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Assessing the Viability of LNG Trucks for India's Clean Goals

While liquefied natural gas (LNG) trucks offer some immediate benefits, leapfrogging to electric trucks aligns better with India's zero-emission trucks (ZET) mission

- *Limited infrastructure, including very few truck manufacturers, operationally expensive filling stations and a lack of cryogenic tank manufacturers, will be a key challenge for replacing diesel trucks with LNG-fuelled ones.*
- *In terms of the total cost of ownership (TCO), there is not much difference between diesel and LNG trucks but the volatility in LNG prices can lead to changes in the TCO of LNG trucks, stripping the slight price advantage.*
- *With India's ambition of 100% zero-emissions trucks by 2050, investing in building the infrastructure for LNG trucks will further face a stranded asset risk.*

Introduction

India is considering liquefied natural gas (LNG) fuelled trucks as the long-haul road freight solution to replace the highly polluting diesel trucks. While there is little doubt that diesel trucks, a primary source of freight transport in India, require a cleaner alternative, the conundrum for policymakers is which technology to adopt – LNG trucks or electric ones.

Carbon emissions from the road transport sector require urgent solutions. Road transport is already responsible for 12% of India's energy-related carbon emissions. Within the road transport sector, medium-to-heavy duty trucks account for 45% of on-road emissions in the country, even though they form only 3% of the total vehicle population. Further, trucks are responsible for 53% of particulate matter (PM) emissions.

With the road freight movement likely to result in 17 million trucks on the road by 2050, from four million in 2022, according to the NITI Aayog, adopting zero-emission trucks (ZETs) is imperative and urgent. The government realises this, and its Bharat Zero Emission Trucking policy advisory outlines potential interventions to achieve 100% ZET deployment by 2050.

While LNG trucks lower carbon emissions, they do not entirely eliminate them. According to some studies, trucks powered by LNG lower carbon emissions by 28% to 30% compared to diesel trucks. Another study points to negligible benefits when all greenhouse gases are considered when switching to LNG trucks instead of diesel trucks. According to the study, there are two to five times more nitrogen oxide emissions from LNG trucks than diesel trucks. This could vary for trucks with new emission standards, such as the China VI emission standard, largely equivalent to Euro VI, which requires heavy-duty vehicles to be equipped with remote emissions monitoring systems.

Studies also point to the possibility of increased ammonia emissions from China VI emissions standards aligned LNG trucks due to changes in the type of combustion. The emission benefits of LNG trucks over diesel would perhaps need more research. For instance, lifecycle emissions analysis of LNG extraction, production and transportation could indicate possibly higher overall emissions due to the methane emissions from using LNG.

This note evaluates the recent policy measures to promote LNG trucks and gauges whether the country should instead leapfrog to electric trucks.

Understanding the Policy Push for LNG Trucks

The Indian government, with a recent directive, has initiated the promotion of liquefied natural gas (LNG) trucks in the country's overall trucking market. The draft policy, announced in September 2024, ordered the replacement of one-third of the current diesel trucks with LNG over the next five to seven years.

To facilitate the availability of cheaper fuel, the government also proposes to allocate 0.5 million metric standard cubic meters per day (MMSCMD) of cheaper domestic gas per day for about 50,000 trucks for the next few years. According to a NITI Aayog study, switching 10% of new vehicles from diesel to LNG by 2032 could save US$1.5 billion in imports and lower tank-to-wheel emissions. Notably, the study cites emissions reduction from different European studies, which, on average, show a decrease of 8% in emissions between diesel and LNG trucks. The report recommends LNG as a "viable alternative fuel" for heavy-duty trucks for a "transitional period" of 10-15 years.

On the face of it, LNG trucks offer a good alternative for long-haul transport as they can travel up to 1,000 km in one refill. However, it is imperative to undertake a comprehensive analysis to understand if this benefit outweighs all the other challenges posed in the Indian context.

While LNG trucks are better than diesel trucks in emissions, the need for high capital expenditure for infrastructure development and purchasing LNG trucks puts a question mark on their economic viability. If setting up infrastructure to enable the operations of LNG trucks requires government support, it eats into the limited public capital available, which could otherwise fund the deployment of true zero-emissions trucks (ZETs) like electric trucks and hydrogen trucks. Even LNG liquefication capacity is in a pilot stage in India right now, resulting in complete import dependence for the fuel. This limits the above-stated benefit of lowering import bill and brings down the price competitiveness against other fuels.

In terms of the total cost of ownership (TCO), there is not much difference between the two technologies. The TCO for diesel trucks is Rs35.61/km (US$0.41/km), while that for LNG is Rs34.88/km (US$0.41/km). The volatility in LNG prices can lead to changes in the TCO of LNG trucks, stripping the slight price advantage.

Therefore, deploying LNG trucks in India needs a more careful evaluation, especially as India is looking at a 2050 ZET timeline, restricting the LNG truck use window. Retrofitting freight trucks with LNG is not viewed as a reliable alternative due to safety and cost concerns.

Compared to electric vehicles, LNG trucks offer much faster refuelling time and longer range, but the higher fuel cost and lower tank-to-wheel efficiency of LNG trucks can potentially offset these benefits. The table below illustrates some of the differences between different types of technologies.

Table 1: Benefits of Different Fuel Technologies for Trucking

	ICE - Diesel	ICE - LNG	Battery Electric Vehicle (BEV)
Technology Description	Propulsion through engine powered by petrol or diesel	Propulsion through the engine, powered by LNG	Propulsion through a battery and electric motors
Emissions	Highest tailpipe and carbon emissions	Lower emissions as compared to diesel (potential non-tailpipe methane emissions)	No tailpipe emissions
Refuelling Time	5-10 min	5-20 min	90 min - 8 hours
Alignment to ZET 2050	No	No	Yes
Energy Security - Fuel	Low	Low	Moderate
Ease of adoption	NA	Low (technology training for drivers, station owners, etc needed)	Moderate
Tank-to-wheel efficiency	28%-42%	28%-42% (taken the same as diesel engine but could be lower based on technology)	64-86%
Range	400-500 km per tank	600-1000 km per tank	150-350 km per charge

Source: IEEFA

The table above illustrates the advantages battery electric vehicles offer over internal combustion engine (ICE) trucks. The only drawback of lower range per charge is at present limited in Indian context as long haul trucks in India cover 300-325km per day.

Medium to Long Haul Trucking: LNG vs Electric

The government's idea of LNG trucks as a transitional measure for lowering carbon emissions and better economic return against diesel for the next 10-15 years may have merit. But evaluating the option against battery electric trucks (BETs), the other available option for medium to long-haul freight transport, is also important. To its credit, the government is also actively promoting BETs, which aligns with the proposed ZET timelines.

While BETs have already emerged as an effective solution for the short-haul or light-duty trucks (LDTs), their viability in the medium to long-haul and medium-to-heavy-duty trucks (MHDTs) market requires an assessment. Freight vehicles with gross vehicle weight (GVW) exceeding 3.5 tonnes or those coupled with a trailer not exceeding 750 kilograms are classified as MHDTs, with up to 12 tonnes classified as medium-duty vehicles.

The use of both electric and LNG trucks for medium to long haul transport or as MHDTs is in a nascent stage at present, but certain parameters can help understand which has a better growth trajectory in India.

The table below shows a quick comparison of electric trucks and LNG trucks as MHDTs.

Table 2: Evaluation of Electric and LNG trucks as MHDTs

Parameters		Battery Electric Trucks	LNG Trucks
Cost & Pricing	Capital cost (base price)	Starting from Rs1.5 million (US$17,480) [Tata Motors for 9 tonne GVW]	Starting from Rs2.8 million onwards [Ashok Leyland 18.5 tonne GVW]
	Fuel cost	~Rs3-4/km (~US¢4)	~Rs14-15/km (US¢16)
	Total Cost of Ownership	Rs42-44/km (US$0.50/km) Expected to lower with battery advancements	Rs33-35/km (US$0.41/km) Dependent on LNG price, which is volatile
Market Maturity	Manufacturers	Tata, Ashok Leyland, Olectra, Propel, EKA, Montra Electric, Eicher, BYD	Blue Energy Motors, Tata, Ashok Leyland, Volvo
	Retrofitting/Battery Swapping	Battery swapping is well demonstrated for buses, emerging technology for heavy-duty trucks	Retrofitting is not a preferred option due to cost and safety concerns
	Segments	Two-wheelers, three-wheelers, passenger cars, LDT, MDTs, HDTs, buses, construction machinery	Heavy duty trucks
	Fuel infrastructure	Widely available for LCVs, limited for MHDTs	Limited
Operations	Refuelling time	90 minutes to 8 hours	20 minutes
	Payload	50%-60% of GVW	34%-85% of GVW
	Range	180 km – 280 km	600 km – 1000 km
	Tailpipe Emissions	Nil	100 tonne CO2 per year per truck

Source: IEEFA

A few advantages that LNG trucks offer versus electric trucks are fast refuelling and longer range. The long recovery timeline of 1.5 years to recoup the differential in the high upfront cost of LNG trucks versus diesel trucks is a hindrance. This could also be longer depending on the operational costs due to high LNG prices. On the other hand, heavy-duty electric trucks will likely reach TCO parity with diesel trucks by 2027.

Case Study: China Also Going Electric

China started its LNG truck journey a decade back. It has local truck manufacturing capacity and access to pipeline gas, which costs less than LNG. Strict emission standards also helped China's LNG trucks market gain momentum. The country has been working on increasing its LNG truck fleet for over a decade and is expected to have 1 million LNG trucks in 2025.

It will be difficult for India to emulate China's LNG success story due to a lack of infrastructure, higher LNG import prices, limited truck manufacturers, and various other factors.

China has had the largest influx of LNG trucks in the world in the last decade but is also looking to transition to electric trucks in the next few years. It seems, China is looking at LNG as a transitional fuel for its trucking segment until battery swapping and other related infrastructure are put in place rapidly. The sales of heavy-duty electric trucks are already gaining momentum in China. Electric trucks already hold a larger market share than LNG trucks in the medium-duty trucks category. LNG trucks have a larger market share in the long-haul segment, probably due to the limited range and battery recharging time. Electric trucks already form 13% of the heavy trucks market and 14% of the medium trucks market in China.

Battery swapping can be a further game changer for higher uptake of electric trucks. Aware of this, China has implemented policies to produce swap-capable vehicles, including a two-year pilot programme to promote battery swapping across 11 cities, with three cities focused on battery-swapping applications for trucks. China's target is to have 16,000 battery swap stations by 2025.

Challenges for LNG Trucks in India

India faces several challenges and risks in promoting LNG trucks as a transitional option. It may need to import more fuel and build fresh infrastructure for operating LNG trucks, which could become stranded assets as the switch to electric trucks accelerates. This section highlights the challenges India faces in switching to LNG trucks.

Increased Import Dependency

The NITI Aayog's estimate of saving US$1.5 billion in fuel imports by switching to LNG trucks may not completely materialise as LNG imports will offset some of the gains of lower crude oil imports. It could potentially increase if India meets its target of 15% gas in the energy mix target by 2030. Meeting the gas-use target would require India to import 70% of its gas needs, up from about 50% at present.

Limited Infrastructure

A major challenge that LNG trucks will face in India is the limited infrastructure across the value chain. The country has limited truck manufacturers. LNG fuel stations are expensive and expanding slowly. There are around 20 LNG retail outlets functional in India right now, much lower than the target of 1,000 stations, and these are also struggling to remain operational. There are only a few cryogenic fuel tank manufacturers, limiting the supply for truck makers.

Additionally, India does not have enough liquefaction plants at present, nor does it have low-cost gas sources to feed liquefication plants, leading to dependence on imported LNG, which lowers competitiveness and inhibits the development of refuelling stations.

Stranded Asset Risk

The Ministry of Petroleum and Natural Gas had already set out the directive to establish 1,000 LNG stations across the country by 2030. The initial plan was to set up 1,000 LNG stations by 2024.

Setting up this infrastructure could cost Rs100 billion (US$1.16 billion) to be spent by private and public players. GAIL plans to invest Rs6.5 billion (US$75.8 million) to develop LNG filling stations on national highways.

However, the mismatch in the high number of proposed stations versus actual trucks on the road could lead to a major stranded asset issue. An IndianOil LNG dispensing station in Chennai has sold around 80 tonnes of LNG a month since its commissioning in 2023, which is not enough to cover costs and expenses. To minimise losses, the station needs to sell three times more LNG per month.

Price Volatility to Impact TCO

The price volatility that LNG has displayed in the past could lead to much higher operational costs for LNG trucks, exacerbating stranded asset risk for LNG trucks related infrastructure. Of the estimated TCO of Rs34.88/km (US$0.41/km) for LNG trucks in a NITI Aayog report, Rs14.27/km (US¢17/km) is the fuel cost. The report also notes, “LNG is highly volatile particularly spot LNG and hence there may be significant difference in TCO”.

Technical Drawbacks

Boiloffs are another technical limitation that further lowers the feasibility of LNG trucks for Indian roads. Boiloff is when gas gradually escapes from LNG, which is lying stored and unutilised in tanks. This can weaken the cost economics of LNG versus diesel. LNG stations, for instance, need to have enough traffic to refuel their tanks in three days to minimise losses.

Opportunities for LNG Trucks in India

While there are challenges and potential competition from BETs, LNG trucks can offer some relief from the increasing number of diesel trucks in the country. The implementation should be in areas where it can be genuinely transitional without locking in more fossil fuel-related investments for the longer term.

Retrofitting of Trucks in Specific Sectors

Coal India Limited (CIL) has initiated retrofitting LNG kits in two 100-tonne dumpers at a coal mine. Dumpers are used for the transportation of coal in mines, and CIL has around 2,500 such trucks in its open-cast mines. Retrofitting such trucks used for a specific purpose at defined locations could be of merit to India to lower emissions tremendously, save import bills, and increase the fuel efficiency of projects.

Building LNG Infrastructure on Golden Quadrilateral

There can be a case for using LNG trucks on the 5,800km golden quadrilateral connecting Mumbai, Delhi, Kolkata and Chennai. As the electrification of trucks and building the relevant infrastructure on these highways could take time, deploying LNG trucks on this route can be considered as a transitional measure. There must be strategic and limited infrastructure built to avoid any future standard asset risk. Notably, an LNG retail outlet is time and capital-intensive and needs a threshold of traffic to prevent boiloffs and losses, which require consideration while planning refuelling infrastructure.

At present, LNG stations are being planned mainly on the Golden Quadrilateral and the north-south and east-west corridor. Along with the location, the requirement must also be carefully vetted, and a proper assessment must be made to determine if India will have enough LNG trucks to require 1,000 LNG dispensing stations. As per a NITI Aayog report, 2500 trucks are needed for 50 LNG stations. This implies that a minimum of 50,000 trucks would be needed to keep 1,000 LNG stations operational.

Conclusion

Various factors must align for LNG trucks to succeed in India. It requires stable LNG prices to realise the benefits of lowering the import bill. The lack of infrastructure is another aspect that will deter the accelerated shift to LNG trucks. Further, electric trucking limits the lifecycle of LNG trucks. There is further competition likely from hydrogen powered trucks. The recent introduction of hydrogen trucks, although in nascent stages, sets the ball rolling for another cleaner technology in India. The government has introduced a 2-year pilot program till FY2024-25 worth Rs4,960 million (US$58 million) to test the use of green hydrogen in the transport sector including buses and trucks. While there could be some merit in exploring LNG trucks for some segments as a transitionary measure, India should focus on increased electrification of trucks and hydrogen to align with its long-term vision of ZET2050.

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