Review of CO_2 Emission Cutbacks with Electric Vehicles in China

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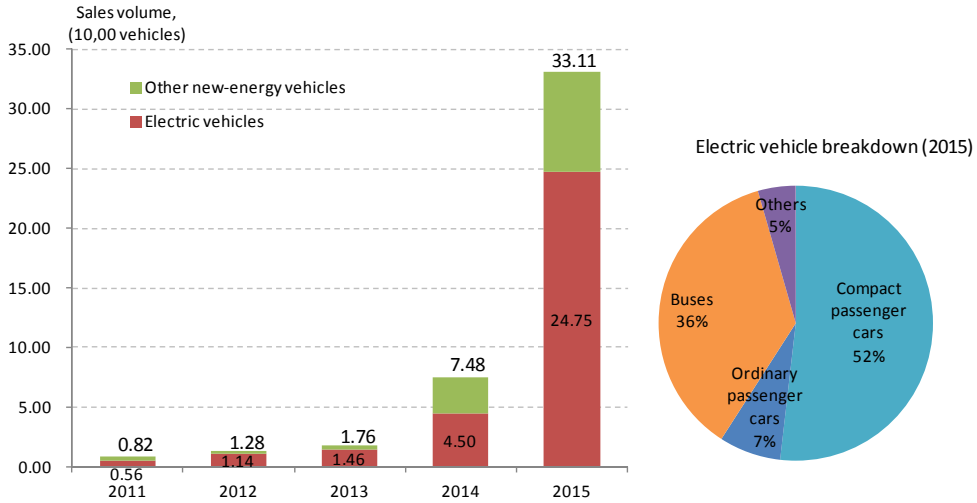
Electric vehicle sales in China surpassed 240,000 vehicles in 2015, a roughly five-fold increase over the previous year, putting China ahead of the US as the global leader. Key factors behind rapid expansion of electric vehicles in China are subsidies and tax incentives for electric vehicle purchases and exemption of electric vehicles from number-plate regulations in Beijing, Shanghai, and other major cities. By promoting adoption of electric vehicles, the Chinese government mainly aims to develop the automobile industry, as well as alleviate air pollution stemming from auto exhaust gas. And it can also be expected to contribute to energy security through reduction of oil usage in light of China's reliance on imports for over 60% of its oil needs.

At the same time, many observers are doubtful about the CO_2 cutback effect of wider adoption of electric vehicles in China with its heavy reliance on coal in power generation. This report reviews the introduction situation of electric vehicles in China and consider whether wider adoption of electric vehicles in China contributes to cutbacks in CO_2 emissions in light of the forecast for China's power source composition based on our " IEEJ Asia/World Energy Outlook 2016" released in October 2016.

■ Trend in electric vehicle introduction in China

The number of electric vehicles sold in China has risen sharply in recent years with an increase from about 8,000 vehicles in 2011 to 247,500 vehicles in 2015 that works out to an average annual growth rate of over 150%. Production and sale of electric vehicle continued to expand in 2016. Cumulative sales volume for Jan-Nov 2016 was already over 300,000 vehicles, rising about 80% versus the previous year. The Chinese government's plan presents goals for production and sale of new-energy vehicles[1], which mainly consist of electric vehicles, of at least 2 million vehicles per year and cumulatively 5 million vehicles by 2020.

Figure 1: Sales of new-energy vehicles (mainly electric vehicles) in China



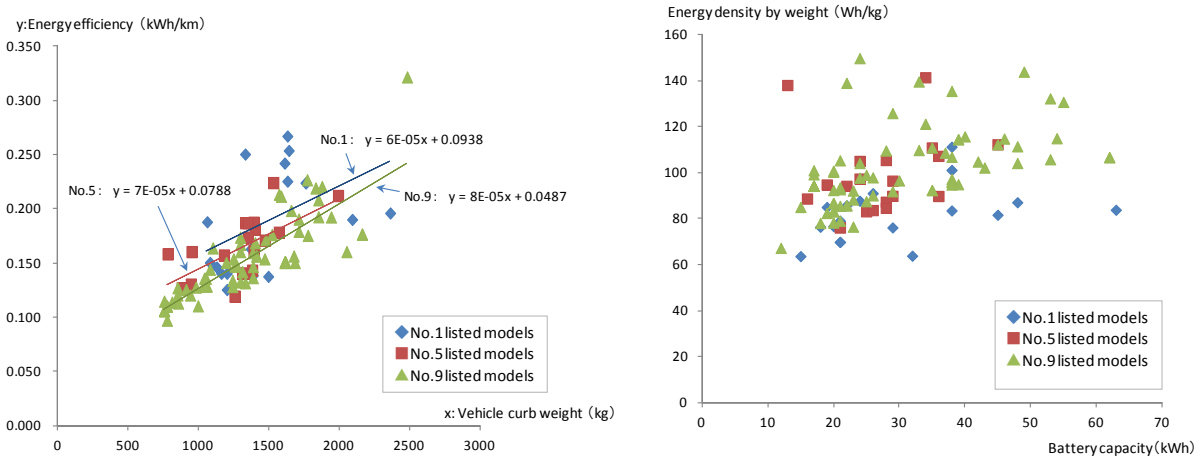
Notes: 1) Other new-energy vehicles covered hybrid vehicles and plug-in hybrid vehicles in 2011, but only plug-in hybrid vehicles from 2012.
2) Compact passenger cars refer to vehicle curb weight of 1,000 kg or less.
(Source) Prepared from materials disclosed by the China Association of Automobile Manufacturers

[1] Chinese defines new-energy vehicles as electric vehicles (EVs), plug-in hybrid vehicles (PHVs), and fuel cell vehicles (FCVs).

Almost all electric vehicles sold in China are currently domestic-made vehicles from local car manufacturers. The breakdown of electric vehicles sold in 2015 was passenger cars at about 60% and buses at just under 40%. Compact cars with a curb weight of 1,000kg or less accounted for around 90% of passenger cars.

The Chinese government disclosed the lists of new-energy vehicle models on exemption from vehicle purchase tax nine times during August 2014 to November 2016. Energy efficiency improves with each release as seen in a graph of energy efficiency for electric vehicles (passenger cars) listed in the 1st (August 2014), 5th (September 2015), and 9th (November 2016) releases (Figure 2). While the energy density per unit of weight for battery systems has been steadily increasing too, the Chinese government's plan targets a level of at least 200Wh/kg[2] by 2020 and steep improvements are necessary to reach the goal. Furthermore, many of the leading electric vehicles in terms of sales volume have a maximum speed in the 80km/h range, and considerable room still exists for enhancing performance.

Figure 2: Energy efficiency and battery performance of Chinese electric vehicles (passenger cars)



a) Energy efficiency　　b) Energy density per unit of weight for battery systems

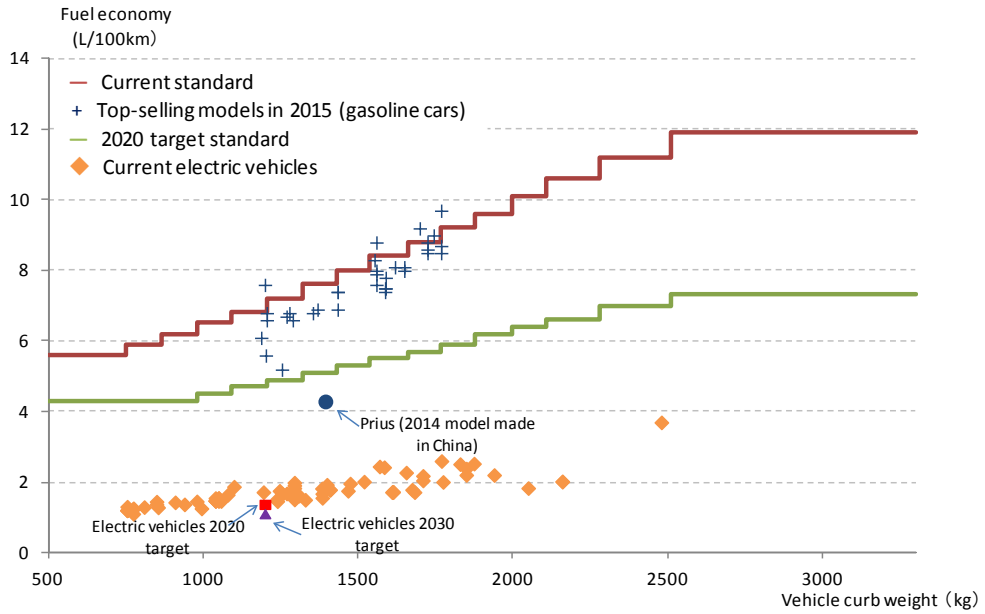
(Source) Prepared from the "List of new-energy vehicle models on exemptions from the vehicle purchase tax" issued by China's Ministry of Industry and Information Technology

The Chinese government is strengthening fuel-economy standards for automobiles[3] and seeks improvement of the target standard for 2020 (corporate average fuel economy) by about 30% versus the current level. Fuel economy of electric vehicles currently available in the market is 1/4-1/3 of gasoline vehicles using simple conversion of electricity to gasoline on a calorific value basis, and increased sales of electric vehicles provide an important means of curtailing corporate average fuel economy amid limited leeway to improve fuel economy in gasoline vehicles.

[2] The "Energy-saving and new-energy automobile industry development plan (2012-20)" released by the State Council of the People's Republic of China in 2012 presented a goal of 200Wh/kg as the energy density per unit of weight for battery systems in 2020. Meanwhile, the "Energy-saving and new-energy vehicle technology roadmap" prepared by the Society of Automotive Engineers of China with a group of experts at the request of the Ministry of Industry and Information Technology and issued in October 2016 sets goals for the same value of 260Wh/kg in 2020 and 350Wh/kg in 2030.

[3] Energy consumption per 100km.

Figure 3: Passenger vehicle fuel economy and gasoline-equivalent fuel economy of electric vehicle in China



Notes: 1) Current standard (since January 2016) is standard for AT vehicles, top-selling vehicle models (by volume) in 2015 covers the top five models selling over 300,000 vehicles, 2020 target standard covers three-rows and fewer vehicles, and the current electric vehicles covers vehicles listed in the list of new-energy vehicle models on exemptions from the vehicle purchase tax (No.9)" issued by China's Ministry of Industry and Information Technology (November 2016). Target fuel economy for electric vehicles (1,200 kg vehicle curb weight) from the "Energy-saving and new-energy vehicle technology roadmap" prepared by the Society of Automotive Engineers of China.
2) Gasoline's lower calorific value for use in conversion from electricity to gasoline is set at 7,452 kcal/L.
(Source) Prepared from disclosed materials of China's Ministry of Industry and Information Technology, etc.

■ China's power source composition and outlook

The level of CO_2 emissions at the power-generating stage (electricity's CO_2 emission coefficient) strongly affects results in comparison of electric vehicles and gasoline vehicles by the unit of CO_2 emissions. This section looks at the electricity CO_2 emission coefficient in China.

China's electricity generation is 5,666 TWh in 2014, according to IEA data. This included 4,115TWh from coal-fired facilities, or 73% of the total, and 115TWh from natural gas-fired power plants and 10TWh from oil-fired power plants. Fossil fuel-fired electricity accounted for a 75% share of total output. Coal, natural gas, and oil used to generate electricity were 925 million ton oil equivalent (Mtoe), 21Mtoe, and 2.3Mtoe respectively. CO_2 emissions from consuming these fuels amounted to about 3.72 billion tons[4]. These values put China's CO_2 emission coefficient at the power generation end in 2014 at 656 gCO_2/kWh. Additionally, the CO_2 emission coefficient at the final consumption level was 788gCO_2/kWh after factoring in consumption within the power plant and electricity lost in transmission.

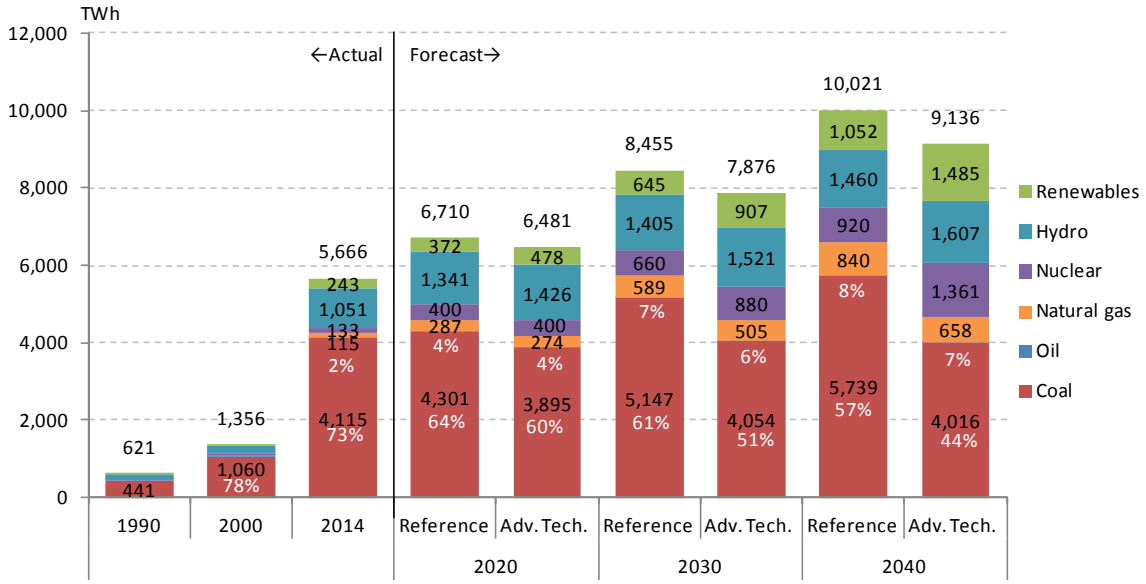
China is steadily expanding installations of non-fossil energy power generation, and the No.13 five-year plan (2016-20) presents goals of 58GW, 340GW, 210GW, and 110GW accumulated installed capacities for nuclear power, hydropower, wind power, and solar power by 2020 respectively. Our "IEEJ Asia/World Energy Outlook 2016" released in October 2016 indicates decline in the share of coal in China's power supply composition from 64% in 2020 to 57% in 2040 in the reference case that reflects past trends as well as energy and environment policies that have been introduced so far. While natural gas-fired power generation is slated to increase, the share

[4] This assumes CO_2 emission coefficients of 3.96 tCO_2/toe for coal, 3.07 tCO_2/toe for oil, and 2.35 tCO_2/toe for natural gas.

of fossil fuel-fired power generation shrinks to 69% in 2020 and 66% in 2040. The electricity CO_2 emission coefficient on the final consumption basis decrease to 691gCO_2/kWh in 2020, a 12% drop from the 2014 level, and 601gCO_2/kWh in 2040, a further 24% decline (vs. 2014), thanks to upturn in power generation efficiency and decline in power transmission loss.

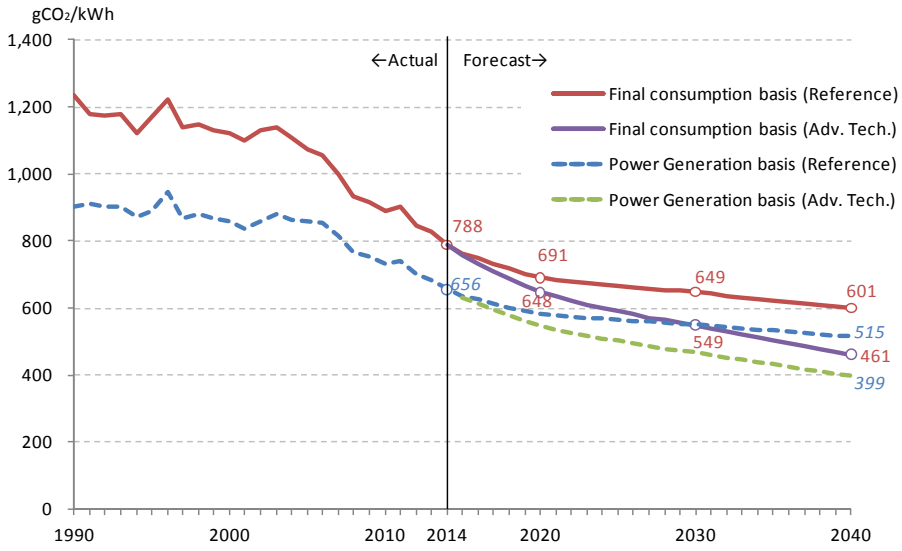
In the Advanced Technology case (Adv. Tech.) that assumes robust energy and environmental policies and technology advances in non-fossil fuel power generation, the share of fossil fuel-fired power generation narrows to 64% in 2020 and 51% in 2040, and the electricity CO_2 emission coefficient on the final consumption basis moves to 648gCO_2/kWh in 2020 (-18% vs. 2014) and 461gCO_2/kWh (-42% vs. 2014).

Figure 4: China's electricity generation by energy source



（Source） The Institute of Energy Economics, Japan (IEEJ) "Asia/World Energy Outlook 2016"

Figure 5: China's CO_2 emission efficient for electricity



（Source） The Institute of Energy Economics, Japan (IEEJ) "Asia/World Energy Outlook 2016"

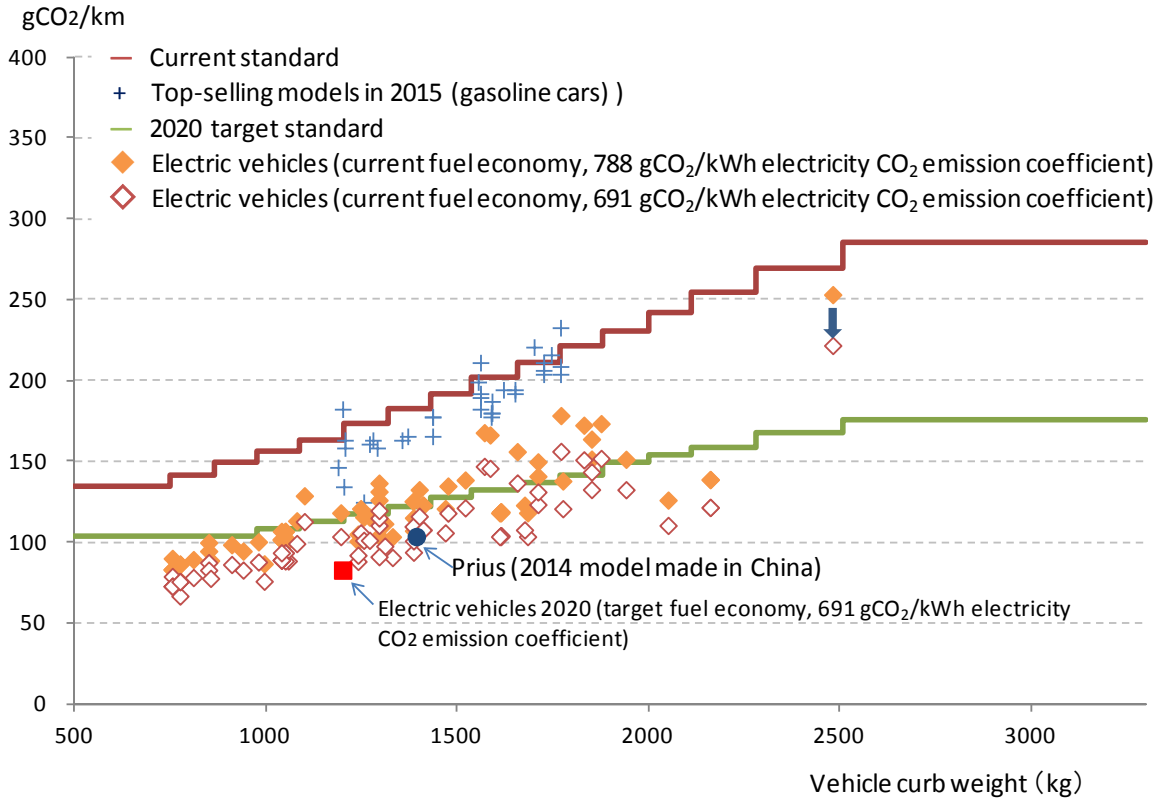
■ CO_2 emissions unit for electric vehicles in China

Figure 6 presents results from calculating the electricity CO_2 emissions unit for electric vehicles in China based on fuel-economy values from Figure 3 utilizing the above-mentioned electricity CO_2 emission coefficients at the final consumption level. The CO_2 emissions unit for current electric vehicles has an estimated range of 76-253gCO_2/km in the case of the 2014 electricity CO_2 emission coefficient (788gCO_2/kWh). Many models have a lower value than existing gasoline passenger cars. However, few models exceed the target standard for 2020 and values are larger than for hybrids.

Meanwhile, if the electricity CO_2 emission coefficient drops to the level in the reference case (691gCO_2/kWh; -12% vs. 2014), the CO_2 emissions unit for electric vehicles has an estimated range of 67-223gCO_2/km, even at the same energy efficiency as currently. Many models are below the 2020 target standard, though values are roughly on par with hybrid vehicles.

If the electricity CO_2 emission coefficient declines to the level in the technology advancement case (648gCO_2/kWh in 2020 and 549gCO_2/kWh in 2030) and energy efficiency in electric vehicles rises on track with the roadmap, the CO_2 emissions unit for electric vehicles (1,200kg vehicle curb weight) falls to 78gCO_2/km in 2020 and 53gCO_2/km in 2030,putting it at less than half of gasoline vehicles at the target standard for 2020.

Figure 6: CO_2 emissions unit for electric vehicles in China



Note: Current standard, top-selling vehicle models (by volume) in 2015, 2020 target stand, and Prius are calculated using 2.4kg/L as the gasoline CO_2 emission coefficient based on fuel economy values in Figure 3. Electric vehicles calculated using the electricity CO_2 emission coefficient on the final consumption basis from Figure 5 based on fuel economy in Figure 3.

(Source) Prepared from The Institute of Energy Economics, Japan IEEJ “Asia/World Energy Outlook 2016”, disclosed materials of China’s Ministry of Industry and Information Technology

■ Conclusions

Coal-fired power occupied a share of over 70% of China's power generation composition in 2014, the electricity CO_2 emission coefficient on the final consumption basis was high at 788gCO_2/kWh. Currently, from the perspective of reducing CO_2 emissions, electric vehicles do not exhibit much of an advantage over gasoline vehicles and have a higher CO_2 emission unit than hybrid vehicles. Nevertheless, China is likely to make significant advances in lowering carbon content in power generation, in this context wider adoption of electric vehicle will substantially lower CO_2 emissions in China, with the consistent improvement in the efficiency of electric vehicle.

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