EMOBILITY SOLUTIONS

Electric Vehicle Infrastructure
Frequently Asked Questions

The market for plug-in electric vehicles has increased rapidly in recent years and is projected to become significantly larger during the next decade. This document answers common questions about the cars, the technology, the energy and the infrastructure supporting the growing population of EVs around the world.

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With millions of EVs now on roads around the world, and many more models on the way, we have answers to many questions asked about EVs and the charging infrastructure needed to power them.

Why do people buy electric cars?
Buyer values include energy cost savings, reducing vehicle emissions, premium performance, technology, energy security and lower maintenance costs.

What is a PEV? BEV? PHEV?
All vehicles with a battery that can be recharged from an external source of electricity are considered PEVs, or plug-in vehicles. BEV stands for Battery Electric Vehicle, or a fully electric vehicle powered by an electric motor with no gas engine, such as the Nissan Leaf, BMW i3, Chevy Bolt, VW e-Golf and Tesla's Model S, X and 3. A PHEV, or plug-in hybrid electric vehicle, has both a plug-in electric system and a gasoline engine as backup to power the car; examples include the Chevy Volt, Toyota Prius Prime, Chrysler Pacifica Hybrid Minivan or Honda Clarity PHEV.

Does any premium paid for buying an EV offset the energy savings over gasoline?
It can, but more so when including vehicle lifecycle costs. Savings are already realized by the lower cost of electricity versus gasoline (MPGe) as well as greatly reduced maintenance. In addition, with the steep cost reduction of Li ion batteries already seen and continuing, electric vehicles offer an ever-evolving equation toward a lower cost of ownership versus traditional gas engine vehicles.

Electricity is a fossil fuel-based source of energy as well, so are EV's really cleaner?
Yes. Even if your EV is powered by electricity generated by coal, EVs have a lower carbon footprint in terms of both CO2 and traditional pollutants like nitrogen oxides, carbon monoxide and volatile organic compounds. Not only is the overall emissions content lower, but the location and timing of the emissions is better for air quality in high population centers. Gasoline vehicles emit pollution in the middle of the city during the day. The emissions related to EV charging typically happens at off-peak hours at plant locations away from population centers. An EV's carbon footprint is further improved as electricity generation portfolios add more clean generation technologies and renewable energy sources; and as more EV owners install solar power that supports their home vehicle charging.

How much savings can be achieved when using electricity instead of gasoline?
Driving an EV can save over $1000 per year in typical energy costs. When primarily charged at home, electricity costs a fractional amount of the price of equivalent gasoline needs. For example, if electricity rates are 12 cents per kWh; charging an EV for 100 miles of range would cost around $3. Those same 100 miles would cost around $10 in gasoline for a

combustion engine car rated at 25 mpg, and a gas price of $2.50 per gallon. Public charging prices will often exceed residential electricity costs for offering the convenience of quick charging away from home, and often on par with gasoline price levels.

Do electric vehicles still make sense when gas prices go down?

Sure; the example above illustrates the equation with a fairly low $2.50 per gallon example. In addition, historical price indexes for gasoline are quite volatile as compared to electricity. Figure 1 shows the price index for gasoline by the gallon, versus comparable electricity prices for equivalent energy over the last 40 years. The chart shows that economic, geopolitical and natural disaster related events can make a significant impact on the fluctuation of gasoline prices, but electricity has been far less subject to those forces. This is an important distinction not only for how highly variable energy costs can impact personal finances, but larger national economic and energy security concerns as well.

Do electric cars have the same speed and performance as traditional gas-engine vehicles?

In many cases, even better. While top speeds for EV's are comparable to similarly sized gas-engine vehicles, vehicles powered by electric motors enjoy the inherent benefit of high torque, and can get up to traveling speed very quickly. In addition, EV drivers usually express an appreciation for the smooth, quiet and quick performance provided by an electric drivetrain.

Are maintenance costs higher with an EV?

Maintenance costs for EVs have been shown to be significantly lower than comparably equipped gas-powered cars. Electric vehicles do not require oil changes, have no transmission or exhaust system service/parts needs, and have much longer brake life due to regenerative designs. Fewer moving parts and lower vibration mean a lot less wear and tear on the entire vehicle over time.

Will an electric motor last as long as a traditional gas engine?

Longer. Electric motors have been replacing combustion engines for decades in stationary industrial applications for their much higher reliability and efficiency, low maintenance and emissions, and much longer lifetimes. Traditional combustion engine systems that have a thousand or more moving parts are subject to more vibration wear as well as regular maintenance of the supporting fuel, exhaust, fluid and cooling systems.

How long does an EV battery last?

Current lithium-ion battery packs in electric vehicles are estimated to last 8-10 years or longer. All electric vehicle manufacturers offer lengthy battery warranties, and most EVs have already shown excellent performance due to sophisticated battery management systems and cooling technologies.

Can EV batteries be recycled?

EV batteries can be recycled, and can also find significant afterlife use in energy storage applications to manage electricity supply and demand for both utilities and users.

Is an EV more dangerous in an accident than a gas engine vehicle?

All cars can be dangerous machines due to their power and size, regardless of what gives them energy. Protective features such as seat belts, airbags, and well-engineered 'crumple' zones have saved thousands of lives, but there are also energy-related safety concerns as well. With about 170,000 vehicle fires reported every year in the United States alone, gas combustion engines have always faced the risk of flammable petrochemicals igniting due to mechanical and electrical failures. Battery electric vehicles do not have those same concerns.

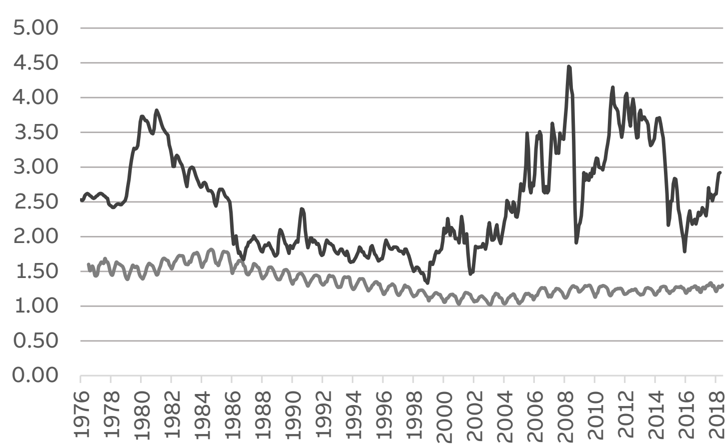

Figure 1: The chart shows the price of gas per gallon (in black) against residential electricity price equivalents (in lighter gray) over a period of 40 years, in real prices. The electricity data is based on an eGallon equivalent. Price data from U.S. Energy Information Administration, and eGallon calculation from the U.S. Department of Energy.

However, whenever there is stored energy, safety is a paramount consideration. For optimal battery safety, EV automakers engineer sophisticated battery management systems with sensors and protection devices that disconnect the battery when the pack is about to sustain damage. In addition, battery cooling systems are installed to keep batteries in an optimal temperature range while the car is running to mitigate heat issues. In their construction, EV batteries are generally organized in an array, modularized into steel-protected sections that further safety objectives.

With millions of EVs now driven around the world, emergency personnel are regularly trained on how to approach electric and hybrid vehicles most safely, with standardized response protocols in the event of an accident.

Who is ABB?
ABB is a pioneering technology leader that works closely with utility, industry, transport and infrastructure customers, with 150,000 employees in over 100 countries. In North America, we employ about 35,000 people throughout the region. Our EV infrastructure offering is part of ABB's overall power delivery expertise, including our deep experience with power electronics, grid connected systems and digitally connected and enabled technology.

Does ABB manufacture electric vehicles?
No, we provide charging infrastructure, both hardware and software, that enables drivers, service providers and utilities to power electric vehicles.

Do I need special infrastructure at my home to charge an EV?
No, all EV's come with a standard plug for charging in any home outlet. Many EV owners do choose to install a "Level 2" AC 240V charger at their home to charge their vehicle a bit faster. With their higher power features, DC fast charging units are best suited for many public, transit and commercial fleet settings.

How fast do EV's charge?
A standard 120V outlet can charge at about 5 miles of range per hour; a Level 2 charger at 220/240V can deliver anywhere from 10 to 25 miles of range per hour depending on the power limitations of the charger, the vehicle, and the home or facility. DC fast charging systems can charge an EV in about 15-30 minutes at 50kW of rated power, and in less than 15 minutes with higher power technology. Some DC fast chargers can be also charge more slowly to manage site power concerns, and fit 1-2 hour use cases at 20KW rated power, for example (see Figure 2).

What is the difference between AC and DC charging?
An AC charger supplies AC (Alternating Current) to an onboard charging device that then charges the EV battery. Faster charging is accomplished with DC (Direct Current). A DC fast charging station supplies power directly to the battery management system inside the vehicle with no onboard charging infrastructure needed inside the vehicle.

What is the benefit of fast charging?
Case studies of EV adoption rates show that fast public charging is a key component in the successful roll-out of electric vehicles to reduce or eliminate range anxiety. Drivers are more likely to adopt EV technology when they are assured quick charging availability along their regular travel routes.

Which cars are able to fast charge?
Most BEV's launched in the North American market over the last few years have fast charging capability, including the Nissan Leaf, BMW i3, Tesla Model S, Kia

Public EV Charging

AC Level 2	DC	DC Fast	DC High Power
3-19 kW	20kW	50kW	150 to 350kW+
4 to 12 hours	1 to 3 hours	15 to 60 min	5 to 30 min
• Office, workplace • Multi family housing • Hotel and hospitality • Overnight fleet • Supplement DC charging sites for PHEVs	• Workplace, multifamily • Parking structures • Dealerships • Urban fleets • Public or private campus • Sensitive power supply applications	• Retail, grocery, mall, big box, restaurant • High turnover parking • Convenience fueling stations • Highway truckstops and travel plazas • OEM R&D	• Highway corridor travel • Metro 'charge and go' • Large fleet • Bus and heavy vehicle • OEM R&D

Figure 2: The chart shows common power ratings and average charge times for public EV infrastructure solutions. Variance among power and charge times related to vehicle capabilities (charging protocol, BMS, environmental), battery capacity (state of charge, overall kWh capacity) and charging hardware power rating. Level 1 charging at 1kW or less is not included in this chart as is limited for most public, fee-based charging applications.

Soul EV, Volkswagen e-Golf and Chevrolet Bolt. Many more models have been announced to enter the market over the next 2-3 years that will charge at even higher rates such as 150-350kW.

Why do DC fast chargers "fill" to 80% and not 100%?
Modern battery chemistries achieve the longest lifetime when not frequently charged to full capacity. In order to lengthen the lifetime of EV car batteries, DC fast charging standards provide for quickly getting an EV to 80% of capacity, and then switching to slow trickle charging. This method gets drivers back on the road sooner, while extending the lifespan of the vehicle battery.

Does fast charging affect battery performance?
Multiple studies suggest that cycling, that is, frequency of charging, causes some measurable impact on battery lifetime, as all batteries degrade over long periods of time and use. However, charging speed has been shown to have little or no impact on long term BEV battery performance. Fortunately, automakers build reserve capacity into their battery management design to buffer against the effects of excessive cycling.

Do multiple fast charging standards hinder EV adoption?
CHAdeMO and CCS are the only two open fast charging protocols that have been adopted by most vehicle manufacturers for North America. ABB manufactures DC fast chargers that meet both standards in a single unit, supporting fast charging for drivers of all vehicles that are compliant with either standard. While Tesla is unique with their proprietary fast charging network, they do offer their drivers adaptors that allow charging via open charging protocols.

Does ABB have DC fast chargers installed anywhere?
Yes, we have nearly a thousand installed throughout North America, and thousands more installed globally.

Where are DC fast chargers usually installed?
Fast chargers are ideally installed in 'charge and go' locations such as near highways and convenience locations, as well as serving fleet charging needs. They're also in higher demand at commercial sites such as shopping centers, restaurants, campuses and urban parking cases and fleets (see figure 2). DC charging can be integrated into existing AC installations as well. These charging locations are growing quickly, and can be easily found in smart device apps and websites, such as PlugShare.

Will a rise in EVs strain the electric grid?
Most EV charging is done at home and work in slower AC voltages, and often not during peak demand hours. With rate incentives and smart charging, utilities actually have a nice opportunity to use EVs to balance loads and ramping to better balance generation and demand.

At the public station level, fast chargers have intelligence to throttle power down to lower levels and address any immediate demand issues for the site owner. In addition, energy storage technologies offer demand reduction possibilities, as well as with solar power integration. ABB is a leader in these smart grid and renewable technologies, supporting site owners, infrastructure providers and utilities.

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