

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com/ Impact Factor: 7.249/

Vol. 8, Issue 12, December 2019

The Role of Electric Vehicles in Controlling Air Pollution

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ABSTRACT: An electric vehicle (EV)^[note 1] is a vehicle that uses one or more electric motors for propulsion. It can be powered by a collector system, with electricity from extravehicular sources, or it can be powered autonomously by a battery (sometimes charged by solar panels, or by converting fuel to electricity using fuel cells or a generator).^[1] EVs include, but are not limited to, road and rail vehicles, surface and underwater vessels, electric aircraft, and electric spacecraft. For road vehicles, together with other emerging automotive technologies such as autonomous driving, connected vehicles, and shared mobility, EVs form a future mobility vision called Connected, Autonomous, Shared, and Electric (CASE) Mobility.^[2]

EVs first came into existence in the late 19th century, when electricity was among the preferred methods for motor vehicle propulsion, providing a level of comfort and ease of operation that could not be achieved by the gasoline cars of the time. Internal combustion engines were the dominant propulsion method for cars and trucks for about 100 years, but electric power remained commonplace in other vehicle types, such as trains and smaller vehicles of all types.

Government incentives to increase adoption were first introduced in the late 2000s, including in the United States and the European Union, leading to a growing market for vehicles in the 2010s.^{[3][4]} Increasing public interest and awareness and structural incentives, such as those being built into the green recovery from the COVID-19 pandemic, are expected to greatly increase the electric vehicle market. During the COVID-19 pandemic, lockdowns reduced the number of greenhouse gases in gasoline or diesel vehicles.^[5] The International Energy Agency said that governments should do more to meet climate goals, including policies for heavy electric vehicles.^{[6][7]} Electric vehicle sales may increase from 2% of the global share in 2016 to 30% by future.^{[8][9][10]} As of July 2015 the global EV market size was \$280 billion and was expected to grow to \$1 trillion by future.^[11] Much of this growth is expected in markets like North America, Europe, and China;^[9] a 2017 literature review suggested that growth in the use of electric 4-wheeled vehicles appears economically unlikely in developing economies, but that electric 2-wheeler growth is likely.^[12] There are more 2 and 3 wheel EVs than any other type.^[13]

KEYWORDS: electric vehicles, combustion engines, control air pollution, green recovery, COVID-19, future

I.INTRODUCTION

Electric motive power started in 1827, when Hungarian priest Ányos Jedlik built the first crude but viable electric motor, which used a stator, rotor, and commutator; and the next year he used it to power a small car.^[14] In 1835, professor Sibrandus Stratingh of the University of Groningen, in the Netherlands, built a small-scale electric car, and sometime between 1832 and 1839, Robert Anderson of Scotland invented the first crude electric carriage, powered by non-rechargeable primary cells.^[15] American blacksmith and inventor Thomas Davenport built a toy electric locomotive, powered by a primitive electric motor, in 1835. In 1838, a Scotsman named Robert Davidson built an electric locomotive that attained a speed of four miles per hour (6 km/h). In England a patent was granted in 1840 for the use of rails as conductors of electric current, and similar American patents were issued to Lilley and Colten in 1847.^[16]

The first mass-produced electric vehicles appeared in America in the early 1900s. In 1902, the Studebaker Automobile Company entered the automotive business with electric vehicles, though it also entered the gasoline vehicles market in

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1904. However, with the advent of cheap assembly line cars by Ford Motor Company, the popularity of electric cars declined significantly.^[17]

Due to lack of electricity grids^[18] and the limitations of storage batteries at that time, electric cars did not gain much popularity; however, electric trains gained immense popularity due to their economies and achievable speeds. By the 20th century, electric rail transport became commonplace due to advances in the development of electric locomotives. Over time their general-purpose commercial use reduced to specialist roles as platform trucks, forklift trucks, ambulances,^[19] tow tractors, and urban delivery vehicles, such as the iconic British milk float. For most of the 20th century, the UK was the world's largest user of electric road vehicles.^[20]

Electrified trains were used for coal transport, as the motors did not use the valuable oxygen in the mines. Switzerland's lack of natural fossil resources forced the rapid electrification of their rail network. One of the earliest rechargeable batteries – the nickel-iron battery – was favored by Edison for use in electric cars.

EVs were among the earliest automobiles, and before the preeminence of light, powerful internal combustion engines (ICEs), electric automobiles held many vehicle land speed and distance records in the early 1900s. They were produced by Baker Electric, Columbia Electric, Detroit Electric, and others, and at one point in history outsold gasoline-powered vehicles. In 1900, 28 percent of the cars on the road in the US were electric. EVs were so popular that even President Woodrow Wilson and his secret service agents toured Washington, D.C., in their Milburn Electrics, which covered 60–70 miles (100–110 km) per charge.^[21]

Most producers of passenger cars opted for gasoline cars in the first decade of the 20th century, but electric trucks were an established niche well into the 1920s.^{[22][23][18]} A number of developments contributed to a decline in the popularity of electric cars.^[24] Improved road infrastructure required a greater range than that offered by electric cars, and the discovery of large reserves of petroleum in Texas, Oklahoma, and California led to the wide availability of affordable gasoline/petrol, making internal combustion powered cars cheaper to operate over long distances.^[25] Electric vehicles were not seldom marketed as a women's luxury car, which may have been a stigma among male consumers.^[26] Also, internal combustion powered cars became ever-easier to operate thanks to the invention of the electric starter by Charles Kettering in 1912,^[27] which eliminated the need of a hand crank for starting a gasoline engine, and the noise emitted by ICE cars became more bearable thanks to the use of the muffler, which Hiram Percy Maxim had invented in 1897. As roads were improved outside urban areas, electric vehicle range could not compete with the ICE. Finally, the initiation of mass production of gasoline-powered vehicles by Henry Ford in 1913 reduced significantly the cost of gasoline cars as compared to electric cars.^[28]

In the 1930s, National City Lines, which was a partnership of General Motors, Firestone, and Standard Oil of California purchased many electric tram networks across the country to dismantle them and replace them with GM buses. The partnership was convicted of conspiring to monopolize the sale of equipment and supplies to their subsidiary companies, but was acquitted of conspiring to monopolize the provision of transportation services.

The Copenhagen Summit, which was conducted in the midst of a severe observable climate change brought on by human-made greenhouse gas emissions, was held in 2009. During the summit, more than 70 countries developed plans to eventually reach net zero. For many countries, adopting more EVs will help reduce the use of gasoline.^[29]

In January 1990, General Motors' President introduced its EV concept two-seater, the "Impact", at the Los Angeles Auto Show. That September, the California Air Resources Board mandated major-automaker sales of EVs, in phases starting in 1998. From 1996 to 1998 GM produced 1117 EV1s, 800 of which were made available through three-year leases.^[30]

Chrysler, Ford, GM, Honda, and Toyota also produced limited numbers of EVs for California drivers during this time period. In 2003, upon the expiration of GM's EV1 leases, GM discontinued them. The discontinuation has variously been attributed to:

- the auto industry's successful federal court challenge to California's zero-emissions vehicle mandate,
- a federal regulation requiring GM to produce and maintain spare parts for the few thousand EV1s and

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- the success of the oil and auto industries' media campaign to reduce public acceptance of EVs.

A movie made on the subject in 2005–2006 was titled *Who Killed the Electric Car?* and released theatrically by Sony Pictures Classics in 2006. The film explores the roles of automobile manufacturers, oil industry, the U.S. government, batteries, hydrogen vehicles, and the general public, and each of their roles in limiting the deployment and adoption of this technology.

Ford released a number of their Ford Ecostar delivery vans into the market. Honda, Nissan and Toyota also repossessed and crushed most of their EVs, which, like the GM EV1s, had been available only by closed-end lease. After public protests, Toyota sold 200 of its RAV4 EVs; they later sold at over their original forty-thousand-dollar price. Later, BMW of Canada sold off a number of Mini EVs when their Canadian testing ended.

During the late 20th and early 21st century, the environmental impact of the petroleum-based transportation infrastructure, along with the fear of peak oil, led to renewed interest in electric transportation infrastructure.^[34] EVs differ from fossil fuel-powered vehicles in that the electricity they consume can be generated from a wide range of sources, including fossil fuels, nuclear power, and renewables such as solar power and wind power or any combination of those. The carbon footprint and other emissions of electric vehicles vary depending on the fuel and technology used for electricity generation.^{[35][36]} The electricity may be stored in the vehicle using a battery, flywheel, or supercapacitors. Vehicles using internal combustion engines usually only derive their energy from a single or a few sources, usually non-renewable fossil fuels. A key advantage of electric vehicles is regenerative braking, which recovers kinetic energy, typically lost during friction braking as heat, as electricity restored to the on-board battery. There are many ways to generate electricity, of varying costs, efficiency and ecological desirability.

Connection to generator plants

- Direct connection to generation plants as is common among electric trains, trams, trolleybuses, and trolleytrucks (See also: overhead lines, third rail and conduit current collection)
- Online electric vehicle collects power from electric power strips buried under the road surface through electromagnetic induction

Onboard generators and hybrid EVs

- Generated on-board using a diesel engine: diesel–electric locomotive and diesel–electric multiple unit (DEMU)
- Generated on-board using a fuel cell: fuel cell vehicle
- Generated on-board using nuclear energy: nuclear submarines and aircraft carriers
- Renewable sources such as solar power: solar vehicle

It is also possible to have hybrid EVs that derive electricity from multiple sources, such as:

- On-board rechargeable electricity storage system (RESS) and a direct continuous connection to land-based generation plants for purposes of on-highway recharging with unrestricted highway range^[37]
- On-board rechargeable electricity storage system and a fueled propulsion power source (internal combustion engine): plug-in hybrid

For especially large EVs, such as submarines, the chemical energy of the diesel–electric can be replaced by a nuclear reactor. The nuclear reactor usually provides heat, which drives a steam turbine, which drives a generator, which is then fed to the propulsion. See Nuclear marine propulsion.

A few experimental vehicles, such as some cars and a handful of aircraft use solar panels for electricity.

Onboard storage

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These systems are powered from an external generator plant (nearly always when stationary), and then disconnected before motion occurs, and the electricity is stored in the vehicle until needed.

- Full Electric Vehicles (FEV).^[38] Power storage methods include:
 - Chemical energy stored on the vehicle in on-board batteries: Battery electric vehicle (BEV) typically with a lithium-ion battery
 - Kinetic energy storage: flywheels
 - Static energy stored on the vehicle in on-board electric double-layer capacitors

Batteries, electric double-layer capacitors and flywheel energy storage are forms of rechargeable on-board electricity storage systems. By avoiding an intermediate mechanical step, the energy conversion efficiency can be improved compared to hybrids by avoiding unnecessary energy conversions. Furthermore, electro-chemical batteries conversions are reversible, allowing electrical energy to be stored in chemical form.^[39]

II.DISCUSSION

Most electric vehicles use lithium-ion batteries (Li-Ions or LIBs). Lithium ion batteries have higher energy density, longer life span and higher power density than most other practical batteries. Complicating factors include safety, durability, thermal breakdown, its environmental impact and cost. Li-ion batteries should be used within safe temperature and voltage ranges in order to operate safely and efficiently.^[42]

Increasing the battery's lifespan decreases effective costs. One technique is to operate a subset of the battery cells at a time and switching these subsets.^[43]

In the past, nickel-metal hydride batteries were used in some electric cars, such as those made by General Motors.^[44] These battery types are considered outdated due to their tendencies to self-discharge in the heat.^[45] Furthermore, a patent for this type of battery was held by Chevron, which created a problem for their widespread development.^[46] These factors, coupled with their high cost, has led to lithium-ion batteries leading as the predominant battery for EVs.^[47]

The prices of lithium-ion batteries are constantly decreasing, contributing to a reduction in price for electric vehicles.^[48]

The power of a vehicle's electric motor, as in other machines, is measured in kilowatts (kW). Electric motors can deliver their maximum torque over a wide RPM range. This means that the performance of a vehicle with a 100 kW electric motor exceeds that of a vehicle with a 100 kW internal combustion engine, which can only deliver its maximum torque within a limited range of engine speed.

Efficiency of charging varies considerably depending on the type of charger,^[49] and energy is lost during the process of converting the electrical energy to mechanical energy.

Usually, direct current (DC) electricity is fed into a DC/AC inverter where it is converted to alternating current (AC) electricity and this AC electricity is connected to a 3-phase AC motor.

For electric trains, forklift trucks, and some electric cars, DC motors are often used. In some cases, universal motors are used, and then AC or DC may be employed. In recent production vehicles, various motor types have been implemented; for instance, induction motors within Tesla Motor vehicles and permanent magnet machines in the Nissan Leaf and Chevrolet Bolt.^[50]

A hybrid electric vehicle (HEV) is a type of hybrid vehicle that combines a conventional internal combustion engine (ICE) system with an electric propulsion system (hybrid vehicle drivetrain). The presence of the electric powertrain is intended to achieve either better fuel economy than a conventional vehicle or better performance. There is a variety of HEV types and the degree to which each function as an electric vehicle (EV) also varies. The most common form of HEV is the hybrid electric car, although hybrid electric trucks (pickups and tractors), buses, boats and aircraft also exist.

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Modern HEVs make use of efficiency-improving technologies such as regenerative brakes which convert the vehicle's kinetic energy to electric energy, which is stored in a battery or supercapacitor. Some varieties of HEV use an internal combustion engine to turn an electrical generator, which either recharges the vehicle's batteries or directly powers its electric drive motors; this combination is known as a motor-generator.^[51] Many HEVs reduce idle emissions by shutting down the engine at idle and restarting it when needed; this is known as a start-stop system. A hybrid-electric produces lower tailpipe emissions than a comparably sized gasoline car since the hybrid's gasoline engine is usually smaller than that of a gasoline-powered vehicle. If the engine is not used to drive the car directly, it can be geared to run at maximum efficiency, further improving fuel economy.

There are different ways that a hybrid electric vehicle can combine the power from an electric motor and the internal combustion engine. The most common type is a parallel hybrid that connects the engine and the electric motor to the wheels through mechanical coupling. In this scenario, the electric motor and the engine can drive the wheels directly. Series hybrids only use the electric motor to drive the wheels and can often be referred to as extended-range electric vehicles (EREVs) or range-extended electric vehicles (REEVs). There are also series-parallel hybrids where the vehicle can be powered by the engine working alone, the electric motor on its own, or by both working together; this is designed so that the engine can run at its optimum range as often as possible.^[52]

A plug-in electric vehicle (PEV) is any motor vehicle that can be recharged from any external source of electricity, such as wall sockets, and the electricity stored in the Rechargeable battery packs drives or contributes to drive the wheels. PEV is a subcategory of electric vehicles that includes battery electric vehicles (BEVs), plug-in hybrid vehicles, (PHEVs), and electric vehicle conversions of hybrid electric vehicles and conventional internal combustion engine vehicles.^{[57][58][59]} On-road electric vehicles include electric cars, electric trolleybuses, electric buses, battery electric buses, electric trucks, electric bicycles, electric motorcycles and scooters, personal transporters, neighborhood electric vehicles, golf carts, milk floats, and forklifts. Off-road vehicles include electrified all-terrain vehicles and tractors. The fixed nature of a rail line makes it relatively easy to power EVs through permanent overhead lines or electrified third rails, eliminating the need for heavy onboard batteries. Electric locomotives, electric multiple units, electric trams (also called streetcars or trolleys), electric light rail systems, and electric rapid transit are all in common use today, especially in Europe and Asia.

Since electric trains do not need to carry a heavy internal combustion engine or large batteries, they can have very good power-to-weight ratios. This allows high speed trains such as France's double-deck TGVs to operate at speeds of 320 km/h (200 mph) or higher, and electric locomotives to have a much higher power output than diesel locomotives. In addition, they have higher short-term surge power for fast acceleration, and using regenerative brakes can put braking power back into the electrical grid rather than wasting it.

Maglev trains are also nearly always EVs.^[62]

There are also battery electric passenger trains operating on non-electrified rail lines.

Most large electric transport systems are powered by stationary sources of electricity that are directly connected to the vehicles through wires. Electric traction allows the use of regenerative braking, in which the motors are used as brakes and become generators that transform the motion of, usually, a train into electrical power that is then fed back into the lines. This system is particularly advantageous in mountainous operations, as descending vehicles can produce a large portion of the power required for those ascending. This regenerative system is only viable if the system is large enough to utilise the power generated by descending vehicles.

In the systems above, motion is provided by a rotary electric motor. However, it is possible to "unroll" the motor to drive directly against a special matched track. These linear motors are used in maglev trains which float above the rails supported by magnetic levitation. This allows for almost no rolling resistance of the vehicle and no mechanical wear and tear of the train or track. In addition to the high-performance control systems needed, switching and curving of the tracks becomes difficult with linear motors, which to date has restricted their operations to high-speed point to point services.

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III.RESULTS

EVs release no tailpipe air pollutants, and reduce respiratory illnesses such as asthma.^[92] However, EVs are charged with electricity that may be generated by means that have health and environmental impacts.^{[93][94]}

The carbon emissions from producing and operating an EV are typically less than those of producing and operating a conventional vehicle.^[95] EVs in urban areas almost always pollute less than internal combustion vehicles.^[96]

One limitation of the environmental potential of EVs is that simply switching the existing privately owned car fleet from ICEs to EVs will not free up road space for active travel or public transport.^[97] Electric micromobility vehicles, such as e-bikes, may contribute to the decarbonisation of transport systems, especially outside of urban areas which are already well-served by public transport.^[98]

Internal combustion engined vehicles use far more raw materials over their lifetime than EVs.^[99]

Since their first commercial release in 1991, lithium-ion batteries have become an important technology for achieving low-carbon transportation systems. The sustainability of production process of batteries has not been fully assessed in either economic, social or environmental terms.^[100]

Business processes of raw material extraction in practice raise issues of transparency and accountability of the management of extractive resources. In the complex supply chain of lithium technology, there are diverse stakeholders representing corporate interests, public interest groups and political elites that are concerned with outcomes from the technology production and use. One possibility to achieve balanced extractive processes would be the establishment of commonly agreed standards on the governance of technology worldwide.^[100]

The compliance of these standards can be assessed by the Assessment of Sustainability in Supply Chains Frameworks (ASSC). Hereby, the qualitative assessment consists of examining governance and social and environmental commitment. Indicators for the quantitative assessment are management systems and standards, compliance and social and environmental indicators.^[101]

One source estimates that over a fifth of the lithium and about 65% of the cobalt needed for electric cars will be from recycled sources by 2035.^[102] On the other hand, when counting the large quantities of fossil fuel non-electric cars consume over their lifetime, electric cars can be considered to dramatically reduce raw-material needs.^[102] A 2003 study in the United Kingdom found that "[p]ollution is most concentrated in areas where young children and their parents are more likely to live and least concentrated in areas to which the elderly tend to migrate," and that "those communities that are most polluted and which also emit the least pollution tend to be amongst the poorest in Britain."^[103] A 2018 UK study found that "households in the poorest areas emit the least NO_x and PM, whilst the least poor areas emitted the highest, per km, vehicle emissions per household through having higher vehicle ownership, owning more diesel vehicles and driving further."^[104] Electric motors are mechanically very simple and often achieve 90% energy conversion efficiency^[105] over the full range of speeds and power output and can be precisely controlled. They can also be combined with regenerative braking systems that have the ability to convert movement energy back into stored electricity. This can be used to reduce the wear on brake systems (and consequent brake pad dust) and reduce the total energy requirement of a trip. Regenerative braking is especially effective for start-and-stop city use.

They can be finely controlled and provide high torque from stationary-to-moving, unlike internal combustion engines, and do not need multiple gears to match power curves. This removes the need for gearboxes and torque converters.

EVs provide quiet and smooth operation and consequently have less noise and vibration than internal combustion engines.^[106] While this is a desirable attribute, it has also evoked concern that the absence of the usual sounds of an approaching vehicle poses a danger to blind, elderly and very young pedestrians. To mitigate this situation, many countries mandate warning sounds when EVs are moving slowly, up to a speed when normal motion and rotation (road, suspension, electric motor, etc.) noises become audible.^[107]

Electric motors do not require oxygen, unlike internal combustion engines; this is useful for submarines and for space rovers.

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EV 'tank-to-wheels' efficiency is about a factor of three higher than internal combustion engine vehicles.^[106] Energy is not consumed while the vehicle is stationary, unlike internal combustion engines which consume fuel while idling. However, looking at the well-to-wheel efficiency of EVs, their total emissions, while still lower, are closer^l to an efficient gasoline or diesel in most countries where electricity generation relies on fossil fuels.^{[109][110]}

Well-to-wheel efficiency of an EV has less to do with the vehicle itself and more to do with the method of electricity production. A particular EV would instantly become twice as efficient if electricity production were switched from fossil fuels to renewable energy, such as wind power, tidal power, solar power, and nuclear power. Thus, when "well-to-wheels" is cited, the discussion is no longer about the vehicle, but rather about the entire energy supply infrastructure – in the case of fossil fuels this should also include energy spent on exploration, mining, refining, and distribution.

The lifecycle analysis of EVs shows that even when powered by the most carbon-intensive electricity in Europe, they emit less greenhouse gases than a conventional diesel vehicle.^[111] In cold climates, considerable energy is needed to heat the interior of a vehicle and to defrost the windows. With internal combustion engines, this heat already exists as waste combustion heat diverted from the engine cooling circuit. This process offsets the greenhouse gases' external costs. If this is done with battery EVs, the interior heating requires extra energy from the vehicles' batteries. Although some heat could be harvested from the motor or motors and battery, their greater efficiency means there is not as much waste heat available as from a combustion engine.

However, for vehicles which are connected to the grid, battery EVs can be preheated, or cooled, with little or no need for battery energy, especially for short trips.

Newer designs are focused on using super-insulated cabins which can heat the vehicle using the body heat of the passengers. This is not enough, however, in colder climates as a driver delivers only about 100 W of heating power. A heat pump system, capable of cooling the cabin during summer and heating it during winter, is a more efficient way of heating and cooling EVs.

The IEA suggests that taxing inefficient internal combustion engine vehicles could eventually become a means to finance subsidies for EVs.^[7] Government procurement is sometimes used to encourage national EV manufacturers.^{[123][124]} Many countries will ban sales of fossil fuel vehicles between 2025 and 2040.^[125]

Many governments offer incentives to promote the use of electric vehicles, with the goals of reducing air pollution and oil consumption. Some incentives intend to increase purchases of electric vehicles by offsetting the purchase price with a grant. Other incentives include lower tax rates or exemption from certain taxes, and investment in charging infrastructure.

Companies selling EVs have partnered with local electric utilities in order to provide large incentives on some electric vehicles.^[126]

By reducing air pollution, such as nitrogen dioxide, EVs could prevent hundreds of thousands of early deaths every year,^{[131][132]} especially from trucks and old cars in cities.^[133]

Vehicle batteries rely heavily on the mining industry of rare earth metals such as cobalt, nickel, and copper.^{[134][135]} In 2014 the US State Department said that the supply of lithium would need to increase 42-fold by 2050 globally to support a transition to clean energy.^[136] Rare-earth metals (neodymium, dysprosium) and other mined metals (copper, nickel, iron) are used by EV motors, while lithium, cobalt, manganese are used by the batteries.^{[137][135]} The full environmental impact of electric vehicles includes the life cycle impacts of carbon and sulfur emissions, as well as toxic metals entering the environment. Most of the lithium ion battery production occurs in China, where the bulk of energy used is supplied by coal burning power plants. A study of hundreds of cars on sale in 2016 concluded that the life cycle GHG emissions of full electric cars are slightly less than hybrids and that both are less than gasoline and diesel fuelled cars.^[138]

An alternative method of sourcing essential battery materials being deliberated by the International Seabed Authority is deep sea mining, however carmakers are not using this as of 2014.^[139]

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IV. CONCLUSIONS

Since EVs can be plugged into the electric grid when not in use, battery-powered vehicles could reduce the need for dispatchable generation by feeding electricity into the grid from their batteries during periods of high demand and low supply (such as just after sunset) while doing most of their charging at night or midday, when there is unused generating capacity.^{[163][164]} This vehicle-to-grid (V2G) connection has the potential to reduce the need for new power plants, as long as vehicle owners do not mind reducing the life of their batteries, by being drained by the power company during peak demand. Electric vehicle parking lots can provide demand response.^[165]

Furthermore, current electricity infrastructure may need to cope with increasing shares of variable-output power sources such as wind and solar. This variability could be addressed by adjusting the speed at which EV batteries are charged, or possibly even discharged.^[166]

Some concepts see battery exchanges and battery charging stations, much like gas/petrol stations today. These will require enormous storage and charging potentials, which could be manipulated to vary the rate of charging, and to output power during shortage periods, much as diesel generators are used for short periods to stabilize some national grids.^{[167][168]}

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- 147.^ Domonoske, Camila (17 March 2016). "From Amazon To FedEx, The Delivery Truck Is Going Electric". National Public Radio. Retrieved 13 June 2016. All major delivery companies are starting to replace their gas-powered fleets with electric or low-emission vehicles, a switch that companies say will boost their bottom lines, while also fighting climate change and urban pollution. UPS has placed an order for 10,000 electric delivery

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vehicles. Amazon is buying 100,000 from the start-up Rivian. DHL says zero-emission vehicles make up a fifth of its fleet, with more to come. And FedEx just pledged to replace 100% of its pickup and delivery fleet with battery-powered vehicles.

- 148.^ Joselow, Maxine (11 January 2017). "Delivery Vehicles Increasingly Choke Cities with Pollution". Scientific American. Retrieved 13 June 2016. Electric vehicles, delivery drones and rules on when delivery trucks can operate are some solutions proposed in a new report. The report provides 24 recommendations for policymakers and the private sector, including mandating that delivery vehicles are electric. The report notes that if policymakers care about sustainability, they may want to impose aggressive new electric vehicle regulations.
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