The large size of the US auto market and high GDP per capita, as well as easy access to financing options, make it a leading candidate for electric vehicle uptake. However, the lack of a strong regulatory foundation represents a substantial barrier, as does the relatively low cost of gasoline and diesel.

Depending on the region, S&P Global Platts Analytics forecasts plug-in electric vehicles to reach total cost of ownership parity with internal combustion engine vehicles over the next 10 years. Market fundamentals will begin to drive PEV sales to a greater degree as consumers become aware of the savings associated with reduced operational costs.

As PEV adoption gradually moves away from early adopters, the development of a robust and ubiquitous charging infrastructure will become even more important than it is now.

PEVs will raise power demand, but the effect on the grid will depend on the speed, time and location of the charging. In this article, we will take a look at the impact on the grid of rapid PEV adoption, focusing on passenger vehicles and taking the US state of Virginia as a case study. The electrification of commercial and other heavy duty vehicles would pose different challenges to the grid due to different utilization patterns and charging requirements.

State regulations a key driver

The operational costs of PEVs are considerably lower than those of ICEs. Despite this, the high purchase premium of a PEV compared with an ICE, driven primarily by battery costs, now makes PEV ownership less economically attractive for many consumers. Furthermore, low PEV ownership also presents challenges for profitable investment in charging infrastructure.

As a result, PEV market growth will initially rely heavily on government subsidies and incentives. The US lacks a long-term, federal PEV adoption strategy, which is likely to stymie PEV market growth relative to other PEV-focused markets such as the EU and China.

However, local air quality concerns, environmental targets, and the desire to support a nascent industry have proved powerful arguments to justify government support. States, power providers, transportation authorities, and local governments have made substantial ground in filling this void by instituting their own PEV sales targets and incentive packages.

In the short-to-medium term, different states' regulation, support schemes, vehicle fees and infrastructure will lead to variation in the pace of PEV adoption. The US coasts are likely to have the fastest adoption during that period, but PEV adoption will also grow in other regions. Longer-term, market fundamentals including the total cost of ownership will be the primary driver of adoption as the cost of PEVs comes down.

Platts Analytics forecasts PEVs will account for about 14% of total passenger vehicle sales in Virginia in 2030, up from less than 2% in 2019, according to our latest EV Essentials report. However, the vehicle stock turnover is relatively slow as vehicles' lifetimes average 11-12 years in the US. This means PEVs will account for about 3.5% of Virginia's vehicle stock by 2030.

More charging options needed

The availability of various options and ubiquitous charging infrastructure is seen by many as a prerequisite to the rapid adoption of PEVs. Charging technologies have evolved in the last decade as more PEV models entered the market. PEV charging network operators have both increased the number and the speed/rating of DC fast chargers, as

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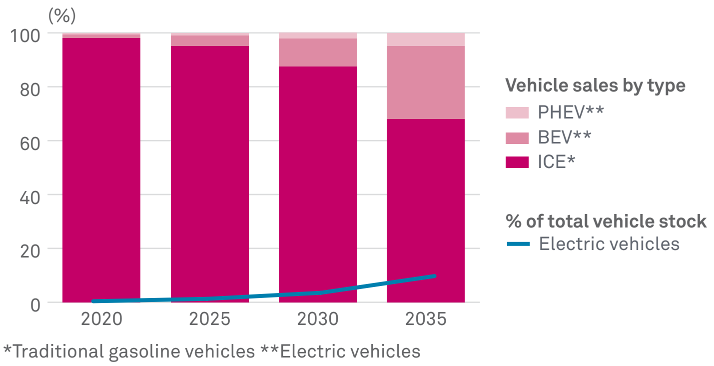
Forecast vehicle sales in Virginia, US



*Traditional gasoline vehicles **Electric vehicles
Source: S&P Global Platts Analytics

vehicles have become capable of sustaining a higher speed of charging.

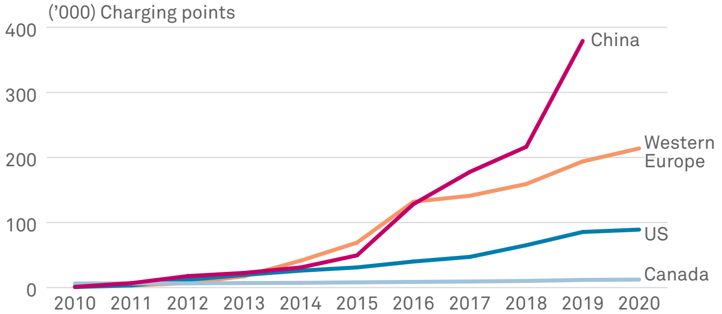
In 2019, the US had around 85,000 charging points according to the latest data from Platts Analytics EV Essentials. China and the EU-28 region have more charging points with 379,000 and 193,000 installed, respectively.

PEV owners charge either at home or public infrastructure, which could include public curb-side charging, workplace charging, or PEV operator-owned networks. These options differ in terms of availability, convenience (speed, proximity to home or work) and cost.

On average, US commuters drive 40 miles a day to go to work according to the National Household Travel Survey. Home night charging with a level 1 (standard) outlet or level 2 outlet would generally sufficiently recharge a vehicle for the next day. Home charging is more likely in areas with single-family homes.

Public charging infrastructure can provide additional flexibility and options to PEV owners, and be critical for adoption in densely populated areas with limited access to curb-side charging, or without home charging possibilities. The share of charging happening at home versus public facilities would likely vary by region, depending on the available charging infrastructure,

China leads in number of public charge points



Source: S&P Global Platts Analytics, US Alternative Fuel Data Center, European Alternative Fuels Observatory, China EV Charging Infrastructure Promotion Alliance charging cost and consumer behavior, and will evolve as EVs penetrate more markets and household income levels.

Level 3 DC fast chargers are available in different ratings or speed of charging. In the US, the Electrify America network ranges from 50 kW to 350 kW, and the EVgo network mostly has 50 kW chargers. The higher the power rating, the higher the charging speed, though the speed is also affected by the vehicle's maximum ability. At 150 kW, a vehicle would add 45 miles of range in five minutes, or 270 miles in half an hour.

While fast charging has the potential to facilitate PEV adoption, it could also have a major impact on the grid both in terms of local grid reinforcement costs and the need for peaking power. Distributed generation could help limit the impact of charging on the local grid.

However, one vehicle charging at 50 kW would add an incremental demand equivalent to more than eight individual residential solar PV installations, as the US average size is 6 kW. Standalone batteries, as discussed in previous European Power Storage Outlook reports, will increasingly be used in charging stations to limit the impact on the grid.

An asset to the grid, or a burden?

A growing share of passenger vehicles moving toward electricity would be an upside for power demand after years of declining growth in many regions. Platts Analytics forecasts light-duty PEVs alone to add over 40 TWh of load to the US demand by 2030, which could represent either a burden for grids to mitigate, or a resource for the integration of renewable power.

The scale of the impact on the grid will depend mostly on the time and speed of charging, which in turn are affected by the charging infrastructure, the retail tariff structure, and consumer preferences. Impacts will vary at the system and regional/local levels.

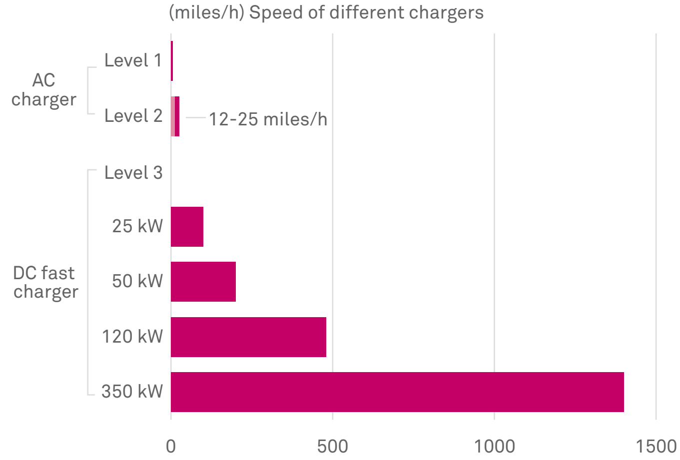
We will outline four PEV charging scenarios with incremental level of sophistication to frame the impact of PEV charging on the power system. The state of Virginia is used as a case study, as it features average EV adoption.

1.Non-managed home charging

All passenger PEVs would charge at home, starting at the evening peak demand time. Virginia in this scenario could add an extra 2 GW to peaking power needs by 2030. At a high level of PEV adoption, non-managed charging could add a significant amount of load to peak demand. This would affect the grid infrastructure and power capacity investment needs, and the incremental PEV load would likely be served by highly emitting sources, such as natural gas peakers or dual-fuel peakers.

This scenario is unlikely in places with high PEV adoption due to a combination of regulatory and technological factors. The pressure on retail rates from additional grid investment would likely lead utility regulators to implement tariff changes that would incentivize different charging behavior. This may include time-of-use tariffs, with higher rates at peak time and/or the addition of demand charges to residential retail rates similar to what Commercial and Industrial (C&I) customers are paying.

How far on an hour's charge?



Source: S&P Global Platts Analytics

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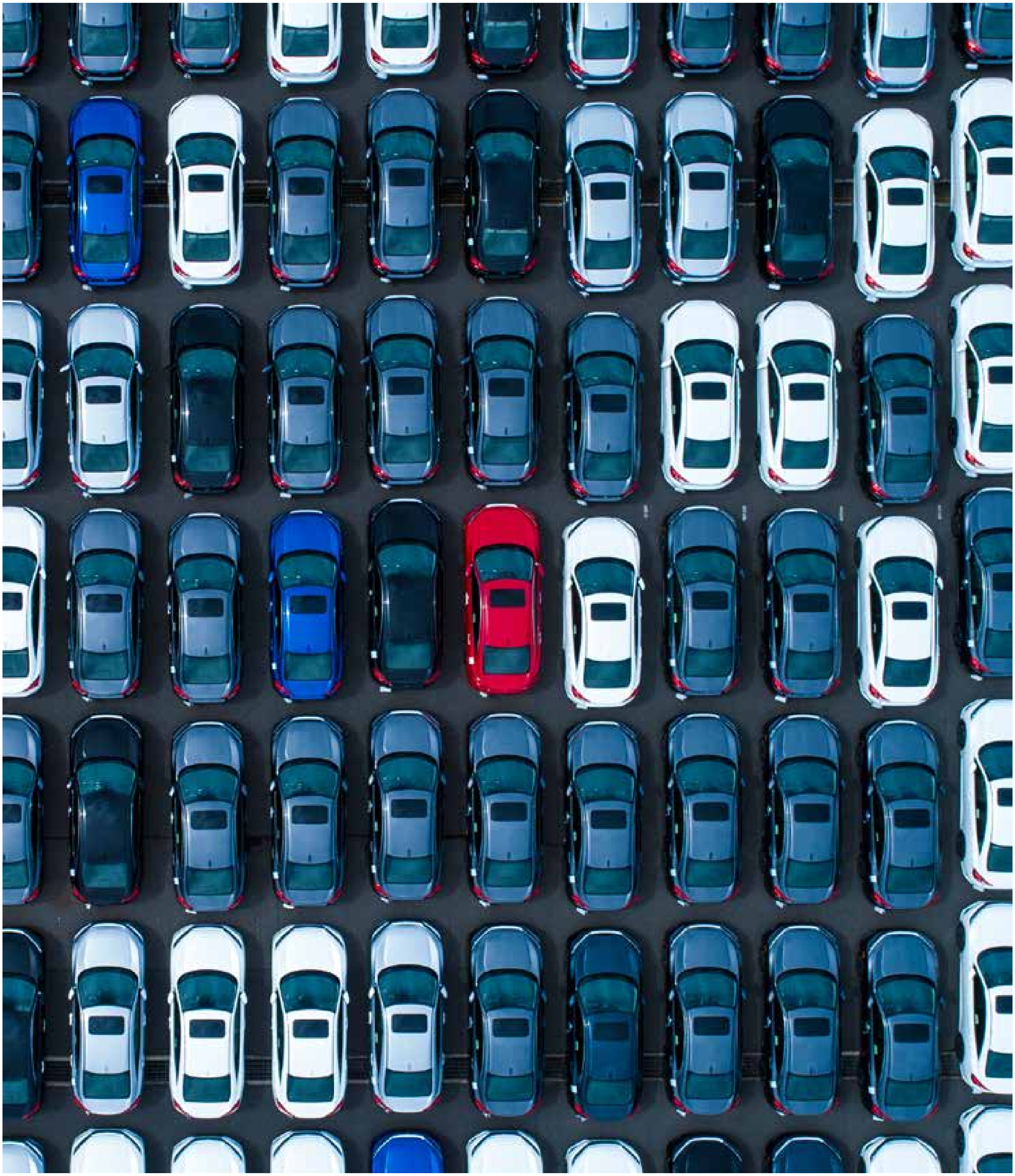


Ultimately, regulators have to balance the scale and distribution across households of the incremental infrastructure cost with the need to support broader PEV adoption.

2.Smart charging

Most of the charging would still be done at home, but with a charging profile minimizing the impact on the grid. As most personal vehicles remain parked at night for eight to 10 hours, charging could be spread through the night and still provide a sufficient range for the next day's commute.

The likelihood of this scenario will depend on regulatory and technological developments as customers would need to be incentivized to change their behavior. Sufficiently differentiated time-of-use rates, and/or demand response opportunity (e.g. with managed charging or V1G, through a third-party provider) could provide the economic signals to charge at night. Technology could facilitate this change, for instance with the option to let the vehicle charge intelligently without the need of human interactions (e.g. "set and forget"). In California, eMotorsWerk – acquired by EnelX – provided the California Independent System Operator with 30 MW of demand response from the

Platts Analytics forecasts light-duty PEVs alone to add over 40 TWh of load to US demand by 2030 aggregation of 6,000 individual charging points. The company pays the customer for the ability to modify their EV charging profile to reduce load at the time of peak demand without having a major impact on the PEV owner. Many regions are looking into these types of solutions, for instance in the US with Xcel Energy and in Europe with Jedlix or in Asia.

3.Workplace charging

Adding workplace charging to the previous scenario would enable greater integration of renewable generation, particularly in regions with high solar PV resources. In a scenario with very high solar PV generation, a large PEV fleet would limit the need to curtail solar PV generation, overbuild storage capacity or additional technologies.

In the example of Virginia depicted to the right, our model optimized the PEV charging profile to benefit from low marginal cost renewable generation during the day, while ensuring that vehicles have a sufficient range for daily commuting. This charging behavior decreases the system cost and transportation emissions by increasing the share of renewable used for PEV charging.

The number of workplace chargers will reflect employer choices and regulatory requirements. Workplace chargers may include a mix of level 2 and level 3 DC fast chargers.

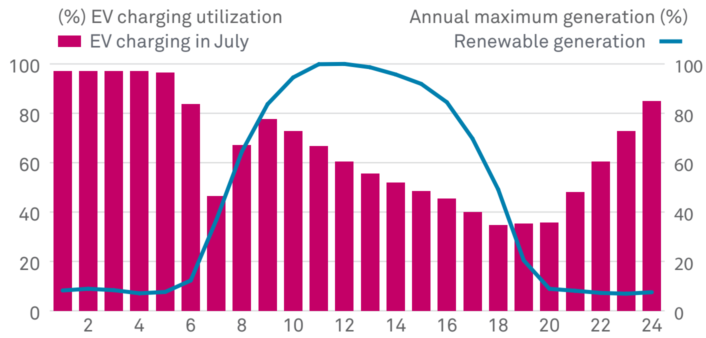
4.Fully optimized

In this scenario, PEV could provide additional services to the grid (vehicle-to-grid or V2G). In essence, a PEV can be seen as a large movable battery system. Taking again the example of Virginia, the equivalent battery size of the entire BEV fleet may already reach 11 GWh by 2030, a level of storage capacity much higher than our 2030 forecast for standalone storage in that state.

Assuming these vehicles charge during the day and are connected to the grid during the peak time, they may provide peaking capacity. They could also help to balance the grid with the increasing renewable generation. Many regions are conducting V2G pilots, for instance for the provision of ancillary services, such as frequency regulation or spinning reserve, with vehicles.

Ultimately, the extent to which vehicles will be able to support the grid and broader renewable generation will depend on regulatory and technological developments because the benefits will have to balance the potential costs. Greater grid integration of EVs may either infringe on some customer convenience or increase the EV operating cost, both of which could work to slow EV uptake. ■

EV charging pattern vs renewable power supply, month of July, Virginia



Source: S&P Global Platts Analytics

Go deeper

S&P Global Platts Analytics forecasts country-level outlooks of passenger and commercial EV adoption and energy impacts, for the US broken down to the state, ISO and PADD level. Explore coverage of alternative transport and electric vehicles, part of Platts Analytics Scenario Planning Service: **spglobal.com/scenario**