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FORECASTS OF ELECTRIC VEHICLE PENETRATION AND ITS IMPACT ON GLOBAL OIL DEMAND

BY MARIANNE KAH, WITH SAMANTHA LANG, JASMINE CHIU, AND HON XING WONG

DECEMBER 2022

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ACKNOWLEDGMENTS

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EXECUTIVE SUMMARY

The transportation sector is responsible for more than half of global oil demand, with passenger vehicles and trucks making up by far the largest fraction. Many countries with decarbonization goals therefore seek to expand electrification of road transport to meaningfully decrease reliance on this fossil fuel. The degree to which electric vehicle (EV) penetration can alter global oil demand has implications for whether more stringent government decarbonization policies will be needed to reach net zero targets.

This report, part of an oil and gas research initiative at Columbia University's Center on Global Energy Policy, compiles medium- and long-term forecasts of EV penetration and addresses the question of whether the sharp increase in EV sales in recent years—a fourfold rise from 2019 to 2021—is projected to continue or even accelerate. It compares survey responses from 14 entities, including governments, think tanks, oil companies, consultants, and investment banks in the fourth quarter of 2021 with a similar survey conducted in 2019. The report examines forecasts for passenger EV sales and fleet share as well as those for electric commercial trucks out to 2050, and considers some of the key underlying drivers of passenger vehicle oil demand (e.g., population growth, GDP growth, battery cost trends). Some forecasters offered multiple scenarios, including business as usual (BAU), carbon constrained, and net zero carbon emissions (NZ) by 2050, with meaningfully different results.

Overall, survey respondents anticipate an acceleration in the rate of EV penetration in passenger vehicles and light-duty trucks in the medium and long term, both in terms of sales and the ensuing share of the total fleet. Other findings from the forecasts include the following:

- The penetration of EV to total passenger car sales in 2030 forecasts range from 11 percent to 63 percent. Projections for 2050 range from 31 percent to nearly 100 percent. The wide range is due to varying degrees of anticipated carbon constraints, with NZ 2050 forecasts having the highest EV penetration. Significant changes (e.g., in government policy, technology, cost) would be needed to reach the level of EV penetration necessary for a net zero 2050 trajectory.
- All NZ and carbon constrained responses project that EVs will make up over half of the passenger vehicle fleet around 2040 and above 90 percent by 2050. Many non-carbon-constrained projections tend to be lower, with EVs making up 20 to 45 percent of the passenger fleet by 2050.
- With the Russian invasion of Ukraine and higher oil prices unfolding after the survey was conducted, several respondents provided additional information. They indicated that despite these occurrences that might further encourage a move away from oil, they wouldn't significantly increase their EV penetration forecasts because of lower economic growth decreasing new car sales, battery supply chain and cost issues, and higher power prices.

- Forecasters generally cite government policies as a key driver of EV penetration, including regulations on fleet emissions, bans on internal combustion engine vehicles in certain geographies, incentives for purchasing EVs, and funding for EV charging infrastructure. Other potential drivers of increased EV penetration forecast in the 2021 survey versus the 2019 survey are the additional two years of technology and market maturation, with rapid new EV model introduction by multiple manufacturers.
- Due to stronger government policies, China is projected to lead EV penetration in medium- to long-term forecasts, with the US behind China and the EU due to historically weaker policy drivers and longer driving distances (which still cause range anxiety in some consumers).
- Most forecasts show passenger vehicle global oil demand peaking at or before 2030, with the NZ forecasts peaking before 2025. However, there was not much consensus among NZ forecasts of how rapid the decline will be between 2020 and 2030. In the NZ and carbon constrained forecasts, passenger vehicle oil demand falls from about 25 million barrels per day today to 3–6 million barrels per day by 2050. Most other forecasts ranged between 10 and 20 million barrels per day by 2050.
- Light-duty commercial trucks have the highest forecasts for EV penetration of all truck classes, and they even outpace some projections for passenger vehicle EV penetration by 2030. In contrast, electrification of heavy-duty trucks is projected to remain challenged by the size and weight of the batteries required to move them over long distances.

INTRODUCTION

Transportation is responsible for more than half of global oil demand, with road transport having the largest share. Electrifying vehicles with clean electricity could therefore go a long way toward reducing dependence on fossil fuels to meet decarbonization goals. This report compiles forecasts for electric vehicle (EV) penetration in road transport by leading forecasters in the public and private sectors to gauge whether recent trends are impacting medium- and long-term predictions of EV sales and market share and global oil demand.

EV purchases accelerated globally in 2020 and 2021. In 2019, 2.2 million electric cars were sold, representing just 2.5 percent of global car sales. In 2020, sales increased almost 36 percent to 3 million electric cars despite the year's global economic downturn that led to an overall vehicle sales decline of about 6 percent. In 2021, electric car sales reached 6.6 million vehicles—almost 10 percent of the global car market.[1] EVs had a much higher sales penetration in China and Europe, representing 16 and 17 percent of new car sales, respectively.[2] But what does the future hold?

This study surveys forecasters' medium- and long-term views on EV penetration in 2021 and compares results with a similar survey conducted in 2019. The recent survey involved 14 entities, including governments, think tanks, oil companies, consultants, and investment banks. Some forecasters offered multiple scenarios, including business as usual (BAU), carbon constrained, and net zero (NZ) carbon emissions by 2050. Because the survey was completed before Russia's invasion of Ukraine, the authors followed up with participants to ask whether recent events would alter their forecasts.

After describing some factors influencing EV penetration today, the authors provide their methodology and survey results. The report turns to macroeconomic and technological factors potentially affecting future uptake of EVs before delving into the forecasts for passenger EV penetration and passenger sector oil demand, as well as EV penetration in commercial trucks.

Factors Driving EV Adoption

As a new technology, EVs have faced various barriers to adoption in the past, including high purchase costs, limited driving range, insufficient charging infrastructure, and long charging times.[3] Although improvements in the performance of batteries and their reduction in costs from $1,000 per kilowatt-hour (kWh) for the first models more than a decade ago to about $130 in 2021[4] have greatly improved EVs' value proposition, many EVs still will not be cost competitive with conventional vehicles until battery pack costs fall to $100 per kWh.[5]

In addition to improvements in battery technology, government policies have been a large driving force for global electric car markets, particularly in Europe and China in recent years. During 2020 and 2021, many governments set targets to phase out sales of internal combustion engines. Other policies—such as carbon dioxide (CO_2) limits in Europe, zero emissions vehicle sales targets in China, and EV sales incentives in many countries—helped accelerate short-term EV sales. A recent working paper on the rapid penetration of EVs in China showed that central and local subsidies accounted for over half of the EVs sold between 2015 and 2018.[6] Some green stimulus packages to encourage economic recovery from COVID-19 included mechanisms and incentives for EV purchases and EV charger implementation. But a review of green spending in 2020 concluded that only the EU committed a meaningful share of its stimulus—15 percent.[7] Similarly, a study by Oxford and the United Nations (UN) Environment program concluded that 18 percent of announced recovery spending could be considered green.[8] A study by the Organisation for Economic Co-operation and Development (OECD) also concluded that the spending allocated to green measures represented around 17 percent of recovery spending and 2 percent of total COVID-19–related spending.[9]

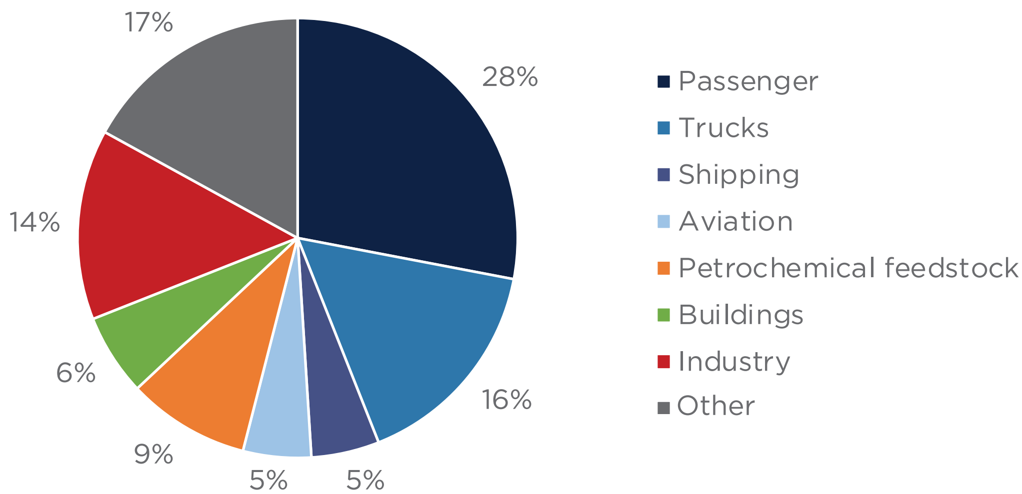
Auto manufacturers also released many new models of EVs during this period, which provided consumers greater choice in purchasing vehicles. For example, there were five times more models in 2021 than in 2015.[10]

METHODOLOGY

Rationale for Studying Passenger Vehicle and Truck Sectors

The authors focus on the transportation sector because it is responsible for more than half of global oil demand (see Figure 1). The largest potential change expected in oil usage is in the electrification of road transport vehicles.

Figure 1: Global oil demand by sector, 2019



Source: International Energy Agency, "World Energy Outlook 2020," October 2020, Figure 5.8, (and extended data set), https://www.iea.org/reports/world-energy-outlook-2020.

The authors focus on the passenger vehicle sector because it uses the largest volume of oil of any sector, consuming around 27 million barrels per day in 2019, or 28 percent of global oil demand.[11] In addition, this sector is easier to electrify than other transportation sectors such as aviation and shipping. The passenger vehicle sector includes cars, two-wheelers, three-wheelers, and buses. Two-wheelers and three-wheelers are easier to electrify than cars because they require smaller batteries. Electric buses have the advantage of taking a standardized route with a designated place for charging they return to each day. However, the authors focus on passenger cars in this report because they are responsible for about 80 percent of the oil demand in the passenger vehicle sector today.

The authors also focus on trucks, ranging from light duty to heavy duty,[12] because they consume about 16 percent of global oil demand, or 15 million barrels per day.[13] In addition, the International Energy Agency's Stated Policies Scenario (STEPS) from the 2021 World Energy Outlook projects around 4 million barrels per day of oil demand growth from medium- and heavy-duty trucks through 2030.[14] Trucks are also easier to electrify than airplanes and ships. However, when compared to passenger vehicles and lighter trucks, heavy-duty trucks face larger challenges with scaling technology, reaching price parity, and adhering to regulatory weight limits on road infrastructure given the weight of the batteries.[15]

The trajectory of oil demand is also important for numerous policies surrounding the security of oil supply and oil price as well as implications for climate change mitigation. The world has observed the sensitivity of oil prices to a global pandemic on the downside and international conflict with a major oil supplier on the upside. An important policy objective is to ensure that oil supplies are sufficient to meet oil demand, which will vary depending on the rate of EV penetration in automobile and truck fleets. In order for the world to get on a net zero 2050 trajectory, global oil demand needs to peak in the mid-2020s.[16] If the rate of technological progress for batteries and EV penetration is not consistent with that trajectory, more policy incentives or regulations, or other factors influencing uptake, would be needed to close the gap.

An important limitation of the study is that it does not address future oil market dynamics given that it did not assess oil demand outside of road transport or the response of oil demand to lower oil prices, and it did not address oil supply and its response to changes in demand and oil prices.

Survey Structure

The authors sent a survey on future EV penetration to 14 entities, including governments, think tanks, oil companies, consultants, and investment banks in the fourth quarter of 2021. Some forecasters offered multiple scenarios, including business-as-usual (BAU), carbon constrained, and net zero carbon emissions by 2050 (NZ). In total, the authors received 19 different sets of forecasts.

Since unpublished data was collected, it was agreed that individual identities of survey participants would not be disclosed. Instead, forecasts were categorized into the following groups:

- Government, without stringent carbon constraints (four forecasts)
- Oil company, without stringent carbon constraints (three forecasts)
- Other (including consultants, banks, and think tanks), without stringent carbon constraints (six forecasts)
- Stringent carbon constraints (three forecasts from a combination of the three groups bulleted above)
- NZ by 2050 (three forecasts from a combination of the three groups bulleted above)

Some of the forecasts collected represent policy-prescribed scenarios such as what it would take to get to a NZ outcome in 2050, while other forecasts describe what the authors believe is likely to happen. That distinction should be considered when comparing the different forecasts.

The results reflect perceptions of how quickly passenger vehicles and trucks may electrify and influence oil demand. They also allow the authors to compare forecasts from multiple stakeholders. For passenger cars, the authors also compare results to a similar survey conducted in 2019. The 2021 survey assesses differences in views annually up to and beyond 2040 on:

- Global and regional EV sales and as a percentage of total vehicle sales
- Global and regional EVs in the fleet and as a percentage of the fleet
- The year in which battery pack cost declines put EVs at cost parity with conventional cars
- Vehicle miles traveled
- Global oil demand for passenger vehicles

Underlying Assumptions

The authors also collected views on underlying assumptions from the various scenarios. The main assumptions included:

- **Projections for climate change:** Unlike in the previous survey, forecasters were explicitly asked if their forecasts were based on a target degree of warming, such as a 1.5°C warming, 2°C warming, or a NZ by 2050 scenario. This allowed for categorization into (1) limited or no carbon constraints, (2) carbon constraints but short of NZ 2050, and (3) NZ 2050. Associated with the level of carbon constraint is the level of regulation surrounding EV penetration. The scenarios with carbon constraints were more likely to include such policies as stringent vehicle efficiency standards and support for EV infrastructure. A number of forecasters submitted forecasts for multiple scenarios ranging from BAU to NZ. It is important to note that NZ scenarios generally represent what needs to happen to achieve the NZ 2050 target rather than a forecast of what is likely to happen.
- **Projections for global population growth:** The authors asked participants for global population growth assumptions behind the EV penetration and oil demand forecasts to determine whether forecasts differed because they had dissimilar views on population growth. Population growth is a large driver of gross domestic product (GDP) growth and the size of vehicle fleets, which are both large drivers of oil demand.
- **Projections for global GDP growth:** The authors also asked participants for their GDP growth assumptions because economic growth is a large driver of vehicle purchases, vehicle miles traveled, and global oil demand. Compared to the 2019 survey, the 2021 survey factors included lost economic growth due to COVID-19, which influenced some forecasts. Given the unprecedented economic downturn and resulting decrease in vehicle purchases and vehicle miles traveled, it was critical to ask for economic growth assumptions related to COVID-19 and the change in the pandemic's impact during its fluctuations and recovery.

Other assumptions that explained differences in the forecasts include the following:

- **COVID-19 impacts on vehicular oil use:** The forecasts may also account for the COVID-19 pandemic's impact on driving behavior. While the authors explicitly asked about the impacts of COVID, the comparison between 2019 and 2021 results shed light on this subject since COVID had its largest impact on road transport in 2020. A survey was not sent to participants in 2020 during the start of COVID because of the lack of economic predictability and many forecasters choosing to skip any updates in that year.

- **Scrappage rate for passenger vehicles:** This is the measure of vehicles exiting the active population. The scrappage rate assumption can vary over time and across different regions. For example, some carbon-constrained scenarios included an accelerating scrappage rate from the mid-2020s.

Differences in oil price views could also explain differences in EV penetration rates. The oil price view is also implicit in economic growth assumptions. However, the authors did not capture oil price views in the surveys. Many of the participants don't publish or share oil price forecasts, which are considered sensitive information.

Data Issues

Some inconsistencies in the data received needed to be accounted for. Some data was provided in different units than what was requested and required conversion calculations. Often, this simply required adjusting the scale of values (i.e. converting billions of vehicles to millions of vehicles), but some unit conversions were required (e.g., kilometers to miles; exajoules per year to million barrels per day). The source for conversion from exajoules per year to million barrels per day was the International Energy Agency's 2021 World Energy Outlook.[17] Additionally, some survey respondents gave values annually and others provided estimates on a 5- or 10-year basis. In most of this report's graphics, the values that did not reflect annual numbers were entered in the format in which they were provided, and the line charts connected the values to show a smooth progression. For any instance where the graphic is meant to measure a rate of change or growth rate, if a value was given as opposed to a rate, the rate was derived by calculating the percent change in value year-over-year. If these values were given on a nonannual basis, the percent change was calculated and then annualized over the period to derive a yearly rate. If an average value was given over a period of time (as is the case with the UN population projections), the average value was given for each year in the period.

There was some difference in definitions of passenger vehicles—both historical and in the forecast—that made comparison of absolute numbers difficult. This was caused by some participants' inability to separate their data into the requested categories. Two survey participants include two- and three-wheelers in the passenger vehicle sector, whereas most respondents only counted traditional automobiles as passenger vehicles. To avoid misrepresenting data, no transformative calculations were used in this case; it was noted and is called out in instances where it appears to alter projections significantly. Trends in the data are still relevant, which is a major reason the authors did not exclude data that was on a slightly different basis.

The trends shown in this study should be viewed as directional and not statistically significant due to the relatively small sample size of comparable forecasts from year to year. As previously mentioned, the trends are also more important than the absolute numbers because there were different base values in some of the forecast variables. In addition to resulting from slightly different definitions of light-duty vehicles, differences in base values also resulted from the use of different conversion factors across the studies. Some of the forecasters were unable to provide data in the exact form that was requested. Forecasters were asked for historical data back to 2015 so the authors could see how much their baselines differed. In some cases, the history represented the result of the forecaster's model and is not actual data. Many of the figures in the report show history back to 2015, but the history will differ between forecasts for the reasons described. There were also differences in the methodologies for calculating purchasing power parity in the GDP growth estimates.

Definitions of Passenger Vehicles and Trucks

For purposes of this survey, passenger vehicles include SUVs, light trucks, and vans except those used for commercial purposes, and excludes buses and two- and three-wheelers.

For commercial trucks, the authors used the IEA's classification of light-, medium- and heavy-duty commercial trucks. Light-duty commercial vehicles include pickups, vans, and small trucks with a gross vehicle weight (GVW) of less than 3.5 metric tons, and they are used for the transportation of goods. They are often used for last-mile deliveries among other purposes. Medium-duty commercial trucks have a GVW from 3.5 to 15 metric tons. They include small lorries, rigid trucks, and tractor-trailers generally performing regional operations. They also include trucks used in public service such as garbage trucks. Heavy-duty commercial trucks have a GVW of greater than 15 metric tons. They are typically used for long-haul shipments. Heavy-duty trucks account for about 70 percent of road freight activity and about 50 percent of truck energy use.[18]

SURVEY RESULTS

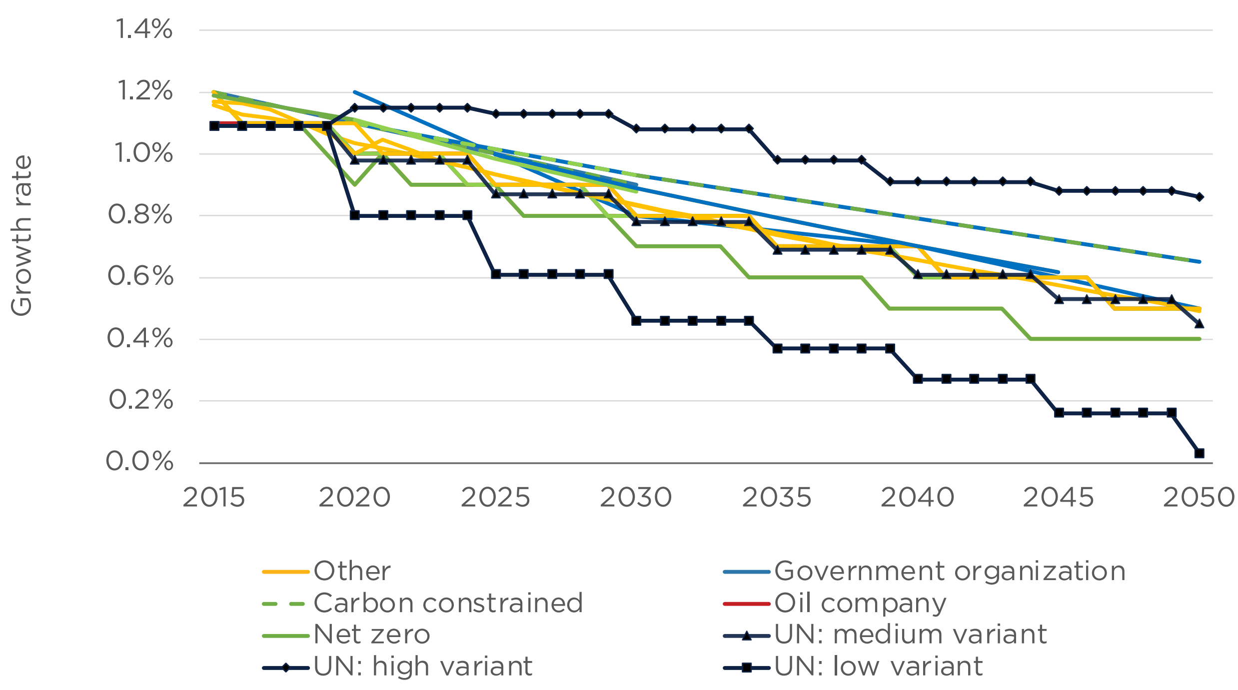
Underlying Macroeconomic Factors

Macroeconomic factors are significant underlying drivers of the demand for passenger vehicles and trucks and overall projected demand for oil. The authors requested that study participants provide world population and economic growth projections because their levels influence vehicle purchases and miles driven.

Global Population Growth

Figure 2 shows forecasts for the rate of population change in the coming decades. The UN medium, high, and low variant projections are included as benchmarks.

Figure 2: Forecasts of global population growth



All forecasts are between the UN high and low variant projections in the coming decades, with the UN medium variant lying generally in the middle of forecasts, illustrating a fair amount of consensus. All forecasts show a decreasing rate of population growth, which results in slower economic growth, as well as a slower rate of increase in demand for passenger vehicles, vehicle miles traveled, and demand for oil. Several primarily government forecasts were above the UN medium variant, which would lead them to have higher predictions for fleets and miles traveled.

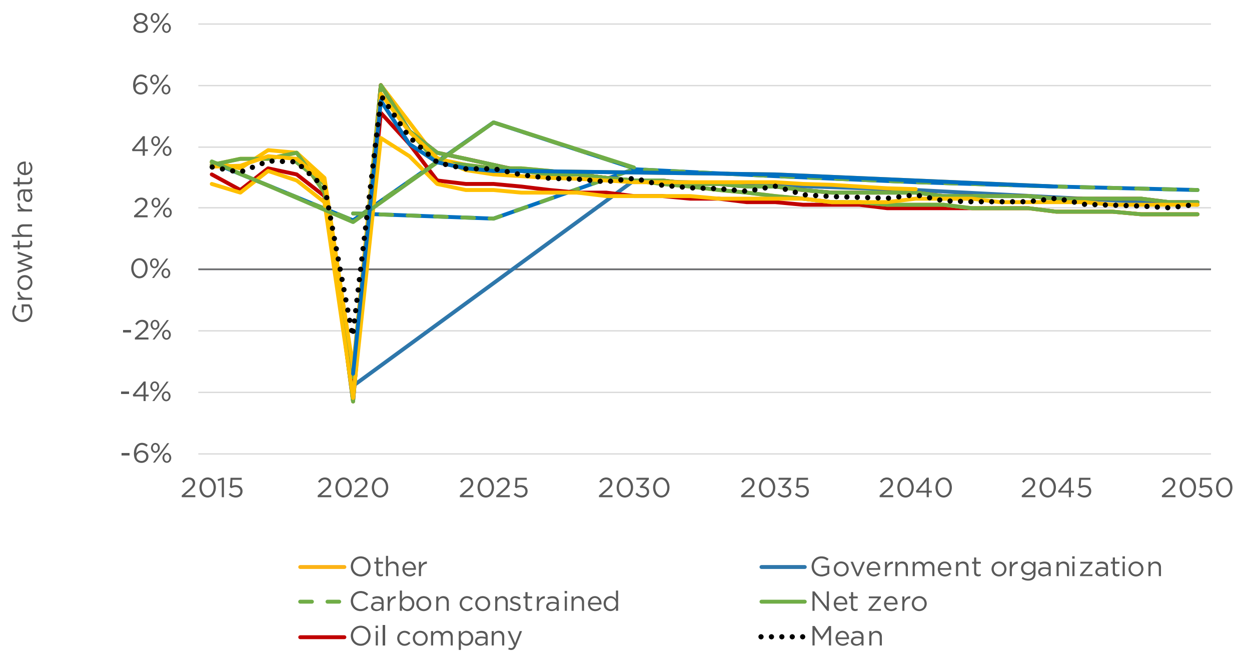
While all forecasts show a downward trend in the rate of population growth, the projected growth rates vary by the economic maturity of the region. In comparing the projected population growth of OECD countries compared to non-OECD countries, growth rates are expected to decrease across both sets of countries. But growth rates remain higher in non-OECD countries across the coming decades.

Forecasts for OECD population growth in 2050 generally range between 0–0.10 percent per year, with one oil company forecasting negative growth of -0.10 percent by midcentury. By contrast, projections for non-OECD countries anticipate that population growth will remain between 0.40–0.75 percent by 2050. There is some volatility in estimates of OECD population growth in 2020; this is likely due to complications of tracking population during the COVID-19 pandemic.

Global Economic Growth

Figure 3 shows forecasts for GDP growth underlying passenger vehicle and truck projections. Similar to population growth forecasts, global GDP growth forecasts also trend downward over time. By 2050, projections for global GDP growth are between 1.8–2.6 percent annually.

Figure 3: Forecasts for real global GDP growth



Source: Authors' 2021 survey results.

All of the forecasts demonstrate disturbances to economic growth in 2020 in response to the COVID-19 pandemic, and the forecasts of the economic downturn and rate of recovery differ across entity and scenario type. It is important to note that the focus of this study is not on economic changes or recovery as a result of 2020's global economic downturn but rather the medium- to long-term outlook on economic growth. However, the pandemic's depressive impact must be considered when evaluating long-term economic expectations.

Compared to the International Monetary Fund's (IMF) World Economic Outlook released in July 2022, the respondents' forecasts for global GDP growth in the near term were generally higher.[19] The IMF forecasted that global growth will slow to 3.2 percent in 2022 and 2.9 percent in 2023 whereas the average of participants' forecasts for those years were 4.3 percent and 3.5 percent, respectively. It is important to note that there may be differences between forecasts on how purchasing power parity is calculated.

GDP growth forecasts vary when comparing OECD and non-OECD countries. Forecasts for annual GDP growth in OECD countries by 2050 range between 0.7–1.9 percent. Most of the forecasts show decreases in GDP growth rates over time with only a few exceptions. In non-OECD countries, the projected annual GDP growth rates in 2050 are between 2.2–2.9 percent, which is consistent with higher population growth and more rapid development.

In comparing 2021 and 2019 forecasts for global GDP growth, economic forecasts in the short and medium term were lower in the 2021 survey than in the 2019 survey. This observation is not surprising given the advent of COVID-19. In the long term, about half of the forecasts were lower in the 2021 survey than the 2019 survey.

Technological Factors

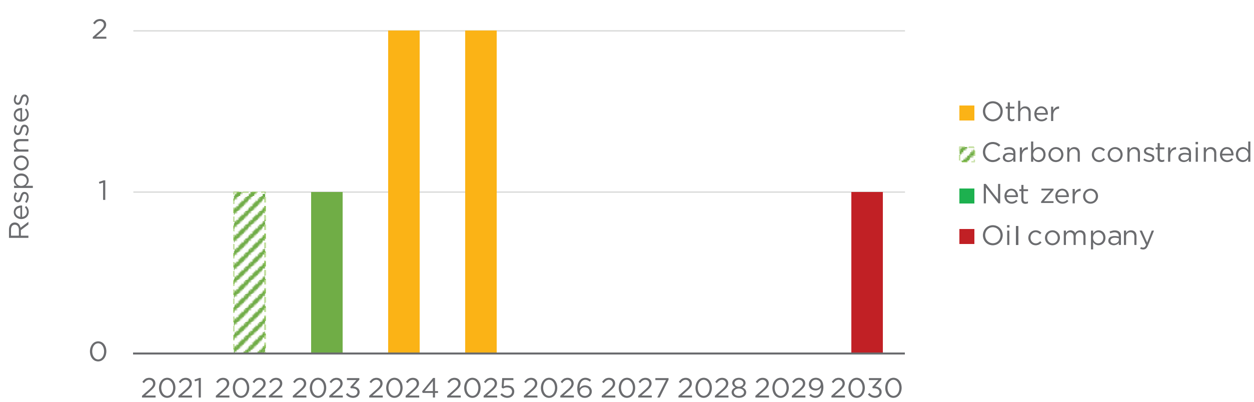
Battery Cost

The cost of EV battery packs is a key driver in vehicle price and, therefore, EV demand. It is commonly stated that for EVs to become cost competitive with traditional passenger vehicles, battery pack prices must decline to $100/kWh,[20] and an even greater decline is necessary for SUVs. EV battery pack prices have declined dramatically, starting at $1,000/kWh decades ago, reaching $140/kWh in 2020, and falling further to $132/kWh in 2021.[21] Decreasing prices depend largely on technological improvements and production efficiencies, as well as the prices of metals used in batteries including lithium, nickel, and cobalt. However, in the wake of the Russian invasion of Ukraine, average battery costs have increased.[22] Prices of lithium, nickel, and cobalt, which can represent some 27 percent of the total battery input costs for certain battery chemistries, had already been rising in recent months due to increased demand from the automotive sector due to the ramp-up in sales of EVs. Prices of nickel, cobalt, and lithium had already increased by 36 percent, 125 percent, and 750 percent respectively in the trailing twelve months to January 2022.[23] Russia's invasion of Ukraine exacerbated nickel price increases because Russia supplies 13 percent of the global high-grade nickel market.[24] This conflict and the impact on battery prices may delay EVs reaching price parity.

Figure 4 illustrates respondents' forecasts predicting when battery pack prices will reach

$100/kWh for the average passenger vehicle.[25] The median timing is in 2024, and the majority of the participant's forecasts indicate that parity will be reached by 2025. However, a survey by Bloomberg New Energy Finance last year indicated that there were already examples of batteries being offered at prices below $100/kWh, which helps explain why some of the forecasts show parity being reached by 2024 or earlier.[26] Projections are largely clustered around 2024–2025, indicating that it is the expectation that battery costs will decline to the point of allowing EVs to be price competitive within the next 2–3 years. The average of forecasts in our survey is in 2025, but it is skewed due to one participant predicting that prices will not reach $100/kWh until 2030. In justifying their later projection for price parity, this participant explained that they predict supply chain issues and the time lag associated with expanding manufacturing would delay battery pack manufacturers' ability to reach economies of scale. Additionally, this participant was skeptical of continued high technology learning rates, which would further slow the decrease in battery pack prices.

Figure 4: Forecast of when battery prices reach $100/kWh



Source: Authors' 2021 survey results.

Comparing the 2021 survey to the 2019 survey, the results are largely similar, with the 2021 survey being slightly more aggressive on timing.

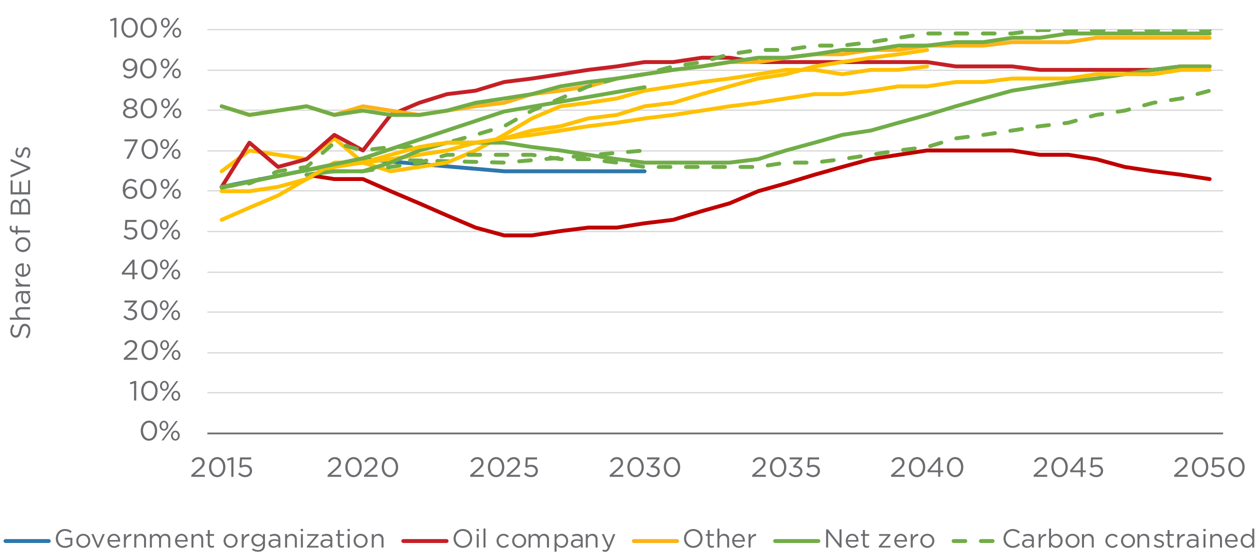
There are other aspects of electric vehicles important to consumers besides cost, including the availability of charging infrastructure, the range of the vehicle, the time it takes to charge it, and perceptions about battery life. However, the authors were not able to obtain forecasts on these factors.

Battery EVs Versus Plug-In Hybrid Vehicles

The two types of electric vehicles, battery electric vehicles (BEVs) and plug-in hybrids (PHEVs), offer different benefits in terms of their contribution to transportation decarbonization and EV market penetration. PHEVs include a small internal combustion engine (ICE), which reduces range anxiety[27] and gives drivers an alternative when electric charging infrastructure is not readily available. They also don't need to have high-cost batteries as large as those in BEVs given that they have a small internal combustion engine to boost their range.[28] However, some PHEVs currently for sale rely on their internal combustion engine during most acceleration episodes and have all-electric ranges shorter than the length of a typical commuting trip. In fact, the EU has recently agreed to assess PHEV emissions based on how much they actually emit on the road rather than making an assumption about how many miles are driven in electric mode.[29] Additionally, the decline in battery prices and increase in EV range should increase the attractiveness of fully electric vehicles.

Figure 5 shows the projected share of the total EV market made up by BEVs in the various forecasts collected. Since definitional issues result in different starting points, the trends are more important than the absolute levels. Though there is some volatility, most forecasts in the survey predict that while BEVs are already more common than PHEVs, they will continue to dominate the EV market. The average projection of BEV's share of the market was 78 percent for 2030, and 90 percent for 2050. It is interesting to note that despite the higher range anxiety for BEVs versus hybrids, BEVs have a higher market share than hybrids today and that is expected to increase according to the survey. Many auto manufacturers appear to be shifting focus to BEVs versus hybrids. For example, an analysis of industry car production plans in Europe through 2028 shows only 28 PHEV models versus 86 BEV models.[30]

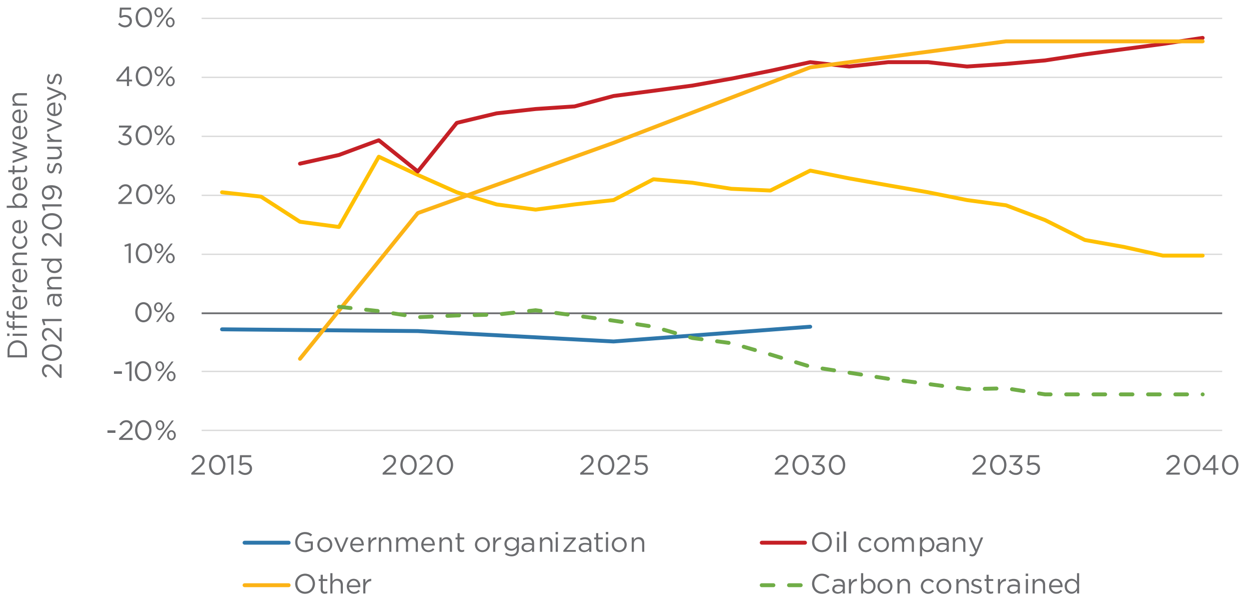
Figure 5: Forecast BEV share of total EV market (BEVs+PHEVs)



Source: Authors' 2021 survey results.

Figure 6 shows the difference in projections for the portion of the total EV market made up by BEVs between the 2021 and 2019 surveys. There is little consistency on the difference between the two surveys, but the majority of respondents that participated in both surveys have higher projections for BEVs' share than they did in 2019. In addition, the majority of responses indicated BEV market shares 20 to 30 percent higher beyond 2025 in the 2021 versus the 2019 survey.

Figure 6: Forecast difference in BEV share of total EV market (BEV+PHEV) between the 2021 and 2019 surveys



Source: Authors' 2021 and 2019 survey results.

EV Penetration in the Passenger Vehicle Sector

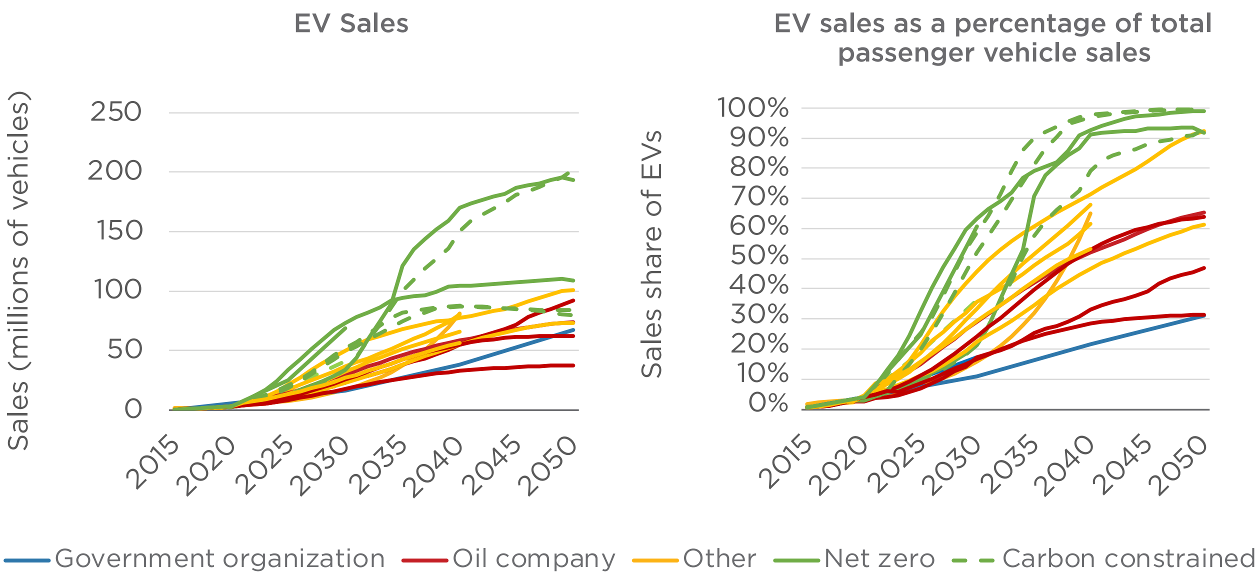
EV Penetration of New Car Sales

A body of literature identifies factors that affect EV adoption, including vehicle ownership costs, driving range, and charging time.[31] There are also many external factors cited, including relative fuel prices, gender, location and environmental concerns of the consumer, the availability of charging stations, public visibility and social norms, and policy incentives.[32] As batteries become cheaper, EVs become more affordable, and there are more choices of models, EVs may become more popular and make up a larger percentage of the passenger vehicle market. The rate at which this occurs depends on the macroeconomic and technological factors discussed above, as well as policies that incentivize purchases of EVs, availability of charging infrastructure, consumer attitudes toward environmentalism, and innovation to raise consumer confidence in EV reliability, among other factors.

To understand why the authors anticipated changes in forecasts in the 2021 survey, it is first important to recognize how EV sales have progressed in key markets in recent years. Nearly 10 percent of new car sales were electric in 2021, four times the market share in 2019.[33] In China, EVs accounted for 16 percent of domestic car sales in 2021, up from under 5 percent in 2019.[34] They reached a monthly share of 20 percent in December 2021.[35] In Europe, electric cars accounted for 17 percent of auto sales in 2021.[36] In addition, automobile manufacturers have greatly expanded their offerings of EVs. Globally, there were over 450 electric car models available in 2021, about 50 percent higher than in 2019 and more than twice the number available in 2018.[37] In 2021, several major automakers (e.g., Volkswagen, Volvo) announced plans to accelerate the transition to a fully electric future by developing new product lines as well as converting existing manufacturing capacity.[38]

Figure 7 shows the global sales forecasts for electric passenger vehicles in the survey, as well as EV sales as a percentage of global annual passenger vehicle sales. Though all forecasts show an increase in the EV market over time, sentiment around the extent to which EVs will dominate the passenger vehicle sales market varies widely. Looking out to 2030, the range of views on EV sales penetration is relatively large, with a low projection of 11 percent and a high of 63 percent. Projections for 2050 range from 31 percent to 99.5 percent. The higher penetration levels depend on the degree of carbon constraint in the forecast; NZ and carbon-constrained estimates have notably higher percentages, with all NZ and carbon-constrained forecasts going above 90 percent by 2050. BAU oil company and government organization forecasts tended to be lower, with projections ranging between 30 to 65 percent by the middle of the century, with other respondents somewhere in the middle. In the chart showing EV sales, the top two projections—NZ and carbon-constrained—are two of the scenarios submitted by oil companies that include two- and three-wheelers in the passenger sector; this could contribute in part to their high projections for EV sales.

Figure 7: Forecast world sales and market share of electric passenger vehicles

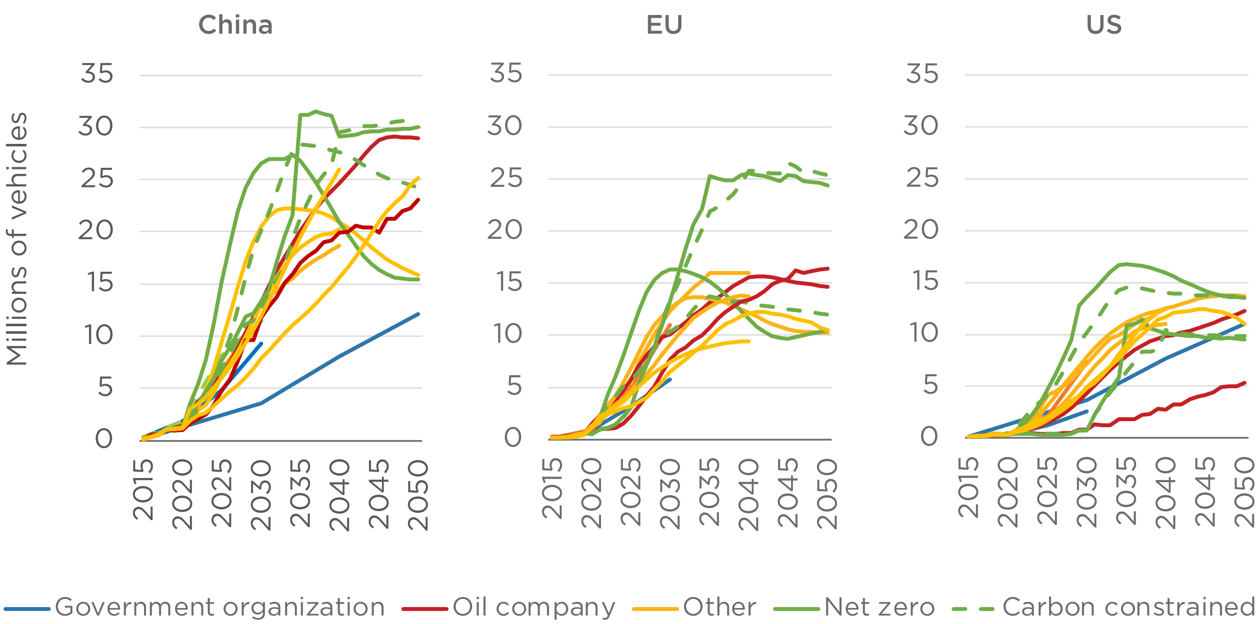


Source: Authors' 2021 survey results.

As shown in Figure 8, electric vehicle sales are forecast to be largely dominated by sales in China and the EU, whereas survey respondents predicted a lesser EV market in the US. High EV sales in the EU are likely due to policies that make it increasingly difficult for conventional vehicles to meet CO2 standards and governments providing incentives for EV purchases and support for EV charging infrastructure. China's projected EV growth likely can be attributed to several national and municipal policies that encourage EV sales and charging infrastructure development (e.g., zero emissions vehicle targets, buyer subsidies, support for charging infrastructure, ease of licensing EVs versus conventional vehicles, free and preferential parking for EVs, etc.).[39]

The US doesn't provide the same level of policy incentives found in Europe and China, although the provision of $7.5 billion for EV charging in the new Infrastructure Investment and Jobs Act will help alleviate one barrier. And the recently passed Inflation Reduction Act expands the tax credits available to EV buyers in the US, albeit with a few new limitations. But continued range anxiety in a geographically large country, much of which is rural and requires long driving distances, could discourage some EV ownership in the US. While the improving range of EVs makes many commutes acceptable, many customers want to drive electric SUVs, which require more battery power and could shift cost parity out in time.

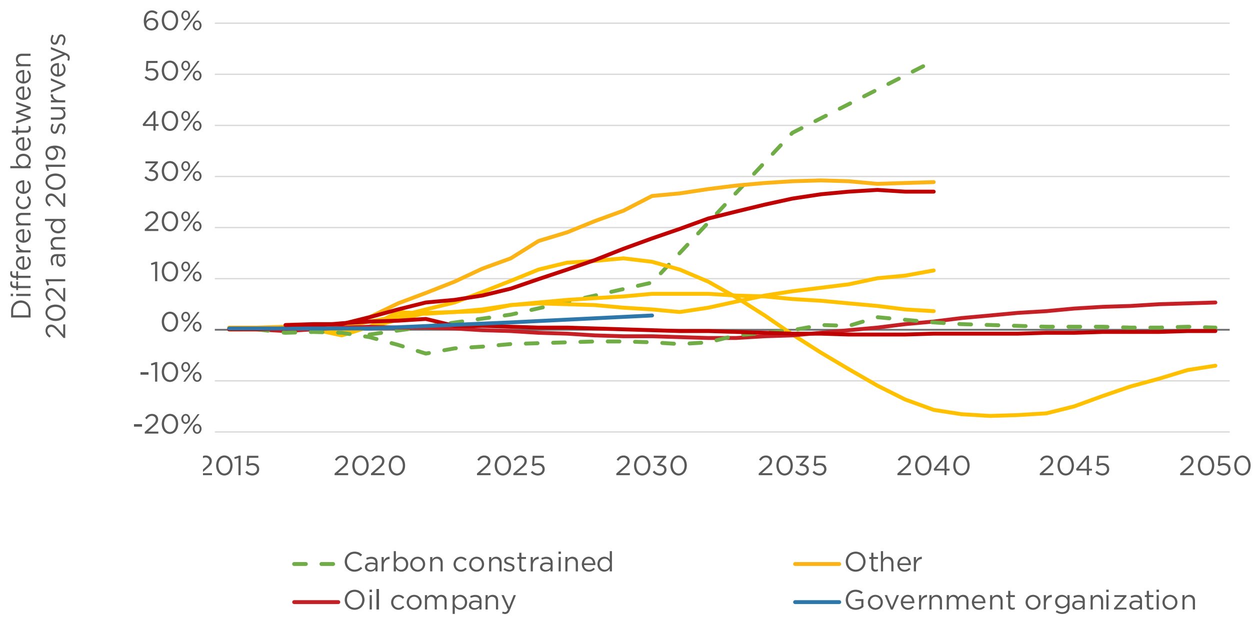
Figure 8: Forecast annual sales of electric passenger vehicles in China, the EU, and the US



Source: Authors' 2021 survey results.

In comparing the 2021 survey to the 2019 results, most respondents predict a higher percentage of EV passenger vehicle sales. Figure 9 illustrates the difference in projections between the two surveys, exclusively for respondents that participated in both years. As shown, most 2021 forecasts are similar to or slightly higher than each respondent's 2019 estimates, with one carbon-constrained scenario, one oil company, and one other respondent showing significant growth in the projection. There weren't any NZ scenarios submitted in the 2019 survey for comparison.

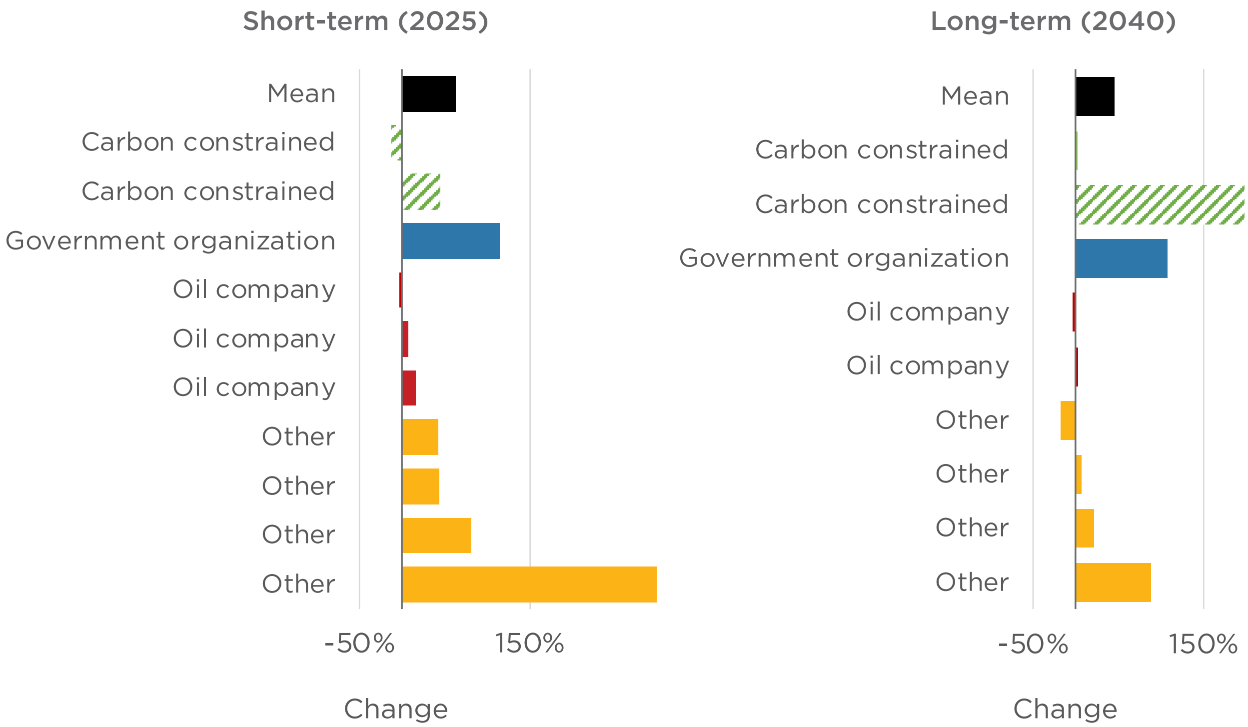
Figure 9: Forecast difference in global electric vehicle sales as a percentage of passenger vehicle sales



Source: Authors' 2021 and 2019 survey results.

There was slightly greater change in the 2021 survey versus the 2019 survey in near-term views about EV penetration than longer-term views. Comparing forecasts of the percentage of EV passenger vehicle sales for 2025 and 2040 illustrates this.

Figure 10: Difference between forecasts of EV sales as a proportion of passenger vehicle sales between the 2021 and 2019 surveys, for 2025 and 2040



Source: Authors' 2019 and 2021 survey results.

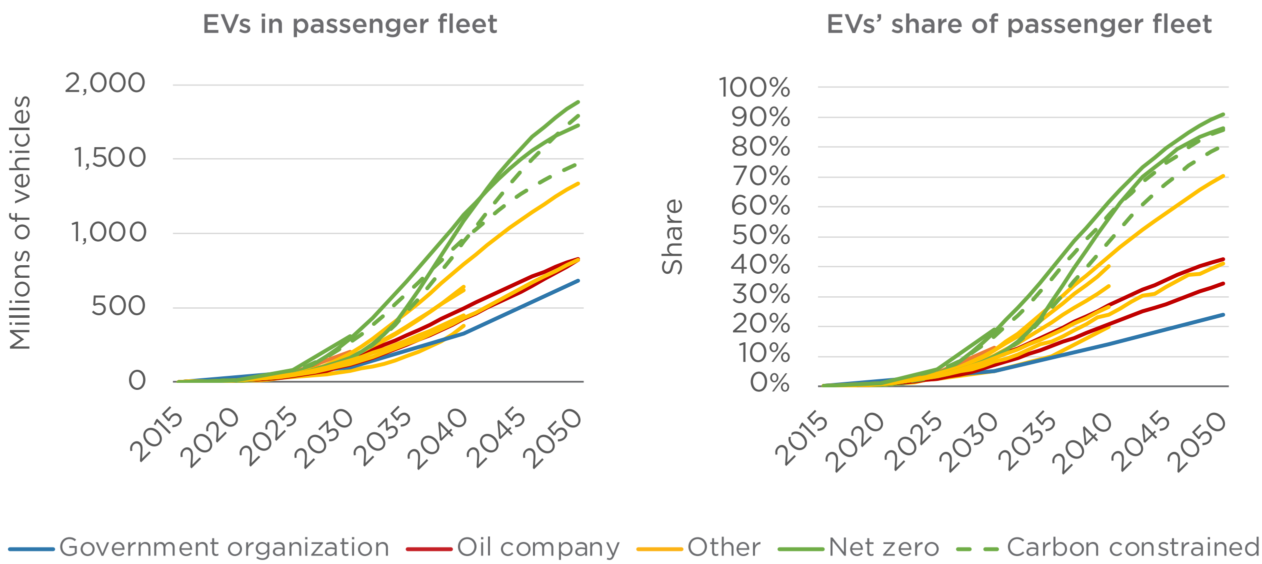
The average increase from the 2019 survey to the 2021 survey for 2025 is 63 percent. There is still a significant increase for 2040, at 45 percent, but with more respondents showing little to no change between survey years.

In light of the Russian invasion of Ukraine and higher oil prices, the authors contacted respondents in July 2022 to see whether they would change their forecasts for 2030, representing a medium-term outlook, as a result. The three participants that responded indicated little change, with one indicating a slight increase in EV market share, a second indicating no change with the potential for lowering it, and a third indicating a slight decline in EV market share. They indicated that despite the boost to EV penetration from higher oil prices, there would be little gain in EV market share due to lower economic growth, decreasing new car sales, battery supply chain issues, higher costs for EVs, and higher power prices.

EV Penetration in the Global Auto Fleet

Figure 11 shows projections for the number of EVs in the passenger fleet and the percentage of the passenger fleet made up of EVs. In 2021, there were just over 10 million EVs in the global passenger fleet.[40] The amount of EVs in the passenger fleet is a function of EV sales, which is also a function of the scrappage rate for existing conventional vehicles. Vehicle scrappage rates have been falling over time in the US (age of existing vehicles rising), and scrappage rates are particularly low during recessions.[41] If consumers keep their existing conventional vehicles for longer, it may delay the rate at which EVs can penetrate the passenger fleet. This will have adverse environmental effects, both from the delay of EV penetration, as well as the delayed use of new ICE vehicles with higher fuel efficiency.

Figure 11: Forecast global electric vehicles in passenger fleet and global EVs' share of passenger fleet

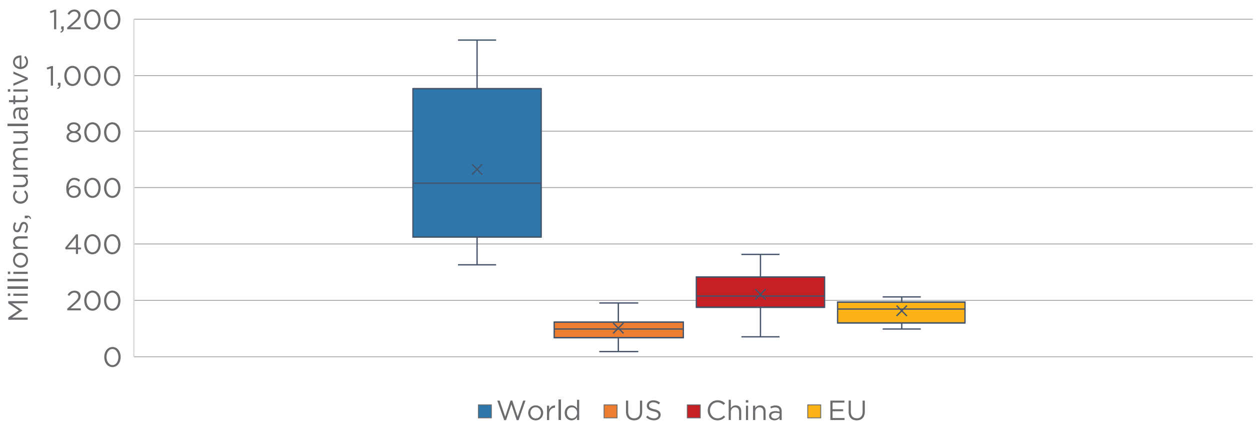


Source: Authors' 2021 survey results.

While projections regarding the overall size of the passenger fleet vary, the EV fleet projections follow a similar pattern to EV sales projections. For both the number of passenger EVs and the portion of the passenger fleet made up of EVs, NZ and carbon-constrained scenarios have the highest estimates. All NZ and carbon-constrained responses project that EVs will make up over half of the passenger vehicle fleet around 2040 and will continue to dominate the fleet moving forward. Non-carbon-constrained government organization and oil company projections tend to be lower, with projections showing EVs making up 20 to 45 percent of the passenger fleet by 2050.

Comparing regions, China is projected to contribute most to the global EV passenger fleet by 2040. Figure 12 shows the forecasted range of views for the 2040 EV fleet size, first shown globally and then broken down by region. As with the regional breakdown of EV sales, the US is perceived to face similar challenges that may hinder the EV market's growth in the coming decades, whereas China and the EU are well positioned to have strong growth.

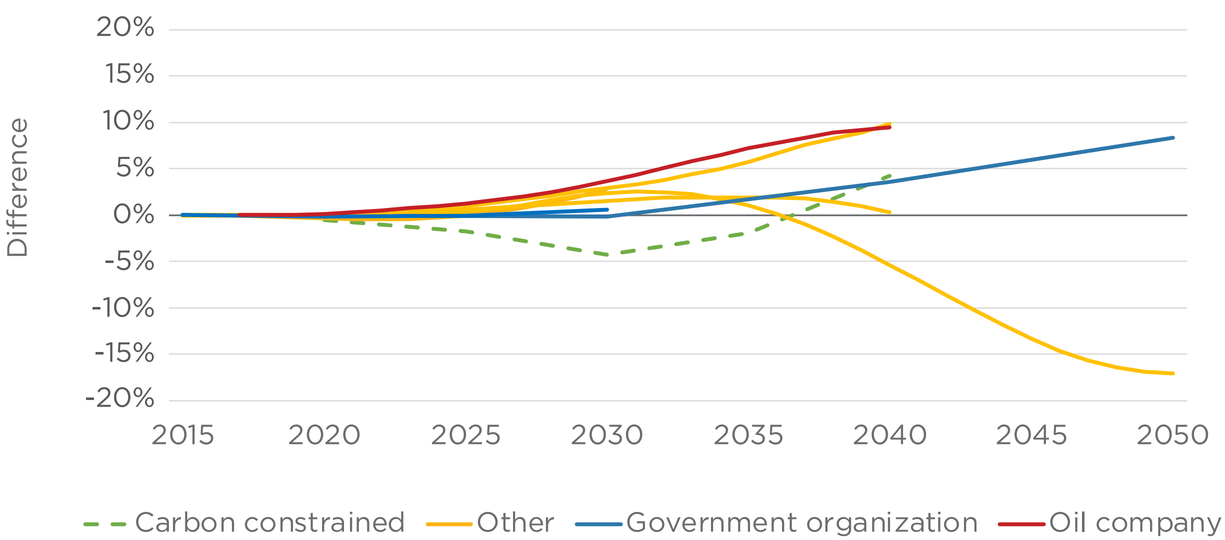
Figure 12: Forecasts of 2040 EV fleet size globally and in different regions



Source: Authors' 2021 survey results.

Figure 13 compares passenger fleet projections for EVs from the 2021 and 2019 surveys. It generally shows a modest increase in EV fleet penetration in the short term in the 2021 survey widening to a substantial increase beyond 2030. It is important to remember that given the time it takes to turn over vehicles in the fleet, there is a built-in lag between EV sales and its percentage of the fleet. The average age of the US passenger car fleet, for example, is 12.1 years.[42]

Figure 13: Forecast difference in EVs as a percentage of the global passenger vehicle fleet between the 2021 and 2019 surveys



Source: Authors' 2021 and 2019 survey results.

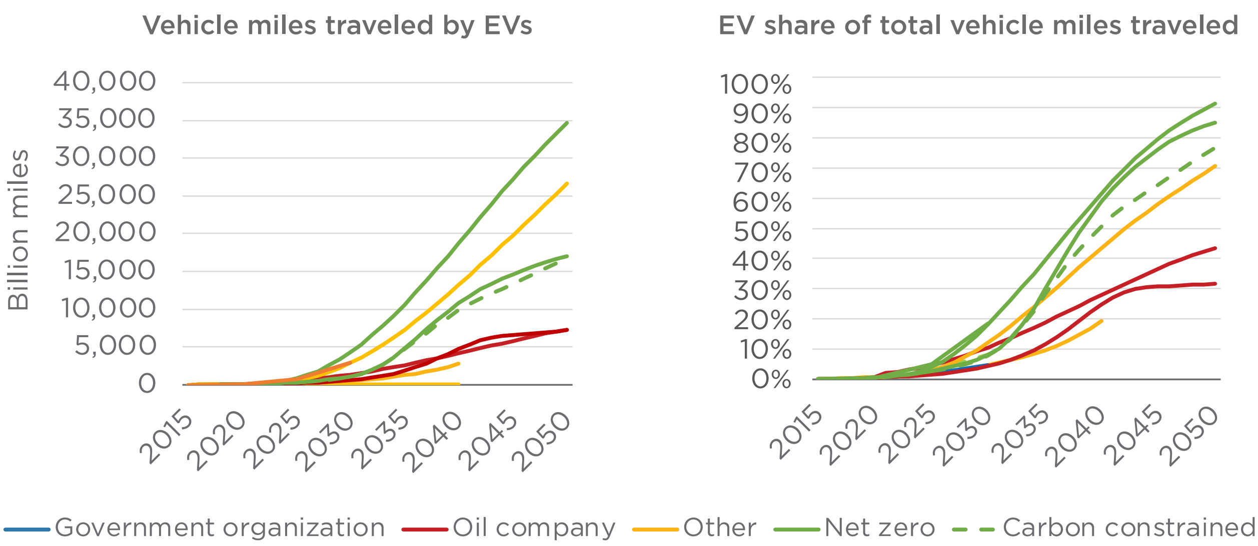
EV Share of VMT

Beyond sales and fleet size, the last major passenger vehicle demand factor the authors studied is vehicle miles traveled (VMT). VMT is projected to increase across projections in all the forecasts as the number of drivers and size of the fleet expand. Increased VMT has significant implications, as even small changes in VMT globally can add up to a significant increase in oil demand.

Figure 14 focuses on the projected VMT of EVs, as well as the share of total passenger VMT attributable to EVs. Carbon-constrained and NZ projections predict significant growth in EV VMT. These respondents project that EVs will account for an average of 12 percent of all passenger VMT by 2030; this number increases substantially to 84 percent by 2050. Oil company BAU/evolutionary trend scenarios predict the portion will be between 30-45 percent by mid-century, and “other” respondents had little consensus.

There has not been a significant change in projections around the portion of passenger VMT made up by EVs through 2030 in the 2021 versus the 2019 survey. Beyond 2030, there was less of a consensus on direction. Questions about EVs’ share of passenger car VMT may arise from the research indicating that EVs have historically traveled half the mileage of conventional cars in the US.[43] However, this result could be explained by EVs being used primarily as a second commuter car. As their performance improves, they may well become the primary car and be driven more miles.

Figure 14: Forecast Global VMT for EVs and share of total passenger VMT attributed to EVs



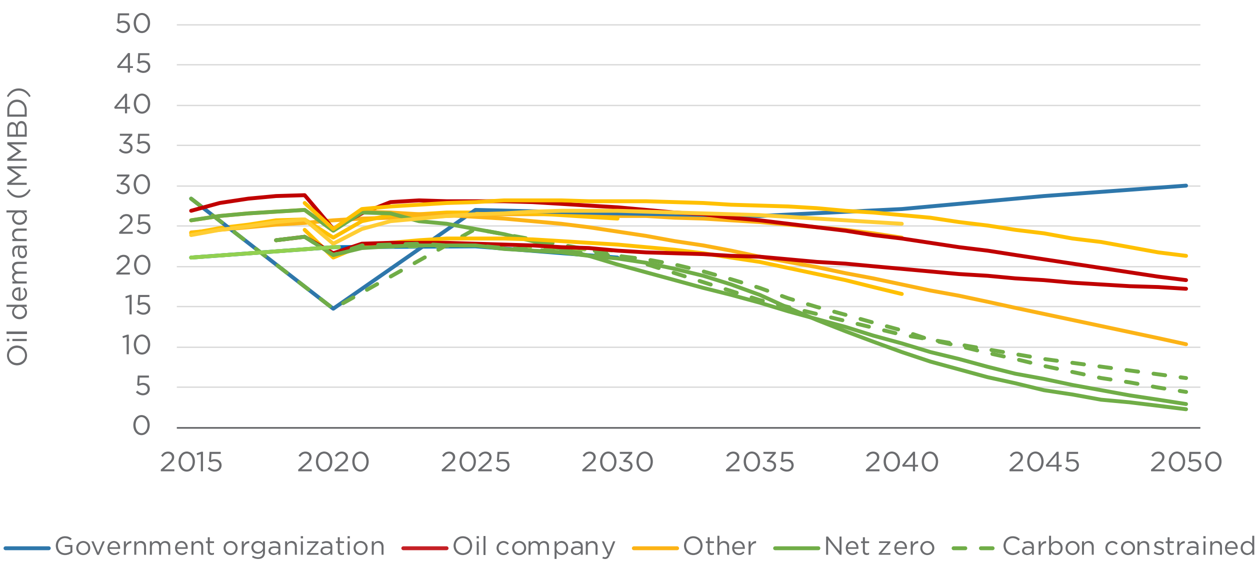
Source: Authors’ 2021 survey results.

Comparing the 2021 survey results with those from 2019 reveals that there has not been a significant change in projections around the portion of passenger VMT made up by EVs through 2030. In the years thereafter, two respondents had higher forecasts in the 2021 survey for EV's share in total passenger VMT. However, one respondent had a lower forecast in the 2021 survey.

Forecasts of Global Passenger Sector Oil Demand

EV sales, market penetration, passenger sector VMT, and the fuel efficiency of ICE vehicles all contribute to future oil demand within the passenger vehicle sector. Figure 15 shows forecasts of the estimated global oil demand within the passenger sector. Projections show a dip in oil demand in 2020 due to the COVID-19 pandemic, which reduced mobility. However, estimates show oil demand rebounding to pre-2020 levels by 2025 at the latest.

Figure 15: Forecast global oil demand within the passenger sector resulting from EV sales projections



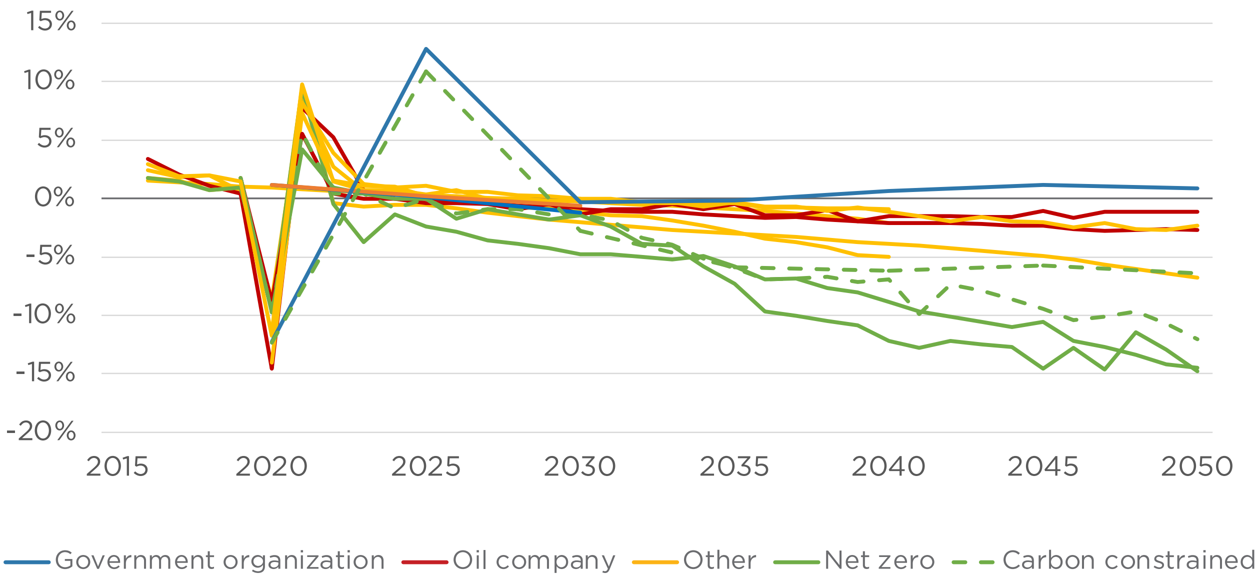
Source: Authors' 2021 survey results.

Most forecasts show passenger vehicle global oil demand peaking at or before 2030, and the ones with significant declines by 2030 were generally the NZ 2050 projections. However, there was not much consensus among NZ forecasts of how much of a decline there will be in passenger vehicle oil demand between 2020 and 2030, with one NZ forecast projecting it will fall by 400 thousand barrels per day between 2020 and 2030, and another NZ forecast projecting a 4 million barrels per day decrease. Global passenger vehicle oil demand was about 25 million barrels per day in 2020.[44] Beyond 2030, all of the NZ forecasts in the survey show steep declines.

Most estimates beyond 2030 predict that passenger vehicle oil demand will decrease by 2050. In the carbon-constrained forecasts, it falls from about 25 million barrels per day in 2020 to 3–6 million barrels per day by 2050. Most other forecasts ranged between 10 and 20 million barrels per day by 2050. One outlier projection that oil demand would increase by 11 percent between 2025 and 2050 also had a high economic growth and VMT forecast.

The sharp decline in the carbon-constrained and NZ estimates through 2050 is illustrated in Figure 16, which displays the annualized rate of change of projected oil demand. Each estimate shows a sharp decline in 2020, with the exception of survey respondents that did not provide yearly demand estimates between 2015–2020. Respondents also predicted a sharp increase in demand following the start of the pandemic, with most projections showing that demand will level out or begin to decrease after 2025.

Figure 16: Forecast annualized rate of change of global oil demand projections for passenger vehicles



Source: Authors' 2021 survey results.

This graph confirms that while NZ and carbon-constrained scenarios include a significant forecasted decrease in oil demand within the passenger sector, oil companies' BAU/evolutionary trend scenarios, government organizations, and "other" respondents were more inclined to predict a more modest decline in oil demand, or flat demand, in the coming decades.

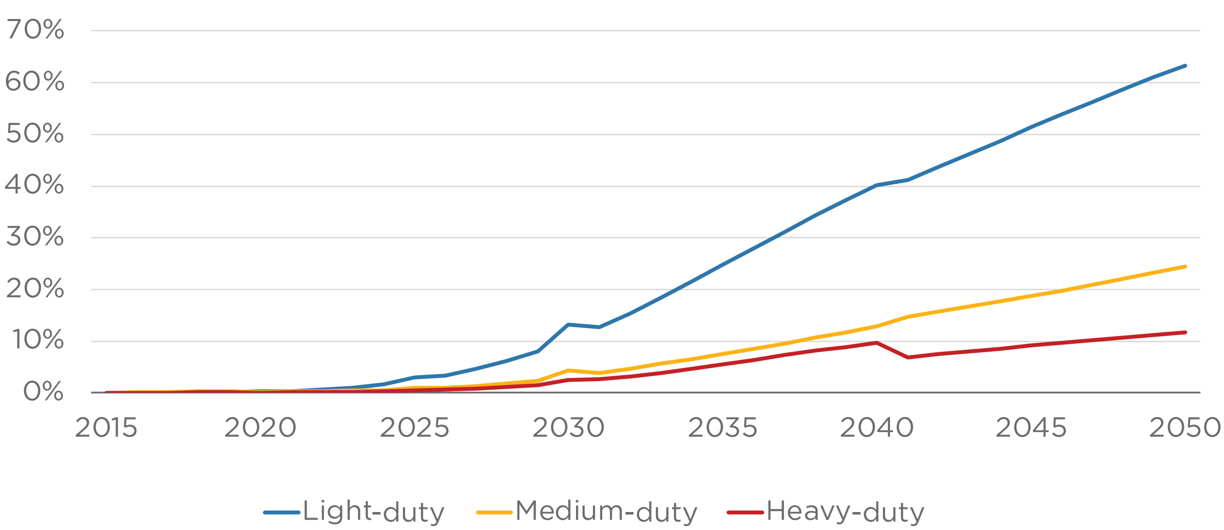
EV Penetration in Commercial Trucks

Road freight vehicles, or commercial trucks, deliver freight from points of production to intermediate and final destinations. Road freight vehicles are a central source of global oil demand, consuming around 15 million barrels per day in 2019.[45]

A key factor in forecasting road transport oil demand is the rate of electric truck penetration for light-duty, medium-duty, and heavy-duty trucks. It is important to note that about 70 percent of freight activity is accomplished by heavy-duty trucks. While they are the most efficient for hauling cargo, their large annual mileage means that they currently consume half the oil in the road freight sector.[46]

EVs are not expected to penetrate at the same rate across weight classes. Figure 17 shows the average of forecasts for electric truck makeup in the total truck fleet broken up into the three weight classes. Overall, the projections for electric truck penetration in the total truck fleet show an upward trend, but the rate of electric truck penetration is projected to differ across the three weight classes; forecasts of percentage of truck fleet made up of electric trucks decrease as truck weight increases. Survey respondents predicted that the light-duty truck fleet would be about 60–70 percent electric by 2050, whereas it was closer to 10 percent in the heavy-duty fleet. Challenges surrounding electrification of heavy-duty trucks include federal and state weight limits for trucks, which have been put in place to reduce wear and tear on roads and for safety purposes.[47] Given the additional weight of batteries for larger electric trucks that travel long distances, weight limits could reduce the carrying capacity of the truck, which greatly hurts its economics. The batteries and other parts needed for heavy-duty electrical truck models can weigh up to 5,300 pounds more than their diesel counterparts.[48]

Figure 17: Forecast average percentage of global truck fleet made up of electric trucks, separated into three weight classes: light-duty, medium-duty, and heavy-duty



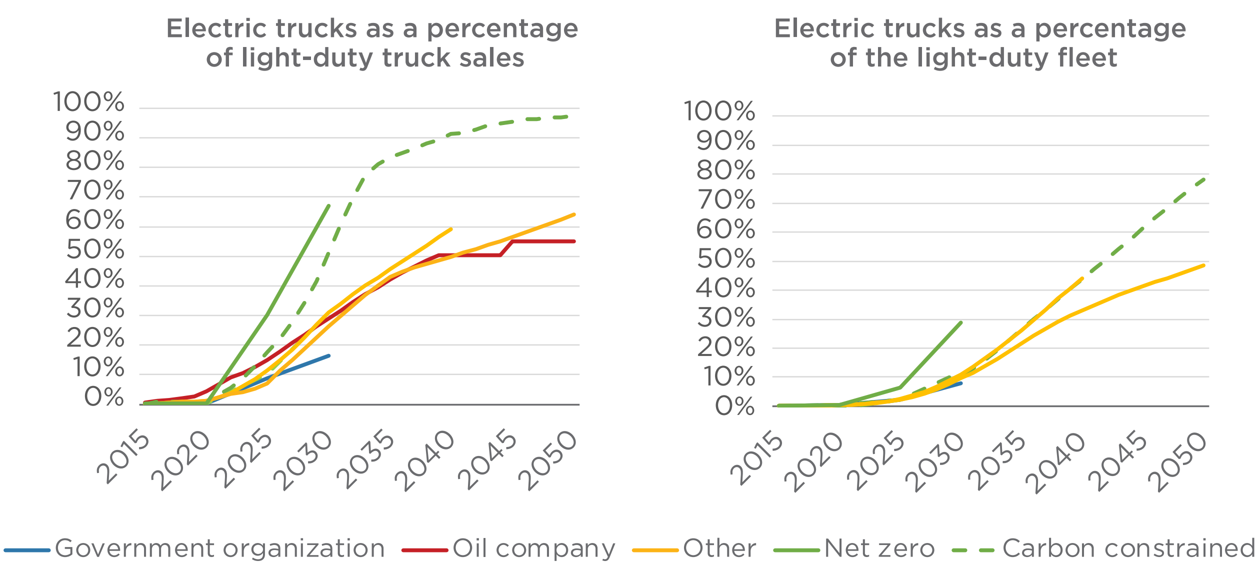
Source: Authors' 2021 survey results.

Light-Duty Trucks

Light-duty trucks are characterized as pick-up vehicles, vans and small trucks that weigh less than 3.5 tons.[49] Out of all the different sized trucks, light-duty electric trucks have the highest outlook for EV penetration. As shown in Figure 18, 2030 forecasts for the percentage of light-duty electric truck sales show a range between 16 and 67 percent; the lower estimate is from a government forecast, and the higher estimate is from a NZ forecast. By 2050, light-duty EV commercial trucks as part of light-duty truck sales are projected to be between 55 percent, from an oil company forecast, and 98 percent from a carbon-constrained forecast. It is interesting to note the expectation that light-duty commercial trucks will have more rapid EV penetration than passenger vehicles. For example, in 2030 the range of global EV sales penetration among passenger vehicles was from 11 to 63 percent, while the range of EV light-duty truck sales penetration was from 16 to 67 percent. Commercial vehicles are usually driven more miles than passenger vehicles, and EVs may be viewed as advantageous given their lower fuel (e.g., electricity versus gasoline or diesel) and maintenance costs.

Figure 18 also shows that the forecast range of EVs in the light-duty commercial truck fleet by 2050 is between 48 percent, a forecast from an entity from the "other" category, and 78 percent, from a carbon-constrained forecast.

Figure 18: Forecast electric trucks as a percentage of global light-duty commercial truck sales and as a percentage of the global light-duty commercial truck fleet



Source: Authors' 2021 survey results.

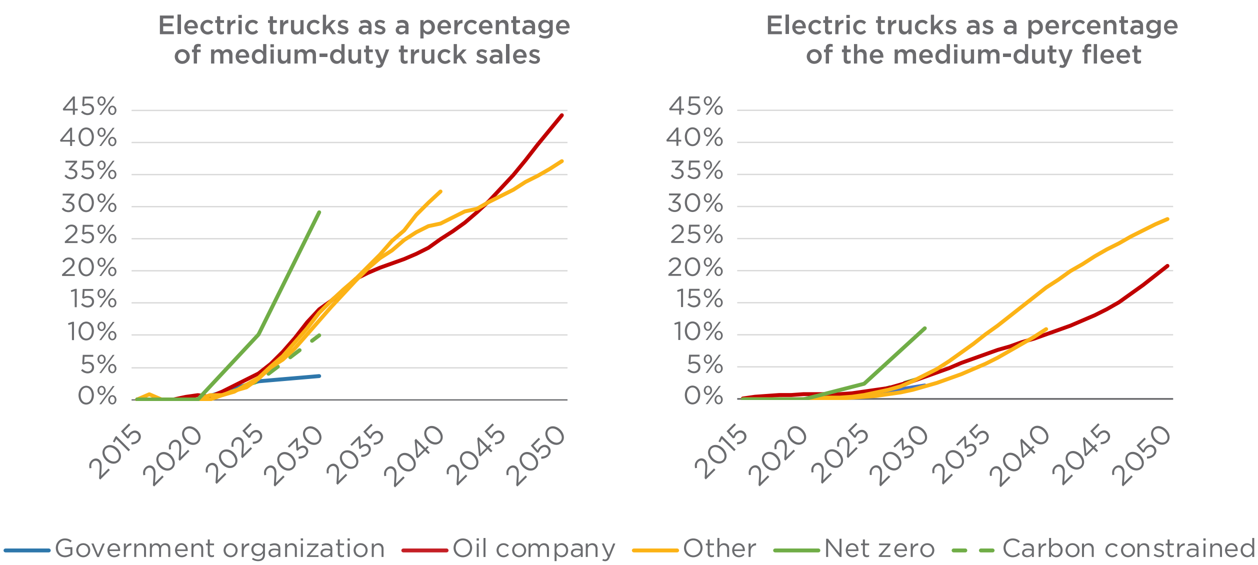
The NZ forecast has the fastest rate of EV increase in both the percentage of light-duty truck sales and percentage of light-duty truck fleet: it anticipates that by 2030, 67 percent of light-duty truck sales will be electric, and 29 percent of the total light-duty fleet will be electric.

By 2050, the carbon-constrained forecast projects that 98 percent of light-duty vehicle sales will be electric, and 78 percent of the light-duty truck fleet will be electric.

Medium-Duty Trucks

Medium-duty trucks are characterized as commercial vehicles that weigh between 3.5 and 15 tons.[50] Forecasts for the percentage of medium-duty electric truck sales for 2030 range between 4 and 29 percent as shown in Figure 19. The lowest represents a government forecast and the highest is a NZ forecast. By 2050, medium-duty electric truck sales are forecast to rise to between 37 and 44 percent of total medium-duty commercial truck sales. The figure also shows the market share of medium-duty electric trucks in the medium-duty truck fleet. In 2050, electric trucks are projected to comprise between 21 and 28 percent of the medium-duty fleet. Both values are lower than the projections for light-duty trucks. This is likely due to the lag in technological development with truck batteries for larger trucks and weight limits on roads.

Figure 19: Forecast electric trucks as a percentage of global medium-duty commercial truck sales and as a percentage of the global medium-duty commercial truck fleet



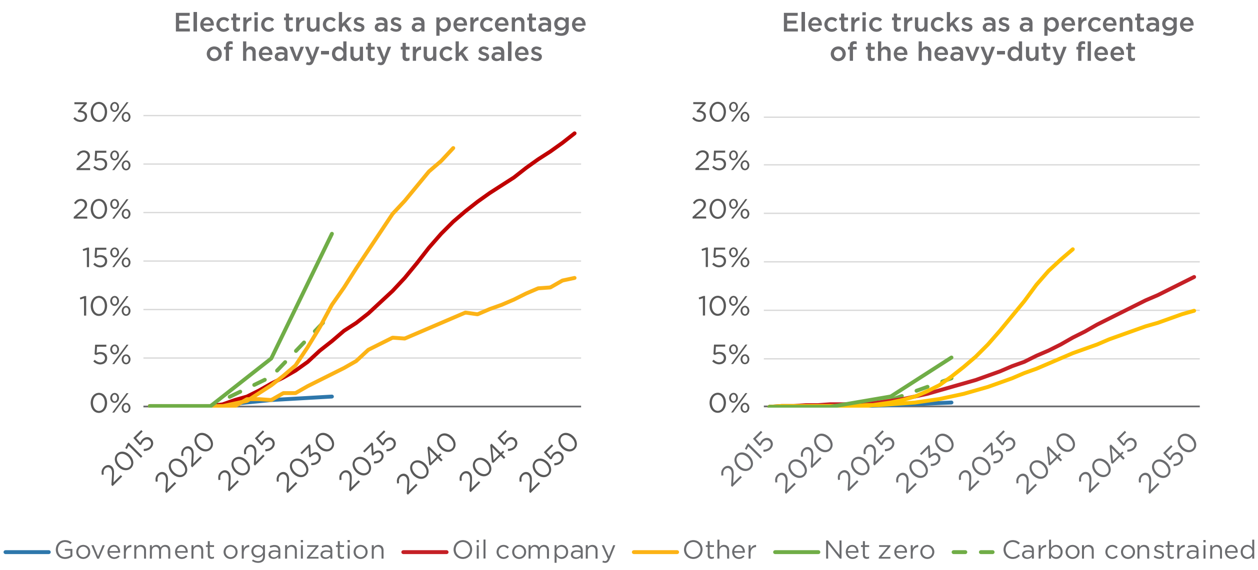
Source: Authors' 2021 survey results.

Heavy-Duty Trucks

Heavy-duty trucks are defined as rigid body and articulated trucks with a gross weight of more than 15 tons.[51] Figure 20 shows forecasts for the percentage of heavy-duty trucks sold that are electric and the percentage of electric trucks in the global heavy-duty truck fleet. By 2030, forecasts for the percentage of electric heavy-duty truck sales ranged between 1 and 18 percent, the former from a government forecast and the latter from a NZ forecast. For heavy-duty electric truck sales by 2050, only two forecasts were provided, and they range between 13 percent, from an entity listed as "other," and 28 percent from an oil company's forecast. These percentages are significantly lower than those for the light-duty fleets. For example, in 2030, the range of EV sales penetration in the light-duty fleet was 16 to 67 percent versus the 1 to 18 percent range for heavy-duty trucks.

By 2050, heavy-duty electric trucks are expected to make up between 10 and 13 percent of the fleet. Similar to the explanation for medium-duty trucks, heavy-duty trucks have more considerations in regard to battery weight and compliance with weight limits on roads. They also face greater resistance to scale because of their larger size, power requirements to move higher weights, and generally longer distances traveled.

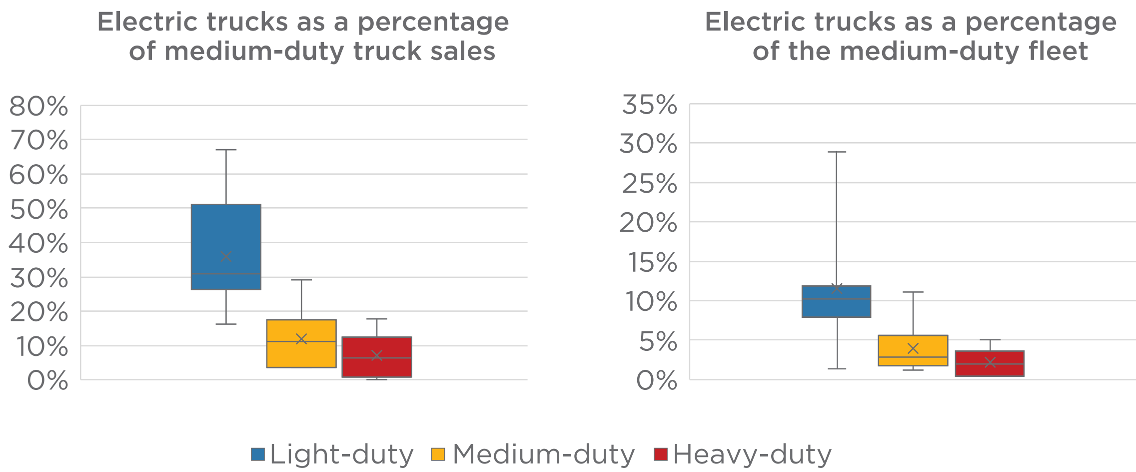
Figure 20: Forecast electric trucks as a percentage of global heavy-duty commercial truck sales and as a percentage of the global heavy-duty commercial truck fleet



Source: Authors' 2021 survey.

Given the challenges, options other than battery electrification are being considered for heavy-duty trucks including road embedded or overhead power lines on major highways, liquefied natural gas, biofuels, and fuel cells. Overall, Figure 21 shows that the lighter the truck, the greater the expectation for electrification. The range of the bar represents the range of the forecasts for each weight class.

Figure 21: Range of forecasts for 2030 percentage of global truck sales made up by EVs, and 2030 projections for percentage of global truck fleet made up by EVs



Source: Authors' 2021 survey results.

CONCLUSION

The purpose of this analysis was to compare long-term EV penetration forecasts and to determine how sentiment regarding EV market penetration has changed since 2019. While forecasters most often cited government policies such as increased fleet efficiency and decarbonization schemes as drivers for increasing EV penetration, other explanations could be the maturing of the technology and automotive industry investments.

In general, respondents anticipate an acceleration of the rate of EV penetration. In comparing the 2021 survey results with 2019's survey, projections around the percentage of passenger vehicle sales as well as the passenger vehicle fleet that will be made up of EVs have increased.

A significant portion of the growth in EV penetration is expected to come from China, which is projected to have the highest EV sales as compared to the EU and the US (see Figure 12). The US is projected to have slower EV penetration than China and the EU. The US has barriers to EV uptake such as preferences for SUVs that until recently have not been available in EV powertrains and the population living in less densely populated locations with much higher range needs than in other nations. Improvements in battery technology will reduce these barriers. Greater policy incentives, such as funding for EV charging infrastructure in the Infrastructure Investment and Jobs Act and the tax credits to EV buyers in the Inflation Reduction Act, may also help.

Some survey participants offered varied projections depending on whether a scenario included changing policies, such as NZ and carbon constraints, or BAU. NZ and carbon-constrained forecasts showed significantly higher levels of EV penetration than the non-carbon-constrained projections. Major changes in government policy and/or technology would be needed to move to the NZ 2050 pathway.

The 2021 survey also asked for projections of electric sales and fleet growth for commercial trucks. While electric light-duty truck sales are expected to increase substantially in the coming decades, less electric penetration is expected for medium- and heavy-duty trucks, likely as a result of the larger battery size and the accompanying cost and weight.

Differing views about rates of EV penetration in the survey reflect different views about the degree of government incentives and mandates for adopting and charging EVs, both of which are related to government decarbonization policies. Another critical factor is the speed at which battery technology can fall in cost and increase in performance. Battery cost is adversely impacted by the rising costs of battery metals accompanying the ramp up of EV production, and has been exacerbated by the Russian war in Ukraine—Russia being a large supplier of nickel to the world. Another uncertainty is consumer acceptance of EVs, which would be enhanced by oil supply uncertainty and higher gasoline prices, lower EV battery prices, improved range, reduced charging time, and more certainty in consumer perceptions around the life of the battery.

Global EV penetration levels have important implications for global oil demand growth. Due to varying EV penetration forecasts, there is a wide range of views of passenger sector oil demand growth by 2030. Some forecasts have as much as 4 to 7 million barrels per day of growth between 2020 and 2030, whereas those on the NZ 2050 trajectory show significant declines. These oil demand forecasts in the 2021 survey include differences in efficiency and alternative fuel penetration as well as electrification. The 2019 survey isolated how much oil demand was lost to EV penetration alone. In 2040 (in the 2019 survey), the displaced oil demand forecasts were about 5 million barrels per day, with 18 million barrels per day in lower-carbon forecasts.[52] With the higher EV penetration rates in the 2021 survey, the displaced oil demand from electrification alone would be higher.

Areas for Further Research

Limitations of this study with regard to understanding EV penetration forecasts relate to the authors' inability to isolate the impacts of several factors they were unable to gather data on and were difficult to quantify. It would be useful in future surveys to ask for greater detail from forecasters on the specific drivers behind their EV penetration forecasts that are difficult to quantify, such as specific climate policies and consumer preferences. It would also be useful to understand the oil price forecasts behind each of the predictions.

Another limitation of the 2021 study is its inability to isolate the impact of electrification on global oil demand versus other potential drivers such as efficiency improvement of conventional vehicles. For any future survey of EV penetration forecasts, it would be useful to isolate the extent to which EV penetration alone is lowering oil demand growth in the passenger vehicle and truck sectors. It would also be useful to quantify how much of lower oil demand growth is due to other drivers such as efficiency improvement in conventional vehicles, VMT loss associated with greater working from home, and oil prices.

The authors also didn't look at the feedback loops of lower oil demand causing lower oil prices and what impact that might have on global oil demand and supply. It would be useful to utilize a global energy model to study the oil market impacts of various EV penetration rates.

NOTES

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