China Leads the Global Energy Revolution

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EXECUTIVE SUMMARY

China is leading the world in research, development and investment in the renewable energy industry. This long-term strategic initiative has important consequences not only for China's own growth, but also for world sustainable development. During the last hundred years, countries have relied on petroleum as their main energy source. However, this is unsustainable. The world has reached a point in which leaders will have to make decisions about the new energy matrix for the next 50 years. Early innovators will have access to new information and knowledge, and thus, will most likely be the leaders of tomorrow. This paper assesses where the United States stands within the clean energy revolution and the threats arising from an ambitious China.

Keywords: China, Renewable Energy Industry, Clean Energy Revolution, Sustainable Development, Energy Matrix

INTRODUCTION

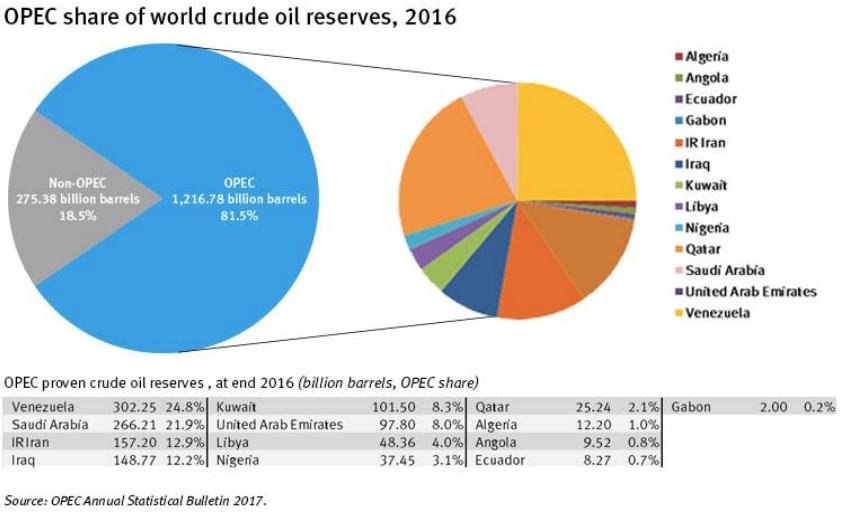
The use of petroleum dates back to ancient China more than 2000 years ago. The Chinese were the first to use petroleum as fuel as early as the fourth century BC (Deng, 2005). The demand for oil ramped up with the invention of the first commercially manufactured motor car in 1885 by the German engineer Karl Benz (Kaiserlicht Patentatm, 1886). This new vehicle ran on a cheap by-product called gasoline, and the need for this new fuel rose greatly with Henry Ford's Model T in 1908. Throughout the 20th century, oil usage expanded to almost all goods and services world-wide, and since then, countries have become essentially addicted to it. However, this heavy reliance on oil is unsustainable, not only because world consumption and population have been steadily increasing, but also because the discovery of new oil reserves has been diminishing. Currently, the world is widely debating environmental issues and a consensus has emerged about the negative impacts that fossil fuels have on the world climate and the long-term unsustainability of oil being the main energy source.

The pursuit of renewable energy also has long historical roots. For example, in the 1890s, the German inventor Rudolph Diesel developed a powerful and efficient diesel engine using vegetable oil fuels. He envisioned that pure vegetable oils could power early diesel engines for agriculture in remote areas of the world where petroleum was not available at the time (Chalkley, 1912). Many other inventions in different parts of the world were created during the last century, but most of them on a small scale. These efforts may have been limited because of the pragmatic view that oil was plentiful, and therefore, there were few incentives to foster new technologies on a larger scale. During the 21st century, world leaders have awakened, and major initiatives have been taking place. As reflected in the countries that signed the Paris Climate Agreement, there is a consensus on the importance of expanding renewable energy sources. One fact is evident: China is leading by far this race and threatening the historic American hegemony on energy.

RELIANCE ON OIL IS UNSUSTAINABLE – DATA AND FORECASTS

It is clear that the equation of oil supply versus oil demand will not balance in the near future. The question focuses on how many years we still have ahead before total oil reserves are mostly depleted. Below is a 2016 chart provided by an OPEC data base. It shows the number of barrels from proven crude oil reserves for OPEC and non-OPEC members. Adding both figures, the world still has approximately 1,500 billion barrels of crude oil. (OPEC, 2016)

FIGURE 1



OPEC proven crude oil reserves , at end 2016 *(billion barrels, OPEC share)*

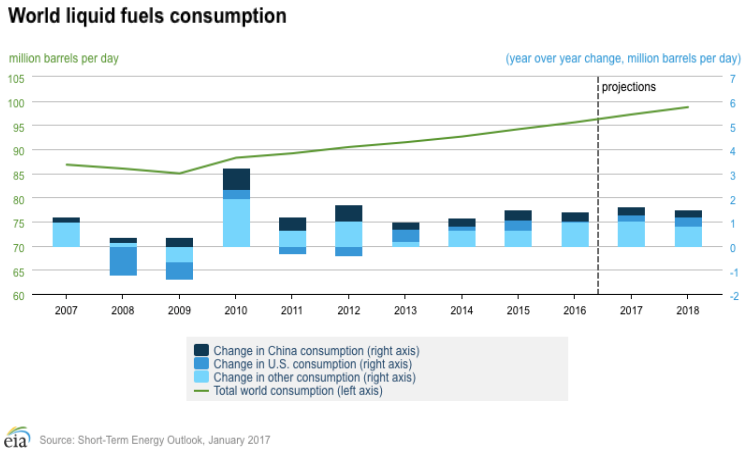
Venezuela	302.25	24.8%	Kuwait	101.50	8.3%	Qatar	25.24	2.1%	Gabon	2.00	0.2%
Saudi Arabia	266.21	21.9%	United Arab Emirates	97.80	8.0%	Algeria	12.20	1.0%			
IR Iran	157.20	12.9%	Libya	48.36	4.0%	Angola	9.52	0.8%			
Iraq	148.77	12.2%	Nigeria	37.45	3.1%	Ecuador	8.27	0.7%			

Source: OPEC Annual Statistical Bulletin 2017.

Source: OPEC website

In addition, from the OPEC data base, the chart below shows world oil consumption per day and per year. If we assume that in the future world consumption will be equal to that of 2016 (95 million barrels per day or 34.6 billion per year), we can estimate that total depletion will happen in the next 43 years. It is important to note that this yearly estimate may be overstated, since world population and consumption may increase, and there is an oil availability level at which extraction is not financially viable. The number of cars in China increased at an impressive rate of 912% over 15 years, from 16 million cars in 2000 to 163 million cars in 2015 (Statista, 2016). This fact alone shows the gravity of the problem and the impact that high economic growth countries will have on the world-wide demand for oil in the coming years.

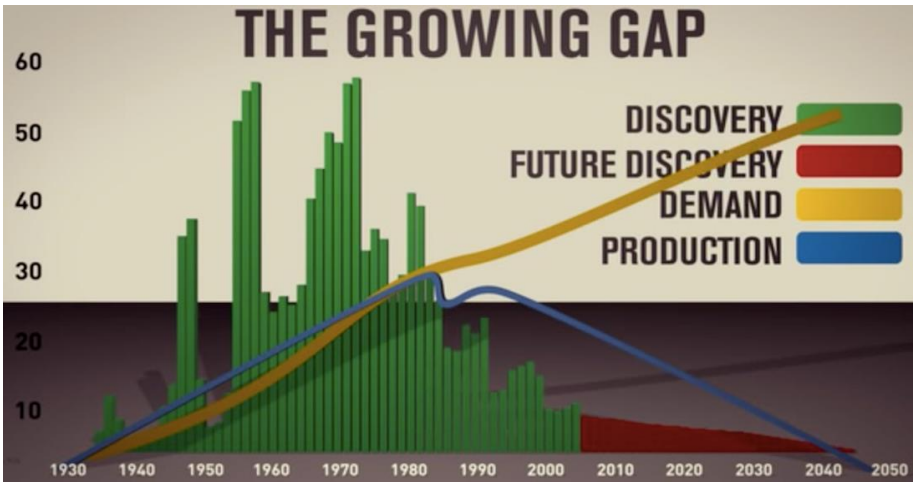
FIGURE 2



Source: OPEC website

This view is in line with that of Dr. William Shepard, professor of renewable energy, who has forecast that in the next 25 years, oil reserves are going to be seriously depleted. Matthew Simmons, former energy adviser to U.S. President George W. Bush, pointed out that the heads of the world's largest oil reserves testified and agreed upon the oil depletion issue in front of Congress. An example of this consensus is that ExxonMobil printed the graph below in the Oil and Gas journal. The chart shows future oil demand increasing along with decreasing oil discovery and production (Tickell, 2008).

FIGURE 3



Source: Fields of Fuel (Tickell, 2008)

In sum, it is evident from the data that there is agreement on oil supply running out and on challenging times ahead.

UNITED STATES AND ENERGY

Since the beginning of the 1900s, America has been able to demonstrate an entrepreneurial and leadership position in research and development of new technologies. This is part of its DNA. This was dramatically shown when President John F. Kennedy gave a speech on September 12, 1962 about sending the first man to the Moon. More recently, in the last 25 years, the United States has led the advance and development of information and communications technology (ICT), and transforming the world economy. In terms of energy, the 1970's oil crisis also generated entrepreneurial initiatives after America saw its national security and sovereignty threatened by the OPEC members, which then controlled 80% of the oil reserves. In 1979, President Jimmy Carter became an advocate of clean energy initiatives as a way to reduce U.S. dependence on foreign exporters. He not only stipulated a target of 20% of the U.S. energy generation coming from renewable sources by 2000, but also installed solar panels on the roof of the White House as a sign of support for the clean alternatives. Furthermore, during this same period, a Wisconsin farming community called Soldiers Grove implemented a plan to become America's first all solar energy town. A few years later, despite the limited solar technology at the time, the community achieved its plan (New York Times, 1987). These basic examples demonstrate pro-active characteristics commonly found in creative and entrepreneurial people. But what happened afterwards? Which path did the U.S. choose to follow?

Right after the election defeat of President Carter, President Ronald Reagan ordered the removal of the solar panels installed in the White House. In addition, one of his cabinet secretaries said that solar was not a technology befitting a superpower. Moreover, in 1986, the Reagan administration cut the research and development budget for renewable energy and eliminated tax breaks for the deployment of wind turbines and solar technologies. With this, US decided not to diversify its energy matrix, but to rely on inexpensive, but polluting fossil fuels. But the question remained of how would America achieve its energy freedom?

The United States consumes 22% of the world's oil but has only 2% of its reserves. It would be reasonable to think that an entrepreneurial country would work out ways to increase its efficiency in renewable energy generation; however, this did not happen. Whereas solar, wind and energy storage technologies have been researched and developed throughout the country, these initiatives have not received government support to allow larger scale deployment. At the same time, there is a pollution effect. The U.S. represents only 5% of the world's population, but the American car fleet creates almost 50% of the world's automotive CO2 emission (Borger, 2006). The end result has been a country addicted to oil, which creates harmful pollution and which lacks a long-term alternative plan for its energy matrix.

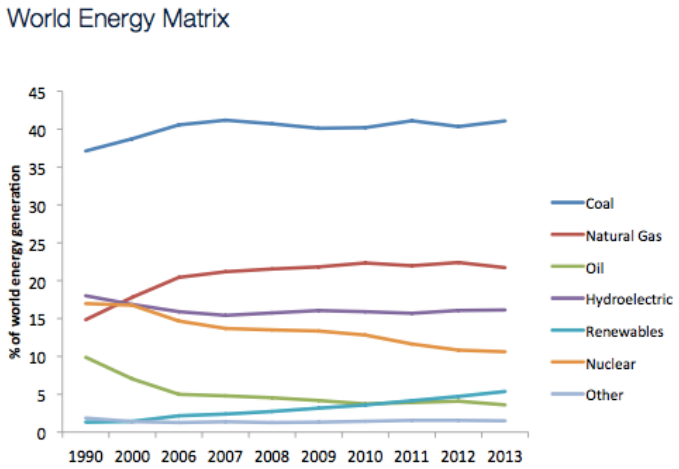
This fossil fuel imprisonment is most likely explained by an energy industry which is over 100 years old and which uses it economic power to fight threats from innovation. The oil companies contributed $500 million to politicians and political parties from 2014 to 2017, according to OpenSecrets.org, one of the leading websites tracking the influence of money on U.S. politics. (Center for Responsive Politics, 2017). In Louisiana, which is one of the largest producers of gasoline in the nation with 150 petrochemical facilities in a 100-mile area, its Environmental Protection Agency gets 90% of its funding from permits issued to oil companies. This is a clear conflict of interest, since this Agency should enforce laws to protect U.S. citizens. According to Beth Zilbert, an attorney and resident of Lake Charles, the number of birth defects, fertility/reproductive problems and incidents of miscarriages have increased in the area. Also, Louisiana has the highest cancer incidents in the U.S., most likely linked to oil processing (Tickell, 2008).

This fight against clean energy became evident when President Barack Obama was first elected. The climate crisis and the need for energy alternatives were top priorities on his agenda, and in March 2009, Carol Browner, the White House energy czar in the White House, invited Van Jones, co-founder of the nonprofit Green for All, to join her team as a special advisor for green jobs in the U.S. However, in September 2009, Van Jones resigned after being attacked by opponents of green reform (Kantayya, 2016).

RENEWABLE ENERGY INDUSTRY

In the graph below, we can see the world energy matrix. Although coal still represents the vast majority of energy generation, its future seems uncertain, as many countries have been shifting towards cleaner energy sources. Moreover, we see that the use of renewables has been increasing throughout the years, a trend that will most likely continue in the future. The development of renewable energy alternatives has been underway for decades, but with limited government support.

FIGURE 4



Source: 2016 World Economic Forum Renewable Infrastructure Investment Handbook

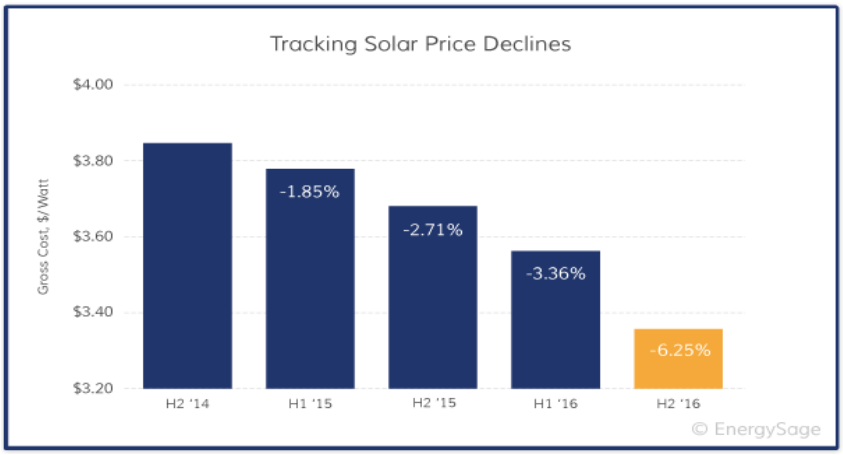
Although China has made huge investments in the renewable energy industry, other countries have also been taking the necessary steps to keep competitive in this race. For instance, Germany has been pursuing technologies, such as solar, wind

and biodiesel, to decrease its reliance on fossil fuels. Renewable energy, depending on weather, can cover 100% of German power use (Amelang, 2018). In addition, the government offers tax breaks for biodiesel to be competitive in the market place, averaging 85% of the price of the ordinary diesel. Sweden is another European country that has been moving in this direction. The Scandinavian country set a national target mandate to be petroleum free by 2020. Furthermore, Sweden removed all taxes on renewable fuels (Tickell, 2008). Spain has also been following this trend. The country mandated new construction codes for buildings in the public sector, requiring the integration of solar thermal with photovoltaic technology. Seville, for instance, will soon cover its energy needs using solar energy, which already powers 6,000 households. On a larger scale, the European Union set a target to be 20% renewable by 2020, and according to the Senior Advisor of Younicos Renewable Energy Systems, Philip Hiersemenzel, it will seek to achieve 80% by 2030 (Wired, 2011).

Despite different levels of investment, political will and pace of implementation of reforms, one factor seems quite clear: the shift towards clean energy has been possible not only because of greater public awareness and demand for alternative sources, but also because of concerns regarding future oil shortages and the need for a viable long-term plan with stable energy supplies and prices. The target mandate implemented in Sweden was decided by the public, and the government followed (Tickell, 2008). Germany has more than 1,900 public filling stations for biodiesel (German Energy Agency, 2007). This is quite different from the U.S., where the government still stimulates sales of non-efficient fossil fuel for large cars and petroleum companies create barriers to oil station owners to offer cleaner alternatives to the public in general. (Meckler, 2007).

The efficiency and the costs of clean energy sources have improved, and it is expected that new technologies will soon become very competitive with fossil fuels. For example, according to EnergySage Solar Market Place, one of the largest U.S. data platforms for the solar energy industry, in 2008, the cost of a solar residential panel installation was $ 8.82/watt. Less than 10 years later, the cost fell by over 60%, to $ 3.36/watt. Below is a chart depicting this downward trend.

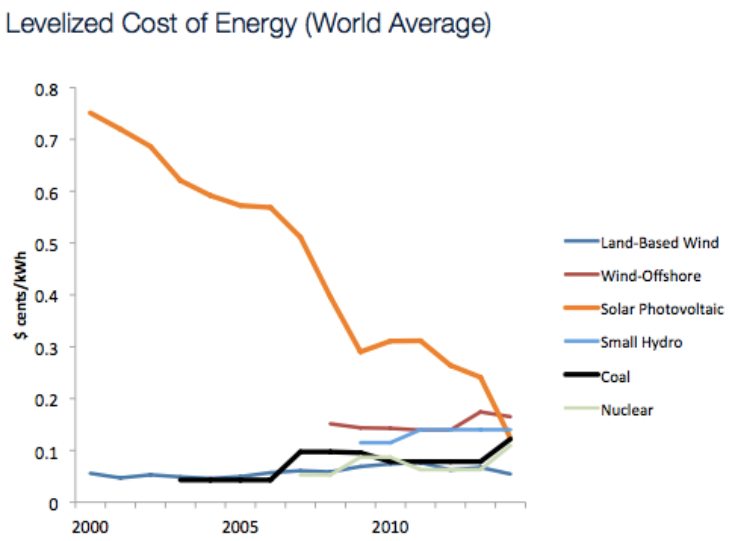
FIGURE 5



Source: EnergySage website

Regarding efficiency, it is now possible to find solar panels with 22.8% conversion rate, compared to just 17.8% from five years ago. According to a World Economic Forum publication in August 2017, the US National Renewable Energy Laboratory has developed a solar cell with 44.5% efficiency, making it the world leader. Although this level of efficiency is still not available for commercial use, it is reasonable to believe that as the demand for cleaner solutions continues to increase, more investment will be deployed in R&D and new efficiency targets will be achievable. This is also true for wind power. According to the IEA, capacity factors for wind turbines have improved substantially, from about 25% to 50% in the past decade. This prediction is reinforced in the graph below. Large improvements in the unsubsidized, levelized cost of electricity (LCOE) for utility-scale solar photovoltaic, which was highly uncompetitive only a few years ago, has declined at a 20% compounded annual rate without much incentives (EnergySage, 2017).

FIGURE 6



Source: OpenEI, Transparent Cost Database

The evolution of renewable energy technology has reached a point of competitive cost-effectiveness, and further improvements are expected to continue. Estimates by the International Renewable Energy Agency (IRENA) suggest that solar LCOE will still fall by 59% over the next decade, while the same metric for wind will decline by 26% for onshore turbines. (IRENA, 2017). Currently, the average gross cost for a standard 6kW home solar system has fallen from $52,920 to $14,110 in the past ten years (EnergySage, 2017). So, imagine how much technological progress could be achieved with more incentives and demand?

When it comes to economic competitiveness, renewable energy technology, especially solar and wind, has made enough progress to achieve in many cases grid parity with other types of energy sources. By 2020, solar photovoltaic is projected to have a lower LCOE than coal or natural gas generation throughout the world. While the average global LCOE for coal has hovered around $100/MWh for over a decade, solar has seen its cost plummet from around $600 a decade ago to $300 only a few years later, and now close to or below $100 for utility-scale photovoltaic. Wind LCOE is around $50. In this sense, the two major sources of non-hydro renewable energy have reached grid parity in a number of countries. Countries that have already reached grid parity include those in which demand is rising at a fast pace (i.e. Chile, Mexico) or those where sunlight exposure is high (i.e. Brazil, Australia). In many other countries, installing solar/wind capacity is more economical than installing coal capacity (IRENA, 2017)

The previous analysis is strengthened by the World Economic Forum, which has estimated that more than 30 countries have already reached renewable grid parity without subsidies, and around two thirds of the world should reach grid parity in the next couple of years (World Economic Forum, 2016). If electricity costs were to rise by 3% annually, 80% of the global market would reach grid parity in the next couple of years, according to Deutsche Bank (Clearbridge Investments, 2016). This is in line with the projections made by the U.S. Department of Energy which announced that utility-grade solar panels have hit 2020 cost targets ($1.00/watt) three years early, which is seen as the threshold below which building solar power arrays becomes competitive, without subsidies, with the cost of fossil fuel plants (Hao, 2017). Wind turbine prices have fallen by more than 30% over the past three years. In addition, wind power capacity factor, which is the actual electrical energy output over a given period of time compared to the maximum possible electrical energy output over the same amount of time, increased from 25% to 50% in just 10 years, according to Keith Longtin, wind products general manager at General Electric. This means that wind power can be installed in more locations where the wind is slower. This increase in the capacity factor was possible due to another technology improvement. For example, the 1.6 MW predominant turbine in the U.S. is now equipped with a 100-meter rotor, compared to the 70-meter rotor used in the past (IRENA, 2018).

The previous examples show the advantages of clean energy sources over fossil fuels. It is hard to imagine all the positive implications in our lives, since complementary new industries will most likely be created. For example, solar panels will transform sunlight into electricity and power the needs of households. The excess energy will be stored in already available grids, which in turn, will "fuel" electric cars. If we just think about the direct impact of the changes in renewable energy sources,

the size of the industry is estimated to be $1.5 trillion, according to David Crane, former CEO of NRG Energy, a leading power energy company in the U.S. This figure alone demonstrates how much potential there is ahead. (Pyper, 2016).

CHINA AND THE RENEWABLE ENERGY INDUSTRY

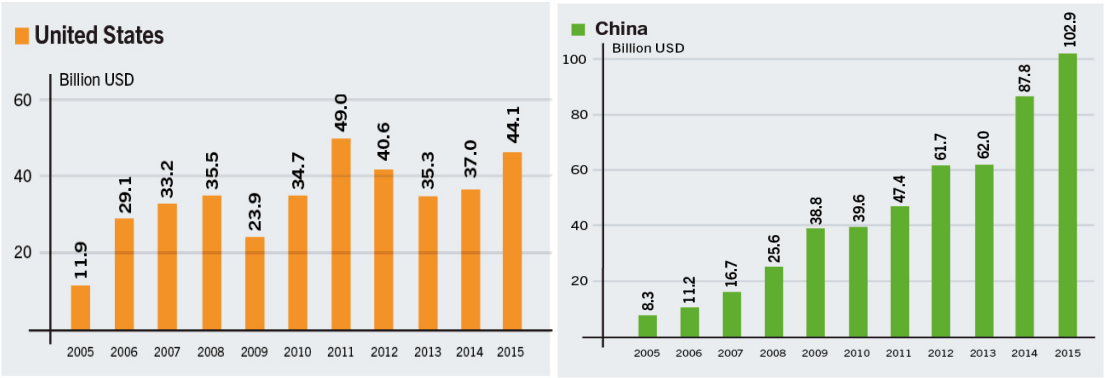
China has progressively become a major player in the renewable industry as its share of world energy consumption has grown to 23% as compared to the USA at 16%. (Kejun and Woetzel, 2017). According to Peggy Liu, chairwoman of the nonprofit Joint US-China Collaboration on Clean Energy, China has been going through a "clean tech" revolution because of fear. This fear is explained by the future oil shortage and the outcomes of such scenario. She says that China does not want to create conflicts with other countries when oil becomes scarce. This would threaten the country's energy and national security. In addition, she says this is the main reason why China has been deploying immense resources to implement sustainable technologies on a large scale. A second reason is that the country sees climate change as a real threat, moving in the opposite direction to the current U.S. administration, which withdrew from the Paris Agreement and promised to put American coal workers back to work. A third reason is that China is taking advantage of this "required" shift and transforming the trends into business ventures. The country sees this new market not only as a possibility to expand jobs, but also as an opportunity to acquire knowledge and fight for a world leadership position. The renewable industry is viewed as a race in which the champion will get most of the benefits. (Kantayya, 2016).

China currently boasts 3.5 million jobs out of the total global 8.1 million renewable energy jobs, by far the largest percentage for a single country, according to the International Renewable Energy Agency. Moreover, China's National Energy Administration projects that the new investments being deployed will create 13 million jobs in the sector. In contrast, the American renewable sector employs only 769,000 people, according to the most recent annual report from the International Renewable Energy Agency. (IRENA, 2016)

The view that the clean energy market has a tremendous potential to create new jobs is shared by Van Jones, who constantly says that solar energy could be used not only to create jobs in states with high unemployment rates, but also to help reduce crime and violence in low income neighborhoods. He says this is possible, because solar energy is a labor intensive industry. This assertion is reinforced when we look at what happened to Solar Energy Westech, one of the most successful privately owned solar energy Chinese companies. According to Mr. Wally Jiang, the founder and CEO, 15 people were employed in 2003 when the company started operating. He now employs 15,000 people in manufacturing and research and development. He says that this was only possible because of government incentives and targeted low-interest rate loans used by banks to foster new projects in the clean energy sector (Kantayya, 2016).

But how large is the gap in investment in renewable energy sources between China and the US? As shown in the two charts below, when we analyze the data in 2015, China's investment accounted for more than twice that of the U.S.:

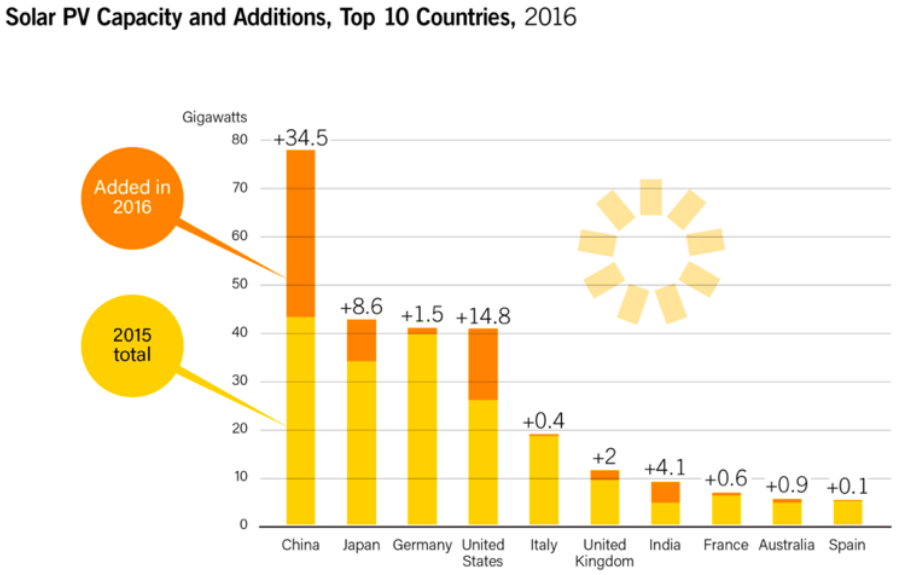
FIGURE 7



Source: Frankfurt School-UNEP Centre / BNEF Global Trends in REI 2015

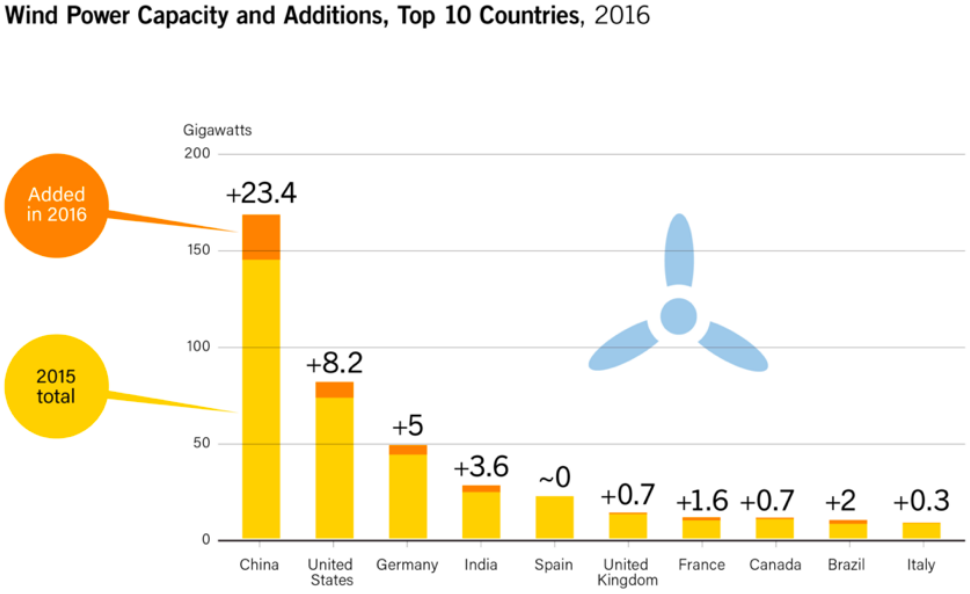
China shows the highest added capacities when compared to those of any other country as shown in the two graphs below:

FIGURE 8



Source: REN 21: Renewables 2017 Global Status Report

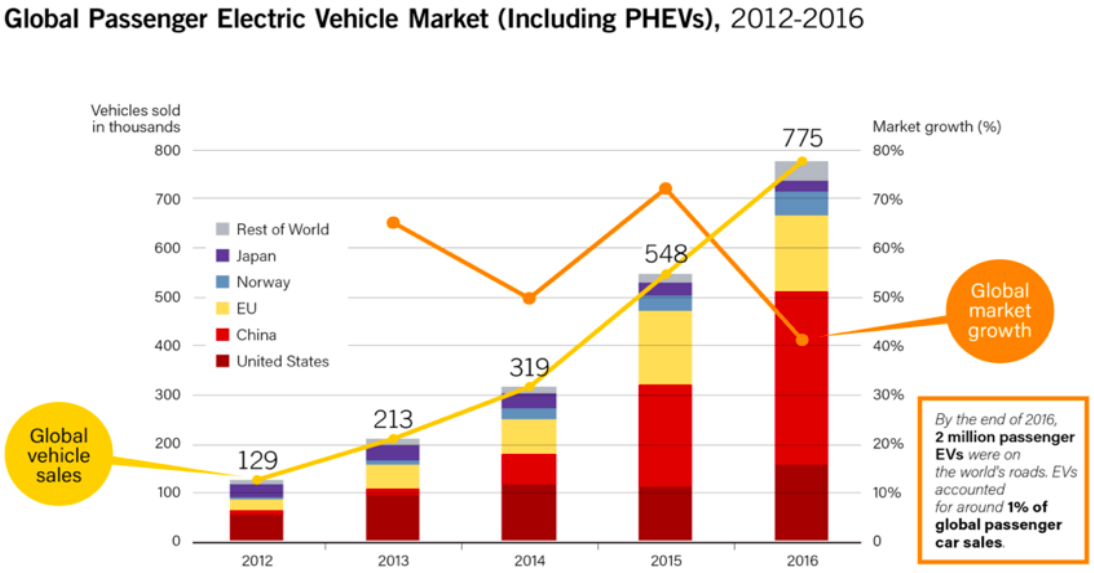
FIGURE 9



Source: REN 21: Renewables 2017 Global Status Report

Another alarming factor for the United States is that China is also embracing more complex manufacturing, such as electric cars. China's market has seen dramatic growth in recent years, with electric vehicles (EVs) sales increasing from about 11,600 vehicles in 2012 to more than 350,000 in 2016. China surpassed the United States in 2016 to become the country with the most passenger EVs on its roads, with more than 650,000 units in use by year's end.

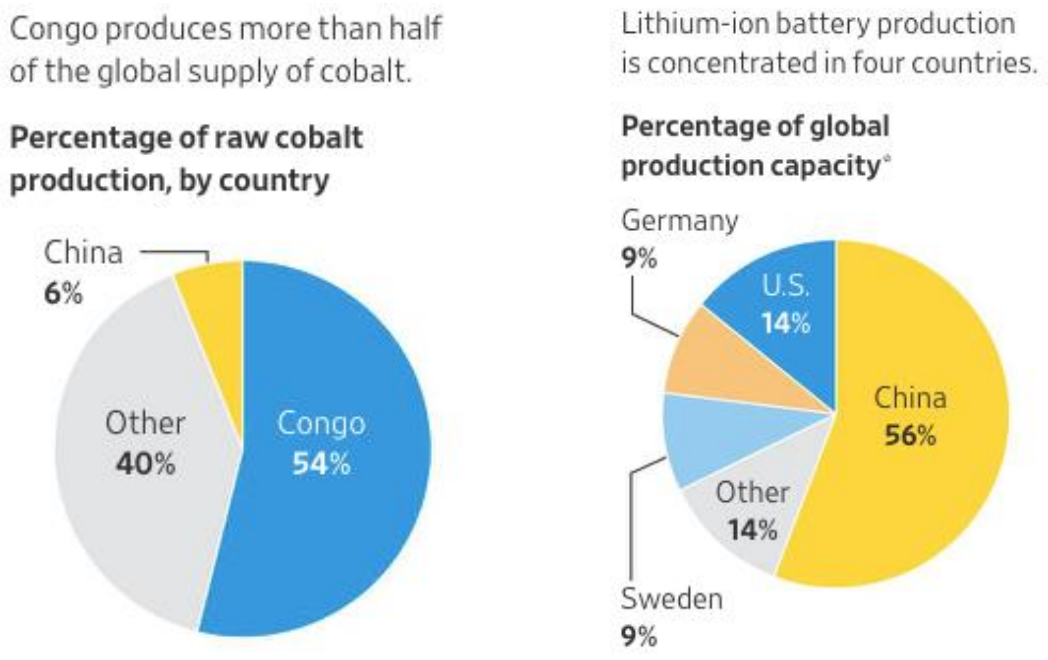
FIGURE 10



Source: REN 21: Renewables 2017 Global Status Report

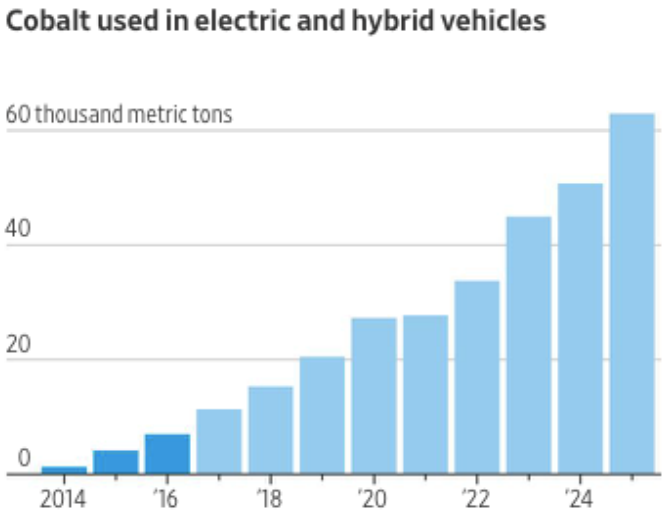
With the projected rise in EV sales, there has been a global race to lock up reserves of cobalt, which is an essential raw material used in the production of lithium ion, an important input for electric vehicle batteries. The country is already one of the largest importers of cobalt from Congo, the world's largest producer. In addition, China already has the largest lithium ion battery production capacity. Moreover, in 2011, China listed electric vehicles as one of seven strategic emerging industries (REN21, 2017).

FIGURE 11



Source: (Patterson and Gold, 2018). U.S. Geological Survey (cobalt production)

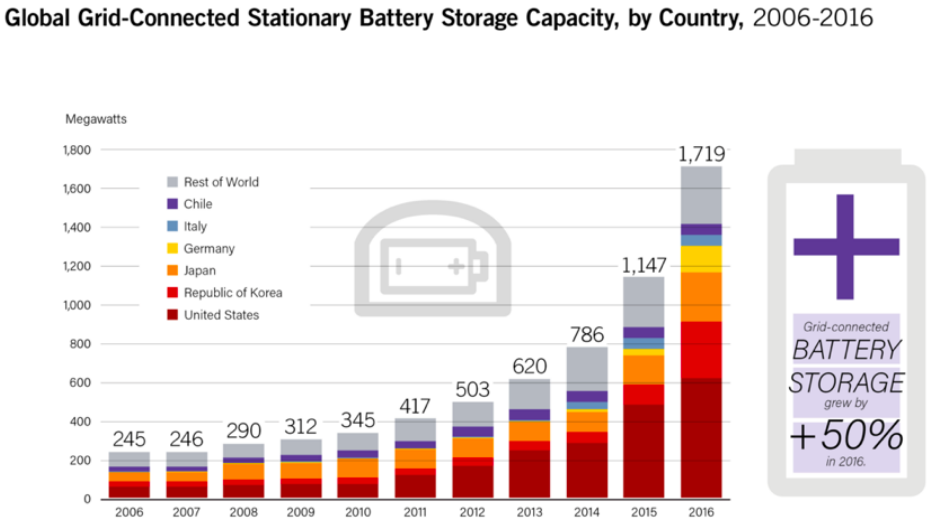
FIGURE 12



Source: (Patterson and Gold, 2018). Morgan Stanley

Finally, battery storage capacity is another factor that has hampered the utilization and competitiveness of renewable energy sources. However, due to technological advancement, battery costs and capacity have improved dramatically in recent years. Boosted by the growth of electric vehicle markets, the average price of battery packs has fallen from $1000/kWh in 2010 to $209/kWh in 2018, according to the United Nations Environment Programme (UNEP). The graph below shows increasing battery storage from 2006 to 2016 (McCrone et al, 2018).

FIGURE 13



Source: REN 21: Renewables 2017 Global Status Report

It is clear that China is the leader in the renewable energy industry. We could expect that this gap could narrow if the U.S. became more aware of the current and future situation. The U.S. appears to be moving contrary to the trends observed around the world. The Trump administration continues to support the coal industry and to emphasize fossil fuels through tax incentives. This is in large contrast to China. Although coal still represents the largest part of China's energy consumption, Beijing has moved to restrict the construction of new coal power plants. (Buckley, 2014). China's National Energy Administration established in January 2017 a mandatory target to reduce coal energy consumption. Furthermore, China is investing an

additional $367 billion in the next two years for renewable power generation and is setting a goal for clean energy to meet 20% of China's energy needs by 2030. This represents a large portion of the $1 trillion in annual renewable infrastructure investment by 2030 to meet the goal of limiting global warming to 2 degrees, according to the conclusions from the United Nations Conference on Climate Change (COP21) in December 2015 (Kejun and Woetzel, 2016). Currently, the world annual average capacity investment is a little over $200 billion, with developing countries representing the majority of investment commitment led by China ($102.9 billion), India ($10.2 billion) and Brazil ($7.1 billion). (Bleich and Guimaraes, 2016.)

Finally, Liu Zhenya, former chairman of China's state-owned power company, State Grid Corp. said that China is aiming to build a global power grid that could transmit 80% renewable energy by 2050. Initially, a network of long-distance, high-voltage direct-current power lines would be built to move renewable power from the north of China to the south and from the east to the west by 2025. Next, regional grids would be built to transmit substantially more power across national borders in Northeast and Southeast Asia, between Africa and Eurasia, and between nations in both North and South America. (Baculinao, 2016)

These facts and plans show how serious China is when it comes to the clean energy sector. China has already become the major manufacturer and exporter of renewable energy technology, supplying two-thirds of the world's solar panels (China Daily, 2013) and installing nearly half of the world's wind turbines in 2017 (Pham and Rivers, 2017).

CONCLUSION – WHAT TO EXPECT?

Renewable energy is here to stay. Those countries that still doubt its potential benefits and question the reliability of clean energy sources will be left behind in the race to develop new competitive technologies. The biggest problem in developing clean energy projects is to fight the fossil fuel industry, which means that this shift in future power supplies means a shift in political power relations. The remaining challenges encountered on a case-by-case basis will naturally disperse as the renewable sector gains momentum. A catalyst for this process has been and will continue to be the 2015 Paris Agreement.

The U.S. produces 14 million barrels of oil per day but uses 19 million barrels (eia, 2018a). This is not sustainable. Over 60% of the electricity in the U.S. still comes from fossil fuels (eia, 2018b) and it is necessary to burn 100 cars of coal to keep a power plant functioning for just one day, clearly a non-efficient and polluting type of energy. The world is now building more solar capacity than coal generation. Most new demand for electricity is being supplied by renewable resources, with solar providing the most.

In terms of job creation, the U.S. Department of Energy estimates that 20% of electricity coming from wind power could generate an additional 500,000 jobs (Wind Energy Foundation, 2018). Solar power also has great potential and does not require enormous amounts of land. According to Michael Totten, chief advisor of Climate Freshwater & Ecosystems at Conservation International, only 15% of the existing U.S. urban land area including the use of rooftops, would be enough to provide 100% of America's electricity requirements (Seligmann and Totten, 2013). Solar power can also be deployed on water as evidenced by China developing the world's largest floating solar panel facility covering about 100 square miles and producing enough energy to power 15,000 homes. Although this energy farm on water is more expensive than solar farms on land, floating solar panels can run more efficiently in the long run, because they are cooled by the water underneath (Pham and Rivers, 2017).

Even with the declining costs of wind and solar power, trillions of dollars will be necessary for these investments. This reality echoes the strategic issue raised by President Dwight Eisenhower in his iconic Farewell Address about the dangers of the Military Industrial Complex. That speech came nearly eight years after his "Chance for Peace" address at the United Nations in 1953 at which Eisenhower elaborated on the biblical phrase of "turning swords into plowshares." Pentagon spending in America is enormous, especially for military conflicts. In an article entitled, "Beating Swords into Wind Turbines-or Solar Panels if You Like," Paul Gipe discussed the dynamics of military spending versus renewable energy investments. The Iraqi war alone has been estimated to cost $2 trillion in deficit spending which will eventually double to $4 trillion after interest expenses. If the Iraqi war dollars had been spent on a combination of wind and solar power, over 50% of our electricity would now come from renewables (Gipe, 2013). In strategic contrast, China has apparently taken the words of President Eisenhower seriously by completely acknowledging the energy crisis and investing in pioneering new technologies. China produces 63% of the world's solar photovoltaic technology and has emerged as the world's largest wind turbine manufacturer (China Daily, 2013) surpassing Denmark, Germany, Spain, and the United States (Frangoul, 2018).

This shift from fossil fuels to renewable energy sources is the technical revolution of the 21st century. New technologies will help governments achieve higher sustainable growth rates previously thought impossible. In addition, many other new industries will be created, which in turn will generate more jobs, and foster more economic growth. The future development of alternative energy seems bright. The only question that remains is who is going to get the most benefits. China will be a major source of both energy demand and cutting-edge technology with the strategic implication that it will have a unique opportunity to provide global leadership. Its investments in renewable energy at home and abroad can lead to additional technological breakthroughs that drive down costs for consumers everywhere and also fight global warming. If China keeps the same pace and America continues as a mere spectator relying too much on fossil fuels, we will most likely see a world with a new geo-political map, one with China as the world's most important economic superpower.

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