Independent clean-energy and policy analysis **March 2019** *by Eric Strid*

The Great Chinese EV Disruption

Summary

- China leads in electric vehicle (EV) sales and production, motivated by energy security, job creation, and toxic and climate pollution. China is on track to achieve 50% EV sales by 2025.
- The EV transition will reset market shares of all automakers and battery makers. Everyone is scrambling to keep pace with China.
- So-what's: Global EV adoptions are likely to exceed all US policy targets; 2 million US auto jobs are at risk without action; infrastructure can be steered to clean at near-zero cost.

I. China is on track for 50% EV sales by 2025

A. EV demand, supply, and disruption

EV adoptions are increasing exponentially. 2018 saw 79% EV sales growth worldwide and 81% growth in the US, indicating the early stage of a classic technology disruption. China has seized this opportunity to gain leadership in EV policy, production, and adoption.

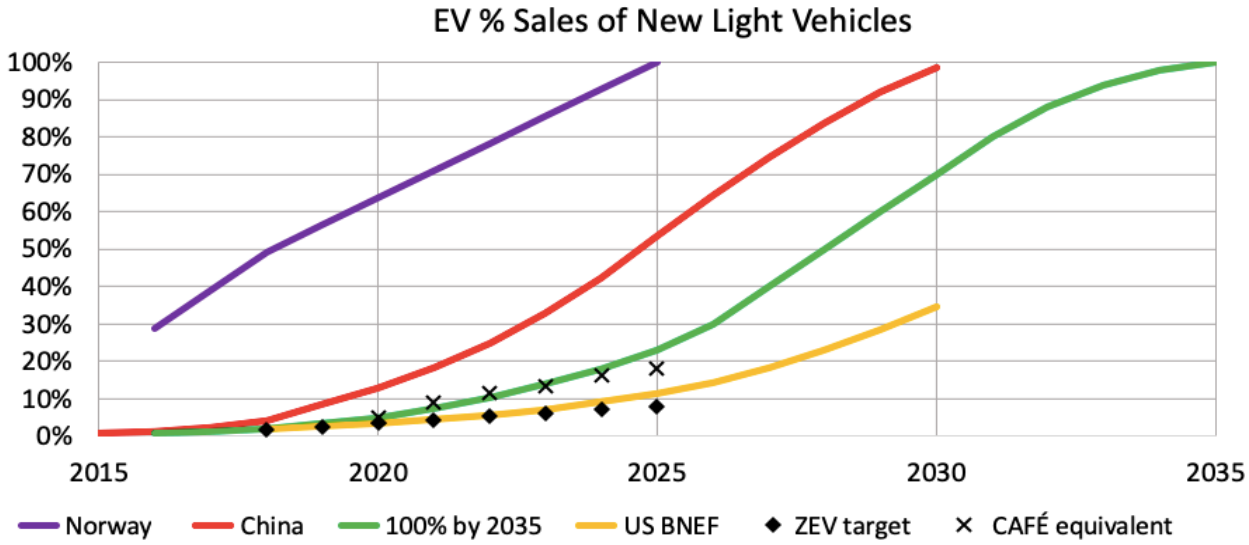


Figure 1. EV forecasts range from Norway targeting 100% by 2025 (violet), to China's investing for 50% by 2025 (red), to the 2018 forecast of Bloomberg New Energy Finance (BNEF) estimating 30% by 2029 in the US (yellow). The green line is a minimum trajectory recommended by the Intergovernmental Panel on Climate Change (IPCC). Sources: BMI Research, Macquarie Bank, Green Car Reports, BNEF, CleanTechnica, InsideEVs. Chart: Eric Strid

Figure 1 illustrates how the investment trajectory of China's automobile industry is readying to produce around 12 million EVs by 2025, or half of new passenger vehicles sold in China. Norway's sales target of 100% by 2025 is about 160,000 vehicles, and BNEF forecasts 12% of US sales, or 2 million EVs by 2025.

The February Strid Energy Report asked *what can accelerate the electric vehicle transition?* A comparison of EV sales and policies found that Norway leads the world with a trajectory to 100% EV sales by 2025, demonstrating that very strong EV demand can be stimulated without large subsidies.

If worldwide demand can be stimulated as desired by policy, then what limits EV supply? Transitioning the worldwide annual output of 100 million internal-combustion engine (ICE) light vehicles to electric vehicles by 2025 would require the urgency of a wartime mobilization.

But another force already urgently mobilizing the EV transition is automakers *competing for survival and dominance* through the largest automobile technology disruption in over a century. China sees this technology disruption as a major opportunity to gain market leadership in vehicle drive trains and sales.

One of the rules of disruptive innovation is that the market shares of all incumbents are reset to zero. Kodak's film business was irrelevant as soon as digital photography became competitive, and Nokia's leading market share in cell phones was irrelevant after the iPhone launch. The global EV transition will redistribute more than $2 trillion of automaker revenue, and the superior cost-performance of EVs will decimate ICE vehicle sales; thus all automakers have existential opportunities to gain share and threats of losing share.

B. Chinese companies have committed production resources to lead in EVs and battery packs.

China already leads the world in EV production and sales, producing over 60% of the world's output of 2 million EVs in 2018. China's EV industry is aided by aggressive government incentivizes for both EV demand, with large rebates, and EV supply through EV mandates and other policies.

CleanTechnica has researched China's existing and evolving capacity to build EVs and the critical battery packs for EVs. "China's appetite for EVs is not slowing down, and looks set to grow by a further 82% this year and achieve 7.5% market share of 2019 auto sales. The market share in China will probably exceed 10% in the month of December. Due to strong policy support for clean transport and strong consumer demand, combined with cultural factors and other positive feedback effects, there is every likelihood that EVs will take 50% market share of autos in China by 2025.

"China-based lithium-ion battery factories are already in the planning pipeline to produce enough capacity to meet the growing domestic demand for EVs, and capacity plans will continue to grow rapidly to accommodate demand from stationary storage applications and other use cases. There is little risk of battery production capacity overshoot by the mid 2020s, due to the multiple growing markets for battery energy storage. As of January 2019 there is enough planned battery production capacity in China to supply 16 million EVs by 2025."

China has three times as many planned battery plants as the rest of the world combined. China's portion is 2/3 of planned global capacity through 2028, which is ten times as large as now.

C. China has strong motivations to lead EV production

1. Energy security: China is the largest importer of petroleum, and they want more control of their energy supplies and lower price volatility. EVs are the obvious option for a country with the largest solar and wind generation and largest solar and wind equipment production.

2. Create jobs and exports: The automobile market in China is nearly 30% of global sales. All of the largest automakers sell in China, but Chinese automakers have struggled to catch up to the quality of imported vehicles. In 2017 China knew that incumbent automakers around the world would resist changing to zero-emission vehicles. Seeing a rare opportunity to develop a cost advantage, they created a New Energy Vehicle (NEV) mandate similar to the California Zero Emission Vehicle (ZEV) program, plus other policies. China clearly intends to establish leadership in EV technology and then export to the world.

3. Air pollution: The pollution in China's cities is famously unhealthy. Much of this is from coal plants, but vehicle pollution is becoming a larger contributor in many cities.

4. Climate leadership that is also economic: EVs always were cheaper to fuel and maintain, and will be cheaper to procure by around 2024. China aims to be the lowest-cost provider of the lowest-cost vehicles.

The Chinese island of Hainan has banned all fossil-fueled vehicles after 2030.

ICCT's 2018 white paper notes, "There is a power play in the works, as governments seek to gain from the transition to electric vehicles with a series of supportive policies. The competition is among countries and companies to be a key part of the economic and market growth of electric vehicles."

Bloomberg observes, "The message coming from the world's largest emitter of greenhouse gases [the United States] is clear: Even as President Trump withdraws support for alternative fuels, attempts to gut mileage requirements, and begins the process of pulling out of the Paris Agreement on climate change, China is dead serious about leading the way to an electrified future. This suggests such leadership will make China a dominant force in vehicle manufacturing going forward. The implication is the US will continue to decline in importance in the industry. For global car makers, it's increasingly clear that policymakers in Beijing, not Washington, are in the driver's seat.

Jim Greenberger, executive director of the National Alliance of Transportation Batteries, noted the need for much more battery manufacturing in the US. "…at some point, we are going to have to start making public investment in whatever we think the next-generation battery is going to be if we are going to get back in the game."

II. Global disruption at automakers

A. Automakers with the highest EV volumes will achieve the lowest costs and further volume benefits worldwide, and vice versa.

The transition to automotive batteries and electric motors is a classic technology disruption where the early leaders use their higher volume to drive down costs faster than competitors. Competitors with significantly lower volumes are continuously handicapped by having less income for offering discounts or for developing competitive technologies or products. Competitors can leapfrog the leaders by investing lots of money, but that becomes less viable as the leading market shares grow and solidify. Thus the scramble to take early market share and endure years of loses like Tesla and Amazon have done, and numerous Chinese EV and battery companies are doing.

Incumbent companies have a tough position in innovative disruptions, since they must develop competitive new products/technologies/business models in parallel with legacy products and with the intent to replace their legacy products. It is very difficult to pick the right time to switch investments to the new, and the transition is likely to be bad for revenue and earnings even if the timing is optimal.

Figure 2 shows the estimated salient costs in an EV build and the trends. Batteries are the largest component cost, and thus more critical for competition than the other vehicle costs.

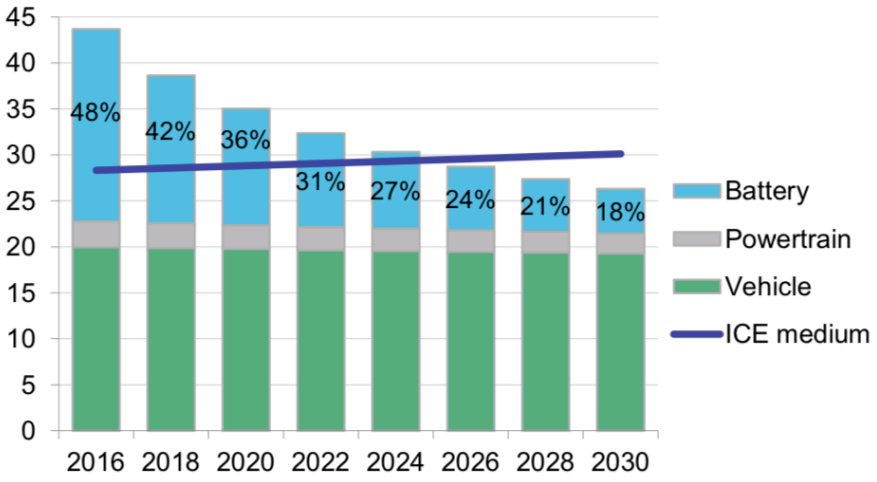


Figure 2. Battery electric vehicle (BEV) vs internal combustion engine (ICE) vehicle pre-tax costs in the US for comparable medium-segment vehicles. Pluggable hybrid electric vehicles (PHEVs) will cost more than BEVs, and thus seen as a short-lived model category. Source: BNEF

The corresponding battery price history and forecast is shown in figure 3. Note that Figure 3 plots *average* battery pack prices—and the share leaders already have cost advantages. Tesla and BYD own major battery plants, and the largest automakers are partnering closely with leading battery suppliers.

BNEF calculates an 18% learning rate since 2010, which is the average cost reduction for every doubling of cumulative production output of the industry worldwide. The volume implied by their price of $94/kWh corresponds to about 32% EV share worldwide by 2025 in Figure 1 (and 10% worldwide EV % of fleet by 2025 in Figure 4). The BNEF forecast corresponds to roughly 50% more worldwide battery capacity by 2025 than CleanTechnica reported to be currently in the planning pipeline.

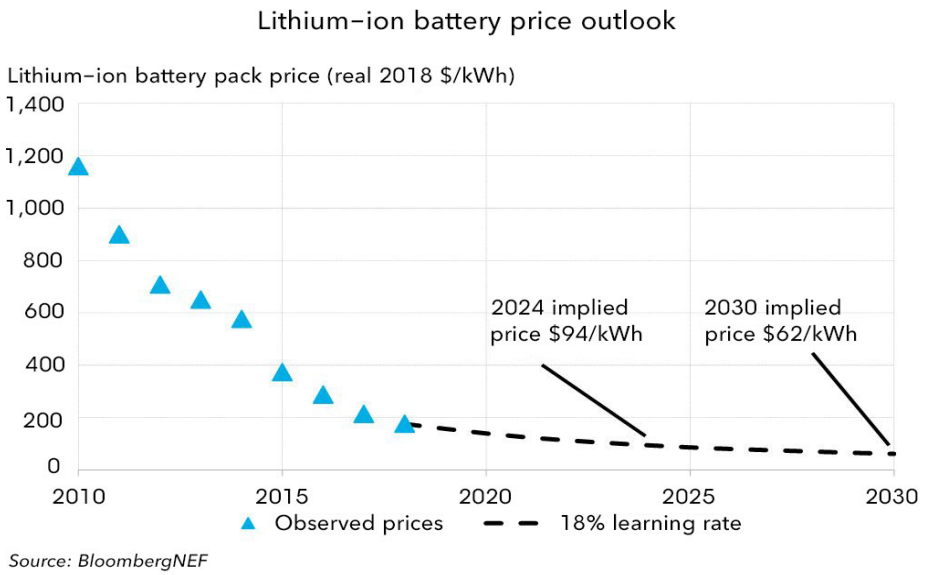


Figure 3. Worldwide average lithium-ion EV battery pack prices as compiled by Bloomberg.

The implication of these projections is that the EV% of worldwide sales may trail the percentage in China, but not by more than a few years. Of course, that all depends on the actions of automakers and governments, especially China's.

B. Automaker survival strategies

Tesla first announced their Gigafactory in 2014 with a target capacity of batteries for 500,000 electric vehicles. They noted that about 200 such factories would be needed to supply auto markets worldwide.

Dozens of those battery factories are being planned or built now, in a global scramble to gain enough scale to compete in the EV transition. There are international battery wars, mostly for battery technology and production capacity. CATL in China has announced plans for a new factory to be the world's largest.

Automakers are scrambling to amass enough scale and technology to compete on vehicle costs and technology and lock up battery supply chains. Some of the strategies include:

1. Make money on gas-guzzlers now to spend it on electrification later: GM and Ford are full-throttle on large pickups and SUVs and scaling back smaller cars. They are at risk from various electric SUV and pickup developments.

2. Partnering: BMW and Daimler are teaming up on autonomous driving. Ford and VW are in talks about EV development and production. Supply chains are partnering.

3. Acquire or merge: PSA, which owns Peugeot, Citroen, and Opel is seeking a partner or merger. Everyone is exploring partnerships, alliances, or mergers.

4. Develop the next generation battery technology. Toyota Executive Vice President Shigeki Terashi asserted that, "The one who conquers batteries will conquer the electrification of cars."

The possibility that China's EV goals may be leapfrogged by foreign companies is increasingly remote. The objective now is to keep pace with China. Regardless of the winners, EVs are coming on strong.

C. The EV fleet

Figure 4 plots the cumulative totals of EVs sold, as a portion of the country's light vehicle fleet. Each assumes the trajectory of Figure 1 and only EV sales after reaching 100% share. Note that Norway's fleet is likely all imported, China's will be nearly all domestically sourced, and the US will be a mix of both. The worldwide % of fleet is likely to be similar to China's trajectory.

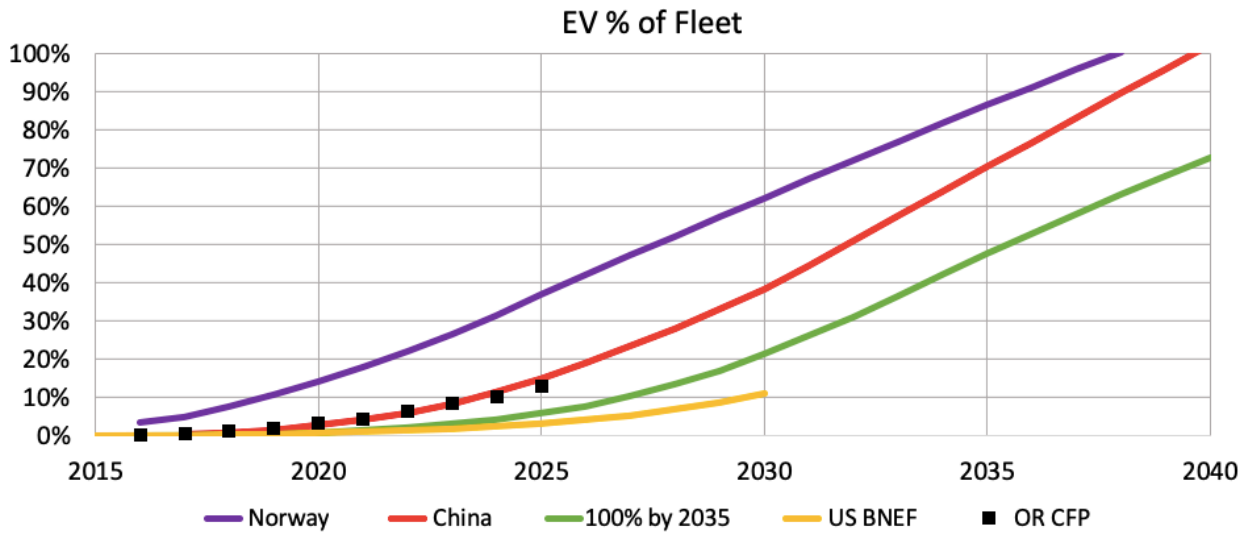


Figure 4: The EV portion of a fleet is the time integration of the annual EV additions as in Figure 1, minus retired vehicles. OR CFP is the Oregon Clean Fuels Program targets. Sources: BMI Research, Macquarie Bank, Green Car Reports, BNEF, CleanTechnica, InsideEVs. Chart: Eric Strid

Of course, these are extrapolations of current trajectories and assume minimal changes from today's forces. All of the results will be higher or lower than these forecasts. The intent here is to illustrate the likely range of EV adoption rates. These forecasts consider only the electrification of light vehicles; medium- and heavy-duty vehicles will probably have similar ramps, as China has shown for electric buses and heavy vehicles.

These forecasts do not consider the potential impacts of transportation as a service (TaaS) or autonomous vehicle (AV) technologies. TaaS offers the potential of much greater vehicle utilization, major cost savings, and much less real estate devoted to parking. Additionally, AV technologies portend even more savings, higher safety, and vast productivity improvements. But the timing of sufficient AV control software is highly uncertain. Widespread adoption of TaaS could dramatically reduce the number of vehicles necessary in the fleet.

III. Observations and policy opportunities

China's acceleration of the global EV transition will impact automakers, supply chains, consumers, policymakers, utilities, and oil companies worldwide.

A. Electric vehicles are the quickest opportunity to reduce climate emissions

Co-benefits include reducing local toxic emissions and their health-related costs, keeping vehicle fuel spending local, reducing fuel and maintenance costs, adding flexible load to the grid, absorbing more fixed costs of the grid, adding local resilience for transportation, and more.

B. Global EV adoptions are likely to exceed all existing US policy targets

A Green New Deal (GND) target for zero fossil-fuel vehicles sold after 2030 would be China's current trajectory (figure 1). Roughly three times as many EVs as China's demand will be built worldwide, so the US would only need to mandate EV demand, such as raising the ZEV program targets to ramp to 100% by 2030 in all states. The current ZEV program targets are plotted as diamonds in Figure 1.

The Off Fossil Fuel Act mandates zero fossil-fueled vehicles sold after 2035.

The federal CAFÉ targets are also plotted in Figure 1, calculated as if all of the improvements in fuel efficiency after 2019 are from new EVs. It is likely that global EV business-as-usual will overtake the CAFÉ standards as well.

The Clean Fuels Program in California and Oregon drives down fleet emissions by requiring fuels with lower carbon intensity. Figure 4 plots the cumulative EV share necessary to achieve Oregon's Clean Fuels Program targets with EVs only, as powered by the current average emissions from Oregon's electricity.

State policies cannot mandate vehicle performance, but they can add carrots or sticks for EV incentives.

Instead of targeting absolute numbers of vehicles, policymakers should consider mirroring the targets or policies of other countries (particularly, China's EV policies).

With so many strong forces urgently tugging the EV transition, the effect of a given policy or group of policies may be impossible to discern. But data from other jurisdictions can provide useful relative comparisons.

C. Protect and create US jobs

If US automakers don't transition to EVs, then foreign competitors will fill the gaps within a few years. That would put two million jobs and 3% of US GDP at risk. If the administration was serious about saving and creating jobs and reducing the trade imbalance with China, they would be incentivizing EV demand and supply. This is the most urgently needed policy of a GND.

Independent of automaker market shares, many EV chargers of all sorts and their utility hookups will need to be installed. This will be a growth industry that creates well-paying jobs.

D. Accelerating clean-tech disruptions

Rapid clean-energy transitions like EVs should be a top strategy for quick and deep decarbonization. What other opportunities exist for rapid clean-tech adoptions that can be accelerated by proper policies? Some people simply assert that technology won't save us, but it's obvious that the right applications of the right technologies are necessary (but not sufficient).

Besides fast decarbonization, EVs are a perfect example of near-zero government cost for steering an infrastructure upgrade to clean options. Grossly estimating the replacement of 264 million vehicles in the US at $35,000 equals $9.2 trillion. All of those vehicles will be replaced over 10 to 20 years as they wear out. And EVs would save the US about $350 billion per year net by buying electricity instead of gasoline or diesel fuel at $2.50 a gallon.

E. Capitalism can be a strong force for good when properly governed

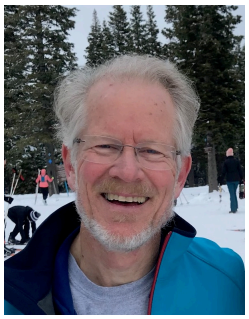
In the bigger picture of civilization's problems, climate change is a symptom of root causes like greed. In this case China's policies are driving the EV transition for their own benefits and global markets are quickly responding. Except in the US, where governance has been largely derailed by oligarchs.

F. Impacts on oil demand

Oil stock prices will soon reflect the decreasing demand due to EV growth. Norway's $1 trillion wealth fund recently announced that it will divest from oil and gas exploration. Petroleum demand for vehicles will approach zero around 2045. In the meantime, global oil prices are likely to drop significantly, and this will create some headwind for EVs.

A good policy response to dropping oil prices would be a fuel tax that maintains fuel prices, perhaps ~$2 per gallon. That would continue to incentivize EV demand and provide revenues to retrain fossil-fuel workers; clean up fossil fuel sites; fund R&D on biofuels, seasonal energy storage technologies, atmospheric carbon capture, etc.

Bio: Eric Strid is a retired high-tech entrepreneur and CEO, now working for our children on climate policy. Schooled as an electrical engineer at MIT and UC Berkeley, he worked as a microwave engineer and then cofounded Cascade Microtech in Beaverton, OR in 1983. Eric served as CEO, took it public in 2004, transitioned to the CTO role in 2008, and retired in 2012.



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