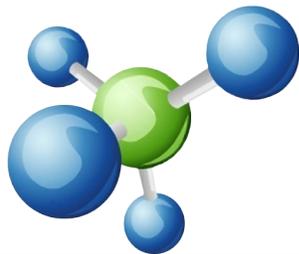


Transportation >>>>>

^ Industry White Paper



Natural Gas in the Trucking Industry

Throughout the transportation industry, more and more carriers are experimenting with using alternative, sustainable fuels to power heavy-duty vehicles. The low cost of natural gas, in particular, is attractive since diesel prices are 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 emits fewer greenhouse gases than diesel.

Despite these benefits, several 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 severely limited—though it is slowly expanding. And trucks running on natural gas require different engines than those powered with diesel; at this time, few engine options are readily available for heavy-duty trucks.

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 sustainable fuel. In addition, this white paper highlights Ruan Transportation Management Systems' approach to using natural gas, primarily compressed natural gas (CNG).





## 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.<sup>1</sup> But, less than 0.1 percent of total natural gas consumed in America is currently used as transportation fuel.<sup>2</sup>

## NATURAL GAS IN HEAVY-DUTY TRUCKS

Only recently has natural gas been used to power heavy-duty vehicles, though it is more widely used in smaller service vehicles and personal cars. 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.<sup>3</sup> 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).

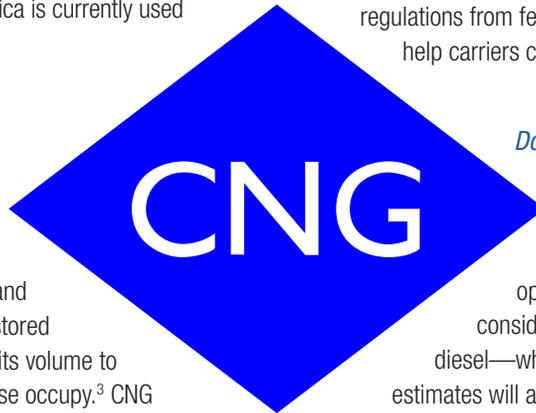
As a result of these differences, CNG is stored differently on trucks than diesel. CNG is generally stored at 3,600 psi at ambient temperatures, and these specifications require a durable—and expensive and heavy—tank.<sup>4</sup> Special engines—which burn natural gas as a vapor—are required to power heavy-duty trucks with CNG, and only a few engine options currently exist, though more are under development. 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 than a comparable new diesel engine, according to the National Energy Policy Institute. LNG can be used with the spark-ignited engine and a compression-ignited engine, which also uses diesel fuel for combustion.

## BENEFITS OF CNG

In the past few years, CNG has become much more popular in the transportation industry—primarily because it is less expensive than diesel. Transit buses, refuse trucks and medium-duty trucks are able to use natural gas for regional trips, and now heavy-duty carriers are taking notice. Truck suppliers are quickly developing natural gas technology for Class 8 trucks, and refueling infrastructure is finally being expanded to accommodate increased demand. Worldwide, natural gas powered vehicles are expected to increase in number considerably over the next

decade; Pike Research estimates that by 2019, more than 930,000 medium- and heavy-duty natural gas trucks will be sold.<sup>5</sup>

The environmental benefits of natural gas are also compelling for carriers and their customers. Sustainability has become a priority for most companies, and carriers that are able to switch to natural gas can help their customers meet sustainability goals while potentially lowering transportation spend. And, the future may see more and more emissions regulations from federal and state governments. 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 is considerably less expensive and less volatile than diesel—which the Energy Information Administration estimates will average \$3.93 per gallon in 2013.<sup>6</sup> The cost of natural gas it is expected to remain relatively flat for at least the next decade, and natural gas is approximately \$1.50 to \$2 less expensive than diesel at the pump on an energy equivalent basis, according to the National Energy Policy Institute.<sup>7</sup> Consequently, the use of natural gas instead of diesel to power heavy-duty vehicles could reduce the per-mile fuel cost by 20 to 25 cents. Initially, these savings will be offset by the additional cost of the trucks and their maintenance, both of which are expected to decline as the industry matures.

Another benefit of natural gas is that it is abundantly available in the United States, and a domestically produced fuel source would allow America to achieve its goal of relying less on foreign oil. In 2011, President Barack Obama challenged America to import 33 percent less foreign oil in 10 years; so far, the U.S. is on track to achieve this goal, according to NGVAmerica.<sup>8</sup> Using less foreign oil is critical since frequent and regular 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. And this energy resource is so abundant in the U.S. that its supply has as much energy potential as all of Saudi Arabia's oil.<sup>9</sup> As natural gas becomes more commonplace worldwide, it is estimated that the U.S. will be a net exporter of natural gas by 2030, allowing America to significantly reduce its trade deficit.<sup>10</sup>

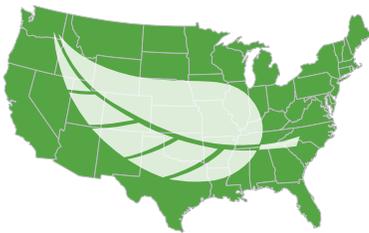
**930,000** *By 2019, more than 930,000 medium- and heavy-duty natural gas trucks will be sold.*



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 1 million Americans were employed in the unconventional gas industry in 2010, and by 2015, the industry is expected to support 1.5 million jobs.<sup>11</sup>

### *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 CO<sub>2</sub> than other fuels, making it the best fossil fuel for reducing emissions.<sup>12</sup> CNG can also be produced from landfill gas, wastewater treatment and farm animal waste, and these sources reduce emissions by 85 to 90 percent.<sup>13</sup>



*According to the American Gas Association, natural gas emits 30 percent less CO<sub>2</sub> than other fuels, making it the best fossil fuel for reducing emissions.*

In 2010, the Environmental Protection Agency (EPA) created standards for diesel engines, requiring ultra-low emissions levels from all 2010 and beyond engines.<sup>14</sup> The industry standard technology to meet these requirements, Selective Catalytic Reduction (SCR), adds expense and 300 to 400 pounds of additional weight to vehicles. SCR emissions technology also requires the use of diesel exhaust fluid, which adds expense as well. Compressed natural gas powered engines meet the EPA 2010 emissions standards without additional systems.

Sustainability and natural gas development are priorities for the federal government, and consequently, some incentives may soon become available to those who use the environmentally friendly fuel. Among the ideas under consideration are tax incentives and grants for the additional costs of 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.<sup>15</sup>

## **CHALLENGES OF CNG**

Despite the benefits of CNG, several barriers to its widespread use still exist. CNG powered trucks are much more expensive than diesel powered trucks, so many carriers are barred from entry due to cost. 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 very limited, fleets lack flexibility to serve

customers using natural gas trucks; for now, they must operate where the infrastructure exists, mainly in California and the Midwest.

### *Limited and Expensive Equipment*

Only one CNG engine is currently widely available for large trucks: the Cummins-Westport ISL-G 8.9L—and it is expensive. The Cummins-Westport 8.9L engine increases the cost of a truck by \$30,000 to \$40,000 over a diesel counterpart—mainly because of the fuel system.<sup>16</sup> Spark-ignited engines, like the ISL, 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.

Many carriers are apprehensive about switching to natural gas because the engines are small and, therefore, less powerful. Heavy-duty natural gas vehicles currently on the market have less horsepower available than diesel-operated trucks. When carriers are trying to haul more and have the highest payload, the lack of power can be a serious deterrent against natural gas.

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 provide a range of 250 to 350 miles with CNG. Consequently, CNG powered vehicles are best for regional routes with a 350-mile maximum radius. According to the National Energy Policy Institute, some trucks are currently operating with five CNG fuel tanks. While this configuration allows the truck to travel up to 800 miles without refueling, it requires 3,000 pounds of fuel. Federal weight limits mandate that trucks cannot weigh more than 80,000 pounds, and when carriers are trying to maximize payload, 3,000 pounds of fuel could be too much. 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.

Cummins developed an 11.9L CNG engine that went to market in 2013, and Volvo is working on a 13L engine—both will offer carriers a higher-powered option.<sup>18</sup> As natural gas increases in popularity, suppliers will continue to create more efficient, higher powered and lighter weight options.

### *Limited Fueling Infrastructure*

Natural gas requires special fueling systems, and due to previous lack of demand, not many fast-fill CNG fueling stations exist. Gas companies are apprehensive to build expensive stations without a local client base,





but without the proper fueling stations, carriers will not operate natural gas fleets in those areas. Consequently, natural gas fueling stations are primarily located in concentrated areas where natural gas powered vehicles are widely used. California, for instance, has 36 of the nation's 47 public and private LNG fueling stations. The Midwest has the majority of America's 936 public and private CNG fueling stations.

As a result of limited infrastructure, CNG-powered fleets are confined to operating regionally in an area that has the appropriate fueling stations. For long-haul carriers, the lack of refueling flexibility all but prohibits them from using the natural gas.

Clean Energy is leading the way in developing the nation's natural gas fueling infrastructure. Clean Energy and Pilot-Flying J are partnering to create 150 LNG fueling stations along major U.S. interstates in 2013.<sup>19</sup> Later, they will expand their efforts to developing regional fueling infrastructure. Several CNG fueling stations are in development as well. Shell and TravelCenters of America recently entered an agreement to install CNG pumps at more than 100 existing truck stops throughout the U.S.<sup>20</sup>

Some fleets may opt to build their own natural gas fueling stations. While this option is expensive, it allows more flexibility than the national fueling infrastructure can provide. According to the National Energy Policy Institute, a carrier operating with CNG should use 250,000 DGE per year in order for the on-site fueling station to be cost effective, as the stations can cost between \$400,000 and \$1.5 million.

With already limiting federal hours-of-service rules, which dictate the number of hours professional drivers can operate vehicles and work on a daily and weekly basis, the amount of time refueling with CNG requires can be a downside for many carriers. Fueling stations with large compressors can pump eight gallons per minute, but older stations may require more than 30 minutes to fill a tank. In a professional driver's 14-hour work day, 30 minutes is a significant amount of time.

### *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. These requirements could cost approximately three cents more per mile than diesel-powered trucks. But, these costs are often offset because spark-ignited engines do not require diesel after-treatment systems or related maintenance.



*Ruan's CNG-powered tractor*

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 \$200,000 and \$1 million; however, anecdotal evidence suggests lower ranges from \$80,000 to \$200,000 may be more accurate.<sup>21</sup>

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 seven fires occurred during the 180 million miles they travelled collectively, and only one was a result of a failure of the natural gas system.<sup>22</sup>

### **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 its 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.



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 fleet — one of the largest Class 8 CNG fleets in America — that Ruan uses to haul milk.

Ruan transports more than 300,000 gallons of milk each day—or 118 million gallons per year—to plants in the Midwest and travels more than 11 million miles annually. The trucks replace diesel powered models and, by displacing more than one and half million gallons of diesel per year, significantly reduce both direct emissions and the traditional carbon footprint of energy production. The two fueling stations in Fair Oaks and southern Indiana provide all the fuel in the delivery network.



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. The Kenworth T440 trucks are powered with the Cummins-Westport ILS-G 8.9L engine, and they are equipped with two side rail fuel tanks and three behind the cab. The equipment weighs 17,000 pounds and can haul close to 53,000 pounds of milk. In 2013, Ruan is phasing the Cummins 11.9L engines into the Fair Oaks operation, allowing for more power.

Ruan has also tested 8.9L CNG trucks for retail, manufacturing and grocery customers in California. And the company is planning to acquire more trucks equipped with the 11.9L Cummins-Westport engine as they become available.

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 its use of alternative fuels. Ruan's fuel expert 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

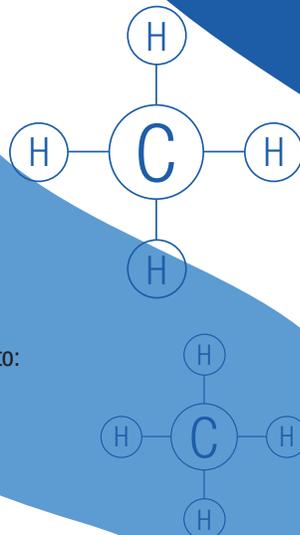
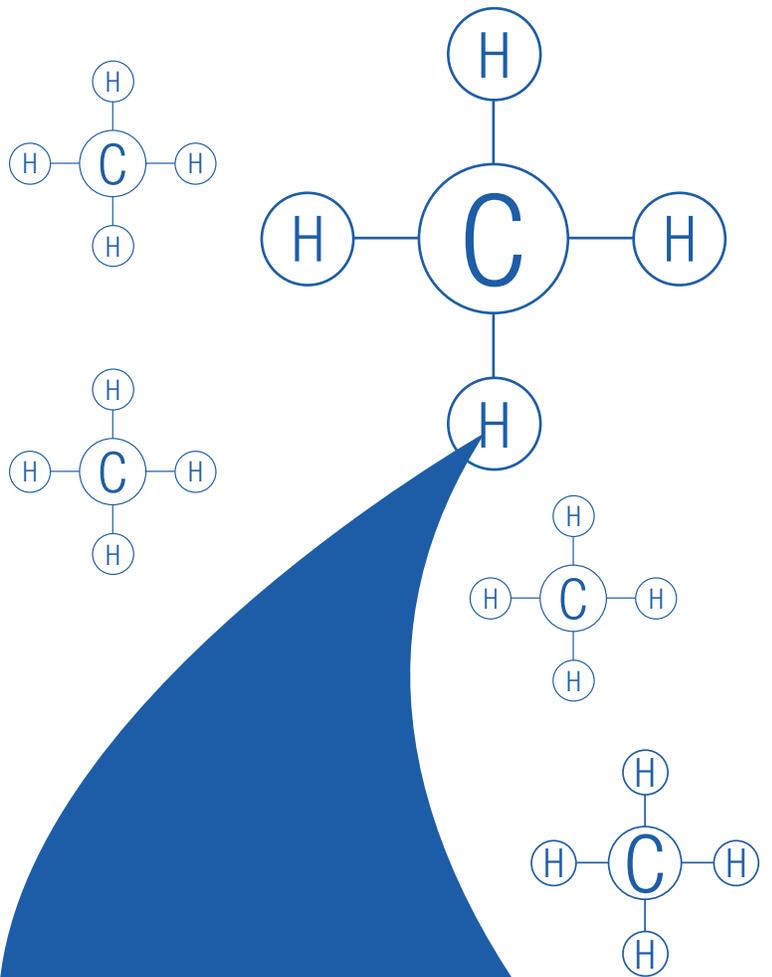
Carriers will need to weigh the benefits of natural gas against the many challenges that it presents. If diesel prices remain high and volatile—like they are expected to—natural gas power will continue to be an attractive option for high mileage fleets. If trucks run enough miles, the per-mile savings of using CNG over diesel can outweigh the higher cost and weight of the trucks and the subsequent maintenance requirements.

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

# **RUAN**

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