Comparison of CO_2 emission between conventional internal combustion vehicles (CICVs) and electric vehicles (EVs)

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Abstract. As the climate changes on earth, people are caring more about the issue of global warming. In that, they invented electric cars, which is touted as an effective way to reduce vehicles emissions of CO_2. So, this essay will explain whether EVs helps the environment. Research on different aspects of both cars have been done, structures, history and others are being included. As the study result, which being found out is that the electric vehicles averagely emit less CO_2 than conventional internal combustion cars. Also, what is affecting the carbon dioxide emission of EVs are their dependence of time and time of the day. What's more, many proposed solutions of reducing carbon emission on EVs are being used now efficiently.

Keywords: Conventional internal combustion vehicles; electric vehicles; carbon dioxide emission.

1. Introduction

In the realm of contemporary transportation, the ongoing global concern for environmental sustainability has brought about a seismic shift in the automotive industry. As the effects of climate change become more pronounced, the imperative to reduce carbon dioxide CO_2 emissions has become an unparalleled challenge. In this context, a profound transformation is underway, primarily manifesting in the rivalry between Conventional Internal Combustion Vehicles (CICVs) and Electric Vehicles (EVs). This paper undertakes a comprehensive analysis of the CO_2 emissions associated with these two contrasting automotive technologies. By delving into the intricate mechanics of their operation, energy sources, and overall environmental impact, this comparison aims to illuminate the pivotal role that CICVs and EVs play in shaping the future of transportation and the urgent global mission to mitigate climate change. Through a meticulous examination of their emissions profiles, this essay endeavors to offer a nuanced understanding of the benefits and challenges presented by each technology, ultimately contributing to informed decisions for a more sustainable automotive landscape.

2. Description of CICVs

2.1. Development History of CICVs

As a very common vehicle nowadays, the conventional internal combustion cars hadn't appeared until 200 years before. The history of cars all started with a concept. Leonardo Da Vinci, the well-known painter came up with the idea of a car, and the people after him tried to make their dreams come true. The first modern automobile was invented by Karl Benz in 1866, which is a three-wheeled motor car, known as "Motorwagen". The throttle system, spark plugs, gear shift, water radiator, carburetor, and other essential vehicle components are all unified in one vehicle for the first time. As for all parts in a car, the power system is the most vital section. And the power system of conventional cars is engine. In that, Nicolaus August Otto, who created a powerful gas motor engine, is credited with creating one of the most significant turning points in engine design. His "Otto Cycle Engine" was the first usable four-stroke internal combustion engine. Then, in 1889, Gottlieb Daimler made improvements to the engine design. It helps the car achieve the speed of 10mph. because of his invention, gasoline cars started to gain traction, while the market began to grow actively compared to other types of motor vehicles, and the demand was through the roof [1]. The popularity of gasoline cars came from their faster speed and more cost-effective power. And these are why gasoline conventional cars kept popular so long time until present.

2.2. Structure of CICVs

The main structure of CICVs is shown in fig.1. The function of the main parts is summarized as follow. Battery offers power to turn on the engine. Electronic control module manages the emissions system, ignition timing, and fuel mixture. Additionally, it is able to detect engine activity. Gasoline is injected into the intake manifold or combustion chamber, where it mixes with air and is ignited by a spark from a spark plug.

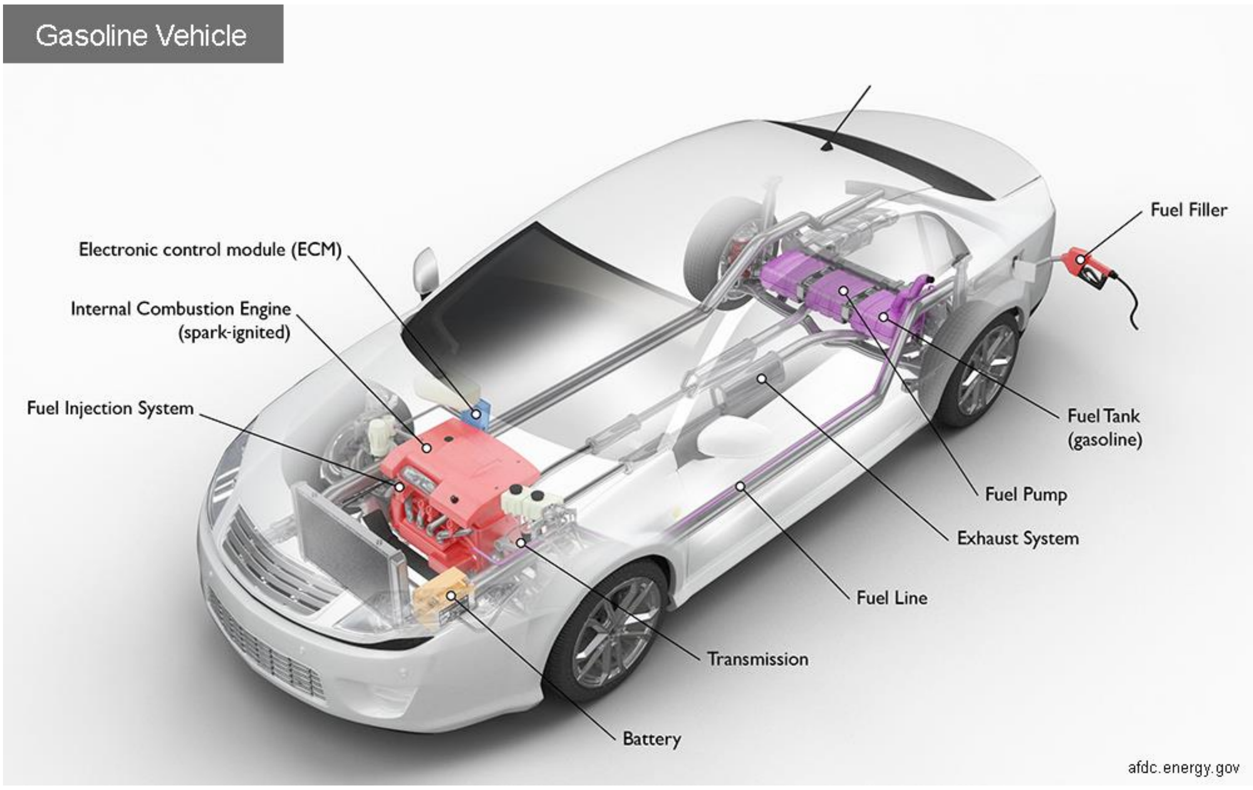

Fig 1. Inner structure of combustion cars [2].

2.3. CO_2 emission of CICVs

On the one hand, the CICVs provide so much convenience to people's transportation. However, on the other hand, the burning of fuels of CICVs emit large percentage of carbon dioxide in atmosphere, which cause a series of environmental problems. The most severe problem nowadays is the global warming and climate change which caused by air pollution. The main reason for criticism of traditional fuel vehicles can refer to the production of CO_2 [3]. And CO_2 generation, which accounts for a staggering 76% of the world greenhouse gas emissions in 2010, is the source of the biggest portion of greenhouse gas [3]. So, either government or individuals these days are eager to find ways to reduce the emission of CO_2. And elements in fuels also affects the emission a lot. Ambient temperature impacts evaporative and exhaust emissions in a manner similar to how it affects gasoline-powered vehicles. At lower temperatures, organic and carbon monoxide exhaust emissions increase significantly, while evaporative emissions rise slowly as the temperature rises [4].

Fig.2 shows a test scheme of exhaust and evaporative emissions. The test vehicle is General Motors (GM) Variable Fuel Corsica [4]. Using the gas chromatography to analyze the methanol samples after the test is done. The presence of controlled (OM, CO, and NOx) and unregulated pollutant emissions was assessed for all emissions[4].

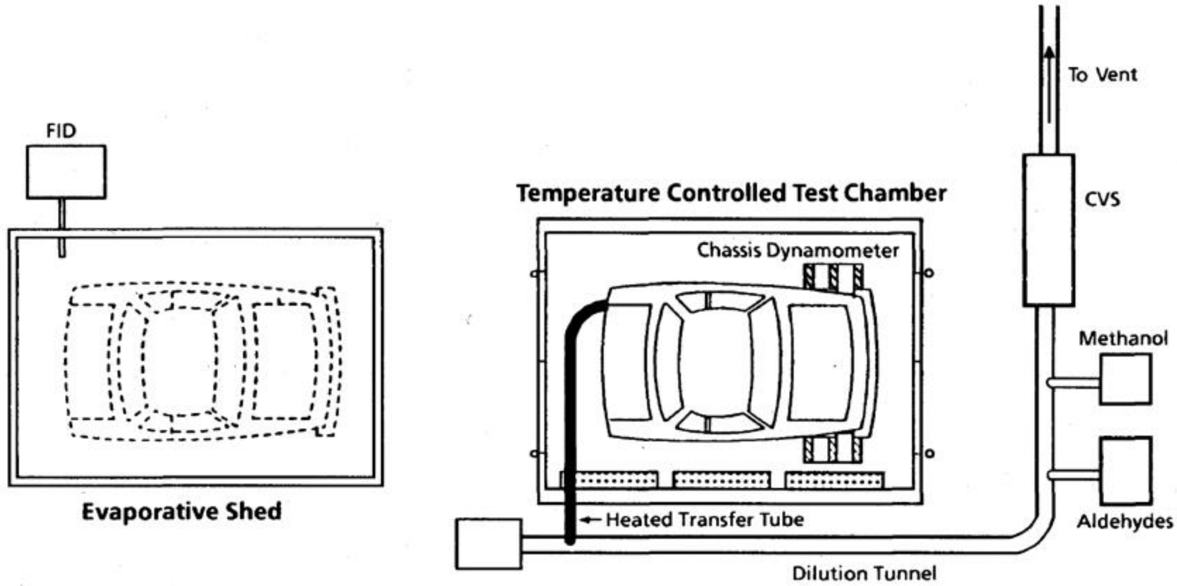

Fig 2. Emissions sampling scheme [4].

3. Description of EVs

3.1. Development History of EVs

The history of EVs is tightly related to batteries. In 1800, the Italian Alessandro Volta demonstrated that electric energy could be stored chemically [5]. Several decades after that, the most popular period for electric car deployment was coming. Up to the early 1920s, it depicts the EV industry's golden age. EVs have never experienced another prosperous era of technological advancement and implementation. The majority of significant technological advances were also made during this time. Even now, a hundred years later, they still form the basis for electric car [5].

Soon in the 1960s, a new controversial topic occurred, which is significantly focused on the issue of environmental pollution. At the same time, a separate debate was on as the air pollution of big cities. In that, the CICVs have been considered as one of the most pollutant thing. Then, by the end of this decade, California enacted the first zero-emission regulations in 1990, which considerably sparked new initiatives in developing EVs. Snice then, people’s hope on clean cars has been started and promoted.

Research on EVs has been accelerated due to environmental pollution and energy-related issues [6]. Infrastructure and EV technology have advanced in the modern era thanks to the involvement of government and industry. One million electric vehicles were sold worldwide in 2016 [7], also, five million light-duty EVs and plug-in hybrids were sold globally in 2018. Known automakers like Volkswagen, Mercedes, and Ford have spoken about their goals to promote EVs [6].

3.2. Structure of EVs

The main structure of EVs can be seen in fig.3. The function of the main parts are summarized as follow. DC/DC converter converts higher-voltage DC power from the traction battery pack to lower-voltage DC power. An onboard charger converts incoming AC power from the charge port to DC power so that it can be used to recharge the traction battery. Power electronics controller regulates the flow of electrical energy from the traction battery and controls the speed of the electric traction motor.

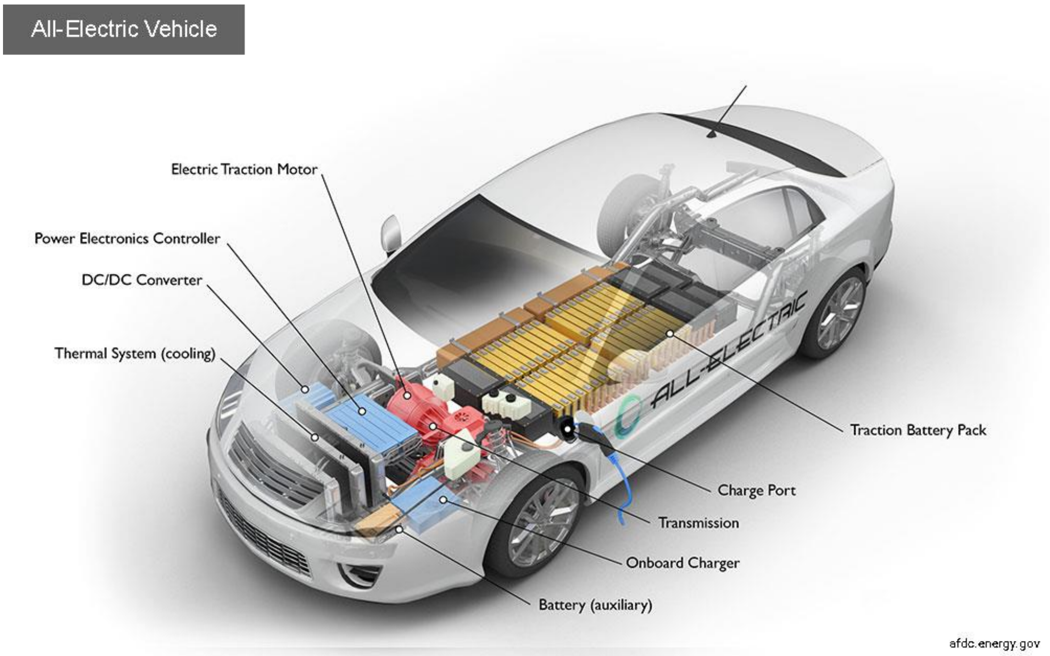

Fig 3. Inner structure of combustion cars [8].

3.3. CO_2 emission of EVs

It’s well-known that electric vehicles are made for reducing the carbon dioxide emission and improve the global warming brought by greenhouse gas. Although it's crucial to understand that this potential is reliant on the sort of power used to charge the battery, the use of electric vehicles could reduce carbon emissions. The location of a car's charging station has a huge impact on the emissions of electric vehicles because the majority of electricity generation on Earth is grid-tied. Additionally, there are unreported carbon emissions associated with car production [9].

The US Data Center's Department of Energy reports that the average annual CO_2 emissions from electric cars are 3932 pounds (fig. 4). This is less precise and accurate because it averages out distances, grid sources, and car models. Additionally, 11,435 pounds of CO_2 are released annually by gasoline-powered vehicles. In light of this, when grid sources from multiple states are averaged, gas cars release 2.9 times as much carbon as electric cars do in the US. In a similar vein, we examine the carbon emissions of electric automobiles in 20 of the most developed nations in the world by taking into account the whole range of emissions that arise in both the production of energy and vehicles. As discussed previously, gasoline and petrol vehicles also have carbon emission ratings [9].

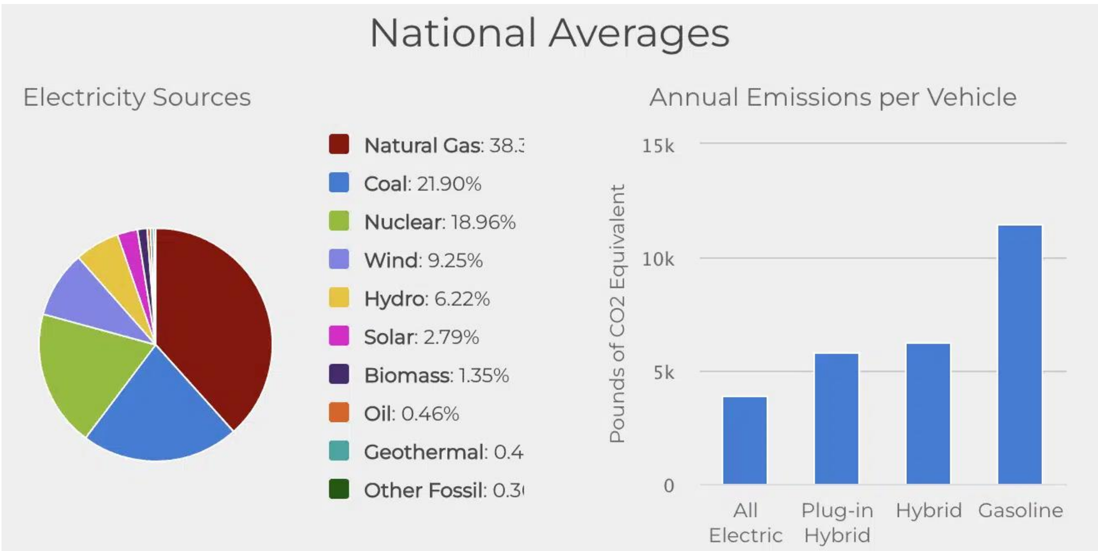

Fig 4. AFDC estimates for emissions of different types of cars [9].

Actually, the amount of carbon emission can be influenced by the local energy structure. Fig. 5 clearly shows the difference of CO2 emissions between different places around the world. For example, we can see that all the difference between Paraguay and India has something to do with the power source, which includes the fuel elements, high carbon coal at the top to low carbon hydro at the bottom.

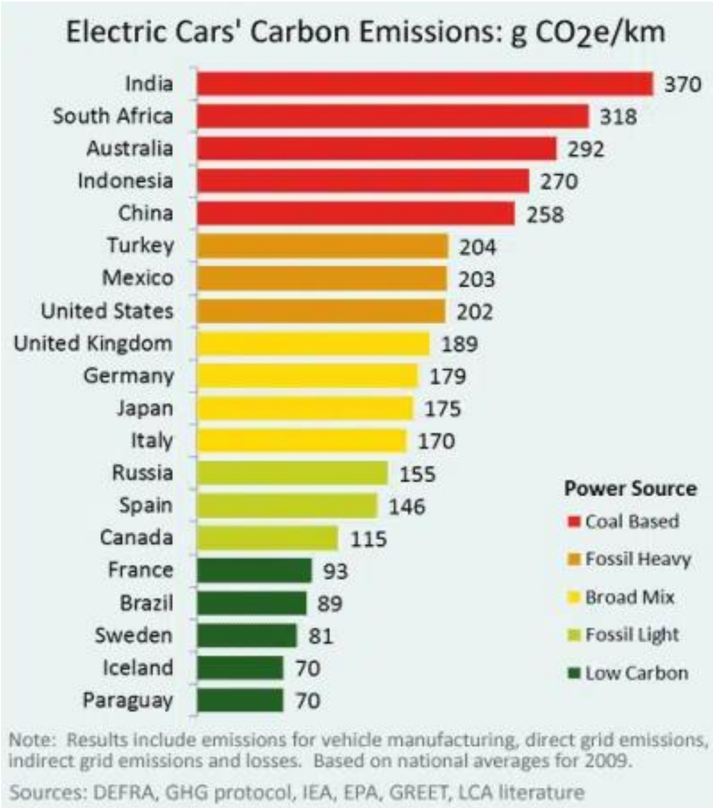

Fig 5. Electric car emissions in different countries [9].

In the United States, the average emission of an electric car is 202 g CO_2e/km. It is undoubtedly superior to a gasoline or diesel vehicle in the same nation, but inferior to an electric vehicle in a nation where the electricity comes from less carbon-intensive sources. Additionally, hydroelectric powerhouse Paraguay triumphs. Compared to using solar energy, the carbon emissions of electric automobiles are substantially lower at 70 g CO_2e/km, which includes both the production of the vehicle and electric driving.

In contrast, grid-powered electric cars in China, India, and Australia emit emissions ranging from 258 g CO2e/km to 370 g CO_2e/km, which are many times higher than those produced by automobiles fueled by low-carbon sources [9]. It's clear that what dominates a country's energy structure also dominates the electric sources for electric cars in that country. So that's the dependence of carbon dioxide emissions on deferent locations. Moreover, another carbon emission session on EVs despite the electric source is the emissions while manufacturing.

4. Comparison between their emissions

The emission of coventional cars has been a troublesome issue for a long time as the carbon dioxide emission. Additionally, internal combustion engine-powered vehicles are a significant producer of pollutants and greenhouse gases [10]. To this situation, the EVs is a possible solution for precent condition. They are regard as "zero tail gas emission". However, the use of electric vehicles is still conversial, as the car's emssion reduced, the emssion of producing the electricity increased at the same time. In that, whether the electric cars can reduce the carbon dioxide emission is a question.

For CICVs, According to figures for Europe as of 2012, light-duty vehicles account for 15% of the continent's CO2 emissions [11]. This is as depicted in Fig.6.

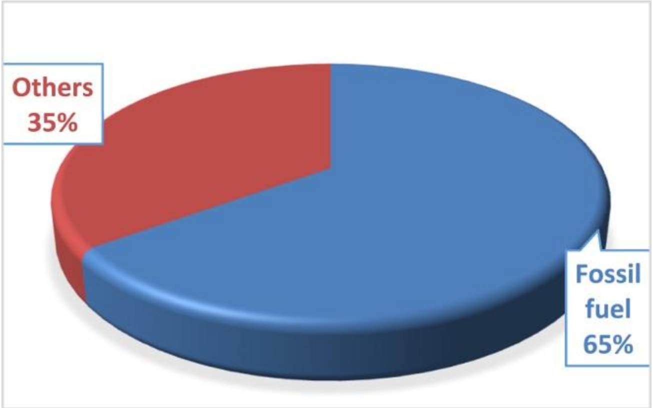

Fig 6. Fossil fuel contribution to global CO_2 [12].

According to the global power generation, unless the extra electricity needed is entirely produced from green energy sources, the switch to electric vehicles around the world and the elimination of internal combustion engine-powered vehicles will increase the load on the power grid. China is the world largest producer of electricity, then is the United States and India following [12], fossil fuels account for more than 75% of energy generation in 2015 in China, with coal accounting for 72% of the total. According to projections for the year 2040, this dependence will rise to over 50%. [13], assuming everything goes as planned. However, as of 2017, coal continues to contribute for around 30% of the United States' electricity generation and 65% of her electrical generation [14]. It is noteworthy that the recently disclosed data for 2018 revealed that energy consumption in the United States in 2018 hit a record high [15]. CO_2 emissions from electricity generation based electric vehicles versus internal combustion engine vehicles used on the road in the UK, Germany, India and China are shown in Fig. 7.

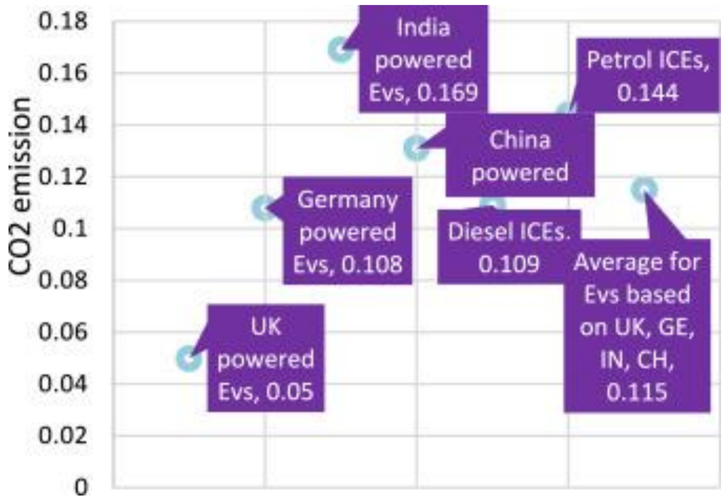

Fig 7. CO_2 footprints of Electric vehicles in different countries [12].

Using the average of power generation emissions for the four countries mentioned above, it can be seen that the CO_2 emissions from internal combustion engine vehicles are close to those of electric vehicles, and in a practical sense, diesel-powered vehicles have lower CO_2 emissions. For India, using internal combustion engines with diesel fuel is more environmentally beneficial than using electric motors, and even China has rigorous regulations in place to phase out the usage of internal combustion engines soon.

5. Conclusion

In this research, emissions of two kinds of vehicles are compared. The stark contrast in their carbon footprint is not merely a statistical difference; it reflects a paradigm shift towards a more sustainable and eco-conscious future. The inherent nature of EVs to produce zero tailpipe emissions places them at the forefront of efforts to combat climate change and foster environmental stewardship.The ongoing research and development in battery technology, charging infrastructure, and energy management are instrumental in addressing the remaining challenges of EV adoption. The future promises improvements in driving range, shorter charging times, and enhanced affordability, bolstering the appeal of EVs to a broader spectrum of consumers. However, to truly achieve a holistic reduction in carbon emissions, the evolution of EVs should not stop at electrification alone. The integration of renewable energy sources for charging, the optimization of battery production processes, and the exploration of second-life applications for used batteries are areas ripe for exploration. By targeting the entire lifecycle of EVs, from manufacturing to disposal, we can maximize their positive impact on the environment.

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