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Are EVs really Greener? The Sustainability of EVs

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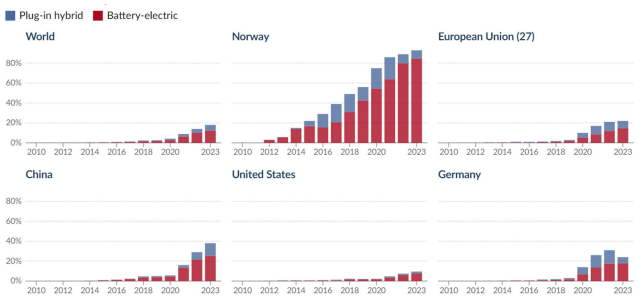
Electric Vehicles are gaining traction with EVs now appearing in the top 10 list of many Asian countries. BYD is now in the top 5 best-selling brands in Singapore and Thailand. As a result, EV penetration has been increasing around the world. The country that is the leader in adoption of EV is Norway with EV cars now 80% of total cars sold (see chart 1). Of the large countries, China is leading the way with penetration reaching 40% in 2023 and the latest data show that penetration has reached 50%.

Chart 1: EV Penetration



Source: Ourworldindata | Period: 2010 - 2023

Some of the factors driving the increased sales in EVs include the performance where acceleration and the smooth and quiet ride have been positives. Driving range on a single charge has also improved from 200km for the 1st generation EVs to 400-500km recently. Range anxiety is no longer a major concern as the range is similar to a full tank of petrol. Of course, EV cars have also been sold on the basis that they are green and would burnish the green credentials of the buyers. Early buyers of EV cars were perhaps virtue signaling, indicating that they were caring for the environment and trendsetters in the green movement.

As a result, EV penetration has been increasing around the world. The country that is the leader in adoption of EV is Norway with EV cars now 80% of total cars sold (see chart 1). Of the large countries, China is leading the way with penetration reaching 40% in 2023 and the latest data show that penetration has reached 50%.

Recently, there have been doubts on whether these EV cars are green and whether the environmental benefits of these cars are real. There have been comments such as "Are EV cars really green if they are powered by electricity coming from coal plants?".

This paper will try to address these issues. We will of course be comparing EVs with ICE (Internal Combustion Engine) cars. Clearly, taking public transport where available would be the greenest option but the fairest way of assessing if EV cars are green would be to compare it with the current alternative, ICE cars.

We will look at the situation by using the entire life cycle of cars. There are 2 aspects to this: Firstly, we have to consider the carbon footprint during manufacture of the cars and secondly look into the carbon emission while the car is being operated. For the second area, we will have to consider the source of energy for the car that is being used.

Looking from the aspect of manufacturing, it has to be conceded that EVs have a higher carbon footprint. The manufacture of EV cars emits 12.2 tonnes of CO2 while for ICE cars it is only 7.4 tonnes. This comes from a study by University of Toronto, where they compared a Toyota RAV4 and a Tesla Model 3. The reason for the higher carbon footprint is due to the batteries in the EV car. Batteries require more energy intensive processes to manufacture. Raw materials for batteries include Nickel, Lithium, Cobalt and the copper.

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There is also controversy surrounding where these commodities are mined. For instance, the largest cobalt reserves are found in the Democratic Republic of Congo where there have been reports of labour rights issues including the use of child labour. In mitigation, battery and EV technology are improving every day. The latest Lithium Iron Phosphate (LFP) batteries do not use cobalt. Battery manufacturers have also developed sodium ion batteries which do not use lithium. Therefore, the CO2 emissions from the manufacture of EV cars should decline over time through technology progress.

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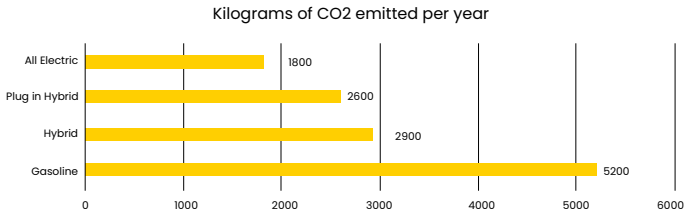
In terms of operations, day-to-day use, this is where the EV cars have an edge over the ICE cars. There are no tail pipe emissions for EV cars while ICE cars emit massive amounts of CO2 with the burning of fossil fuels. Even after adjusting for the CO2 emission from electricity generation, the all-electric car emits just 3,900k pounds (1,800 kg) of CO2 compared to the 11,400 (5,200 kg) generated by the ICE (See chart 2). This assumes mileage of 20,000km annually. The all-electric car on a per year basis emits just a third of the gasoline. Each year the electric vehicle will have an advantage over the ICE car.

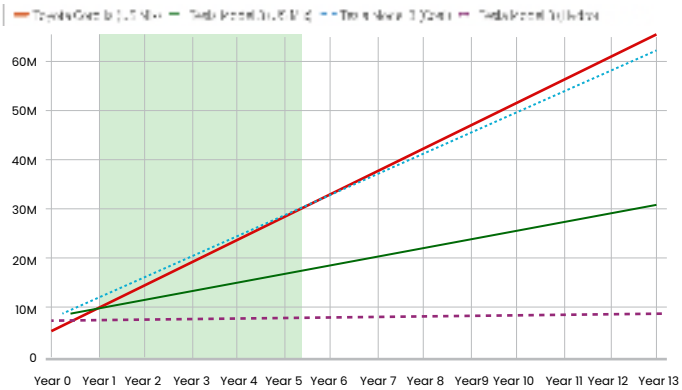
Chart 2: CO2 Emissions average per year



Source : Department of energy (https://usafacts.org/articles/how-much-emissions-do-electric-cars-produce/) converted to KG from pounds

If we combine the two, the manufacture and the operations, to get the entire life cycle of the vehicles we find that EV cars are better (see chart 3). The chart below plots out the total emissions over the lifetime of the vehicle. The chart shows 4 categories, one showing the ICE car and the 3 others EVs but with different sources of electricity:
1) ICE car (Toyota Corolla)
2) EV Tesla Model (US mix)
3) EV Tesla Model 3 (with Coal)
4) Tesla Model 3 (with Hydro)

Chart 3: Total Lifetime CO2 Emissions



Note: Total lifetime CO2 emissions in millions of grams
Data source: Argonne National Laboratory GREET model

The chart shows that even though the ICE car starts off with an advantage (Toyota Corolla - Orange Line), over the lifetime of the vehicles, the EVs will emit less CO2. For EVs that are powered with the most renewable source, Hydro (Tesla Model 3 (Hydro) – Purple Line), this EV will catch up with the ICE car within a year. While the EV powered by hydro emits zero CO2, in the first year the ICE car will consume 11,400 pounds of CO2, approximately 5200 kg or 5m grams of CO2. Cumulatively after a year, the ICE car will emit 7 tonnes of CO2 during the manufacture plus the 5 tonnes of CO2 emitted over the year when the car is used. This 12 tonnes is roughly the same as the manufacture of the EV car.

Table 1: Table of CO2 by Vehicle Type

		Manufacturing CO2 Emissions (kg) (A)	Usage CO2 Emissions/year (kg) (B)	10 year Usage CO2 emissions (kg) (10xB=C)	Total CO2 Emissions over 10 years (A+C)	Breakeven (Years)r
ICE (Toyota Corolla)	Petrol	7,400	5,200	52,000	59,400	NA
EV (Tesla Model 3)	Coal	12,200	4,300	43,000	55,200	5.33
EV (Tesla Model 3)	us Mix	12,200	1,500	15,000	27,200	1.30
EV (Tesla Model 3)	Hydro	12,200	-	-	12,200	0.92

Source: University of Toronto, Argonne National Lab, Maybank Asset Management, https://afdc.energy.gov/vehicles/electric-emissions

So it takes just a year for the EV to achieve 'carbon parity' with the ICE car. Even if we take the extreme case where the EVs is charged by the dirtiest source (Tesla Model 3 (Coal) – Dotted Blue Line), the ICE car will still emit more CO2 over the lifetime. This time the 'carbon parity' occurs somewhere in the 5th year.

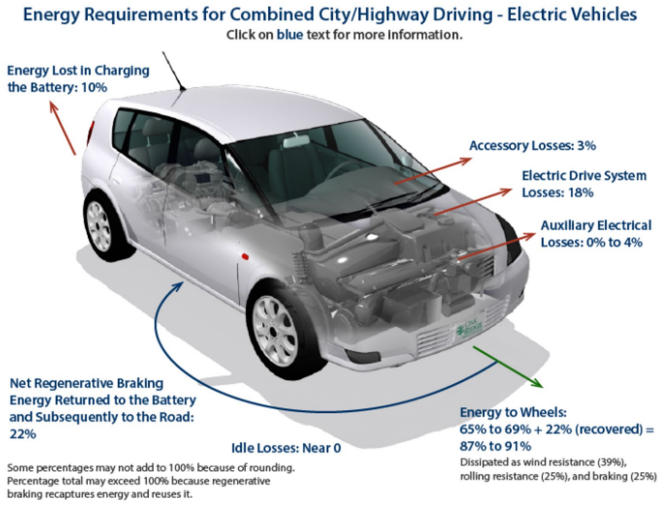
For simplicity, Table 1 shows the type of vehicle and the emissions during manufacture, during usage and the total CO2 emissions over 10 years. We have listed the EV vehicles by power source from the most polluting using solely coal to the cleanest using hydropower. The US mix represents the mix of power sources that is used in the US currently with the 3 biggest sources being gas (38%), coal (19.9%) and nuclear (18.6%). We find that the ICE car will emit more CO2 over the lifecycle of the vehicle. Even over 10 years all the EVs regardless of power source comes out ahead of the ICEs.

Bear in mind that the ICE car used in the comparisons is a Toyota Corolla a compact sedan. In the US, the best sellers are now trucks and SUVs that generate more CO2 in the manufacturing process and during usage than sedans. Even in ASEAN, SUVs are popular, with the Proton X70 and Proton X50 being the best sellers in Malaysia, while trucks are big in Thailand. Another factor to consider for ICEs is that diesels will emit more CO2 than petrol vehicles. Therefore, the current example of using the Toyota Corolla may actually underestimate the CO2 emitted by the average ICE car.

The reason EV cars are superior to ICE even when the source is from fossil fuels is that there is a higher efficiency of the conversion from fossil fuels to electricity and then to the power on the wheels with the EV power supply chain.

For instance, even if the source of electricity comes from coal, coal power plants are running at thermal efficiencies of 40-50% and the electric vehicle will then convert the stored electricity to the wheels at 87-91% (see chart 4). If you work out the maths, the efficiency of EVs from coal source to power at the wheels is between 35%-45% (40-50% x 87%-91%).

Chart 4: Energy to Wheels for EVs



Source: https://www.fueleconomy.gov/feg/atv-ev.shtml. US Department of Energy

In contrast, just looking at the internal combustion engine, there are substantial losses from friction, heat and noise. After all, the ICE is powered by a series of mini explosions. With all that heat generated you will have to have a separate system of cooling to ensure that the engine is not overheating and running at the optimum temperature. This cooling is an additional load on the engine. As a result, only 16-25% of the input energy ends up powering the wheels (see chart 5) which is below that of EVs.

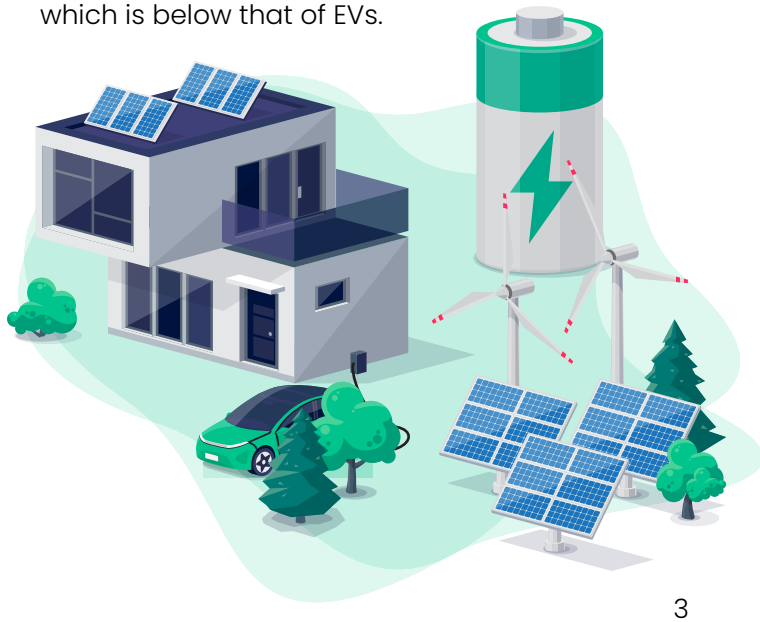
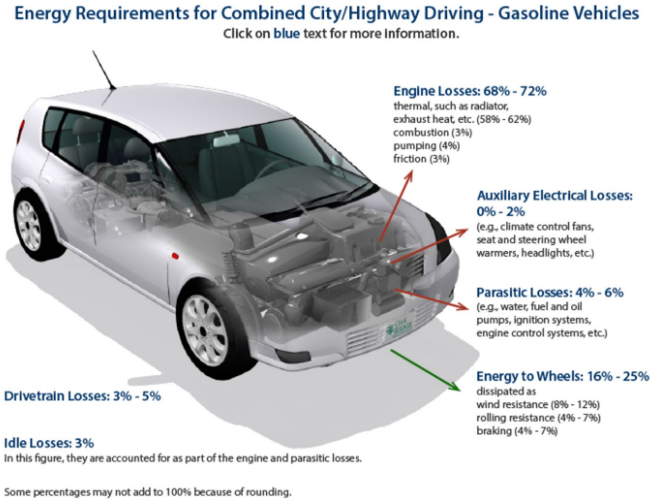


Chart 5: Energy to Wheels for Gasoline Vehicles



Source: https://www.fueleconomy.gov/feg/atv.shtml, US Department of Energy

A side benefit of the EV is that the pollutants from the energy chain are far away from high population density areas. Coal and Gas power plants are typically located far away from major cities. Contrast that from the ICE vehicles where pollutants are constantly coming out of the tailpipe. Diesels are particularly hazardous and following the diesel gate scandal it turns out that diesels are not as clean as once thought.

Many car makers were gaming the emissions tests with the car being aware that it was being tested (tests usually follow set patterns and the car would 'realize' it was being tested once certain steps were done) and therefore would move into low emissions mode. In real world use, diesels are highly polluting and many countries want to limit the number of diesel cars sold in future as it has become a public health hazard. For instance, Singapore has announced that starting from 2025 the registrations for diesel cars and taxis would cease.

In conclusion, it is clear that EVs are definitely greener than ICEs. Yes, even if the source of energy is coal.

> **Energy sources are already moving rapidly away from coal to renewable sources. With the selling prices of EVs in many countries already competitive with ICE vehicles, there is every reason to opt for EVs.**

One last point to note is that ICE vehicles have already seen more than 150 years of improvements since the combustion engine was invented by Nicolaus Otto in 1864. Modern ICEs are already at the peak of efficiency with turbo charging, multivalve and computer controlled engines.

EVs are in their infancy and are already surpassing the ICEs in terms of sustainability. EVs and the energy chain can only improve. With better batteries, weight of the EVs can be lower and efficiency can be enhanced. New batteries are being researched which require less energy to make and use less rare raw materials.

Companies are already researching batteries that are more easily recycled and companies are coming out with new processes to recycle the batteries. Energy sources are already moving rapidly away from coal to renewable sources. With the selling prices of EVs in many countries already competitive with ICE vehicles, there is every reason to opt for EVs.

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