Plug-In Vehicle: Basics

Vehicle Types

PHEV (Plug-in Hybrid Electric Vehicle)

Some are designed to operate exactly like a BEV, using only electricity. Others take advantage of electricity to boost overall efficiency. With either, it will drive as a hybrid when plug-supplied electricity is used up.

BEV (Battery Electric Vehicle)

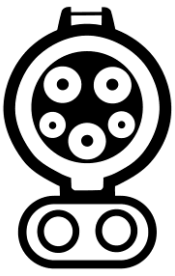
This type of vehicle relies exclusively upon electricity for all operation. There is no ICE (Internal Combustion Engine) or gas tank. Propulsion is provided by electric motors powered only by a battery-pack.

Charging-Station Types

EVSE (Electric Vehicle Service Equipment) is the true name for "*chargers*" used at home, using either 120 or 240 volts. The device is only an adapter with cord & handle for connecting to a power source. Inside the vehicle itself is where equipment to convert AC power to DC is located.

Level-1 (120-volt AC) provides basic recharging. That's enough electric range for most daily driving, about 40 miles. Speed is slow, but finding a location to plug in is convenient. It uses a standard household outlet.

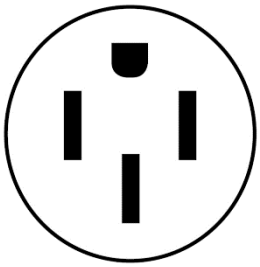
Level-2 (240-volt AC) is what most homeowners use for charging BEV battery-packs. Speed is fast enough to restore full capacity overnight. It uses a high-power dedicated outlet.



DCFC (DC Fast-Charge) is the fastest type. These charging-stations are great for travel. Speed is significantly faster than Level-2. For a typical BEV, charging from 20% to 80% capacity will take around 30 minutes. Maximum rate of DCFC power will vary, as will the vehicle's ability to draw electricity. Time is also influenced by battery state-of-charge and temperature.

Recharging Voltage

Standard Household outlets in your home provide 120-volt service for level-1 charging. This option is very practical, since it is common and often conveniently located. However, it is slow. Overnight charging will provide only minimal electric range.



High-Power Dedicated outlets deliver 240-volt service for level-2. This type (with at least 30-amp capacity) is great overnight charging, enough to fully recharge a BEV (around 200 miles in 8 hours).

Pictured here is a "**NEMA 14-50**" outlet, the most common connection type for home install EVSE use.

Battery-Pack Longevity

Usable Capacity is the portion of battery-pack used by plug-in vehicles for electric power. That portion not used is for ensuring longevity. It's a simple matter of preventing deep discharges and full recharges. The vehicle's system will automatically control those limits for you.

Operating Temperature is a vital aspect of battery-pack longevity. This is another control the vehicle's system will automatically handle for you. Some use forced-air. Others circulated liquid. Some also have heating elements. All are used to optimize performance and slow aging.

Recharge Frequency is nothing to be concerned about. Recharge when opportunity is available, stopping when it's time to depart. There's no need to fully charge. Most cost-effective is overnight. Note that it may take extra time, since battery-pack warming or cooling prior to start is sometimes needed (which the system will automatically handle for you).

Full or Partial recharging is not a factor of battery-pack longevity. Recharge as little or as much without concern. The easiest approach is to just allow the system to automatically stop at the default setting. For the common batteries (NCA and NMC), that's 80% capacity. For the newer type (LFP), that's 100% capacity.

Estimating Miles

Mi/kWh is the most common means of stating EV drive efficiency. This “miles per kilowatt-hour” measure depicts a distance expectation for a unit of electricity. It resembles MPG; your results will vary. Dependent upon driving conditions, such as temperature & speed, the value will change.

Heater use have significant impact on travel distance, since electricity consumed for cabin warming comes from the battery-pack. More heat requested means fewer EV miles available. Efficiency varies among plug-in vehicles. Resistance heaters use more electricity than heat-pumps.

A/C use reduces electric miles available, but not as much as the heater. Electricity needed is supplied by the battery-pack. Keep in mind that some vehicles share cooled air for battery-pack cooling, others have independent liquid-cooling systems.

Defrost is the use of A/C to eliminate condensation from cabin air. This is a handy feature when the front windshield begins to fog. This is always electric for BEV. This can be either electric or gas-engine assist for PHEV.

Distance Expectation

There are a few basics to keep in mind for distance expectation. If your travel includes very highway driving and/or cabin heating & cooling, that would be **heavy** consumption. Less demanding conditions can be considered **ordinary**. Under best conditions, when circumstances are ideal, that is **efficient**.

Associate these numbers for those categories:

- **2.5** mi/kWh = **heavy** consumption
- **3.0** mi/kWh = **ordinary** consumption
- **3.5** mi/kWh = **efficient** consumption

Knowing those categories, next is to determine available electricity. PHEV utilize about 70% of the battery’s total capacity for electric-only operation. BEV will allow up to 100%.

Consider a BEV at 100%. It’s best to avoid completely depleting the battery, since estimates can be inaccurate and to ensure longevity. Subtract 10%. If the battery had 72 kWh total capacity, that would provide 64.8 kWh for travel:

- **2.5** mi/kWh = **162** miles
- **3.0** mi/kWh = **194** miles
- **3.5** mi/kWh = **227** miles

Charging Topics

Recharge Duration will differ, since electricity amount is based upon state-of-charge and outside conditions. If cooling or heating is required, need for additional electricity extends charging time.

Cents per kWh is how most billing is calculated. Price per "kWh" (Kilowatt Hour) varies depending upon power source and when charging takes place. A typical price example is $0.14/kWh.

Time Of Use is a discount opportunity your electricity provider may offer. If available, billing is based upon the time electricity is drawn. Overnight price is best, since demand is lowest then. During the day is discounted. During peak (early evening) may be very expensive to discourage charging then.

Off Peak is a discount opportunity your electricity provider may offer. If available, power for charging is only available during late night hours. In return, pricing is better than a time-of-use plan.

kWh/100mi is a standardized measure for vehicle comparisons. That kilowatt-hour-per-100-miles unit allows for easy anticipation of cost, but isn't convenient as mi/kWh for distance expectation.

For example at $0.14/kWh, the same 100 miles will cost $10.07 with GMC Hummer EV but only $4.62 with Toyota bZ4X Limited. Here is a list of common BEV models with AWD and their efficiency ratings, calculated over equal distance:

AWD GMC Hummer EV	72 kWh/100mi	47 MPGe combined	1.39 mi/kWh	$10.07
4WD Ford F-150 Lightning	49 kWh/100mi	68 MPGe combined	2.02 mi/kWh	$6.93
AWD Rivian RS1	49 kWh/100mi	69 MPGe combined	2.05 mi/kWh	$6.83
AWD Ford Mach-E	36 kWh/100mi	93 MPGe combined	2.76 mi/kWh	$5.07
AWD Toyota RAV4 Prime	36 kWh/100mi	94 MPGe combined	2.79 mi/kWh	$5.02
AWD Audi Q4 e-tron quattro	36 kWh/100mi	95 MPGe combined	2.82 mi/kWh	$4.96
AWD Hyundai Ioniq 5	34 kWh/100mi	98 MPGe combined	2.91 mi/kWh	$4.81
AWD VW ID.4	33 kWh/100mi	101 MPGe combined	3.00 mi/kWh	$4.67
AWD Toyota bZ4X Limited	33 kWh/100mi	102 MPGe combined	3.03 mi/kWh	$4.62
AWD Toyota bZ4X XLE	32 kWh/100mi	104 MPGe combined	3.09 mi/kWh	$4.53
AWD Kia EV6	32 kWh/100mi	105 MPGe combined	3.12 mi/kWh	$4.49
AWD Tesla Model Y LR	28 kWh/100mi	123 MPGe combined	3.65 mi/kWh	$3.84
AWD Tesla Model 3 LR	26 kWh/100mi	131 MPGe combined	3.89 mi/kWh	$3.60
AWD Toyota RAV4 LE	-	* 35 MPG combined	-	$11.14

* For traditional vehicle comparison, $3.899 per gallon of gas was used.

Monthly Electric Bill

The most common question asked is: "*How much will my monthly electric bill go up?*"

Here's some basic numbers to consider:

- **3.0 Miles/kWh** = average efficiency rate
- **$0.20/kWh** = regular electricity price
- **1,000 miles** = average monthly distance

1,000 miles would consume 333.3 kWh of electricity, which calculates to **$66.67** per month.

Signing up for discounted electricity, from overnight and off-peak charging would lower price:

- **$0.075/kWh** = discounted electricity price

In that case, those same 1,000 miles would calculate to **$25.00** per month.

How far will a traditional vehicle travel on just $25.00 worth of gas?

- **$3.999/gallon** = typical gasoline price
- **35 MPG** = typical vehicle efficiency

That's enough to purchase 6.25 gallons and travel **219** miles.

Timing Estimates

Results vary significantly depending upon several factors, such as battery state-of-charge and temperature. Nonetheless, some generalizations can be made to understand how different electricity rates available influence timing. The charts below provide a basic overview of how charging speeds deliver electricity amount, giving you a rough idea how long charging may take.

Assumptions:

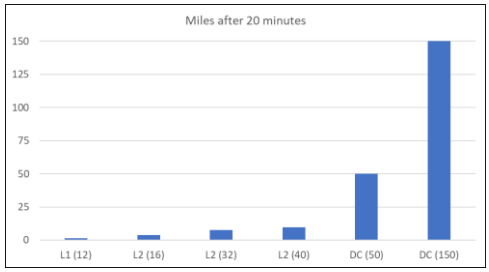
- **3.0 Miles/kWh** = Current vehicle efficiency
- **50°F (10°C)** = Battery temperature (at least)
- **20%** = Battery state-of-charge (start level)
- **225 miles** = Battery driving range (at least)

Vital Fact:

- Charging rate is not linear. Speed (depicted by kW) will decrease as state-of-charge for the battery rises. That's why DCFC times are often quoted for 30-minute sessions.

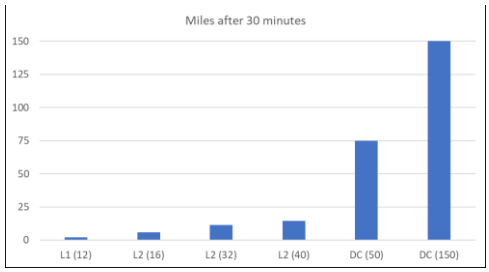
20 Minutes of charging:

Type	**kW** (speed)	**kWh** (quantity)	**Miles** (distance)
Level-1 (12 amps @ 120 v)	1.44	0.48	1.4
Level-2 (16 amps @ 240 v)	3.8	1.3	3.8
Level-2 (32 amps @ 240 v)	7.7	2.6	7.7
Level-2 (40 amps @ 240 v)	9.6	3.2	9.6
DCFC (50 kW)	50	16.7	50
DCFC (150 kW)	150	50	150



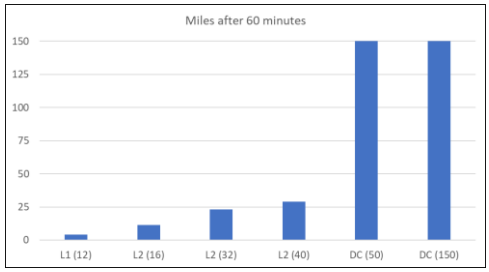
30 Minutes of charging:

Type	**kW** (speed)	**kWh** (quantity)	**Miles** (distance)
Level-1 (12 amps @ 120 v)	1.44	0.72	2.2
Level-2 (16 amps @ 240 v)	3.8	1.9	5.8
Level-2 (32 amps @ 240 v)	7.7	3.8	11.5
Level-2 (40 amps @ 240 v)	9.6	4.8	14.4
DCFC (50 kW)	50	25	75
DCFC (150 kW)	150	75	+200



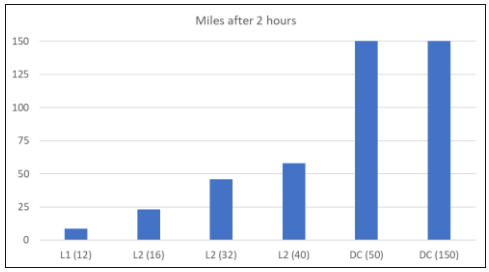
60 Minutes of charging:

Type	**kW** (speed)	**kWh** (quantity)	**Miles** (distance)
Level-1 (12 amps @ 120 v)	1.44	1.44	4.3
Level-2 (16 amps @ 240 v)	3.8	3.8	11.5
Level-2 (32 amps @ 240 v)	7.7	7.7	23
Level-2 (40 amps @ 240 v)	9.6	9.6	29
DCFC (50 kW)	50	50	150
DCFC (150 kW)	150	+100	+200



2 Hours of charging:

Type	**kW** (speed)	**kWh** (quantity)	**Miles** (distance)
Level-1 (12 amps @ 120 v)	1.44	2.88	8.6
Level-2 (16 amps @ 240 v)	3.8	7.6	23
Level-2 (32 amps @ 240 v)	7.7	15.4	46
Level-2 (40 amps @ 240 v)	9.6	19.2	58
DCFC (50 kW)	50	100	+200
DCFC (150 kW)	150	+100	+200



8 Hours of charging:

Type	**kW** (speed)	**kWh** (quantity)	**Miles** (distance)
Level-1 (12 amps @ 120 v)	1.44	11.5	35
Level-2 (16 amps @ 240 v)	3.8	30	91
Level-2 (32 amps @ 240 v)	7.7	62	185
Level-2 (40 amps @ 240 v)	9.6	77	+200
DCFC (50 kW)	50	+100	+200
DCFC (150 kW)	150	+100	+200