Introducing Japan's 1st LPG-Diesel Dual Fuel Truck

Environmentally Friendly Clean Diesel Engine

Cost Effective Fuel LP Gas

Fuel Diversification In A Time Of Crisis

Lowers total fuel costs by lowering diesel consumption (BCP Option)

Add LPG components onto an existing diesel truck

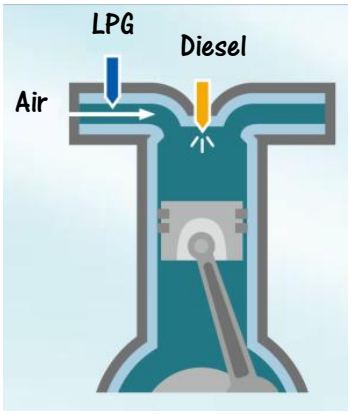
Dual Fuel Truck

Powerful & Durable

For sale in Japan only

What is a Dual Fuel Truck?

The base truck is the Mitsubishi Fuso Canter (2-3 tons) that carries the latest clean diesel engine system. This engine delivers better fuel economy which also means less carbon dioxide emissions. LPG (Liquefied Petroleum Gas) tank and system parts are installed onto the diesel system so that it can operate on a mixture of LPG and diesel fuels. LPG is injected through the air throttle and mixed with diesel in the combustion chamber. Then the mixed fuels are compressed and ignited.



LPG & Diesel Dual Truck Committee

Daruma Energy だるまエナジー

JOTO GARAGE 株式会社 城東自動車工場

2014 METI Subsidized Project (project relating to improving business environments for petroleum distributors)

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The Dual Fuel Truck uses the most innovative technology to lower fuel costs and can run on diesel fuel alone.

The LPG & Diesel Dual Truck Committee received a 50% subsidy from Japan's Ministry of Economy, Trade and Industry to build a truck that can help truck operators lower fuel costs. Cost effectiveness was the primary goal, and we attained this by mixing liquid fuel (diesel) and gaseous fuel (LPG) together.

Outstanding Characteristics of the Dual Fuel Truck

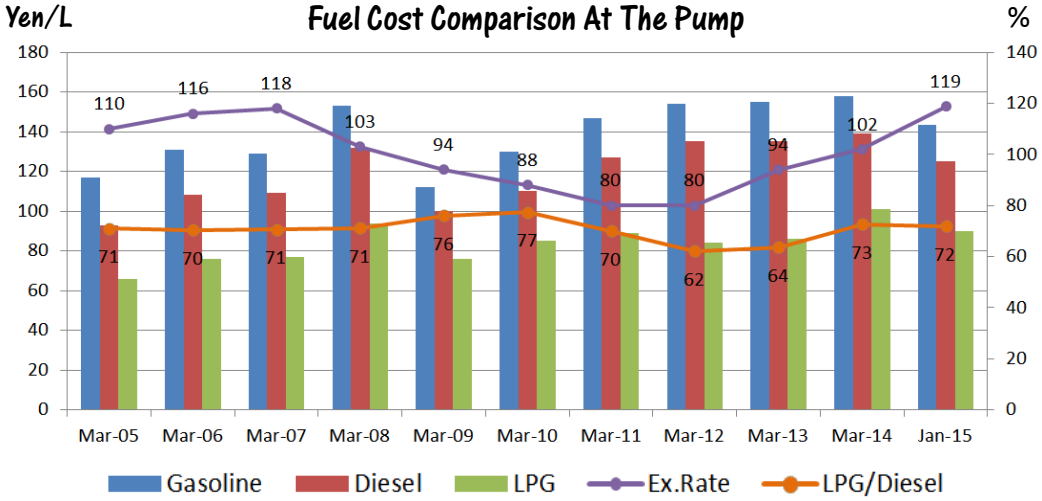
① Worry-free: If the truck runs out of LPG, the system can be manually switched back to the original diesel engine system so the truck will continue to run on diesel alone. (mono-fuel ⇔ dual fuel)

② Economical: Currently, diesel costs about ¥107/L while LPG costs about ¥70/L. Substituting a portion of diesel with cheaper LPG reduces total fuels costs.

③ Safe: This truck meets all vehicle standards and emissions requirements set by the Japanese government.

Project Background

There are roughly 60,000 logistic companies nationwide, and about 90% are small to medium-sized companies that operate less than 50 trucks. These companies spend 17%-38% of their yearly budget on diesel fuel, and while CP prices are falling drastically, they will not stay low. Fuel costs will continue to be a problem as the majority of these companies are already in the red for several consecutive years, with very little hope for recovery. Meanwhile, LPG (Liquefied Petroleum Gas) has become highly regarded in Japan due to its relatively low price and positive environmental performance. Its resilient characteristics were proven in the aftermath of the Great Tohoku Earthquake so the government is emphasizing the importance of LPG and included it as a vital source of energy in Japan's Energy Policy. In Japan's auto industry, LPG is mainly used as fuel for taxis but this market is slowly shrinking, and LPG refilling stations are shutting down one by one, spreading fears that LPG vehicles will completely disappear from Japan. This trend counteracts Japan's energy security measures.



Source: Oil Information Center

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How the Dual Fuel Truck Differs From Other Converted Vehicles

There are vehicles that operate on CNG, ethanol, methanol, etc. but none of them spread as widely as vehicles that operate on conventional fuel because of 2 main reasons: 1) the lack of refueling stations and 2) the need to purchase a brand new vehicle that runs on that specific fuel. The Dual Fuel Truck is different.

① There are adequate refilling stations for both diesel and LPG fuels (1500 stations nationwide), but if the vehicle runs out of LPG, the system can be manually switched back to the original diesel engine system to operate on diesel alone.

② The LPG system can be installed on your existing truck so no need to purchase another vehicle.

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Efficiency Characteristics of the Dual Fuel Truck

① **Diesel consumption decreases by up to 50%**

The fuel ratio varies depending on the speed and load, but more LPG can be added at higher speeds.

② **Total fuel costs decrease by up to 15%**

Diesel: ¥ 107/L, LPG: ¥ 70, 100 km/h in 5th gear

③ **Travel distance doubles**

By carrying 2 fuel tanks, the aggregate fuel load increases, leading to longer driving distance.

④ **More powerful than the original diesel truck**

Mixing the fuels increased the engine torque to levels that destroy engine parts so the torque was lowered to match durability levels set by the manufacturer.

Diesel Only Mode

km	RPM	km/h	Kw	kpa	Int.Mani. ℃	Exhaust ℃	Water ℃
0	2698	75.7	32.9	180	59	470	79
5	2700	75.7	32.7	179	55	496	84
8	2700	75.8	32.7	178	52	494	84

Diesel Consumed: 1990 cc Fuel Efficiency: 5.03 km/L

Dual Fuel Mode

km	RPM	km/h	Kw	kpa	Int.Mani. ℃	Exhaust ℃	Water ℃
0	2710	75.9	32.9	148	50	487	80
5	2700	76.8	33.1	145	44	491	82
8	2700	75.8	32.8	144	45	485	82

Diesel Consumed: 1012 cc Fuel Efficiency: 9.88 km/L

LPG Consumed: 1019.6 cc Fuel Efficiency: 9.81 km/L

Test Conditions

- Distance: 10 km
- Speed: 80 km/h in 4th gear
- Load: 1500 N
- Atmospheric Pressure: 100.5
- Temperature: 10℃
- Humidity: 40%
- Weather: Sunny

Fuel Efficiency Increased 197%

Diesel Consumption Decreased 49.1%

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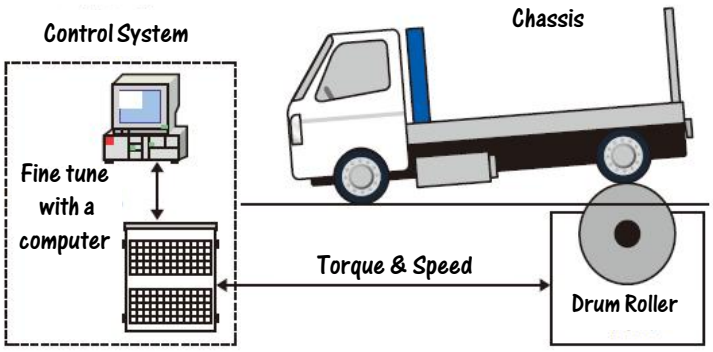
Data Accuracy

Fuel efficiency rates calculated merely with data taken from actual test drives are too inaccurate. We used the same equipment major automakers and the Japanese government uses to test vehicles. Joto Garage tested the vehicle on using a chassis dynamometer that is installed on their premise.



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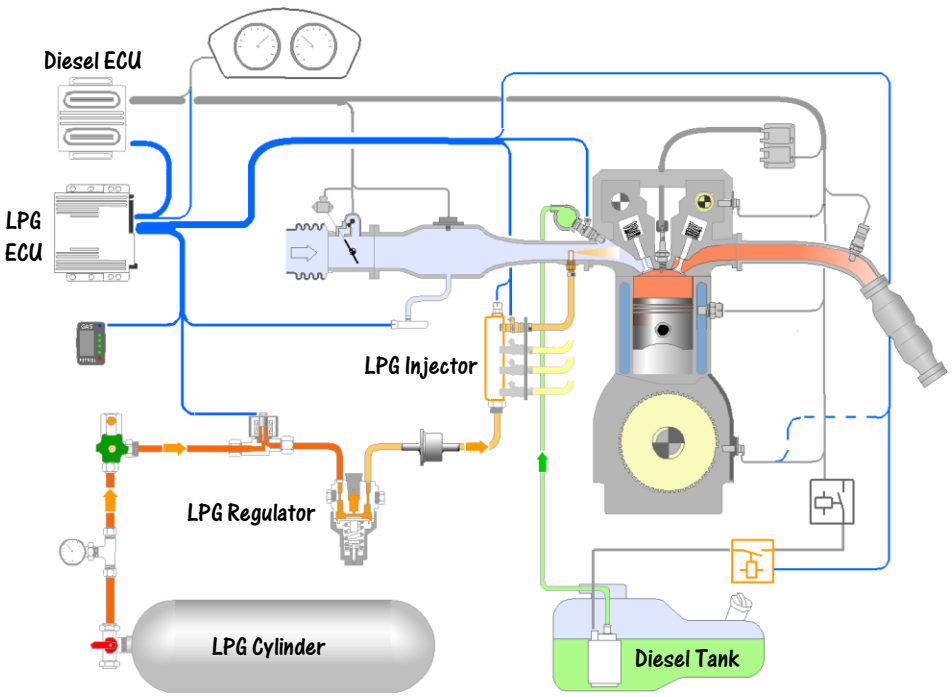
Dual Fuel System Layout



Simply attach LPG components onto the original diesel system. The engine itself is not altered in any way.

Vehicle Specifications

- Engine Type — 4P10, 2990 cc Turbo Engine, Output: 110KW/3500rpm, Max torque: 370N・m/1350- 2840rpm
- Injector — Nikki Injector
- Sensors Installed — Axel pedal position sensor, crank angle sensor, revolution sensor, boost pressure sensor, LPG pressure sensor, fuel-air ratio sensor at each cylinder, knock sensor, 4 temperature sensors (intake manifold, exhaust, coolant, LP gas)
- Installation & Setting
  1) Each of the 4 cylinders were connected to an LPG injector pod with an LPG guide pipe.
  2) LPG injection timing was set to top dead center on the compression stroke for cylinder 1
  3) Diesel consumption was measured using the "Full Tank Method"
  4)LPG consumption was measured by subtracting the tank weight (specific gravity: 0.56)
- Test Procedure for 100 km/h in 5th gear and for 80 km/h in 4th gear
  1) Vehicle gross weight: 5785 kg (including driver weight of 65 kg)
  2) After warming up the engine, the truck ran for 10 km on the chassis dynamometer in diesel only mode to calculate its fuel efficiency.
  3) Immediately afterwards, the truck ran for another 10 km on the chassis dynamometer in dual fuel mode to calculate its fuel efficiency.

LP Gas and LPG Vehicles

LP Gas is the generic term for propane gas (gas in canisters often used in camping) and butane gas (lighter fluid). Research to use LPG for vehicles started before WWII and its 1st application was for taxis and small trucks in 1963 . Currently, there are about 220,000 taxis and 30,000 small trucks that operate on LPG. As a result, there are about 1500 LPG refilling stations nationwide, located in every region where taxis operate.

LPG & Diesel Dual Truck Committee Members

- Committee Chair: Toshinobu Kanaya D.Sc.
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