

# Comparative Overview of Compressed Natural Gas Vehicle (CNGV) and Electric Vehicle (EV)

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**Abstract:** The paper provides the comparative analysis between Compressed Natural Gas Vehicles (CNGVs) and Electric Vehicles (EVs) across various parameters. Both CNGVs and EVs contribute significantly to a clean and sustainable environment. Natural gas can be utilized for electricity generation, which can subsequently charge EVs. Thus, this study explores the role of natural gas in meeting the needs of both CNGVs and EVs from a future perspective. The widespread adoption of CNGVs and EVs not only enhances technological advancements in the transportation sector but also aids in mitigating global warming.

**Keywords:** Natural Gas Vehicle, Electric Vehicle.

## I. INTRODUCTION

CNG vehicles operate much like traditional gasoline-powered vehicles with spark-ignited internal combustion engines. The engine functions similarly to a gasoline engine, utilizing natural gas stored in a rear-mounted fuel tank or cylinder. The CNG fuel system transports high-pressure gas from the tank through fuel lines, regulated by a pressure regulator to match the engine's fuel injection system requirements. The gas is then introduced into the intake manifold or combustion chamber, where it mixes with air, undergoes compression, and is ignited by a spark plug.

CNG vehicles present clear economic benefits over electric vehicles in the Indian market. Their significantly lower initial purchase price, often 40-50% less than comparable EVs, enhances accessibility for the average Indian consumer and reduces financing burdens.

Additionally, CNG offers distinct advantages in ongoing fuel costs. Governed by stable pricing mechanisms set by the government, CNG serves as a reliable and cost-effective substitute for volatile petrol and diesel prices. This stability proves especially advantageous for high-mileage drivers, as it leads to substantial savings over the vehicle's lifetime.

An availability and cost-effectiveness of natural gas through city gas distribution networks, CNG vehicles have experienced a significant surge in adoption across major metropolitan areas. This trend is now extending to new suburban regions nationwide, driven by the inherent advantages of CNG vehicles compared to other fuel-based alternatives.

When evaluating parameters such as emissions, economy, refuelling costs, vehicle price, refuelling time, efficiency, public awareness, safety, vehicle range, fuel expenses, and maintenance, it becomes clear that natural gas vehicles offer distinct benefits over electric vehicles.

Both vehicle types hold promise for the future. Additionally, natural gas plays a dual role: serving as the primary fuel for CNG vehicles and as a secondary energy source for generating electricity to charge EVs. This dual application positions natural gas favourably, especially as hybrid vehicles combining CNG and electricity gain traction in the automotive industry, indicating a robust future demand for natural gas.

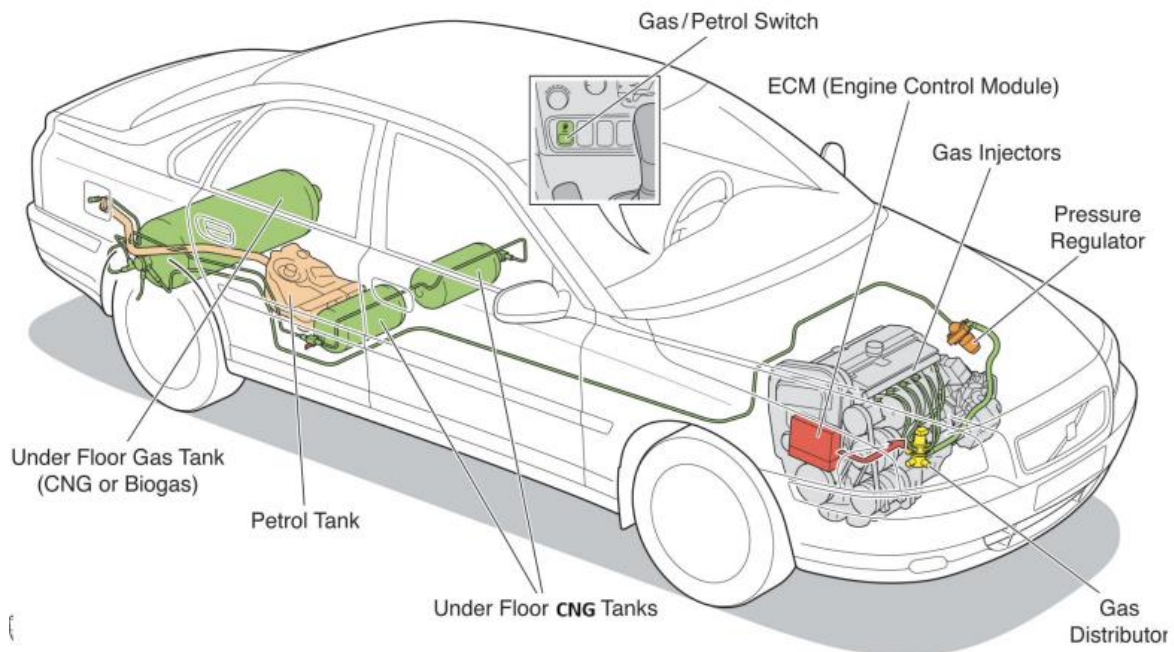


Fig. 1. - Overview of CNG Vehicle

CNG vehicles offer a significant advantage in quick refuelling times compared to the extended charging periods required for electric vehicles (EVs). Refuelling a CNG car takes just a few minutes, similar to filling up a petrol or diesel car, making it straightforward and convenient during trips.

In contrast, fully recharging an EV battery can take hours—typically 6-12 hours with a standard charger, and even fast charging still requires 30-60 minutes to reach 80% capacity. For consumers accustomed to the swift refuelling process at petrol pumps, the prolonged charging times of EVs pose a considerable inconvenience. This disparity in refuelling versus charging times makes CNG vehicles particularly suitable for long-distance travel.



Fig. 2. - CNG Vs Electric Vehicle

CNG vehicle user refuel as needed during journeys, while EV owners often contend with range anxiety and the necessity for lengthy charging breaks every few hundred kilometers. Overall, the rapid refuelling capability of CNG cars offers a substantial advantage over EVs in terms of driver convenience and practicality, especially for Indian consumers accustomed to the freedom of frequent and expedient refuelling.

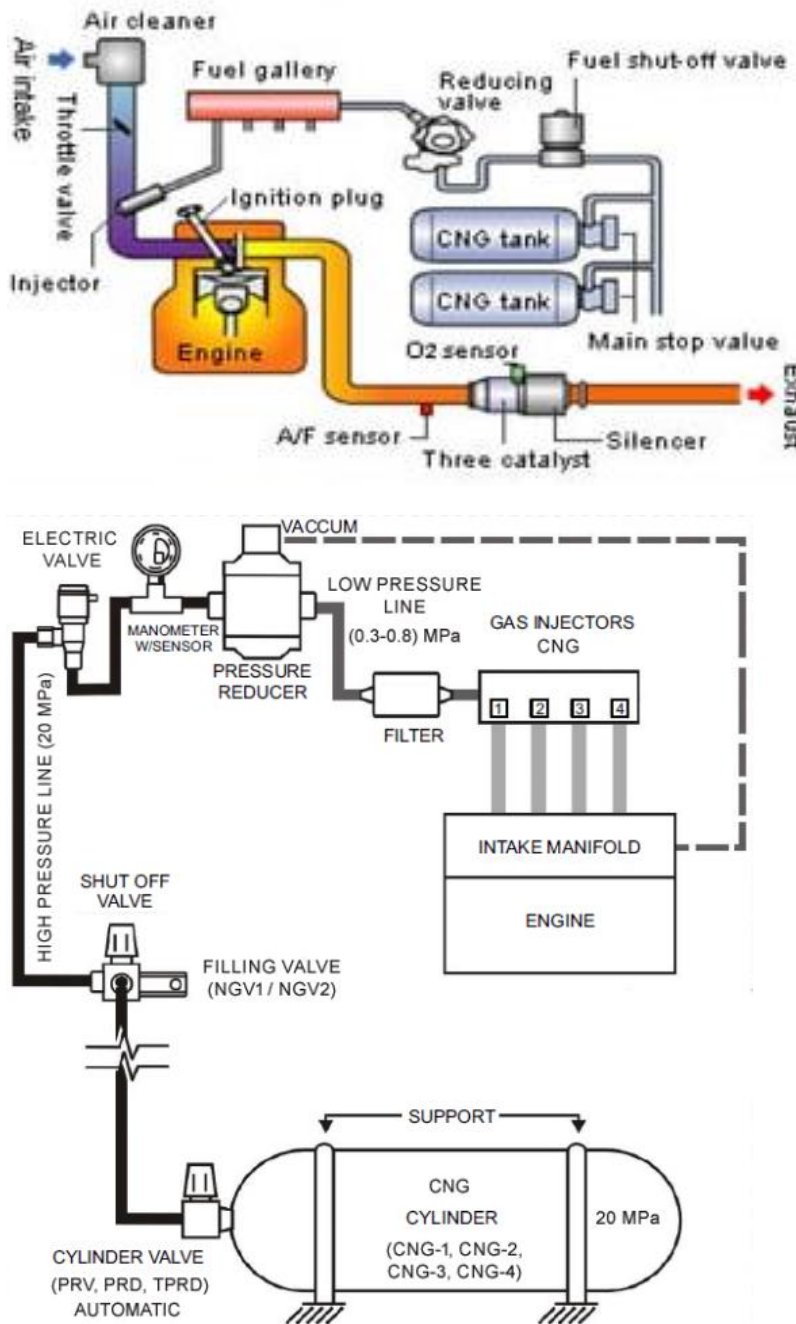


Fig. 3. - Construction and Working of CNG

CNG stands out as an eco-friendly fuel option compared to diesel and petrol. Indian consumers have shown significant interest in CNG-powered vehicles, prompting automakers to introduce a wider array of models and variants in response.

## II. CNG INFRASTRUCTURE

Unlike conventional gasoline or diesel stations, compressed natural gas (CNG) stations do not follow a universal model. Constructing a CNG station for either retail use or fleet operations involves carefully determining the optimal combination of pressure and storage capacity tailored to the specific vehicles being refueled. Selecting the appropriate compressor size and storage capacity for the station directly influences both the fuel cost and the driving range of the vehicles served. CNG infrastructure comes in three types: time-fill, fast-fill, and a hybrid of the two.

The primary distinctions between these systems lie in their storage capacity and compressor size. These factors dictate both the quantity of fuel dispensed and the speed of delivery. While most CNG stations adopt either time-fill or fast-fill configurations, hybrid stations incorporate elements of both system.

**Fast Fill Stations:**Fast-fill stations are primarily designed for retail environments where vehicles arrive unpredictably and require rapid refuelling. All public CNG stations feature a fast-fill capability. These stations receive natural gas from local utility lines at low pressure, employing on-site compressors to raise the pressure significantly. The compressed CNG is then stored in vessels ready for quick dispensing. Alternatively, CNG can be dispensed alongside gasoline or other fuels using dedicated dispensers.

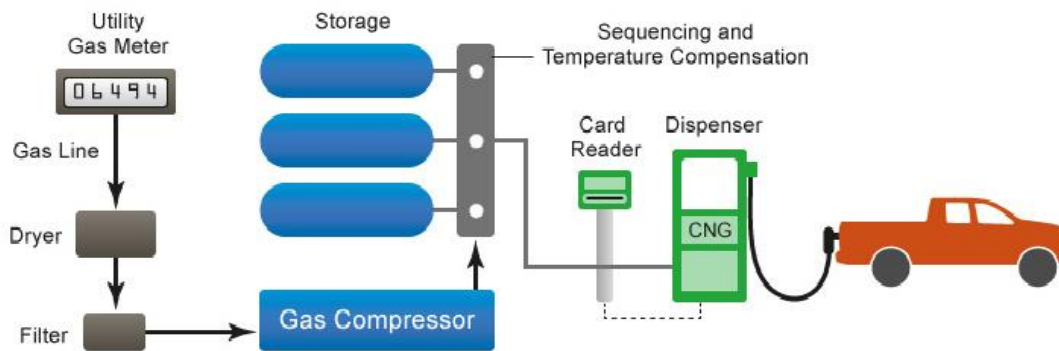


Fig. 4. - Fast Fill Stations

At fast-fill CNG stations, fuel is typically stored in high-pressure vessels (4,300 psi) to enable rapid dispensing to vehicles. Dispensers at these stations utilize sensors to monitor pressure and measure the amount of gasoline gallon equivalents (GGEs) transferred to the vehicle's tank, adjusting for temperature variations.

**Time Fill Stations:** Time-fill stations are primarily utilized by fleets, especially those with vehicles equipped with large tanks that return to a central location nightly for refuelling. In a time-fill setup, natural gas is delivered at low pressure from a utility via a fuel line to an on-site compressor. Unlike fast-fill stations, vehicles at time-fill stations are typically refueled directly from the compressor rather than high-pressure storage vessels. The size of the compressor required depends on the fleet size. Although there is a small buffer storage tank, its role is not to directly fuel vehicles but rather to prevent unnecessary cycling of the compressor, which conserves electricity and reduces wear. Occasionally, this tank is used to top off vehicle tanks during the day.

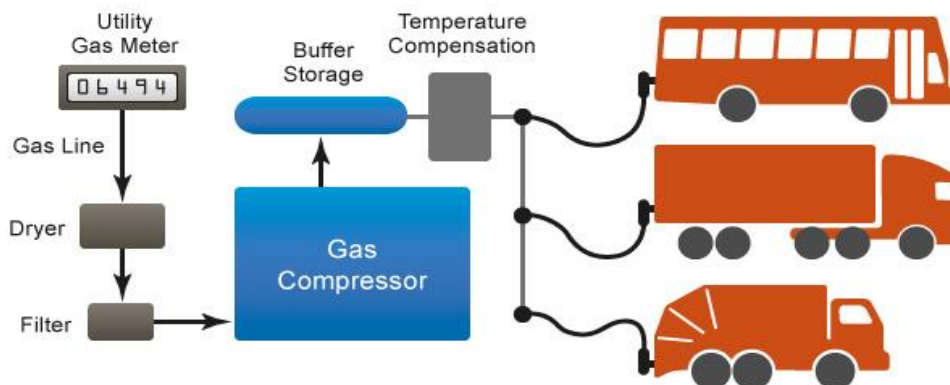


Fig. 5. - Time Fill Stations

The refuelling time varies based on factors such as fleet size, compressor capacity, and buffer storage volume, ranging from several minutes to several hours per vehicle. One advantage of time-fill stations is that they generate less heat during compression, resulting in more complete fills compared to fast-fill stations. Another benefit is the ability for fleet managers to schedule refuelling during off-peak hours, leveraging lower electricity rates.



Time-fill stations are meticulously designed based on specific fleet requirements; for instance, a transit bus operation might necessitate a larger compressor capable of delivering 8 to 9 gallons per minute, while a waste management fleet could suffice with a smaller compressor providing 3 gallons per minute. Consumer applications may require even less, such as under a gallon per hour, contributing to the varied costs of installation.

**Combined of Fast Fill and Time Fill Station:** Combination-fill stations integrate both fast-fill and time-fill functionalities within a single system. Vehicles using the time-fill posts are directly fuelled from the compressor, often overnight. Those using the fast-fill dispensers are supplied from either the storage vessels or the compressor, depending on immediate requirements. This design offers fleets greater operational flexibility.

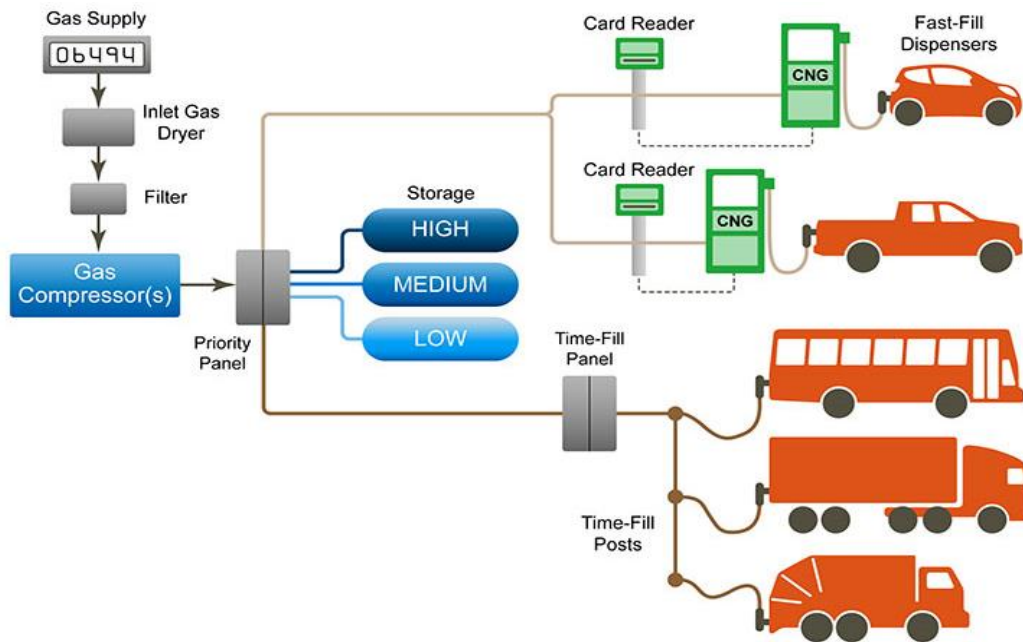


Fig. 6. - Combined of Fast Fill and Time Fill Station

Construction of combination-fill stations generally incurs higher costs compared to standalone fast-fill or time-fill stations. Additionally, if fast-fill dispensers are accessible to the public, a combination-fill station can potentially generate revenue.



Fig. 7. - CNG Charging Station

### III. COMPARISON OF CNGV Vs EV

#### Pros of CNG Cars:

- CNG does not rely on fossil fuels, is environmentally friendly, and emits fewer harmful gases compared to petrol and diesel.
- The running cost is lower than that of electric vehicles.
- It is a more affordable alternative fuel compared to petrol and diesel.
- CNG vehicles offer the flexibility to switch to petrol or diesel, allowing you to drive to the nearest CNG station if you run out of CNG.

#### Cons of CNG Cars:

- Installing a CNG kit in the boot space of your car occupies significant space, making it difficult to load luggage.
- CNG stations are still being developed, making it challenging to find them outside of specific areas such as Delhi and Mumbai.
- Driving a vehicle using CNG may reduce the car's power output by 10% compared to using diesel or petrol.

#### Pros of Electric Cars:

- Electric vehicles operate using electricity, resulting in zero emissions and making them an eco-friendly alternative to petrol and diesel.
- Governments offer tax benefits on purchasing electric cars to encourage consumers to buy more electric vehicles and help control pollution levels. Additionally, several states provide subsidies that reduce the purchase cost.
- The running cost of electric cars is lower than that of all other fuel-powered vehicles available on the market.
- Electric vehicles feature single-gear automatic transmission, making them convenient to drive in traffic or on highways.
- Maintenance costs are minimal since electric cars do not operate via combustion engines or complex parts.

#### Cons of Electric Cars:

- Electric vehicles are expensive due to the high cost of batteries.
- Finding electric vehicle charging stations can be challenging.
- Affordable electric cars may cover less than 400 kilometers on a single charge, making long-distance travel difficult without preparing for alternatives.

### IV. HYBRID VEHICLE

CNG hybrid uses three different types of energy: electric, gasoline and CNG. We call this 'tri-fuel'. When the car runs out of electric battery, the car driver is able to switch to CNG instead of gasoline.

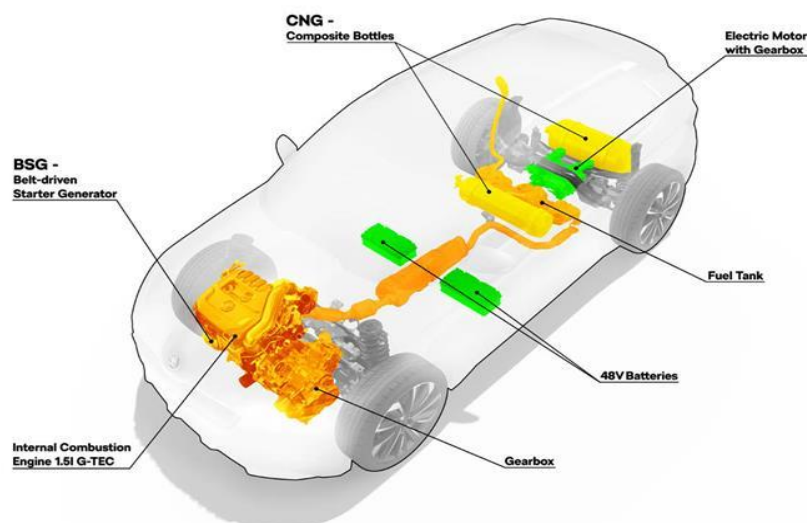


Fig.8. - CNG Hybrid Vehicle

**Diesel Hybrid:**

CNG-powered vehicles are hybrid vehicles sold in bi-fuel configurations, allowing their engines to switch between different types of fuel as needed. This capability provides a higher level of refinement compared to diesel engines. However, CNG as a fuel has low energy density, resulting in reduced power and acceleration. Despite this, CNG engines are more fuel-efficient compared to petrol or diesel engines.

**Petrol Hybrid:**

Petrol-powered engines are used for higher-end performance and are more refined compared to diesel engines. In terms of fuel efficiency, petrol engines rank lower than diesel and CNG engines. However, incorporating an electric aid in the form of a Plug-in Hybrid Electric Vehicle (PHEV) changes the dynamics, improving the fuel efficiency, performance, and refinement of the engine.

**V. MAINTENANCE OF CNG VEHICLES**

Natural gas vehicles (NGVs) employ spark-ignited engines similar to traditional gasoline vehicles, with a fuel system adapted for natural gas. Modifications include reinforced exhaust valves and seats, though these alterations do not visibly change the engine's appearance or its maintenance requirements. Spark plugs are crucial components responsible for fuel combustion, necessitating regular inspection and replacement with high-quality, CNG-compatible options to avoid engine damage or fire hazards. Regular air filter checks and replacements are also essential for engine efficiency and fuel economy, preventing dust and contaminants from compromising performance. CNGV fuel systems are intricate, tailored for precise fuel delivery to optimize performance and minimize emissions. Maintenance involves periodic inspection of fuel storage tanks, especially after accidents, and adhering to tank lifespan guidelines to ensure safe decommissioning. Natural gas's cleaner combustion extends engine oil life compared to conventional fuels. CNGV owners should adhere to recommended oil-change intervals and consider laboratory testing for oil samples, especially for converted vehicles or fleet management. While CNGVs use spark plugs for ignition like gasoline engines, they are more sensitive to spark quality and voltage. Proper maintenance of ignition components (spark plugs, wires, coils) is crucial, with specific CNGV-designed products available to enhance performance and longevity. Consultation with the vehicle's maintenance manual is advised for inspection and replacement intervals. Overall, maintaining an NGV involves adherence to specialized maintenance routines tailored to its unique fuel system and combustion characteristics, ensuring both safety and longevity of engine components.



Fig. 9. - Efficient Green Environment CNG Powered Hybrid Vehicle

Continuous enhancement of CNG usage across the nation and world will provide huge benefits such as lesser emissions, lower maintenance cost and superior performance and CNG is a sustainable fuel for the future.

**VI. CONCLUSION**

With over 15 million natural gas vehicles worldwide, compressed natural gas (CNG) stands as a promising future for alternative fuels. CNG primarily consists of methane compressed to less than 1% of its volume under standard atmospheric pressure, offering significant environmental benefits and economic advantages. CNG-powered vehicles typically boast lower operating costs due to stable CNG prices compared to gasoline and diesel. The accessibility of natural gas reserves contributes to the expanding availability of CNG refuelling stations, enhancing convenience for consumers adopting CNG vehicles. Refuelling with CNG is fast and convenient, taking only a few minutes compared to the hours required for electric vehicle (EV) charging, thereby minimizing downtime for drivers. As a sustainable transportation option, CNG offers reduced emissions, utilizes abundant domestic resources, and benefits from a growing refuelling infrastructure. While initial costs and infrastructure limitations present challenges to widespread adoption, government backing, technological advancements, and increased public awareness are expected to drive CNG's continued expansion. As global focus on sustainable transportation intensifies, CNG remains pivotal in efforts to lower emissions, enhance air quality, and foster a more sustainable future.

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