Electric Vehicles - Frequently Asked Questions

by Sam Carana http://bit.ly/EV-FAQs

1. Are electric cars expensive?

The Nissan LEAF EV promises to be as cheap as a similar-sized conventional car. EVs qualify for rebates, tax breaks and further incentives.

Furthermore, electricity is cheaper than gasoline, while EVs can also be expected to require less servicing, as it has less mechanical complexity than a traditional gasoline-powered car.

The Nissan LEAF (pictured right) is slated for launch in late 2010 in Japan, the U.S., and Europe. The Mitsubishi i-MiEV Electric Minivan (pictured below) is on sale in Japan with a price tag of 4,599,000 yen (incl consumption tax), while a subsidy of 1,380,000 yen can bring the price down to 3,219,000 yen ($32,904 but the yen may have meanwhile become cheaper or more expensive).

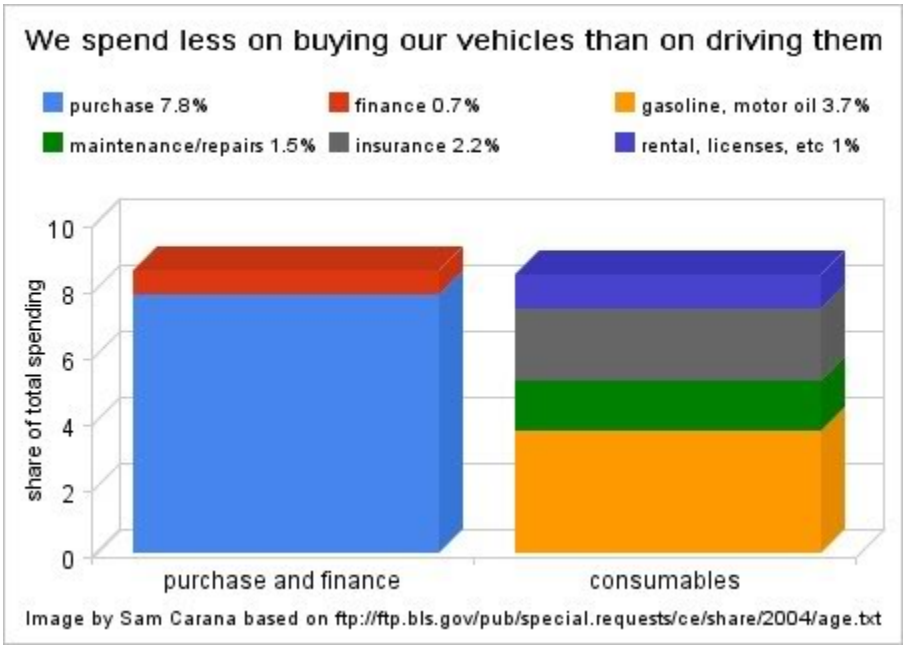
Mitsubishi plans to cut the price by more than half to less than 2 million yen ($21,000) as government incentives and tighter emission rules boost demand for fuel-efficient cars, reports Bloomberg. Mitsibishu will cut the i-MiEV's price tag by the "mid-2010s", President Osamu Masuko said at the company's annual shareholders' meeting in Tokyo. The price target includes tax breaks and subsidies from the government, he added. Source and photo credit: Mitsubishi

Mitsubishi expects to distribute some 1,400 *i-MiEV* models in fiscal 2009 on a maintenance lease basis, mainly to corporations and local authorities.

Mitsubishi plans to start sales of *i-MiEV* to individuals in April 2010 and will start taking orders from next month.

Mitsubishi quotes research showing that the vast majority of cars in Japan are driven for less than 60 km (about 37 miles) daily. Nonetheless, the *i-MiEV* will have a relatively large 16 kWh battery, giving the *i-MiEV* a range of up to 160 km (about 100 miles) on a single charge. The larger capacity also means that it will take longer to fully charge the battery. A full charge will take some 7 hours from a 200-volt domestic outlet, or 14 hours from a 100-volt outlet, using the cables supplied with the vehicle, while a "quick charge" (to 80% of its capacity) will take some 30 minutes at quick-charge stations that are currently being established throughout Japan.

Purchase cost of electric cars is still high, partly due to battery cost, but also due to low volumes, which could change rapidly. With further innovation, mass production and economies of scale, electric cars can be expected to become cheaper than gasoline cars, since electric cars have less parts; the motors can be in the wheels, so there's no need for a differential, axle, or shaft. There is no need for a gearbox. There's no need for the starter motor, alternator and traditional battery of gasoline cars. This also means there's no need for maintenance on those items. Apart from the purchase price, cost of driving a car is an important consideration.



Electric cars don't need a regular change of engine oil, filters, gaskets, hoses, plugs, belts, there's no catalytic converter or exhaust pipe to replace. There's not the vibration of gasoline cars causing wear and tear, nor the heat, so often there's no need for a radiator to cool things down.

At some stage in the not-too-distant future, as more electric cars and less gasoline cars are sold, economies of scale will be working against gasoline cars. It's not just that new gasoline cars will be more expensive as production volumes fall, getting parts for gasoline cars will also become

increasingly expensive. There will be fewer and fewer service stations, while the price of gasoline will keep rising, as taxes will be added to reflect environmental harm.

And of course, one could covert an existing car, rather than buy a new one. Read this story in Suburban Journals about how Ron Erb's brother-in-law had a Ford Ranger that had just stopped running, but the body was still in good condition. Ron converted the truck into an electric vehicle for $7,700. A rebate program offered by the state of Illinois, called Green Fleets, gives rebates of up to 80% of the conversion cost up to $4,000. So it looks like he's got an electric vehicle for about $3,500. Furthermore, he may have tax advantages and he'll make savings on the cost of driving and on maintenance, so he'll practically have a good, clean truck for free.

If you like that story, have a look at EV album where you can click on a car and see what they've done, how much it did cost and all kinds of details. I can see a huge cottage industry developing around conversion.

2. Is it hard to travel long distance with electric cars?

The range of electric vehicles depends on what battery pack they have. The Tesla Roadster has a range of about 220 miles. The Mitsubishu *i-MiEV* has a 16 kWh battery, giving the *i-MiEV* a range of up to 160 km (about 100 miles) on a single charge.

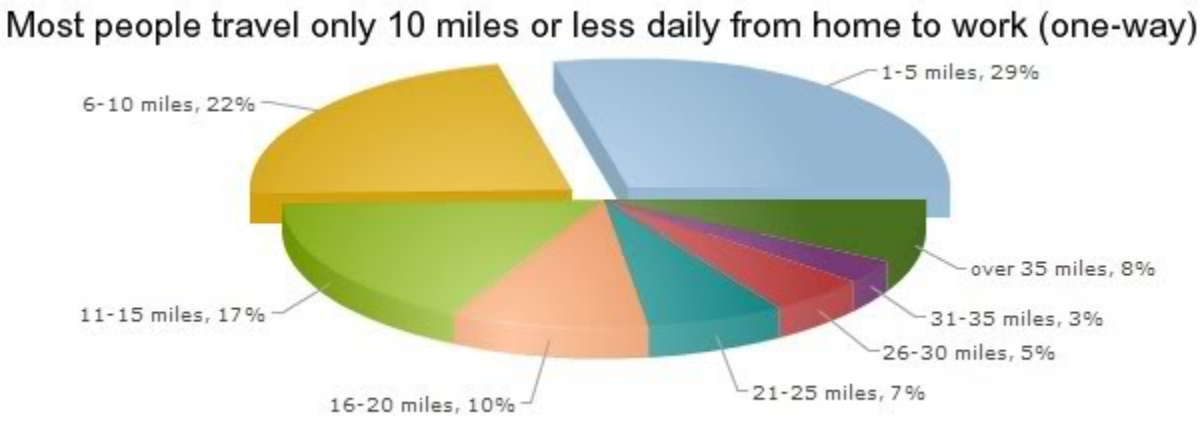


Image by Sam Carana, based on US Department of Transportation, Bureau of Transportation Statistics, Omnibus Household Survey, Oct. 2003.

Battery capacity is still expensive. Therefore, buying a smaller battery for now will make an EV a lot more affordable, and this will suffice for most daily usage. Most people live less than 10 miles away from their work, while the car could be recharged when they are at their place of work, as more recharging points become available.

In many cases, recharging can take place several times a day, i.e. throughout the night at home, while additional recharging can take place while the car is parked at the place of work, at the mall, etc. One doesn't have to wait for the battery pack to be fully recharged, a partly recharged battery pack may well suffice to make the trip back home. Many people rarely travel long distances, some 80% of cars are driven for 50 miles or less daily.

Therefore, it makes sense to buy an electric vehicle with a small battery and go to a battery swapping station to swap it for a larger-capacity battery on the odd day that one needs to travel interstate. The battery may still require recharging during travel, but rapid chargers can do this in a matter of

minutes. When returning to one's hometown, one then swaps back to a smaller (and cheaper) battery. This approach is followed by Better Place. Alternatively, one could also rent a car with a large battery capacity for long distance travel.

Battery technology is rapidly improving, with huge amounts of money going into research and development of batteries with higher capacity. In early 2008, CNET reported how researchers used silicon nanowires to give rechargeable lithium ion batteries a tenfold improvement in battery life. The study can be found at Nature.

Battery provider Southern California Edison (SCE) has demonstrated a lithium ion battery with a lifespan of more than 180,000 miles. Since the average family car travels about 10,000 to 15,000 miles each year, the battery could last a decade before it needed replacing.
Prices will come down with such innovation and with mass manufacturing and economies of scale. Therefore, many expect that within a few years, large capacity batteries will be available at low prices.

3. Are electric vehicles slow?

You may be surprised about the acceleration of electric cars. Who do you think did win the race below, the Corvette or the 1972 Datsun 1200 with electric motor and batteries?
Clue: The Datsun can do 0-60 mph in 2.9 seconds.

Also note the KillaCyle electric bike. It can do 0-60 mph in under 1 second, can do the quarter mile in 7.89 seconds and can reach a speed of 174.05 mph. It used only around $0.07 worth of electricity for each run.

The Tesla Roadster has faster acceleration than most other cars, from zero to 60 mph in under 4 seconds. Some electric cars may be slow at times, as they have only a small battery, but this could be improved by adding capacitors. The fact that electric cars make less noise doesn't mean they are slower.

In the electric Hi-Pa Drive™ Ford F-150, four in-wheel motors are used each weighing 66-lb and each delivering over 150 lb-ft of torque directly to the wheel, at any speed. Together, these motors deliver 600 combined horsepower and 2,000 lb-ft of cumulative torque at the wheels — more horsepower and torque than the 320-hp 5.4L V8 in the original F-150 truck.

The top speed of many electric vehicles is electronically limited to to comply with road regulations. In Japan there's a 62 mph (100 km/h) speed limit, so that's the top speed mentioned for cars like the Subaru Stella, currently for sale in Japan. It actually could quite easily go a lot faster than that. The Tesla Roadster's top speed is electronically limited to 125 mph.

The Tesla S will have an electronically limited top speed of 130 mph. Acceleration from zero to 60 mph is 5.6 seconds, while sport versions are expected to achieve 0-60 mph acceleration well below five seconds. It has a single-speed gearbox and seats 7 people (five adults and two children).

4. Does it take all night to recharge electric vehicles?

It depends on what battery one has and what electricity outlet is used for recharging. Recharging the Tesla Roadster takes about 3.5 hours using the Tesla Motors High Power Connector.

The Tesla model S costs about $4 to fully charge. You can charge it from any outlet. With QuickCharge, Model S can charge to 80% of capacity in 45 minutes. Standard charging times will vary depending on battery capacity, ranging from approximately 3 to 5 hours. Alternatively, you can apply a 5 minute battery swap. Three battery pack options offer a range of 160, 230 or 300 miles per charge. The Model S battery will have a useful life of 5 to 7 years, while proper care can result in a 10-year life.

Prices for the Model S are expected to start at $49,900, after a $7,500 federal tax credit. Deliveries of the Signature Series Model S will begin at the end of 2011 with deliveries of the standard model beginning in early 2012.

The larger the battery capacity, the longer it will take to fully charge the battery. To fully recharge the battery from empty for the iMiev will take some 7 hours from a 200-volt domestic outlet, or 14 hours from a 100-volt outlet, using the cables supplied with the vehicle. That will give the iMiev a range of160 km (about 100 miles).

But the battery can also be part-charged, and part-charging will suffice in many cases. A "quick charge" (to 80% of its capacity) will take some 30 minutes at quick-charge stations that are currently being established throughout Japan.

The Subaru Stella, also on sale in Japan, has a smaller battery and will drive up to 90km (56 miles) on a single charge. The 9kWh Lithium-ion battery can be charged in 8 hours with an AC100V household power outlet or in 5 hours with an AC200V outlet. Charging up to 80% of its capacity can also take place in 15 minutes with a quick-charging system.

New Scientist described all this years ago in an article called Charge a battery in just six minutes. Here are some technical details, from a Altairnano presentation dating back to 2006.

The Phoenix truck below has a Nanosafe battery that can be charged with a 440-volt charger from flat to almost full in a few minutes. The grid could cope with that by drawing power from the batteries of numerous grid-connected cars.

Altairnano envisages 440V to 480V rapid charging stations (1000A), at locations such as service stations and parking meters. To cope with rapid recharging, the electricity could be supplied by numerous grid-connected cars selling surplus electricity that they got from the grid earlier, at cheaper rates and over a period of several hours during the night, using standard household connections.

According to this document, the Altairnano has demonstrated that their NanoSafe cell can be charged to over 80% charge capacity in about one minute.

With further innovation, mass production and the associated economies of scale, batteries will improve in this respect as well. MIT researchers have managed to dramatically reduce the time it takes to recharge lithium ion batteries. GM-Volt.com gave the story the title a 100-Fold Lithium-ion Battery Breakthrough.

5. Do electric cars need to be recharged frequently when traveling long distances?

If one has a car with a small battery, recharging will have to be done multiple times when traveling long distances. France is planning EV rentals as the next step up from the public electric bicycle hire system that's very popular in Paris and some other cities. In the odd case that one needed to travel long distances, one could use a hired electric vehicle.

Better Place envisages people using a cheaper battery for their urban use, while turning to a battery swapping station to put in a battery with a larger capacity on the odd days that one wanted to travel to another city. Then, when returning to one's home town, the battery is swapped back for a cheaper battery. One would only need to swap the battery once or twice during one's travel between cities, or recharge the battery with a rapid charger at service stations or at night from a standard domestic power outlet. The cost would be similar to what one now pays for gasoline and maintenance associated with such travel.

6. Electric Vehicles - where can I buy them?

In the US, the Tesla Roadster has been for sale for some time, while the Subaru Stella and the Mitsubishi iMiev are for sale in Japan. The Nissan LEAF is slated to be introduced around the world next year. The Reva is for sale in India and Europe. Most car manufacturers are working on getting electric cars ready for sale within one or two years. GM's Volt is also slated for a 2010 launch. Ford plans to launch a battery electric commercial van in 2010 and is investing $550 million in a plant to produce the Ford Focus (launch 2010) and a battery-electric version of the Focus Focus (launch 2011). Chrysler is working on four EVs, one of which will be for sale in 2010.

Norway's electric car maker, Think, plans to open a manufacturing plant and technical center in the United States. The plant will build the THI!NK city, an all-electric car that can travel up to 112 miles on a single charge.

The TH!NK city vehicle draws on the company's 17 years of experience in EV development and production and more than $100 million invested by Ford Motor Company during the four years the company held a majority stake in Think. [source]

The Think City is a two-seater with an optional back seat. The City for the European market has a top speed of 62 mph, a range of 112 miles and its batteries need several hours to recharge. Think's goal is to produce a car priced at less than $20,000 with a $90 monthly lease for the batteries, according to a report in The Detroit News. The new TH!NK city has a top speed of 62 mph. Before offering the car to American consumers, Think aims to increase top speed to 70 or 75 mph and to further improve driving range and acceleration, reports Autoweek.

Of course, there's also the option of converting an existing car.

7. Will there be enough lithium?

Virtually all car batteries in the U.S. are recycled and I imagine the same will occur with lithium-ion car batteries. Recycling could be encouraged by imposing a deposit fee, to be returned when the battery is disposed of at a collection point.

According to the U.S. Geological Survey, Bolivia has 5.4 million tons of lithium, Chile 3 million, China 1.1 million and the U.S. 410,000. However, according to other sources, such as Western Lithium, it is likely that millions of tons of lithium can be mined in the US alone. A 24kWh battery for the Leaf EV will use 4kg of lithium (metal equivalent), so 1 million tons of lithium would suffice for 250 million vehicles, or approximately the number of motor vehicles registered in the US in 2007 (Department of Transportation data for cars, trucks and buses).

Seawater, according to the Institute of Ocean Energy, Saga University, Japan, contains some 230 billion tons of lithium, at concentrations of 0.1 to 0.2 ppm. While it may now be cheaper to mine lithium in South America, recovery from seawater may be more viable when combined with desalination, as discussed in Four Cycles of a Sustainable Economy and when using surplus energy, e.g. as discussed in CETO wave power.

If - despite the above - there would nonetheless be a shortage of lithium, there are a number of different types of batteries to fill the gap.

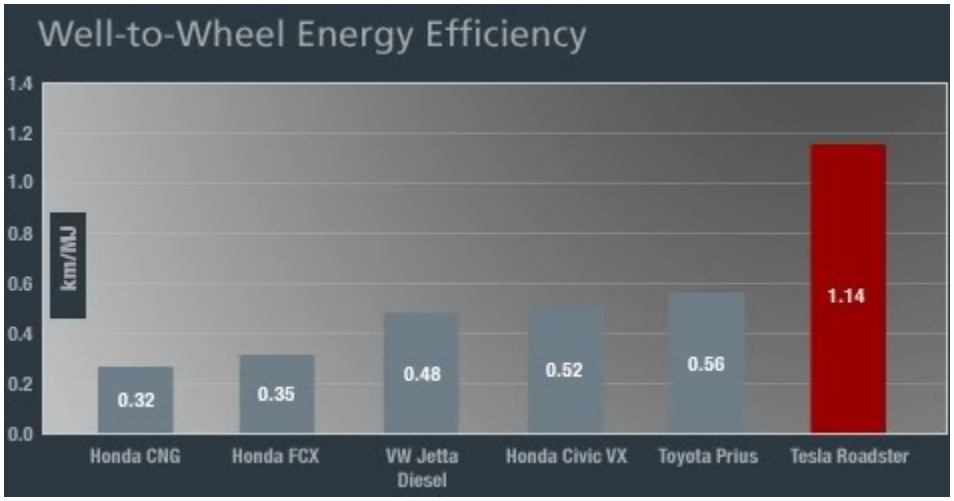
8. Won't replacing all existing cars with new electric cars cause a lot of pollution?

If new cars are produced at clean facilities, there will be very little pollution. With energy sourced from clean and safe facilities, emissions can be minimal.
Furthermore, existing cars could be converted.

9. If most electricity for the EV comes from coal-fired power plants, than isn't diesel cleaner?

As the EPA says, diesel emits more carbon dioxide per gallon (22.2 pounds) than gasoline (19.4 pounds). One may drive longer on a gallon of diesel, but apart from carbon dioxide there are particles included in diesel emissions that affect health and that act as a greenhouse gas. Furthermore, these particles end up on glaciers, ice and snow, causing it to melt, resulting in albedo change.

Electric cars cause less emissions, even if the electricity came from coal-fired power plants. When cars drive on fossil fuel, only a small part of the energy actually powers the wheels, in the case of gasoline it's only 20%. Most of the fuel burned turns into heat. For a closer look at ways to compare how clean and efficient cars are, see the Automotive X Prize and the EPA references and the various EPA calculations to work things out.



In the above image, Tesla uses distance (km) per megaJoule (MJ) to compare the efficiency of

different cars. Note that the Tesla is built for speed and fast acceleration, there are many electric cars that drive further on the same electricity.

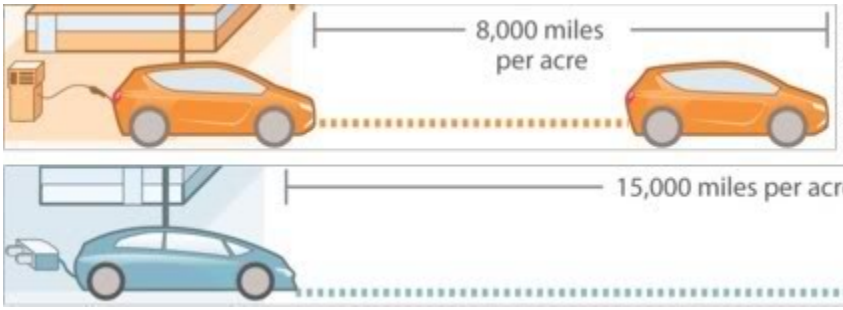
Furthermore, a coal-fired power plant cannot be suddenly switched on or off, it takes a long time to power it up. Therefore, power plants commonly keep burning coal at night, just to keep the plant going, even when the energy is wasted. Thus, recharging EVs at night, when demand for electricity is low, will cause little or no extra emissions and can be done without requiring much additional infrastructure.

But this is a largely academic discussion. We need to move away from burning coal anyway. As utilities clean up their act, emissions associated with generating electricity will come down and it will make even more sense to drive EVs.

10. Isn't driving a car on renewable biofuel just as clean?

Ethanol is not the best way to power cars. Farms that grow corn for ethanol use pesticides, fertilizers, energy, water and land, which drives up food prices and puts extra burdens on the environment.

As a recent study points out, it would make more sense to convert biomass to electricity, rather than to ethanol. But of course, there are better ways to produce electricity, such as with solar or wind power, rather than by burning biomass.



Switchgrass could drive a car 81% further, if burned in a power plant and used to power an electric car. Credit: McDade & Campbell, 2009.

11. Are electric vehicles safe?

There are several safety issues related to electric vehicles, each of which can be dealt with adequately.

Warning lights and sounds can make other road users more aware of electric vehicles, especially when reversing. Artificial engine sound can be added. Sensors and cameras can further be added to avoid collisions.

Electrical hazards is another issue - electric vehicles have to comply with safety standards that require batteries to be adequately covered and insulated, to prevent people from accidental getting electric shocks.

Some electric vehicles would not pass rigorous crash testing, but they are meant to be used as Neighborhood Electric Vehicles (NEVs). In many cities, NEVs are allowed to drive within certain boundaries; they don't have to comply with more rigid standards set for cars that drive at higher speeds on highways.

As carbon fiber becomes more common, such NEVs will also become increasingly safe. Carbon fiber typically is much stronger and stiffer than steel, and last longer than metal because it is resistant to fatigue or corrosion. Furthermore, carbon fiber weighs less than comparable steel products, making it particularly attractive for use in car bodies, hoods, etc.

12. Do batteries make electric vehicles more heavy? And is there less room?

In the electric Hi-Pa Drive™ Ford F-150, in-wheel motors are used. The Hi-Pa Drive system effectively replaces the mechanical drivetrain, axles, gearbox, transmission, differential, driveshafts and transfer case that would otherwise be necessary for a four-wheel drive truck. Furthermore, it replaces the engine, exhaust system, supporting subsystems and the fuel tank, freeing up space for a 40-kilowatt hour battery that sits under the chassis, under the rear part of the cab and the bed where the fuel tank normally sits. This means there's no loss of load space, in fact it creates more space under the hood.

The many further parts that aren't needed in all-electric cars include starter motor, air filter, air intake manifold, fuel lines, fuel filters, fuel pumps, carburetors (or fuel injection system), water pump, coolant pipes, radiator, fans, motor oil tank, alternator and all kinds of sensors and management devices to monitor and control all this.

Instead, there are in-wheel motors each with built-in control, and there is a battery pack, battery controller/management system, power inverter/charger system and associated wiring. This can make an all-electric car less heavy than a gasoline version, but the weight of electric cars much depends on the size of the battery pack.

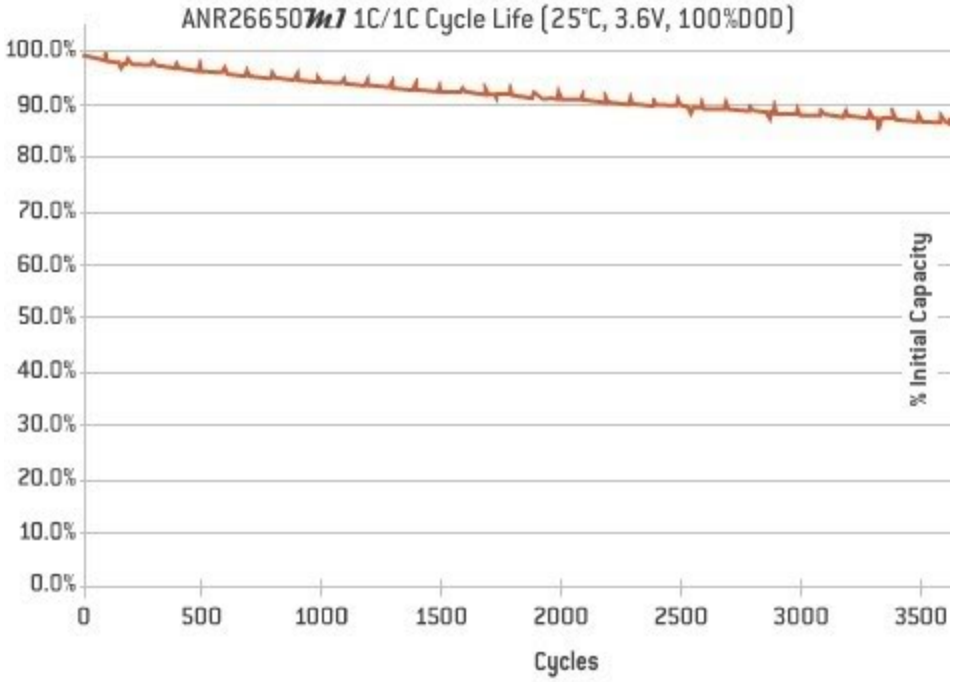
The display F-150 features a 40-kilowatt hour Lithium-ion battery pack, weighing roughly 1000 pounds and giving the truck a range of up to 100 miles. This range depends on how the truck is driven. Highway driving will give it a smaller range than urban driving, as the Hi-Pa Drive system acts as a generator, recapturing kinetic energy during braking. Apart from this regenerative braking, the hydraulic friction brakes are retained in the truck, for additional braking capability.

13. Is there government support for EVs?

Yes, there is support, but not enough. There still is too much support for the fossil fuel industries, but that situation will not continue. There will be a an increasing amount of support for EVs in future. Government at all levels support electric vehicles with tax deductions, subsidies, rebates, free parking and recharging facilities and more.

14. Do batteries lose their ability to be fully recharged over time?

Some batteries gradually loose their charge over time. But the batteries for electric cars carry warranty for years. The A123 Systems batteries are meant to keep working for 10 years or more. On their site, there's a chart like the one below:



There are similar documents at the Altairnano site. According to this document, the Altairnano NanoSafe battery cells have in laboratory testing achieved over 9,000 charge and discharge cycles at charge and discharge rates up to 40 times greater than are typical of common batteries, while retaining up to 85% charge capacity.

15. Is there a risk that lithium-ion batteries will explode?

This is an old story. Battery manufacturers have put a lot of attention on this issue and much work has gone into the production of separators to prevent overheating. The risk seems minimal compared to the risk of gasoline tanks exploding in case of fire.

16. Can the power grid cope with the extra demands of electric vehicles?

As Rob Pratt pointed out in his June 2007 workshop, idle capacity in the U.S. grid could supply 73% of the energy needs of today's cars, SUVs, pickup trucks and vans, without adding generation or transmission, if vehicles are charged at off peak hours.

Pacific Gas and Electric Company has off-peak rates (in summer, midnight to 7.00 am) as low as $0.05/kwh, while peak rates are as high as $0.28/kwh. Such Time of Use (TOU) rates are a great incentive for owners of electric vehicles to recharge at off-peak hours.

There's further synergy between rooftop solar panels and electric cars, which makes that a shift to electric vehicles goes hand in hand with more solar panels. Owners of electric cars are more likely than other car owners to add solar panels and wind turbines on their premises. In a survey of RAV4-owners, 48% responded that solar energy powered their car. Storing electricity from rooftop solar panels in car batteries during the day can deliver electricity to households in the evening.

Retailers and offices have an opportunity to provide extra service to customers and staff with electric vehicles, if they install solar panels on the roofs of business premises and car covers, and allow electric

vehicles to be recharged during the day. Such recharging from solar panels can take place without putting stress on the grid. Once returned home, owners of electric vehicles could then sell their surplus electricity to the grid, thus helping the grid cope with the evening peak.

In conclusion, rather than being a burden to the grid, electric vehicles can help the grid better cope with demand. Furthermore, we need to shift away from coal-fired power plants anyway, so this discussion is rather academic. Instead of conventional power plants, we need to look at clean and safe technologies, such as solar and wind energy.

17. Are electric cars merely a novelty that will go away?

Electric cars are not a novelty, they have been around for longer than gasoline cars. In 1895, an electric car won the very first auto race in America. In 1899, an electric vehicle called La Jamais Contente, set a world record for land speed of about 66 mph. Around 1900, more electric cars were sold than gasoline cars.

Moreover, the need to act on global warming makes that gasoline cars have got to go and that electric vehicles are the way of the future.