= Plug @-@ in electric vehicle =

A plug @-@ in electric vehicle ( PEV ) is any motor vehicle that can be recharged from an 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 subset of electric vehicles that includes all @-@ electric or battery electric vehicles ( BEVs ) , plug @-@ in hybrid vehicles ( PHEVs ) , and electric vehicle conversions of hybrid electric vehicles and conventional internal combustion engine vehicles .

Plug @-@ in cars have several benefits compared to conventional internal combustion engine vehicles . They have lower operating and maintenance costs , and produce little or no local air pollution . They reduce dependence on petroleum and may reduce greenhouse gas emissions from the onboard source of power , depending on the fuel and technology used for electricity generation to charge the batteries . Plug @-@ in hybrids capture most of these benefits when they are operating in all @-@ electric mode . Despite their potential benefits , market penetration of plug @-@ in electric vehicles has been slower than expected as adoption faces several hurdles and limitations . As of 2016 , plug @-@ in electric vehicles are significantly more expensive than conventional vehicles and hybrid electric vehicles due to the additional cost of their lithium @-@ ion battery packs . Other factors discouraging the adoption of electric cars are the lack of public and private recharging infrastructure and , in the case of all @-@ electric vehicles , drivers ' fear of the batteries running out of energy before reaching their destination due to the limited range of existing electric cars . Plug @-@ in hybrids eliminate the problem of range anxiety associated to all @-@ electric vehicles , because the combustion engine works as a backup when the batteries are depleted , giving PHEVs driving range comparable to other vehicles with gasoline tanks .

Several national and local governments have established tax credits , subsidies , and other incentives to promote the introduction and adoption in the mass market of plug @-@ in electric vehicles depending on their battery size and all @-@ electric range . The term " plug @-@ in electric drive vehicle " is formally used in U.S. federal legislation to grant this type of consumer incentive . In China , plug @-@ in electric vehicles are called new energy vehicles ( NEVs ) , and only pure electric vehicles and plug @-@ in hybrid electric vehicles are subject to purchase incentives . Cumulative global sales of highway legal plug @-@ in electric passenger cars and light utility vehicles passed the 1 @.@ 5 million unit milestone in May 2016 . Despite their rapid growth , plug @-@ in electric cars represented just 0 @.@ 1 % of the one billion cars on the world 's roads by the end of 2015 .

As of September 2015 , there were almost 70 models of highway legal plug @-@ in electric passenger cars and light @-@ duty utility vans available for retail sales in the world . As of March 2016 , the Nissan Leaf is the world 's all @-@ time top selling highway @-@ capable all @-@ electric car , with global sales of almost 220 @,@ 000 units , followed by the Tesla Model S with about 120 @,@ 000 units sold worldwide , and the Chevrolet Volt plug @-@ in hybrid , which together with its sibling the Opel / Vauxhall Ampera has combined global sales of over 110 @,@ 000 units . Ranking next are the Mitsubishi Outlander P @-@ HEV with about 102 @,@ 000 units sold , and the Toyota Prius Plug @-@ in Hybrid with 75 @,@ 000 delivered worldwide .

As of June 2016 , cumulative sales by country are led by the United States with a stock of about 474 @,@ 000 highway legal light @-@ duty plug @-@ in electric vehicles delivered since 2008 . China ranks second with almost 390 @,@ 000 units sold between 2011 and May 2016 , followed by Japan with more than 150 @,@ 000 plug @-@ ins sold between 2009 and April 2016 . Over 500 @,@ 000 plug @-@ in passenger cars and utility vans have been registered in Europe up until May 2016 , making the continent the world 's largest light @-@ duty plug @-@ in regional market . European sales are led by Norway with over 105 @,@ 000 units registered through May 2016 , followed by the Netherlands with over 93 @,@ 300 units registered at the end of May 2016 , and France with about 89 @,@ 600 units registered through May 2016 . China is the world 's leader in the plug @-@ in heavy @-@ duty segment , including electric all @-@ electric buses , and plug @-@ in commercial and sanitation trucks . The stock of new energy vehicles sold in China since 2011 passed the 500 @,@ 000 unit milestone in March 2016 .

= = Terminology = =

= = = Plug @-@ in electric vehicle = = =

A plug @-@ in electric vehicle ( PEV ) is any motor vehicle with rechargeable battery packs that can be charged from the electric grid , and the electricity stored on board drives or contributes to drive the wheels for propulsion . Plug @-@ in electric vehicles are also sometimes referred to as grid @-@ enabled vehicles ( GEV ) and also as electrically chargeable vehicles .

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 . Even though conventional hybrid electric vehicles ( HEVs ) have a battery that is continually recharged with power from the internal combustion engine and regenerative braking , they can not be recharged from an off @-@ vehicle electric energy source , and therefore , they do not belong to the category of plug @-@ in electric vehicles .

" Plug @-@ in electric drive vehicle " is the legal term used in U.S. federal legislation to designate the category of motor vehicles eligible for federal tax credits depending on battery size and their all @-@ electric range . In some European countries , particularly in France , " electrically chargeable vehicle " is the formal term used to designate the vehicles eligible for these incentives . While the term " plug @-@ in electric vehicle " most often refers to automobiles or " plug @-@ in cars " , there are several other types of plug @-@ in electric vehicle , including scooters , motorcycles , neighborhood electric vehicles or microcars , city cars , vans , light trucks or light commercial vehicles , buses , trucks or lorries , and military vehicles .

= = = Battery electric vehicles = = =

A battery electric vehicle ( BEV ) uses chemical energy stored in rechargeable battery packs as its only source for propulsion . BEVs use electric motors and motor controllers instead of internal combustion engines ( ICEs ) for propulsion .

A plug @-@ in hybrid operates as an all @-@ electric vehicle or BEV when operating in charge @-@ depleting mode , but it switches to charge @-@ sustaining mode after the battery has reached its minimum state of charge ( SOC ) threshold , exhausting the vehicle 's all @-@ electric range ( AER ) .

= = = Plug @-@ in hybrid electric vehicles = = =

A plug @-@ in hybrid electric vehicle ( PHEV or PHV ) , also known as a plug @-@ in hybrid , is a hybrid electric vehicle with rechargeable batteries that can be restored to full charge by connecting a plug to an external electric power source . A plug @-@ in hybrid shares the characteristics of both a conventional hybrid electric vehicle and an all @-@ electric vehicle : it uses a gasoline engine and an electric motor for propulsion , but a PHEV has a larger battery pack that can be recharged , allowing operation in all @-@ electric mode until the battery is depleted .

= = = Aftermarket conversions = = =

An aftermarket electric vehicle conversion is the modification of a conventional internal combustion engine vehicle ( ICEV ) or hybrid electric vehicle ( HEV ) to electric propulsion , creating an all @-@ electric or plug @-@ in hybrid electric vehicle .

There are several companies in the U.S. offering conversions . The most common conversions have been from hybrid electric cars to plug @-@ in hybrid , but due to the different technology used in hybrids by each carmaker , the easiest conversions are for 2004 ? 2009 Toyota Prius and for the Ford Escape / Mercury Mariner Hybrid .

= = = New energy vehicles = = =

In China the term new energy vehicles ( NEVs ) refers to vehicles that are partially or fully powered by electricity , such as battery electric vehicles ( BEVs ) and plug @-@ in hybrids ( PHEVs ) . The Chinese government began implementation of its NEV program in 2009 to foster the development and introduction of new energy vehicles .

= = Advantages = =

= = = Lower operating and maintenance costs = = =

Internal combustion engines are relatively inefficient at converting on @-@ board fuel energy to propulsion as most of the energy is wasted as heat , and the rest while the engine is idling . Electric motors , on the other hand , are more efficient at converting stored energy into driving a vehicle . Electric drive vehicles do not consume energy while at rest or coasting , and modern plug @-@ in cars can capture and reuse as much as one fifth of the energy normally lost during braking through regenerative braking . Typically , conventional gasoline engines effectively use only 15 % of the fuel energy content to move the vehicle or to power accessories , and diesel engines can reach on @-@ board efficiencies of 20 % , while electric drive vehicles typically have on @-@ board efficiencies of around 80 % .

In the United States , as of early 2010 with a national average electricity rate of US $ 0 @.@ 10 per kWh , the cost per mile for a plug @-@ in electric vehicle operating in all @-@ electric mode is estimated between $ 0 @.@ 02 to $ 0 @.@ 04 , while the cost per mile of a standard automobile varies between $ 0 @.@ 08 to $ 0 @.@ 20 , considering a gasoline price of $ 3 @.@ 00 per gallon . As petroleum price is expected to increase in the future due to oil production decline and increases in global demand , the cost difference in favor of PEVs is expected to become even more advantageous .

According to Consumer Reports , as of December 2011 the Nissan Leaf has a cost of 3 @.@ 5 cents per mile and the Chevrolet Volt has a cost in electric mode of 3 @.@ 8 cents per mile . The Volt cost per mile is higher because it is heavier than the Leaf . These estimates are based on the fuel economy and energy consumption measured on their tests and using a U.S. national average rate of 11 cents per kWh of electricity . When the Volt runs in range @-@ extended mode using its premium gasoline @-@ powered engine , the plug @-@ in hybrid has a cost of 12 @.@ 5 cents per mile . The out @-@ of @-@ pocket cost per mile of the three most fuel efficient gasoline @-@ powered cars as tested by the magazine are the Toyota Prius , with a cost of 8 @.@ 6 cents per miles , the Honda Civic Hybrid with 9 @.@ 5 cents per mile , the Toyota Corolla with 11 @.@ 9 cents per mile , and the Hyundai Elantra 13 @.@ 1 cents per mile . The analysis also found that on trips up to 100 mi ( 160 km ) , the Volt is cheaper to drive than the Prius and the other three cars due to the Volt 's 35 mi ( 56 km ) driving range on electricity . The previous operating costs do not include maintenance , depreciation or other costs .

All @-@ electric and plug @-@ in hybrid vehicles also have lower maintenance costs as compared to internal combustion vehicles , since electronic systems break down much less often than the mechanical systems in conventional vehicles , and the fewer mechanical systems on board last longer due to the better use of the electric engine . PEVs do not require oil changes and other routine maintenance checks .

The following table compares out @-@ of @-@ pocket fuel costs estimated by the U.S. Environmental Protection Agency according to its official ratings for fuel economy ( miles per gallon gasoline equivalent in the case of plug @-@ in electric vehicles ) for series production all @-@ electric passenger vehicles rated by the EPA as of December 2015 , versus EPA rated most fuel efficient plug @-@ in hybrid with long distance range ( Chevrolet Volt - second generation ) , gasoline @-@ electric hybrid car ( Toyota Prius Eco - fourth generation ) , and EPA 's average new

2016 vehicle , which has a fuel economy of 25 mpg @-@ US ( 9 @.@ 4 L / 100 km ; 30 mpg @-@ imp ) .

The following table compares EPA 's estimated out @-@ of @-@ pocket fuel costs and fuel economy ratings of serial production plug @-@ in hybrid electric vehicles rated by EPA as of May 2016 expressed in miles per gallon gasoline equivalent ( mpg @-@ e ) , versus the most fuel efficient gasoline @-@ electric hybrid car , the 2016 Toyota Prius Eco ( fourth generation ) , rated 56 mpg @-@ US ( 4 @.@ 2 L / 100 km ; 67 mpg @-@ imp ) , and EPA 's average new 2016 vehicle , which has a fuel economy of 25 mpg @-@ US ( 9 @.@ 4 L / 100 km ; 30 mpg @-@ imp ) . The table also shows the fuel efficiency for plug @-@ in hybrids in all @-@ electric mode expressed as KWh / 100 mile , the metric used by EPA to rate electric cars before November 2010 .

The Edison Electric Institute ( EEI ) conducted an analysis that demonstrated that between January 1976 and February 2012 the real price for gasoline has been much more volatile than the real price of electricity in the United States . The analysis is based on a plug @-@ in electric vehicle with an efficiency of 3 @.@ 4 miles per kW @-@ hr ( like the Mitsubishi i MiEV ) and a gasoline @-@ powered vehicle with a fuel economy rated at 30 mpg @-@ US ( 7 @.@ 8 L / 100 km ; 36 mpg @-@ imp ) ( like the 2012 Fiat 500 ) . The EEI estimated that operating a plug @-@ in would have had an equivalent cost of around US $ 1 @.@ 50 a gallon in the late 1970s and early 1980s , and around US $ 1 @.@ 00 a gallon since the late 1990s . In contrast , the price to operate an internal combustion engine vehicle has had much ample variations , costing more than US $ 3 @.@ 50 per gallon during the 1979 energy crisis , then had a couple of lows with prices at less than US $ 1 @.@ 50 during 1999 and 2001 , only to climb and reach a maximum of more than US $ 4 @.@ 00 before the beginning of the 2007 ? 2009 financial crisis , by early 2012 has fluctuated around US $ 3 @.@ 50 . The analysis found that the cost of an equivalent electric @-@ gallon of gasoline would have been not only cheaper to operate during the entire analysis period but also that equivalent electricity prices are more stable and have been declining in terms of equivalent dollars per gallon .

= = = Air pollution and greenhouse gas emissions = = =

Electric cars , as well as plug @-@ in hybrids operating in all @-@ electric mode , emit no harmful tailpipe pollutants from the onboard source of power , such as particulates ( soot ) , volatile organic compounds , hydrocarbons , carbon monoxide , ozone , lead , and various oxides of nitrogen . The clean air benefit is usually local because , depending on the source of the electricity used to recharge the batteries , air pollutant emissions are shifted to the location of the generation plants . In a similar manner , plug @-@ in electric vehicles operating in all @-@ electric mode do not emit greenhouse gases from the onboard source of power , but from the point of view of a well @-@ to @-@ wheel assessment , the extent of the benefit also depends on the fuel and technology used for electricity generation . This fact has been referred to as the long tailpipe of plug @-@ in electric vehicles . From the perspective of a full life cycle analysis , the electricity used to recharge the batteries must be generated from renewable or clean sources such as wind , solar , hydroelectric , or nuclear power for PEVs to have almost none or zero well @-@ to @-@ wheel emissions . On the other hand , when PEVs are recharged from coal @-@ fired plants , they usually produce slightly more greenhouse gas emissions than internal combustion engine vehicles and higher than hybrid electric vehicles . In the case of plug @-@ in hybrid electric vehicles operating in hybrid mode with assistance of the internal combustion engine , tailpipe and greenhouse emissions are lower in comparison to conventional cars because of their higher fuel economy .

The magnitude of the potential advantage depends on the mix of generation sources and therefore varies by country and by region . For example , France can obtain significant emission benefits from electric and plug @-@ in hybrids because most of its electricity is generated by nuclear power plants ; California , where most energy comes from natural gas , hydroelectric and nuclear plants can also secure substantial emission benefits . The U.K. also has a significant potential to benefit from PEVs as natural gas plants dominate the generation mix . On the other hand , emission benefits in Germany , China , India , and the central regions of the United States are limited or non @-@ existent because most electricity is generated from coal . However these countries and

regions might still obtain some air quality benefits by reducing local air pollution in urban areas . Cities with chronic air pollution problems , such as Los Angeles , México City , Santiago , Chile , São Paulo , Beijing , Bangkok and Kathmandu may also gain local clean air benefits by shifting the harmful emission to electric generation plants located outside the cities . Nevertheless , the location of the plants is not relevant when considering greenhouse gas emission because their effect is global .

= = = = Carbon footprint during production = = = =

Ricardo

A report published in June 2011 , prepared by Ricardo in collaboration with experts from the UK 's Low Carbon Vehicle Partnership , found that hybrid electric cars , plug @-@ in hybrids and all @-@ electric cars generate more carbon emissions during their production than current conventional vehicles , but still have a lower overall carbon footprint over the full life cycle . The higher carbon footprint during production of electric drive vehicles is due mainly to the production of batteries . As an example , 43 percent of production emissions for a mid @-@ size electric car are generated from the battery production , while for standard mid @-@ sized gasolineinternal combustion engine vehicle , around 75 % of the embedded carbon emissions during production comes from the steel used in the vehicle glider . The following table summarizes key results of this study for four powertrain technologies :

The Ricardo study also found that the lifecycle carbon emissions for mid @-@ sized gasoline and diesel vehicles are almost identical , and that the greater fuel efficiency of the diesel engine is offset by higher production emissions .

Volkswagen

In 2014 Volkswagen published the results of life @-@ cycle assessment of its electric vehicles certified by TÜV NORD , and independent inspection agency . The study found that CO

2 emissions during the use phase of its all @-@ electric VW e @-@ Golf are 99 % lower than those of the Golf 1 @.@ 2 TSI when powers comes from exclusively hydroelectricity generated in Germany , Austria and Switzerland . Accounting for the full lifecycle , the e @-@ Golf reduces emissions by 61 % , offsetting higher production emissions . When the actual EU @-@ 27 electricity mix is considered , the e @-@ Golf emissions are still 26 % lower than those of the conventional Golf 1 @.@ 2 TSI . Similar results were found when comparing the e @-@ Golf with the Golf 1 @.@ 6 TDI . The analysis considered recycling of the three vehicles at the end of their lifetime .

= = = = Well @-@ to @-@ wheel GHG emissions in the U.S. = = = =

Environmental Protection Agency

The following table compares tailpipe and upstream CO2 emissions estimated by the U.S. Environmental Protection Agency for all series production model year 2014 plug @-@ in electric vehicles available in the U.S. market . Total emissions include the emissions associated with the production and distribution of electricity used to charge the vehicle , and for plug @-@ in hybrid electric vehicles , it also includes emissions associated with tailpipe emissions produced from the internal combustion engine . These figures were published by the EPA in October 2014 in its annual report " Light @-@ Duty Automotive Technology , Carbon Dioxide Emissions , and Fuel Economy Trends : 1975 Through 2014 . " All emissions are estimated considering average real world city and highway operation based on the EPA 5 @-@ cycle label methodology , using a weighted 55 % city and 45 % highway driving . For the first time , the 2014 Trends report presents an analysis of the impact of alternative fuel vehicles , with emphasis in plug @-@ in electric vehicles because as their market share is approaching 1 % , the EPA concluded that PEVs began to have a measurable impact on the U.S. overall new vehicle fuel economy and CO2 emissions .

For purposes of an accurate estimation of emissions , the analysis took into consideration the differences in operation between plug @-@ in hybrids . Some , like the Chevrolet Volt , can operate in all @-@ electric mode without using gasoline , and others operate in a blended mode like the

Toyota Prius PHV , which uses both energy stored in the battery and energy from the gasoline tank to propel the vehicle , but that can deliver substantial all @-@ electric driving in blended mode . In addition , since the all @-@ electric range of plug @-@ in hybrids depends on the size of the battery pack , the analysis introduced a utility factor as a projection of the share of miles that will be driven using electricity by an average driver , for both , electric only and blended EV modes . Since all @-@ electric cars do not produce tailpipe emissions , the utility factor applies only to plug @-@ in hybrids . The following table shows the overall fuel economy expressed in terms of miles per gallon gasoline equivalent ( mpg @-@ e ) and the utility factor for the ten MY2014 plug @-@ in hybrids available in the U.S. market , and EPA 's best estimate of the CO2 tailpipe emissions produced by these PHEVs .

In order to account for the upstream CO2 emissions associated with the production and distribution of electricity , and since electricity production in the United States varies significantly from region to region , the EPA considered three scenarios / ranges with the low end scenario corresponding to the California powerplant emissions factor , the middle of the range represented by the national average powerplant emissions factor , and the upper end of the range corresponding to the powerplant emissions factor for the Rocky Mountains . The EPA estimates that the electricity GHG emission factors for various regions of the country vary from 346 g CO2 / kWh in California to 986 g CO2 / kWh in the Rockies , with a national average of 648 g CO2 / kWh .

Union of Concerned Scientists

The Union of Concerned Scientists ( UCS ) published a study in 2012 that assessed average greenhouse gas emissions in the U.S. resulting from charging plug @-@ in car batteries from the perspective of the full life @-@ cycle ( well @-@ to @-@ wheel analysis ) and according to fuel and technology used to generate electric power by region . The study used the model year 2011 Nissan Leaf all @-@ electric car to establish the analysis baseline , and electric @-@ utility emissions are based on EPA 's 2009 estimates . The UCS study expressed the results in terms of miles per gallon instead of the conventional unit of grams of greenhouse gases or carbon dioxide equivalent emissions per year in order to make the results more friendly for consumers . The study found that in areas where electricity is generated from natural gas , nuclear , hydroelectric or renewable sources , the potential of plug @-@ in electric cars to reduce greenhouse emissions is significant . On the other hand , in regions where a high proportion of power is generated from coal , hybrid electric cars produce less CO2 equivalent emissions than plug @-@ in electric cars , and the best fuel efficient gasoline @-@ powered subcompact car produces slightly less emissions than a PEV . In the worst @-@ case scenario , the study estimated that for a region where all energy is generated from coal , a plug @-@ in electric car would emit greenhouse gas emissions equivalent to a gasoline car rated at a combined city / highway driving fuel economy of 30 mpg @-@ US ( 7 @.@ 8 L / 100 km ; 36 mpg @-@ imp ) . In contrast , in a region that is completely reliant on natural gas , the PEV would be equivalent to a gasoline @-@ powered car rated at 50 mpg @-@ US ( 4 @.@ 7 L / 100 km ; 60 mpg @-@ imp ) .

The study concluded that for 45 % of the U.S. population , a plug @-@ in electric car will generate lower CO2 equivalent emissions than a gasoline @-@ powered car capable of combined 50 mpg @-@ US ( 4 @.@ 7 L / 100 km ; 60 mpg @-@ imp ) , such as the Toyota Prius and the Prius c . The UCS also found that for 37 % of the population , the electric car emissions will fall in the range of a gasoline @-@ powered car rated at a combined fuel economy of 41 to 50 mpg @-@ US ( 5 @.@ 7 to 4 @.@ 7 L / 100 km ; 49 to 60 mpg @-@ imp ) , such as the Honda Civic Hybrid and the Lexus CT200h . Only 18 % of the population lives in areas where the power @-@ supply is more dependent on burning carbon , and the greenhouse gas emissions will be equivalent to a car rated at a combined fuel economy of 31 to 40 mpg @-@ US ( 7 @.@ 6 to 5 @.@ 9 L / 100 km ; 37 to 48 mpg @-@ imp ) , such as the Chevrolet Cruze and Ford Focus . The study found that there are no regions in the U.S. where plug @-@ in electric cars will have higher greenhouse gas emissions than the average new compact gasoline engine automobile , and the area with the dirtiest power supply produces CO2 emissions equivalent to a gasoline @-@ powered car rated at 33 mpg @-@ US ( 7 @.@ 1 L / 100 km ) .

In September 2014 the UCS published an updated analysis of its 2012 report . The 2014 analysis

found that 60 % of Americans , up from 45 % in 2009 , live in regions where an all @-@ electric car produce fewer CO2 equivalent emissions per mile than the most efficient hybrid . The UCS study found several reasons for the improvement . First , electric utilities have adopted cleaner sources of electricity to their mix between the two analysis . The 2014 study used electric @-@ utility emissions based on EPA 's 2010 estimates , but since coal use nationwide is down by about 5 % from 2010 to 2014 , actual efficiency in 2014 is better than estimated in the UCS study . Second , electric vehicles have become more efficient , as the average 2013 all @-@ electric vehicle used 0 @.@ 33 kWh per mile , representing a 5 % improvement over 2011 models . Also , some new models are cleaner than the average , such as the BMW i3 , which is rated at 0 @.@ 27 kWh by the EPA . An i3 charged with power from the Midwest grid would be as clean as a gasoline @-@ powered car with about 50 mpg @-@ US ( 4 @.@ 7 L / 100 km ) , up from 39 mpg @-@ US ( 6 @.@ 0 L / 100 km ) for the average electric car in the 2012 study . In states with a cleaner mix generation , the gains were larger . The average all @-@ electric car in California went up to 95 mpg @-@ US ( 2 @.@ 5 L / 100 km ) equivalent from 78 mpg @-@ US ( 3 @.@ 0 L / 100 km ) in the 2012 study . States with dirtier generation that rely heavily on coal still lag , such as Colorado , where the average BEV only achieves the same emissions as a 34 mpg @-@ US ( 6 @.@ 9 L / 100 km ; 41 mpg @-@ imp ) gasoline @-@ powered car . The author of the 2014 analysis noted that the benefits are not distributed evenly across the U.S. because electric car adoptions is concentrated in the states with cleaner power .

In November 2015 the Union of Concerned Scientists published a new report comparing two battery electric vehicles ( BEVs ) with similar gasoline vehicles by examining their global warming emissions over their full life @-@ cycle , cradle @-@ to @-@ grave analysis . The two BEVs modeled , midsize and full @-@ size , are based on the two most popular BEV models sold in the United States in 2015 , the Nissan Leaf and the Tesla Model S. The study found that all @-@ electric cars representative of those sold today , on average produce less than half the global warming emissions of comparable gasoline @-@ powered vehicles , despite taken into account the higher emissions associated with BEV manufacturing . Considering the regions where the two most popular electric cars are being sold , excess manufacturing emissions are offset within 6 to 16 months of average driving . The study also concluded that driving an average EV results in lower global warming emissions than driving a gasoline car that gets 50 mpg @-@ US ( 4 @.@ 7 L / 100 km ) in regions covering two @-@ thirds of the U.S. population , up from 45 % in 2009 . Based on where EVs are being sold in the United States in 2015 , the average EV produces global warming emissions equal to a gasoline vehicle with a 68 mpg @-@ US ( 3 @.@ 5 L / 100 km ) fuel economy rating . The authors identified two main reason for the fact that EV @-@ related emissions have become even lower in many parts of the country since the first study was conducted in 2012 . Electricity generation has been getting cleaner , as coal @-@ fired generation has declined while lower @-@ carbon alternatives have increased . In addition , electric cars are becoming more efficient . For example , the Nissan Leaf and the Chevrolet Volt , have undergone improvements to increase their efficiencies compared to the original models launched in 2010 , and other even more efficient BEV models , such as the most lightweight and efficient BMW i3 , have entered the market .

National Bureau of Economic Research

One criticism to the UCS study is that the analysis was made using average emissions rates across regions instead of marginal generation at different times of the day . The former approach does not take into account the generation mix within interconnected electricity markets and shifting load profiles throughout the day . An analysis by three economist affiliated with the National Bureau of Economic Research ( NBER ) , published in November 2014 , developed a methodology to estimate marginal emissions of electricity demand that vary by location and time of day across the United States . The marginal analysis , applied to plug @-@ in electric vehicles , found that the emissions of charging PEVs vary by region and hours of the day . In some regions , such as the Western U.S. and Texas , CO2 emissions per mile from driving PEVs are less than those from driving a hybrid car . However , in other regions , such as the Upper Midwest , charging during the recommended hours of midnight to 4 a.m. implies that PEVs generate more emissions per mile than the average car currently on the road . The results show a fundamental tension between electricity load

management and environmental goals as the hours when electricity is the least expensive to produce tend to be the hours with the greatest emissions . This occurs because coal @-@ fired units , which have higher emission rates , are most commonly used to meet base @-@ level and off @-@ peak electricity demand ; while natural gas units , which have relatively low emissions rates , are often brought online to meet peak demand .

= = = = Well @-@ to @-@ wheel GHG emissions in several countries = = = =

A study published in the UK in April 2013 assessed the carbon footprint of plug @-@ in electric vehicles in 20 countries . As a baseline the analysis established that manufacturing emissions account for 70 g CO2 / km for an electric car and 40 g CO2 / km for a petrol car . The study found that in countries with coal @-@ intensive generation , PEVs are no different from conventional petrol @-@ powered vehicles . Among these countries are China , Indonesia , Australia , South Africa and India . A pure electric car in India generates emissions comparable to a 20 mpg @-@ US ( 12 L / 100 km ; 24 mpg @-@ imp ) petrol car .

The country ranking was led by Paraguay , where all electricity is produced from hydropower , and Iceland , where electricity production relies on renewable power , mainly hydro and geothermal power . Resulting carbon emissions from an electric car in both countries are 70 g CO2 / km , which is equivalent to a 220 mpg @-@ US ( 1 @.@ 1 L / 100 km ; 260 mpg @-@ imp ) petrol car , and correspond to manufacturing emissions . Next in the ranking are other countries with low carbon electricity generation , including Sweden ( mostly hydro and nuclear power ) , Brazil ( mainly hydropower ) and France ( predominantly nuclear power ) . Countries ranking in the middle include Japan , Germany , the UK and the United States .

The following table shows the emissions intensity estimated in the study for those countries where electric vehicle are available , and the corresponding emissions equivalent in miles per US gallon of a petrol @-@ powered car :

= = = Less dependence on imported oil = = =

For many net oil importing countries the 2000s energy crisis brought back concerns first raised during the 1973 oil crisis . For the United States , the other developed countries and emerging countries their dependence on foreign oil has revived concerns about their vulnerability to price shocks and supply disruption . Also , there have been concerns about the uncertainty surrounding peak oil production and the higher cost of extracting unconventional oil . A third issue that has been raised is the threat to national security because most proven oil reserves are concentrated in relatively few geographic locations , including some countries with strong resource nationalism , unstable governments or hostile to U.S. interests . In addition , for many developing countries , and particularly for the poorest African countries , high oil prices have an adverse impact on the government budget and deteriorate their terms of trade thus jeopardizing their balance of payments , all leading to lower economic growth .

Through the gradual replacement of internal combustion engine vehicles for electric cars and plug @-@ in hybrids , electric drive vehicles can contribute significantly to lessen the dependence of the transport sector on imported oil as well as contributing to the development of a more resilient energy supply .

= = = Vehicle @-@ to @-@ grid = = =

Plug @-@ in electric vehicles offer users the opportunity to sell electricity stored in their batteries back to the power grid , thereby helping utilities to operate more efficiently in the management of their demand peaks . A vehicle @-@ to @-@ grid ( V2G ) system would take advantage of the fact that most vehicles are parked an average of 95 percent of the time . During such idle times the electricity stored in the batteries could be transferred from the PEV to the power lines and back to the grid . In the U.S this transfer back to the grid have an estimated value to the utilities of up to $ 4

@,@ 000 per year per car . In a V2G system it would also be expected that battery electric ( BEVs ) and plug @-@ in hybrids ( PHEVs ) would have the capability to communicate automatically with the power grid to sell demand response services by either delivering electricity into the grid or by throttling their charging rate .

= = Disadvantages = =

= = = Cost of batteries and cost of ownership = = =

Cost of batteries

As of 2015 , plug @-@ in electric vehicles are significantly more expensive as compared to conventional internal combustion engine vehicles and hybrid electric vehicles due to the additional cost of their lithium @-@ ion battery pack . According to a 2010 study by the National Research Council , the cost of a lithium @-@ ion battery pack was about US $ 1 @,@ 700 / kWh of usable energy , and considering that a PHEV @-@ 10 requires about 2 @.@ 0 kWh and a PHEV @-@ 40 about 8 kWh , the manufacturer cost of the battery pack for a PHEV @-@ 10 is around US $ 3 @,@ 000 and it goes up to US $ 14 @,@ 000 for a PHEV @-@ 40 . As of June 2012 , and based on the three battery size options offered for the Tesla Model S , the New York Times estimated the cost of automotive battery packs between US $ 400 to US $ 500 per kilowatt @-@ hour . A 2013 study by the American Council for an Energy @-@ Efficient Economy reported that battery costs came down from US $ 1 @,@ 300 per kWh in 2007 to US $ 500 per kWh in 2012 . The U.S. Department of Energy has set cost targets for its sponsored battery research of US $ 300 per kWh in 2015 and US $ 125 per kWh by 2022 . Cost reductions through advances in battery technology and higher production volumes will allow plug @-@ in electric vehicles to be more competitive with conventional internal combustion engine vehicles .

According to a study published in February 2016 by Bloomberg New Energy Finance ( BNEF ) , battery prices fell 65 % since 2010 , and 35 % just in 2015 , reaching US $ 350 per kWh . The study concludes that battery costs are on a trajectory to make electric vehicles without government subsidies as affordable as internal combustion engine cars in most countries by 2022 . BNEF projects that by 2040 , long @-@ range electric cars will cost less than US $ 22 @,@ 000 expressed in 2016 dollars . BNEF expects electric car battery costs to be well below US $ 120 per kWh by 2030 , and to fall further thereafter as new chemistries become available .

Cost of ownership

A study published in 2011 by the Belfer Center , Harvard University , found that the gasoline costs savings of plug @-@ in electric cars do not offset their higher purchase prices when comparing their lifetime net present value of purchase and operating costs for the U.S. market at 2010 prices , and assuming no government subidies . According to the study estimates , a PHEV @-@ 40 is US $ 5 @,@ 377 more expensive than a conventional internal combustion engine , while a battery electric vehicles is US $ 4 @,@ 819 more expensive . These findings assumed a battery cost of US $ 600 per kWh , which means that the Chevrolet Volt battery pack cost around US $ 10 @,@ 000 and the Nissan Leaf pack costs US $ 14 @,@ 400 . The study also assumed a gasoline price of US $ 3 @.@ 75 per gallon ( as of mid June 2011 ) , that vehicles are driven 12 @,@ 000 miles ( 19 @,@ 000 km ) per year , an average price of electricity of US $ 0 @.@ 12 per kWh , that the plug @-@ in hybrid is driven in all @-@ electric mode 85 % of the time , and that the owner of PEVs pay US $ 1 @,@ 500 to install a Level II 220 / 240 volt charger at home .

The study also include hybrid electric vehicles in the comparison , and analyzed several scenarios to determine how the comparative net savings will change over the next 10 to 20 years , assuming that battery costs will decrease while gasoline prices increase , and also assuming higher fuel efficiency of conventional cars , among other scenarios . Under the future scenarios considered , the study found that BEVs will be significantly less expensive than conventional cars ( US $ 1 @,@ 155 to US $ 7 @,@ 181 cheaper ) , while PHEVs , will be more expensive than BEVs in almost all comparison scenarios , and only less expensive than conventional cars in a scenario with very low

battery costs and high gasoline prices . The reason for the different savings among PEVs is because BEVs are simpler to build and do not use liquid fuel , while PHEVs have more complicated powertrains and still have gasoline @-@ powered engines . The following table summarizes the results of four of the seven scenarios analyzed by the study .

According to a study by the Electric Power Research Institute published in June 2013 , the total cost of ownership of the 2013 Nissan Leaf SV is substantially lower than that of comparable conventional and hybrid vehicles . For comparison , the study constructed average hybrid and conventional vehicles and assumed an average US distance per trip distribution . The study took into account the manufacturer 's suggested retail price , taxes , credits , destination charge , electric charging station , fuel cost , maintenance cost , and additional cost due to the use of a gasoline vehicle for trips beyond the range of the Leaf .

= = = Availability of recharging infrastructure = = =

Despite the widespread assumption that plug @-@ in recharging will take place overnight at home , residents of cities , apartments , dormitories , and townhouses do not have garages or driveways with available power outlets , and they might be less likely to buy plug @-@ in electric vehicles unless recharging infrastructure is developed . Electrical outlets or charging stations near their places of residence , in commercial or public parking lots , streets and workplaces are required for these potential users to gain the full advantage of PHEVs , and in the case of EVs , to avoid the fear of the batteries running out energy before reaching their destination , commonly called range anxiety . Even house dwellers might need to charge at the office or to take advantage of opportunity charging at shopping centers . However , this infrastructure is not in place and it will require investments by both the private and public sectors .

Several cities in California and Oregon , and particularly San Francisco and other cities in the San Francisco Bay Area and Silicon Valley , already have deployed public charging stations and have expansion plans to attend both plug @-@ ins and all @-@ electric cars . Some local private firms such as Google and Adobe Systems have also deployed charging infrastructure . In Google 's case , its Mountain View campus has 100 available charging stations for its share @-@ use fleet of converted plug @-@ ins available to its employees . Solar panels are used to generate the electricity , and this pilot program is being monitored on a daily basis and performance results are published on the RechargeIT website . As of December 2013 , Estonia is the first and only country that had deployed an EV charging network with nationwide coverage , with 165 fast chargers available along highways at a minimum distance of between 40 to 60 km ( 25 to 37 mi ) , and a higher density in urban areas .

The importance to build the infrastructure necessary to support electric vehicles is illustrated by the decision of Car2Go in San Diego , California , that due to insufficient charging infrastructure decided to replace all of its all @-@ electric car fleet with gasoline @-@ powered cars starting on 1 May 2016 . When the carsharing service started in 2011 , Car2Go expected 1 @,@ 000 charging stations to be deployed around the city , but only 400 were in place by early 2016 . As a result , an average of 20 % of the carsharing fleet is unavailable at any given time because the cars are either being charged or because they don ? t have enough electricity in them to be driven . Also , many of the company ? s 40 @,@ 000 San Diego members say they often worry their Car2Go will run out of charge before they finish their trip .

= = = = Battery swapping = = = =

A different approach to resolve the problems of range anxiety and lack of recharging infrastructure for electric vehicles was developed by Better Place . Its business model considers that electric cars are built and sold separately from the battery pack . As customers are not allowed to purchase battery packs , they must lease them from Better Place which will deploy a network of battery swapping stations thus expanding EVs range and allowing long distance trips . Subscribed users pay a per @-@ distance fee to cover battery pack leasing , charging and swap infrastructure , the

cost of sustainable electricity , and other costs . Better Place signed agreement for deployment in Australia , Denmark , Israel , Canada , California , and Hawaii . The Renault Fluence Z.E. was the electric car built with switchable battery technology sold for the Better Place network . The robotic battery @-@ switching operation was completed in about five minutes .

After implementing the first modern commercial deployment of the battery swapping model in Israel and Denmark , Better Place filed for bankruptcy in Israel in May 2013 . The company 's financial difficulties were caused by the high investment required to develop the charging and swapping infrastructure , about US $ 850 million in private capital , and a market penetration significantly lower than originally predicted by Shai Agassi . Less than 1 @,@ 000 Fluence Z.E. cars were deployed in Israel and around 400 units in Denmark .

Tesla Motors designed its Model S to allow fast battery swapping . In June 2013 , Tesla announced their goal to deploy a battery swapping station in each of its supercharging stations . At a demonstration event Tesla showed that a battery swap operation with the Model S takes just over 90 seconds , about half the time it takes to refill a gasoline @-@ powered car used for comparison purposes during the event . The first stations are planned to be deployed along Interstate 5 in California where , according to Tesla , a large number of Model S sedans make the San Francisco @-@ Los Angeles trip regularly . These will be followed by the Washington , DC to Boston corridor .

= = = = Other charging solutions = = = =

The REVA NXR exhibited in the 2009 Frankfurt Motor Show and the Nissan Leaf SV trim both have roof @-@ mounted solar panels . These solar panels are designed to trickle charge the batteries when the car is moving or parked . Another proposed technology is REVive , by REVA . When the REVA NXR 's batteries are running low or are fully depleted , the driver is able to send an SMS to REVive and unlock a hidden reserve in the battery pack . REVA has not provided details on how the system will work . The Fisker Karma uses solar panel in the roof to recharge the 12 @-@ volt lead @-@ acid accessory battery . The Nissan Leaf SL trim also has a small solar panel at the rear of the roof / spoiler that can trickle charge the auxiliary 12 @-@ volt lead @-@ acid battery .

= = = Potential overload of the electrical grid = = =

The existing electrical grid , and local transformers in particular , may not have enough capacity to handle the additional power load that might be required in certain areas with high plug @-@ in electric car concentrations . As recharging a single electric @-@ drive car could consume three times as much electricity as a typical home , overloading problems may arise when several vehicles in the same neighborhood recharge at the same time , or during the normal summer peak loads . To avoid such problems , utility executives recommend owners to charge their vehicles overnight when the grid load is lower or to use smarter electric meters that help control demand . When market penetration of plug @-@ in electric vehicles begins to reach significant levels , utilities will have to invest in improvements for local electrical grids in order to handle the additional loads related to recharging to avoid blackouts due to grid overload . Also , some experts have suggested that by implementing variable time @-@ of @-@ day rates , utilities can provide an incentive for plug @-@ in owners to recharge mostly overnight , when rates are lower .

General Motors is sponsoring the Pecan Street demonstration project in Austin , Texas . The project objective is to learn the charging patterns of plug @-@ in electric car owners , and to study how a residential fleet of electric vehicles might strain the electric grid if all owners try to charge them at the same , which is what the preliminary monitoring found when the plug @-@ in cars return home in the evening . The Mueller neighborhood is the test ground , and as of June 2013 , the community has nearly 60 Chevrolet Volt owners alone . This cluster of Volts was achieved thanks to GM 's commitment to match the federal government 's $ 7 @,@ 500 rebate incentive , which effectively halves the purchase price of the plug @-@ hybrid electric cars .

= = = Risks associated with noise reduction = = =

Electric cars and plug @-@ in hybrids when operating in all @-@ electric mode at low speeds produce less roadway noise as compared to vehicles propelled by an internal combustion engine , thereby reducing harmful noise health effects . However , blind people or the visually impaired consider the noise of combustion engines a helpful aid while crossing streets , hence plug @-@ in electric cars and conventional hybrids could pose an unexpected hazard when operating at low speeds .

Several tests conducted in the U.S. have shown that this is a valid concern , as vehicles operating in electric mode can be particularly hard to hear below 20 mph ( 30 km / h ) for all types of road users and not only the visually impaired . At higher speeds the sound created by tire friction and the air displaced by the vehicle start to make sufficient audible noise . However , a 2011 study , commissioned by the UK Department for Transport ( DfT ) and conducted by the Transport Research Laboratory , found little correlation between pedestrian vehicle involvement density and noise level for the majority of vehicles . In addition , the analysis found no evidence of a pattern in pedestrian vehicle involvement densities when only considering those accidents occurring on 30 mph ( 48 km / h ) or slower roads , or where the pedestrian was disabled . A previous study did not found an increased pedestrian vehicle involvement density for electric and hybrid vehicles with respect to their conventional counterparts which raised the question as to whether added sound is necessarily required .

Some carmakers announced they have decided to address this safety issue , and as a result , the new Nissan Leaf electric car and Chevrolet Volt plug @-@ in hybrid , both launched in December 2010 , as well as the Fisker Karma plug @-@ in hybrid launched in 2011 launched in 2012 , include electric warning sounds to alert pedestrians , the blind and others to their presence . As of January 2014 , most of the hybrids and plug @-@ in electric and hybrids available in the United States , Japan and Europe make warning noises using a speaker system . The Tesla Model S is one of the few electric cars without warning sounds , because Tesla Motors will await until regulations are enacted . Volkswagen and BMW also decided to add artificial sounds to their electric drive cars only when required by regulation .

The Japanese Ministry of Land , Infrastructure , Transport and Tourism issued guidelines for hybrid and other near @-@ silent vehicles in January 2010 . In the United States the Pedestrian Safety Enhancement Act of 2010 was approved by the U.S. Senate and the House of Representatives in December 2010 . The act does not stipulate a specific speed for the simulated noise but requires the U.S. Department of Transportation to study and establish a motor vehicle safety standard that would set requirements for an alert sound . A proposed rule was published for comment by the National Highway Traffic Safety Administration ( NHTSA ) in January , 2013 . It would require hybrids and electric vehicles traveling at less than 18 @.@ 6 miles per hour ( 30 km / h ) to emit warning sounds that pedestrians must be able to hear over background noises . According to the NHTSA proposal carmakers would be able to pick the sounds the vehicles make from a range of choices , and similar vehicles would have to make the same sounds . The rules were scheduled to go into effect in September 2014 . However , in January 2015 the NHTSA rescheduled the date for a final ruling to the end of 2015 . Since the regulation comes into force three years after being rendered as a final rule , compliance was delayed to 2018 .

On 6 February 2013 , the European Parliament approved a draft law to tighten noise limits for cars to protect public health , and also to add alerting sounds to ensure the audibility of hybrid and electric vehicles to improve the safety of vulnerable road users in urban areas , such as blind , visually and auditorily challenged pedestrians , cyclists and children . The draft legislation states a number of tests , standards and measures that must first be developed for an Acoustic Vehicle Alerting Systems ( AVAS ) to be compulsory in the future . The approved amendment establishes that the sound to be generated by the AVAS should be a continuous sound and should be easily indicative of vehicle behavior and should sound similar to the sound of a vehicle of the same category equipped with an internal combustion engine . " In April 2014 the European Parliament approved legislation that requires the mandatory use of the AVAS for all new electric and hybrid electric vehicles and car manufacturers have to comply within 5 years .

= = = Risks of battery fire = = =

Lithium @-@ ion batteries may suffer thermal runaway and cell rupture if overheated or overcharged , and in extreme cases this can lead to combustion . To reduce these risks , lithium @-@ ion battery packs contain fail @-@ safe circuitry that shuts down the battery when its voltage is outside the safe range . When handled improperly , or if manufactured defectively , some rechargeable batteries can experience thermal runaway resulting in overheating . Especially prone to thermal runaway are lithium @-@ ion batteries . Reports of exploding cellphones have been reported in newspapers . In 2006 , batteries from Apple , HP , Toshiba , Lenovo , Dell and other notebook manufacturers were recalled because of fire and explosions . Also , during the Boeing 787 Dreamliner 's first year of service , at least four aircraft suffered from electrical system problems stemming from its lithium @-@ ion batteries , resulting in the whole Dreamliner fleet being voluntarily grounded in January 2013 .

Several plug @-@ in electric vehicle fire incidents have taken place since the introduction of mass @-@ production plug @-@ in electric vehicles in 2008 . Most of them have been thermal runaway incidents related to the lithium @-@ ion batteries and have involved the Zotye M300 EV , Chevrolet Volt , Fisker Karma , BYD e6 , Dodge Ram 1500 Plug @-@ in Hybrid , Toyota Prius Plug @-@ in Hybrid , Mitsubishi i @-@ MiEV and Outlander P @-@ HEV . As of November 2013 , four fires after a crash have been reported associated with the batteries of all @-@ electric cars involving a BYD e6 and three Tesla Model S cars .

The first modern crash @-@ related fire was reported in China in May 2012 , after a high @-@ speed car crashed into a BYD e6 taxi in Shenzhen . The second reported incident occurred in the United States in October 1 , 2013 , when a Tesla Model S caught fire after the electric car hit metal debris on a highway in Kent , Washington state , and the debris punctured one of 16 modules within the battery pack . A second reported fire occurred on October 18 , 2013 in Merida , Mexico . In this case the vehicle was being driven at high speed through a roundabout and crashed through a wall and into a tree . On November 6 , 2013 , a Tesla Model S being driven on Interstate 24 near Murfreesboro , Tennessee caught fire after it struck a tow hitch on the roadway , causing damage beneath the vehicle .

The U.S. National Highway Traffic Safety Administration ( NHTSA ) is conducting a study due in 2014 to establish whether lithium @-@ ion batteries in plug @-@ electric vehicles pose a potential fire hazard . The research is looking at whether the high @-@ voltage batteries can cause fires when they are being charged and when the vehicles are involved in an accident . Both General Motors and Nissan have published a guide for firefighters and first responders to properly handle a crashed plug @-@ in electric @-@ drive vehicle and safely disable its battery and other high voltage systems .

= = = Rare earth metals availability and supply security = = =

Common technology for plug @-@ ins and electric cars is based on the lithium @-@ ion battery and an electric motor which uses rare earth elements . The demand for lithium , heavy metals , and other specific elements ( such as neodymium , boron and cobalt ) required for the batteries and powertrain is expected to grow significantly due to the future sales increase of plug @-@ in electric vehicles in the mid and long term . As of 2011 , the Toyota Prius battery contains more than 20 lb ( 9 @.@ 1 kg ) of the rare earth element lanthanum , and its motor magnets use neodymium and dysprosium . While only 0 @.@ 25 oz ( 7 g ) of lithium carbonate equivalent ( LCE ) are required in a smartphone and 1 @.@ 1 oz ( 30 g ) in a tablet computer , electric vehicles and stationary energy storage systems for homes , businesses or industry use much more lithium in their batteries . As of 2016 a hybrid electric passenger car might use 11 lb ( 5 kg ) of LCE , while one of Tesla 's high performance electric cars could use as much as 180 lb ( 80 kg ) .

Some of the largest world reserves of lithium and other rare metals are located in countries with strong resource nationalism , unstable governments or hostility to U.S. interests , raising concerns

about the risk of replacing dependence on foreign oil with a new dependence on hostile countries to supply strategic materials .

Lithium

The main deposits of lithium are found in China and throughout the Andes mountain chain in South America . In 2008 Chile was the leading lithium metal producer with almost 30 % , followed by China , Argentina , and Australia . In the United States lithium is recovered from brine pools in Nevada .

Nearly half the world 's known reserves are located in Bolivia , and according to the US Geological Survey , Bolivia 's Salar de Uyuni desert has 5 @.@ 4 million tons of lithium . Other important reserves are located in Chile , China , and Brazil . Since 2006 the Bolivian government have nationalized oil and gas projects and is keeping a tight control over mining its lithium reserves . Already the Japanese and South Korean governments , as well as companies from these two countries and France , have offered technical assistance to develop Bolivia 's lithium reserves and are seeking to gain access to the lithium resources through a mining and industrialization model suitable to Bolivian interests .

According to a 2011 study conducted at Lawrence Berkeley National Laboratory and the University of California Berkeley , the currently estimated reserve base of lithium should not be a limiting factor for large @-@ scale battery production for electric vehicles , as the study estimated that on the order of 1 billion 40 kWh Li @-@ based batteries ( about 10 kg of lithium per car ) could be built with current reserves , as estimated by the U.S. Geological Survey . Another 2011 study by researchers from the University of Michigan and Ford Motor Company found that there are sufficient lithium resources to support global demand until 2100 , including the lithium required for the potential widespread use of hybrid electric , plug @-@ in hybrid electric and battery electric vehicles . The study estimated global lithium reserves at 39 million tons , and total demand for lithium during the 90 @-@ year period analyzed at 12 @-@ 20 million tons , depending on the scenarios regarding economic growth and recycling rates .

A 2016 study by Bloomberg New Energy Finance ( BNEF ) found that availability of lithium and other finite materials used in the battery packs will not be a limiting factor for the adoption of electric vehicles . BNEF estimated that battery packs will require less than 1 % of the known reserves of lithium , nickel , manganese , and copper through 2030 , and 4 % of the world ? s cobalt . After 2030 , the study states that new battery chemistries will probably shift to other source materials , making packs lighter , smaller , and cheaper .

Rare earth elements

China has 48 % of the world 's reserves of rare earth elements , the United States has 13 % , and Russia , Australia , and Canada have significant deposits . Until the 1980s , the U.S. led the world in rare earth production , but since the mid @-@ 1990s China has controlled the world market for these elements . The mines in Bayan Obo near Baotou , Inner Mongolia , are currently the largest source of rare earth metals and are 80 % of China 's production . In 2010 China accounted for 97 % of the global production of 17 rare earth elements . Since 2006 the Chinese government has been imposing export quotas reducing supply at a rate of 5 % to 10 % a year .

Prices of several rare earth elements increased sharply by mid @-@ 2010 as China imposed a 40 % export reduction , citing environmental concerns as the reason for the export restrictions . These quotas have been interpreted as an attempt to control the supply of rare earths . However , the high prices have provided an incentive to begin or reactivate several rare earth mining projects around the world , including the United States , Australia , Vietnam , and Kazakhstan .

In September 2010 , China temporarily blocked all exports of rare earths to Japan in the midst of a diplomatic dispute between the two countries . These minerals are used in hybrid cars and other products such wind turbines and guided missiles , thereby augmenting the worries about the dependence on Chinese rare earth elements and the need for geographic diversity of supply . A December 2010 report published by the US DoE found that the American economy vulnerable to rare earth shortages and estimates that it could take 15 years to overcome dependence on Chinese supplies . China raised export taxes for some rare earths from 15 to 25 % , and also extended taxes to exports of some rare earth alloys that were not taxed before . The Chinese government also announced further reductions on its export quotas for the first months of 2011 , which represent a 35

% reduction in tonnage as compared to exports during the first half of 2010 .

On September 29 , 2010 , the U.S. House of Representatives approved the Rare Earths and Critical Materials Revitalization Act of 2010 ( H.R.6160 ) . The approved legislation is aimed at restoring the U.S. as a leading producer of rare earth elements , and would support activities in the U.S. Department of Energy ( US DoE ) to discover and develop rare earth sites inside of the U.S. in an effort to reduce the auto industry 's near @-@ complete dependence on China for the minerals . A similar bill , the Rare Earths Supply Technology and Resources Transformation Act of 2010 ( S. 3521 ) , is being discussed in the U.S. Senate .

In order to avoid its dependence on rare earth minerals , Toyota Motor Corporation announced in January 2011 that it is developing an alternative motor for future hybrid and electric cars that does not need rare earth materials . Toyota engineers in Japan and the U.S. are developing an induction motor that is lighter and more efficient than the magnet @-@ type motor used in the Prius , which uses two rare earths in its motor magnets . Other popular hybrids and plug @-@ in electric cars in the market that use these rare earth elements are the Nissan Leaf , the Chevrolet Volt and Honda Insight . For its second generation RAV4 EV due in 2012 , Toyota is using an induction motor supplied by Tesla Motors that does not require rare earth materials . The Tesla Roadster and the Tesla Model S use a similar motor .

= = = Car dealers reluctance to sell = = =

With the exception of Tesla Motors , almost all new cars in the United States are sold through dealerships , so they play a crucial role in the sales of electric vehicles , and negative attitudes can hinder early adoption of plug @-@ in electric vehicles . Dealers decide which cars they want to stock , and a salesperson can have a big impact on how someone feels about a prospective purchase . Sales people have ample knowledge of internal combustion cars while they do not have time to learn about a technology that represents a fraction of overall sales . As with any new technology , and in the particular case of advanced technology vehicles , retailers are central to ensuring that buyers , especially those switching to a new technology , have the information and support they need to gain the full benefits of adopting this new technology .

There are several reasons for the reluctance of some dealers to sell plug @-@ in electric vehicles . PEVs do not offer car dealers the same profits as gasoline @-@ powered car . Plug @-@ in electric vehicles take more time to sell because of the explaining required , which hurts overall sales and sales people commissions . Electric vehicles also may require less maintenance , resulting in loss of service revenue , and thus undermining the biggest source of dealer profits , their service departments . According to the National Automobile Dealers Association ( NADS ) , dealers on average make three times as much profit from service as they do from new car sales . However , a NADS spokesman said there was not sufficient data to prove that electric cars would require less maintenance . According to the New York Times , BMW and Nissan are among the companies whose dealers tend to be more enthusiastic and informed , but only about 10 % of dealers are knowledgeable on the new technology .

A study conducted at the Institute of Transportation Studies ( ITS ) , at the University of California , Davis ( UC Davis ) published in 2014 found that many car dealers are less than enthusiastic about plug @-@ in vehicles . ITS conducted 43 interviews with six automakers and 20 new car dealers selling plug @-@ in vehicles in California ? s major metro markets . The study also analyzed national and state @-@ level J.D. Power 2013 Sales Satisfaction Index ( SSI ) study data on customer satisfaction with new car dealerships and Tesla retail stores . The researchers found that buyers of plug @-@ in electric vehicles were significantly less satisfied and rated the dealer purchase experience much lower than buyers of non @-@ premium conventional cars , while Tesla Motors earned industry @-@ high scores . According to the findings , plug @-@ in buyers expect more from dealers than conventional buyers , including product knowledge and support that extends beyond traditional offerings .

In 2014 Consumer Reports published results from a survey conducted with 19 secret shoppers that went to 85 dealerships in four states , making anonymous visits between December 2013 and

March 2014 . The secret shoppers asked a number of specific questions about cars to test the salespeople ? s knowledge about electric cars . The consumer magazine decided to conduct the survey after several consumers who wanted to buy a plug @-@ in car reported to the organization that some dealerships were steering them toward gasoline @-@ powered models . The survey found that not all sales people seemed enthusiastic about making PEV sales ; a few outright discouraged it , and even one dealer was reluctant to even show a plug @-@ in model despite having one in stock . And many sales people seemed not to have a good understanding of electric @-@ car tax breaks and other incentives or of charging needs and costs . Consumer Reports also found that when it came to answering basic questions , sales people at Chevrolet , Ford , and Nissan dealerships tended to be better informed than those at Honda and Toyota . The survey found that most of the Toyota dealerships visited recommended against buying a Prius Plug @-@ in and suggested buying a standard Prius hybrid instead . Overall , the secret shoppers reported that only 13 dealers ? discouraged sale of EV , ? with seven of them being in New York . However , at 35 of the 85 dealerships visited , the secret shoppers said sales people recommended buying a gasoline @-@ powered car instead .

The ITS @-@ Davis study also found that a small but influential minority of dealers have introduced new approaches to better meet the needs of plug @-@ in customers . Examples include marketing carpool lane stickers , enrolling buyers in charging networks , and preparing incentive paperwork for customers . Some dealers assign seasoned sales people as plug @-@ in experts , many of whom drive plug @-@ ins themselves to learn and be familiar with the technology and relate the car ? s benefits to potential buyers . The study concluded also that carmakers could do much more to support dealers selling PEVs .

= = Government incentives = =

Several national and local governments around the world have established tax credits , grants and other financial and non @-@ financial incentives for consumers to purchase a plug @-@ in electric vehicle as a policy to promote the introduction and mass market adoption of this type of vehicles .

= = = Asia = = =

Japan

In May 2009 the Japanese Diet passed the " Green Vehicle Purchasing Promotion Measure " that went into effect on June 19 , 2009 , but retroactive to April 10 , 2009 . The program established tax deductions and exemptions for environmentally friendly and fuel efficient vehicles , according to a set of stipulated environmental performance criteria , and the requirements are applied equally to both foreign and domestically produced vehicles . The program provides purchasing subsidies for two type of cases , consumers purchasing a new passenger car without trade @-@ in ( non @-@ replacement program ) , and for those consumers buying a new car trading an used car registered 13 years ago or earlier ( scrappage program ) .

China

On June 1 , 2010 , The Chinese government announced a trial program to provide incentives up to 60 @,@ 000 yuan ( ~ US $ 8 @,@ 785 ) for private purchase of new battery electric vehicles and 50 @,@ 000 yuan ( ~ US $ 7 @,@ 320 ) for plug @-@ in hybrids in five cities .

= = = Europe = = =

As of 2010 , 17 of the 27 European Union member states provide tax incentives for electrically chargeable vehicles . The incentives consist of tax reductions and exemptions , as well as of bonus payments for buyers of PEVs and hybrid vehicles .

In the UK the Plug @-@ in Car Grant scheme provided a 25 % incentive towards the cost of new plug @-@ in electric cars that qualify as ultra @-@ low carbon vehicles , capped at GB £ 5 @,@ 000 ( US $ 7 @,@ 800 ) until February 2016 . Both private and business fleet buyers are eligible for

the government grant . In December 2015 , the Department for Transport ( DfT ) announced that Plug @-@ in car grant was extended to encourage more than 100 @,@ 000 UK motorists to buy cleaner vehicles . The criteria for the Plug @-@ in Car Grant was updated and the maximum grant dropped from GB £ 5 @,@ 000 ( ~ US $ 7 @,@ 450 ) to GB £ 4 @,@ 500 ( ~ US $ 6 @,@ 700 ) . The eligible ultra @-@ low emission vehicles ( ULEVs ) must meet criteria in one of three categories depending on emission levels ( CO2 emissions bands between 50 and 75g / km ) and zero @-@ emission @-@ capable mileage ( minimum of 10 mi ( 16 km ) ) .

A price cap is in place , with all Category 1 plug @-@ in vehicles eligible for the full grant no matter what their purchase price , while Category 2 and 3 models with a list price of more than GB £ 60 @,@ 000 ( ~ US $ 90 @,@ 000 ) will not be eligible for the grant . Vehicles with a zero @-@ emission range of at least 70 miles ( 110 km ) ( category 1 ) , including hydrogen fuel cell vehicles , will get a full GB £ 4 @,@ 500 ( ~ US $ 6 @,@ 700 ) , but plug @-@ in hybrids ( categories 2 and 3 ) costing under GB £ 60 @,@ 000 ( ~ US $ 90 @,@ 000 ) will receive GB £ 2 @,@ 500 ( ~ US $ 3 @,@ 725 ) . Under the extended scheme , some plug @-@ in hybrid sports car will no longer be eligible for the grant , such as the BMW i8 because of its GB £ 100 @,@ 000 ( ~ US $ 150 @,@ 000 ) purchase price tag . The updated scheme went into force on 1 March 2016 .

Germany approved an incentive scheme in April 2016 with a budget of ? 1 billion ( US $ 1 @.@ 13 billion ) . The cost of the purchase incentive will be shared equally between the government and automakers . Electric car buyers will get a ? 4 @,@ 000 ( US $ 4 @,@ 520 ) discount while buyers of plug @-@ in hybrid vehicles will get a discount of ? 3 @,@ 000 ( US $ 3 @,@ 390 ) . Premium cars , such as the Tesla Model S and BMW i8 , are not eligible to the incentive because there is a cap of ? 60 @,@ 000 ( US $ 67 @,@ 800 ) for the purchase price . The scheme is scheduled to start as early as May 2016 . Nissan , Volkswagen , Daimler and BMW have signed up to participate in the scheme .

= = = North America = = =

United States

In the United States the Energy Improvement and Extension Act of 2008 , and later the American Clean Energy and Security Act of 2009 ( ACES ) granted tax credits for new qualified plug @-@ in electric vehicles . The American Recovery and Reinvestment Act of 2009 ( ARRA ) also authorized federal tax credits for converted plug @-@ ins , though the credit is lower than for new PEVs .

The federal tax credit for new plug @-@ in electric vehicles is worth $ 2 @,@ 500 plus $ 417 for each kilowatt @-@ hour of battery capacity over 5 kWh , and the portion of the credit determined by battery capacity cannot exceed $ 5 @,@ 000 . Therefore , the total amount of the credit allowed for a new PEV is $ 7 @,@ 500 . Several states have established incentives and tax exemptions for BEVs and PHEV , and other non @-@ monetary incentives .

President Barack Obama set the goal of bringing 1 million plug @-@ in electric vehicles on the road by 2015 . However , considering the actual slow rate of PEV sales , as of mid @-@ 2012 several industry observers have concluded that this goal is unattainable . In September 2014 Governor of California Jerry Brown signed a bill , the Charge Ahead California Initiative , that sets a goal of placing at least 1 million zero @-@ emission vehicles and near @-@ zero @-@ emission vehicles on the road in California by January 1 , 2023 .

Canada

Ontario established a rebate between CA $ 5 @,@ 000 to CA $ 8 @,@ 500 ( ~ US $ 4 @,@ 900 to US $ 8 @,@ 320 ) , depending on battery size , for purchasing or leasing a new plug @-@ in electric vehicle after July 1 , 2010 . The rebates are available to the first 10 @,@ 000 applicants who qualify .

Quebec offers rebates of up to CA $ 8 @,@ 500 ( US $ 8 @,@ 485 ) from January 1 , 2012 , for the purchase of new plug @-@ in electric vehicles equipped with a minimum of 4 kWh battery , and new hybrid electric vehicles are eligible for a CA $ 1 @,@ 000 rebate . All @-@ electric vehicles with high @-@ capacity battery packs are eligible for the full C $ 8 @,@ 000 rebate , and incentives are reduced for low @-@ range electric cars and plug @-@ in hybrids .

= = Production plug @-@ in electric vehicles available = =

During the 1990s several highway @-@ capable plug @-@ in electric cars were produced in limited quantities , all were battery electric vehicles , and they were available through leasing mainly in California . Popular models included the General Motors EV1 and the Toyota RAV4 EV . Some of the latter were sold to the public and are in use still today . In the late 2000s began a new wave of mass production plug @-@ in electric cars , motorcycles and light trucks . However , as of 2011 , most electric vehicles in the world roads were low @-@ speed , low @-@ range neighborhood electric vehicles ( NEVs ) or electric quadricycles . Pike Research estimated there were almost 479 @,@ 000 NEVs on the world roads in 2011 . Just in China , a total of 200 @,@ 000 low @-@ speed small electric cars were sold in 2013 , most of which are powered by lead @-@ acid batteries . As of October 2015 , the GEM neighborhood electric vehicle is the market leader in North America , with global sales of more than 50 @,@ 000 units since 1998 .

As of August 2015 , there were almost 70 models of highway @-@ capable plug @-@ in electric passenger cars and light @-@ utility vans available in the world , with 45 different plug @-@ in electric passenger car models offered in Europe , 20 available in North America , 19 in China , 14 in Japan , and 7 in Australia . There are also available several commercial models of plug @-@ in motorcycles , all @-@ electric buses , and heavy @-@ duty trucks .

As of December 2015 , the Renault @-@ Nissan Alliance is the leading electric vehicle manufacturer with global sales of 302 @,@ 000 all @-@ electric vehicles delivered since December 2010 , representing about half of the global light @-@ duty all @-@ electric market segment . Mitsubishi Motors ranks second , with global sales of about 135 @,@ 000 plug @-@ in electric vehicles since 2009 through December 2015 , consisting of all @-@ electric cars of the Mitsubishi i @-@ MiEV family , all @-@ electric Mitsubishi Minicab MiEV utility vans and trucks , and the plug @-@ in hybrid Mitsubishi Outlander P @-@ HEV . Ranking third is Tesla Motors with almost 125 @,@ 000 electric cars sold between 2008 and March 2016 . Next is General Motors with combined global sales since December 2010 of almost 113 @,@ 000 vehicles through December 2015 , consisting of over 106 @,@ 000 plug @-@ in hybrids of the Volt / Ampera family , over 4 @,@ 300 Chevrolet Spark EVs , and over 2 @,@ 400 Cadillac ELRs .

BYD Auto ended 2015 as the world 's best selling manufacturer of highway legal light @-@ duty plug @-@ in electric vehicles , with 61 @,@ 722 units sold , mostly plug @-@ in hybrids , followed by Tesla Motors , with 50 @,@ 580 units sold in 2015 .

= = = Sales and main markets = = =

By mid @-@ September 2015 , the global stock of highway legal plug @-@ in electric passenger cars and utility vans passed the one million sales milestone . When global sales are broken down by type of powertrain , all @-@ electric cars have oversold plug @-@ in hybrids , with the pure electrics capturing 60 % of global sales as of December 2015 . Sales of plug @-@ in electric vehicles achieved the one million milestone almost twice as fast as hybrid electric vehicles ( HEV ) . While it took four years and 10 months to reach one @-@ million PEV sales , it took more than around nine years and a few months for HEVs to reach its first million sales .

Between 2007 and 2010 , only 11 @,@ 768 plug @-@ in electric vehicles were sold worldwide . By comparison , during the Golden Age of the electric car at the beginning of the 20th century , the EV stock peaked at approximately 30 @,@ 000 vehicles . After the introduction of the Nissan Leaf and the Chevrolet Volt in late December 2010 , the first mass @-@ production plug @-@ in cars by major carmakers , plug @-@ in car sales grew to about 50 @,@ 000 units in 2011 , jumped to 125 @,@ 000 in 2012 , and rose to almost 213 @,@ 000 plug @-@ in electric cars and utility vans in 2013 . Sales totaled over 315 @,@ 000 units in 2014 , up 48 % from 2013 . In five years , global sales of highway legal light @-@ duty plug @-@ in electric vehicles have increased more than ten @-@ fold , totaling more than 565 @,@ 00 units in 2015 . Plug @-@ in sales in 2015 increased about 80 % from 2014 , driven mainly by China and Europe . Both markets passed in 2105 the U.S.

as the largest plug @-@ in electric car markets in terms of total annual sales , with China ranking as the world 's best @-@ selling plug @-@ in electric passenger car country market in 2015 . Over 220 @,@ 000 plug @-@ in cars and vans were sold during the first five months of 2016 .

Since 2004 , cumulative global sales totaled over 1 @.@ 5 million plug @-@ in cars and utility vans by the end of May 2016 . Despite the rapid growth experienced , the plug @-@ in electric car segment represented just 0 @.@ 1 % of the one billion cars on the world 's roads by the end of 2015 . JATO Dynamics , based on LMC Automotive ? s forecasts , estimates the global market is expected to reach sales in excess of 700 @,@ 000 units in 2016 due to strong growth in China , Europe and the United States .

Research published by Bloomberg New Energy Finance in February 2016 predicts that as battery prices continue to fall , light @-@ duty electric vehicles without government subsidies will be as affordable as internal combustion engine cars in most countries by the mid @-@ 2020s . As a result , the study forecasts that annual sales of electric vehicles will hit 41 million by 2040 , representing 35 % of new light duty vehicle sales . In another scenario the study considers that if new carsharing services are successful , together with the adoption of autonomous cars , they could boost electric @-@ vehicle market share to 50 % of new car saless by 2040 . On the other hand , the Organization of the Petroleum Exporting Countries ( OPEC ) in its 2015 World Oil Outlook projected that the market share of battery electric cars and fuel cell cars will remain below 1 % in 2040 , while the share of hybrid electric cars is projected to grow from 1 % in 2013 to 14 % in 2040 .

As of June 2016 , cumulative sales of highway legal light @-@ duty plug @-@ in electric vehicles by country are led by the United States with a stock of about 474 @,@ 000 cars delivered since 2008 . China ranks second with 389 @,@ 885 units sold between 2011 and May 2016 , followed by Japan with 150 @,@ 142 plug @-@ in units sold between 2009 and April 2016 . As of May 2016 , more than 500 @,@ 000 light @-@ duty plug @-@ in electric vehicles have been registered in Europe , making the continent the world 's largest plug @-@ in regional market in the light @-@ duty segment , which includes utility vans . European registrations are led by Norway with about 105 @,@ 306 units registered since 2004 through May 2016 , followed by the Netherlands with 93 @,@ 310 units registered at the end of May 2016 , France with 89 @,@ 629 units registered since 2010 through May 2016 , the UK with 75 @,@ 914 plug @-@ in cars and vans registered since 2006 , Germany with 57 @,@ 452 plug @-@ in cars registered since 2010 , and Sweden with 21 @,@ 439 registrations since 2011 . The other top selling country is Canada with 20 @,@ 352 new plug @-@ in cars sold between 2011 and May 2016 . As of April 2016 , over 534 @,@ 000 new energy vehicles have been sold in China since 2011 , making the country the world 's leader in the plug @-@ in heavy @-@ duty segment , including electric buses , plug @-@ in trucks , and sanitation trucks . As of December 2015 , China is also the world 's largest electric bus market .

Sales of series production PEVs during its first two years in the global market have been lower than initially expected in all countries . However , an analysis by Scientific American found that at the international level and considering the global top selling PEVs over a 36 @-@ month introductory period , monthly sales of the Volt , Prius PHV and Leaf are performing better than the conventional Prius during their respective introductory periods , with the exception of the Mitsubishi i @-@ MiEV , which has been outsold most of the time by the Prius HEV over their 36 @-@ month introductory periods . A similar trend was found by the U.S. Department of Energy for the American market . Combined sales of plug @-@ in hybrids and battery electric cars are climbing more rapidly and outselling by more than double sales of hybrid @-@ electric vehicles over their respective 24 month introductory periods , as shown in the graph at the left .

During 2014 , four of the ten top selling countries achieved plug @-@ in electric car sales with a market share higher than 1 % of new car sales , Norway ( 13 @.@ 84 % ) , the Netherlands ( 3 @.@ 87 % ) , Sweden ( 1 @.@ 53 % ) , and Japan ( 1 @.@ 06 % ) . Also two small countries achieved this mark in 2014 , Iceland ( 2 @.@ 71 % ) and Estonia ( 1 @.@ 57 % ) . In 2015 nine countries achieved plug @-@ in electric car sales with a market share equal or higher than 1 % of total new car sales , up from six in 2014 . The nine countries are Norway ( 22 @.@ 39 % ) , the Netherlands ( 9 @.@ 74 % ) , Hong Kong ( 4 @.@ 84 % ) , Iceland ( 2 @.@ 93 % ) , Sweden ( 2 @.@ 62 % ) , Denmark ( 2 @.@ 29 % ) , Switzerland ( 1 @.@ 98 % ) , France ( 1 @.@ 2 % ) , and

the UK ( 1 @.@ 1 % ) . In 2015 the European plug @-@ in passenger car market share passed the one percent mark ( 1 @.@ 41 % ) for the first time .

The following table presents the top 10 countries according to their PEV market share of total new car sales between 2015 and 2013 . The market share for two selected regions , Europe and California , is also shown .

= = = = United States = = = =

As of June 2016 , the United States is the country with the largest fleet of light @-@ duty plug @-@ in electric vehicles in the world , with about 474 @,@ 000 highway @-@ capable plug @-@ in electric cars sold since the market launch of the Tesla Roadster in 2008 . As of May 2016 , the American plug @-@ in stock represented 30 @.@ 7 % of the global stock of light @-@ duty plug @-@ in electric vehicles . California is the country 's largest regional market with 200 @,@ 000 plug @-@ in electric vehicles delivered by March 2016 , representing 47 % of all plug @-@ in cars sold in American market since 2008 . As of mid 2013 , 52 % of American plug @-@ in electric car registrations were concentrated in five metropolitan areas : San Francisco , Los Angeles , Seattle , New York , and Atlanta .

Nationwide sales climbed from 17 @,@ 800 units delivered in 2011 to 53 @,@ 200 during 2012 , and reached 97 @,@ 100 in 2013 , up 83 % from the previous year . Cumulative plug @-@ in electric car sales since 2008 reached the 250 @,@ 000 unit milestone in August 2014 . During 2014 plug @-@ in electric car sales totaled 123 @,@ 248 units , up 27 @.@ 0 % from 2013 , and fell to 114 @,@ 248 in 2015 , down 7 @.@ 4 % from 2014 . A total of 64 @,@ 165 plug @-@ in cars were sold during the first half of 2016 , up 18 @.@ 9 % from the same period in 2015 . June 2016 is the best monthly plug @-@ in sales volume on record , with 13 @,@ 772 units delivered . The previous record was set in December 2015 , with over 13 @,@ 274 units delivered .

The market share of plug @-@ in electric passenger cars increased from 0 @.@ 14 % of new car sales in 2011 to 0 @.@ 37 % in 2012 , 0 @.@ 62 % in 2013 , and reached 0 @.@ 75 % of new car sales during 2014 . As plug @-@ in car sales slowed down during 2015 , the segment 's market share fell to 0 @.@ 66 % of new car sales . The market share increased to 0 @.@ 75 % during the first half of 2016 . The highest @-@ ever market share for plug @-@ in vehicles was achieved also in June 2016 with 0 @.@ 91 % of new car sales . California plug @-@ in sales in 2015 achieved a 3 @.@ 1 % market share , 4 @.@ 7 times higher than the U.S. , and its plug @-@ in market share was surpassed only by two countries , Norway ( 22 @.@ 4 % ) and the Netherlands ( 9 @.@ 7 % ) .

As of December 2014 , cumulative sales of plug @-@ in electric vehicles in the U.S. since December 2010 were led by plug @-@ in hybrids , with 150 @,@ 946 units sold representing 52 @.@ 7 % of all plug @-@ in car sales , while 135 @,@ 444 all @-@ electric cars ( 47 @.@ 3 % ) have been delivered to retail customers . This trend was reversed in 2015 , as the all @-@ electric segment grew much faster , with a total of 72 @,@ 303 all @-@ electric cars sold , up 6 @.@ 6 % year @-@ on @-@ year , while plug @-@ in hybrid were down 22 @.@ 4 % year @-@ on @-@ year , with 42 @,@ 959 units sold . As of December 2015 , a total of 206 @,@ 508 all @-@ electric cars and 193 @,@ 904 plug @-@ in hybrids had been sold in the U.S. since 2010 , with all @-@ electrics representing 51 @.@ 6 % of cumulative sales .

As of June 2016 , cumulative sales are led by the Chevrolet Volt plug @-@ in hybrid with 98 @,@ 558 units , followed by the Nissan Leaf all @-@ electric car with 95 @,@ 384 units delivered . The Leaf passed the Chevrolet Volt as the top selling PEV in March 2015 , but the Volt became once again the best selling plug @-@ in car in the American market in March 2016 . Both plug @-@ in cars were released in December 2010 . Launched in the U.S. market in June 2012 , the Tesla Model S ranks as the third top selling plug @-@ in electric car with 74 @,@ 861 units sold , followed by the Prius PHV , launched in February 2012 , with 42 @,@ 335 units . Ranking fifth is the Ford Fusion Energi with 34 @,@ 624 units delivered through June 2016 .

Plug @-@ in electric car sales in 2014 were led by the Nissan Leaf with 30 @,@ 200 units , followed the Volt with 18 @,@ 805 , and the Model S with 16 @,@ 689 units . The Tesla Model S

was the top selling plug @-@ in car in the U.S. in 2015 with 25 @,@ 202 units delivered , followed by the Nissan Leaf with 17 @,@ 269 units , the Volt with 15 @,@ 393 , and the BMW i3 with 11 @,@ 024 . During the first half of 2016 the Model S continued as the top selling plug @-@ in car in the country with about 11 @,@ 700 units , followed by the Volt with 9 @,@ 808 , and the Fusion Energi with 7 @,@ 235 .

= = = = China = = = =

New energy vehicle sales between January 2011 and April 2016 totaled 534 @,@ 344 units , of which , almost 93 % were sold between January 2014 and April 2016 . These figures include heavy @-@ duty commercial vehicles such buses and sanitation trucks , and only include vehicles manufactured in the country as imports are not subject to government subsidies . As of March 2016 , the Chinese stock of plug @-@ in electric vehicles consisted of 366 @,@ 219 all @-@ electric vehicles ( 72 @.@ 9 % ) and 136 @,@ 353 plug @-@ in hybrids ( 27 @.@ 1 % ) .

As of December 2014 , a total of 83 @,@ 198 plug @-@ in electric passenger cars had been registered in the country since 2008 . With 176 @,@ 627 plug @-@ in passenger cars sold in 2015 , China passed the U.S. , the top selling country in 2014 , and became the world 's best @-@ selling plug @-@ in electric car country market in 2015 . As of March 2016 , in terms of light @-@ duty plug @-@ in passenger car stock , China ranks second after the United States , with cumulative sales of around 300 @,@ 000 plug @-@ in cars . As of December 2015 , the Chinese plug @-@ in stock represented 21 % of the global cumulative sales of highway legal plug @-@ in electric passenger cars .

The stock of new energy vehicles sold in China since 2011 , and accounting for all segments , passed the 500 @,@ 000 unit milestone in March 2016 , making the country the world 's leader in the plug @-@ in heavy @-@ duty segment , including electric buses , plug @-@ in trucks , and sanitation trucks . Over 160 @,@ 000 heavy @-@ duty new energy vehicles have been sold between 2011 and 2015 , of which , 123 @,@ 710 ( 77 @.@ 2 % ) were sold in 2015 . Sales of commercial new energy vehicles in 2015 consisted of 100 @,@ 763 all @-@ electric vehicles ( 81 @.@ 5 % ) and 22 @,@ 947 plug @-@ in hybrid vehicles ( 18 @.@ 5 % ) . The share of all @-@ electric bus sales in the Chinese bus market climbed from 2 % in 2010 to 9 @.@ 9 % in 2012 , and was expected to be closed to 20 % for 2013 . As of December 2014 , China had about 36 @,@ 500 all @-@ electric buses . As of December 2015 , China is the world 's largest electric bus market , and by 2020 , the country is expected to account for more than 50 % of the global electric bus market .

A total of 8 @,@ 159 new energy vehicles were sold in China during 2011 , including passenger cars ( 61 % ) and buses ( 28 % ) . Of these , 5 @,@ 579 units were all @-@ electric vehicles and 2 @,@ 580 plug @-@ in hybrids . Electric vehicle sales represented 0 @.@ 04 % of total new car sales in 2011 . Sales of new energy vehicles in 2012 reached 12 @,@ 791 units , which includes 11 @,@ 375 all @-@ electric vehicles and 1 @,@ 416 plug @-@ in hybrids . New energy vehicle sales in 2012 represented 0 @.@ 07 % of the country 's total new car sales . During 2013 new energy vehicle sales totaled 17 @,@ 642 units , up 37 @.@ 9 % from 2012 and representing 0 @.@ 08 % of the nearly 22 million new car sold in the country in 2013 . Deliveries included 14 @,@ 604 pure electric vehicles and 3 @,@ 038 plug @-@ in hybrids . The QQ3 EV was the top selling new energy car in China between 2011 and 2013 , with 2 @,@ 167 units sold in 2011 , 3 @,@ 129 in 2012 , and 5 @,@ 727 in 2013 . Cumulative sales since January 2011 through March 2014 reached 13 @,@ 039 units .

New energy vehicle sales during 2014 reached 74 @,@ 763 units , up 320 % from 2013 , and representing a market share of 0 @.@ 32 % of the 23 @.@ 5 million new car sales sold in the country that year . Of these , 71 % were passenger cars , 27 % buses , and 1 % trucks . A total of 45 @,@ 048 all @-@ electric vehicles were sold in 2014 , up 210 % from a year earlier , and 29 @,@ 715 plug @-@ in hybrids , up 880 % from 2013 . The BYD Qin plug @-@ in hybrid , introduced in December 2013 , ranked as the top selling plug @-@ in electric car in China in 2014 with 14 @,@ 747 units sold , and became the country 's top selling passenger NEV ever . The Qin

was followed by the all @-@ electrics Zotye Zhidou E20 , with 7 @,@ 341 units , and BAIC E150 EV , with 5 @,@ 234 .

Domestically produced new energy vehicle sales in 2015 totaled a record 331 @,@ 092 units , consisting of 247 @,@ 482 all @-@ electric vehicles and 83 @,@ 610 plug @-@ in hybrid vehicles , up 449 % and 191 % from 2014 , respectively . Sales of plug @-@ in passenger cars , excluding imports , totaled 176 @,@ 627 units in 2015 , allowing China to rank as the world 's best @-@ selling plug @-@ in electric car country market in 2015 . The plug @-@ in electric passenger car segment market share rose to 0 @.@ 84 % in 2015 , up from 0 @.@ 25 % in 2014 . The top selling passenger models in 2015 were the BYD Qin plug @-@ in hybrid with 31 @,@ 898 units sold , followed by the BYD Tang ( 18 @,@ 375 ) , and the all @-@ electrics Kandi EV ( 16 @,@ 736 ) , BAIC E150 / 160 / 200 EV ( 16 @,@ 488 ) , and the Zotye Z100 EV ( 15 @,@ 467 ) .

As of December 2015 , the BYD Qin continues to rank as the all @-@ time top selling plug @-@ in passenger car in the country , with cumulative sales of 46 @,@ 787 units since its introduction . The BYD Qin was the world 's second best selling plug @-@ in hybrid car in 2015 after the Mitsubishi Outlander P @-@ HEV , and also ranked fifth among the world 's top selling plug @-@ in electric cars in 2015 . As a reflexion of the explosive growth of the Chinese plug @-@ in electric car market in 2015 , BYD Auto ended 2015 as the world 's best selling manufacturer of highway legal light @-@ duty plug @-@ in electric vehicles , with around 60 @,@ 000 units sold , ahead of Tesla Motors ( 50 @,@ 580 ) .

Sales of domestically produced new energy vehicle sales totaled 58 @,@ 125 units during the first quarter of 2016 , consisting of 42 @,@ 131 all @-@ electric vehicles and 15 @,@ 994 plug @-@ in hybrid vehicles , up 140 % and 43 % from the same quarter in 2015 , respectively . Sales in the new energy passenger segment totaled 39 @,@ 500 units , consisting of 24 @,@ 480 all @-@ electric cars and 14 @,@ 800 plug @-@ in hybrids , up 63 % and 37 % from the same quarter in 2015 , correspondinly .

= = = = Japan = = = =

As of March 2016 , the stock of light @-@ duty plug @-@ in electric vehicles in Japan is the third largest in the world after the United States and China , with about 150 @,@ 000 highway legal plug @-@ in electric vehicles sold in the country since 2009 . During 2012 , global sales of pure electric cars were led by Japan with a 28 % market share of total sales , followed by the United States with a 26 % share . Japan ranked second after the U.S. in terms of its share of plug @-@ in hybrid sales in 2012 , with a 12 % of global sales . A total of 30 @.@ 587 highway @-@ capable plug @-@ in electric vehicles were sold in Japan in 2013 . In 2014 the segment sales remained flat with 30 @,@ 390 units sold , and a market share of 1 @.@ 06 % of total new car sales in the country ( kei cars not included ) .

As of December 2014 , the Nissan Leaf is the market leader with 48 @,@ 641 units sold since December 2010 , followed by the Mitsubishi Outlander P @-@ HEV with 19 @,@ 672 units sold since January 2013 . The Prius PHV has sold 19 @,@ 100 units between January 2012 and September 2014 , and the Mitsubishi i @-@ MiEV , launched for fleet customers in Japan in late July 2009 , with cumulative sales of 10 @,@ 423 i @-@ MiEVs through September 2014 . Combined sales of the van and truck version of the Mitsubishi Minicab MiEV reached 6 @,@ 291 units through December 2014 . Other models available in Japan are the Honda Accord Plug @-@ in Hybrid , Tesla Model S , BMW i3 , BMW i8 , and the Nissan e @-@ NV200 , but official sales figures are not available .

During 2013 sales were led by the Nissan Leaf with 13 @,@ 021 units , followed by the Outlander P @-@ HEV with 9 @,@ 608 units . The Leaf continued as the market leader in 2014 with 14 @,@ 177 units sold , followed by the Outlander P @-@ HEV with 10 @,@ 064 units , together representing about 80 % of the plug @-@ in segment sales in Japan in 2014 ( 30 @,@ 390 ) .

= = = = Europe = = = =

Cumulative sales of light @-@ duty plug @-@ in electric vehicles in Europe passed the 500 @,@ 000 unit milestone in May 2016 , representing about a third of global sales . Of these , 192 @,@ 827 units ( 38 @.@ 6 % ) were registered in 2015 . Out of the plug @-@ in stock registered in 2015 , passenger cars accounted for 186 @,@ 170 units ( 96 @.@ 5 % ) . European sales in the light @-@ duty plug @-@ in electric segment , which includes utility vans , were led by the Netherlands with almost 90 @,@ 000 units registered at the end of 2015 . Almost 25 % of the European stock is on the roads in the Nordic countries , with over 100 @,@ 000 registered plug @-@ in electric cars as of December 2015 . Combined registrations in the four countries in 2015 were up 91 % from 2014 . The stock of light @-@ duty plug @-@ in electric vehicles registered in Norway passed the 100 @,@ 000 unit milestone in April 2016 , making the country the fourth largest plug @-@ in market in the world after the U.S. , China and Japan , and becoming the leading European market .

A total of 1 @,@ 614 all @-@ electric cars and 1 @,@ 305 light @-@ utility vehicles were sold in 2010 . Sales jumped from 2 @,@ 919 units in 2010 to 13 @,@ 779 in 2011 , consisting of 11 @,@ 271 pure electric cars and 2 @,@ 508 commercial vans . In addition , over 300 plug @-@ in hybrids were sold in 2011 , mainly Opel Amperas . Light @-@ duty plug @-@ in vehicle sales totaled 34 @,@ 333 units in 2012 , consisting of 24 @,@ 713 all @-@ electric cars and vans , and 9 @,@ 620 plug @-@ in hybrids . The Opel / Vauxhall Ampera plug @-@ in hybrid was Europe 's top selling plug @-@ in electric car in 2012 with 5 @,@ 268 units , closely followed by the all @-@ electric Nissan Leaf with 5 @,@ 210 units .

The plug @-@ in segment sales more than double to 71 @,@ 943 units in 2013 . Pure electric passenger and light commercial vehicles sales increased by 63 @.@ 9 % to 40 @,@ 496 units . In addition , a total of 31 @,@ 477 extended @-@ range cars and plug @-@ in hybrids were sold in 2013 . Registrations reached 104 @,@ 746 light @-@ duty plug @-@ in electric vehicles in 2014 , up 45 @.@ 6 % from 2013 . A total of 65 @,@ 199 pure electric cars and light @-@ utility vehicles were registered in Europe in 2014 , up 60 @.@ 9 % from 2013 . All @-@ electric passenger cars represented 87 % of the European all @-@ electric segment registrations . Extended @-@ range cars and plug @-@ in hybrid registrations totaled 39 @,@ 547 units in 2014 , up 25 @.@ 8 % from 2013 .

For the first time in the region , in 2015 plug @-@ in hybrids ( 195 @,@ 140 ) outsold all @-@ electric cars ( 89 @,@ 640 ) in the passenger car segment , however , when light @-@ duty plug @-@ in utility vehicles are accounted for , the all @-@ electric segment totaled 97 @,@ 687 registrations in 2015 , up 65 @,@ 199 in 2014 , and ahead of the plug @-@ in hybrid segment . Also in 2015 , the European market share of plug @-@ in electric cars passed the 1 % mark for the first time , with a 1 @.@ 41 % share of new car sales that year .

During 2013 took place a surge in sales of plug @-@ in hybrids in the European market , particularly in the Netherlands , with 20 @,@ 164 PHEVs registered during the year . Out of the 71 @,@ 943 highway @-@ capable plug @-@ in electric passenger cars and utility vans sold in the region during 2013 , plug @-@ in hybrids totaled 31 @,@ 447 units , representing 44 % of the plug @-@ in electric vehicle segment sales that year . This trend continued in 2014 . Plug @-@ in hybrids represented almost 30 % of the plug @-@ in electric drive sales during the first six months of 2014 , and with the exception of the Nissan Leaf , sales of the previous European best selling models fell significantly , while recently introduced models captured a significant share of the segment sales , with the Mitsubishi Outlander P @-@ HEV , Tesla Model S , BMW i3 , Renault Zoe , Volkswagen e @-@ Up ! , and the Volvo V60 Plug @-@ in Hybrid ranking among the top ten best selling models .

In 2014 Norway was the top selling country in the light @-@ duty all @-@ electric market segment , with 18 @,@ 649 passenger cars and utility vans registered , more than doubling its 2013 sales . France ranked second with 15 @,@ 046 units registered , followed by Germany with 8 @,@ 804 units , the UK with 7 @,@ 730 units , and the Netherlands with 3 @,@ 585 car and vans registrations . The Netherlands was the top selling country in the plug @-@ in hybrid segment with 12 @,@ 425 passenger cars registered , followed by the UK with 7 @,@ 821 , Germany with 4 @,@ 527 , and Sweden 3 @,@ 432 units . Five European countries achieved plug @-@ in electric car sales with a market share higher than 1 % of new car sales in 2014 , Norway ( 13 @.@ 84 % ) ,

the Netherlands ( 3 @.@ 87 % ) , Iceland ( 2 @.@ 71 % ) , Estonia ( 1 @.@ 57 % ) , and Sweden ( 1 @.@ 53 % ) .

In 2013 the top selling plug @-@ in was the Leaf with 11 @,@ 120 units sold , followed by the Outlander P @-@ HEV with 8 @,@ 197 units . The Mitsubishi Outlander plug @-@ in hybrid was the top selling plug @-@ in electric vehicle in Europe in 2014 with 19 @,@ 853 units sold , surpassing of the Nissan Leaf ( 14 @,@ 658 ) , which fell to second place . Ranking third was the Renault Zoe with 11 @,@ 231 units .

For a second year running , the Mitsubishi ? s Outlander P @-@ HEV was the top selling plug @-@ in electric car in Europe with 31 @,@ 214 units sold in 2015 , up 57 % from 2014 . The Renault Zoe ranked second among plug @-@ in electric cars , with 18 @,@ 727 registrations , and surpassed the Nissan Leaf to become best selling pure electric car in Europe in 2015 . Ranking next were the Volkswagen Golf GTE plug @-@ in hybrid ( 17 @,@ 300 ) , followed by the all @-@ electric Tesla Model S ( 15 @,@ 515 ) and the Nissan Leaf ( 15 @,@ 455 ) , the BMW i3 , including its REx variant , ( 12 @,@ 047 ) , and the Audi A3 e @-@ tron plug @-@ in hybrid ( 11 @,@ 791 ) .

The Netherlands was the top selling country in the European light @-@ duty plug @-@ in electric market segment , with 43 @,@ 971 passenger cars and utility vans registered in 2015 . Norway ranked second with 34 @,@ 455 units registered , followed by the UK with 28 @,@ 188 units , France with 27 @,@ 701 car and vans registrations , and Germany with 23 @,@ 464 plug @-@ in cars . Eight European countries achieved plug @-@ in electric car sales with a market share higher than 1 % of new car sales in 2015 , Norway ( 22 @.@ 4 % ) , the Netherlands ( 9 @.@ 7 % ) , Iceland ( 2 @.@ 9 % ) , Sweden ( 2 @.@ 6 % ) , Denmark ( 2 @.@ 3 % ) , Switzerland ( 2 @.@ 0 % ) , France ( 1 @.@ 2 % ) and the UK ( 1 @.@ 1 % ) .

As of December 2015 , and accounting for cumulative sales since 2010 , the Mitsubishi Outlander P @-@ HEV is the all @-@ time top selling plug @-@ in electric car in the region with 59 @,@ 264 units delivered , followed by the Nissan Leaf with 48 @,@ 936 units , Renault Zoe with 38 @,@ 890 units , Tesla Model S with 28 @,@ 149 , and the BMW i3 with 23 @,@ 268 units . The Renault Kangoo Z.E. is the top selling all @-@ electric utility van with 21 @,@ 016 units .

= = = = = Norway = = = = =

The stock of light @-@ duty plug @-@ in electric vehicles registered in Norway passed the 100 @,@ 000 unit milestone in April 2016 , making the country the fourth largest plug @-@ in market in the world . Accounting for registrations of both new car sales and used imports , the Norwegian light @-@ duty plug @-@ in electric fleet consist of about 81 @,@ 500 all @-@ electric passenger cars , almost 17 @,@ 100 plug @-@ in hybrids , and over 2 @,@ 000 all @-@ electric vans . The government 's target of 50 @,@ 000 all @-@ electric cars on Norwegian roads was reached in April 2015 , more than two years earlier than expected .

Sales of used imports in Norway are significant , and as of December 2015 , over 11 @,@ 500 used plug @-@ in vehicles from neighboring countries had been imported , mainly pure electric cars . Registrations of used all @-@ electric cars totaled 2 @,@ 086 units in 2013 , 3 @,@ 063 in 2014 and 5 @,@ 122 in 2015 . In addition , about 1 @,@ 300 used electric cars were imported into Norway before 2013 .

The Norwegian fleet of electric cars is one of the cleanest in the world because almost 100 % of the electricity generated in the country comes from hydropower . Norway , with about 5 @.@ 2 million people , is the country with the largest EV ownweship per capita in the world . In March 2014 , Norway became the first country where over one in every 100 registered passenger cars is plug @-@ in electric . The segment 's market penetration reached 2 % in March 2015 , and passed 3 % in December 2015 .

The Norwegian plug @-@ in electric vehicle market share of new car sales is the highest in the world , the EV segment market share rose from 1 @.@ 6 % in 2011 , to 3 @.@ 1 % in 2012 , and reached 5 @.@ 6 % of new car sales in 2013 . The Norwegian all @-@ electric segment increased its market share of new car sales to 12 @.@ 5 % in 2014 , and rises to 13 @.@ 8 % if plug @-@ in

hybrids are accounted for . The combined sales of new plug @-@ in cars reached a market share of 23 @.@ 4 % of all new passenger cars sold in 2015 , with the all @-@ electric car segment reaching 17 @.@ 1 % , while the plug @-@ in hybrid segment reached 5 @.@ 2 % .

Also , Norway was the first country in the world to have electric cars topping the new car sales monthly ranking . The Tesla Model S has been the top selling new car four times , twice in 2013 , first in September and again in December , one more time in March 2014 , and again in March 2015 . The Nissan Leaf has topped the monthly new car sales ranking twice , first in October 2013 and again in January 2014 . In March 2014 the Tesla Model S also broke the 28 @-@ year @-@ old record for monthly sales of a single model regardless of its power source , with 1 @,@ 493 units sold , surpassing the Ford Sierra , which sold 1 @,@ 454 units in May 1986 . In March 2015 another record was set , with three all @-@ electric cars ranking as the top 3 selling new cars in the country , the Tesla Model S with 1 @,@ 140 units , the Volkswagen e @-@ Golf with 956 ( out of a total of 1 @,@ 421 units sold by the Golf nameplate ) , and the Nissan Leaf with 526 .

Plug @-@ in electric vehicle registrations totaled 10 @,@ 769 units in 2013 , and the segment achieved a 6 @.@ 9 % market share of total 2013 car registrations . The Leaf continued as the top selling plug @-@ in electric car in 2013 , with 4 @,@ 604 new units sold , followed by the Tesla Model S with 1 @,@ 986 units , and the Volkswagen e @-@ Up ! with 580 . A total of 23 @,@ 390 plug @-@ in electric vehicles were registered in 2014 including used imports . Combined sales of new and used plug @-@ in electric vehicles captured a 13 @.@ 84 % market share of total passenger car registrations in 2014 . Plug @-@ in electric car sales in 2014 were led by the Nissan Leaf with 4 @,@ 781 new registrations , followed by Tesla Model S with 4 @,@ 040 units . Norway ended 2014 as the top selling European country in the light @-@ duty all @-@ electric market segment , with 18 @,@ 649 passenger cars and utility vans registered .

A total of 39 @,@ 632 light @-@ duty plug @-@ in electric vehicles were registered in Norway in 2015 , up 69 @.@ 3 % from 2014 . New plug @-@ in sales totaled 34 @,@ 455 units , consisting of 25 @,@ 779 pure electric cars , 7 @,@ 964 plug @-@ in hybrids , and 712 all @-@ electric utility vans . A total of 5 @,@ 177 used imports were registered , of which , 5 @,@ 122 were pure electric cars . The Norwegian fleet of light @-@ duty plug @-@ in electric vechicles reached 84 @,@ 401 units registered as of December 2015 , including both new and used imports , and consisting of 74 @,@ 024 all @-@ electric passenger and light @-@ duty vehicles , and 10 @,@ 377 plug @-@ in hybrids .

The combined sales of new plug @-@ in cars reached a market share of 23 @.@ 4 % of all new passenger cars sold in 2015 , with the all @-@ electric car segment reaching 17 @.@ 1 % , up from 12 @.@ 5 % in 2014 , while the plug @-@ in hybrid segment reached 5 @.@ 2 % , up from 1 % in 2014 . The VW e @-@ Golf , with 8 @,@ 943 units sold , was the best @-@ selling plug @-@ in electric car in Norway in 2015 , ahead of the Tesla Model S ( 4 @,@ 039 ) and the Nissan Leaf ( 3 @,@ 189 ) . The top selling plug @-@ in hybrid in 2015 was the Mitsubishi Outlander P @-@ HEV with 2 @,@ 875 units , followed by the Volkswagen Golf GTE with 2 @,@ 000 , and the Audi A3 e @-@ tron with 1 @,@ 684 units .

As of December 2015 , the Nissan Leaf continued as the all @-@ time best selling plug @-@ in electric car in the country with a total of 15 @,@ 245 new Leafs registered since 2011 . In addition , a significant number of used imported Leafs from neighboring countries have been registered in the country , raising the stock of registered Leafs to over 20 @,@ 000 units , meaning that more than 10 % of Leafs sold in the world are on Norwegian roads by November 2015 . Ranking second is the Volkswagen e @-@ Golf , with 10 @,@ 961 new units registered since 2014 , flowed by the Tesla Model S , with 10 @,@ 062 new units registered in Norway through December 2015 , representing about 10 % of the Model S global sales .

The highest @-@ ever monthly market share for plug @-@ in electric passenger segment was achieved in March 2016 with 33 @.@ 5 % of new car sales ; the all @-@ electric car segment had a 18 @.@ 7 % market share among new passenger cars , while the plug @-@ in hybrid segment had a 14 @.@ 8 % . Sales of new light @-@ duty plug @-@ in vehicles totaled 22 @,@ 425 units during the first half of 2016 , consisting of 11 @,@ 744 all @-@ electric cars , 10 @,@ 338 plug @-@ in hybrids , and 343 all @-@ electric vans . The combined sales of new plug @-@ in cars

reached a market share of 28 @.@ 4 % of all new passenger cars sold during the first six months of 2016 , with the all @-@ electric car segment reaching 15 @.@ 1 % , down from 18 @.@ 4 % in the same period in 2015 , while the plug @-@ in hybrid segment reached a record 13 @.@ 3 % , up from 4 @.@ 5 % in 2015 . The all @-@ electric van segment captured 2 @.@ 2 % of new van sales , up from 0 @.@ 4 % during the same period the previous year . The VW e @-@ Golf continued as top selling all @-@ electric car during the first half of 2016 with 2 @,@ 859 units , representing 24 @.@ 3 % of the all @-@ electric car sales , while the Mitsubishi Outlander P @-@ HEV was the top selling plug @-@ in hybrid , with 2 @,@ 843 units representing 27 @.@ 5 % of the segment sales .

= = = = = Netherlands = = = = =

A total of 93 @,@ 310 highway legal light @-@ duty plug @-@ in electric vehicles were registered in the Netherlands by the end of May 2016 , consisting of 81 @,@ 124 range @-@ extended and plug @-@ in hybrids , 10 @,@ 690 pure electric cars , and 1 @,@ 496 all @-@ electric light utility vans . When buses , trucks , motorcycles , quadricycles and tricycles are accounted for , the Dutch plug @-@ in electric @-@ drive fleet climbs to 94 @,@ 726 units . The country 's electric vehicle stock reaches 128 @,@ 936 units when fuel cell electric vehicles ( 23 ) , mopeds ( 3 @,@ 682 ) , electric bicycles ( 30 @,@ 265 ) , and microcars ( 240 ) are accounted for .

As of May 2016 , the Netherlands ranks as the second top selling European market after Norway , and also has the world 's fifth largest light @-@ duty plug @-@ in vehicle stock . With 43 @,@ 971 plug @-@ in passenger cars and utility vans registered in 2015 , the Netherlands was the world 's third best @-@ selling country market for light @-@ duty plug @-@ in vehicles that year . The Netherlands is also among the country 's with the highest EV market penetration in the world .

Registrations of plug @-@ in electric car represented a 0 @.@ 57 % share of total new car registrations in the country during 2011 and 2012 . During 2013 plug @-@ in electric passenger car registrations totaled 22 @,@ 415 units , climbing 338 % from 2012 , the highest rate of growth of any country in the world in 2013 . The segment 's market share surged almost ten times from 2012 to 5 @.@ 37 % new car sales in the country during that year , the world 's second highest in 2013 after Norway ( 5 @.@ 6 % ) . The rapid growth of segment during 2013 , allowed the Netherlands to reach a market penetration for plug @-@ in vehicles of around 1 @.@ 71 vehicles per 1 @,@ 000 people , second only to Norway ( 4 @.@ 04 ) . The market share of the plug @-@ in electric passenger car segment in 2014 fell to 3 @.@ 86 % of total new passenger car registrations , after the end of some of the tax incentives . With 43 @,@ 769 plug @-@ in passenger cars registered in 2015 , the segment market share rose to a record 9 @.@ 7 % of new car sales in the Dutch market in 2015 , the second highest after Norway ( 22 @.@ 4 % ) .

In November 2013 , a total of 2 @,@ 736 Mitsubishi Outlander P @-@ HEVs were sold , making the plug @-@ in hybrid the top selling new car in the country that month , representing a market share of 6 @.@ 8 % of all the new cars sold . Again in December 2013 , the Outlander P @-@ HEV ranked as the top selling new car in the country with 4 @,@ 976 units , representing a 12 @.@ 6 % market share of new car sales , contributing to a world record plug @-@ in vehicle market share of 23 @.@ 8 % of new car sales . The Netherlands is the second country , after Norway , where plug @-@ in electric cars have topped the monthly ranking of new car sales . The strong increase of plug @-@ in car sles during the last months of 2013 was due to the end of the total exemption of the registration fee for corporate cars , which is valid for 5 years . From January 1 , 2014 , all @-@ electric vehicles pay a 4 % registration fee and plug @-@ in hybrids a 7 % fee .

A total of 15 @,@ 678 light @-@ duty plug @-@ in electric vehicles were registered in the Netherlands in 2014 , consisting of 12 @,@ 425 plug @-@ in hybrids , down 38 @.@ 4 % from 2013 , 2 @,@ 664 all @-@ electric cars , up 18 @.@ 3 % from a year earlier , and 589 vans , up 236 @.@ 6 % from 2013 . Sales in 2014 were led by the Outlander P @-@ HEV with 7 @,@ 666 units , followed by Volvo V60 Plug @-@ in Hybrid with 3 @,@ 126 units , and Tesla Model S with 1 @,@ 465 units sold .

The top 5 best @-@ selling plug @-@ in electric cars in 2015 were all plug @-@ in hybrids , led by the Mitsubishi Outlander P @-@ HEV ( 8 @,@ 757 ) , followed by the Volkswagen Golf GTE ( 8

@,@ 183 ) , Audi A3 e @-@ tron ( 4 @,@ 354 ) , Volvo V60 Plug @-@ in Hybrid ( 3 @,@ 851 ) , and Volkswagen Passat GTE ( 2 @,@ 879 ) . The top selling all @-@ electric car was the Tesla Model S ( 1 @,@ 842 ) . Plug @-@ in car sales achieved its best monthly volume on record ever in December 2015 , with about 15 @,@ 900 units sold , and allowing the segment to reach a record market share of about 23 % . The surge in plug @-@ in car sales was due to reduction of the registration fees for plug @-@ in hybrids . From January 1 , 2016 , all @-@ electric vehicles continue to pay a 4 % registration fee , but for a plug @-@ in hybrid the fee rises from 7 % to 15 % if its CO2 emissions do not exceed 50 g / km . The rate for a conventional internal combustion car is 25 % of its book value .

As of December 2015 , the Mitsubishi Outlander P @-@ HEV continues as the all @-@ time top @-@ selling plug @-@ in car in the country with 24 @,@ 506 registered . Ranking second is the Volvo V60 Plug @-@ in Hybrid ( 14 @,@ 470 ) , followed by the Volkswagen Golf GTE ( 8 @,@ 806 ) , Opel Ampera ( 4 @,@ 947 units ) , Tesla Model S ( 4 @,@ 832 ) , and Audi A3 e @-@ tron ( 4 @,@ 657 ) . A total of 78 @,@ 163 plug @-@ in hybrids out of 87 @,@ 531 passenger plug @-@ in electric vehicles were registered in the Netherlands as of 31 December 2015 , meaning that plug @-@ in hybrids dominate the Dutch market with a share of 89 @.@ 3 % of the country 's highway legal plug @-@ in electric car stock .

= = = = = France = = = = =

Since January 2010 , a total of 86 @,@ 909 light @-@ duty plug @-@ in electric vehicles have been registered in France through April 2016 , consisting of 54 @,@ 066 electric passenger cars , 22 @,@ 473 all @-@ electric utility vans , and 10 @,@ 370 plug @-@ in hybrids . Electric car registrations increased from 184 units in 2010 to 2 @,@ 630 in 2011 . Sales in 2012 increased 115 % from 2011 to 5 @,@ 663 cars , allowing France to rank 4th among the top selling EV countries , with an 11 % market share of global all @-@ electric car sales in 2012 . Registrations reached 8 @,@ 779 electric cars in 2013 , up 55 @.@ 0 % from 2012 , and the all @-@ electric market share of total new car sales went up to 0 @.@ 49 % from 0 @.@ 3 % in 2012 .

In addition , 5 @,@ 175 electric utility vans were registered in 2013 , up 42 % from 2012 , and representing a market share of 1 @.@ 4 % of all new light commercial vehicles sold in 2013 . Sales of electric passenger cars and utility vans totaled 13 @,@ 954 units in 2013 , capturing a combined market share of 0 @.@ 65 of these two segments new car sales . When sales of pure electric cars and light utility vehicles are accounted together , France was the leading the European all @-@ electric market in 2012 and 2013 .

During 2014 sales of all @-@ electric vehicles in France passed the 10 @,@ 000 unit milestone for the first time . A total of 15 @,@ 045 all @-@ electric cars and vans were registered in 2014 , up 7 @.@ 8 % from 2013 . A total of 10 @,@ 560 pure electric passenger cars registered in 2014 , up 20 @.@ 3 % from the previous year . This figure rises to 10 @,@ 968 units if the BMW i3 with range extender is accounted for . All @-@ electric utility vans continued to be a significant share of the all @-@ electric segment , with 4 @,@ 485 units registered in 2014 , but down 13 @.@ 3 % from 2013 . All @-@ electric cars captured a 0 @.@ 59 % market share of the 1 @.@ 7 million new car registered in France in 2014 , while light @-@ duty electric vehicles reached a 1 @.@ 22 % market share of their segment . Combined both segments represented a market share of 0 @.@ 70 % of new registrations in the country in 2014 . Light @-@ duty all @-@ electric vehicle sales achieved its best monthly volume on record ever in December 2014 , with 2 @,@ 227 units registered , twice the volume registered the same month in 2013 . The slow down in sales that took place in the French EV market during the first half of 2014 , allowed Norway , with 18 @,@ 649 new all @-@ electric vehicles registered , to end 2014 as the top selling European market in the light @-@ duty all @-@ electric segment , and France ranked second . A total of 14 @,@ 833 light @-@ duty all @-@ electric vehicles were sold during the first nine months of 2015 , up 48 % from 2014 year @-@ on @-@ year .

In the French market plug @-@ in hybrids or rechargeable hybrids are classified and accounted together with conventional hybrid electric vehicles . Almost 1 @,@ 500 plug @-@ in hybrids were

registered during 2012 and 2013 , 666 units in 2012 , and 808 units in 2013 . Plug @-@ in hybrid car registrations totaled 1 @,@ 519 units in 2014 , almost doubling registrations from a year earlier . Plug @-@ in hybrid sales were driven by the Mitsubishi Outlander P @-@ HEV , with 820 units registered in 2014 , representing 54 % of the segment registrations in France that year . Between 2012 and 2014 , cumulative plug @-@ in hybrid registrations totaled 2 @,@ 985 units , rising cumulative French registrations of light @-@ duty plug @-@ in electric vehicles since 2005 to 46 @,@ 590 units , just ahead of the Netherlands ( 45 @,@ 020 ) , and making France the European country where there are more plug @-@ in electric vehicles on the road .

During 2012 , all @-@ electric car registrations in France were led by the Bolloré Bluecar with 1 @,@ 543 units . The Renault Kangoo Z.E. was the top selling utility electric vehicle with 2 @,@ 869 units registered in 2012 , representing a market share of 82 % of the segment . The Renault Twizy electric quadricycle , launched in March 2012 , sold 2 @,@ 232 units during 2012 , surpassing the Bolloré Bluecar , and ranked as the second best selling plug @-@ in electric vehicle after the Kangoo Z.E. During 2013 , registrations of pure electric cars were led by the Renault Zoe with 5 @,@ 511 units , representing 62 @.@ 8 % of total EV sales . Registrations of all @-@ electric light utility vehicles were led by the Renault Kangoo Z.E. with 4 @,@ 174 units , representing 80 @.@ 7 % of the segment sales .

The Zoe continued leading all @-@ electric vehicle registration in 2014 , with 5 @,@ 970 units registered , followed by the Kangoo Z.E. van with 2 @,@ 657 registrations , and the Nissan Leaf ranked next with 1 @,@ 600 units . As of December 2014 , the French leader in the all @-@ electric segment is the Renault Zoe with 11 @,@ 529 units registered since 2012 , followed by the Kangoo Z.E. utility van with 10 @,@ 483 units registered since 2010 , the Bolloré Bluecar with 3 @,@ 770 units , and the Nissan Leaf with 3 @,@ 645 units . Most units of the Bluecar are in operation for the Autolib ' carsharing service in Paris , and similar carsharing programs in Lyon and Bordeaux .

= = = = = United Kingdom = = = = =

About 71 @,@ 000 plug @-@ in electric vehicles have been registered in the UK up until March 2016 , including about 67 @,@ 000 plug @-@ in hybrids and all @-@ electric cars , and about 4 @,@ 000 plug @-@ in commercial vans . This figure includes a significant number of registered plug @-@ in electric cars and vans which were not eligible for the grant schemes . Since the launch of the Plug @-@ In Car Grant in January 2011 , a total of 66 @,@ 296 eligible cars have been registered through June 2016 , and , as of March 2016 , the number of claims made through the Plug @-@ in Van Grant scheme totaled 2 @,@ 167 units since the launch of the scheme in 2012 .

Before the introduction of series production plug @-@ in vehicles , a total of 1 @,@ 096 all @-@ electric vehicles were registered in the UK between 2006 and December 2010 . All @-@ electric car sales grew from 138 units in 2010 to 1 @,@ 082 units during 2011 . Before 2011 , the G @-@ Wiz , a heavy quadricycle , listed as the top @-@ selling EV for several years . During 2012 , a total of 2 @,@ 254 plug @-@ in electric cars were registered in the UK . Sales in 2012 were led by the Nissan Leaf with 699 units , followed by the Toyota Prius Plug @-@ in Hybrid with 470 . Vehicles eligible for the Plug @-@ in Car Grant accounted for 0 @.@ 1 % of total new car sales in 2012 . Plug @-@ in electric car registrations totaled 3 @,@ 584 units in 2013 , up 59 @.@ 0 % from 2012 . Plug @-@ in car sales represented a 0 @.@ 16 % market share of new cars sold in the UK in 2013 . The top selling plug @-@ in electric car in 2013 was the Nissan Leaf , with over 1 @,@ 650 units sold , and the Prius PHV ended 2013 as the top selling plug @-@ in hybrid with 509 units .

The British market experienced a rapid growth of plug @-@ in car sales during 2014 , driven by the introduction of new models such as the BMW i3 , Tesla Model S , Mitsubishi Outlander P @-@ HEV , Renault Zoe , and Volkswagen e @-@ Up ! . Plug @-@ in electric car registrations in the UK quadruple from 3 @,@ 586 in 2013 to 14 @,@ 518 units in 2014 . Registrations consisted of 6 @,@ 697 pure electrics and 7 @,@ 821 plug @-@ in hybrids . Total registrations in 2014 were up 305 % from 2013 , with all @-@ electric cars growing 167 % while plug @-@ in hybrid registrations were up 628 % from a year earlier . The plug @-@ in electric car segment captured a 0 @.@ 59 % market share of new car sales in 2014 , up from 0 @.@ 16 % in 2013 . In November 2014 the

passenger plug @-@ in segment 's market share passed 1 % of monthly new car sales for the first time in the UK .

The Mitsubishi plug @-@ in hybrid became the top selling plug @-@ in electric vehicle in July 2014 and captured 43 % of all applications to the Plug @-@ in Car Grants scheme that month . The Outlander P @-@ HEV ended 2014 as the top selling plug @-@ in electric car in the UK that year with 5 @,@ 370 units sold . The Nissan Leaf sales also experienced a significant growth in 2014 , with 4 @,@ 051 units sold , up 124 % from the 1 @,@ 812 units sold in 2013 .

The surge in demand for plug @-@ in cars continued during 2015 . Plug @-@ in electric car registrations in the UK totaled 28 @,@ 188 units in 2015 , consisting of 9 @,@ 934 pure electric cars and 18 @,@ 254 plug @-@ in hybrids . Total registrations in 2015 were up 94 @.@ 0 % from 2014 , with all @-@ electric cars growing 48 @.@ 3 % year @-@ on @-@ year , while plug @-@ in hybrid registrations were up 133 @.@ 0 % year @-@ on @-@ year . The plug @-@ in electric car segment raised its market share of new car sales in 2015 to almost 1 @.@ 1 % , up from 0 @.@ 59 % in 2014 . The plug @-@ in segment reached a record market share of 1 @.@ 7 % of new car sales in the UK , the highest ever .

Sales of the Mitsubishi Outlander P @-@ HEV in the British market reached the 10 @,@ 000 unit milestone in March 2015 , allowing the plug @-@ in hybrid to overtake the Leaf as the all @-@ time top selling plug @-@ in electric vehicle in the UK . Sales of the Nissan Leaf sales passed the 10 @,@ 000 unit milestone in June 2015 . The top selling models in 2015 were the Outlander P @-@ HEV with 11 @,@ 681 units registered , up 118 % from 2014 , followed by the Leaf with 5 @,@ 236 units ( up 29 % ) , and the BMW i3 with 2 @,@ 213 units ( up 59 % ) . As of December 2015 , the Outlander P @-@ HEV continued to rank as the top selling plug @-@ in electric car in the UK ever , with 17 @,@ 045 units registered , and the Nissan Leaf , the top selling all @-@ electric car ever , totaled 12 @,@ 433 units registered . Plug @-@ in car sales in March 2016 achieved the best monthly plug @-@ in sales volume on record ever , with 7 @,@ 144 grant eligible cars registered , exceeding the previous high of 6 @,@ 104 units , recorded in March 2015 .

A total of 19 @,@ 252 plug @-@ in electric cars were registered in the UK during the first half of 2016 , consisting of 5 @,@ 267 pure electrics , up 12 @.@ 5 % from the same period in 2015 , and 13 @,@ 985 plug @-@ in hybrids , up 40 @.@ 8 % from 2015 . During the first half of 2016 the plug @-@ in car segment 's market share reached 1 @.@ 36 % of new car sales . While overall new car registrations year @-@ to @-@ date increased 3 @.@ 2 % from the same period in 2015 , total plug @-@ in car registrations during the quarter increased 31 @.@ 8 % from 2015 .

= = = = = Germany = = = = =

As of April 2016 , there were about 57 @,@ 000 plug @-@ in electric cars registered in Germany . About 73 % of the about 50 @,@ 000 plug @-@ in cars registered in the country by the end of 2015 took place during the last two years , with 13 @,@ 049 units registered in 2014 , and 23 @,@ 464 registered in 2015 . The official German definition of electric vehicles changed at the beginning of 2013 , before that , official statistics only registered all @-@ electric vehicles because plug @-@ in hybrids were accounted together with conventional hybrids . As a result , the registrations figures for 2012 and older do not account for total new plug @-@ in electric car registrations . As of November 2014 , the country had 4 @,@ 800 public charging stations .

Total plug @-@ in electric car registrations increased from 1 @,@ 558 units in 2009 to 2 @,@ 307 in 2010 . The total registered plug @-@ in electric stock in 2011 increased 96 @.@ 8 % from 2010 to 4 @,@ 541 cars , to 7 @,@ 114 in 2012 , and reached 12 @,@ 156 registered cars on 1 January 2014 . Registrations of plug @-@ in electric drive vehicles represented a 0 @.@ 028 % market share of all passenger vehicles registered in Germany at the beginning of 2014 . The plug @-@ in hybrid segment in the German market in 2014 experienced an explosive growth of 226 @.@ 9 % year @-@ over @-@ year , and the overall plug @-@ in segment increased 75 @.@ 5 % from a year earlier . The surge in sales continued in 2015 , the plug @-@ in hybrid segment grew 125 @.@ 1 % year @-@ over @-@ year , while the all @-@ electric segment climbed 91 @.@ 2 % from the previous year .

During 2011 , a total of 2 @,@ 154 pure electric cars were registered in the country , up from 541 units in 2010 . All @-@ electric car sales for 2011 were led by the Mitsubishi i @-@ MiEV family with 683 i @-@ MiEVs , 208 Peugeot iOns and 200 Citroën C @-@ Zeros , representing 50 @.@ 6 % of all electric car registrations in 2011 . Plug @-@ in hybrid registrations totaled 266 units in 2011 , 241 Opel Amperas and 25 Chevrolet Volts , for a total of 2 @,@ 420 plug @-@ in electric vehicles registered in 2011 .

A total of 2 @,@ 956 all @-@ electric vehicles were registered in Germany during 2012 , a 37 @.@ 2 % increase over 2011 . When 901 registered plug @-@ in hybrids are accounted for , 2012 registrations climb to 3 @,@ 857 units , and sales of plug @-@ in electric car represented a 0 @.@ 12 % market share of new passenger vehicles sold in the country in 2012 . Most sales in the country were made by corporate and fleet customers and 1 @,@ 493 all @-@ electric vehicles were registered by the automobile industry , as demonstration or research vehicles . Registrations of plug @-@ in electric @-@ drive vehicles were led by the Opel Ampera extended @-@ range electric car with 828 units , followed by the Smart electric drive with 734 units . In addition , a total of 2 @,@ 413 Renault Twizys were sold during 2012 , making Germany the top selling European market for the electric quadricycle .

A total of 5 @,@ 042 plug @-@ in electric cars were registered in Germany in 2013 . Registrations were led by the Smart electric drive with 2 @,@ 146 units , followed by Renault Zoe with 1 @,@ 019 , the Nissan Leaf with 855 units , and the BMW i3 with 559 . During the first six months of 2014 the BMW i3 was the leader , with 1 @,@ 378 units registered , followed by the Volkswagen e @-@ Up ! with 884 and the Smart ED with 645 . Accounting for registrations of plug @-@ in electric cars between January 2010 and June 2014 , the leading model is the Smart electric drive with 3 @,@ 959 units registered , with a significant number in use by carsharing services , followed by the BMW i3 with 1 @,@ 937 units , the Renault Zoe with 1 @,@ 532 , and the Opel Ampera with 1 @,@ 450 units .

= = = = Canada = = = =

Cumulative sales of plug @-@ in electric cars in Canada passed the 20 @,@ 000 unit mark in May 2016 . The Chevrolet Volt , released in 2011 , is the all @-@ time top selling plug @-@ in electric vehicle in the country , with cumulative sales of 6 @,@ 387 units through May 2015 , representing over 30 % of all plug @-@ in cars sold in the country . Ranking second is the Tesla Model S with 4 @,@ 160 units sold through April 2016 , followed by the Nissan Leaf with 3 @,@ 692 units delivered as of May 2016 .

As of December 2015 , there were 18 @,@ 451 highway legal plug @-@ in electric cars registered in Canada , consisting of 10 @,@ 034 ( 54 % ) all @-@ electric cars and 8 @,@ 417 ( 46 % ) plug @-@ in hybrids . Until 2014 Canadian sales were evenly split between all @-@ electric cars ( 50 @.@ 8 ) % and plug @-@ in hybrids ( 49 @.@ 2 % ) . The Model S was the top selling plug @-@ in electric car in Canada in 2015 with 2 @,@ 010 units sold .

= = = Top selling PEV models = = =

= = = = All @-@ electric cars and vans = = = =

The world 's top selling highway @-@ capable all @-@ electric car ever is the Nissan Leaf with global sales of almost 220 @,@ 000 units by mid @-@ April 2016 . The top markets for Leaf sales is the United States with 93 @,@ 309 units delivered through April 2016 , followed by Japan with 64 @,@ 635 units sold through March 2016 , and Europe with over 55 @,@ 000 Leafs sold through March 2016 . The European market is led by Norway with 17 @,@ 199 new units registered up until April 2016 .

Ranking second is the all @-@ electric Tesla Model S , with global deliveries of about 120 @,@ 000 units through March 2016 . The United States is the leading market with about 71 @,@ 000

units sold through April 2016 . Norway is the Model S largest overseas market , with 10 @,@ 871 new units registered through April 2016 , followed by China with 5 @,@ 524 units registered through September 2015 . The world 's top selling all @-@ electric light utility vehicle is the Renault Kangoo Z.E. , with global sales of 21 @,@ 220 electric vans delivered through December 2015 .

The following table presents global sales of the top selling highway @-@ capable electric cars and light utility vehicles produced between 2008 and December 2015 . The table includes all @-@ electric passenger cars and utility vans with cumulative sales of about or over 25 @,@ 000 units since the introduction of the first modern production all @-@ electric car in 2008 , the Tesla Roadster .

= = = = Plug @-@ in hybrids = = = =

The Volt / Ampera family is the world 's best selling plug @-@ in hybrid and the third best selling plug @-@ in electric car after the Model S , with combined sales of over 110 @,@ 000 units worldwide through March 2016 , including about 10 @,@ 000 Opel / Vauxhall Amperas sold in Europe through the end of 2015 . As of April 2016 , sales are led by the United States with 94 @,@ 720 Volts delivered , followed by Canada with 6 @,@ 117 units sold . The Netherlands is the leading Ampera market with 4 @,@ 947 units registered as of December 2015 .

Ranking next is the Mitsubishi Outlander P @-@ HEV with almost 102 @,@ 000 units sold worldwide as of March 2016 . Europe is the leading market with 65 @,@ 529 units sold , followed by Japan with 33 @,@ 730 units . European sales are led by the Netherlands with 24 @,@ 572 units registered , followed by the UK with 21 @,@ 053 units registered , both at the end of March 2016 , and Sweden with 4 @,@ 433 units sold through November 2015 .

Ranking third is the first generation Toyota Prius Plug @-@ in Hybrid with 75 @,@ 400 units sold worldwide through April 2016 . The United States is the market leader with 42 @,@ 320 units delivered through April 2016 . Japan ranks next with about 22 @,@ 100 units , followed by Europe with 10 @,@ 500 units , both , through April 2016 . The leading European market is the Netherlands with 4 @,@ 134 units registered as of 30 November 2015 . Production of the first generation Prius Plug @-@ in ended in June 2015 . The second generation Prius plug @-@ in hybrid , the Toyota Prius Prime , is expected to be released in the U.S. by the end of 2016 .

The following table presents cumulative sales through December 2015 of those plug @-@ in hybrid models that have sold about 10 @,@ 000 units since the introduction of the first modern production plug @-@ in hybrid vehicle in December 2008 , the BYD F3DM .

= = Books = =

David B. Sandalow , ed . ( 2009 ) . Plug @-@ In Electric Vehicles : What Role for Washington ? ( 1st. ed . ) . The Brookings Institution . ISBN 978 @-@ 0 @-@ 8157 @-@ 0305 @-@ 1 .

Mitchell , William J. ; Borroni @-@ Bird , Christopher ; Burns , Lawrence D. ( 2010 ) . Reinventing the Automobile : Personal Urban Mobility for the 21st Century ( 1st. ed . ) . The MIT Press . ISBN 978 @-@ 0 @-@ 262 @-@ 01382 @-@ 6 .