

# Total Cost of Ownership of Electric Vehicles and Internal Combustion Engine: A Real-World Comparison in Kuwait

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## Abstract

Car ownership paradigms are shifting sporadically with most purchasers considering multiple factors before effecting their purchases. The goal of this study is to provide a comparison of the total cost of internal combustion engine (ICE) and electric vehicles (EVs) in Kuwait. This is an important research area the total cost of ownership (TCO) is a key factor that influences the purchasing decision of car buyers, and it can vary significantly between different types of vehicles. By comparing the TCO of ICE and EV vehicles in Kuwait, experts can gain a better understanding of the economic advantages and disadvantages of each type of vehicle, and how they compare in terms of affordability and value for money. This information can be useful for policymakers, automakers, and consumers in Kuwait who are interested in promoting the adoption of EVs and reducing the country's reliance on fossil fuels.

**Keywords**— TOC, EV, ICE, electric.

## Introduction

The automobile industry has undergone rapid evolution over the past two centuries. The 19th century marked a significant humankind achievement that was the Invention of an automobile. The goal of these initial automobiles was to increase human mobility and enhance economic expansion through the development of Road infrastructure that facilitated the transportation of goods and services to the markets.[1] Evolutions witnessed in the automobile industry aimed at reducing the carbon footprint by developing new technologies and engine options that you limit CO2 emissions and increase automobile efficiency. Kuwait is a major oil-producing country and has one of the highest per capita ownership rates of vehicles in the world. The automotive industry in Kuwait is dominated by the sale and service of internal combustion engine (ICE) vehicles, which account for the vast majority of vehicles on the roads. However, in recent years, there has been growing interest in electric vehicles (EVs) as a more sustainable and cost-effective alternative to ICE vehicles. The Kuwaiti government has implemented several policies to promote the adoption of EVs, such as tax exemptions and subsidies for EV buyers, and the construction of public charging stations. [2] However, the adoption of EVs in Kuwait is still in its early stages, and EVs currently make up only a small fraction of the total vehicle fleet in the country.

The Kuwaiti government has implemented several policies to promote the adoption of electric vehicles (EVs) in the country,

in order to reduce the country's reliance on fossil fuels and improve air quality. [3] These policies include:

- Tax exemptions: EVs are currently exempt from value-added tax (VAT) in Kuwait, which can make them more affordable compared to internal combustion engine (ICE) vehicles.
- Subsidies for EV buyers: The Kuwaiti government provides subsidies for individuals and businesses who buy EVs, in order to encourage the adoption of these vehicles [12]. The amount of the subsidy varies depending on the type and size of the EV, and it can be applied towards the purchase price of the vehicle or towards the cost of installing a charging station at the buyer's home or workplace.
- Construction of public charging stations: The Kuwaiti government is investing in the construction of public charging stations for EVs, in order to improve the availability and convenience of charging infrastructure in the country.[14] These charging stations are located in various locations, such as shopping malls, office buildings, and residential areas, and they are available for use by the public at a nominal fee.

Overall, these government policies play a significant role in promoting the adoption of EVs in Kuwait and making them a more attractive and viable option for car buyers.[14] By providing financial incentives and improving the charging infrastructure, the Kuwaiti government is helping to reduce the barriers to EV adoption and making EVs more competitive with ICE vehicles in the Kuwaiti market. The government policies that promote the adoption of electric vehicles (EVs) in Kuwait, such as tax exemptions, subsidies, and the construction of public charging stations, can affect the total cost of EVs and their competitiveness with internal combustion engine (ICE) vehicles in several ways. [9]

First, these policies can reduce the upfront cost of EVs by providing financial incentives that reduce the purchase price of the vehicle. For example, the exemption from VAT and the subsidies for EV buyers can make EVs more affordable compared to ICE vehicles, which can make them a more attractive option for car buyers.[3] Second, these policies can also reduce the ongoing costs of owning and operating an EV, such as fuel costs and charging fees. By investing in the construction of public charging stations, the government is making it easier for EV owners to recharge their vehicles, and by setting lower charging fees, it is making EV ownership more affordable compared to ICE vehicles. Third, these policies can

improve the competitiveness of EVs by reducing the barriers to EV adoption and increasing the awareness and acceptance of EVs in the Kuwaiti market. By providing financial incentives and improving the charging infrastructure, the government is encouraging more people to consider EVs as a transportation option, and by promoting EVs through public education and outreach campaigns, it is increasing the visibility and desirability of these vehicles. [5]

Overall, the government policies that promote the adoption of EVs in Kuwait can have a positive effect on the total cost of EVs and their competitiveness with ICE vehicles in the Kuwaiti market. By reducing the upfront and ongoing costs of EV ownership and increasing the awareness and acceptance of EVs, these policies can help to make EVs a more attractive and viable option for car buyers in Kuwait.

## Data and Methods

### Introduction and Modelling Factors

The primary goal of this section is to compare various factors that affect the total cost of ownership of internal combustion engines and electric vehicles and to facilitate the process of determining what model is the best fit for the Kuwaiti market. This study uses a ten-year period to provide concise comparison of the two main variables. Different models will be developed based on the years needed for owners to exploit the full benefits of electric vehicles and internal combustion engines and other factors affecting our vehicles' price, such as the initial acquisition cost, curb weight, MPG, and power rating. Additional factors determining the total cost of ownership of a vehicle include engine sizes and the nature of transmission.

### Total Cost of Ownership

The primary premise of the concept of the total cost of ownership is the underlying costs that determine the ultimate value of vehicles. Therefore, the total cost of ownership is shown by the equation below.

$$TOC = \sum_{n=1}^N \frac{OC}{(i+1)^n} + CC$$

CC is the capital costs and equates to the initial acquisition price, while OC is the operating costs compounded annually using an NPV model.

OC can be further calculated as

$$OC = AT + Fuel + MR + RF + IP$$

While CC;

$$CC = HCC + RF + AC$$

Where AT is the costs for alternative transport, Fuel is the cost of fuel, RF is the registration fees, HCC denotes home charging costs, IP is insurance premiums paid and AC is the vehicle acquisition costs. ICE cost based on the power train was calculated using the equation;

$$CE = 0.174 \times P(KW^{1.808})$$

The central components of the power train of the ICE are as shown below

**Table 1:** Powertrain costs [1] [4]

	ECU	Exhaust	Transmission	Engine
<b>Minimum</b>	\$230	\$380	\$1.11/kg	\$4.4/KW
<b>Average</b>	\$280	\$714.5	\$1.38/kg	\$15.05/KW
<b>Maximum</b>	\$330	\$1049	\$1.64/kg	\$25.7/KW

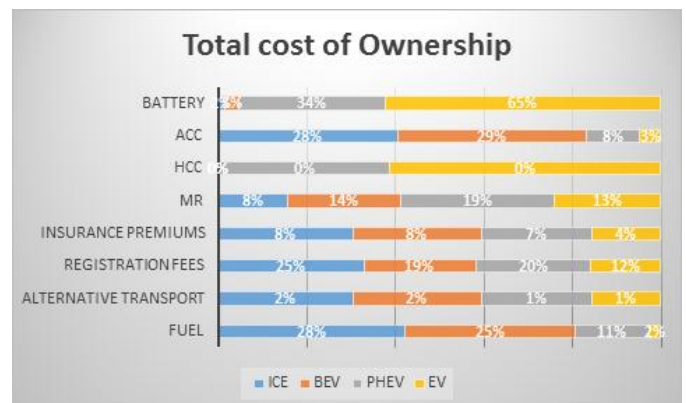
### Data sources and Real-World Comparisons

The primary data used for this research was derived from the Kuwaiti consumer market, with critical analysis being used to compare vehicle prices and other operating costs based on the information derived from major car corporations. Real-world comparisons of automobiles within the ICE segment were conducted using different parameters such as the power terrain. The obtained results are as shown in the next section.

## Results and Discussions

### Total Cost of Ownership

The study established that the TOC of EVs was the highest due to several factors shown in figure 1 below.



**Figure 1:** Total Cost of Ownership

The total cost of ownership (TCO) for a vehicle is the amount of money a person or business will spend on a vehicle over its entire lifetime. TCO includes the initial purchase price of the vehicle and all the ongoing costs associated with owning and operating the vehicle, such as fuel, maintenance and repair, insurance, taxes, and financing costs. TCO is a useful metric for comparing the costs of different types of vehicles because it considers all the costs that a vehicle owner will incur, not just the upfront purchase price. By comparing the TCO of different vehicles, experts can get a more complete and accurate picture of their relative costs and value for money.

Several factors contribute to the total cost of ownership (TCO) of the internal combustion engine (ICE) and electric vehicles (EVs) in Kuwait. These include:

1. Purchase price: The purchase price of a vehicle is the initial cost a buyer pays to acquire the vehicle. The purchase price of ICE and EV vehicles in Kuwait can vary depending on

the vehicle's make, model, and trim level, as well as any rebates or incentives that may be available. In general, the purchase price of EVs is typically higher than that of comparable ICE vehicles due to the higher cost of the battery and electric drivetrain. [5]

2. **Fuel costs:** Fuel costs are the expenses associated with purchasing gasoline or diesel for ICE vehicles or electricity for EVs. In Kuwait, gasoline and diesel costs are relatively low compared to other countries due to the country's abundant oil reserves. On the other hand, the cost of electricity is higher than in some other countries, but it is still significantly lower than the cost of gasoline or diesel. As a result, the fuel costs of EVs in Kuwait are generally lower than those of ICE vehicles.
  3. **Maintenance and repair costs:** Maintenance and repair costs are the expenses associated with keeping a vehicle in good working condition, such as regular servicing, tire replacements, and fixing any mechanical or electrical issues that may arise. [5] In general, EVs' maintenance and repair costs are lower than those of ICE vehicles due to the simpler and more reliable design.
  4. **Insurance:** Insurance is a type of financial protection that covers the cost of damage to a vehicle or third-party liability in the case of an accident. [14] The insurance cost for a vehicle in Kuwait depends on various factors, such as the type of vehicle, its age, and the driver's driving history. It needs to be clarified whether the cost of insurance for EVs is higher or lower than that of ICE vehicles in Kuwait, as this can vary depending on the specific circumstances.
- Taxes and Registration fees:** Taxes are the fees and charges that a vehicle owner must pay to the government for owning and operating a vehicle. In Kuwait, various taxes and fees apply to vehicles, such as registration fees, road taxes, and value-added tax (VAT). The amount of taxes a vehicle owner must pay in Kuwait depends on the type of vehicle and its value. EVs are currently exempt from VAT in Kuwait, making them more affordable than ICE vehicles.

### A Ten-year Trend Analysis

The findings also demonstrated that the total cost of ownership over the next 10 years may not reviews for any type of engine used.

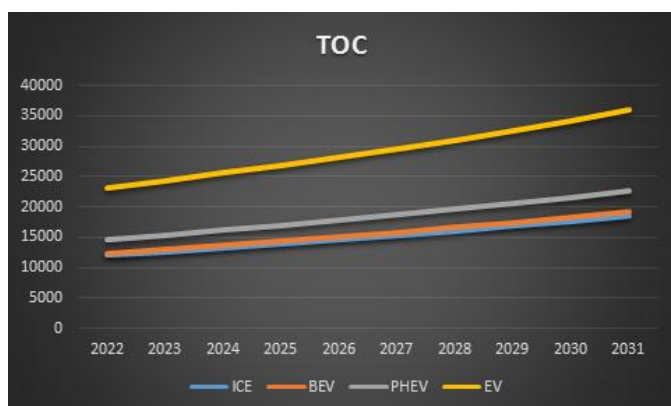


Figure 2: Total Cost of Ownership over the next 10 years

One of the primary rationales for this trend is there a high dependence on oil and other products by Kuwait. The country's oil prices is relatively low compared to other types of fuel or energy used to propel automobiles. Therefore, the use of electric vehicles in Kuwait might only be viable if various considerations and legislations with debilitating implications on the use of petroleum are put in place.

### EV INFRASTRUCTURE KUWAIT

The charging infrastructure for electric vehicles (EVs) in Kuwait is currently in the early stages of development, but it is growing rapidly in response to the increasing demand for EVs in the country. According to the Kuwait National Development Plan, the government aims to install at least 1,000 public charging stations for EVs by 2025, in order to support the growth of the EV market and improve the accessibility and convenience of charging infrastructure.

Currently, there are several types of public charging stations for EVs available in Kuwait, including:

- **Level 1 charging stations:** These are the most basic type of charging station, and they use a standard 120-volt household outlet to charge an EV. Level 1 charging stations are widely available, and they can be found in many public places, such as shopping malls, office buildings, and residential areas. However, they are relatively slow and can take several hours to charge an EV battery [5].
- **Level 2 charging stations:** These are more powerful charging stations, and they use a 240-volt outlet to charge an EV. Level 2 charging stations are less common than Level 1 charging stations, but they are still widely available in Kuwait, and they can be found in some public places, such as shopping malls, office buildings, and residential areas. Level 2 charging stations can charge an EV battery in a few hours, depending on the size of the battery and the charging speed of the EV.[9]
- **Level 3 charging stations:** These are the most powerful type of charging station, and they use high-voltage DC power to charge an EV quickly. Level 3 charging stations are relatively rare in Kuwait, but they are starting to appear in some public places, such as highways and service stations. Level 3 charging stations can charge an EV battery in a matter of minutes, depending on the size of the battery and the charging speed of the EV. [13]

Overall, the availability and accessibility of public charging stations for EVs in Kuwait is increasing, but there is still room for improvement. In order to support the growth of the EV market and make EVs a more viable transportation option, the Kuwaiti government needs to continue investing in the construction of public charging stations, and to ensure that they are widely distributed and easily accessible to EV owners. [8] The availability and convenience of charging infrastructure for electric vehicles (EVs) in Kuwait can have a significant impact on the total cost of EVs and their attractiveness as a transportation option. First, the availability of charging infrastructure can affect the total cost of EVs by reducing the time and effort that EV owners need to spend on charging their vehicles. [11]If there are enough charging stations available,

and if they are conveniently located, EV owners can recharge their vehicles easily and quickly, without having to spend a lot of time or money on charging. This can reduce the total cost of EV ownership, and make EVs a more attractive and cost-effective transportation option compared to internal combustion engine (ICE) vehicles. [6] Second, the convenience of charging infrastructure can also affect the attractiveness of EVs as a transportation option by increasing the range and flexibility of EVs. If EV owners can easily and quickly recharge their vehicles at various locations, such as shopping malls, office buildings, and residential areas, they can travel longer distances and use their EVs for a wider range of purposes. This can make EVs a more attractive and versatile transportation option compared to ICE vehicles, which are limited by the availability of gasoline or diesel fuel. [10] Overall, the availability and convenience of charging infrastructure for EVs in Kuwait can have a positive effect on the total cost of EVs and their attractiveness as a transportation option. By reducing the time and effort that EV owners need to spend on charging their vehicles, and by increasing the range and flexibility of EVs, charging infrastructure can help to make EVs a more affordable and appealing transportation option in Kuwait. [7]

## CONCLUSION

In summary, the total cost of ownership (TCO) of the internal combustion engine (ICE) and electric vehicles (EVs) in Kuwait is influenced by a complex interplay of factors, such as purchase price, fuel costs, maintenance and repair costs, insurance, and taxes. A detailed comparison of the TCO of ICE and EV vehicles in Kuwait should consider all of these factors to provide a comprehensive and accurate picture of the relative costs of each type of vehicle.

Government policies that promote the adoption of EVs in Kuwait, such as tax exemptions, subsidies, and the construction of public charging stations, can positively affect the TCO of EVs and their competitiveness with ICE vehicles in the Kuwaiti market. By reducing the upfront and ongoing costs of EV ownership and increasing the awareness and acceptance of EVs, these policies can help to make EVs a more attractive and viable option for car buyers in Kuwait.

The availability and convenience of charging infrastructure for EVs in Kuwait are increasing, but there is still room for improvement. To support the growth of the EV market and make EVs a more viable transportation option, the Kuwaiti government needs to continue investing in the construction of public charging stations and ensure that they are widely distributed and easily accessible to EV owners.

Overall, comparing the total cost of ICE and EV vehicles in Kuwait shows that EVs can be a more affordable and attractive transportation option, thanks to their lower fuel costs and maintenance costs, as well as the availability of government incentives and charging infrastructure. However, the TCO of EVs and ICE vehicles in Kuwait can vary depending on the specific factors that apply to each vehicle, and a detailed comparison of the TCO of each vehicle is necessary to determine its relative costs and value for money.

The findings of the comparison of the total cost of ownership (TCO) of the internal combustion engine (ICE) and electric

vehicles (EVs) in Kuwait have several implications for the automotive industry and consumers in the country.

First, the findings suggest that EVs can be a more affordable and attractive transportation option in Kuwait, thanks to their lower fuel costs, maintenance costs, and taxes, as well as the availability of government incentives and charging infrastructure. This can positively affect the automotive industry in Kuwait, as it can encourage more people to consider buying EVs, which can lead to increased sales and revenue for automakers.

Second, the findings also suggest that the Kuwaiti government's policies to promote the adoption of EVs positively affect the competitiveness of EVs in the Kuwaiti market by reducing the upfront and ongoing costs of EV ownership and increasing the awareness and acceptance of EVs. This can benefit consumers in Kuwait, as it can make EVs a more viable and appealing transportation option. It can also help reduce the country's reliance on fossil fuels and improve air quality.

Third, the findings indicate that the availability and convenience of charging infrastructure for EVs in Kuwait is a key factor that can affect the attractiveness of EVs as a transportation option. To support the growth of the EV market and make EVs a more viable transportation option, the Kuwaiti government needs to continue investing in the construction of public charging stations and to ensure that they are widely distributed and easily accessible to EV owners.

Overall, comparing the TCO of ICE and EV vehicles in Kuwait has important implications for the automotive industry and consumers in the country. By highlighting the economic advantages and disadvantages of EVs compared to ICE vehicles, the comparison can help to inform policymakers, automakers, and consumers about the potential benefits and challenges of EV adoption in Kuwait, and it can provide valuable insights for future developments in this area.

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