

The development of EV and its impact on energy, environment and other socioeconomic aspects

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Abstract

People draw more and more attention to EVs (EV) since they are regarded as energy-efficient and environmental friendly. According to research, EV has advantages in consuming less gasoline and emitting less greenhouse gas. In the meantime, electric cars have disadvantages such as cost-inefficiency, long charging time and short travel range. In addition, LNG cars and vehicles with clean energy engines are strong competitors to EVs in marketplace. Therefore, governments and car manufactures should take measures, including cutting down the price and offering subsidies, and improving technologies with regard to charging, batteries and energy efficiency. In this way, EVs will be prosperous and become the major vehicle types in the near future.

Keywords: electric vehicle, influence on energy, power generation, environment impact, development constraints, competitors

1. Introduction

With the increasing worries about negative environmental impact brought by gasoline-powered conventional cars and the oil dependence on foreign energy market, EV draw more and more people's intention since they are considered as the clean substitute for conventional cars. However, the paper tries to answer two frequently asked questions. The first one is that whether EV will reduce the consumption of oil and whether they are environmentally friendly. The other question is that whether EV will lead the tendency of vehicles in the future.

The paper consists of seven parts. First, it will introduce the brief history of EV and different types of EV in marketplace. Second, it talks about the influence of EV on the energy consumption, including the decrease use of gasoline, the reduction of oil dependence on foreign market and the probable increase consumption of coal during power generation. Third, it tries to explain both the positive and negative effects on the environment by using EV. Fourth, it proposes factors that constrain the development of EV, such as cost-inefficiency and technological immaturity. Then, it presents development conditions of EV in three typical countries in the world, namely, the US, Norway and China. Next, the paper talks about the competitors, which include LNG cars and vehicles with clean gasoline engines, to the development of EV. In the end, this paper offers several suggestions for the development of EV in this stage.

2. Background

2.1. The history of EV

Only in recent years do people pay much more attention to electric cars. However, the history of EV dates back to nearly two centuries ago. The first EV was built in 1835 while the first successful and practical one was created in 1891. By the end of the 19-century, more than 4,000 electric cars were

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produced in the US. Nevertheless, with the development of gasoline-powered cars, which were equipped with the advantage of long-distance capability, and the increasing availability of gasoline, electric cars became less popular than gasoline-powered vehicles. In the following decades, gasoline-powered cars kept developing and turned into the mainstream means of transportation around the world. In the 1970s, with the mounting oil prices caused by the oil embargo and the growing environmental concerns, electric cars came into sight once more. Despite the fact that gasoline-powered cars still take up the great percentage in the market share, greater amount of people give attention to electric cars and more and more brands and models of EVs appear in the market.

2.2. *Types of EV*

Although there is a general title of the electric car, there are actually four different categories under this name. Electric cars can be divided into four types due to their different functional principles: hybrid EVs (HEV), plug-in hybrid vehicles (PHEV), battery EVs (BEV) and fuel cell EVs (FCEV).

HEVs are the most developed and most popular cars among those four categories. Unlike other three types, HEVs don't have plug-in batteries. A HEV uses an internal combustion engine, the same as conventional cars, and an electric motor to generate energy in the same time. When an HEV is braking or coasting, the electric motor will capture the energy released from wheels and convert it into electricity, which will be stored in a battery that prepared to be used. Even though HEVs don't have plug-in systems, the combination of the internal combustion engine and the electric motor allows cars to travel longer than conventional cars by using the same amount of gasoline. Nowadays, the HEV technology is a comparatively mature one and many auto companies are producing this type of cars.

PHEV is different from HEV since it has a plug-in recharging system, which allows the car to use electricity as the power resource for the first forty miles or less and then functions the same as an HEV. In this way, PHEVs consume even less gasoline than HEVs. However, the electric ranges of different types of PHEVs vary greatly. Though it is said that the average mileage that powered by battery electricity is forty miles, some cars can only endure eleven miles while some can travel nearly fifty miles. What's more, PHEVs need to be charged for three to sixteen hours by using a 120V outlet while for one to six hours by 240V outlet.

BEV is a kind of vehicle that relies only on electricity. Unlike PHEVs, BEVs cannot be powered by gasoline. Thus, they require longer time of charging while they travel shorter distance than the previous types. Despite that the newly developed Tesla asserts that their vehicles require less than one hour to charge by using its Supercharger system and are able to travel up to 285 miles range at 65mph, most of PHEVs are known for time-costly of charge and short distance that can travel, especially compared with conventional gasoline-powered vehicles.

FCEV is an uncommon type of EV. By pumping hydrogen fuel and oxygen into the car, the engine will produce electricity. Even though the hydrogen fuel can fully combust when generate electricity, part of the hydrogen has to evaporate for some safety reasons. In this way, a part of hydrogen is wasted and the efficiency of FCEVs decreases to some extent. In addition, FCEVs have other shortcomings, such as difficulties to store liquefied hydrogen, hard to keep hydrogen as the liquefied condition and huge cost of constructing separate infrastructures. Therefore, FCEVs are the least popular electric cars in this phase. [1]

2.3. *Market share of EV*

In 2017, global EV sales (including BEV and PHEV) reached 1.22 million. China, accounting for 606 thousand units and 49.5% of global EV sales, became the largest growth contributor in marketplace. [2] Even though the promotion of EVs in China started later than developed countries, Chinese EV consumption is undergoing fastest development in the world thanks to positive government support. In the meantime, China, surpassing the US, ranked as the number one country of EV stock and made up of one third of total global EV stock. The EV sales in Europe were 308 thousand in 2017, making up 25% of total global sales. However, EVs are more prevailing and popular in Europe with highest ratio of EV consumption among all passenger light-duty vehicles (PLDVs). For instance, EV sales accounted for 39%

of PLDV sales in Norway and the number was 14% in Iceland, representing the top two countries concerning the ratio of EV sales. Moreover, Norway, the Netherlands and the UK has announced that they are going to allow only EV sales by 2020s. Due to the delayed delivery of Tesla Model-3, the growth pace in the US slowed down, with 200 thousand of EV sales last year.

3. Influence on Energy Consumption

3.1. Less oil consumption

As mentioned above, HEVs can travel longer by using the same amount of gasoline as conventional cars do; PHEVs consume less gasoline and BEVs consume zero gasoline. According to joint scientific research conducted by the Electric Power Research Institute and the Natural Resources Defence Council, hybrid vehicles consume 36% less oil than conventional vehicles while plug-in hybrid EVs consume 67% less per year. Without considering other aspects, such as high cost of purchase and the energy used for generating electricity, which the paper will talk in the following, electric cars have obvious advantages over conventional vehicles with regard to oil consumption. Therefore, it will make a huge difference in oil consumption if we consider the total amount of electric cars currently and the probable booming in the future.

What's more, electric cars have higher efficiencies in energy utilization aspect. For those gasoline-powered vehicles, only 20% of the energy within gasoline is used to drive the vehicle while the remaining part is wasted during the combustion process. Nevertheless, nearly 75% of the electricity stored in the batteries of EV can be used efficiently.

3.2. Reduction in energy dependence

For the US, to reduce the energy dependence on OPEC countries is an important factor in order to increase energy security. Electric cars consume less oil than conventional cars. In the same time, the electricity that fuel electric cars can be generated by a mixture of energy resources, such as gas, nuclear, coal and renewables. In addition, thanks to the shale revolution, which triggers greater amount of natural gas explored in the US, gas is becoming more and more important to generate electricity. In this way, the US can be more dependent on energy production by itself and the energy security is enhanced as well.

For other rapidly developing or energy dependent countries, to develop electric cars is also a favourable way to become more self-sufficient or less dependent. What's more, the high price of oil will drop since the lower amount of consumption world-widely.

4. Environment Impact

4.1. Fewer GHG emissions

Electric car is in a favourable position with regard to the reduction in GHG emissions and air pollution. However, it is more beneficial when using environmental-friendly resources to generate electricity or utilizing CCS technology when burning coal and other fossil fuels.

According to the National Defence Resources Council and the Union of Concerned Scientists, electric cars generate fewer global warming emissions. HEVs emit 36% less GHG than conventional vehicles while PHEVs emit 45% less on average. BEVs consumes 47% less than average compact cars. However, the number varies greatly if we consider different fuels to generate electricity.

4.2. Negative environment effects generated by electricity

Although EVs are powered by less oil and then emit less greenhouse gas, it still has the possibility to impose negative effect on environment. It is well known that certain amount of energy should be used to generate electricity, which is the fuel resource of electric cars. In China, coal is the primary resource within the energy mix to generate electricity, with 71.79% electricity generated by thermal power plants

(mainly coal-fired power plants) in 2017. [3] Other clean resources, such as nuclear, solar, hydro and wind make up only 28% in the total consumption of fuels used to generate electricity. By contrast, in US, coal-fired power plants generated 30% of electricity in 2017 while natural gas and nuclear accounted for 34% and 20% respectively. As for Norway, where 96.3% electricity was based on hydro power in 2017, achieved real environmental friendly from the electricity generation perspective. Coal, without any processing before burning in the coal-fired power plants, will impose very negative impact on environment when generate electricity. The pollutants emit by coal-fired power plants cover noxious fumes, such as sulphur dioxide and nitrogen oxide, and greenhouse gas. In 2017, the proportion of waste gas emissions by coal-fired power plants among all the industrial waste gas emissions was 30% in China.

That is to say, the performance of GHG abatement varies greatly by considering different types of fuels for electricity. If coal is the principle resource to generate electricity for electric cars, the reduction in global warming emissions is not striking. For this reason, renewables and clean energies should be used in order to achieve the goal of GHG abatement.

5. Development Constraints

Notwithstanding advantages, electric cars are still taking a small part of market share. Most people will not consider electric cars as the first choice since they have several drawbacks.

5.1. High price and low cost-efficient

First of all, electric cars are comparatively more expensive than conventional cars in most countries. Although car manufacturers and dealers advocate that customers can save a big proportion of money on gasoline and electric cars are cleaner as well, most of the consumers will become discouraged when they see the price of electric cars.

Here we compare three different models of Honda Accord, including a traditional sedan, a hybrid one and a plug-in type. Even though those three types are not identical with regard to drive motors, combustion process and other power principles, they are almost the same in appearance, comfortableness and most of the parts of the car body. As we can see from the chart, Accord hybrid sales for \$29,305, which is \$6,400 or 28% higher than Accord sedan. The price of Accord plug-in is \$39,780, which is \$16,875 or 74% higher than Accord sedan. [4]

As for the combined fuel-economy of those cars, Accord sedan is 31 mpg, Accord hybrid is 47 mpg while Accord plug-in is 46 mpg. We can make a rough judgment from those numbers that Accord plug-in is the least cost-efficient since its fuel-economy is even lower than that of Accord hybrid while the price is much higher. Now we set the price of gasoline as \$3 per gallon and every car travels 15,000 miles per years. By using the function $(\$3 \times 15,000 \times (1/\text{mpg}))$, it can be calculated that Accord sedan uses \$1451 of gasoline, Accord hybrid needs \$957 of gasoline and Accord plug-in requires \$978 of gasoline. If we draw functions $(22,905 + 1,451x_1 = 29,305 + 957x_1)$ and $(22,905 + 1,451x_2 = 39,780 + 978x_2)$ to determine the years for a consumer who has purchased an Accord hybrid or Accord plug-in to breakeven with the opportunity cost of an Accord sedan, we can obtain the outcome that $x_1 = 13$ years and $x_2 = 35$ years. Compared with the average year of a car in the US as 11.4, neither Accord hybrid nor Accord plug-in is cost-efficient.

Thus, the best solutions to this problem are to anticipate a high price of gasoline in the future or to increase the fuel-economy level of electric cars.

5.2. Travelling range

Besides the high price to purchase an electric car and the low cost-efficient of it, there are also some problems concerning the price and the service life of the battery and the range propelled and supported by the battery.

The prices and longevities of batteries vary significantly. In general, the battery of an electric car can last for 50,000 to 100,000 miles. Meanwhile, the cost of a battery falls between the \$300 to \$700 range for most of the electric cars. In contrast, conventional cars don't bear the shortcomings like this since the

technology of engines are comparatively mature and are able to survive for a longer time.

Hybrid cars don't have the problem with batteries. Similarly, PHEVs combine both electricity and gasoline to propel even though they have smaller fuel tanks. However, people are concerned with how a BEV can travel by depending solely on a battery. Tesla is probably the most advanced BEV in this stage. According to its advertisement, it can travel up to 306 miles at a 55mph level. Compared to conventional cars, this number is small. Meanwhile, there are several restraints that ensure this mileage, including favourable temperature and steady speed.

Consequently, battery is one of the constraints of the development and large-scale expansion of EVs.

5.3. Charging system

Similar with conventional cars that get refuelled with gasoline, PHEVs and BEVs require charging stations to charge electricity. There are several issues related to charging. First, the availability of charging stations is a problem. In the US, especially in big cities, charging stations are available freely. In contrast, the situation is different in Beijing, the ratio of EV ownership to public charging stations is comparatively. The condition is similar in many other developing countries in the world. Although consumers can build their own charging system in garage, it costs much money and the outcome is not satisfying compared to specialized charging stations. Thus, infrastructure construction is one of the constraints on its development.

Second, the long-time of charging is another shortcoming. Unlike only several minutes to refuel a conventional car, to charge an electric car can take up hours. What's more, even though people can charge their cars at home, it will take a whole night. In addition, drivers have to wait for nearly one hour for the car to be replenished in a supercharge station.

What's more, charging may increase national peak load by 7% and household peak load by 54%. Hence, it will generate unexpected pressures on electricity distribution infrastructure or cause abrupt blackouts.

Therefore, electric cars are more suitable for people who commute a short way every day by using them or have other alternatives when they need to use a car immediately.

6. Competitors to Electric Cars

Despite advantages in environment protection and energy consumption, electric cars have several competitors in marketplace. One is conventional car with cleaner gasoline or diesel engine and the other is LNG vehicle.

Firstly, some of the vehicles are already equipped with cleaner gasoline engines. Vehicles with clean gasoline engines will use traditional gasoline as the fuel while their engines are upgraded in order to increase combustion efficiency and cut down emissions. For example, Ford EcoBoost technology achieves 20% increase in fuel efficiency and 15% reduction in greenhouse emissions. Many models of Ford vehicles have been equipped with this technology. In addition, clean diesel-powered cars are also becoming prosperous in Europe, where diesel cars have already captured half of the market share. Major brands such as Audi and Mercedes have manufactured cars with diesel-powered engines. Diesel cars have the merit with smaller but high efficient engines and light car body, which leads to a high combustion ratio and less fuel consumption. Hence, those kinds of vehicle are strong competitors faced by electric cars because they use conventional means of fuel while achieving the goal of cleaner and greater efficiency as well.

Next, LNG vehicle is another kind of competitor with electric cars. There are several virtues of the LNG vehicle. First of all, compared with conventional cars, HEVs and PHEVs, the fuel of LNG vehicles is relatively cleaner. Natural gas is considered as a perfect substitute for oil since it emits less pollution. Second, the LNG technology is comparatively mature and natural gas is in a high availability.

Third, LNG cars have an advantage in travel range. Unlike BEVs, LNG cars can travel as far as conventional cars. Then, the cost of LNG cars is lower than both the conventional and electric cars since

the price of LNG is almost the half of gasoline. Nevertheless, the biggest disadvantage is that the container of LNG inserted in vehicle is huge. Thus, LNG technology is widespread among trucks and vans. In this way, electric car takes a favourable position since it is light and household convenient.

7. The Development of Electric Cars in Major Countries

In this part, we will introduce the development of electric cars in the US, Norway and China. Those countries are three typical countries with regard to the development of electric cars. The US is the primary producer and consumer of electric cars in the world; Norway has booming electric car sales; meanwhile, China is the representative of potential electric car market. Consequently, we will focus on the government policies, the market performance and the development trend in those three countries.

7.1. The US

The history of the electric car in the US dates back to 1830s while it drew people's attention once again after 1970s. In 1990s, the US government started to promote the commercialization of EVs by launching the California's Zero Emission Vehicle (ZEV) program. Thus, California has the most rapid growth rate and the largest market share of electric cars. Not until 2008 did this promotion become nationwide when the Congress created a \$7,500 consumer tax credit for purchasing EVs. [5] In the following, the US government has imposed several policies in order to boost the development of electric cars in the US. In 2009, the Obama administration established the goal of putting one million plug-in EVs on the road by 2015. Meanwhile, the US Department of Energy has been improving the electric car system by conducting series of research and programs. What's more, preferential policies are offered to EV-related manufactures, such as providing favourable loans to battery packs and charger producers.

Influenced by those favourable policies, more and more consumers in the US pay attention to electric cars. As we mentioned previously, the market share of electric cars is steadily increasing in recent years and it also has the trend to mount in the following decades. According to the survey conducted by Axsen and Kurani, there is a broad support for electric cars among new car consumers. Depending on the survey, most respondents express their willingness to buy an HEV, PHEV or EV for their next vehicle. In addition, less than 1/6 of the respondents show that they will stay with conventional cars. Nevertheless, not all the EVs are as popular as PHEVs since respondents think that PHEV is a mix of electricity and gasoline and depend less on the battery. In contrast, BEVs are the least popular.

7.2. Norway

Norway is a typical consumption country of electric cars in both Europe and the world. Notwithstanding the fifth biggest oil exporter and the third largest gas exporter country, the Norwegian government tries to control the domestic oil consumption and limit the CO₂ emissions. In order to achieve this goal, the government actively promotes electric cars by cutting the cost of purchasing EVs while increasing the cost of purchasing and operating costs of conventional cars.

The government imposes several measures and incentives. First, electric cars are exempt from VAT or high sales tax. Second, electric car users are free from urban toll payments or public parking fees. Meanwhile, they can recharge their cars in public charging stations without any cost. Third, electric cars can occupy the reserved bus lanes during rush hours. Under those rules, the market share of electric cars in Norway is mounting rapidly. In a country with only 5.1 million of population, there are already 32,000 electric cars on the road.

With the sales of electric cars keep growing, the goal of emission abatement is approaching. Nevertheless, there are several problems triggered by those incentives. First, bus lanes become congested during rush hours while there is no substantial measure to tackle this problem. People are complaining about it because it causes the decreasing efficiency of public transportations. Second, it is estimated that the tax exemptions account for 4 billion kroner, which is about \$650 million. This leads to pressures on government revenues. However, it is not possible for the government to eliminate those fiscal advantages

since half of the drivers who purchase electric cars consider saving money as the biggest advantage of buying them. Hence, ending fiscal incentives means that the electric car market could collapse and the climate goal would be unachievable. Thus, the Norwegian government has to think about other measures to increase government revenues and reach the goal of climate in the same time.

7.3. China

Unlike EU countries and other developed countries such as Japan, China has focused on the promotion of BEVs instead of HEVs and PHEVs since the incipient stage. It is reflected in both manufacture, sales and consumption sectors.

China initiated the large-scale development of EVs in 2009, when the Chinese State Council passed a plan to carry out the electric cars strategy. Under this strategy, China plans to meet the goal of 500,000 EV production and 5% market share of EV sales in three years. In the following years, the Chinese government enacted a series of policies to boost the production and consumption of EVs. However, the EV market sales increased by a 60% year-on-year growth to 75,000, accounting for merely 0.85% of all the PLDV sales. Consequently, the Chinese government continues and enlarges the promotion of EVs. The Ministry of industry and information has enacted a new plan, which says EV sales should reach 20% of the total PLDV sales by 2025. In order to accomplish this goal, the Chinese government is taking various measures. The supporting policies by the government contain subsidies, tax exemption and license plate incentives. Currently, consumers who purchase BEVs will obtain subsidies ranging from RMB 30,000-66,000 (roughly USD 4,620-10,163) from both the central and local governments based on different mileage scales EVs can travel. In addition, BEV consumers will be exempted from paying purchase tax. [6] It is worth noting that the subsidies and tax exemption regulations are applicable for only domestic EV brands. In other words, those measures could stimulate both the production and sales of EVs within China. What's more, BEV consumers will acquire license plates for free or with high probabilities. In many Chinese metropolis, such as Beijing, Shanghai and Guangzhou, local governments implemented purchase restrictions and license plate lotteries for conventional gasoline-powered cars in order to control the rising number of vehicles and the execrating air conditions. Nevertheless, BEVs are exempt from those regulations and restrictions. In Beijing, citizens are able to buy a BEV directly without competing in the license plate lotteries for conventional gasoline-powered vehicles, which has a 0.11% low success rate. Similarly, in Shanghai, where the license plates can only be purchased by auction with prices no less than RMB 80,000 (approximately USD 12330), the local government provides additional 20,000 license plates every year for BEVs without any charge. [7]

In 2017, the government took a more active part in stimulating the production and sales of EVs by introducing 32 policies. [8] The "Double Credits" policy was the most important and influential one, which stipulated specific amount of oil consumption and proportion of EV sales of car manufacturing companies. In this way, car manufactures in China, including both local enterprises and joint ventures, have no option but to increase the ratio of EV production.

8. Suggestions for Increasing the Market Share of EVs

After examining the development of electric cars in typical countries, we can deduce that electric cars are still in the initial stage in most countries in the world. Although it has the tendency to boom in the future due to the need of less energy consumption and emission, several steps should be taken in order to foster its expansion.

First of all, the initial price of electric car should become lower. As addressed in the previous part, electric cars have a low cost-efficiency when compared to conventional cars. Since the price oil cannot go up significantly in a short-term, the best way to increase the cost-efficiency is to cut down the price of electric cars and lower the price gap between them and conventional cars. Or if the price is not able to go down by a big margin, the government should impose more fiscal incentives for the consumers to consider buying electric cars. Norway is a good example but other countries should impose moderate policies that are in conformity with their national conditions. Only when the actual cost of buying an

electric car become lower than that of a conventional car will more and more consumers divert their attention into electric cars.

Secondly, manufactures should improve the technologies related to electric cars. Since long charging time, short travel range and short longevity of batteries are the major shortcomings that constrain the expansion of electric cars, car manufactures should focus more on the R&D of those aspects in order to overcome those flaws. We should be optimistic about the rapid development of electric cars for the reason that the newly produced Tesla has a great break through compared to previous electric cars. We can foresee a rapid growth of EV industry in the following decade because an increasing number of manufactures and research institutes are paying attention to it.

Thirdly, the development of the electric car should surpass its competitors, including LNG vehicles and cars with clean energy engines. That is to say, the energy efficiency of electric cars should be improved and the cost of using the combination of gasoline and electricity or electricity alone should be lower than that of LNG vehicles and clean energy engine cars.

9. Conclusion

Electric car is on its road to become popular in the US, Europe and developing countries such as China. The reason that electric car draws more and more attention is that it is considered as environmental-friendly and energy efficient. However, some people question whether the electric car can achieve these goals. After analysing statistical comparison between electric cars and conventional cars, we can draw the conclusion that electric cars consume less gasoline and emit fewer emissions compared to conventional cars.

Notwithstanding those merits, electric cars have several drawbacks such as cost-inefficiency, long charging time and short travel range. The infrastructures of electric cars are not mature in developing countries. What's more, electric car has several strong competitors, which include LNG cars and vehicles with clean gasoline or diesel engines. Nevertheless, electric car has the advantages in light car body while electric car is well matched in strength with clean energy engines. By studying different cases in the US, Norway and China, there are several measures for the government and manufactures to take in order to develop electric car industry. Those actions include narrowing the price between electric cars and conventional cars and increasing investment of R&D in electric car technology.

In this way, there is a greater possibility that the electric car industry will become more and more prosperous and electric cars will become the tendency of vehicle development in the near future.

References

- [1] Axsen, Jonn & Kurani, Kenneth S., Hybrid, plug-in hybrid, or electric—What do car buyers want? *Energy Policy*, 2013-61, pp. 532–543.
- [2] OECD/IEA, “Global EV Outlook 2017”, June 2017.
- [3] Abdul-Martin, Ibrahim. Are Electric Cars Really That Green? *PC Magazine*, September 2013.
- [4] Compare Your Accord Hybrid to a Honda, Honda Automobile website. [Online]. Available: <http://automobiles.honda.com/tools/compare-hondas/results.aspx#hondatrim=39790&comptrim1=39793&comptrim2=35588>
- [5] Consumption of Fuels Used to Generate Electricity, US Energy Information Administration. [Online]. Available: http://www.eia.gov/electricity/annual/html/epa_01_02.html
- [6] Han Y & Liu Y. Current status and future development of electric vehicle in China. *Journal of Chemical & Pharmaceutical Research*, 2014; 6(7): 284-288.
- [7] Graham, John D & Cisney J. No time for pessimism about electric cars. *Issues in Science & Technology*, Fall 2014; 33-40.
- [8] Chang SY & Zhuo JK. Clean coal technologies in China: Current status and future perspectives. *Engineering*, December 2016