronics fuel cell recharger, called UPP[276], is being sold in Apple stores today and recently won the 2015 Edison Award in the area of Energy and Sustainability. IE's distributed power and generation fuel cells were first deployed in 2011 to India to replace diesel generators and provide backup power to India's remote telecom towers. In the automotive sector, IE's technology is being used by the London Taxi company in its hydrogen fuel cell taxis and Japan's Suzuki in their zero emission scooters.

- New York-based Plug Power[277] is a leader in in hydrogen and fuel cell power systems including material handling (forklifts and pallet jacks) and turn-key hydrogen distribution and refueling systems. As a leader in the commercial integration of PEM fuel cells, Plug Power deployed over 9,000 fuel cell products globally. Plug Power's GenKey solution, launched in 2014, provides a turn-key package that includes: GenDrive fuel cells, GenFuel infrastructure for supply, dispensing and storage of hydrogen; and GenCare on-site maintenance service, making the adoption of hydrogen and fuel cells seamless for customers like Walmart, BMW, Mercedes-Benz, Kroger and Procter & Gamble. In 2014, Plug Power entered into the stationary power market (storage and backup systems) with its ReliOn fuel cell product suite.

- General Electric (GE) is advancing state-of-the-art solid oxide fuel cells (SOFC) that use ceramic electrolyte (solid oxide). SOFCs offer high efficiency, long-term stability, low emissions and much lower cost compared to current fuel cells. GE SOFC's power generation efficiency can reach an unprecedented 65% that can grow to 95% when the system is configured to capture waste heat produced by the process, and can generate 1MW to 10MW of power. GE is also using stainless steel in place of expensive metals to lower cost. GE's pilot fuel cell manufacturing and development facility is in upstate New York[278].

- Founded in 2001, California-based, Bloom Energy[279] is advancing state-of-the-art solid oxide fuel cells that convert natural gas or biogas methane into electricity. Since its inception, Bloom Energy has raised $1.2 billion in funding. As of 2014, Bloom has installed approximately 130MW of its fuel cells in the leading American companies including: retail and logistics giants (including Walmart, Ikea, Fedex, Safeway, Target and Staples), as well as major technology, banking and financial

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[274] Tokyo Gas, Development of the new model of a residential fuel cell, "ENE-FARM", http://www.tokyo-gas.co.jp/techno/stp1/00h1_e.html
[275] Intelligent Energy, http://www.intelligent-energy.com/
[276] UPP, http://www.beupp.com/
[277] Plug Power, http://www.plugpower.com
[278] General Electric, Fuel Cell Startup Could Spark a Revolution, http://www.geglobalresearch.com/innovation/fuel-cell-startup-could-spark-a-revolution & http://www.gereports.com/post/92454271755/the-new-power-generation-this-fuel-cell-startup
[279] Bloom Energy, Solid Oxide Fuel Cells, http://www.bloomenergy.com/fuel-cell/solid-oxide/

services, healthcare, manufacturing, utilities, universities, food and beverage and entertainment companies, and government institutions.

- FuelCell Energy[280], a Connecticut-based company, has 50 fuel cell power plants up and running or under construction in nine countries with more than 300MW of power generation capacity installed or in backlog (average 6MW per plant). Their power plants have generated more than 3 billion kilowatt hours of ultra-clean electricity, equivalent to powering 245,000 U.S. homes per year. In addition, FuelCell Energy's advanced technology group is experimenting with alternative fuels (hydrogen and biomass) and using fuel cells to capture and commercialize waste CO_2 emissions from fossil fuel plants.

  The world's largest 59MW fuel cell power plant, located in Hwasung City, South Korea, uses 21 2.8MW hydrogen fuel cells supplied by FuelCell Energy. In the United States, FuelCell Energy's Bridgeport Fuel Cell Park, in the heart of Connecticut's most populous city, provides 14.9MW of clean energy 24/7—enough to power 15,000 homes—by converting natural gas to electricity[281]. The Park is owned by Dominion (one of the largest electric utilities in the United States) and sells its power to Connecticut Power and Light Company under a 15 year power purchase agreement. While slightly more expensive than other forms energy, fuel cell power plants can be located in urban areas close to the customer, thereby reducing transmission costs and losses. The Bridgeport Fuel Cell Park operates quietly, cleanly and safely on a former polluted and abandoned 1.5 acre parcel of land. The Bridgeport Park was constructed in approximately 12 months and is currently the largest fuel cell power plant in America.

- CT Energy & Technology, a Connecticut-based development company, recently announced it will use FuelCell Energy's fuel cells to build the world's largest fuel cell power plant near Beacon Falls, CT. Beacon Falls was chosen due to it low tax structure and proximately to a newly renovated substation. The Beacon Hill Energy Park will be composed of 21 fuel cells that will generate 63MW of power, energy to power 60,000 Connecticut homes. Construction is tentatively scheduled in early 2016 and will take three years to complete[282]. Connecticut is one of 11 states that classify fuel cells as a renewable energy, which qualifies fuel cells for renewable energy incentives. The Connecticut Green Bank, America's first full-scale Green Bank, includes fuel cells as one of six clean energy alternatives (the other five are wind, solar, water, waste-to-energy and biomass).

As of 2015, major government, commercial and industrial institutions are now installing large fuel cell power plants. Automakers have now marketing fuel cell electric vehicles. Residential fuel cells are being installed by the hundreds of thousands. Notwithstanding, fuel cell technology is still a largely misunderstood technology with enormous potential in America. The opposite is true in Japan. The success of residential fuel cells and commitment of Japan's three biggest automakers to hydrogen fuel

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[280] FuelCell Energy, http://www.fuelcellenergy.com/about-us/company-overview/ and http://fcel.client.shareholder.com/index.cfm

[281] Bridgeport Fuel Cell Park Brochure, http://www.fuelcellenergy.com/assets/PID000218_FCE_BFCP_Open-House-Spotlight_r2_HIRES.pdf

[282] Beacon Falls News, Plans for fuel plant unveiled, 1 May 2015, http://www.mycitizensnews.com/news/2015/05/plans-for-fuel-cell-plant-unveiled/ & New Haven Register, 5 May 2015, http://www.nhregister.com/business/20150505/fuel-cell-power-plant-will-out-town-on-map-officials-say

cell vehicles has encouraged Japan to give hydrogen and fuel cells a central role in Japan's energy future[283].

Jobenomics asserts that distributed and dispersed fuel cell applications will make a major contribution to energy generation by 2030 and will be a primary enabler of renewable energy and advanced vehicles.

Hydrogen Vehicles.

Hydrogen-powered transportation has truly revolutionary potential as well as a major disruptive effect on the petroleum-based internal combustion engine industry. Fuel cells have the potential to replace the internal combustion engine in vehicles and to provide electrical power in stationary and portable power applications that are energy efficient and environmentally clean. Hydrogen-powered vehicles take approximately the same time to refuel as gasoline vehicles, whereas electric vehicles can take much longer.

For hydrogen-powered transportation to be a success, three elements are needed: (1) hydrogen fuel cells for energy storage, (2) hydrogen-powered vehicles at a reasonable cost, and (3) a hydrogen-power transportation infrastructure. Each of these elements have enormous economic and employment potential—assuming that they become reality.

The 2015 Toyota Mirai is the first hydrogen fuel cell electric vehicle (FCEV) to be sold commercially, followed by Hyundai's Tucson FCEV and Honda's FCX Clarity FCEV. Other automakers are planning to launch fuel cell electric vehicles in California shortly thereafter.

The costs of these vehicles will not be cheap. Initial pricing for the 2015 Mirai is over $58,000[284]. To be competitive in the $25,000 to $30,000 mid-sized vehicle market, carmakers are aggressively pursuing ways to reduce cost, especially costs associated with fuel cells that use expensive catalysts like platinum. Japanese automaker Toyota recently claimed a hydrogen fuel cell breakthrough that involves a better method to analyze the way platinum catalysts strip away electrons from hydrogen molecules. Platinum is scarce, expensive and degrades over time via a phenomenon called "coarsening". Coarsening is akin to a plaque buildup that restricts catalytic conductivity, which reduces fuel cell output. Toyota's breakthrough allows company scientists a way to observe real-time the coarsening process at the microscopic particle level. This knowledge will help Toyota manufacture more efficient and affordable fuel cells for the Mirai and subsequent models[285].

California is committed to making hydrogen-powered transportation a reality. Hydrogen-powered vehicles have to overcome a number of challenges, including compliance, infrastructure, safety, cost and zero emissions.

[283]Japanese Ministry of Economy, Trade and Industry, METI has compiled a Strategic Road Map for Hydrogen and Fuel Cells, June 2014, http://www.meti.go.jp/english/press/2014/0624_04.html

[284] California state incentives will drop the price down to about $45K. Toyota says that about 90 percent of Mirai customers, however, are expected to choose the $499-per-month lease with $3649 due at signing.

[285] Toyota, Press Release, 18 May 2015, R&D Breakthrough Sets Stage for More Efficient, Durable Fuel Cell Stacks, http://corporatenews.pressroom.toyota.com/releases/rd+breakthrough+efficient+durable+fuel+cell+stacks.htm

- Regarding compliance, California regulators have decreed that the six largest automakers build increasing numbers of zero-emissions models, toward a goal of having 87% of new cars produce zero tailpipe emissions by 2050.
- Regarding infrastructure, today California only has 9 hydrogen fueling stations compared to 7,748 gasoline, 3,847 diesel, 805 propane, 51 E85 and 32 natural gas stations[286]. The California Fuel Cell Partnership plans to focus development of hydrogen refueling stations in five geographic clusters located throughout San Francisco and Los Angeles metropolitan areas. By the end of 2016, 51 stations are planned, along with free fuel and leasing options for new hydrogen-powered cars. The state will even pick up the down payment for the car. Honda and Toyota are helping to fund construction of the hydrogen stations. By 2019, 77 stations are planned. According to Honda North America, 75 stations will be able to serve a total on-road population of 17,000 to 24,000 hydrogen-fueled vehicles.
- Regarding safety, hydrogen is a volatile fuel. The 1937 Hindenburg disaster put an early end to the airship era when its hydrogen exploded and killed 36 people. To assuage the volatility issue, automakers have taken extraordinary safety precautions like bulletproof hydrogen storage tanks sealed in ultra-strong carbon fiber casings. Whether these precautions will stand the test of time will depend on safety testing and public perception, especially after highly-publicized crashes.
- Regarding cost, the cost of hydrogen fuel is an issue as compared to electric vehicles that can be charged at home. Hydrogen costs approximately the same as gasoline, whereas electricity is only a fraction of the cost. To mitigate the cost issue, vehicle manufacturers are offering free fuel to get hydrogen-powered vehicles established as a viable form of transportation. California is also offering $5000 incentives for hydrogen-powered vehicles as opposed to $2500 for all-electric vehicles.
- Regarding zero-emissions, hydrogen fuel is produced from reforming natural gas, which, in turn, produces GHGs. Until clean production methods, such as hydrogen from nuclear or renewable resources or even clean coal processes, are available, hydrogen-powered transportation will not be a zero-emissions climate change contributor.

By 2025, California currently plans for 1.5 million zero emission vehicles. By 2050, alternative fuels could provide more than half the energy needed to power California's transportation system[287]. Jobenomics applauds such bold ETR efforts. It is also important to emphasize the fact that California's citizens seem to be unified in supporting and financing these initiatives in an era often characterized by hyper-partisan politics.

Advanced Vehicles Employment Outlook.

Worldwide, the automotive manufacturing industry supports over 50 million jobs[288]. Approximately 10 million are direct manufacturing employees and 40 million are indirect or induced jobs. If vehicle manufacturing were a country, it would be the sixth largest economy in the world.

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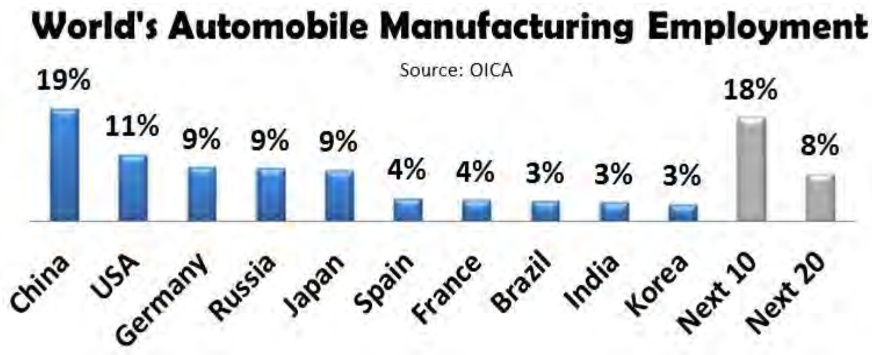
[286] CA.gov, Energy Almanac, *Retail Fuel Report and Data for California*, http://energyalmanac.ca.gov/gasoline/piira_retail_survey.html
[287] A California Road Map, *Bringing Hydrogen Fuel Cell Electric Vehicles to the Golden State*, http://www.cafcp.org/sites/files/20120814_Roadmapv(Overview).pdf
[288] The International Organization of Motor Vehicle Manufacturers or Organisation Internationale des Constructeurs d'Automobiles (OICA), http://www.oica.net/category/economic-contributions/auto-jobs/



As shown, as a percentage of the 10 million direct employees, no single country dominates the automotive industry or the alternative fuel and advanced vehicle domain. Moreover, a technological breakthrough is just as likely to be achieved outside the manufacturing realm in some university laboratory or perhaps in an inventor's garage shop in an emerging economy. Tens of millions of jobs (and national power) is at stake. Perhaps that is why the majority of the 40 countries involved in automobile manufacturing have some form of national advanced battery, advanced vehicle and alternative fuel programs. These next-generation programs are prizes in a trillion-dollar lottery that is much too lucrative not to be involved at some level.

US Motor Vehicle Employment in 2014

Employment	All Motor Vehicle-reated Manufacturing	Auto Dealerships	Total
Direct	843,000	710,000	**1,553,000**
Intermediate (Indirect)	2,069,300	246,700	2,316,000
Spin-off (Induced)	2,687,700	693,300	3,381,000
Total	5,600,000	1,650,000	**7,250,000**
Multiplier	6.6	2.3	4.7

Source: Center for Automotive Research

A study commissioned by the Alliance of Automobile Manufacturers (alliance of top 12 manufacturers) reports that the U.S. motor vehicle industry directly employs 1,553,000 Americans, with a total direct, indirect and induced employment of 7,250,000 U.S. jobs[289]. The Bureau of Labor Statistics[290] puts the US "automotive industry" direct employment at 4,049,000 jjobs, including 911,000 in motor vehicles and parts manufacturing, 337,000 in motor vehicle and parts wholesale trade, 1,910,000 in automotive and tire retail trade, and 891,000 in automotive repair and maintenance. If one applies a 1:3 direct to

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[289] Alliance of Automobile Manufacturers, 2015 Jobs Report, http://www.autoalliance.org/auto-jobs-and-economics/2015-jobs-report, and, Center for Automotive Research, Contribution of the Automotive Industry to the Economies of All Fifty States and the United States, Page 30, http://www.autoalliance.org/files/dmfile/2015-Auto-Industry-Jobs-Report.pdf

[290] U.S. Bureau of Labor Statistics (BLS), Automotive Industry: Employment, Earnings, and Hours, April 2015, http://www.bls.gov/iag/tgs/iagauto.htm

indirect/induced ratio to the BLS number, the grand total would equate to about 12 million American jobs—approximately 1 out of every 12 employed Americans[291].

Considering the magnitude of these numbers, the upside for ETR breakthroughs in electric and hydrogen-powered vehicles is huge. On the other hand, losing market share to other countries would be equally as huge in terms of job losses.

Of the two technologies (electric and hydrogen), a hydrogen economy would be more disruptive since its applications far exceed the transportation sector alone. According to a DoE report to Congress[292], under a rapid transformation scenario, hydrogen would (1) completely replace new light-duty vehicle sales, (2) replace 11 million barrels/day of oil by 2040, and (3) provide 10% of U.S. electrical consumption by 2050. According to the same report, 675,000 net new direct jobs could be created with manufacturing hydrogen fuel cells, fuel cell maintenance and support systems, and hydrogen production from fossil fuels like coal and natural gas. Net employment in the automotive industry would remain unchanged between the gasoline and hydrogen economies, but replacement of gasoline-related skills with hydrogen-related skills would be substantial in the dealership and repair industries.

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[291] The BLS reports that the total number of employed Americans in April 2015 was 148,523,000 citizens out of a total population of 320,893,000.

[292] DoE Hydrogen Program, Effects of a Transition to a Hydrogen Economy on Employment in the United States, Report to Congress, Page 6, July 2008, http://www.hydrogen.energy.gov/pdfs/epact1820_employment_study.pdf

Nuclear Power Employment Outlook.

EIA forecasts that nuclear energy will **decrease** from 9% to 8% share of the total U.S. energy market from 2013 to 2030, and domestic energy consumption will **increase** from 8.3 quadrillion Btu in 2013 to 8.5 quads in 2030 for a net growth of 2%[293].

Contrary to popular perception, the nuclear industry is projected to grow substantially over the next decade in both OECD and non-OECD countries. Contrary to popular opinion, nuclear power may be the most viable option mitigating the ill effects of greenhouse gas as evidenced by the breakneck pace that the Chinese government is replacing coal-fired electrical generation plants with nuclear reactors.

According to the European Nuclear Energy Agency[294] and World Nuclear Association[295], there are 435 operating commercial nuclear reactors worldwide, in 31 countries, with total installed capacity of 392GW. In addition, 56 countries operate a total of about 240 research reactors and a further 180 nuclear reactors power some 140 ships and submarines. Eight countries are known to have a nuclear weapons capability.

Nuclear power plants provide 11% of the world's electricity as continuous, reliable base-load power, without any carbon dioxide emissions. France gets 75% of its power from nuclear. 15 other countries depend on nuclear power for at least 25% of their power.

About 80% of capacity is in OECD countries, but non-OECD countries are set to account for the bulk of future nuclear growth. Over 45 countries that currently do not have nuclear power have started nuclear programs (e.g., Iran, UAE, Turkey, Vietnam, Belarus, Poland and possibly Jordan) or are actively embarking on starting a nuclear power program[296]. Saudi Arabia plans to construct 16 nuclear power reactors over the next 20 years at a cost of more than $80 billion, with the first reactor on line in 2022.

By 2040, nuclear generation capacity is projected to be 624GW, an increase of 60%, which includes 380GW of new capacity and 148GW of retirements from approximately 200 older reactors. China's 132GW increase exceeds current installed capacity of the United States and Russia combined. Also by 2040, the amount of spent nuclear fuel will double—still without any established disposal facilities for commercial high-level radioactive waste.

The Fukushima Daiichi Nuclear Power Plant disaster's negative impact on nuclear energy directly or indirectly lead to (1) halting of all 50 of Japan's operable reactors until a new reinforced regulatory

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[293] EIA, Annual Energy Outlook 2015, Table A2 Energy Consumption by Sector and Source, http://www.eia.gov/forecasts/aeo/

[294] European International Energy Agency, Nuclear Energy Technology Roadmap, http://www.iea.org/publications/freepublications/publication/nuclear_roadmap.pdf

[295] World Nuclear Association, Nuclear Power in the World Today, http://www.world-nuclear.org/info/Current-and-Future-Generation/Nuclear-Power-in-the-World-Today/

[296] World Nuclear Association, Emerging Nuclear Energy Countries, updated June 2015, http://www.world-nuclear.org/info/Country-Profiles/Others/Emerging-Nuclear-Energy-Countries/

framework is established, (2) permanent shutdown of eight reactors in Germany, and (3) the phase out of nuclear power in Belgium and Switzerland. On the other hand, Fukushima had limited effect on other countries. Belarus and the United Arab Emirates are constructing their first plants and projects are advancing in the United Kingdom, Vietnam, Turkey, Bangladesh, Jordan, Poland and Saudi Arabia. China, Russia, India and Korea remain committed to steady advancement of their nuclear industries[297].

China Nuclear. Driven by its need for energy and solving its chronic smog problems, China is leading the way for the next generation of nuclear reactors. Its breathtaking approach to a national nuclear power industry is largely based on indigenously developed systems. According to the World Nuclear Association[298], while China has made full use of western technology, China has become largely self-sufficient in reactor design, plant construction and the nuclear fuel chain. Domestic uranium mining supplies less than ¼ of China's nuclear fuel needs so state-owned enterprises are acquiring foreign sources. China also has a domestic enrichment program and a very robust R&D effort.

China's nuclear program got a big jump start from American nuclear technology transfer. While the Chinese are paying for a number of state-of-the-art U.S. nuclear reactors, technology transfer has largely been a one-way goodwill endeavor from the U.S. to China. This endeavor predates the current Administration and reaches back to President Reagan, who negotiated the original U.S.-China Nuclear Cooperation Agreement (called the 123 Agreements), which is set to expire on December 30, 2015[299]. Negotiations are currently underway and the agreement is subject to congressional review. Congress will examine whether China's record on nuclear proliferation warrants continued cooperation in nuclear power. Non-proliferation (to North Korea, Iran, Pakistan and the Middle East) is a key issue for continuance of this peaceful technology transfer program that should play a key role in reducing China's coal-fired power plant CO_2 emissions.

Mainland China has 26 nuclear power reactors operational, 24 under construction and over a hundred more about to start construction. Today, China generates 18GW from nuclear power. By 2020, planned capacity will be 58GW—a 3-fold increase over today's capacity. By 2030, planned capacity should be 150GW—an 8-fold increase. And by 2050, as reported by the 10th China Nuclear Energy Congress 2014, planned capacity should be 400GW—a 22-fold increase. A 22-fold increase in nuclear reactor capacity extrapolates to almost 500 Chinese reactors based on current reactor size[300].

In 2008, the Chinese purchased four Westinghouse AP1000 nuclear reactors for $8 billion, which are currently under construction. Thirty more AP1000s are planned with Chinese firms performing an increasing share of the work as well as incorporating enhanced features. In addition to the AP1000, the U.S. exports nuclear components and materials to China to the tune of over $130 million per year—a bargain compared to the billions of dollars spent on R&D for these products.

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[297] European International Energy Agency, World Energy Outlook 2014 Factsheet, Nuclear power: retreat, revival or renaissance?, http://www.iea.org/media/news/2014/press/141112_WEO_FactSheet_Nuclear.pdf
[298] World Nuclear Association, Nuclear Power in China, 18 December 2014, http://www.world-nuclear.org/info/country-profiles/countries-a-f/china--nuclear-power/
[299] Congressional Research Service, U.S.-China Nuclear Cooperation Agreement, 20 April 2015, http://www.nei.org/CorporateSite/media/filefolder/Policy/Trade/CRS-China-123-Report.pdf?ext=.pdf
[300] 10th China Nuclear Energy Congress 2014, http://www.cdmc.org.cn/2014/cnec/

The U.S. Department of Energy is now helping the Chinese with the design of new and improved nuclear reactors, including molten-salt nuclear reactors that use thorium as fuel. As a byproduct of China's domestic mining of rare earth metals (seventeen scarce chemical elements in the periodic table used in high-tech electronics), China has a significant stockpile of thorium.

Thorium-based nuclear reactors were developed by DoE's Oak Ridge National Laboratory in Tennessee in the 1960s, but were abandoned by in favor of uranium-based reactors. While thorium was made into a bomb, it proved to be unreliable and uranium became the dual-use fuel of choice for both civil and military applications. In addition to being a poor bomb-making material, thorium has other peaceful power generation characteristics such as being meltdown and proliferation proof.

The Chinese have placed a high priority in thorium development. The Chinese Academy of Sciences employs around 750 scientists and engineers in their thorium effort, which is headed by Jiang Mianheng, an engineering graduate of Drexel University (Philadelphia, Pennsylvania) and son of Jiang Zemin, the former General Secretary of the Communist Party of China—the latter qualification being an indicator of the priority of this program to Chinese leadership. Jiang's team plans to have a prototype thorium reactor online in 2015 and an operational commercial molten thorium salt reactor (aka the Oak Ridge reactor) by 2017.

Chinese state-owned enterprises have competing designs and are even considering outside funding from the Hong Kong stock exchange. Part of China's strategic nuclear vision is to take their indigenous designs global. To do so, safety is paramount and aggressive goals may have to be scaled down for safety reasons or to prevent a political backlash against the regime in Beijing. Thorium reactors provide a way to avoid this backlash. In addition to domestic usage, China plans to develop safe, small, low-cost, exportable thorium nuclear reactors, which could place nuclear power generation back in the forefront as a leading global energy resource—especially for the growing number of power hungry mega-cities constrained by power density issues.

United States Nuclear. Nuclear electric power supplies 8% of America's energy needs with a projected 3% growth rate in consumption over the next fifteen years.

The U.S. nuclear power industry is currently the largest in the world, with 100 operating commercial nuclear fission reactors at 62 locations in 31 states[301]. The largest nuclear plant is in Palo Verde, Arizona, with three reactors, generating 3,937MW of power. The smallest plant is in Fort Calhoun, Nebraska, with one reactor, generating 478MW of power. The newest nuclear plant, Watts Bar 1 in Tennessee, began operating in June 1996, and the oldest plant, in Oyster Creek, New Jersey, began operating in April 1969.

Five nuclear plants are under construction including two in South Carolina, two in Georgia and one in Tennessee. Almost all plants have received or applied for 20-year extensions to operate for a total of 60 years. In 2013, three plants closed in California, Wisconsin and Florida. In 2014, the plant in Vermont is closing due to economic reasons (low demand, low energy prices, restructured market).

Small Modular Reactors (SMR). SMRs are gaining traction in Canada and the United States. Russia is building its first modern SMR. SMRs have generating capacities ranging from tens to a few hundred

[301] Nuclear Energy Institute, http://www.nei.org/Why-Nuclear-Energy/Economic-Growth-Job-Creation

megawatts and can be deployed as single or multiple reactors in remote areas. SMRs are small enough to be fabricated in factories and can be shipped to sites with a construction period of approximately three years. In March 2012, the U.S. Department of Energy announced its intention to provide funding to assist in the initial development of SMR technology to achieve commercial operation by 2025. To date, DoE selected companies to prepare license applications for up to four SMRs in Tennessee and one in Oregon.

Fusion Reactors. Lockheed Martin, a U.S. defense contractor, claims that they may be able to field a nuclear fusion reactor within a decade. Their program is called "Compact Fusion"[302]. If successful, Compact Fusion would be a ground-breaking ETR advancement.

Fission involves splitting one atom into two, whereas fusion involves merging two smaller atoms into a larger one. Compared to fission, fusion is safer (no chance for meltdowns), creates orders-of-magnitude less radioactive material and has a nearly unlimited fuel supply since fusion relies largely on sea water (deuterium hydrogen isotope) and lithium (to produce tritium) as opposed to uranium used in fission reactors. Fusion was all the rage 50 years ago but operational challenges, such as controlling the reaction in a confined space, put the technology on back burner until recently. Lockheed's Compact Fusion reactor is small enough to fit on a semi-trailer truck yet large enough to produce enough power (100MW) for a small city of up to 100,000 people. Lockheed also envisions nuclear-powered ships and aircraft that virtually never require refueling.

International partners from the European Union, China, Russia and the United States are also building the largest-ever demonstration fusion reactor in Cadarache, France. The projects name is ITER, which stands for "the way" in Latin. ITER[303] is a large-scale scientific experiment that aims to demonstrate the technological and scientific feasibility of fusion energy. From 50MW of input power, the ITER machine is designed to produce 500MW of fusion power—the first of all fusion experiments to produce net energy. Construction is scheduled to be finished in 2019 followed thereafter by ITER's operational phase that will last for 20 years.

Employment Outlook. From a near-term employment potential, Jobenomics forecasts that employment in the nuclear energy industry will remain relatively unchanged in the near future even though it shed approximately 5,000 jobs in 2013 due to recent plant closures. According to the Nuclear Energy Institute (NEI)[304], the nuclear industry employs approximately 100,000 employees, of which approximately 53,000 work at nuclear plants. The NEI also claims that 25,000 new hires will be needed to replace retiring workers over the next several years. Operation of a nuclear plant requires 400 to 700 direct permanent jobs. These jobs pay 36% more than average salaries[305].

The far-term employment potential is somewhere between stable and explosive depending on the success of small modular fission reactors, new fusion technology and participation (technical, engineering and financial services) with the 45 emerging nuclear energy countries.

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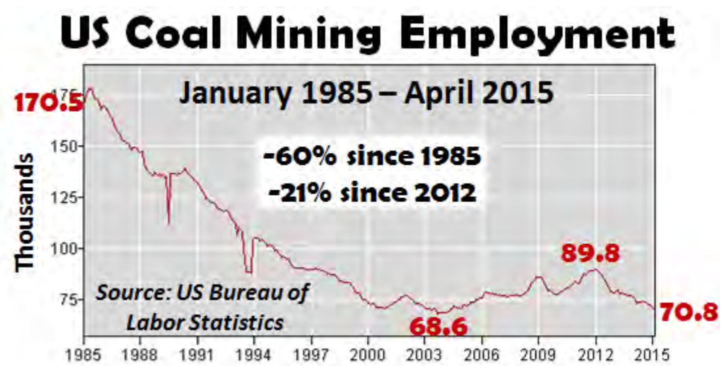
[302] Lockheed Martin, Compact Fusion, http://www.lockheedmartin.com/us/products/compact-fusion.html
[303] ITER, The way to new energy, http://www.iter.org/
[304] Nuclear Energy Institute, Economics, http://www.nei.org/Issues-Policy/Economics
[305] Nuclear Energy Institute, Nuclear Energy's Economic Benefits — Current and Future, April 2014, http://www.nei.org/CorporateSite/media/filefolder/Policy/Papers/jobs.pdf?ext=.pdf

Coal Employment Outlook.

EIA forecasts that coal will **maintain** its share as a percentage of the total U.S. energy market at 19% in 2013 and 2030, and domestic energy consumption will **increase** from 18.0 quadrillion Btu in 2013 to 19.2 quads in 2030 for a net growth of 6%[306].

The common perception in America is that coal is either dead or a dying industry, especially from a global warming and Environmental Protection Agency point of view. However, the U.S. Energy Information Agency and other international agencies forecast status quo in terms of consumption and percentage of the U.S. energy mix for the next decade and a half. Moreover, much maligned coal is not inherently dirty. Modern "ultra-supercritical" coal-fired power plants are much cleaner than older dirtier models that represent 75% of the world's operational plants. Older plants burn coal inefficiently at lower temperatures than modern plants that use powdered coal laced with additives that absorb toxic materials before they can be emitted.



From an employment perspective, Jobenomics forecasts that the coal industry will continue to lose jobs. According to the U.S. Bureau of Labor Statistics[307], from January 1985 to April 2015, the U.S. coal industry has shrunk from 170,500 jobs to 70,800 jobs, a loss of 60%. Many forecasters believed that employment had bottomed in the early 2000s due to the brief employment upsurge that ended in 2012. Since January 2012, coal employment has dropped by 21% and is likely to continue to due to four factors: harsh new EPA air quality standards that are being contested at the Supreme Court, low natural gas prices, increasingly competitive renewable energy technologies, and plummeting investor and market confidence.

Plummeting investor and market confidence does not bode well for the American coal industry. According to EIA, in 2012, the top five producers of coal accounted for over 57% of total U.S. coal production. Since then, these five producers' stock prices have been devastated: Peabody Energy down 93%, Arch Coal down 97%, Alpha Natural Resources down 98%, Cloud Peak Energy down 73% and Consol Energy down 48%. The broader Dow Jones U.S. Coal Index is also down significantly (85%) from its 2011/2012 peak. Between 2011 and 2013, 264 U.S. coal mines shut down with dozens of coal companies declaring bankruptcy. To make matters worse, a number of leading institutions, such as Stanford University and The World Bank, launched divestiture movements to eliminate coal stocks from their investment portfolios. Energy divestiture movements are designed to cut of capital to fossil fuel industries and divert these resources to renewable energy projects. Since the centuries-old coal industry is more thinly capitalized than other fossil fuel industries, it is the main target of these

[306] EIA, Annual Energy Outlook 2015, Table A2 Energy Consumption by Sector and Source, http://www.eia.gov/forecasts/aeo/

[307] U.S. Bureau of Labor Statistics, Establishment Data, Table B-1, Employees on nonfarm payrolls by industry sector and selected industry detail, Coal Mining, http://www.bls.gov/webapps/legacy/cesbtab1.htm

divestiture movements. However, the coal industry remains hopeful that these movements will fail and the international market will make up for a slack U.S. market. Worldwide, coal powers 40% of electrical production and will continue to do so for many years henceforth.

The bright spot for coal exports is India that is expected to import 19% more coal this year. Indian demand for coal is not likely to peak before 2030. On the other hand, India has started a national initiative to exploit its untapped coalfields, which will damper future imports when these domestic sources come online. India's Energy Minister Goyal announced at the G20 summit in 2014 that India plans to completely stop coal imports within a period of 2 to 3 years[308]. However, in 2014, over half of India's 103 coal-fired power plants had only enough coal for less than a week's usage. Many India observers believe that coal imports are likely to remain high for a number of years. Over the last five years, India Coal, the largest producer of coal in India, has struggled to grow by 2% per year. Minister Goyal has ordered a 100% increase over the next five years.

China is still the largest consumer of coal, accounting for approximately 80% of global demand growth. In November 2014, Presidents Obama and Xi announced a United States-China 21st Century Coal Initiative[309] to promote cleaner uses of coal, including launching large-scale carbon capture and storage (CCS) demonstration projects, developing near-zero emissions coal-fired power plants, conducting a joint feasibility study for an integrated gasification combined cycle (IGCC) power plant in China using American technology, and studying how to capture and convert coal mine methane gas to electrical power. Also in 2014, China implemented protectionist measures resulting in a 22% decline in coal imports. China's demand for coking coal, used for production of steel, has also decreased. Apparently, China likes U.S. coal technology more than U.S. coal.

Notwithstanding the attributes of modern coal technology, clean coal in America has become a political pariah for the Democrat Party and the Obama Administration, both of whom have acquired the political moniker "War on Coal." From a policy perspective, President Obama and the Democrat Party are walking away from U.S. clean coal initiatives in favor of diverting the funds to renewable energy and to show the world that the United States is taking a climate change leadership position. Politicization of coal-versus-renewables is not constructive. Renewable energy can stand on its own merits, and, as evidenced by its rapid rise and acceptance, is doing so. Moreover, the prospective of clean, or much cleaner, coal is vitally important since the world is not going to switch from coal in the foreseeable future.

In February 2015, the Obama Administration cancelled America's leading clean coal initiative called FutureGen[310]—a first-of-its-kind, near-zero emissions coal-fueled power plant located in Meredosia, Illinois. This plant can capture more than 90% of its CO_2 emissions and reduce other emissions to near-zero levels. It also included a research and training center for U.S. and international clean-coal collaboration. In addition to eliminating FutureGen, the Administration, via the EPA, enacted its "Clean Power Plan" that includes new standards that will put many U.S. coal-fired power plants out of business. The National Mining Association estimates that more than 300 plants will retire nationwide due to EPA

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[308] CleanTechnica, India Shocks Australia, To Stop Coal Imports In 2-3 Years, 14 November 2014, http://cleantechnica.com/2014/11/14/india-shocks-australia-stop-coal-imports-three-years/
[309] The White House, U.S.-China Clean Energy Announcements, 5. 21st Century Coal, 17 November 2014, http://www.whitehouse.gov/the-press-office/us-china-clean-energy-announcements
[310] FutureGen Alliance, FutureGen 2.0 Project, http://futuregenalliance.org/futuregen-2-0-project/

rules over the next six years. The Office of Surface Mining Reclamation and Enforcement in the Department of the Interior, and the Mine Safety and Health Administration in the Department of Labor, have also introduced or finalized new rules that will adversely impact the coal industry and drive up costs for consumers.

Clean coal advocates point to North Dakota. Operational since 2014, the Dakota Gasification Company[311] owns and operates the Great Plains Synfuels Plant near Beulah, North Dakota. Great Plains Synfuels Plant is America's only commercial-scale coal gasification facility that manufactures pipeline-quality synthetic natural gas and related products (such as fertilizers) from lignite coal. According to the North Dakota Department of Health, this synfuels plant is the cleanest energy plant operating in the state of North Dakota producing 153 million cubic feet per day of natural gas. It also captures up to 3 million metric tons of CO_2 per year that is shipped via a 200-mile pipeline to the world's largest carbon capture and storage project in Saskatchewan, Canada. The captured CO_2 is used for enhanced oil recovery in Canadian oil fields. The $2.1-billion plant began operation in 1984 and subsequently invested $665 million to achieve environmental compliance, improve efficiency, and diversify the product slate. As part of the 1988 purchase agreement from the Department of Energy, Dakota Gas has provided the U.S. government with approximately $2.1 billion in revenue—the amount roughly equivalent to the cost of building the plant. The Great Plains Synfuels Plant employs about 700 direct employees. At a 1:3 direct to indirect/induced ratio, Great Plains supports approximately 2,800 local jobs.

On the other hand, clean coal advocates are not without their white elephants, such as the Kemper Project, a purported clean coal showcase. Mississippi Power's Kemper Project[312] is a controversial $6.2 billion integrated coal gasification power plant project. Kemper is designed to convert the state's abundant lignite coal reserves into synthesis gas to burn in its 582MW electricity-generating turbines that captures at least 65% of CO_2 emissions. A two-year delay and several billion dollar cost overrun have increased utility rates for nearly 190,000 Mississippi consumers by 18%, triggered law suits and power purchase agreement terminations, which collectively put the entire project at risk. Moreover, it has put other planned integrated coal gasification power plant projects at risk in the United States as well as abroad.

Notwithstanding the problems at Kemper, walking away from U.S. clean coal is wrongheaded for three reasons: (1) negative financial impact on middle-class Americans, (2) increased legal and political paralysis, and (3) putting the climate change 2°C goal almost certainly out of reach.

- Due to advancements in fossil fuel technology, the typical middle-class American household is now saving about $750 per year, which will be returned to the government in the form of subsidies and incentives for renewable industries if current anti-coal Administration actions are implemented. Heritage Foundation (a conservative think tank) analysts modeled the financial impact of anti-coal actions on a typical family of four and concluded that their annual income would drop $1,200 per year[313].

[311] Dakota Gasification Company, http://www.dakotagas.com/
[312] Mississippi Power, Kemper County Energy Facility, http://www.mississippipower.com/about-energy/plants/kemper-county-energy-facility/
[313] The Heritage Foundation, EPA Power Plant Regulations: A Backdoor Energy Tax, http://www.heritage.org/research/reports/2013/12/epa-power-plant-regulations-a-backdoor-energy-tax

- Legal and political paralysis is escalating as a dozen states and multiple companies have filed suits against the Administration's Clean Power Plan and the political divide in Washington is intensifying. As of this posting, 21 states, most of which are led by Republican governors, have appealed to the U.S. Supreme Court to rule that the Administration and its EPA have overstepped its authority to regulate the coal industry.

- Most importantly, the promise of "clean coal" is the single most important ETR technology that is needed to achieve the climate change 2°C goal. Coal generates 29% of America's electricity—more than any other energy source[314]. Moreover, America has unique technical and financial resources to make the clean coal promise come true for the rest of the world that is dependent on coal for their growing energy needs. If America walks away from clean coal, it is likely that the rest of the world will do so as well at a time when worldwide coal usage is rising. According to the International Energy Association[315], in 2013, coal added more primary energy than any other fuel and was the fastest-growing fossil fuel. Worldwide coal consumption is forecast to increase by 2.1% per year until 2019 with Asia being the chief consumer. If coal is truly the world's fastest-growing fossil fuel, U.S. climate change leaders should embrace clean coal as opposed to rejecting it.

According to the EIA's International Energy Outlook 2013 (latest comparable data)[316], coal consumption is projected to grow in the United States by 8% by 2013 (note EIA Annual Energy Outlook 2015 forecasts 6.4% from 18.0 to 19.2 quads). Non-U.S. OECD countries (34 developed economies including Japan and most of Europe) are projected to decrease coal consumption by 4%. Non-OECD countries (China, India and most emerging economies) are projected to grow significantly by 46%. Overall world coal consumption growth will increase by 34% over the next decade and a half from 311 to 416 quads.

Global Coal Consumption Growth Rate Forecast

Consumption	2013	2030	Growth Rate
	Quadrillion Btu		
United States	18	20	8%
OECD (non US)	24	23	-4%
Non-OECD	113	165	46%
World	155	208	34%
Total	**311**	**416**	**34%**

Source: EIA International Energy Outlook 2013

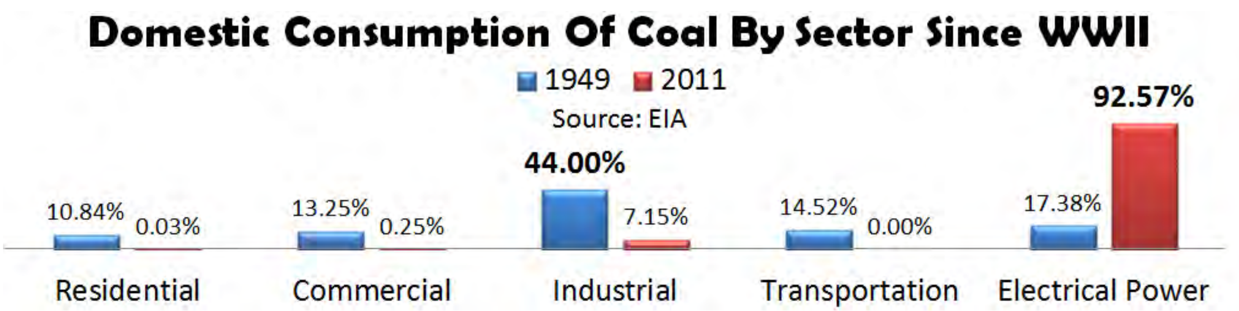
Based on total British thermal units (Btus), U.S. coal resources are much larger than comparable natural gas and oil resources. Current U.S. recoverable coal reserves are 257 billion short tons[317], or approximately 250 years' worth at current consumption rates. In 2013[318], the United States produced 1,023 million short tons and exported 106 million short tons of coal. By 2030, U.S. production is

[314] EIA, Annual Energy Outlook 2015, Table A9 Electricity Generating Capacity, http://www.eia.gov/forecasts/aeo/
[315] IEA, Medium-Term Coal Market Report 2014, http://www.iea.org/bookshop/495-Medium-Term_Coal_Market_Report_2014
[316] EIA International Energy Outlook 2013, World Consumption by Region, Reference case, Coal, http://www.eia.gov/oiaf/aeo/tablebrowser/#release=IEO2013&subject=7-IEO2013&table=7-IEO2013&region=0-0&cases=Reference-d041117
[317] EIA, U.S. Coal Reserves, http://www.eia.gov/coal/reserves/
[318] EIA, AEO 2013, Table 15 Coal Supply, http://www.eia.gov/forecasts/archive/aeo13/source_coal.cfm

estimated at 1,153 million short tons with exports of 144 million short tons of coal, which equates to increases of 13% and 36% respectively over 2013.

Coal supplies approximately one-fifth of total U.S. energy needs. Coal is the biggest source for generating U.S. electricity (43%, followed by nuclear 22%, gas 22%, renewables 13% and petroleum 1%). Over the last five years, U.S. coal exports have increased from 1 billion short tons to 1.4 billion short tons, a 40% increase.

According to the EIA, coal production is projected to remain constant for the foreseeable future with western and interior U.S. mines replacing the decline in eastern mines. Wyoming is the leading U.S. coal supplier producing more coal than all other states combined[319]. Rail is the primary form of transportation (68%) followed by river (12%), truck (11%) and slurry pipeline (8%). The electrical power sector received 93% of U.S. domestic distribution.



Since WWII, domestic uses of coal have doubled from 483 million tons to 1 billion tons per year—mostly to satisfy the need for electrical power. In 1949, the industrial sector used 44% of all coal followed by electrical power at 17%, transportation (mainly coal-fired railroad engines) at 15%, commercial buildings with 13% and homes with coal furnaces at 11%. Today, electrical power generation plants are the overwhelming user, followed by a few industrial coal-fired plants.

Approximately 1,300 U.S. coal-fired electrical plants generated 292GW of power for the grid in 2014. About 20% of these plants will retire by 2020 due to planned retirements and decommissioning, as well as significant economic pressure caused by low natural gas prices, slow electricity demand growth and environmental concerns. Valid concerns over climate change and carbon emissions could induce political and environmental protectionist action that would place severe constraints on domestic coal production and consumption.

Over his last two years in office, President Obama has stated that he intends to implement a carbon cap-and-trade system that would penalize highly polluting coal-fired electrical power plants. In June 2014, the EPA proposed a plan[320] to cut carbon pollution from existing fossil fuel-fired electric generating plants. The EPA proposal sets different carbon reduction thresholds for each state to help achieve a 30% reduction in carbon emissions nationally by 2030. While the EPA lays out state-specific CO_2 goals for each state, it does not prescribe how a state should meet its goal. To reach their respective goals, each state can choose from a variety of options, ranging from closing inefficient plants, to implementing

[319] EIA, Annual Coal Distribution Report, http://www.eia.gov/coal/distribution/annual/?src=email
[320] EPA, Clean Power Plan, http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule

regional cap and trade networks, to building more clean renewable energy plants, and to implementing smart grid technology. Notwithstanding its length and numerous caveats, the EPA proposal[321] appears to be a reasonable system-of-systems approach that will motivate states to develop more aggressive plans to mitigate CO_2 emissions. However, state governments are unlikely to have much real power over coal-burning electric power companies that employ millions of Americans. If state standards are deemed unobtainable, existing coal-burning plants will simply close causing higher unemployment and consumer costs.

Jobenomics believes a "30% cleaner goal" concept should be introduced as opposed to the current "clean coal" concept. Coal will never be clean, but it can be clean enough to meet a 30% reduction standard. A 30% cleaner coal goal is likely to be within the ETR's wherewithal. Efficiency improvements in plant design, new supercritical combustion technologies and CO_2 capture retrofits are coming on-line.

Unfortunately, there is a large contingent of environmentalists (including many in the EPA) that believe that clean, or cleaner, coal is not technically achievable or politically palatable, and that renewable energy is the only sensible choice. According to the naysayers, clean-coal technologies are primarily demonstration-phase technologies that are too expensive and should be deemed impractical. Jobenomics rejects this position and believes that cleaner coal should be given a chance for no other reasons than the Btu-power locked up in this abundant natural resource, and the importance that cleaner coal-fired plants can play internationally to reduce CO_2 emissions from dirty coal-fired plants.

Another way to make coal cleaner is to gasify it. Coal gasification is a process that converts coal into a syngas comprised of methane (CH_4), hydrogen (H_2), carbon monoxide (CO), carbon dioxide (CO_2) and water (H_2O). These elements can be used to create synthetic natural gas, synthetic fuels (gasoline, diesel, and hydrogen) and other commodities. Modern coal gasification plants can sequester CO_2 to keep it from entering the atmosphere.

Converting coal to sulfur-free synthetic gas or synthetic fuels with low particulates is not new. Coal-to-gas and coal-to-liquids (CTL) processes are generally known as Fischer-Tropsch technologies. Franz Fischer and Hans Tropsch were two German chemists who invented a process to convert coal to liquids in the 1920s. By the start of WWII, the Fischer-Tropsch process was combined with a hydrogenation process to convert lignite (low quality coal) and bituminous (mid quality coal) into gasoline, diesel and aviation fuel. By 1943, Germany produced half of its annual fuel supplies from synthetic fuels derived from CTL. After WWII, CTL was abandoned in Germany due the destruction of refineries and the switch to imported oil. In 1955, South Africa began producing Fischer-Tropsch coal-derived synthetic fuels largely in response to worldwide fuel embargos against apartheid policies. Apartheid ended in 1993 but South Africa continues to gasify coal today. South Africa's Sasol energy company produces enough fuel (160,000 barrels per day) to satisfy 30% of the nation's gasoline, diesel and aviation fuel needs.

According to the U.S. DoE[322], "coal gasification offers one of the most versatile and clean ways to convert coal into electricity, hydrogen, and other valuable energy products. Coal gasification electric

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[321] Federal Register, *Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units*, https://www.federalregister.gov/articles/2014/06/18/2014-13726/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating
[322] U.S. Department of Energy, Energy.Gov, Gasification Technology R&D, http://energy.gov/fe/science-innovation/clean-coal-research/gasification

power plants are now operating commercially in the United States and in other nations, and many experts predict that coal gasification will be at the heart of future generations of clean coal technology plants."

A 2008 DoE report to Congress[323] stated of the seven technologies that can produce hydrogen, coal gasification with sequestration is forecast to be the dominant method by 2035. This could be extremely important consideration to the coal industry if hydrogen-powered vehicles and stationary hydrogen fuel cells become commonplace. Moreover, few policy-makers are looking at the potential role of coal in an ultra-clean hydrogen-based economy.

According to the Office of Fossil Energy[324], while still in the research phase, producing hydrogen from coal has significant potential. Coal gasification involves subjecting coal to high-pressure steam and oxygen to produce a synthetic gas. The syngas is then cleaned of impurities and the purified syngas is again reacted with steam to produce hydrogen and carbon dioxide. The hydrogen is used for fuel and the carbon dioxide is captured and sequestered. The hydrogen can be used in combustion turbines and fuel cells, or as a feedstock for the petrochemical industry. End uses for carbon dioxide currently include enhanced oil recovery, food and beverage manufacturing, pulp and paper manufacturing, and metal fabrication. In the future, sequestered carbon dioxide may be able to be used as feedstock for algal fuels or potentially as carbonates used in building materials[325]. Jobenomics believes that coal gasification and related CO_2 sequestration technologies need to be put into high gear, not only for the potential benefits for a hydrogen-based economy but for climate change applications as well as utilization of America's most abundant energy resource.

More and more U.S. coal-fired plants are using coal-derived syngas. Integrated Gasification Combined Cycle (IGCC) systems are being introduced to convert synthetic gas into electrical power. "Combined cycle" refers to producing energy by burning syngas in turbines and then using the resultant heat to produce steam for steam turbine-generators, thereby doubling the power of the plant. Future concepts that incorporate fuel cell-gas turbines could achieve even greater efficiencies.

Duke Energy's Edwardsport Generating Station[326] in Knox County, Indiana, began commercial operations in June 2013 replacing an older 160-megawatt plant with a 618-megawatt advanced IGCC plant. The plant is one of the world's cleanest coal-fired power generating stations. It is the first to use IGCC technology on this scale, generating enough energy to power approximately a half million homes. The Edwardsport plant will produce ten times more electricity than the previous facility, with up to 70% fewer sulfur dioxide and nitrogen oxides emissions. In addition, Edwardsport will use significantly less water that will be recycled. Edwardsport will support 170 direct coal miners and 160 direct plant operators for a total of 1,300 total direct, indirect and induced employees, not including the 3,500 construction jobs needed to build the plant.

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[323] DoE, Effects of a Transition to a Hydrogen Economy on Employment in the United States Report to Congress, July 2008, Table 2.5 -2.7, http://www.hydrogen.energy.gov/pdfs/epact1820_employment_study.pdf
[324] DoE, Office of Fossil Energy, Hydrogen from Coal, http://energy.gov/fe/science-innovation/clean-coal-research/hydrogen-coal
[325] MIT News, MIT biological engineers have found a way to convert carbon-dioxide emissions to useful building materials, using genetically altered yeast, 22 September 2010, http://newsoffice.mit.edu/2010/belcher-carbon-0922
[326] Duke Energy, IGCC Project Overview, http://www.duke-energy.com/about-us/edwardsport-overview.asp

According to the Institute for Energy Research[327], China plans to build 50 coal gasification plants in less-populated northwestern parts of the country, which will export produced syngas to generate electricity in the more-populated areas where smog is prevalent. Two coal gasification pilot plants have been built, three are under construction, and 16 have been approved for construction, while the rest are planned.

Another exciting ETR coal-to-gas technology involves underground coal gasification. Underground coal gasification turns unworked underground coal (in-situ) into an easily extractable gas. The basic process involves drilling injection and extraction boreholes into the coal bed. Oxidants comprised of water/air/oxygen mixtures are injected to heat the coal to temperatures where the coal emits a gas that is evacuated via the extraction borehole. In many ways this technique is similar to the horizontal drilling and hydraulic fracturing used to extract natural gas from shale beds. Underground coal gasification gas contains various amounts of methane, hydrogen, CO and CO_2 that can be used for power generation, manufacture of chemicals and fertilizers, production of hydrogen, or re-injected for enhanced oil recovery. Compared to traditional coal mining, underground coal gasification mitigates surface damage and much of the toxic emissions associated with above-ground burning of coal. Demonstration projects are happening around the world. China reportedly has 30 major demonstration projects underway. Linc Energy[328] recently received a research and development license (the first issued in the United States in twenty years) for an underground coal gasification demonstration project in Wyoming's Powder River Basin.

Most modern coal-fired power plants use pulverized coal as fine as talcum powder that is blown into the firebox for efficient combustion of the solid fuel. Other materials can be added to pulverized coal to increase combustion temperatures and reduce emissions. Jobenomics is collaborating with RePower South (RPS)[329] that has patented and EPA-approved technology that will convert more than 70% of a community's municipal solid waste (garbage) stream into an advanced biofuel that can be co-fired with pulverized coal to achieve significant reductions in harmful emissions in the burning of coal. RPS' advanced biofuel emission control performance has been proven at scale to produce 40% to 80% reductions in key EPA regulated pollutants including sulfur dioxide, sulfur trioxide, nitrous oxide, mercury and chloride. This type of ETR technology is not only good for coal-fired electrical plant atmospheric emissions, but it reduces landfill usage and landfill emissions.

The 2010 National Algal Biofuels Technology Roadmap[330] portrayed algal biofuels as a potential silver-bullet technology for energy independence and an ideal solution to carbon capture and utilization of coal-fired electrical plant CO_2 flue gas emissions. Algae use sunlight (photosynthesis) to produce oils and alcohols that are the building blocks of advanced biofuel versions of gasoline, diesel, and jet fuel. As a source of biofuel feedstock, algae double in volume every few hours, which can produce volumes of biomass many times greater the than most proliferous land plants. In addition to high productivity,

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[327] Institute for Energy Research, *China to Build 50 Coal Gasification Facilities*, 6 August 2014, http://instituteforenergyresearch.org/analysis/china-build-50-coal-gasification-facilities/
[328] Breaking Energy, Underground Coal Gasification Gets New Start in USA, by Edward Dodge, 6 November 2014, http://breakingenergy.com/2014/11/06/underground-coal-gasification-gets-new-start-in-usav/
[329] RePower South (RPS), http://www.repowersouth.com/
[330] Department of Energy, *National Algal Biofuels Technology Roadmap*, May 2010, http://www1.eere.energy.gov/bioenergy/pdfs/algal_biofuels_roadmap.pdf

algae contain a high percentage of lipids (oils), equivalent to yielding 2000 to 5000 gallons per acre[331]. As far as carbon sequestration, compared to other plants, algae voraciously consume CO_2. Consequently, algal farms could be co-located with CO_2 emission sources like coal-fired power plants and ethanol facilities.

According to the Roadmap, algal biofuels could provide sufficient fuel feedstock to meet the transportation fuels needs of the entire United States, while being completely compatible with the existing transportation fuel infrastructure. A 2014 national survey by the Algae Biomass Organization[332] predicts that algae-based fuels could be cost competitive with gasoline by 2020, which, in turn, could create broad industry and job growth. Algae also have other potential environmental benefits including purifying waste water as well as feedstock for plastics, fertilizers and even food protein. While algal biofuel production works great in the laboratory, it has not been able to be produced at scale. However, genetic engineering may soon be able to produce optimal algae strains that can be commercialized.

In 1985, the coal industry employed 170,500 miners. Today, the number of employees has dropped to 70,800 people. Jobenomics forecasts that the number of jobs associated with the coal industry will remain relatively stable until either government regulates them out of business, or an ETR technology makes coal much cleaner. ETR technologies like clean-coal processes, above-ground gasification, in-situ (underground) gasification, and CO_2 sequestration could revolutionize the industry—if not in the United States, perhaps internationally. If underground coal gasification technology proves to be viable, America could enjoy a major economic and employment boom similar to the recent natural gas boom.

In conclusion, coal will be a major source of energy for the foreseeable future despite its opposition. Coal will be replaced by alternative fuels only when they can produce electricity at competitive kilowatt-hour prices. Via the ETR, the American coal-fired electric power generation industry can be made the global model for efficient coal-burning.

Oil and Natural Gas Employment Outlook.

EIA forecasts that **petroleum and other liquids** will **decrease** their share as a percentage of the total U.S. energy market mix from 37% in 2013 to 35% by 2030, and will slightly **increase** their domestic energy consumption from 35.9 quadrillion Btu in 2013 to 36.5 quads in 2030 for a net increase of 2%[333]. EIA forecasts that **natural gas** will **maintain** its share as a percentage of the total U.S. energy market mix at 28% in 2013 and 2030, and domestic energy consumption will **increase** from 26.9 quadrillion Btu in 2013 to 28.8 quads in 2030, an increase of 7%[334].

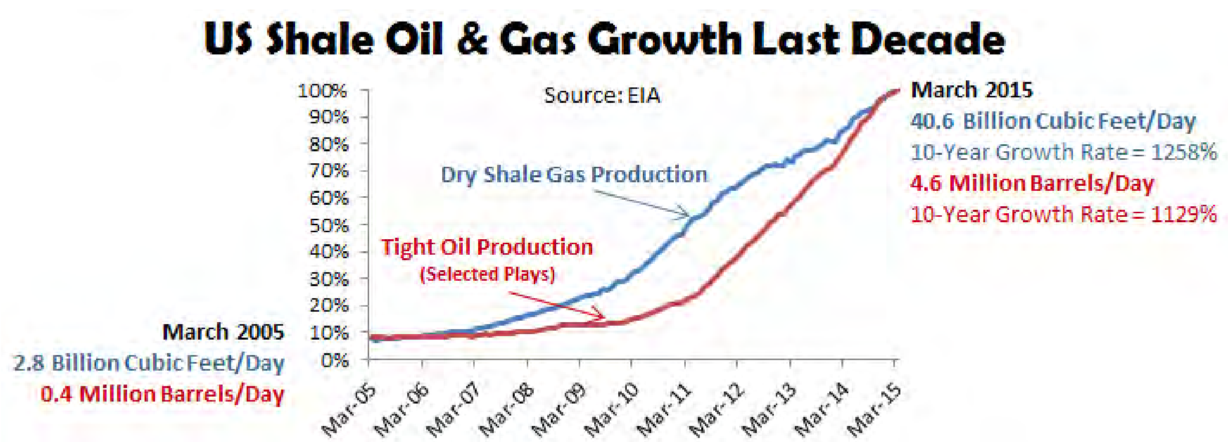
[331] All About Algae.com, Algae Basics: Benefits, http://allaboutalgae.com/benefits/
[332] Algae Biomass Organization, 2014 Industry Survey, http://www.algaebiomass.org/wp-content/gallery/2012-algae-biomass-summit/2014/03/ABO_2014survey_exec_summary_Mar25.pdf
[333] EIA, Annual Energy Outlook 2015, Table A2 Energy Consumption by Sector and Source, http://www.eia.gov/forecasts/aeo/
[334] EIA, Annual Energy Outlook 2015, Table A2 Energy Consumption by Sector and Source, http://www.eia.gov/forecasts/aeo/

According to the American Petroleum Institute[335], as of 2011, the oil and natural gas industry supported 9.8 million full-time and part-time U.S. jobs and 8% of the U.S. economy.

2014 was the best year ever for the U.S. oil and gas industry. The U.S. oil and gas industry will continue to be a booming business in the foreseeable future. To a large degree, the oil and natural gas boom is due to explosive growth in the unconventional oil and gas sector. In addition to unconventional oil and gas production, there are significant near-term employment growth opportunities in liquid natural gas production and shipping, gas-to-liquid technologies and emerging petroleum liquids technologies. In the far-term, methane hydrates reserves could be larger than all other fossil fuel reserves combined.

From a Jobenomics perspective, even if domestic oil and gas consumption remains at current levels, U.S. oil and gas employment could conceivably double or triple by year 2030 via exports of products and services. The biggest obstacle comes from anti-fossil fuel groups and policies that emphasize renewable energy over fossil fuels regardless of how clean or how much cleaner the fossil fuel technology is compared to current energy sources.

Unconventional Oil and Gas. Conventional oil and gas deposits are the ones that historically have been the deposits that were the most practical and easy to exploit and were generally close to the earth's surface. Unconventional oil and gas deposits were the one that were significantly more difficult and expensive to extract. With the advent of new technology, such as horizontal drilling and hydraulic fracturing, these "unconventional" deposits have become "conventional".



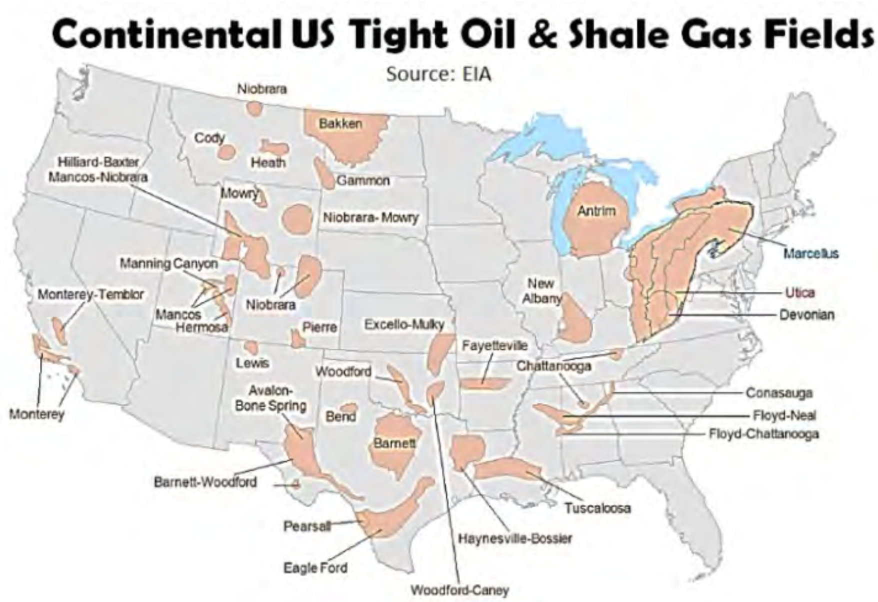
The combination of horizontal drilling and hydraulic fracturing has provided access to large volumes of oil and natural gas that were previously uneconomical to produce from low permeability (tight) geological formations composed largely of shale, sandstone and carbonates.

Over the past decade, dry shale gas production has grown from 2.8 billion cubic feet per day (Bcf/d) to 40.6 Bcf/d, a growth rate of 1258%, and tight oil production of the major shale oil fields has grown from

[335] American Petroleum Institute, Vendor Survey Findings Report 2014, *Oil and Natural Gas Stimulate American Economic and Job Growth*, http://www.api.org/policy-and-issues/policy-items/jobs/~/media/Files/Policy/Jobs/Oil-Gas-Stimulate-Jobs-Economic-Growth/API-State-Vendor-Survey-Findings-Report.pdf

0.4 million barrels per day (Bbl/d) to 4.6 million Bbl/d, a growth rate of 1129%[336]. The United States has approximately 610 trillion cubic feet (40 years' worth at current production rates) of technically recoverable shale natural gas resources (ranked fourth after China, Argentina and Algeria) and 59 billion barrels (35 years' worth) of technically recoverable tight oil resources (ranked second after Russia)[337]. It is important to note, just because a country has technically recoverable reserves, it does not mean that these deposits will be retrieved. Retrieval depends on supply and demand (consumption) as well as other constraints like environment protection.

Shale and tight oil is considered "light sweet" crude oil. Light indicates low viscosity that flows freely. Sweet means that it has low sulfur content compared to "sour" crude oil. The terms sweet and sour came from early oilmen who taste and smell tested oil samples to determine quality. Sour crude tasted bitter and often had the "rotten egg" smell associated with sulfur. Sweet crude is easier to refine and safer to extract and transport than sour mainly due to the corrosive nature of sulfur. Consequently, sweet crude often commands up to a $15 dollar premium per barrel over sour. About 90% of 3 million barrels per day of recent (2011 through 2014) U.S. oil production growth (out of a total U.S. production of over 9 million barrels per day) consists of light sweet grades[338].



Tight sources are typically contained in sandstone formations, whereas shale sources are contained in shale formations. Shale formations consist of stratified sedimentary rock that was formed from consolidated mud or clay and can be split easily into fragile slabs. While both tight and shale sources are accessed via fracking, they respond differently. Eons ago, organic material was trapped in sandy soil that turned into sandstone, and clay soil that turned into layers of shale. As the earth compressed these formations over time, sand particles packed together, leaving small gaps between the spherical grains of sand, thereby providing "tight" spaces where bubbles of natural gas and oil collected. Clay particles tend to be flatter and formed ribbons of sedentary rock that eventually cracked as the earth shifted, creating porous and permeable fractures where small pockets of natural gas and oil pooled. When hydraulic fracking

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[336] EIA, Energy in Brief, Shale in the United States, 20 April 2015, http://www.eia.gov/energy_in_brief/article/shale_in_the_united_states.cfm

[337] EIA, Today in Energy, Shale oil and shale gas resources are globally abundant, 10 June 2013, http://www.eia.gov/todayinenergy/detail.cfm?id=11611#

[338] EIA, Today in Energy, 4 June 2015, Increases in U.S. crude oil production are predominantly light, sweet crude, http://www.eia.gov/todayinenergy/detail.cfm?id=21512&src=email

penetrates these formations, the initial release of gas or oil is much slower from the small bubbles trapped in sandstone as compared to the discharge of concentrated pockets of gas and oil trapped between the fissures in shale. As a result, tight gas wells tend to produce steadily over a longer period of time, whereas shale wells discharge and deplete more rapidly.

The shale sector is much more of a "boom or bust" industry than the tight and conventional oil and gas sectors. While many pundits extol the virtue of the shale sector boom period, others are concerned about how quickly shale wells age—many deplete as much as 65% after the first year. The good news is that there are numerous shale reserves to be exploited (albeit new reserves may not be as lucrative as the original reserves) and new reserves are yet to be discovered. Drillers are even finding new oil formations stacked on top of previously discovered ones. The bad news is that shale companies tend to be small companies that fund exploration and development from debt (e.g., bank loans), which is becoming less available due to oversupply and plummeting prices. The U.S. crude oil inventory is higher than any time in the last 80 years (490.9 million barrels as of April 2015, up 30% since January 2015[339]). Many fear the shale oil bubble is about to pop, ushering in a bust period. However, like other small entrepreneurial companies, shale companies are likely to reconstitute when conditions are more favorable. The shale sector also has mobility to switch from oil to natural gas, especially wet gas that contains feedstock for the petrochemical industry, a less volatile industry that offers higher prices and more stability.

The unconventional oil and gas industry may have an Achilles heel in spite of its overall strength. This weakness is called "induced seismicity," also known as man-made earthquakes. Induced seismicity is thought to be caused by lubricating the fissures in tectonic plates by re-injecting billions of gallons of waste oil and water into depleted wells. This phenomenon is occurring in Oklahoma where earthquakes have increased from 1.6 earthquakes per year, to 64 in 2011, to 585 in 2014, and is on pace for 900 in 2015[340]. The Oklahoma Geological Survey (OGS) Statement of Oklahoma Earthquakes states that "OGS considers it very likely that the majority of recent earthquakes, particularly those in central and north-central Oklahoma, are triggered by the injection of produced water in disposal wells[341]."

The OGS further states that the problem is not with fracking itself but by the extraction and the re-injection of high quantities of waste water by companies that specialize in reviving old wells that were once thought depleted. These old abandoned wells often fill with water that needs to be evacuated prior to revitalization. This evacuated wastewater, often salty and toxic, far exceeds, often by tens of millions of barrels, fracking fluid used in the hydraulic fracturing process. It is this oily re-injected wastewater that causes tectonic plates to slip and cause earthquakes. Most of Oklahoma's observed earthquakes are very minor, but they are increasing in both magnitude and frequency. Historically, the OGS recorded an average of 1.5 magnitude three or greater (M3+) yearly. During 2013, 2.0 M3+ quakes occurred weekly. In 2015, 2.5 M3+ quakes occur daily.

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[339] EIA, This Week In Petroleum, U.S. crude oil stocks, http://www.eia.gov/petroleum/weekly/, and, http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=WCESTUS1&f=W

[340] Bloomberg Businessweek, 27 April 2015, Can This Oil Barron's Company Withstand Another Earthquake?, http://www.bloomberg.com/news/articles/2015-04-23/can-this-oklahoma-oilman-s-company-withstand-another-earthquake-

[341] Oklahoma Geological Survey (OGS) Statement of Oklahoma Earthquakes, 21 April 2015, http://wichita.ogs.ou.edu/documents/OGS_Statement-Earthquakes-4-21-15.pdf

According to the U.S. Geological Survey (USGS), man-made earthquakes have been a reality for decades, induced by impoundment of water in reservoirs, surface and underground mining, and the withdrawal or injection of fluids into underground formations. The USGS states that the only large (magnitude 5.6) wastewater injection-induced earthquake "appears to be" the 2011 earthquake that hit central Oklahoma in 2011[342]. According to the USGS, seismic activity increased in the last few years in the central and eastern United States from 21 M3+ earthquakes per year average from 1973-2008, to 99 M3+ earthquakes per year during 2009-2013, and it continues to rise. The increase in seismicity has been found to "coincide" with the injection of wastewater in deep disposal wells in several locations, including Colorado, Texas, Arkansas, Oklahoma and Ohio. Much of this wastewater is a byproduct of oil and gas production and is routinely disposed of by injection into wells specifically designed and approved for this purpose. According to USGS, "Hydraulic fracturing, commonly known as "fracking," does not appear to be linked to the increased rate of magnitude 3 and larger earthquakes"[343].

Legal challenges against induced seismicity could cripple the unconventional oil and gas industry. The Oklahoma Supreme Court recently accepted a lawsuit from a woman injured by falling debris generated by a seismically-induced earthquake. This is a bellwether case that has nationwide ramifications that would hold (1) the oil and gas industry, (2) hydraulic fracturing companies, and (3) wastewater injection companies liable for seismically-induced earthquake damage or injury. The case clearly identifies the oil and gas industry and fracking companies as main culprits. To be specific, the plaintiff's allegations include this statement: *"Scientists have tied these earthquakes to the disposal of wastewater related to fracking operations ….The waste fluids generated from fracking are often disposed of by injecting the polluted fluids back into the earth under extreme pressure….The oil and gas industry has issued public statements to hide the seismic problems they are creating, and in fact continue a mantra that their operations do not cause earthquakes[344]."*

Regulatory challenges also abound for the fracking industry, especially in "blue" states that advocate anti-fossil fuel policies. Vermont and New York ban fracking altogether. More than 400 American communities have attempted to ban fracking and/or associated industry practices[345]. However, "red" pro-petroleum constituencies are fighting back. The Texas government recently introduced a bill to ban its own cities from imposing prohibitions on fracking and related oil and natural gas drilling activities[346]. Well-paying, middle-class jobs are now a core economic issue, which is encouraging "blue" communities to be more fracking agnostic. In February 2015, fifteen New York towns, angry about the fracking ban, threatened Governor Cuomo about seceding to Pennsylvania so they can take advantage of fracking

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342 U.S. Geological Survey (USGS), Man-Made Earthquakes Update, 17 January 2014, http://www.usgs.gov/blogs/features/usgs_top_story/man-made-earthquakes/

343 U.S. Geological Survey (USGS), Earthquake Hazards Program, Induced Earthquakes, retrieved 6 May 2015, http://earthquake.usgs.gov/research/induced/

344 Sandra Ladra, vs. New Dominion, LLC and Spess Oil Company John Does 1-25, 4 August 2014, Factual Allegations, Page 2 of 7, http://bloximages.newyork1.vip.townnews.com/tulsaworld.com/content/tncms/assets/v3/editorial/8/ce/8ce39d3f-d9b5-5750-a76b-e5c43941f8d5/54c4259fc8dcf.pdf.pdf

345 The Boston Globe, Where communities have banned fracking, 18 December 2014, http://www.bostonglobe.com/news/nation/2014/12/18/where-communities-have-banned-fracking/05bzzqiCxBY2L5bE6Ph5iK/story.html

346 CBS News, Texas seems on verge of banning fracking bans, 5 May 2015, http://www.cbsnews.com/news/texas-seems-on-verge-of-banning-fracking-bans/

economic opportunities afforded[347]. According to IHS[348], the unconventional oil and gas industry added $1,200 per home in 2012 and is on track to add $3,500 per home in energy saving and income by 2025 by an industry that supported 2.1 million U.S. jobs in 2012 and is projected to employ 3.9 million by 2025—unless something like a legal or regulatory trauma derails the practice of fracking.

Anti-fossil fuel activists are using the judicial system in other ways to limit fracking. For example, in May 2015, a North Carolina judge ruled that appointments by the N.C. legislature to state's Mining and Energy Commission are "unconstitutional" since the majority commissioners are appointed by the same legislature that created the commission[349]. With the Commission being deemed unconstitutional, the judge ordered North Carolina to cease accepting or processing fracking permits. Until the constitutionality of the state's appointed Mining and Energy Commission is adjudicated by the state Supreme Court, a de facto moratorium on fracking has been imposed. The N.C. legislature appears to responding with a bill that repeals the state's Renewable Energy and Energy Efficiency Portfolio Standard, which is currently at 6%, substantially below the 12.5% goal by 2021. These standards are not only controversial in North Carolina but also in 22 other states (out of a total of 29 states) that are considering changing Renewable Portfolio Standards. 8 states have a voluntary renewable energy standard or target[350].

Over the next several years, the unconventional oil and gas industry is likely to suffer financial headwinds as opposed to the financial tailwinds that they have enjoyed over the last decade. As reported by BloombergBusiness[351], the industry faces investment challenges due to the dropping price of oil and an accounting glitch that was introduced by the Security and Exchange Commission (SEC) six years ago. Over the last year, the price of crude oil has dropped from over $100 per barrel to around $50, which makes shale oil extraction much less profitable. The glitch introduced by the SEC was originally designed to help the industry by allowing them to claim untapped but proven reserves that would extracted in future years. These reserves were viewed by investors as proof of life and poured in $230 billion worth of capital since 2008. Now comes the glitch—to qualify as a proven reserve, the untapped deposit had to be profitability extracted within five years. Of the 44 shale drilling companies in the Bloomberg Intelligence North America Independent Explorers and Producers Index, more than half of their wells consist of untapped proven reserves. If the price of oil remains low, these deposits will remain untapped and the industry will eventually have to erase them from their books, which could cause investors to take flight. The oil will still exist but many of these drillers might not unless they switch to natural gas, especially wet natural gas as addressed later.

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[347] Huff Post, New York Towns Threaten Secession Over Gov. Cuomo's Ban On Fracking, 20 February 2015, http://www.huffingtonpost.com/2015/02/20/new-york-fracking-secession-southern-tier-cuomo_n_6722296.html
[348] IHS, America's New Energy Future: The Unconventional Oil and Gas Revolution and the U.S. Economy, 4 September 2013, http://www.api.org/~/media/Files/Policy/American-Energy/Americas_New_Energy_Future_Mfg_Renaissance_Main_Report_4Sept13.pdf
[349] WRAL, Judge temporarily halts 'fracking' permits in NC, 20 May 2015, http://www.wral.com/judge-temporarily-halts-fracking-permits-in-north-carolina/14657900/#BZdgauAS0ZkIXZo3.99
[350] National Conference of State Legislatures, State Renewable Portfolio Standards and Goals, 19 February 2015, http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx
[351] BloombergBusiness, Millions of Barrels of Oil Are About to Vanish, 21 May 2015, http://www.bloomberg.com/news/articles/2015-05-21/oil-s-whodunit-moment-coming-with-millions-of-barrels-to-vanish, and BloombergBusiness Magazine, Time to Account for Those Untapped Wells, 7 June 2015, Page 16.

Despite these issues, Jobenomics predicts that hydraulic fracking and horizontal drilling have been and will continue to be game changers. The combination of these technologies makes it economically viable to unlock unconventional sources of gas and oil trapped in America's copious shale deposits. Hydraulic fracking and horizontal drilling have turned America into a major oil producer with an output of 4 million barrels a day from unconventional sources. Hydraulic fracking and horizontal drilling have also turned the international oil and gas industry upside down. Major multi-national oil companies now compete with armies of small independent producers that can rapidly spin up or wind down depending on market conditions. These independent producers usurp power and influence many of America's rivals in OPEC and Russia that depend on oil and gas revenues.

Fracking and horizontal drilling have been the driving forces behind America's vast shale boom, which has led to an all-time high in natural gas production, and oil production highs approaching the all-time highs of the 1970s boom era. Critics of fracking and horizontal drilling point out that the output of these wells is short-lived compared to conventional wells. This is true. However, recent ETR advances have led to the term "super fracking." Super fracking consists of new high-intensity fracking technologies (dedicated to drilling deeper and creating wider cracks), new analytical exploration processes (to more accurately predict reservoirs), new enhanced oil and gas recovery systems and improved discharge and wastewater remediation products.

Super fracking should lead to continued growth in oil and gas production for a number of reasons. First, almost half of the wells drilled do not significantly contribute to production. Better analytical techniques could significantly reduce the number of dry holes or marginally productive wells. Second, current operations can be made more productive. For example, Schlumberger's HiWay flow-channel fracturing technique is advertised to increase productivity by more than 20%, while using 40% less proppants (sand or particulate material suspended in fracking fluids) and 25% less water. Third, and most important, 1st generation fracking systems have relatively low recovery factors that recovered less than 10% of the available oil and gas in the shale formation. Super fracking can conceivably double or triple recovery in both new and existing wells—leading to another and perhaps bigger shale boom.

Fracking and horizontal drilling technologies have put an end to the misnomer of "peak oil." The United States, Canada, China, and Argentina are currently the only four countries in the world that are producing commercial volumes of either natural gas from shale formations (shale gas) or crude oil from tight formations (tight oil). Of the four countries, the United States is by far the dominant producer of both shale gas and tight oil.[352] Today, the hydraulic fracking and horizontal drilling industry is a mostly American-only phenomenon but it will soon migrate to the rest of the world. When this happens, the global energy economy will change in ways never envisioned.

North Dakota had the largest increase (1.9 billion barrels, 51%) in oil reserves among individual states in 2013, and now has more reserves than the federal offshore waters of the Gulf of Mexico. Texas remains by far the leading state in oil reserves with 12 billion barrels. Pennsylvania, West Virginia and Texas reported the largest increases in natural gas proved reserves in 2013. The largest decline of 2013 was in Alaska, where proved reserves decreased by 454 million barrels, due mainly to reduced well performance at large existing oil fields.

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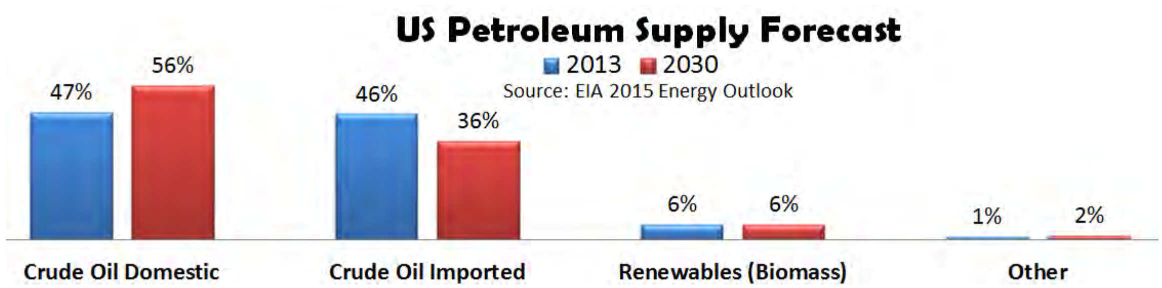
[352] EIA, Today in Energy, Shale gas and tight oil are commercially produced in just four countries, 13 February 2015, http://www.eia.gov/todayinenergy/detail.cfm?id=19991&src=email

Alaska's crude oil production has declined from 1.8 million barrels per day in 1991 to 0.5 million barrels per day in 2014[353]. Alaska's share of the oil and gas labor force is predicted to drop from 7% today to 3% by 2030. However, recent conditional approval for offshore exploratory drilling in the Chukchi Sea (Burger Project, northwest of Alaska in the Arctic Ocean) could revitalize the Alaskan oil industry. The total reserves of the Chukchi Sea are estimated at 77 billion barrels of oil equivalent. The Burger Project lease was initially awarded to Royal Dutch Shell in 2008 for $2.1 billion but has been stalled by environmental and regulatory groups concerned about oil spills in the fragile Arctic offshore ecosystem. Consequently, Shell (perhaps the world's most experienced in company in offshore Arctic oil exploration) is at the center of a larger international debate whether offshore oil production should be allowed in the frigid waters of the Arctic. In June 2015, the 9th U.S. Circuit Court of Appeals upheld the Bureau of Safety and Environmental Enforcement's approval of Shell's Oil Spill Response Plan, which paves the way forward for Shell's drilling fleet to conduct exploratory drilling operations[354]. The Burger Project also contains a large natural gas reservoir.

Petroleum and Other Liquids. 2014 was the best year ever. According to the EIA, *"U.S. oil production growth in 2014 was [the] largest in more than 100 years. U.S. crude oil production (including lease condensate) increased during 2014 by 1.2 million barrels per day to 8.7 million barrels per day, the* ***largest volume increase since recordkeeping began in 1900****. On a percentage basis, output in 2014 increased by 16.2%, the highest growth rate since 1940. Most of the increase during 2014 came from tight oil plays in North Dakota, Texas, and New Mexico where hydraulic fracturing and horizontal drilling were used to produce oil from shale formations….Although oil production is expected to rise in 2015 and again in 2016, the growth is not expected to be as strong as in 2014."* [355]

According to the EIA[356], the combination of record-high U.S. refinery runs (averaging 16,100,000 Bbl/d in 2014) and increased global demand for petroleum products allowed U.S. petroleum product **exports to increase for the 13th consecutive year with 2014 being a record year** averaging 3,800,000 Bbl/d, an increase of 347,000 Bbl/d from 2013. U.S. exports are mostly sent to markets in Central America, South America, Canada and Mexico. At $75/barrel, 3,800,000 Bbl/d equates to over $100 billion per year of U.S. revenue.



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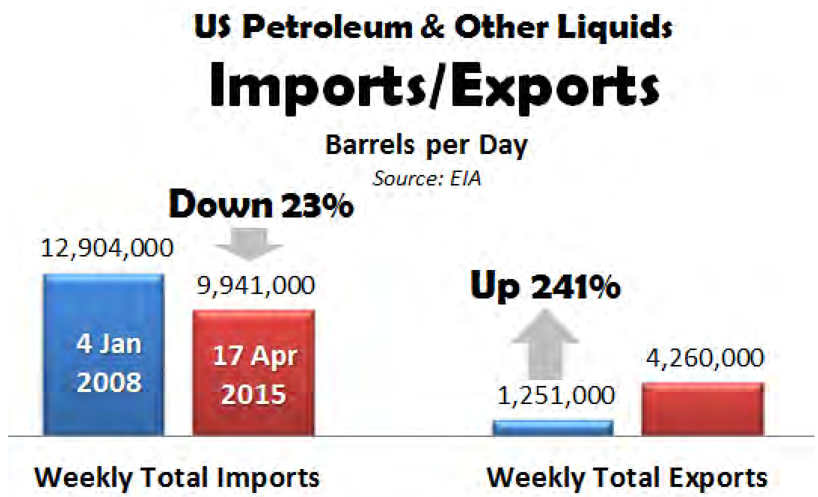
353 EIA, Today in Energy, 12 June 2015, Oil exploration in the U.S. Arctic continues despite current price environment, http://www.eia.gov/todayinenergy/detail.cfm?id=21632&src=email
354 Shell, Shell's Oil Spill Response Plan Upheld by Court, 11 June 2015, http://www.shell.us/aboutshell/projects-locations/alaska/events-news/shells-oil-spill-response-plan-upheld-by-court.html
355 EIA, Today In Energy, U.S. oil production growth in 2014 was largest in more than 100 years, 30 March 2015, http://www.eia.gov/todayinenergy/detail.cfm?id=20572&src=email
356 EIA, Today in Energy, 5 March 2015, http://www.eia.gov/todayinenergy/detail.cfm?id=20232#

According to the EIA's Annual Energy Outlook 2015[357], as a percentage of the total U.S. supply of petroleum products in 2013, domestic crude oil production supplied 47% of U.S. market needs, followed by imported crude oil with 46%, carbon-based renewables (biomass, ethanol and biodiesel) 6% and other petroleum supplies 1%. By 2030, domestic crude oil production is projected to increase by 9%, imported crude oil will drop 10%, renewables will stay the same and other petroleum categories will increase by 1%. The EIA forecasts that the overall petroleum supply will likely remain level over the time period, decreasing slightly from 18,900,000 Bbl/d to 19,400,000 Bbl/d.

The United States is on the path to becoming energy independent. As shown, in January 2008 versus April 2015, total U.S. petroleum and other liquids imports were down 23% compared to exports that have accelerated upwards by 241%[358]. As of 17 April 2015, the weekly average imports were 9,941,000 Bbl/d versus exports of 4,260,000 Bbl/d, for a net import total of 5,681,000 Bbl/d. Peak net imports occurred on 26 May 2006 at 14,009,000 Bbl/d —a 59% decrease from 26 May 2006 to 17 April 2015.



The United States now exports over 500,000 Bbl/d of crude, up from near-zero a decade earlier—which is amazing since crude oil exports are still subject to the 1975 Energy Policy and Conservation Act (EPCA) that banned <u>most</u> U.S. oil exports. The operative word is "most." A company wishing to export crude oil products that are produced in the United States must first obtain a license from the U.S. Department of Commerce's Bureau of Industry. Oil that is exported to Canada, oil that goes through the Trans-Alaskan Pipeline and Alaska's Cook Inlet, and some from California fields are not subject to the ban. Ultralight oil, called condensate, was exempted in 2014. The condensate approved for export comes largely from shale and tight oil. Refined products are also not included. Repealing of the EPCA would significantly increase U.S. oil exports and provide the United States with a powerful new tool in its diplomatic toolkit. In addition, the nature of shale and tight oil (higher value) is not ideal for U.S. refineries that were designed for heavy crude (lower value). The United States can refine low-cost imported crude and export high-cost crude while pocketing the price differential.

U.S. exports of non-crude products (oils, fuels, distillates, renewables, asphalts, etc.) now exceed foreign imports of non-crude products by over 1,500,000 Bbl/d. These trends are projected to continue and

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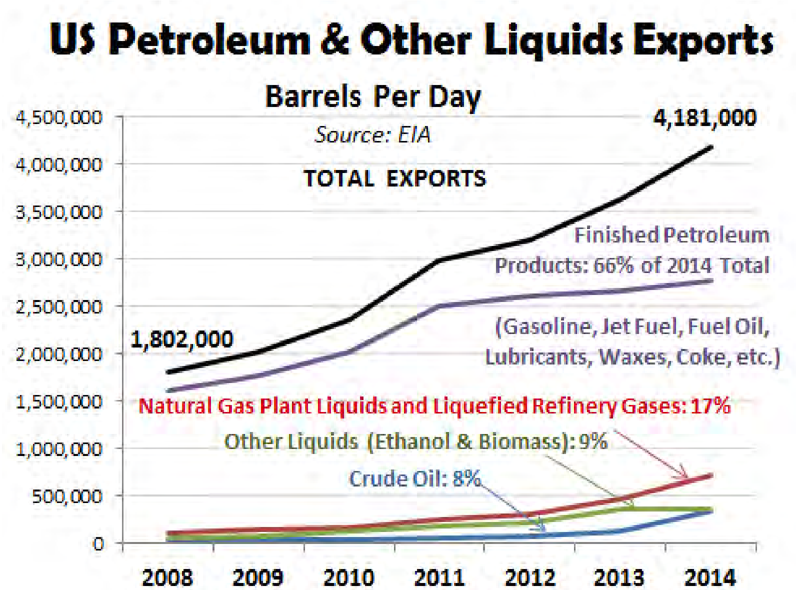
[357] EIA, Annual Energy Outlook 2015, Petroleum and Other Liquids Supply and Disposition, Reference Case, http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2015&subject=0-AEO2015&table=11-AEO2015&region=0-0&cases=ref2015-d021915a
[358] EIA, Petroleum & Other Liquids, Weekly Imports & Exports, http://www.eia.gov/dnav/pet/pet_move_wkly_dc_NUS-Z00_mbblpd_w.htm

possibly increase due to the introduction of new ETR technologies in the production of shale and tight oil, natural gas liquids and renewable liquids.

China is the world's largest net importer of petroleum and other petroleum-based liquid fuels, and the world's second-largest oil consumer following the United States. Sales of private Chinese passenger vehicles have grown by 29% annually over the past 13 years, which significantly increased gasoline consumption. In 2014, China's domestic liquid fuels use was forecast to be 11,000,000 Bbl/d compared to 19,000,000 Bbl/d in the United States. China's liquid fuels imports increased from approximately 5,000,000 Bbl/d in 2011 to an estimated 7,000,000 Bbl/d by 2016, whereas the United States has decreased oil imports from 9,000,000 Bbl/d to 5,000,000 Bbl/d over the same time period[359].



As shown[360], from 2008 to 2014, U.S. petroleum and other liquid exports increased from 1,802,000 Bbl/d to 4,181,000 Bbl/d—an increase of 132% over the last six years. U.S. exports are mostly sent to markets in the Western Hemisphere (Central and South America, Mexico and Canada).

In 2014, finished petroleum products (gasoline, jet fuel, fuel oils, lubricants, waxes, petroleum coke, etc.) claimed 66% of the export market, followed by natural gas plant liquids and liquefied refinery gases (pentane, ethane, propane, butane, etc.) at 17%, other liquids (renewables, unfinished oils and blends) at 9% and crude oil at 8%. Crude oil has made a giant leap with exports of 503,000 Bbl/d on 17 April 2014, up from 58,000 Bbl/d on 3 January 2013—a 767% increase.

Oil and natural gas supply 63% of America's energy needs. Within the last five years, proven U.S. crude oil reserves and proven wet natural gas reserves have increased approximately 80%—a historical record high[361]. Proven reserves are the amount of oil and gas that can be recovered from wells with a reasonable level of certainty. This trend should continue, largely due to massive untapped deposits being unlocked by hydraulic fracking and horizontal drilling in the lower 48 states.

Oil and gas sources are commonly categorized as conventional or unconventional tight or shale. Conventional sources are found in reservoirs that have enough permeability to allow the fluid or gas to

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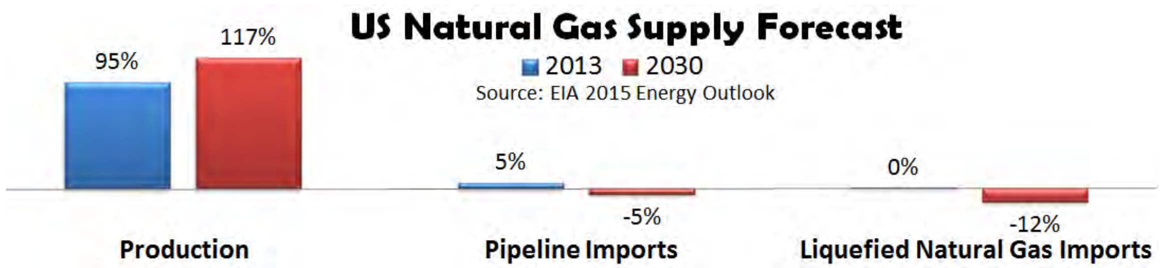
[359] EIA, Comparison of net petroleum and other liquid imports for China and the United States, 24 March 2014, http://www.eia.gov/todayinenergy/detail.cfm?id=15531

[360] EIA, Petroleum & Other Liquids, Weekly Imports & Exports, http://www.eia.gov/dnav/pet/pet_move_wkly_dc_NUS-Z00_mbblpd_w.htm

[361] EIA, Today In Energy, 4/5 Dec 2014, http://www.eia.gov/todayinenergy/detail.cfm?id=19051 and http://www.eia.gov/todayinenergy/detail.cfm?id=19071

move through the rock formation to the well. Unconventional tight and shale sources are found in reservoir rocks with very low permeability that requires assistance (fracking) to release the flow to the wells. The unconventional sector of the oil and gas industry is projected to add 2 million more jobs by 2025[362].

Natural Gas. According to the EIA's Annual Energy Outlook 2015[363], as a percentage of the total U.S. supply of natural gas products in 2013, domestic production supplied 95% of U.S. market needs and 5% was imported via pipelines from Canada and Mexico.



By 2030, domestic natural gas production is projected to increase by a colossal 22% with imported pipeline products dropping 5% and imported liquefied natural gas (LNG) products dropping 10%. Note: annual dry natural gas production will increase from 24.4 trillion cubic feet in 2013 to 33.0 trillion cubic feet in 2030, a gain of 8.6 trillion cubic feet or 35%. The EIA forecasts that the total natural gas supply will increase from 25.75 to 28.27 trillion cubic feet, a 10% increase, which indicates that increased domestic production will be offset by a significant drop in imported natural gas. The EIA also forecasts that the average delivered price of natural gas will increase from $6.32 in 2013 to $11.27 in 2030, a 70% increase.

The majority of this increase is due to growth in shale gas production. Shale gas is natural gas that is found trapped within shale formations. In 1990, shale gas provided only 1% of U.S. natural gas production; by 2013 it was over 39%, and by 2040, 53% of America's natural gas supply will come from shale gas[364]. At current natural gas consumption rates, the U.S. natural gas supply should last for many decades and will be a major producer of American jobs in the fuels and petrochemical industries. Conversely, falling petroleum prices will push a number of America's shale producers into bankruptcy. And a stronger dollar, coupled by weak economies abroad, could hurt exports. 2015 will likely be a pivotal year for the industry.

Natural gas is comprised of organic compounds that include methane (CH_4), ethane (C_2H_6), propane (C_3H_8), butane (C_4H_{10}), and pentane (C_5H_{12}). When natural gas has a high methane concentration, the gas is considered dry. A wet gas is any gas with a small amount of liquid present. When natural gas

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[362] IHS, America's New Energy Future: The Unconventional Oil and Gas Revolution and the U.S. Economy, 4 September 2013, http://www.api.org/~/media/Files/Policy/American-Energy/Americas_New_Energy_Future_Mfg_Renaissance_Main_Report_4Sept13.pdf
[363] EIA, Annual Energy Outlook 2015, Natural Gas Supply, Disposition and Prices, Reference Case, http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2015&subject=0-AEO2015&table=13-AEO2015&region=0-0&cases=ref2015-d021915a
[364] EIA, Shale gas provides the largest source of growth in U.S. natural gas supply, http://www.eia.gov/forecasts/aeo/MT_naturalgas.cfm#shale_gas

contains ethane, butane, or pentane, collectively referred to as natural gas liquids or condensates, it is considered wet. Wet natural gas contains methane, liquefied hydrocarbons and natural gas liquids. The methane in wet natural gas is separated and sold as "dry."

Dry natural gas is typically used in heating, cooling, and electrical power generation. Dry natural gas is transported in its gaseous state via pipelines, or is compressed or liquefied for shipping. Compressed natural gas (CNG) reduces the volume of gas by 300 times and is stored at normal temperatures in fuel storage tanks. Liquid natural gas (LNG) reduces the volume of gas by 620 times and is stored at super-cooled temperatures in double-walled insulated tanks.

Liquefied hydrocarbons and natural gas liquids are collectively known as hydrocarbon gas liquids (HGL). HGL constitutes liquids produced at both natural gas processing plants (NGPL: natural gas plant liquids) and oil refineries (LRG: liquid refinery gases). HGL includes alkanes (ethane, propane, normal butane, isobutane and pentanes) and alkenes (ethylene, propylene, butylene, and isobutylene) that are used as feedstock for various petrochemical and manufacturing applications.

- Ethane is used to make to ethylene that is used to make plastics (polythene) and for other industrial uses. Worldwide production of ethane has grown from 710 thousand barrels/day in 2008 to 1.07 million barrels/day in 2014 (a 50% increase), and is projected to grow to 1.67 million barrels/day by 2018 (an additional 56%)[365].

- Propane is an easily compressible gas used as fuels and refrigerants. Propane production has grown by 51% since 2008. In 2005, the United States imported 20% of its propane. By 2011, the United States became a net exporter of propane. The remaining HGLs have grown anywhere between 33% and 87% since 2008.

- Butane is a highly flammable, colorless, easily liquefied gas used in handheld lighters, industrial torches, and for gasoline blending.

- Pentane is a liquid at room temperate, low cost and relatively safe to handle. Pentane is used as a blowing agent that turns raw plastic material into polystyrene (typically used in plastic cups and containers) and polyurethane (typically used in insulation foams, packaging, furniture padding, memory foam mattresses, coatings, adhesives and sealants).

HGLs are worth anywhere from 2.5 times (in 2014) to 4.0 times (in 2012) the price of dry natural gas. Due to this price differential and increasing demand for HGL-related manufactured products and chemicals, American producers are switching from dry to wet gas. Equally important, the global HGL market is soaring. EIA data show from 2011 to 2016 (estimate), propane production is projected to increase by 76%, followed by butane (65%), ethane (45%) and pentanes (41%)[366].

From an employment perspective, the natural gas industry not only provides energy jobs but underwrites a major portion of the plastics industry. America's Natural Gas Alliance[367] estimates that

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[365] EIA, Hydrocarbon Gas Liquids (HGL): Recent Market Trends and Issues, Table 1, November 2014, http://www.eia.gov/analysis/hgl/pdf/hgl.pdf
[366] EIA, Short-Term Energy Outlook, 12 May 2015, Table 4b : U.S. Hydrocarbon Gas Liquids (HGL) and Petroleum Refinery Balances, http://www.eia.gov/forecasts/steo/tables/?tableNumber=27#
[367] America's Natural Gas Alliance, Jobs, http://anga.us/issues-and-policy/jobs#.VIsRwSvF9u5

the U.S. natural gas industry employed 2.8 million direct, indirect and induced jobs as of 2008—up 17% in two years. New U.S. unconventional sources of natural gas should add 1.4 million additional jobs as well as 1 million more in the United States manufacturing sector (i.e., HGL products). In 2010, unconventional and shale gas employed 600,000 and 1,000,000 respectively. By 2035, these jobs are forecast to increase to 1,700,000 and 2,400,000 for a total of 4.1 million people.

Liquefied Natural Gas (LNG) and Gas-to-Liquids (GTL). Due to excess natural gas supplies, new export industries could be created, including liquefied natural gas (LNG), gas-to-liquid (GTL), and shipbuilding.

LNG Tanker & GTL Plant

For the domestic market (short distances and small loads), compressed natural gas (CNG) delivered by trucks is usually the preferred method of transportation. For international markets (long distances and large loads), LNG or GTL delivered by ships is the preferred method of transportation. LNG involves converting natural gas to a liquid form for transportation and then returning it to its natural state (regasification) at delivery, whereas GTL involves is a process that converts natural gas directly to liquid fuels such as gasoline, jet fuel, and diesel.

There are five GTL plants operating globally ranging from 2,700 Bbl/d to 140,000 Bbl/d[368]. Two GTL plants are operational in Qatar, two in Malaysia and one in South Africa. One plant is under construction in Nigeria. Three plants are proposed in the United States—in Lake Charles, Louisiana; Karns City, Pennsylvania; and Ashtabula, Ohio. The most common technique used at GTL facilities is the Fischer-Tropsch (F-T) process that produces transportation fuels, waxes and lubricants. F-T waxes are used to produce candles, paints, coatings, resins, plastic, synthetic rubber, tires and other products.

Due to high capital costs, market uncertainty, and low gasoline prices, the construction of these American GTL plants is in question. As of January 2015, the South African petrochemical company Sasol was delaying a decision on whether to move forward with a proposed $14 billion gas-to-liquids facility outside of Lake Charles, Louisiana, in response to falling oil prices[369]. The plant was designed to convert natural gas into diesel fuel and other liquids, producing 96,000 Bbl/d. However, Sasol still plans to move forward with an $8 billion ethane cracker that will produce ethylene, a key ingredient in food packaging, fragrances, detergents and tires. The ethane facility is scheduled to be operational in 2018. The $24 billion Sasol GTL/ethane/petrochemical complex was to be one of the largest foreign investment projects in U.S. history. As a result of these delays, EIA's Annual Energy Outlook 2015 (AEO2015) Reference Case projection does not include any large-scale GTL facilities in the United States

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[368] EIA, Today in Energy, 19 February 2014, Gas-to-liquids plants face challenges in the U.S. market, http://www.eia.gov/todayinenergy/detail.cfm?id=15071
[369] The Times-Picayune, Sasol delays $14B gas-to-liquids plant near Lake Charles during oil price slump, 28 January 2015, http://www.nola.com/business/index.ssf/2015/01/sasol_delays_14_billion_gas-to.html

through 2040. Small-scale U.S. GTL plants that focus more on wax and lubricant production are likely to be more economically viable than large-scale plants that are designed to produce transportation fuels.

The conversion of natural gas to liquid (GTL) at or near the source represents a way to monetize stranded natural gas. Jobenomics has been working with micro GTL plant engineers and designers who developed a miniature natural gas to liquid plant that can be used for stranded national gas applications, e.g., gas that is too dirty, too low pressure or too far from a pipeline to be retrieved.

Micro GTL plants (shown) can be transported by truck to remote locations across America. This system uses Fischer-Tropsch[370] technology to convert gas to pure diesel that can easily be transported or used locally. The primary application of this system is to help revitalize the American marginal well industry that has contributed nearly $300 billion to the U.S. economy in the last decade.

Micro GTL Plant

There are 771,000 U.S. marginal wells[371] including stripper (wells that produce less than 10 Bbl/d), marginal (unprofitable wells), idle (temporarily non-producing wells), and plugged/abandoned (wells that have ceased operation, in many cases due to flaring restrictions). The estimated lost revenue from these wells is approximately $750 million/year, mostly to small business owners in rural parts of America. If micro GTL plants could reclaim $^{1}/_{3}$ of this lost revenue, 150,000 new direct, indirect and induced jobs could be created in remote areas where unemployment is highest and new jobs are needed the most. The ultimate potential is an order of magnitude higher if all stranded gas is considered. Stranded natural gas is that gas that is too remote, too dirty or too far from existing pipelines.

The U.S. currently has eleven facilities (3 in Massachusetts, 3 in Louisiana, 2 in Texas, and 1 each in Maryland, Georgia, and Mississippi) capable of receiving LNG[372]. The first U.S. facility to export natural gas will be the Cheniere Energy's (LNG) Sabine Pass liquefaction terminal in Sabine, Louisiana[373]. The Sabine terminal was originally built for LNG imports in 2008, but the dramatic rise in domestic natural gas production cut the demand for imports. Adding liquefaction capabilities will transform the Sabine Pass terminal into a bi-directional facility capable of liquefying and exporting natural gas as well as importing and regasifying foreign-sourced LNG. The Sabine Pass site can readily accommodate up to 4 LNG trains capable of processing 2 billion cubic feet per day (Bcfd) of natural gas. Export operations are expected to commence in late 2015 or early 2016.

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[370] Fischer and Tropsch were two German scientists who converted coal to diesel fuel to support WWII efforts.
[371] National Stripper Well Association, Stripper Well Facts, http://nswa.us/custom/showpage.php?id=25
[372] Center for Liquefied Natural Gas, Imports, http://www.lngfacts.org/lng-market/imports/
[373] Cheniere Energy, http://www.cheniere.com/lng_industry/sabine_pass_liquefaction.shtml

As of 14 April 2015, a total of 18 U.S. LNG export terminals have been proposed to the U.S. Federal Energy Regulatory Commission (FERC)[374]. These proposed terminals are in Coos Bay, Oregon (0.9 Bcfd), two in Lake Charles, Louisiana (2.2 and 1.07 Bcfd), Astoria, Oregon (1.25 Bcfd), Lavaca Bay, Texas (1.38 Bcfd), Elba Island, Georgia (0.35 Bcfd), two in Plaquemines Parish, Louisiana (1.07 and 0.30 Bcfd), Sabine Pass, Texas (2.1 Bcfd), Pascagoula, Mississippi (1.5 Bcfd), Robbinston, Maine (0.45 Bcfd), Cameron Parish, Louisiana (1.34 Bcfd), Jacksonville, Florida (0.075 Bcfd), Hackberry, Louisiana (1.4 Bcfd), Port Arthur, Texas (1.4 Bcfd), and three in Brownsville, TX (0.54, 0.94, and 3.6 Bcfd). If these terminals come to fruition, Louisiana will have 7 LNG export terminals (including Cheniere Energy's Sabine Pass), followed by Texas with 6 terminals, Oregon 2, Florida 1, Maine 1, Georgia 1, and Mississippi 1.

According to a 2013 study from ICF International[375], employment from LNG exports is expected to create or support between 73,100 and 452,300 jobs between 2016 and 2035. 7,800 to 76,800 of those jobs will be in manufacturing, with 1,700 to 11,400 being specifically in the refining, petrochemicals and chemicals sectors.

According to the EIA[376], the U.S. natural gas industry net **imports** were 1.22 trillion cubic feet by pipelines (Canada and Mexico) and 1.35 trillion cubic feet from LNG vessels in 2013. By 2030, EIA projects **exports** of +2.43 trillion cubic feet via pipelines and +3.37 trillion cubic feet via pipelines and LNG vessels. Consequently, the difference in net new revenue between 2013 and 2030 is estimated to be the value of 6.38 trillion cubic feet of natural gas. The latest yearly average price for exported pipeline gas was $5.51 per thousand cubic feet and $15.66 per thousand cubic feet for LNG[377]. Without escalating these prices for future inflation, net new revenue between 2013 and 2030 would be worth $17 billion for pipelines (which transitions from net imports to net exports in 2020) and $511 billion for LNG (which transitions from net imports to net exports in 2016) for a total of $528 billion in new revenue, or $31 billion per year. Using a middle-class salary and benefits of $75,000/year, approximately 414,000 direct jobs would be created and close to 1.6 million total direct, indirect and induced jobs—not including new construction and potential new LNG shipbuilding jobs.

According to U.S. Congressman Garamendi[378], the Ranking Member of the House Committee on Transportation and Infrastructure's Subcommittee on the Coast Guard and Maritime Transportation, the U.S. government should use U.S. shipyards to build LNG supertankers, much in the same way that the U.S. is building warships for the U.S. Armed Forces. The U.S. domestic shipping industry is responsible for nearly 500,000 jobs and more than $100 billion in annual economic output[379].

Today, foreign shipbuilders are likely to build most, if not all, of U.S. LNG ships unless the U.S. government determines that U.S.-built LNG carriers are a national priority and national asset. It will also revitalize the declining U.S. Navy shipbuilding industry. In WWII, the U.S. Navy had 6768 active ship

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374 Federal Energy Regulatory Commission, http://www.ferc.gov/industries/gas/indus-act/lng/lng-export-proposed.pdf

375 Center for Liquefied Natural Gas, Exports, http://lnginitiative.org/facts/

376 EIA, AEO2015, Market Trends: Natural gas, With production growing faster than use, the U.S. becomes a net exporter of natural gas, Figure MT-42, http://www.eia.gov/forecasts/aeo/mt_naturalgas.cfm

377 EIA, Natural Gas Prices, http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm

378 The Marine Executive, LNG Carriers Could Revitalize U.S. Shipbuilding, 9 April 2015, http://www.maritime-executive.com/article/lng-carriers-could-revitalize-us-shipbuilding

379 Shipbuilders Council of America, https://shipbuilders.org/who-we-are

force levels (warships). In the 1970s, the U.S. Navy active ship levels had dropped below 1000. Today, they have 281 including 42 auxiliary supply ships.

The world LNG tanker fleet consists of 402 vessels, with 143 on order[380], built predominantly by South Korean and Japanese shipbuilders (Samsung Heavy Industries, Daewoo, Hyundai, and Kawasaki). According to Reuters[381], the global LNG fleet needs to grow by 225 vessels by 2021; with 125 on order, that leaves 100 vessels up for grab. China plans to enter the LNG shipbuilding industry in an aggressive way as part of a plan to restructure its ailing shipbuilding sector and secure its energy supply chain. There is no reason why America should relinquish the ability to export U.S. LNG on U.S.-flagged vessels when it has its own shipbuilding industry. At a minimum, the U.S. should insist on significant work-share or offset programs involving U.S. LNG carriers built in South Korea or Japan—after all, U.S. Navy ships are defending these countries as well as protecting their supply lines.

The global LNG fleet of approximately 400 vessels transports 11.5 trillion cubic feet per year[382]. As stated, the U.S. will soon be exporting 3.37 trillion cubic feet of LNG per year by these vessels. Using a rough proportional calculation, the U.S. fleet should be comprised of approximately 117 vessels. New LNG carriers cost approximately $200 million to build, which puts the total U.S. LNG fleet cost at $23 billion dollars, or roughly $1.5 billion per year through 2030. Using a middle-class salary and benefits of $75,000/year, up to 20,000 direct jobs and 100,000 total direct, indirect and induced jobs would be created—not counting facility upgrades and R&D jobs or the emerging floating storage and regasification market.

As opposed to building full-scale onshore storage or regasification terminals, many smaller markets are choosing to use specialized ships called floating storage and regasification units (FSRUs) as a cost-effective way to receive, store and process shipments of liquefied natural gas, or as a temporary solution until onshore facilities are built. As compared to onshore regasification, the floating regasification market share has grown from 0.8% in 2006 to 8.8% in 2015[383]. Globally, 10 out of 29 LNG importing countries have floating regasification capacity. An FSRU can be purpose-built or be converted from a conventional LNG vessel. There are currently 21 FSRUs in service. According to the IGU 2014 World LNG Report[384], an additional 23 countries have put forth plans to add offshore regasification capacity. By 2030, world demand for LNG is projected to double—much of which supplied by the United States. From an economic, political and security perspective, America should play a major role in the entire LNG supply chain from natural gas production, to liquefaction, to transportation and finally to regasification.

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380 Lloyd's List Intelligence, LNG, Fleet Summary, http://www.lloydslistintelligence.com/llint/gas/index.htm
381 Reuters, China to build more LNG tankers in high-tech push, 5 August 2014, http://uk.reuters.com/article/2014/08/05/china-lng-ships-idUKL3N0O838P20140805
382 Alaska Natural Gas Transportation Projects, Office of the Federal Coordinator, LNG carriers called 'floating pipelines', by Stan Jones, 29 April 2014, http://www.arcticgas.gov/lng-carriers-called-floating-pipelines
383 EIA, Today in Energy, Floating LNG regasification is used to meet rising natural gas demand in smaller markets, 27 April 2015, http://www.eia.gov/todayinenergy/detail.cfm?id=20972
384 International Gas Union, World LNG Report-2014 Edition, 6.7. Floating And Offshore Regasification, http://www.igu.org/sites/default/files/node-page-field_file/IGU%20-%20World%20LNG%20Report%20-%202014%20Edition.pdf

Methane Hydrate. Methane hydrate (also known as natural gas hydrate, methane clathrate, or colloquially as "fire ice" or "flammable ice" since it is ice that burns fervently as shown) is an extremely abundant, untapped, energy source that is estimated to be twice as large as all fossil fuel reserves combined.

Methane hydrates are ice-like solids that consist of methane and water. In nature, a hydrate is a compound where water molecules are chemically bound to another element, often in a crystalline structure resembling ice. Methane hydrates are formed by ancient decomposed microorganisms that are encased in high-pressure "ice cages" found on or under frigid sea floors or in permafrost layers of the earth's surface that remain frozen year around. Hydrates store large amounts of gas in an extremely compacted area. One cubic meter of hydrate can hold around 160 cubic meters of methane and 0.8 cubic meter of water[385]. When temperatures are increased or pressure decreased, the ice turns to water and the gas released.

Permafrost methane hydrate has been a legitimate climate change concern for years. Since permafrost methane is trapped only a few meters below the earth surface, it is subject to release by thawing due to any temperature increase above the freezing level. It is estimated that there are several thousand times more methane in the permafrost than the atmosphere, so even partial thaws could cause significant emissions release. Environmental researchers are also concerned about maritime methane hydrate extraction and its effects on slope stability, and ocean contamination and acidification.

This ubiquitous resource also presents an energy opportunity that is being pursued by numerous countries. According to the United Nations Environment Programme (UNEP)[386], the global inventory of methane hydrates is estimated somewhere between 100,000 and 1,000,000 trillion cubic feet. As a means of comparison, there is about 2,266 trillion cubic feet of technically recoverable resources of natural gas in the United States[387]. Also according the UNEP, the deposits that appear to be most conducive to production using adaptations of conventional hydrocarbon recovery methods are the Alaska North Slope, northwestern Canada, the Gulf of Mexico, and offshore Japan.

The U.S. Department of Energy is funding methane hydrate research in Alaska and in the Gulf of Mexico. According to a 2014 DoE Methane Hydrates Advisory Committee report to Congress[388], methane hydrate represents an opportunity of the scale of the recent U.S. shale boom, with technically recoverable reserves of 85 trillion cubic feet on onshore Alaskan hydrates and 13,000 trillion cubic feet in offshore Gulf of Mexico and Atlantic hydrate locations (the report does not include Pacific Ocean locations).

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[385] Oil & Gas Journal, Challenges Of Methane Hydrates, 7 May 2014, http://www.ogfj.com/articles/print/volume-11/issue-5/features/challenges-of-methane-hydrates.html

[386] United Nations Environment Programme, Frozen Heat: A Global Outlook on Methane Gas Hydrates, 2014, Page 20, http://www.netl.doe.gov/File%20Library/Research/Oil-Gas/methane%20hydrates/gas-hydrate-global-assessment-executive-summary.pdf

[387] EIA, Frequently Asked Questions, How much natural gas does the United States have and how long will it last?, as 1 January 2012, retrieved June 2015, http://www.eia.gov/tools/faqs/faq.cfm?id=58&t=8

[388] DoE, Methane Hydrates Advisory Committee, 21 May 2014, http://energy.gov/sites/prod/files/2015/06/f22/MHAC_Recommendations_to_Secretary_5_21_2014.pdf

The DoE Methane Hydrates Advisory Committee report also emphasized that the U.S. methane hydrate program is a risk due the lack of funding and emphasis. According the report, the Japanese invested more in their 2013 marine field production test than the U.S. has spent during its entire 15-year methane program. Furthermore, the U.S. has conducted only two short-term Arctic production tests and a single offshore drilling program compared to lesser developed countries, like India that has comprehensively investigated more than two-dozen offshore methane hydrate locations.

Most of the world, including the United States, is watching the Japanese gas hydrate extraction efforts. As discussed earlier, due to power density issues, ramifications of the Fukushima nuclear accident, national dependence and high costs of foreign oil and LNG imports, the Japanese are highly motivated to exploit this abundant offshore but difficult to exact energy resource.

In 2013, the state-controlled Japan Oil, Gas and Metals National Corporation (JOGMEC) was the first company to successfully extract offshore methane hydrate gas from the ocean. The drilling was conducted from a Japanese vessel (shown) in Japanese coastal waters. Over a six day period, the JOGMEG methane hydrate exploration ship extracted approximately 20,000 cubic meters of gas per day. Based on extraction data, the total amount of natural gas at this particular location (Nankai Trough in the Pacific Ocean) is estimated to be 1.1 trillion cubic meters (38.8 trillion cubic feet) of natural gas, enough to power the entire nation of Japan for 14 years[389]. A separate study from the National Institute of Advanced Science and Technology estimated that there is about 100 years' worth of methane hydrate (7 trillion cubic meters or 247 trillion cubic feet) in the waters surrounding Japan[390].

Many environmentalists feel that the Japanese maybe too motivated. Methane hydrates in deep sea beds are perceived as "fragile" and are stabilized not only by frigid temperatures but by high water pressure. Methane hydrates destabilize in response to warming of only a few degrees. Methane gas is significantly more potent to atmospheric warming than carbon dioxide emissions. The degree of disturbance to cause a mass release of methane emissions is unknown and is subject to much more research in order to gain consensus within the scientific community about near-term consequences. Conversely, from a near-term climate change perspective, methane hydrates offer a major opportunity for countries like China and India to switch from coal to gas (much in the same way U.S. scale gas is causing American utilities to switch from coal to gas) in order to reduce emissions by 40% versus coal and 20% versus oil.

[389] Japan Oil, Gas and Metals National Corporation (JOGMEC), Methane Hydrates: A Next-Generation Resource, http://www.jogmec.go.jp/english/oil/technology_015.html

[390] HIS, Japan's methane hydrates natural gas extraction – a game changer?, 23 May 2013, http://blog.ihs.com/japans-methane-hydrates-natural-gas-extraction

According the US Geological Survey[391], depending on a number of caveats with "political will" at the top of the list, the first commercial scale production for permafrost methane hydrate production in the Arctic could occur between 2022 and 2029, and the first commercial scale production for deep water marine methane hydrate in Asia (Japan, South Korea, China, India) could occur between 2025 and 2034. According to the Japanese Petroleum Exploration (JAPEX)[392], a contractor that is supporting JOGMEC's 2016-2018 Medium-to-Long-Term Offshore Production Test, methane hydrate production in Japan could potentially start before year 2020.

From an employment perspective, methane hydrate extraction and usage is difficult to project. If it reaches the scale of U.S. shale industry, tens of millions of new jobs could be created internationally.

Natural Gas and Methane Emissions. In a climate change context, the oil and gas industry is (1) the largest industrial source of emissions of nitrogen oxides and volatile organic compounds that contribute to ground-level ozone or smog, and (2) a significant source of methane emissions[393]. Ground-level ozone is largely caused by industrial facilities and electric utilities emissions, motor vehicle exhaust and chemical solvents that pollute the air we breathe. Methane emissions are caused mainly by leakage across the entire value chain.

Natural gas is a gas in its raw state that requires minimal processing. Consequently, natural gas creates fewer CO_2 and other atmospheric emissions in its production and use than other fossil fuels. However, natural gas is a major source for methane emissions. Methane emissions occur in all sectors of the natural gas industry, from production (45%), through processing (12%) and transmission/storage (27%), to distribution (16%)[394]. Dry natural gas is 95% methane and is delivered via 1.6 million miles of dedicated U.S. pipelines to end-users (largely homes and businesses). The vast length of the transportation chain makes natural gas susceptible to sabotage and terrorist attacks.

Some of the largest methane emissions occur during the fracking flowback phase where fluids and gas regurgitate to the surface. These gases are often burned in a controlled process, called flaring. Flaring is also used to burn off unwanted gas or as a cost-effective alternative to building a waste-gas capture or transport infrastructure.

According to The World Bank's Global Gas Flaring Reduction Partnership[395], 140 billion cubic meters (Bcm) are flared annually. The United States is ranked fifth globally with 7.1 Bcm, behind Iraq (9.4), Iran (11.4), Nigeria (14.6), and Russia (37.4). The amount of annually flared gas is equivalent to the combined gas consumption of all of Central and South America. Gas flared in Africa alone is equivalent to half of that continent's power consumption from all fuel sources.

Given the massive amount of gas flared and the 400 million tons of CO_2 in annual gas emissions, turning unusable flare gas into a commodity would be a major technological achievement.

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[391] US Geological Survey, Gas Hydrates Primer, http://woodshole.er.usgs.gov/project-pages/hydrates/primer.html
[392] Japanese Petroleum Exploration (JAPEX), https://www.japex.co.jp/english/technology/metan.html
[393] U.S. Environmental Protection Agency (EPA), Oil and Natural Gas Air Pollution Standards, Basic Information, Emissions from the Oil & Natural Gas Industry, http://www.epa.gov/airquality/oilandgas/basic.html
[394] EPA, Natural Gas STAR Program, http://www.epa.gov/gasstar/basic-information/index.html#overview2
[395] The World Bank, Global Gas Flaring Reduction, Estimated Flared Volumes from Satellite Data, 2007-2011, Page 2,http://siteresources.worldbank.org/INTGGFR/Resources/Guidance_Document_Flaring_Estimates_Produced_by_Satellite_Observations.pdf

Jobenomics has examined a number of such technologies. For example, micro-scale LNG technology that liquefies flare gas for off-site processing, and combustion technology that converts dirty flare gas (and other dirty fuels) into pure natural gas, can be used to produce on-site electricity. North Dakota's Bakken oil and gas wells flare nearly $1 billion worth of unwanted gas each year. Monetizing this wasted energy could create a significant number of startup businesses and new jobs, as well as reducing CO_2 and CH_4 emissions.

The good news is that the natural gas industry is investing heavily in emission mitigation and security. The latest EPA Inventory of Greenhouse Gases[396] found that natural gas methane emissions fell 15% from 1990 to 2013, while natural gas production grew 37% during the same period.

[396] EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2013, 15 April 2015, http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Main-Text.pdf

ETR Employment Outlook for Net-Zero Communities/Buildings

Net-zero communities are decentralized micro-grids that eliminate or reduce the need for centralized, vulnerable and expensive utility-grade grid energy and services. A "net-zero building" is a governmental, industrial, commercial or residential building that produces and consumes equal amounts of energy. In the United States, buildings account for 65% of electricity consumption, 36% of total energy consumption and 30% of greenhouse gas emissions[397]. Since there are 132 million residential housing units versus 5 million commercial and industrial buildings in the United States, the residential sector is the likely place to focus on net-zero communities.

Burlington, Vermont, the state's largest city, is the first U.S. net-zero community that produces "100%" of their residential electrical power needs from renewables (estimated hydropower 45%, wood biomass 35%, wind 20%, and limited solar)[398]. The Hawaii is the first state, by law, in the nation to set a 100% renewable portfolio standard for the electricity sector[399]. Apple Inc.'s plans to be the first major company be a 100% net-zero (renewable energy) company.

Apple's approach to Net Zero entails engineering gains in energy efficiency, producing indigenous renewable energy, partnering in major renewable energy projects, and purchasing renewable energy from outside venders. In 2014, 100% of Apple's U.S. operations and 87% of Apple's worldwide operations were powered by renewable energy including all their data centers, corporate offices that house 50,000 employees, and over 450 Apple retail stores around the world[400]. Apple renewable energy plans also include their entire supply chain and products—energy consumed by their products represents 21% of their carbon footprint.

Self-sufficient net-zero communities such as these could substantially reduce the cost of modernizing the aging U.S. long-distance electrical grid. In addition, implementation of emerging distributed and dispersed generation technologies, processes and systems will help American communities become energy sufficient, save money and reduce GHG emissions. Tomorrow's smart, integrated net-zero communities could be self-sufficient in terms of energy production and consumption, and independent of the outside grid with the exception of providing backup power to other communities.

Residential energy trends are clear: significantly more energy efficiency and more indigenously produced power. In 2013, U.S. residents consumed 21.10 quadrillion Btu of energy. By 2030, residential energy consumption is projected to decrease 1% to 20.48 quadrillion Btu[401].

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[397] EPA, Green Buildings, http://www.epa.gov/oaintrnt/projects/

[398] PBS News Hour, Running on renewable energy, Burlington, Vermont powers green movement forward, 31 January 2014, http://www.pbs.org/newshour/bb/vermont-city-come-rely-100-percent-renewable-energy/

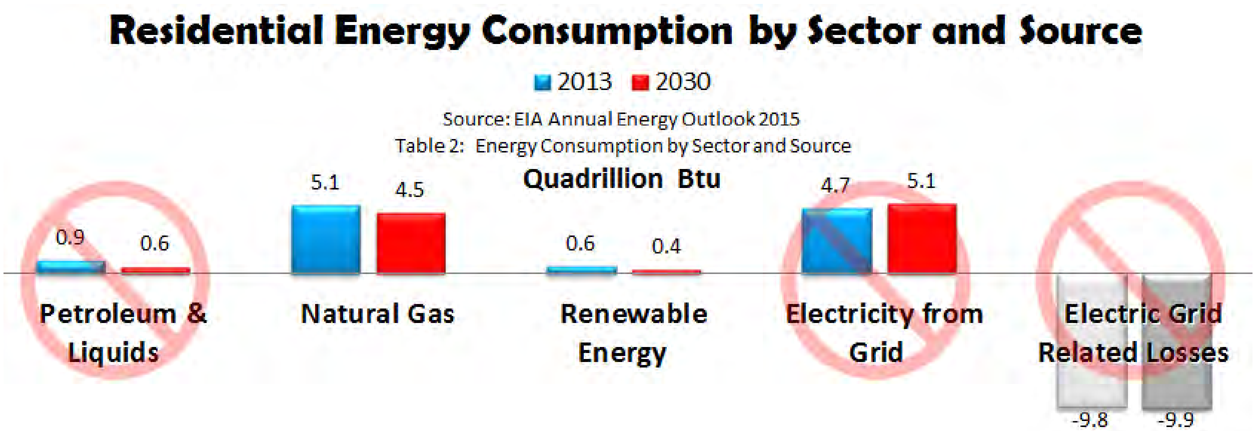
[399] Hawaii News Now, Gov. Ige signs bill setting 100 percent renewable energy goal for state, 8 June 2015, http://www.hawaiinewsnow.com/story/29269793/gov-ige-signs-bill-setting-100-percent-renewable-energy-goal-for-state

[400] Apple, Environmental Responsibility Report, 2015 Progress Report Covering FY2014, http://images.apple.com/environment/pdf/Apple_Environmental_Responsibility_Report_2015.pdf

[401] EIA, Annual Energy Outlook 2015, Table A2, Energy Consumption by Sector and Source: Residential, http://www.eia.gov/forecasts/aeo/

If adjusted for increasing numbers of households and more total floor space per household, the aggregate energy intensity per household and per square foot is expected to decline as much as 50% based on historical trends[402].

On the other hand, the residential energy mix is increasing dramatically to indigenously-produced power. 2014 marked the first year for rooftop solar to break the 1GW threshold with an all-time high of 1.2GW or 19% of all solar photovoltaic power. The residential market remained the fastest growing segment in the solar industry with half coming on-line without state incentives[403]. The vast amount of indigenously-produced residential power is not connected to a net metering system and consequently is not reported in EIA projections.



According to EIA's 2015 Outlook report that reports on on-grid generation, the renewable energy portion of total residential energy consumption is projected to decrease (0.6 quads to 0.4 quads) while grid usage is projected to increase (4.7 quads to 5.1 quads). Equally surprising, already massive electrical grid related losses during transmission and distribution are also expected to increase slightly (-9.8 quads to -9.9 quads). Given today's emphasis on energy efficiency and clean technology, this scenario is misleading, since the future of residential energy is with distributed and dispersed technology. From a Jobenomics perspective, the best forward fix is to replace (shown by ⃠) petroleum and electrical grid energy sources via a point-of-consumption architecture that integrates multi-sources of indigenously-produced energy (wind, solar, biomass, geothermal and/or natural gas) equipped with small-scale residential storage devices.

Producing energy at the point-of-consumption would save about 9.9 quads of electric grid-related losses, 5.1 quads of electricity from the grid, and 0.6 quads of petroleum for a total of 15.6 quads out of the total 20.10 quads in the EIA's 2030 residential energy projection—a whopping 80% energy savings. A point-of-consumption architecture could also save homeowners and renters billions of dollars that could be deployed to produce many millions of net new jobs and local businesses.

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[402] EIA, Drivers of US Household Energy Consumption, 1980-2009, 3 February 2015, http://www.eia.gov/analysis/studies/buildings/households/?src=email, Note: during the 1980-2009 time period, households increased by 33% and total floor space by 52%.
[403] SEIA, Solar Market Insight Report 2014Q4, http://www.seia.org/research-resources/solar-market-insight-report-2014-q4

Energy upgrades to existing homes and energy options for new homes would include renewable energy and natural gas devices and storage systems, fuel cells, computer controlled sensing and management systems, super-insulated walls and ceilings, automated LED lighting, integrated energy saving appliances, energy efficient landscaping and hardscaping, advanced building materials, plug-in vehicle systems, and net-metering systems that would allow homeowners to provide excess energy to the net-zero community grid. In the future, new systems will be available: spray-on solar cell paint, dynamic windows, sunlight harvesters, salt water air conditioners, waste-heat capture systems, tradable carbon credits for green homes and carbon sequestration, high performance coatings, intelligent cladding systems, anaerobic digesters for food and human waste, recycling water systems and a host of other emerging ETR technologies, processes and systems.

Financing for a national Net-Zero Community initiative would come from homeowners, developers and builders, utility companies, private sector investors, government, GSEs (government-sponsored enterprises), and insurance companies.

- **Homeowners.** According to the BLS[404], in 2013 the average household spent $3,477 on utilities and $2,611 for gasoline for a total energy expenditure of approximately $6,000, 12.4% of their annual expenditures. Consequently, America's 132,802,859 households spend approximately $800 billion/year on energy-related expenditures, which could be used for net-zero projects and services.

  In order to make the Net-Zero Community initiative highly-scalable, homeowners should be offered incentives, like rebates and leasing options, oriented to middle-class homeowners. The areas that experienced the most rooftop solar growth from 2011-12 had median incomes from $40,000 to $50,000 in Arizona and California, and $30,000 to $40,000 in New Jersey[405]. Middle-class oriented power purchase agreements will ensure that the electrical utilities are on-board and will help builders and developers incorporate more advanced technology in designs and retrofits.

- **Developers and Builders.** Existing developers and home builders are already engaged in green homebuilding. McGraw Hill Construction's 2014 Smart Market Report[406] states that two-thirds of single-family and multifamily residential builders and developers offer renewables on their projects. Furthermore, the percentage that incorporates renewables in all their projects is projected to increase from 8% in 2013 to 20% by 2016. If underwritten by government loans, like the government does for mortgages, these green developers and builders could rapidly implement affordable energy-efficient programs for new homes and upgrades to existing homes.

- **Utility Companies.** Utility companies are a formidable obstacle to any net-zero initiative. To overcome their resistance, utility companies need to be enticed to become major stakeholders in net-zero. As mentioned earlier, the leading German utility, E.ON, has been reorganized into two separate entities. One entity focuses on traditional fossil fuel and nuclear businesses, while the other focuses on growing renewables, distributed generation and new "smart" services businesses. The two largest American utility companies are located in California, a state that is committed to

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[404] Bureau of Labor Statistics, Consumer Expenditures 2013, February 2015, http://www.bls.gov/cex/csxann13.pdf
[405] Center for American Progress, Solar Power to the People: The Rise of Rooftop Solar Among the Middle Class, 21 October 2013, https://cdn.americanprogress.org/wp-content/uploads/2013/10/RooftopSolarv2.pdf
[406] McGraw Hill Construction's Dodge Construction Market Forecast, Green Multifamily and Single Family Homes Smart Market Report (2014), http://analyticsstore.construction.com/2014GreenHomesSMR?sourcekey=PRESREL

renewable energy and bold new initiatives. Perhaps Southern California Edison and Pacific Gas & Electric, which are investor-owned and serve over five million customers each, could be enticed to lead a Net-Zero Community pilot project.

- **Private Sector Investors.** As discussed in the investment sector, if the private sector is presented with viable ETR investment opportunities with reasonable risk and rewards, it has the means to respond to trillion-dollar opportunities.

- **Government**. As discussed in the investment section, state green energy funds, state green banks and state/municipal tax-exempt bonds could be used for net-zero development. According to the Council of Development Finance Agencies[407], over 50,000 state and local governments and authorities represent a $3 trillion industry that uses tax-exempt bonds to invest in infrastructure. Tax-exempt bonds are the bedrock of public finance and have been used to help build thousands of public and private projects like net-zero buildings and communities.

  Federal, state and local governments should institute or accelerate Net-Zero Community feed-in tariffs (FITs) to accelerate investment in renewable energy technologies. FITs would provide cost-plus, long-term contracts that assure grid access via net-metering for off-grid distributed and dispersed power generation. FITs may differ by technology (solar, wind, geothermal, hydro, biomass), type (residential or commercial scale), size (micro, small and medium) and duration (power purchase agreements that adjust over time to compensate for marketplace changes and technological enhancements). FITs shift the burden from government to the marketplace by giving energy suppliers a cushion for implementing new technology.

- **GSEs and Insurance Companies.** U.S. federal government-sponsored enterprises (GSEs) and private sector insurance companies have a large role to play in underwriting domestic and international initiatives.

  - *Domestic.* A GSE could be created to underwrite a national net-zero or other homeowner energy efficiency initiatives. A GSE is a financial services corporation created by the U.S. Congress. Over the last eight decades, GSEs were created to make the American dream of homeownership come true. In 1932, Congress created the Federal Home Loan Bank System to provide funding to American financial institutions. In 1938, Fannie Mae (Federal National Mortgage Association) was created to make mortgages more available to low-income families. In 1968, Ginnie Mae (Government National Mortgage Association) was created to help make affordable housing a reality for millions of low- and moderate-income households by channeling global capital into the nation's housing markets. In 1970, Freddie Mac (Federal Home Loan Mortgage Corporation) was chartered by Congress to provide liquidity, stability and affordability to the U.S. housing and mortgage markets. In 2008, the Federal Housing Finance Agency (FHFA) was created as a super-agency. Today, the U.S. government, via the FHFA, guarantees 77% of all U.S. residential mortgages, worth $5 trillion. A fraction of this amount could be allocated for second mortgages for net-zero or other homeowner energy efficiency initiatives.

  - *International.* Net-zero technologies, processes and systems have huge export potential as well as providing a basis for bi-lateral agreement, like the United States-China Clean Energy

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[407] Council of Development Finance Agencies, Built by Bonds, http://www.cdfa.net/cdfa/cdfaweb.nsf/ord/builtbybonds.html/$file/CDFA-Built-by-Bonds.pdf

Partnership and the United States-India Climate & Clean Energy Cooperation. Countries like Germany use federal export credit guarantees as a way to cover small and medium-sized German companies. According to the Federal Government of Germany[408], examples include short-term loans, manufacturing risk cover, structured finance, project finance and leasing business insurance. The Federal Government of Germany uses Euler-Hermes to underwrite project financing. Euler-Hermes[409] is the world's leading provider in accounts receivable insurance. A trade credit insurance policy and debt collection service with Euler Hermes allows companies to sell equipment and related-services with confidence, providing valuable protection against the consequences of domestic or overseas customer insolvency and non-payment. Euler Hermes North America offers policies to mitigate commercial and political risk in more than 200 countries worldwide. The U.S. government should look to organizations like Euler Hermes to underwrite small and medium-sized American businesses that are engaged in bilateral net-zero energy programs.

In the near future, many of the ETR technologies and systems will be available at hardware stores, which will provide the grist for new small business installation and maintenance businesses. A new net-zero home improvement industry is possible with the right planning, incentives and underwriting. If government can issue grants and low-interest loans for renewable fuels, it can do the same for an ETR home industry that is oriented to small and medium-sized businesses, such as energy audit, weatherization and solar panel installation.

According to the DoE[410], current weatherization programs have reduced the nation's energy bills by more than $2 billion annually. In addition, 200,000 American workers have been trained in weatherization, which boosts their ability to join the energy labor force or start their own business. The DoE's Weatherization and Intergovernmental Programs Office provides funding and assistance to partners in state and local governments, including weatherization programs that enable low-income families to reduce their energy bills by making their homes more energy efficient. Major solar panel installation companies and electrical utilities are looking for certified subcontractors to help them upgrade homes and businesses in America. The DoE weatherization training and funding programs provide a way to jump-start net-zero small businesses.

If 5% of America's $800 billion/year household energy-related expenditures were allocated to net-zero technologies, approximately 800,000 direct middle-class ($50,000/year) jobs could be created.

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[408] Federal Government of Germany, Federal Ministry of Economic Affairs and Energy, Main Features of Export Credit Cover, http://www.agaportal.de/en/aga/grundzuege.html
[409] Euler-Hermes, http://www.eulerhermes.com/group/Pages/default.aspx
[410] Energy.Gov, Office of Energy Efficiency & Renewable Energy, Homes, http://energy.gov/eere/efficiency/homes

ETR Employment Outlook in the Energy Service Sectors

Energy Efficiency and Energy Conservation Employment Outlook.

Energy efficiency and energy conservation are needed in combination to reduce consumption and emissions. Energy efficiency means using energy more effectively and is often associated with a technological change. Energy conservation means using less energy and it usually requires a behavioral change. Without energy conservation, energy efficiency is likely to lead to a "Jevons paradox"[411] that postulates that resource savings often lead to increased consumption of that resource, which leads to further economic expansion and further energy consumption. This is especially true in rapidly growing emerging economies.

Every year, much of the energy Americans generate is wasted through transmission, heat loss, and inefficient systems. Making American homes, businesses, vehicles, and industry more energy efficient is relatively easy and there are economical ways to reduce energy consumption and mitigate emissions. According to Bloomberg New Energy Finance [412], America's total annual energy consumption in 2013 was 5.0% below 2007 levels, "thanks to advances in energy efficiency."

Energy Efficiency Direct US Jobs by Sector

Source: Brookings-Battelle

Mass Transit	350,547	Energy-saving Consumer Products	19,210
Energy-saving Building Materials	161,896	Battery Technologies	16,129
HVAC and Building Control Systems	73,600	Smart Grid	15,987
Green Architecture and Construction Services	56,190	Electric Vehicle Technologies	15,711
Professional Energy Services	49,863	Lighting	14,298
Appliances	36,608	Water Efficient Products	13,066

Total **823,105**

This table is drawn from the Brookings-Battelle study, which has identified specific sectors within energy efficiency[413]. Altogether the sectors provide 823,105 direct jobs. At a 1:3 labor force ratio, the total number of direct, indirect and induced jobs would be approximately 2.5 million.
Energy efficiency is one of the fastest growing American service industries. Today, energy efficiency is a multi-billion dollar industry with the potential to grow much higher. The Environmental and Energy Study Institute issued a report on Jobs in Renewable Energy and Energy Efficiency[414] that reports the following: "According to the American Council for an Energy-Efficient Economy, robust investment in energy efficiency could save $1.2 trillion by 2020, and the United States could create 1.3 to 1.9 million

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[411] Wikipedia, Jevons Paradox, http://en.wikipedia.org/wiki/Jevons_paradox
[412] Bloomberg New Energy Finance and Business Council for Sustainable Energy, *Sustainable Energy In America 2014 Factbook*, February 2014, http://about.bnef.com/white-papers/sustainable-energy-in-america-2014-factbook/
[413] Muro, Mark; Rothwell, Jonathan; Saha, Devashree, *Sizing the Clean Economy: A National and Regional Green Jobs Assessment*. Brookings, 2011, http://www.brookings.edu/~/media/Series/resources/0713_clean_economy.pdf
[414] Environmental and Energy Study Institute, *Jobs in Renewable Energy and Energy Efficiency*, June 2013, http://www.nacubo.org/Documents/BusinessPolicyAreas/FactSheetGreenJobs061113.pdf

jobs by 2050 through the deployment of energy efficient technologies[415]. Similarly, the Alliance to Save Energy projects 1.3 million jobs by 2030[416]."

Jobenomics forecasts continued growth in energy efficiency as communities broaden focus from reducing losses to capturing and storing sources of kinetic and potential energy. Jobenomics also believes that energy efficiency is an area that is ideal for startup small businesses. The Building Performance Institute (BPI), a national not-for-profit organization, is helping to develop a professionalized residential energy efficiency workforce—a "green-collar" workforce—replete with training and certification programs[417]. BPI's Home Energy Professional (HEP) certifications are supported by the U.S. Department of Energy (DOE) and its National Renewable Energy Laboratory (NREL). In addition, numerous colleges and universities are offering higher education programs in energy, particularly those concerning energy efficiency and renewable energy[418].

Energy-as-a-Service (EaaS) Employment Outlook.

Two global technology revolutions are occurring simultaneously today — the Energy Technology Revolution (ETR) and the Network Technology Revolution (NTR)[419]. The technologies, processes and systems in both of these revolutions are synergistic. Consequently, the NTR will play a major role in transforming the global energy ecosystem. Modelled after the NTR's cloud computing service models (i.e., Software-as-a-Service, Platform-as-a-Service, Infrastructure-as-a-Service), Energy-as-a-Service (EaaS) will emerge as a substantial energy sector industry and a major enabler of intelligent and micro-energy applications in tomorrow's "Internet of Things" world.

The NTR is characterized by a perfect storm of highly advanced technologies, processes and systems, including big data (zettabytes of data stored in "clouds"), semantic webs (thinking websites), machine learning (systems that can learn from data), mobile robotics (automated machines capable of movement), ubiquitous computing (embedding microprocessors in everyday objects to communicate information without requiring human interaction), national broadband system (bringing high-speed networks to everyone), artificial intelligence (intelligent machines), and the Internet of Things (a world where more things are connected to the Internet than people). The NTR will enhance every element of the energy value chain from exploration to end-user support.

The NTR will be both brilliantly innovative and creatively disruptive to the energy sector. Brilliant innovation and creative disruption go hand-in-hand. Brilliant innovation disrupts the status quo by producing something new, more efficient or more worthwhile. The technological combination of emerging NTR technologies, processes and systems will disrupt, displace, or even destroy, existing markets, occupations and the labor force.

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[415] American Council for an Energy-Efficient Economy (ACEEE), ACEEE White Paper Energy Efficiency Job Creation: Real World Experiences, October 2012, aceee.org/files/pdf/white-paper/energy-efficiency-job-creation.pdf
[416] Schmutter, Allyson, Alliance to Save Energy, Diverse Commission Unveils Plan to Double U.S. Energy Productivity, 7 February 2013, http://www.ase.org/news/diverse-commission-unveils-plan-double-us-energy-productivity.
[417] Building Performance Institute, http://www.bpi.org/professionals.aspx
[418] Energy.Gov, Colleges And Universities, http://energy.gov/eere/education/colleges-and-universities
[419] Jobenomics addresses the NTR in more detail at: http://jobenomicsblog.com/network-technology-revolution/

Via the NTR, consumers (and their intelligent machines) will be able to skillfully manage their personal energy value chain from source to device, and maximize the amount of milliwatts (one thousandth of a watt) in every watt of energy consumed. This level of energy efficiency will be orders-of-magnitude better than America's current centralized system that loses most of its electricity from production, to transmission, to distribution, and even to heat loss in device usage. In an Internet of Things world, milliwatts will be a more important measure of energy consumption than megawatts.

Cloud Computing is as big a paradigm shift away from personal computers as PCs were from mainframes in the 1990s. Cloud computing is the practice of using a network of remote servers in mega -data centers to store, manage, and process immense amounts of data. Cloud computing also entails security, connectivity, portability, access, and other issues including privacy, legal and regulatory. In essence, cloud computing is intelligence middle layer to manage large and complex information assets in an interactive, integrated and seamless way.

Today's cloud computing service models are categorized as Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS), Infrastructure-as-a-Service (IaaS) providers[420].

- *Infrastructure as a Service (IaaS).* The consumer does not control the underlying cloud infrastructure, but has control over operating systems, storage, deployed applications, and limited control of networking components. The provider provides customized business solutions. Example: Amazon Web Services' Elastic Compute Cloud (E2C).

- *Platform as a Service (PaaS).* The consumer does not control the underlying cloud infrastructure, but has control over the deployed applications. The provider offers development environments that consumers create business applications. Examples: Google App Engine, Windows Azure.

- *Software as a Service (SaaS).* The consumer does not control the underlying cloud infrastructure including network, servers, operating systems, storage, or applications. The provider provides purpose-built business solutions.

The Energy-as-a-Service (EaaS) service model does not exist yet, but will likely unify the best elements of all three cloud computing service models. When it comes to fruition, the EaaS will function as intelligence middle layer to manage large and complex energy assets in an interactive, integrated and seamless way. EaaS providers will strategically position (and consequently reposition) their clients within a dynamically changing energy ecosystem, by offering integrated, secure, low-cost, and portable service solutions in both centralized and decentralized energy environments.

Cleantech-as-a-Service is a rapidly growing initiative that embodies Energy-as-a-Service. Cleantech (aka clean technology) refers to technology, products and services products, processes or services that reduce waste and require as few non-renewable resources as possible. Cleantech-as-a-Service[421] is pioneered by Sheeraz Haji, the CEO of Cleantech Group[422], which was founded in 2002 with a mission to accelerate sustainable development. Cleantech clients now include top corporations across five key industries: chemicals, industrials, oil and gas, transportation, and utilities.

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[420] For a complete list of the top 20 IaaS, PaaS and SaaS vendors see: http://www.clouds360.com/paas.php
[421] Cleantech Group, Cleantech Meets the Cloud: The Emergence of Cleantech-as-a-Service. 19 November 2014, Sheeraz Haji, http://www.cleantech.com/cleantech-meets-the-cloud-the-emergence-of-cleantech-as-a-service/
[422] Cleantech Group, The Innovation Network that Drives Sustainability, http://www.cleantech.com/about/

In his Cleantech-as-a-Service white paper[423], Sheeraz Haji accurately describes the U.S. energy infrastructure largely as an outdated system designed around "centralized plants that send power through inefficient and one-way…lines to uniformed customers". However, he emphasizes the fact that the U.S. electrical power infrastructure is rapidly evolving to decentralized distributed and dispersed systems, from rooftops to mini-power plants to storage plants located at the point-of-consumption. In a decentralized world, customers and energy providers will become smarter in tracking energy usage, managing storage systems, and using software to interact with the grid, analyze data, and drive towards better decisions. Haji also believes that clean technologies are converging with the cloud to create and enable development of an intelligence middle layer to manage energy assets in an interactive, integrated and seamless way. This new middle layer represents a massive economic and jobs creation opportunity in energy and other Cleantech markets,

If EaaS providers follow the same path as the cloud computing SaaS/PaaS/IaaS providers, potentially millions of new energy jobs will be created. According to research commissioned by Microsoft[424], the cloud computing industry is projected to create 14 million new jobs from 2011 through the end of 2015, producing $1.1 trillion a year in new business revenue thereafter.

Energy Assurance and Energy Security Employment Outlook.

Energy assurance and energy security are becoming major concerns, as well as major employment opportunities. Energy assurance involves providing a steady supply of clean affordable fuels without major disruption. Energy security involves ecosystem protection including people, sources, infrastructure, and information systems.

The United States, and the world, needs a new energy assurance and security model. Today, energy companies are expected to secure their own assets unless they are under extreme duress or when national strategic interests are threatened. Tomorrow, energy security and energy assurance will be the collective responsibility of industry, military, law enforcement and government officials worldwide. Major energy stakeholders must accept the fact that they need to be more proactive in securing the entire energy supply chain as opposed to reacting to occasional crises, incidents and accidents. From an energy outlook, instability is the new normal.


Limburg Oil Tanker Attack

Highly publicized terrorist, organized crime and cyber-attacks against energy producers and infrastructure are increasing in intensity, frequency and cost. In 2002, an Al Qaeda suicide boat attack against the French oil tanker Limburg caused major damage to the vessel (shown) and the dumping of 90,000 barrels of oil into the Gulf of Aden. In 2009, the hijacking of the U.S.-flagged MV Maersk Alabama, the first American cargo ship to be hijacked in two hundred years, brought significant attention (resulting in an Academy Award-winning movie about Captain Phillips) to the prospect of hijacking an oil supertanker transporting two million barrels of oil. In

[423] Ibid 402.
[424] Microsoft, Cloud Computing to Create 14 Million New Jobs by 2015, 5 March 2012, http://news.microsoft.com/2012/03/05/cloud-computing-to-create-14-million-new-jobs-by-2015/

2012, hijacking of maritime vessels by Somali pirates cost $6 billion to pay for security equipment, guards, insurance, ransoms and recovery operations, military operations, counter-piracy operations, and increased operating costs[425]. Over the last two years, Islamic State of Iraq and Syria (ISIS) terrorists captured and sold $2 billion worth of oil on the black market, Mexican crime cartels plundered 30,000 barrels a day of gasoline worth $3.4 billion, and Nigerian crime families and terrorist groups looted 400,000 barrels a day of petroleum worth approximately $45 billion.

Extrapolating to the future, it is not hard to envision critical infrastructure attacks on soft energy targets. Soft targets, like offshore oil platforms, are tempting targets for saboteurs. The world witnessed 200 million gallons of crude oil pump into the Gulf of Mexico, causing $56 billion worth of damage after the BP oil rig explosion. The Stuxnet virus that ruined one-fifth of Iran's nuclear centrifuges set a new standard for state-sponsored cyber-attacks on industrial control systems used in energy generation, refining, pipelines, transmission and distribution.

In April 2015, General Keith Alexander (former Director of the U.S. National Security Agency and U.S. Cyber Command)[426] said that "the greatest risk (from terrorists) is a catastrophic attack on the energy infrastructure" including high-tech attacks on refineries, power stations and the electric grid. The General believes that an integrated defense system is needed for the entire energy sector. Furthermore, he states that an ongoing, systematic, clandestine effort by state-backed cyber hackers, who are stealing technology from Western companies, constitutes "the biggest wealth transfer in history."

As part of the U.S. National Infrastructure Protection Plan, the energy sector has six goals[427] for developing and implementing effective protection measures that form the basis for future employment requirements and business opportunities. (1) Establish robust situational awareness within the sector through timely, reliable, and secure information exchange among trusted public and private sector partners. (2) Use sound risk management principles to implement physical and cyber measures that enhance preparedness, security, and resilience. (3) Conduct comprehensive emergency, disaster, and continuity of business planning, including training and exercises, to enhance reliability and emergency response. (4) Clearly define critical infrastructure protection roles and responsibilities among all Federal, State, local, and private sector partners. (5) Understand key sector interdependencies and collaborate with other sectors to address them, and incorporate that knowledge in planning and operations. (6) Strengthen partner and public confidence in the sector's ability to manage risk and implement effective security, reliability, and recovery efforts.

The U.S. private security market has boomed after 9/11. One recent study[428] reported that in 2012 this market reached $350 billion per year, with $282 billion spent by the private sector and $69 billion by the

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[425] Oceans Beyond Piracy, The Economic Cost of Somali Piracy 2012, published in 2013, http://oceansbeyondpiracy.org/sites/default/files/attachments/View%20Full%20Report_1.pdf

[426] The Telegraph, NSA veteran chief fears crippling cyber-attack on Western energy infrastructure, 26 April 2015, http://www.telegraph.co.uk/news/worldnews/northamerica/usa/11563746/NSA-veteran-chief-fears-crippling-cyber-attack-on-Western-energy-infrastructure.html

[427] Department of Homeland Security, Energy Sector-Specific Plan, An Annex to the National Infrastructure Protection Plan, 2010 (retrieved 1 May 2015), Page 2, http://www.dhs.gov/xlibrary/assets/nipp-ssp-energy-2010.pdf

[428] ASIS International, The United States Security Industry: Size and Scope, Insights, Trends, and Data, 12 Aug 2013, https://www.asisonline.org/Documents/ASIS%20IOFM%20Executive%20Summary%208.23.13.%20final.pdf

federal government. The $282 billion from the private sector bought $202 billion worth of non-IT operational and $80 billion worth of private security services. The $69 billion from the federal government bought private security services primary for the wars in Iraq and Afghanistan. Today, there are nearly 2 million full-time security jobs. The report predicts that 200,000 security officers will be added by 2020. Jobenomics predicts that many of these will be employed for energy security.

Kidnapping is becoming an attack strategy of choice for militants, counterinsurgents and organized crime as evidenced by hostage taking, ransoms and public beheadings. Kidnapping is a stealthy form of asymmetric warfare where less-equipped opponents can exploit a superior power's weakness and vulnerabilities. ISIS terrorists effectively use beheading of innocent kidnapped victims in order to get international media attention for propaganda and fund-raising purposes. U.S. energy personnel are an ideal target for kidnapping due to their affiliation with American oil companies, as well as their often remote and unprotected work environment.

In regard to energy assurance, the crisis in Ukraine has created an energy assurance crisis in Europe that is dependent on Russian natural gas and petroleum. Many argue that Europe should get off Russian gas and switch to alternative suppliers in North America, Africa and the Middle East. Russia is preparing for the diversion and is strengthening its ties with the Chinese who are eager for new energy sources. Islamic militants and other anti-West entities are also a matter of concern. The majority of the oil trade routes and major maritime chokepoints are controlled by Islamic countries. Any major change in the global political/economic/military balance-of-power could make energy assurance the cause célèbre for the Western world.

63% of the world's oil production moves on maritime routes. Blockage of any of the six major oil trade route chokepoints (Strait of Hormuz, Strait of Malacca, Suez Canal, Bab el-Mandeb Strait, Danish Straits, and Panama Canal) would have global repercussions. Iran is threatening to close the narrow Strait of Hormuz, thereby blocking the shipment of 25% of the world's oil supplies and causing massive spikes in oil prices that could devastate many economies. Energy is essential to economic growth and hostile forces know that disrupting energy supplies is an effective form of asymmetrical warfare. Disruption does not have to be local. Disruption anywhere in the global energy supply chain will have local consequences.

Policing of 1,566,495 miles of domestic U.S. natural gas pipelines and 151,912 miles of oil pipelines[429] poses environmental and security issues that will require state-of-the-art command and control, communications, information, intelligence, surveillance, inspection, monitoring operations, maintenance and repair technologies, processes and systems. Each of these areas presents significant business and job creation opportunities for American service-providing industries that can be leveraged internationally to protect the world's 3,500 active pipelines. The need for environmental transparency and verifiability, as well as protection from terrorists, thieves and hackers, will make these opportunities happen sooner rather than later.

Jobenomics forecasts that governments will eventually elevate the energy paradigm from a concentration on supply/demand to a more strategic perspective that focuses on assurance of energy as

[429] Bureau of Transportation Statistics, Table 1-10: Oil and Gas Pipeline Mileage, http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_10.html

an essential commodity for the entire international community, the West, and, lastly, the United States. Global energy assurance supersedes national energy independence, because the United States cannot be truly energy independent in today's interconnected world. Energy security and energy assurance businesses and job opportunities will grow in the next few years. Whether it grows exponentially depends a lot on international events, crises and conflicts, as well as to how proactive governments plan to be.

Disaster Preparedness and Recovery Employment Outlook.

Each year, organizations like the American Red Cross respond to 70,000 natural and man-made disasters in the United States[430]. In the United States, the American Red Cross has 35,000 employees and 500,000 volunteers in 600 locally supported chapters. Not counting state and local emergency management agencies, the U.S. Federal Emergency Management Agency (FEMA), has a $13 billion budget and 10,000 employees dedicated to disaster preparedness, protection, response, recovery and mitigation.

Given the potential catastrophic consequences advertised by the UNFCCC due to climate change and General Keith Alexander regarding terrorist threats, disaster preparedness and recovery employment is likely to grow in three areas: (1) government, (2) social institutions, like the Red Cross, and (3) within the energy sector itself. The first two areas are likely to be reactive and hire workers contingent on the scope of the disaster, while the third area is likely to be more proactive.

According to a recent disaster recovery preparedness survey[431], 73% of all companies surveyed are not prepared for disaster recovery from a cyber-event with only 2% of the surveyed companies getting an "A" grade. According to a Boston University report[432], 60% of all small businesses (that employ 77% of all Americans) do not have an emergency response plan and 25% of all businesses do not reopen following a major disaster.

Climate change is likely a contributing factor to the recent skyrocketing cost of natural disasters. The world will likely witness more extreme weather events as global temperatures rise. Superstorm Sandy caused an estimated $50 billion worth of damage resulting in approximately 750,000 insurance claims and a $48 billion federal government recovery effort. In the wake of Hurricane Sandy, New York utility Consolidated Edison implemented a four-year $1 billion disaster preparedness plan[433]. ConEd's Post Sandy Enhancement Plan focuses on three areas: (1) fortifying the electric, gas, and steam systems against future storms; (2) improving estimated times of restoration, and enhancing storm planning and restoration processes; and (3) improving the flow of information to customers and other stakeholders. This plan is a model for 3,364 other regulated U.S. electric utilities.

The threat of man-made disasters in the United States is also increasing. 9/11 was just a start. Cyber warfare and biological warfare portend catastrophic-level consequences. As a result, disaster

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[430] American Red Cross, Disaster Relief, http://www.redcross.org/what-we-do/disaster-relief
[431] The Disaster Recovery Preparedness Council, Disaster Recovery Preparedness Benchmark Survey, The State of Global Disaster Recovery Preparedness: Annual Report 2014, http://drbenchmark.org/wp-content/uploads/2014/02/ANNUAL_REPORT-DRPBenchmark_Survey_Results_2014_report.pdf
[432] Boston University, http://msmonline.bu.edu/survive-a-natural-disaster/
[433] Consolidated Edison Co. of New York, Post Sandy Enhancement Plan, 20 June 2013, http://www.coned.com/publicissues/PDF/post_sandy_enhancement_plan.pdf

preparedness and recovery services are likely to grow. Fortifying the energy sector from man-made disasters requires redundancy, protection and security upgrades, as well as implementation of new ETR technologies, processes and systems like smart and self-healing grids, hazard-resistant facilities and integrated smart emergency response vehicles.

Examples of new disaster preparedness and recovery services include strategic planning, disaster recovery planning, cost-effective early warning systems, disaster preparedness and recovery education and publications, improved estimated times for system restoration, better continuity of operations, state-of-the-art information operations (smart phone applications, enhanced customer information systems, cyber assurance and security, data collection and computer monitoring, information and document repositories, GIS mapping systems, multi-lingual interactive telephonic voice response system, information/call centers, etc.), large-scale home and business inspection programs, community preparedness programs and exercises, emergency shelters and evacuation services, enhanced insurance programs, restoration and renovation assistance, demolition and disposal services, recycling and materials reclamation, local and augmented workforce enterprises, long-lead and critical materials identification and stockpiling, enhanced logistics, and resource management systems. If the world is truly concerned about the "catastrophic" consequences of not meeting the 2°C climate change goal, it should invest in these services.

As discussed earlier, National Adaptation Plans (NAPs) are posted on the UNFCCC website[434] to help rich nations fund disaster preparedness solutions for poorer nations. These NAPs will essentially serve as Requests for Proposals from the developing world. Some of the adaptive ETR solutions that will be needed include water harvesting and preservation, land and crop management, seawall and storm surge barriers, emergency medical services, infrastructure protection, continuity of critical operations, crisis and crime management, energy assurance and security, and the like. The Green Climate Change Fund is soliciting up to $100 billion per year for these kinds of ETR efforts. While it is doubtful that the $100B goal will be reached, enough funds should be available to jump start or underwrite programs that could attract private sector investment.

[434] United Nations Framework Convention on Climate Change (UNFCCC), National adaptation plans, http://unfccc.int/adaptation/workstreams/national_adaptation_plans/items/6057.php & http://unfccc.int/adaptation/workstreams/national_adaptation_programmes_of_action/items/4585.php

ETR Employment Outlook in Exotics and Yet Unknown Technologies

Exotic technologies, such as energy harvesting, spray-on solar cells, gravity motors, cold fusion and vortex technologies, are in development. Whether any of these exotic technologies will result in a major energy breakthrough is unknown. Perhaps the next profound discovery won't happen in a high-tech laboratory but in a remote third world village where a highly scalable energy invention is yet to be disseminated worldwide.

It is safe to assume that many radically-innovative ETR technological or procedural advancements have not yet surfaced. In this regard, Jobenomics has been working with EmeraldPlanet's *The Emerald Trek*[435] to identify the 1,000 best practices as they pertain to the environment and the promotion of alternative energy sources across the globe. The Trek started in Washington, D.C. in 2014 and will end in 2019 at the United Nations. Over this five-year period, The Emerald Trek will traverse 300,000 miles and include 144 nations, 750 major cities and 50,000 suburban and rural communities. It will be interesting to see what innovations will be uncovered. The EmeraldPlanet's leadership and associated experts work with research institutions, businesses, governments, universities, healthcare providers, clean water advocates, and non-governmental and community-based organizations with the common goal of arresting, and possibly reversing, the ravages of climate change.

Just because the economic and employment potential of exotics and yet unknown energy technologies is impossible to predict, it does not mean that we should focus R&D on more-proven technologies and relegate transformational technologies to the back burner. Every major government department, energy company, and academic institution should develop a "skunkworks" dedicated to exploring uncharted energy and environmental technologies. The original 1943 Skunk Works was created by Lockheed Martin and lead to amazing aircraft like the U-2 and SR-71, to name a few. Lockheed's high beta fusion reactor, mentioned earlier, was developed in 2013 by their Skunk Works. An energy skunkworks would consist of a small and loosely structured group of entrepreneurial engineers who would brainstorm, research and develop programs that have the potential to be brilliantly innovative and creatively destructive.

The Department of Energy has started down this path with its Advanced Research Projects Agency-Energy (ARPA-E)[436], which is modelled after the highly successful Department of Defense's Defense Advanced Research Projects Agency (DARPA), which was created in 1958.

ARPA-E advances high-potential, high-impact energy technologies that are too early for private-sector investment. ARPA-E's FY2016 budget request is $325,000,000, compared to DARPA's FY2016 budget request of $3.0 billion[437]. Jobenomics feels that the ARPA-E budget is adequate for such a relatively new agency, but U.S. decision-makers should be open to significantly higher levels of investment, especially for ETR technologies related to climate change and energy efficiency, which are not currently included in ARPA-E's programs. ARPA-E's program areas are Agile Delivery of Electrical Power Technology, Advanced Management and Protection of Energy Storage Devices, Batteries for Electrical Energy Storage

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[435] EmeraldPlanet, The Emerald Trek, http://www.emerald-planet.org/the-emerald-trek/
[436] Advanced Research Projects Agency-Energy, http://arpa-e.energy.gov/
[437] DoD FY2016 President's Budget Submission, February 2015, http://www.darpa.mil/newsevents/budget.aspx

in Transportation, Building Energy Efficiency Through Innovative Thermodevices, Microorganisms for Liquid Transportation Fuel, Full-Spectrum Optimized Conversion and Utilization of Sunlight, Green Electricity Network Integration, and Grid-Scale Rampable Intermittent Dispatchable Storage. Since 2009, ARPA-E has funded over 400 transformation energy technology projects with many notable successes, such as developing a 1MW silicon carbide transistor the size of a fingernail, engineering microbes that use hydrogen and carbon dioxide to make liquid transportation fuel, and pioneering a near-isothermal compressed air energy storage system.

There are numerous other examples that have been addressed in this report including hydrogen-based economy, electric vehicles, nuclear fusion and methane hydrates—all of which would be game changers. Other ETR breakthroughs are likely on the horizon, such as the ultimate renewable energy technology called artificial photosynthesis. Artificial photosynthesis involves creating fuel in the same manner as plants do by using solar energy to split water into hydrogen and water and carbon dioxide into liquid fuels with an oxygen byproduct. Started in 2010, artificial photosynthesis is a collaborative effort between the Department of Energy and Lawrence Berkeley Lab, which opened a $59 million Solar Energy Research Center aimed principally at producing fuel from sunlight[438]. The center's efforts focus on creating a revolutionary new fuel while at the same time recycling CO_2 extant in the atmosphere—a reverse emissions process.

[438] Inside Bay Area News, Berkeley lab unveils new solar energy center aimed at producing fuel from sunlight, 26 May 2015, http://www.insidebayarea.com/news/ci_28195330/berkeley-lab-unveils-new-solar-energy-center-aimed?source=rss

ETR Concluding Thoughts and Recommendations

The ETR has the potential to create tens of millions of new jobs nationally and globally. The American challenge is to be the international leader and capture as many of these jobs as possible. To do so, American leadership needs to be more engaged than they are now. A laissez-faire approach to managing the ETR will lead to second and third place finishes in the most lucrative segments of the marketplace.

As addressed by this report, the jobs aspect of the American energy sector could be better managed by the U.S. government. The U.S. Department of Labor's Bureau of Labor Statistics (BLS) does not include energy in their ten industry super-sectors and the Department of Energy's Energy Information Administration's (EIA) primary focus is on resources, end-users and the environment. Notwithstanding, Jobenomics has high regard for both the BLS and EIA and hopes that this report will help these invaluable government agencies secure additional funding for an ETR jobs and business creation initiative.

The innovative and disruptive ETR will both create and destroy millions of jobs. Employment churn of job entrants versus departures should be tracked, analyzed and presented to policy-makers and business leaders to ensure that net employment increases domestically to the maximum degree that it can. From a Jobenomics perspective if Technology A and Technology B generate the same amount of energy per unit at the same price, but Technology B employs twice as many Americans, then Technology B should be the system of choice. In an era where twice as many U.S. citizens voluntarily leave the U.S. labor force as enter it (since year 2000, 10.4 million entered the U.S. labor force and 24.5 million able-bodied Americans voluntarily departed[439]), jobs creation should be a major consideration for every government agency.

The BLS is the principal U.S. fact-finding agency for measuring labor market activity, working conditions and price changes in the economy. The BLS does an excellent job surveying domestic employment and unemployment statistics by race, gender and ethnicity across seven service-producing industries, three goods-producing industries and three levels of government (federal, state and local). Based on household and business surveys, the BLS produces highly valuable monthly reports for public and private sector consumption. Jobenomics recommends that a third survey be introduced for major employment growth areas like the energy super-sector. The BLS also does an excellent job comparing U.S. employment trends against other countries. It would be prudent to have the ability to know where ETR employment growth is happening around the world in the same way we track imports and exports.

The EIA is the principal U.S. agency for collecting, analyzing, and disseminating energy information for understanding, policymaking, economics and the environment. Designed by the EIA, the National Energy Modeling System (NEMS)[440] is a computer-based modeling system that is used to project energy, economic, environmental, and security impacts of alternative energy policies and different assumptions about energy markets with an event horizon 25 years in the future. Jobenomics recommends that the statistical agencies adopt a complimentary structure like the Global Industry Classification Standard

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[439] Jobenomics Employment Report, 1 April 2015, http://jobenomicsblog.com/jobenomics-employment-report-q1-2015/

[440] Energy Information Administration (EIA), National Energy Modeling System, http://www.eia.gov/oiaf/aeo/overview/

(GICS)[441] that consists of 10 sectors (including energy and utilities), 24 industry groups, 67 industries and 156 sub-industries. GICS classifications are used worldwide (e.g., the S&P 500) for investment research and asset management. Combining the financial statistics of GICS with the labor force statistics of the BLS and the energy statistics of the EIA could enhance the knowledge and foresight required to supercharge U.S. economic and employment performance.

The conventional definition of the energy value chain emphasizes production and consumption metrics. Jobenomics believes that technology, process and procedural metrics are equally valuable. More importantly, these metrics should be modelled and tested together against national targets and milestones. The U.S. military uses simulation-based nodal analysis for effects-based operations. Effects-based operations (EBO) examine whether a desired effect is being achieved. From an ETR perspective, an EBO can be tons of pollutants emitted, quadrillions of Btu saved, net new energy jobs produced, impact on GDP, or a combination of all.

A national simulation system is need for the ETR. However, this system should not consist of a single national system at the Department of Energy. Instead, it should be a virtual system that connects various communities-of-interest to an energy "ecosystem" where opposing sectors, sources, technologies, processes and systems would compete against desired outcomes, objectives and effects. "White" teams would evaluate results and provide recommendations for competing companies and interest groups, who would prefer to know earlier rather than later if a particular project is worth the risk. A national simulation system could reduce uncertainty and provide greater clarity on energy opportunities with high returns on investment. For the most part, brilliantly innovative and creatively disruptive technology increases net value and business opportunity. However, timing is also important. A national simulation system would be invaluable regarding evaluating the value-opportunity-time conundrum.

American decision-makers and opinion-leaders need to focus on a developing comprehensive strategic energy framework that features a system-of-systems approach covering the entire energy ecosystem. They also need to build consensus in a politically divided nation. The 2016 Presidential elections offer an ideal opportunity to debate new energy architectures and a collaborative approach to the international energy economy, security and the environment.

[441] Global Industry Classification Standard (GICS®), http://www.msci.com/products/indexes/sector/gics/

About Jobenomics. Jobenomics*, the book, deals with the economics of business and job creation. Jobenomics, the national grassroots movement, has a goal of creating 20 million new U.S. private sector jobs within the next decade. The Jobenomics movement has grown significantly, reaching several million people via national and social media, lectures and word-of-mouth. While Jobenomics addresses all businesses, its principal focus is on highly scalable business creation efforts for emerging small and self-employed businesses.*

The Jobenomics national grassroots movement has seven major business creation initiatives. Two initiatives involve emerging technologies, processes and systems related to the Energy Technology Revolution and the Network Technology Revolution. Four initiatives involve demographics with the highest growth potential and the highest need: Women Owned Businesses, Generation Y Owned Businesses, Minority Owned Businesses and Veteran Owned Businesses. The final initiative is an Urban Mining program (http://ecyclingusa.com/) that Jobenomics established to help cities monetize high value waste streams in order to fund local business generation efforts.

The author's biography can be found at http://jobenomicsblog.com/wp-content/uploads/2014/01/Vollmer-Chuck-Jobenomics-BIO-September-2014.pdf