Testimony before the U.S.-China Economic and Security Review Commission

An Assessment of the CCP's Economic Ambitions, Plans, and Metrics of Success

Policies and Planning for Emerging Industries: New Mobility, Cloud Computing, and Synthetic Biology

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In this testimony, I will argue that China's current approach to transportation sector planning and innovation has a clear competitive advantage over the U.S. because of their systems-focused approach that connects the transportation sector with broader economic and societal goals, which differs from the vehicle-focused approach of the U.S. I will focus on what the U.S can learn from China's transportation policies to improve our own domestic transportation systems, but, where applicable, will also comment on the potential for these policies to keep U.S. companies competitive in the transportation industry globally. By way of illustration, I will compare and contrast how China and the U.S. have responded to three mobility innovations—electrification, new business models in the sharing economy, and autonomy and connectivity. The majority of this testimony will focus on electrification given the scale and pace of innovation in this space in China.

Background

In the past two decades, China's vehicle market has seen rapid growth and, in 2009, China overtook the U.S. as the world's largest light-duty vehicle (LDV)[i] market in terms of new sales.[1] Even with this large growth, the country's motorization level of 200 vehicles per thousand people remains very small compared with the number in the United States (more than 800). Therefore, it is expected that ownership and use of personal vehicles will continue to increase along with economic growth in China.[2]

Nationally, China's government continues to see promotion and development of their domestic vehicle industry as an important contributor to economic growth. Because state-owned Chinese original equipment manufacturers (OEMs) were late entrants to this globally competitive market, China's government put in place significant protections to allow domestic companies to grow and learn. In particular, starting in the mid-1990s, restrictions on foreign ownership of automotive companies and importation and sale of vehicles manufactured abroad forced international automakers to form joint ventures with China's state-owned OEMs in order to participate in the burgeoning Chinese car market. These partnerships—including between General Motors and Shanghai Automotive Industry Corporation (SAIC) and between Ford Motor Company and Changan Automobile—allowed Chinese OEMs to learn from established global players and quickly improve their manufacturing and research and development capabilities.

Recognizing that Chinese OEMs would still have trouble competing against incumbent vehicle manufacturers from the U.S. and elsewhere for market share for traditional gasoline- and diesel-

[i] Light-duty vehicles (LDVs) include passenger cars, SUVs, and light-trucks.

powered internal combustion engine vehicles (ICEVs), China's government embraced electric vehicles (EVs)[ii] as the less competitive route to becoming a major player in the global automotive market.[3] The Chinese government declared the EV industry as one of the national, strategic, emerging industries in 2010, and EVs featured prominently in its "Made in China, 2025" strategy plan.[4] Over the past decade, China's national government has played a crucial role in helping the Chinese EV market flourish. Interventions—including investments into start-up businesses, clear standards for battery technologies, targets for "new energy vehicle" (NEV)[iii] sales, the build-out of charging infrastructure networks, and consumer subsidies for EV purchase—have collectively helped to bolster business and consumer confidence and have fueled rapid EV uptake. In 2018, NEVs became the first segment of the automotive industry in China to see relaxations of foreign ownership restrictions, although further liberalization is expected to follow.[5]

While China's national government and its industrial policies have played the most crucial role in shaping vehicle electrification, city-level policies are also playing an increasing role in determining the size and composition of the country's vehicle fleet. While China is often seen as having a top-down, command-and-control political structure, with policy largely dictated by the national government, in recent years, transportation policymaking in China has been decentralized, with municipal/city governments being allowed to enact innovative policies that better respond to local conditions. This has led to heterogeneity in municipal-level transport policies that underscores the diversity of urban challenges and mobility issues facing different Chinese cities.[6]

For example, spurred on by issues of congestion and local air pollution, some of China's megacities are adopting restrictions on private car use and ownership.[7] Car ownership restrictions, in particular, limit growth in vehicle sales by rationing the number of new license plates in a city and allocating these licenses through lottery or auction. To date, six cities and one province have adopted these car ownership restriction policies. Shanghai was the first to adopt such a policy in 1994, followed by Beijing in 2011, Guangzhou in 2012, Tianjin and Hangzhou in 2014, Shenzhen in 2015, and the island province of Hainan in 2018. These city-level policies have meaningful impacts on the size and composition of the national vehicle fleet, since all but one of the policies exclusively apply to ICEVs and exempt the sale of NEVs.[8]

As China's rapidly growing megacities are restricting the sale and use of private cars, they are also investing heavily in alternatives. From 2012 to 2019, the number of cities in China with urban rail transit systems increased from 15 to 40 and operational mileage more than tripled.[9] These public transit systems operate as the backbone of multi-modal transportation systems that are supported by active travel (walking and biking) and new mobility services and technologies.

This background serves as important context for understanding how new mobility innovations are emerging in China, shaped by a different regulatory environment and interacting with different incumbent transportation systems.

[ii] Unless otherwise specified, throughout this testimony I use the term "electric vehicle" (EV) to include both plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) in the light-duty vehicle sector.

[iii] "New energy vehicles" (NEVs) include electric vehicles (PHEVs and BEVs) as well as hydrogen fuel cell vehicles (HFCVs), although the vast majority in China's market are BEVs.

Electrification

As my first and primary example of how China's systems-oriented approach provides a competitive advantage, I will consider vehicle electrification. Around the world, governments are embracing vehicle electrification in response to growing recognition of the global climate crisis and the prominence of the transport sector in current and projected greenhouse gas emissions. With over a decade of national industrial policy fostering their domestic EV industry, China has solidly set itself up as the global leader in vehicle electrification and the lithium-ion battery supply chain.

Electrification of Light-Duty Vehicles

China has quickly emerged as one of the world's largest markets for electric LDVs. While EVs did not hit the Chinese market until 2012, two years after they were introduced to the U.S. market in 2010, phenomenal annual growth (at a rate of 45% for six consecutive years from 2012 to 2017) has bolstered China's EV market.[10] In 2018, new EV sales in China reached nearly 1.1 million and the total stock reached 2.3 million (accounting for almost half of the world's electric LDVs).[11] In 2018, EV sales in the U.S. numbered only 361,000, contributing to a total stock of 1.1 million.[10] See Figure 1 for comparison to ICEV sales and trends over time.

China's preeminence in the electrification of LDVs has been supported by a decade of national-level industrial policy (rather than climate or transportation policy). In 2010, China's national government declared the EV industry as one of seven national, strategic, and emerging industries and put in place a subsidy program for NEVs.[12] Under this program, the amount of subsidies that each vehicle receives depends on the vehicle's category, technology type, and vehicle efficiency performance. By tightening the qualifications for receiving the subsidy each year, China's government has been able to shape the production and consumption of EV technology towards longer-range, lithium-ion battery vehicles. For example, in 2019 the central government announced that it was eliminating purchase subsidies for vehicles that achieve electric ranges of less than 250 kilometers (compared with the 150km threshold previously needed to qualify).[10]

And as the number of EVs produced and sold increases, China's government is reducing the amount of subsidies.[13] These new policies reflect the government's shifting strategy, transitioning from monetary incentives for EV purchases to non-monetary forms of support such as a new "cap and trade" system for NEVs and restrictions that make it harder to set up factories to make ICEVs.[14] Since 2019, OEMs have received credits for each NEV produced, accounting for factors such as the type of vehicle, as well as its maximum speed, energy consumption, weight, and range. Regulators base credit targets for each OEM on its total production of LDVs. If a manufacturer does not reach the target, it must purchase credits from competitors that have a surplus or pay financial penalties.[15]

The U.S. government could learn from China's approach of heavy investment—in the form of purchase subsidies, tax breaks, and other incentives to encourage EV adoption—tied to technological standards to help push domestic EV manufacturing and consumption towards a more sustainable future. The U.S. already has some of the building blocks for a more comprehensive EV policy, with its corporate average fuel economy (CAFE) standards and a federal tax credit for EV purchases.

China has also supported its EV market with the proactive build out of public charging infrastructure. While the majority of EV charging today happens at private level 1 or 2 (slow) chargers installed at homes or workplaces, the provision of publicly accessible charging infrastructure is critical for expanding the EV market. The Chinese central government promotes the development of EV charging networks as a matter of national policy, setting targets, providing funding, and mandating a single standard for fast charging (China GB/T).[16] In China, the role of government-owned utilities in providing public chargers is larger than in the U.S., especially along major long-distance driving corridors. This provides the often over-looked benefit of centralizing data collection on EV charging within the public sector, allowing for greater understanding of grid implications and opportunities for network optimization. Many provincial and local governments also contribute funding towards EV charging infrastructure, particularly in urban areas.

By 2018, China had installed around 111,000 Level 3 (fast) chargers—accounting for 78% of the world's public fast chargers—and 163,000 Level 2 (slow) chargers to achieve a ratio of 119 plugs per 1,000 EVs. In comparison, the U.S. had installed only 4,240 level 3 chargers and 50,250 level 2 chargers by the same year, for a ratio of only 48.5 plugs per 1,000 EVs.[17]

In the U.S., the federal government has played only a modest role in EV charging, with state governments and automakers playing a larger role in the development of EV charging networks. This has contributed to coordination issues such as conflicting EV fast charging standards in the U.S. market (CHAdeMO, SAE Combo, and Tesla) that hampers competitiveness in both the domestic and international markets. U.S. policy makers at the federal level could learn from the Chinese government's multi-year planning with respect to EV charging infrastructure, as well as China's investment in data collection on EV charging.[16]

Electrification of Public Transit Vehicles

China's leading role in the manufacture and consumption of electric vehicles goes well beyond LDVs. In particular, China is the largest producer and user of electric buses.[iv] In 2020, over 98% of the world's e-buses—primarily battery-electric buses, but also including some plug-in hybrid buses—operated in China. In 2017, China added around 100,000 e-buses to its municipal roads, which represented 22% of the bus sales in the domestic market and made up around 17% of the country's total bus fleet. In comparison, in 2017 there were around 360 electric buses deployed by various transit agencies throughout the U.S., making up only 0.5% to the total fleet of 70,000 buses.[18] And the divergence between China and the U.S. is growing, with the U.S. in 2019 having only 450 electric buses deployed in a fleet of 75,000 buses nationally.[19]

Domestic production and demand for e-buses in China has been strongly driven by the central government's industrial policy for vehicle electrification, in general, as well as national and regional subsidies that have brought initial capital costs of e-buses below that of traditional diesel buses. Since the "Ten Cities, One Thousand Vehicles" demonstration program in 2009, China's

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[iv] China is the world's largest bus manufacturer considering all vehicle types, supplying nearly 50% of buses in the global market.

national government has provided substantial subsidies for electric bus purchases. Starting at around 500,000 RMB (around 73,000 USD) per vehicle in 2009,[20] these subsidies decreased over the past decade to 58,000 RMB (around 8,400 USD) in 2019 as domestic production and sales volumes increased.[21] Due to reduced subsidies and the COVID-19 pandemic, domestic demand for e-buses has slowed. But the numbers still suggest that China's national government spent around 3 billion RMB (or 450 million USD) in the year 2019 alone on new e-bus purchase subsidies to help defray upfront costs for public transit agencies. And that number does not account for additional government support, for example, in terms of tax exemptions and expenditures on charging infrastructure.

Further, municipal governments have played a critical role in the uptake of e-buses, particularly to meet growing demand for urban travel while maintaining municipal air quality targets. In fact, major cities, like Shanghai, Beijing, and Shenzhen, have stopped purchasing new internal combustion engine (ICE) municipal buses altogether (and are setting their sights on the taxi industry next).

While many public transit agencies in major cities in the U.S. have also made commitments to electrify their bus fleets, upfront costs of electric buses remain a significant hurdle. In the U.S., an average diesel transit bus costs around 500,000 USD compared to around 750,000 USD for an electric bus (although over the lifetime of an electric vehicle, savings in maintenance and fuel costs can be substantial).[22] The U.S. Federal Transit Administration (FTA) has established the Low or No Emission Program, which provides funding to state and local government agencies to purchase or lease zero- or low-emissions transit buses and related infrastructure. However, in 2019, the program's entire budget amounted to 85 million USD, which is only enough to offset the 250,000 USD difference in upfront purchase cost for 340 vehicles. This amount is orders of magnitude lower than the investments that China's national government is making in electrifying its public transit fleets. Electrifying public transit in addition to LDVs is an important opportunity for the U.S.to improve our domestic transportation system while meeting climate mitigation targets.

When it comes to the international market, e-buses are a significant area of growth. Spurred by interest in Latin America and Europe, China's export of electric buses is growing quickly. Chinese e-bus manufacturers, particularly BYD and Yutong, dominate the global market in terms of units sold, largely due to their lower upfront costs, but they face stiff competition from e-bus manufacturers based in the U.S. and Europe. With better federal government support for public transit agencies to purchase e-buses and their maintenance and charging infrastructure and with carefully crafted "Buy America" provisions, the U.S. could accelerate domestic production of e-buses—creating new jobs and expanding a forward-thinking, globally competitive U.S. transportation industry.

The Whole Battery Supply Chain

Finally, China's industrial policy around vehicle electrification goes well beyond vehicle manufacturing to address the other parts of the value chain, including the market for lithium-ion battery technologies. Lithium-ion battery technology is poised to displace lead-acid batteries in the transportation and heavy equipment sectors. In early 2019, Chinese lithium-ion battery cell manufacturing accounted for 73% of global capacity, with the U.S. in a far-off second place with only 12% of global capacity (a share that is only projected to shrink as global capacity grows).[23] In the absence of sufficient domestic production of lithium-ion battery cells, U.S. electric vehicle (and battery) producers must rely on imports from Chinese manufacturers, putting the U.S. at risk of price-setting and supply chain disruptions. And China is not only controlling the world's production of lithium ion batteries, it also has a major foothold in the upstream extraction and processing of key materials (such as lithium and cobalt) needed for the most commercially-viable lithium-ion battery chemistries. In 2018, Chinese lithium production was 8,000 metric tons, third among all countries and nearly ten times U.S. lithium production. Further, Chinese lithium reserves in 2018 were one million metric tons, nearly 30 times U.S. levels.[23]

While much of the critical research and development that created the lithium-ion battery took place in the U.S., China's bullish investments in the commercialization of battery production and electric vehicle manufacturing have given it a clear edge. With such an advantage in both manufacturing costs and raw materials availability, it is unclear whether the U.S. can compete with China in the world market unless it invests now in supportive clean energy industries such as materials synthesis and battery cell and pack production. Further, as a growing number of lithium-ion batteries reach their end of useable life in vehicles, there is an opportunity for the U.S. to develop a globally competitive market for recycling materials or creating second-life uses in terms of energy storage.

New Mobility

For our next example of China's systems-approach providing a competitive edge, we consider the emergence of "new mobility" providers—private sector companies that provide innovative, on-demand mobility services enabled by improvements in information and communication technology. Prominent players include Uber (U.S.) and DiDi (China) in the ridehailing (or ride-sourcing) and micromobility (bike- or scooter-sharing) markets. I will start with a discussion of how these two companies, from the start, have embodied different approaches to the new mobility business that have significant implications for how well they support existing domestic transportation systems. Then I will briefly point to how these different approaches also provide China's DiDi a potential competitive edge in the highly dynamic international new mobility market.

DiDi was conceived in China's megacities, where private car ownership is still relatively low and walking, biking, and public/shared forms of transport serve the majority of trips. Around 2012, DiDi started as an app for traditional taxis that leveraged information technology to provide a more seamless experience for customers planning, booking, and paying for trips provided by multiple operators. As DiDi grew and diversified the types of services it offered—including starting its own chauffeured ride-hail service in 2015—it maintained its focus on providing a technology platform that could integrate different modes and service providers. It formed collaborative relationships with public transit agencies, incorporating information such as transit schedules directly on their app to help facilitate transfers for users. In 2018, DiDi launched an intermodal transportation recommendation function allowing users to search and book public transportation, online car-hailing and bike-sharing services in a single smartphone application.

This approach of multi-modal integration and collaboration with other service providers echoes the systems-approach to transportation policymaking employed by Chinese cities.

While Uber in the U.S. is also essentially a technology platform, from its inception it has primarily offered its own private chauffeured, on-demand car service in direct competition with traditional taxis and other incumbent modes. This has led to significantly more contentious rather than collaborative relationships with taxi and public transit operators and city governments more generally. While Uber and other players in the U.S. ridehailing market have since entered into individually-negotiated partnerships with certain public transit providers, early tensions have hampered the development of truly systems-oriented mobility technologies that can integrate planning, booking, and payment for multiple types of mobility services and provide real alternatives to private car ownership and use (a concept often referred to as "mobility-as-a-service").

As both of these companies expand into urban markets around the world, their different approaches have played out at scale. Uber was bullish in its expansion and, as a result, has experienced certain growing pains; its rapid and one-size-fits-all entrance into urban mobility markets worldwide often caused friction with city governments (each with its unique regulatory framework) and incumbent operators. DiDi's international expansion has been more methodical, often involving discussions with local policymakers and tailoring of the services provided in their app to the local context. While DiDi may not currently have the same market share as Uber in the global "new mobility" space, its collaborative, systems-oriented approach is likely to give it a competitive advantage, particularly in urban markets in the developing world where incumbent mobility services are provided by many small, private, independent operators.

Autonomy vs. Connectivity

Our final mobility innovation takes us further into the future. Significant advances in 5G communications, 3D imaging, AI, cloud computing, and other technologies may eventually enable the deployment of autonomous and/or connected vehicles. There is an important distinction between these two concepts.[24] An autonomous vehicle is one that has all of the necessary hardware and software on-board to navigate its environment and make its own driving decisions independently. This is the idea of the "self-driving" car. On the other hand, connected vehicles exchange driving information with other vehicles (potentially both automated and non-automated vehicles) and/or transportation infrastructure. Connected vehicle technology enables greater coordination of traffic flows and travel demands, which can unlock potential for cooperation that improves the efficiency of our transport networks.

Private sector innovation in the U.S. has focused on autonomous vehicle technology (e.g., Alphabet's Waymo). However, most of the benefits for transportation system planning and operations are unlocked when vehicles are connected to one another and to infrastructure—with or without autonomy.

While autonomy in the U.S. is likely to develop through private sector initiatives, ensuring connectivity will require active public sector engagement for several reasons. First, because private sector companies are advancing their own, proprietary software solutions, the public sector has a critical role to play in proactively setting standards and protocols for information exchange so that vehicles and infrastructure are speaking a "common language." Second, because technological innovation and mobility networks extend beyond local or regional jurisdictions, the U.S. federal government has a critical role to play in ensuring that communication standards work across state lines. Third, because the public sector owns the transportation infrastructure on which (autonomous) vehicles operate and to which connected vehicles will need to connect, the public sector will need to invest in the design and installation of connectivity-ready infrastructure. Fourth, the public sector has an existing role in providing transit services that must be the critical focal point of multi-modal and sustainable urban mobility networks.

Here again, the U.S. could look to some of the actions of China's national government, which announced a major infrastructure plan as part of its post-COVID-19 relief package that focuses on digital rather than physical infrastructure and includes a new wave of government support for private sector participation.[25] China's investments in innovation, information, and integration infrastructure provides the critical building blocks for an efficient multi-modality, sustainable domestic transportation systems and are likely to catalyze China's autonomous and connected vehicle efforts in the international market.[26]

Recommendations

In summary, the U.S. and its vehicle-centric approach to transportation is at a distinct competitive disadvantage as it faces new mobility innovations, such as electrification, new business models in the sharing economy, and automation and connectivity. There is much that the U.S. can learn from China's more systems-oriented approach to transportation policymaking to improve our own domestic transportation systems and to keep U.S. companies competitive in the transportation sector globally. To fully realize the potential of these new mobility innovations, the public sector in the U.S. will have to embrace a culture shift, rethinking the way we prioritize and invest in transportation services and infrastructure, and the government will have to play a key role in shaping new mobility technologies to align with broader system goals of sustainability, equity, and efficiency.

Continue to strengthen fuel economy standards for LDVs. Even as electric vehicles take off, ICEVs and hybrid electric vehicles are likely to remain a significant segment of the vehicle fleet and vehicle sales (in the U.S. and globally) for the next few decades.[8] While U.S. automakers (with the exception of Tesla) are playing catch-up when it comes to the design and manufacture of BEVs, they still have a clear edge in research and development of vehicle and engine technology that can improve the energy-efficiency of ICEVs and hybrid vehicles. Some of these vehicle improvements, such as downsizing, light weighting using new composite materials, or friction reduction, can also help make BEVs more competitive in the consumer market.[27] The U.S. government can help encourage further innovation in vehicle and engine efficiency by continuing to strengthen fuel economy standards, holding domestic OEMs to stricter standards that will keep them competitive in the global vehicle market.

Extend EV tax credits and invest in public charging infrastructure. As U.S. domestic production and demand for LDVs recover from the COVID-19 pandemic, the federal government should consider extending the federal EV tax credit system. EV purchases could be further encouraged by investing in domestic charging infrastructure networks. If charging infrastructure provision is considered in tandem with upgrades to electricity grids that can support a more renewable energy portfolio, these investments can help bolster domestic EV production and consumption while meeting other goals in the clean energy sector.

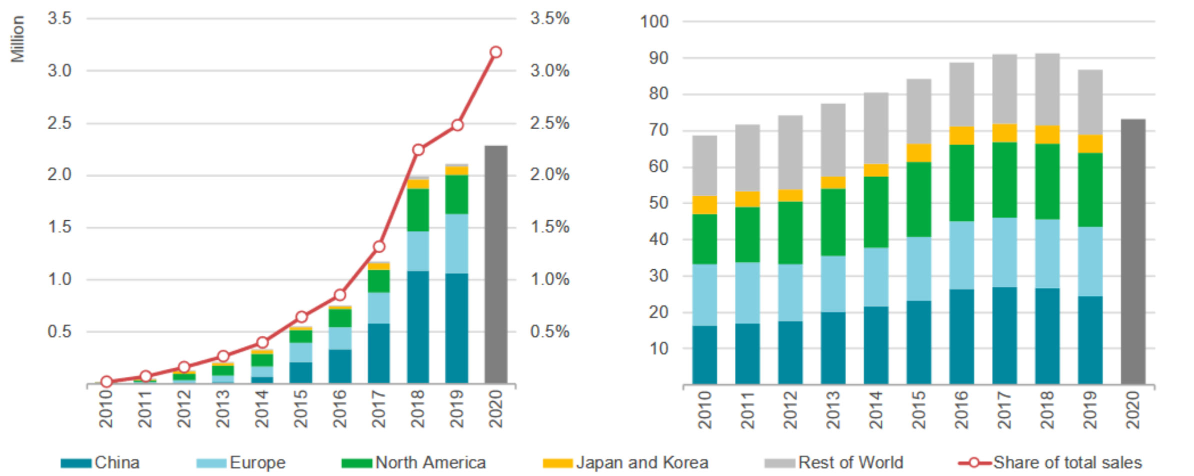
Invest much more in electrifying public transit. On a per-vehicle basis, changing from a diesel to a battery electric bus can save approximately 70 million grams of CO_2 per year, compared to 2 million from changing a passenger car from an ICEV to a BEV powered on the average U.S. grid (see Table 1). Public (and even school) bus electrification is a low-hanging fruit in the path towards achieving zero-emissions transportation because, with guiding legislation, it can be achieved relatively quickly through public procurement. Strong federal support in terms of e-bus purchase subsidies and new charging and maintenance facilities could go a long way in improving the efficiency and long-term financial and environmental sustainability of public transit, which supports the economic vibrancy of our nation's cities and provides quality jobs in the transportation sector. In addition to the benefits to our public transit systems, investing in clean bus technology could help transform nascent domestic e-bus manufacturing industry (e.g., Proterra) from already the largest North American supplier into a globally competitive company.[28]

Build up domestic industries along the battery supply chain. Building U.S. domestic industries in materials synthesis, battery cell and pack production, and battery repurposing or recycling could help keep U.S. OEMs competitive in the global EV market; expand domestic job opportunities related to vehicle electrification; and potentially catalyze other clean energy businesses and domestic technology markets. Furthermore, while the U.S. remains a leader in research and development of new battery technologies, historical experience with lithium-ion batteries suggests that the U.S. national government could do more in terms of programming to support commercialization of battery technologies. For example, competitive research and development grants and national labs could support prototyping, creating a pathway from lab demonstration to large-scale manufacturing.

Support local and regional governments in efforts to integrate new mobility services into multi-modal, transit-centric mobility systems through sandbox programs and information-sharing protocols. The federal government can expand support provided to local and regional governments and transit agencies in the form of grant programs for pilot projects (such as the FTA's Mobility on Demand sandbox program) and research and development focused on the integration of new mobility with existing public transit services and the development of policies and technologies to govern that integration.

Take an active role in goal- and standard-setting for (autonomous and) connected vehicles. The federal government should embrace its multifaceted role in proactively shaping the development of connectivity between vehicles, across modes, and with infrastructure. Clear and consistent federal policy has a critical role to play in supporting and guiding private sector innovation in (autonomous and) connected vehicle technology. As the U.S. considers infrastructure spending as a form of economic stimulus in the wake of the COVID-19 pandemic, the U.S. could look to China's forward-thinking strategies of investing beyond physical infrastructure (e.g., roads, highways, bridges, and rails) to consider digital infrastructure (e.g., 5G connectivity). In particular, U.S. federal government could bolster the Intelligent Transportation Systems Joint Program Office's ongoing efforts in developing protocols and standards for vehicle testing and safety, data- and information-sharing, and vehicle-to-vehicle and vehicle-to-infrastructure communications.

Figure 1. Global electric passenger light-duty vehicle sales and market share (left) and total light-duty vehicle sales (right)[29]



Notes: Includes passenger cars and passenger light trucks. Includes plug-in hybrids, battery EVs and fuel cell EVs. Share of total sales represents the total sales of EVs in countries listed in IEA *Global Electric Vehicle Outlook* as a percentage of total passenger car sales in those same countries. The 2020 estimates are based on the assumptions of a gradual global economic recovery and cautious consumer spending behaviour over the rest of 2020. This accounts for government measures in place at the time of writing, notably in China.
Sources: IEA (2020e); IEA (2020f); Marklines (2020).

Table 1. Comparison of potential emissions savings from electrifying a passenger car vs. a public bus in the U.S.

Statistic	Passenger car	Public bus
Annual miles traveled per vehicle[30]	11,467	43,647
Average vehicle occupancy factor[31]	1.7	10.7
Lifecycle emissions per distance (gCO_2-eq/mile)[6, 32]		
Internal combustion engine	(gas) 370	(diesel) 2,680
Natural gas	--	2,364
Hybrid electric	271	2,212
Battery electric (using average U.S. grid)	204	1,078
Fuel cell electric	267	--
Calculated annual emissions saved (gCO_2-eq) from switching a single vehicle from internal combustion engine to battery electric	2,000,000	70,000,000

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