THE CEO's **Drive to Work**

BBB Industries, LLC

Introduction

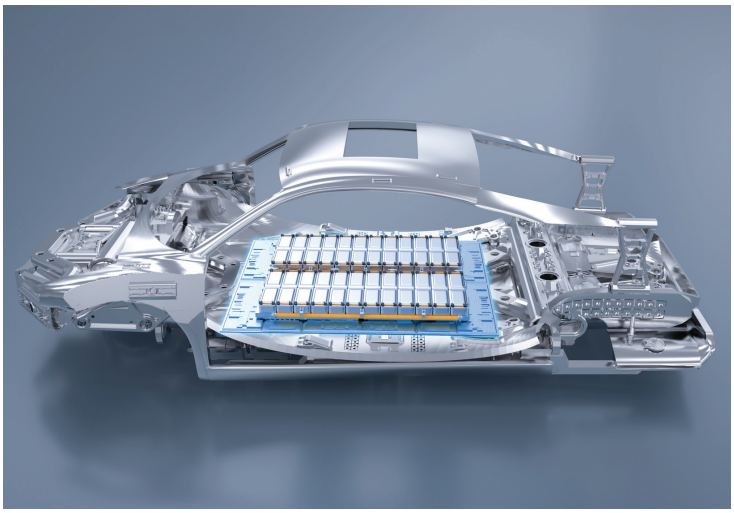
Duncan pours his morning tea and places his laptop into his briefcase. It's another day in Daphne, Alabama where he works as the Chief Executive Officer at BBB Industries. The company he leads collects broken and worn automotive parts and sustainably fixes, cleans, and tests them to be redistributed to major retailers across the globe. He is proud of his company and what it does for the environment by keeping waste out of the waste stream and mitigating unnecessary materials to be mined from the earth. It is a true Circular Economy business model that focuses on retaining product value and keeping drivers on the road in an environmentally responsible way.

On Duncan's commute to his company, a sustainable manufacturer of automotive parts, he considers the personal impact his drive makes on the environment.

During his drive to work this morning, he wondered about the true environmental impact of his commute and if his electric vehicle really was saving the planet. It is a 30-minute, 15-mile journey in an all-electric Ford Mach-E, most of the time accompanied by the soundtrack to the movie "Top Gun" which motivates him for his meetings. On average, he will make this commute 200 days a year, resulting in 6,000 miles on the road.

The Carbon Footprint of the Vehicle

At some point, the Mach-E was produced. Base materials had to be sourced from a far-off country and shipped to a fabricating plant. Then the thousands of fabricated parts were sent over the water to the North American assembly plant where they are brought together in the assembly line. Here the car was born and shipped from the assembly line to the local Alabama dealership where Duncan purchased the vehicle. In total, this is a lot of movements of material and thousands of hands working diligently to bring a finished good to the market.



Researching the mining of material, fabrication process, transportation, and assembly of the vehicle are all important components in understanding the "embodied carbon" of Duncan's EV.

To dig into the "embodied carbon" or the carbon emitted when producing the vehicle, we must research heavy machinery emissions to mine the material, the transportation emissions to transport the material, the energy required to fabricate and assemble the vehicle, and other facets of production. With the average car holding over 30,000 individual components (NAPA, 2023), it is nearly impossible to assess the embodied carbon of each component across each phase of the supply chain, without making some assumptions. For simplicity's sake, we rely on research conducted by the IEA, the International Energy Agency which utilized the Argonne National Laboratory to determine the embodied carbon of an EV at 8 tons of CO_2

The Carbon Footprint of the Vehicle

per vehicle produced. Of the total carbon footprint, 33% is attributed to battery production alone (IEA, 2023). It is important to make a distinction of the battery due to its important role in replacing the traditional engine and the significant critical materials required to create the battery. Understandably, each vehicle's embodied carbon is different due to the differences in component requirements. This analysis is commonly referred to as a "Cradle-to-Gate" analysis. In summary, to make Duncan's electric Mach-E 8 tons of carbon were emitted into the atmosphere.

The Charging of the Vehicle

Duncan pulls into the BBB corporate office and plugs the Mach-E into the EV chargers on site. This energy is provided free of cost to the employees at the office. Normal EV drivers will not consider the source of the electricity that is powering their commute. As Duncan is unlike most EV drivers, he begins to wonder where the energy to charge his vehicle came from and how it was generated.

The office's charging station sources energy from the local utility company which acts as an intermediary between BBB, the Alabama Municipal Electric Authority (AMEA), and its individual electricity producers. AMEA sources its power from a plethora of companies spread across the state who have multiple generation methods. The AMEA website displays a pie chart showing a generation mix of coal, hydro, gas, nuclear, and renewable energy sources. This certainly complicates understanding the exact carbon emitted when generating the power to charge Duncan's car, especially since different energy sources emit different quantities of emissions. (It is important to note and applaud the 11% increase over the past year in renewable power in the AMEA electricity mix). For this study particularly, we will rely on an average Alabama electricity mix to create a generation factor and realize a carbon footprint of 0.356 kgCO2 per kWh produced (Carbon Footprint Grid Specific, 2022). This means that for every kWh produced to charge Duncan's car, .356 kilograms of carbon is emitted into the atmosphere.

To put this in perspective, Duncan's EV requires 37 kWh per 100 miles (U.S. Department of Energy, 2021). This means that with the Alabama generation factor, Duncans's commute is responsible for .79 metric tons of CO2 per year for the 6,000 miles traveled to and from work. The same amount of carbon would be emitted in 2,025 miles (-66% fewer miles!) traveled by a traditional internal combustion engine (ICE) vehicle. (Environmental Protection Agency Calculator, 2023).

When plugging into a charging station, we must begin to identify where the electricity we are relying on is coming from and how it is generated.

A Comparison to ICE Vehicles

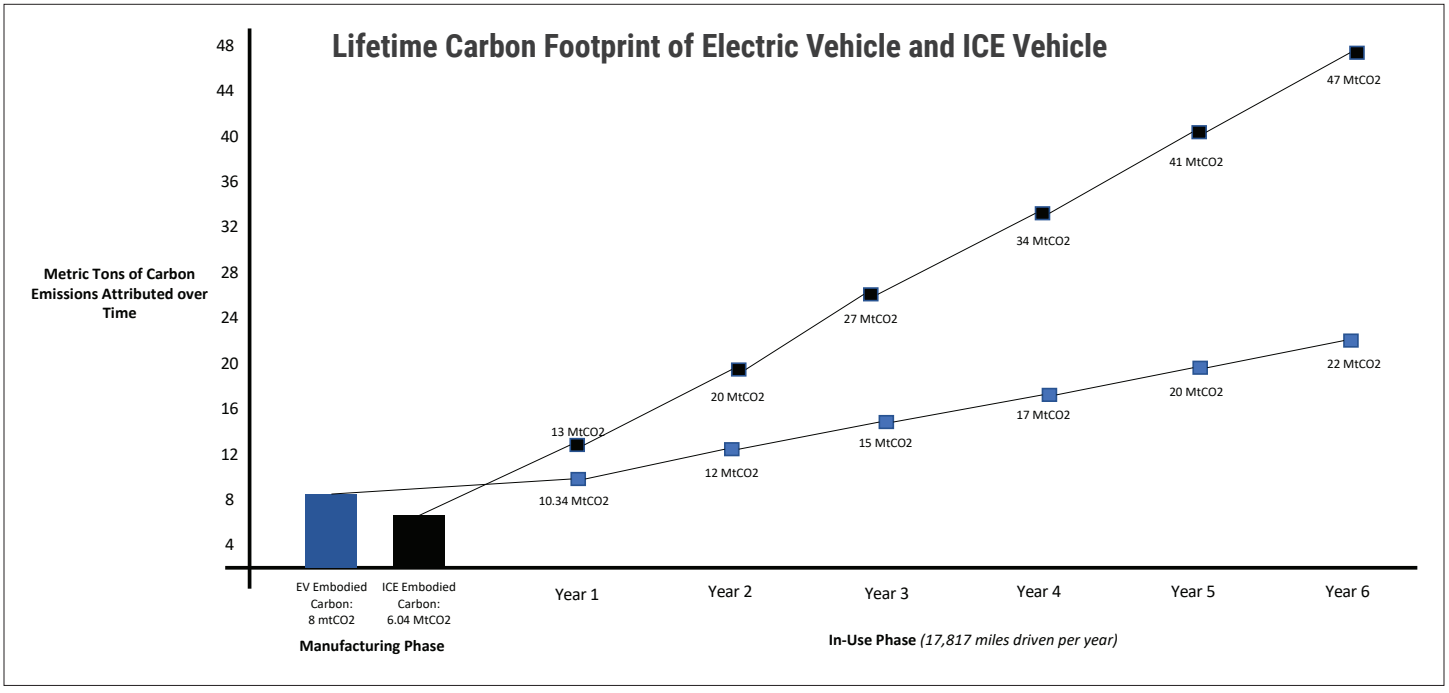
When comparing traditional ICE vehicles to EV vehicles we must consider the carbon emissions attributed to production and the emissions produced during the in-use phase.

A challenging but productive day at the office is complete as Duncan drives home. He passes his neighbor's driveway where he sees a 2020 gas-powered sedan sitting outside. This begs the question: how does the environmental impact of his neighbor's traditional gas car compare to the environmental impact of his own EV?

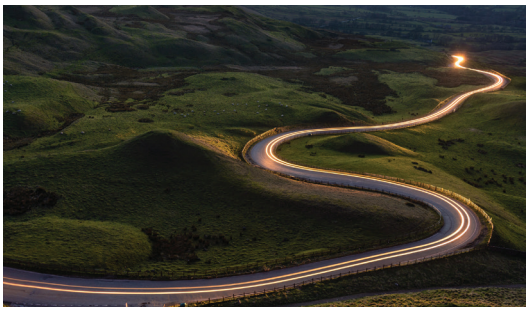
To produce Duncan's EV it took 8 tons of CO_2 emissions. To produce his neighbor's traditional gas-powered vehicle, it took 6.04 tons of CO_2 Emissions (also based on the IEA study previously referenced). From this standpoint, the gas-powered vehicle has done less detriment to the environment than the electric car (this is why sustainably minded manufacturing in the EV space is so important). However, when we investigate the carbon emitted to supply energy throughout the lifetime of the vehicle, our results shift the opposite way. The only question is when does the electric vehicle save enough emissions to be better than a traditional car? Furthermore, when do the avoided emissions of the EV become greater than the production emissions?

The average Alabama driver logs 17,817 miles on the road each year (Meyer, 2023). By using the previous emissions information, this means that Duncan's EV would be responsible for 2.34 metric tons of in-use carbon emissions annually. On the other hand, his neighbor's gas-powered car would be responsible for 6.95 metric tons of in-use carbon emissions each year (EPA Equivalency Calculator). Driving the same number of miles, both vehicles will reach equal lifetime carbon emissions by the sixth month of being on the road. After the sixth month of driving, the rate that the ICE vehicle produces emissions now surpasses the extra emission needed to make the electric vehicle. Furthermore, by the end of the second year of driving the electric vehicle has avoided the same number of emissions it took to produce the vehicle itself.

To put this all into perspective, if a car must be produced, the EV will create more emissions in the production process. However, after the sixth month of average driving, it is now responsible for fewer lifetime emissions than a traditional gas-powered car.



Extending the Life of Vehicles Increases Avoided Emissions



As a large share of lifetime emissions of EVs can be attributed to the production stage, we must keep them on the road as long as possible.

We've come to understand how the impact the energy your car uses has on the environment. This is fine and well, but not all drivers are in a position where they can drive over to their local dealer and purchase a new electric car. As a large portion of all vehicles' lifetime carbon footprint comes from the production stage (especially EVs), we must ensure that we keep the cars we have already produced on the road for as long as possible. In an ideal world we would be discussing how more people can take public transit or bike to work, however, by the nature of our communities, driving continues to be the best option. Keeping a vehicle on the road for as long as possible mitigates the need to create a new one. Furthermore, when your vehicle breaks down, you have the option of buying a sustainably manufactured replacement component. If you are in the market to purchase an electric EV, congratulations, you are well on your way to an environmentally friendly commute, like Duncan. Furthermore, when your EV components break down, you can look to TERREPOWER, a division of BBB Industries, who provides sustainably manufactured replacement components to keep you on the road.

Conclusion

Though all EVs perform differently and certainly assumptions must be made to assess the environmental impact of vehicles, this case study hopes to bring clarity to the electric vehicle space. Furthermore, this study shows the importance of producing vehicles in an environmentally responsible way and developing a circular economy for end-of-life vehicles to ensure that each component is extended for as long as possible. BBB Industries and TERREPOWER welcome the opportunity to discuss this study further and pursue research that brings Sustainability minded action to the automotive sector.

About

BBB Industries, LLC is an industry leader in the sustainable manufacturing of starters, alternators, hydraulic and air disc brake calipers, hydraulic and electronic power steering products, and turbochargers for the OEM, passenger, industrial, and commercial vehicle aftermarket industries.

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