
# *What if gasoline powered cars performed similarly to today's EVs?*

Gasoline powered cars and EVs have completely different drive trains, but they have a couple of key features in common. They are designed to transport people and things from place to place, and everyone wants them to be as efficient and as convenient as possible. How do today's EVs compare to gasoline powered cars in terms of efficiency and convenience?

## If your gasoline powered car performed like today's EVs:

### *1) You can only use about 80% of the capacity of your gas tank*

When you are filling up at a gas station, your car will shut off the flow of gas when the tank gets to about 80% full. You would have to get permission from your car to fill the tank any further – and even then, you could only fill it up to about 90% full.

When your gas tank drops to about 20% full, the car will tell you to stop and add gas. If you ignore the car and continue to drive (because there is still quite a bit of gas remaining in the tank), the car will continuously pester you to stop and get gas. If you keep driving until the tank is about 10% full, the car might go into panic mode and shut down the engine, even though there is still gas in the tank.

You would never get the maximum possible driving range from your gas tank. Typically, you would get a driving range of about 80% to 85% of the actual capacity of the tank.

### *2) Your car intentionally drains small amounts of gas out of the tank on an ongoing basis*

After some number of miles of driving, typically within the first 6 months of ownership, the fuel system will start pumping small amounts of gas out of the tank - while you're trying to fill the tank at a gas station, while you're driving, and sometimes even when the car is parked and the engine is off.

The gas that is drained from the tank is poured onto the engine block and burned.

### *3) Your gas tank starts shrinking*

After 12 to 18 months of driving the gas tank will start shrinking, steadily getting smaller and smaller.

### *4) Your car tells you when and how to add gas to the tank*

When you are driving, your car will tell you when you need to fill your tank and how full you are allowed to fill it. If you don't follow your car's instructions, the gas tank will start shrinking sooner and at a faster rate.

There are two speeds at which you can fill your tank: "fast" which takes 20 to 30 minutes (and only gets the tank about 80% full), and "normal" which takes 4 to 8 hours (and still doesn't get the tank completely full). Your car discourages you from using fast fill, because frequent fast filling accelerates the rate at which your gas tank shrinks and could cause the engine to die.

### *5) Eventually you need to replace the gas tank – at very high cost*

When your gas tank finally gets so small that it must be replaced, you must get a new gas tank installed. The new gas tank will cost about $10,000, plus the cost of labor to install it.

### *Would you buy a gasoline powered car that performs like this?*

Of course not. No automobile manufacturer would make a gasoline powered car that performs like this. Nobody would buy the car and the manufacturer would probably go out of business.

But the scenario described here is directly analogous to what today's EV owners experience.

# How the gas tank analogy applies to today's EVs

## *If you currently own and drive an EV…*

### *You can't utilize the full capacity of the battery*

Your EV has a big expensive battery and your car typically uses only about 80% to 85% of the battery's true capacity. If you need to take a long trip, you can "ask permission" from the car to charge the battery more fully. Usually that will let you charge up to about 90% of the battery's capacity.

When you're driving, the car starts asking you to recharge when there is still a lot of energy remaining in the battery. The car can't utilize all of the energy that is stored in the battery – so it can't give you maximum driving range. The car does this because the BMS is unable to access all of the battery's energy.

### *The balancing system is constantly draining energy from the battery*

The balancing system does this to try to keep the cells balanced. It drains energy from higher SOC cells to try to get them into balance with lower SOC cells. This wastes energy that could be used to drive the car.

The energy that is drained from the battery is converted to heat, and heat accelerates degradation of batteries and electronics. This is why we used the analogy that a gasoline powered vehicle would drain small amounts of gas from the tank and would pour the gas onto the engine block and burn it.

### *The battery's capacity starts declining as the cells drift out of balance*

The capacity of a battery is equivalent to the size of a gas tank. The rate at which battery capacity decreases depends on the quality of the battery. There are variations in quality from manufacturer to manufacturer, and variations in battery-to-battery quality from any given manufacturer. Every battery will lose capacity at a different rate.

The rate at which battery capacity decreases also depends on your driving patterns. If you drive very conservatively, you can slow down the decline in battery capacity. (You can slow it down, but you can't eliminate it.) If you drive like most people, the loss of capacity will be noticeable and you will talk about declining driving range every time you get together with any of your friends who also own EVs.

### *The car tries to control when and how you recharge the battery*

If you have a gasoline powered car, you can add gas to the tank whenever you want to, wherever you want. You can add as much or little gas as you want to. And you can pump gas into the tank at the fastest rate available on the gas station pump.

If people recharged the battery in their EV the same way they refuel gasoline powered cars, battery capacity would drop so quickly that nobody would buy an EV. That is why EVs tell you when and how you can recharge your battery. Eventually the EV will force you to stop driving and recharge even though there is still energy in the battery.

This can lead to charging anxiety.

### *Eventually you need to replace the battery*

The battery in an EV is like the fuel tank in a gasoline powered car. It stores the energy that propels the car. Eventually the battery will lose so much capacity that it needs to be replaced – and battery replacement is very expensive. You want the life of the battery to be as long as possible. Existing battery management technologies are unable to maximize the life of the battery. So battery replacement must occur sooner and more frequently than should be necessary.

## *True Balancing mitigates or eliminates all of the issues described above.*

## *Unlock the Full Power of Your Battery With True Balancing*