Electric vehicle adoption people s republic of china

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In recent decades, China"s rapid economic growth has enabled more and more consumers to buy their own cars. The result has been improved mobility and the largest automotive market in the world--but also serious urban air pollution, high greenhouse gas emissions, and growing dependence on oil imports.

To counteract those troubling trends, the Chinese government has imposed policies to encourage the adoption of plug-in electric vehicles (EVs). Since buying an EV costs more than buying a conventional internal combustion engine (ICE) vehicle, in 2009 the government began to provide generous subsidies for EV purchases. But the price differential and the number of buyers were both large, so paying for the subsidies became extremely costly for the government.

As a result, China"s policy makers will phase out the subsidies by the end of 2020 and instead rely on a mandate imposed on car manufacturers. Simply stated, the mandate requires that a certain percent of all vehicles sold by a manufacturer each year must be battery-powered. To avoid financial penalties, every year manufacturers must earn a stipulated number of points, which are awarded for each EV produced based on a complex formula that takes into account range, energy efficiency, performance, and more. The requirements get tougher over time, with a goal of having EVs make up 40% of all car sales by 2030.

This move will have a huge impact on the worldwide manufacture of EVs, according to William H. Green, the Hoyt C. Hottel Professor in Chemical Engineering. "This is one of the strongest mandates for electric cars worldwide, and it"s being imposed on the largest car market in the world," he says. "There will be a gigantic increase in the manufacture of EVs and in the production of batteries for them, driving down the cost of both globally."

But what will be the impact of the mandate within China? The transition to EVs will bring many environmental and other benefits. But how much will it cost the nation? In 2016, chemical engineering colleagues Green and then-graduate student I-Yun Lisa Hsieh PhD "20 decided to find out. Their goal was to examine the mixed impacts of the mandate on all affected factors: battery prices, manufacturing costs, vehicle prices and sales, and the cost to the consumer of owning and operating a car. Based on their results, they could estimate the total societal cost of complying with the mandate in the coming decade.

"The main reason why EVs are costly is that their batteries are expensive," says Green. In recent years, battery prices have dropped rapidly, largely due to the "learning effect": As production volumes increase, manufacturers find ways to improve efficiency, and costs go down. It"s generally assumed that battery prices will continue to decrease as EVs take over more of the car market.

Using a new modeling approach, Green and Hsieh determined that learning effects will lower costs

appreciably for battery production but not much for the mining and synthesis of critical battery materials. They concluded that the price of the most widely used EV battery technology--the lithium-ion nickel-manganese-cobalt battery--will indeed drop as more are manufactured. But the decline will slow as the price gets closer to the cost of the raw materials in it.

Using the resulting estimates of battery price, the researchers calculated the extra cost of manufacturing an EV over time and--assuming a standard markup for profit--determined the likely selling price for those cars. In previous work, the researchers had used a variety of data sources and analytical techniques to determine "affordability" for the Chinese population, in other words, the fraction of their income available to spend on buying a car. Based on those findings, they examined the expected impact on car sales in China between 2018 and 2030.

Their results are shown in the figure above. As a baseline for comparison, the researchers first assumed a "counterfactual" (not true-to-life) scenario--here, car sales without significant adoption of EVs, so without the new mandate. As the dashed black curve shows, under that assumption, annual projected car sales climb to more than 34 million by 2030. (The drop in 2021 is a response to higher prices due to new emissions and fuel economy standards in 2020.)

The solid red curve shows what happens when the subsidy on EV purchases is eliminated and the mandate is enacted in 2020. Total car sales shrink in 2021 after the subsidies are eliminated. But thereafter, the growing economy and rising incomes increase consumer purchasing power and drive up the demand for private car ownership. Annual sales are on average 20% lower than in the counterfactual scenario, but they"re projected to reach about 30 million by 2030.

The pie charts below show the breakdown in projected sales between ICE vehicles and battery EVs at three points in time. In 2020, EVs make up just 7% of the total (1.6 million vehicles). By 2025, that share is up to 21% (5.4 million). And by 2030, it"s up to 37% (11.2 million)--close to the government"s 40% target. Altogether, 66 million EVs are sold between 2020 and 2030.

Two types of plug-in EVs are indicated by color: Red represents pure battery EVs, and orange represents hybrid EVs (which are powered by both batteries and gasoline). About twice as many pure battery EVs are sold than hybrid EVs, even though the former are more expensive due to the higher cost of their batteries. "The mandate includes a special preference for cars with a longer range, which means cars with large batteries," says Green. "So carmakers have a big incentive to manufacture the pure battery EVs and be awarded extra points under the mandate formula."

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