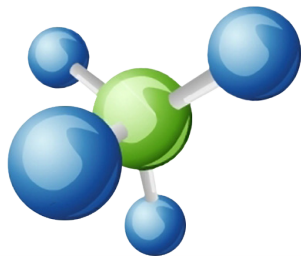


Transportation >>>>>>

^ Industry White Paper

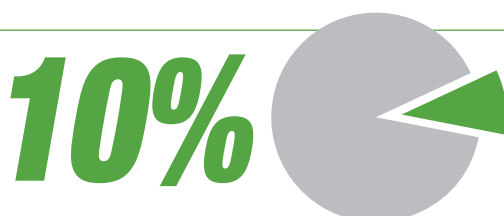


Natural Gas in the Trucking Industry

Throughout the transportation industry, more carriers are committing to use alternative, sustainable fuels to power heavy-duty vehicles. The low and stable cost of natural gas, in particular, is attractive since diesel prices can be high and often volatile. Additionally, natural gas is produced domestically and is abundantly available. Many environmental groups champion natural gas because it is cleaner-burning and has fewer emissions than diesel.

Despite these benefits, some challenges face fleets that desire to convert to natural gas. Primarily, because natural gas use in commercial vehicles is a relatively new phenomenon, the national fueling infrastructure is limited, though it is rapidly expanding. Trucks running on compressed natural gas (CNG) require different fuel delivery systems than those powered with diesel, as well as special fuel tanks. The fuel delivery systems make CNG trucks more expensive than their diesel counterparts. Recent declines in diesel prices have also narrowed the CNG fuel price advantage.

This document is designed to educate readers on natural gas options in the United States and outline the benefits and challenges of operating a heavy-duty fleet with this cleaner fuel. In addition, this white paper highlights Ruan Transportation Management Systems' approach to using compressed natural gas as a transportation fuel.



By 2020, natural gas vehicles will make up 10 percent of the truck sales market.





NATURAL GAS

Natural gas is a fossil fuel made primarily of methane, though it also contains propane, ethane, butane and trace amounts of oxygen, nitrogen and carbon dioxide. It can be used as CNG and liquefied natural gas (LNG). Natural gas is colorless and odorless in its pure form, and it is widely used in a variety of applications. According to the Energy Information Administration (EIA), energy from natural gas accounts for 24 percent of total energy consumed in the United States.¹

NATURAL GAS IN HEAVY-DUTY TRUCKS

Over the last few years, natural gas has been used more frequently to power heavy-duty vehicles in the U.S. Millions of natural gas powered vehicles are already operating outside the United States. To be used on a truck, CNG is stored as a gas under high pressure, which reduces its volume to 1/100 of the space natural gas would otherwise occupy.² CNG weighs less than diesel, but it also contains less energy than diesel on a per gallon basis. Therefore, when comparing natural gas and diesel, energy is often described in terms of a diesel gallon equivalent (DGE). CNG fuel suppliers dispense and price CNG in a gasoline gallon equivalent (GGE) unit of measure. The energy content of a DGE is 139,000 British thermal units (BTUs) vs. 125,000 BTUs for a GGE. Thus, the conversion from DGE to GGE is 1.112.

CNG is generally stored at 3,600 psi at 70°F ambient temperatures, and these specifications require a durable tank that is heavier and more expensive than a comparable diesel tank.³ Special engines that burn natural gas as a vapor are required to power heavy-duty trucks. CNG is used with spark-ignited engines, which use spark plugs similar to a gasoline engine. These engines increase the cost of the truck and are approximately 10 percent less fuel efficient on a DGE basis than a comparable new diesel engine, according to the National Energy Policy Institute.⁴ This equates to a gap of approximately 22 percent from diesel when comparing to the smaller GGE unit of measure.

BENEFITS OF CNG

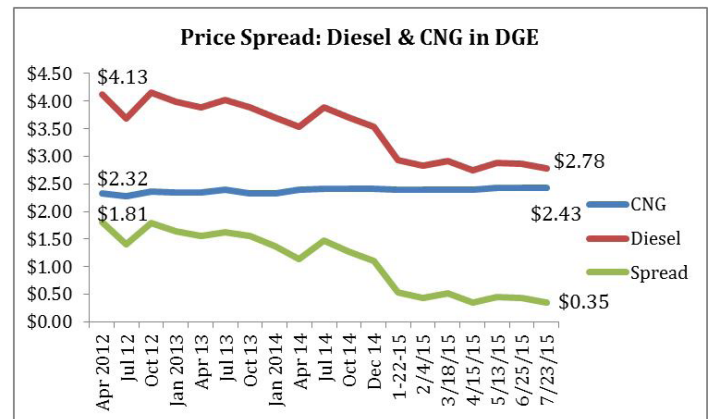
In the past few years, CNG has become much more popular in the transportation industry—namely because it is less expensive than diesel and has dramatically lower price volatility. In some cases, posted CNG prices can remain the same for months at a time. Transit buses, refuse trucks and medium-duty trucks are able to use natural gas for regional trips. Heavy-duty carriers are using CNG trucks for regional hauls or in areas with developed station infrastructure. Refueling infrastructure is continuing to expand, and CNG powered vehicles are expected to continue market share growth, albeit more slowly than previously projected due to the narrowing of the diesel/CNG price gap.

The environmental benefits of natural gas are also compelling for carriers and their customers. Sustainability has become a priority for most companies. Carriers that are able to switch to natural gas can help their customers meet sustainability goals while potentially lowering their transportation spend. The future will likely see more emissions regulations from federal and state governments, and natural gas will help carriers comply with these rules.

Domestic, Low-Cost Fuel Source



The most persuasive reason for carriers to investigate natural gas as a fuel source is its price. Fuel is one of the most expensive operating costs for carriers, and natural gas can be considerably less expensive and less volatile in pricing than diesel. The Energy Information Administration estimates that diesel pricing is projected to move toward an average of \$3.25 per gallon by 2016, while the cost of natural gas is expected to remain relatively flat for at least the next decade.⁵ Prior to the late 2014 oil price drop, natural gas had been approximately \$1.50 to \$2.00 less expensive than diesel at the pump on an energy equivalent basis. There are regional differences in CNG prices as well, reflecting variance in utility charges for CNG, the regulatory environment and taxes, as well as the local competitive landscape.



Source: NGV Today

Because natural gas is a newer fuel for heavy-duty vehicles requiring compression equipment and storage vessels, companies are paying for the cost of the new infrastructure with every gallon of fuel. With diesel prices, however, the infrastructure is largely established; most of the cost per gallon is derived from the underlying commodity price.



Please consider this example:

\$0.50 (natural gas)
 + \$1.75 (infrastructure, taxes and fees)
 \$2.25 per gallon CNG (DGE)

\$3.00 (diesel)
 + \$0.85 (infrastructure, taxes and fees)
 \$3.85 per gallon diesel

If both natural gas and diesel fuel commodity costs were to double in price, the cost of diesel would increase much more than CNG.

\$1.00 (natural gas)
 + \$1.75 (infrastructure, taxes and fees)
 \$2.75 per gallon CNG (DGE)

\$6.00 (diesel)
 + \$0.85 (infrastructure, taxes and fees)
 \$6.85 per gallon diesel

HYDRAULIC FRACTURING

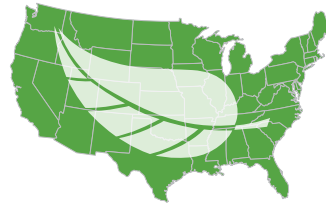
Natural gas plays a key role in our nation's clean energy future. The U.S. has vast reserves of natural gas that are commercially viable as a result of advances in horizontal drilling technologies. Hydraulic fracturing (also known as fracking) is a technique used to stimulate the production and extraction of natural gas during the drilling process.⁷ It consists of injecting a mixture of water, sand and chemical additives through the well drilled into the rock and shale formations under high but controlled pressure. This process enhances the permeability of these rocks to a point where the gas can be economically extracted. The EPA is working with states and other key stakeholders to help ensure that natural gas extraction does not come at the expense of public health and the environment. The agency is investing in improving the scientific understanding of hydraulic fracturing, providing regulatory clarity with respect to existing laws, and using existing authorities where appropriate to enhance health and environmental safeguards.⁸

A doubling of raw commodity fuel costs affects diesel prices far more than CNG. In fact, natural gas is such a stable commodity that CNG prices can often be locked for five or six years. As a result, shippers and transporters can use CNG as a hedge against the volatility of oil prices.

Another benefit of natural gas is that it is abundantly available in the United States. A domestically produced fuel source would allow America to achieve its goal of relying less on foreign oil. Using less foreign oil is critical since frequent turmoil in the oil-rich Middle East and high international demand causes the cost of oil to be high and volatile, making it difficult for carriers to properly and accurately budget their diesel expenses. As natural gas becomes more commonplace worldwide, it is estimated that the U.S. will be a net exporter of natural gas by 2030.⁶

The production and distribution

of natural gas in America has also had the positive consequence of generating a considerable number of domestic jobs. One study found that employment related solely to natural gas development will exceed 1.6 million workers by 2020.⁹ And, the industry could contribute \$225 billion to the national GDP in the same time period.¹⁰



According to the American Gas Association, natural gas emits 30 percent less CO₂ than other fuels, making it the best fossil fuel for reducing emissions.

Environmentally Friendly Fuel Source

Not only is natural gas less expensive than diesel, the fuel is better for the environment. Natural gas burns cleaner and emits fewer greenhouse gases than conventional fuels. According to the American Gas Association, natural gas emits 30 percent less CO₂ than other fuels, making it the best fossil fuel for reducing emissions.¹¹ CNG can also be produced from landfill gas, wastewater treatment and farm animal waste, and these sources reduce emissions by 85 to 90 percent.¹²

Natural gas vehicles may reduce some types of tailpipe emissions, which result from fuel combustions in a vehicle's engine, depending on vehicle type, drive cycle and engine calibration. The emissions of primary concern include hydrocarbons, oxides of nitrogen, carbon monoxide and carbon dioxide.¹³ The U.S. Environmental Protection Agency (EPA) is requiring all fuels and vehicle types to meet the same thresholds for tailpipe emissions of air pollutants. The industry standard technology to meet these emissions requirements for diesel powered trucks, Selective Catalytic Reduction (SCR), adds expense and 300 to 400 pounds of additional weight. SCR emissions technology also requires the use of diesel exhaust fluid (DEF), which adds expense as well. CNG powered engines meet the EPA emissions standards without additional systems.

Sustainability and natural gas development are priorities for federal and state governments, and consequently, many incentives are available to those who use the environmentally friendly fuel. Options include tax incentives and grants to mitigate the additional costs of CNG trucks and maintenance facilities; low-interest loans; and a weight exclusion to offset the weight of natural gas fuel tanks, according to the National Energy Policy Institute.¹⁴

CHALLENGES OF CNG

Despite the benefits of CNG, several barriers to its widespread use still exist. CNG powered trucks are more expensive than diesel powered trucks, so many carriers are resistant to invest due to cost differences. The maintenance specifications for CNG engines and fueling systems differ from diesel trucks, and regulations could require costly upgrades to shops that maintain natural gas trucks. Also, because the nation's natural gas fueling infrastructure is somewhat limited, some fleets lack flexibility to serve customers using natural gas trucks—particularly long-haul carriers.





Expensive Equipment

Just a couple of years ago, only one CNG engine was widely available for large trucks: the Cummins-Westport ISL-G 9L. Now, however, many more trucks are available that are equipped with a 12L engine that is much more powerful than the 9L. While many carriers were initially apprehensive about switching to natural gas because the engines were small and, therefore, less powerful, the new 12L options allow for much more horsepower and offer a driving experience similar to diesel counterparts.

Still, CNG engines increase the cost of a truck by 40 percent or more over a diesel counterpart—mainly because of the fuel system.¹⁵ This additional cost can be mitigated by spec'ing the truck with the appropriately sized fuel tanks. Oversized tanks add range flexibility, but also weight and cost. Spark-ignited CNG engines are estimated to be 10 percent less fuel efficient than diesel engines. But, as outlined in a previous section, the natural gas is significantly less expensive than diesel, which could offset the inefficiency. New waves of tighter engine regulations go into effect for 2017, with diesel trucks generally expected to be unfavorably impacted price-wise, while CNG trucks may have lesser or no price impact.

The robust fuel tanks required for CNG are also an issue. CNG tanks are heavier and larger than diesel tanks. Most standard fuel tank configurations of around 120 DGE capacity provide a range of 500 to 600 miles with CNG. Consequently, CNG powered vehicles are best for regional routes with a 500-mile maximum round trip. Larger tank packages can be configured to add range between fuelings, but these configurations will require more weight and cost. With a standard configuration, a full CNG truck can weigh up to 1,000 pounds more than a comparable truck fueled with a full tank of diesel, but this can be at least partially mitigated with spec'ing adjustments. There are currently four types of CNG fuel tanks:

- Type I: Entirely made of metal (steel or aluminum). This is the most cost-effective—but heaviest—choice
- Type II: Metal liner reinforced with composite wrap (glass/carbon fiber) around the middle of the cylinder. These tanks are lighter than Type I but more expensive
- Type III: Aluminum composite material liner reinforced with composite wrap (glass/carbon fiber) around the entire tank. These tanks weigh less but are more expensive than Type I or Type II tanks
- Type IV: These tanks do not use any metal in their structural design. They are made with a gas-tight, thick rubber membrane liner reinforced by composite wrap (glass/carbon fiber) around the entire tank. The entire strength of the cylinder is composite reinforcement. This is the most lightweight and expensive tank

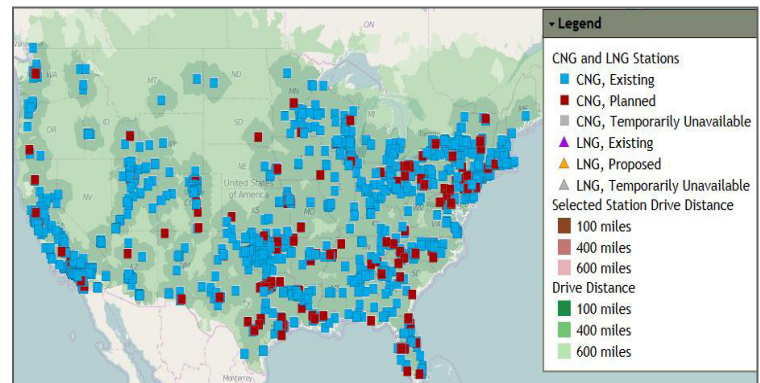
Type III and Type IV tanks are approved for installation on vehicles that meet or exceed the Department of Transportation (DOT) safety

standards.

Engineers continue to develop more efficient fuel tanks that will both extend travel range and weigh less. As natural gas increases in popularity, suppliers will continue to compete to create more efficient, higher powered and lighter weight options.

Limited Fueling Infrastructure

Natural gas requires special fueling systems consisting of large compressors and storage vessels. CNG suppliers were apprehensive to build expensive stations without a local client base, but without the proper fueling stations, carriers would not operate natural gas fleets in those areas. Consequently, natural gas fueling stations were primarily located in concentrated areas where natural gas powered vehicles are widely used. As a result of limited infrastructure, CNG powered fleets have historically been confined to operating regionally in an area that has the appropriate fueling stations. For long-haul carriers, the lack of refueling flexibility had largely prohibited them from using CNG, but the infrastructure is developing rapidly.



Source: <http://ngvamerica.stone-env.net/>

The CNG fueling station count has grown dramatically in the last few years with a total of 1,539 CNG natural gas stations currently operating in the United States (818 of which are public), and an additional 171 CNG fueling stations are planned for 2015.¹⁶ According to the consulting firm Navigant, the CNG refueling station count in the U.S. could more than double in the next seven years.¹⁷

Some fleets may opt to build their own natural gas fueling stations. While this option requires significant up-front capital, the resulting fuel cost is very attractive, and it may allow more flexibility than the national fueling infrastructure can provide at this point. Sometimes fueling companies will build a new station in partnership with a carrier that commits to purchase fuel as an anchor customer, according to *Transport Topics*.¹⁸

Maintenance Requirements

Specialized engines and fuel systems have different maintenance requirements than their diesel counterparts. Spark-ignited engines require more frequent valve adjustments and spark plug replacements



than their diesel counterparts. Natural gas engines require oil changes more often since they tend to run hotter than diesel trucks, according to *Transport Topics*.¹⁹ CNG tank inspections are also required every 36,000 miles. These requirements could cost approximately 1 to 2 cents more per mile than diesel-powered trucks.²⁰ However, these costs are often offset because spark-ignited engines do not require diesel after-treatment systems or related maintenance. As the 12L CNG trucks are fairly new in Class 8 service (having not completed a life cycle yet), CNG maintenance projections are fairly wide—ranging from \$0.00 to \$0.03 higher than diesel.

Because natural gas is heavily regulated, shops that service natural gas vehicles may require significant and expensive upgrades. Fleets that seek to use natural gas vehicles must decide if they want to upgrade their shops to service these vehicles or outsource the maintenance. Depending on local fire codes, shops may be required to have sloped roofs, methane detection systems (since natural gas is odorless and colorless), ventilation systems and explosion proof lighting. Some studies estimate that these upgrades could cost between \$80,000 and \$200,000.²¹

Despite these requirements, natural gas does not present significant safety concerns. Because natural gas is lighter than air and rises, it does not pool, eliminating the risk of ground or water contamination. Proper ventilation systems, however, are necessary since the gas is flammable and can be contained along ceilings. According to survey of more than 8,000 natural gas vehicles, only one fire occurred during the 180 million miles they travelled collectively as a result of a failure of the natural gas system.²²

THE RUAN APPROACH

As a member of the SmartWay Transport Partnership, Ruan views sustainability as more than a high priority—it is an essential requirement for the future. As a result, Ruan's strategic plan outlines ways to make our trucks cleaner and more efficient. Increasingly, transportation providers must develop and deploy sustainable solutions to attract new customers, improve operations and provide services that positively impact clients' businesses. Ruan has done just that.



Ruan's CNG-powered tractor

Since August 2011, Ruan has been hauling milk with a fleet of CNG trucks for Fair Oaks Farms, one of the most recognized dairies in the world. This environmentally friendly transportation solution is a truly innovative example of sustainability because the CNG used to power the trucks is produced from the Fair Oaks, IN, farm's dairy cattle waste.



In a process called anaerobic digestion, microorganisms feed on manure from the 32,000 cows on the farms and excrete methane, which Fair Oaks Farms traps

and processes. The gas is piped to a fueling station in Fair Oaks for compression and distribution. The CNG fuel powers the 42-truck Ruan fleet. The two fueling stations in Fair Oaks and southern Indiana provide all the fuel in the delivery network.

Ruan transports more than 323,000 gallons of milk each day, which equals approximately 118 million gallons of milk per year. Ruan travels more than 11 million miles annually delivering the milk to plants in the Midwest. The trucks replaced diesel powered models, displacing more than one and half million gallons of diesel per year and significantly reducing both direct emissions and the traditional carbon footprint of energy production.

Ruan team members manage the transportation network from Fair Oaks, providing 24/7 customer service. Including professional drivers and management staff, the operation created 115 jobs. When the operation started, the trucks were powered by the Cummins-Westport ILS-G 9L engine. In 2014, Ruan began phasing in the new Cummins ISXG-12L engine allowing for more power. The trucks are equipped with one side rail fuel tank and two fuel tanks behind the cab, and the equipment weighs 17,000 pounds and can haul close to 53,000 pounds of milk. Ruan's professional drivers comment that the 12L CNG trucks drive like diesels with enough power to pull a tanker full of milk, but without the noise and smell of the traditional diesel powered engines.

Ruan is also operating CNG trucks for retail, manufacturing, dry bulk and grocery customers across the country. Ruan currently has 100 CNG tractors operating or on order and has accumulated 30 million miles of experience using CNG powered Class 8 tractors. Ruan continues to support the use of CNG and regularly evaluates the savings and environmental benefits CNG can offer customers. Most new business or contract renewal quotes, as long as it makes economic and logistical sense, is quoted using both conventional diesel trucks and CNG trucks. Ruan also considers ways to pass along additional savings to customers via early renewal with CNG equipment.

Ruan's alternative fuels strategic committee, which includes team members in senior management, information technology, assets, maintenance, operations, sales, marketing and fuel, meets regularly to discuss ways in which the company can continue to expand our use of alternative fuels. Ruan has fostered relationships with natural gas suppliers across the country and stays abreast of the latest natural gas news and developments. The assets department works closely with natural gas engine providers to have the most up-to-date data on performance and cost, and the maintenance team has identified CNG maintenance providers in key areas of the country. Together, this team is creating innovative, sustainable natural gas strategies for customers and prospective customers across the country in a variety of industries.



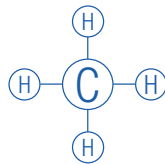
CONCLUSION

Carriers understand that natural gas will be an important part of transportation in the future and must identify opportunities that provide the largest benefits of CNG fuel usage. If diesel prices spike and remain volatile, natural gas fuel will continue to be an attractive option for Class 8 fleets. The per-mile fuel savings of using CNG over diesel can outweigh the higher cost and weight of the trucks and the subsequent maintenance requirements. In addition, the stability of the CNG prices offers excellent predictability of costs. In general, if carriers operate regional routes and CNG is approximately \$1 less at the pump than diesel on an energy equivalent basis (or around \$1.10 to \$1.20 lower using GGE pricing), CNG can be a cost-effective method of transportation.

According to industry experts, the heavy-duty natural gas trucks in the Class 8 market will continue to show sales growth year after year, and we will see continued development of natural gas fueling infrastructure, equipment and technology improvements. It is projected that natural gas vehicles will make up 10 percent of the heavy-duty truck sales market by the year 2020.²³ The pace of CNG adoption will likely continue to be driven by future diesel prices and volatility.

Ruan will continue researching and implementing alternative fuel use, facilitating strategic conversations with clients about natural gas options and ensuring industry-leading sustainability results. As more and more engine and fuel tank technologies are developed, Ruan will be at the forefront of their implementation.

RUAN



Questions regarding the content of this document should be directed to:

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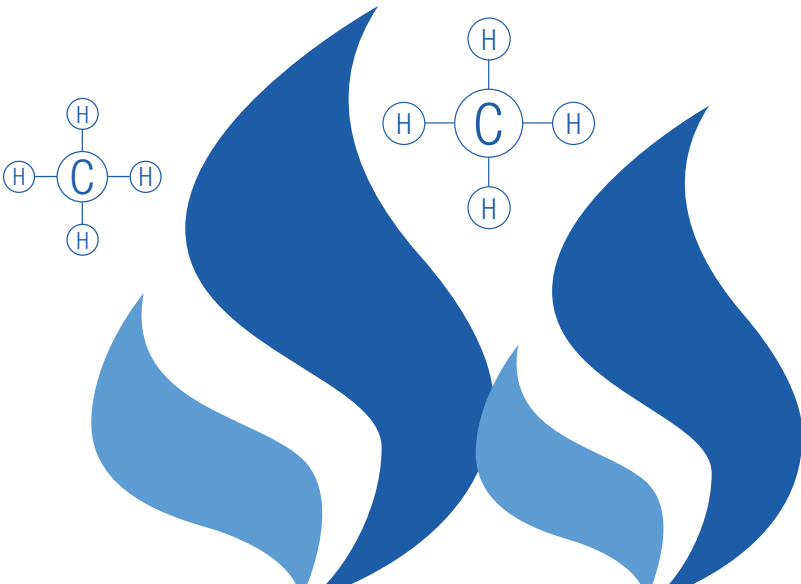
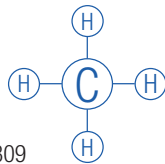
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