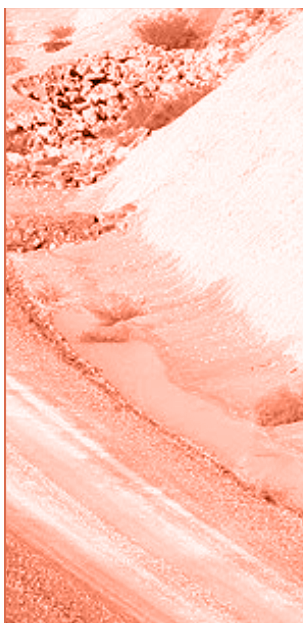




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LNG, Oil Prices, and the High Horsepower Market

Edward Dodge
January 25, 2015

The Off-Road and High Horsepower (HHP) sectors of the LNG industry have been under a great deal of pressure with the recent drop in oil prices.

Crude oil has fallen from a high of around \$100 per barrel in June 2014 to under \$50 per barrel in January 2015. This drop in prices has eliminated most of the recent pricing advantages that Liquefied Natural Gas (LNG) held over diesel fuel, its direct competitor in the HHP market, but LNG retains decisive advantages over diesel environmentally, operationally and in price stability.

Since natural gas emissions have almost no sulfur or particulate matter, it easily beats the toughest emissions standards that are enforced on diesel and other traditional fuels. As engine makers and fleet managers work to meet Tier 4 diesel standards and maritime emissions rules, the virtues of natural gas engines are becoming apparent. Modern natural gas engines are reliable for tough jobs and eliminate the need for intrusive exhaust gas after-treatment equipment, reducing maintenance and down time.

Efforts to reduce methane emissions, particularly from oil and gas drilling, is creating new business opportunities to fuel heavy-duty drilling and pumping equipment. Using field gas to replace diesel saves money and helps the environment at the same time.

The close price spread between LNG and diesel fuel will slow down conversion to LNG in the near term, since it is harder to cover the expense of new equipment without the fuel cost savings. But the long term trends remain very favourable for LNG.

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Retail LNG and diesel prices are nearly even in Jan, 2015 at a Blu LNG station in Georgia.

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Sam Thigpen of TRF Energy Solutions, which was formed in a recent merger of Thigpen Energy, a leader in LNG fueling services, Recapture Solutions, a leader in flare gas capture, and Flex Leasing Power and Service, a leader in remote power generation solutions.

David Kailbourne, CEO of RevLNG, who is a pioneer in the LNG solutions market and one of the first trucking operators to convert their traditional diesel fueled trucks to LNG.

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John Hatley of Wärtsilä, who is one of the biggest and most important firms in the global maritime and power plant businesses. Wärtsilä is the largest manufacturer of marine engine and power systems.

Ben Deal, of LNG Energy, who are consultants and brokers for LNG high horsepower solutions.

Travis Balaski, of Ferus Fuels, who provide end-to-end LNG and compressed natural gas (CNG) fueling services, including liquefaction, compression, transportation, and storage to customers in all high horsepower industries.

LNG Remains Competitive against Diesel Even As Oil Prices Fall

In June 2014, LNG was selling for about half the price on a BTU basis of diesel fuel but now the retail price for the commodities is more or less even.

There are more nuances to the price story though than just the price of oil. Diesel fuel prices have not fallen as dramatically as crude oil prices and at the same time natural gas prices have also dropped from a high of nearly \$5 per MMBtu (million BTU) in June 2014 to under \$3 per MMBtu in mid-January 2015. So while the price spread between LNG and diesel has narrowed, it has not reversed.



Natural gas prices, and specifically LNG prices, are far less volatile than oil and diesel prices. Crude oil is an international market subject to geopolitical events while natural gas is a stable North American market.

For LNG, the feedstock gas price is less than half of the production costs, whereas liquefaction and transportation make up more than half of the cost. This means that the final retail price of LNG is less sensitive to fluctuations in natural gas prices than diesel is to fluctuations in crude oil prices.

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FCBI: So how are the low oil prices impacting your business?

David Kailbourne, Rev LNG: Obviously with the price of oil and diesel at five and a half year lows, we've certainly seen a slight slowdown in interest, but actually the spread between natural gas and diesel has maintained itself fairly well because natural gas prices have fallen severely in the last thirty five days as well, going from about \$4.25/mmBtu down to around \$2.93/mmBtu. So that's over a 25% decrease in natural gas prices in the last month, which maintains some of the spread between diesel and natural gas.

LNG today, delivered price at the pump, depending on what state you're in would trade between probably \$2.50 and \$3.00 for the full diesel gallon equivalent (DGE).

It is certainly challenging to attract new business such as truck fleets with diesel when diesel is priced as low as it has been in the last few weeks. However, most people realize that the commodity markets are cyclical and fluctuate with volatility and chances are they know that the price of diesel probably won't stay down here for that much longer and they still are looking at natural gas as an alternative.

The other problem that exists in the LNG market is the federal tax level. LNG is taxed on a volume basis and not on a BTU or energy equivalent basis. LNG is taxed at 42 cents in federal taxes right now, and compared to diesel is over taxed basically 18 cents per gallon, or in DGE it is overtaxed around 30 cents. If you were able to subtract nearly 30 cents off of that market, you would see LNG for on road applications become one of the most economic forms of fuel there is. LNG is cheaper than CNG and it would be cheaper than diesel.

A lot of people forget that CNG is priced in a gasoline gallon equivalent (GGE), so they automatically assume CNG is cheaper than LNG, but when you do the BTU equivalent basis to get back to diesel gallon equivalent you would have to add about 15% to the price of CNG at the pump. Now all of a sudden LNG has become substantially more economically viable than almost any fuel out there.



LNG Transport Tanker.

photo by RevLNG

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Travis Balaski, Ferus Fuels: If you are looking at today's spread, oil versus natural gas, call it 16:1. That is still a decent spread for long term economics. Currently, if there was a large enough refuelling infrastructure in place, natural gas would be still very competitive and would offer quite a good discount over diesel. Because we are still trying to build infrastructure there has been some short-term strain on investment. But the longer term economics are still there, even at today's ratios. And that's why we haven't held back at all. We're responding to some short-term reaction from the market but it has not hampered our long-term vision at all.

Sam Thigpen, TRF Energy: We always knew that LNG was way more price sensitive to the change in diesel price versus the change of natural gas price. The commodity piece of an LNG gallon is a pretty small piece of that gallon and so it's not a huge fluctuation when the gas market goes up and down, but where the economics do suffer is when diesel drops like it has. And if we are at \$2 or \$2.50 out in the field for diesel then it is hard for LNG to compete in that market.

The LNG price in the exploration and production (E&P) market is pretty much the same as diesel and sometimes, depending on location can actually run a little bit more than the diesel price. This is mainly due to transportation of the LNG to long distances. So right now we see it as a tough sell for the operators to use the fuel for a cost savings measure.

Now, obviously, there's still a tremendous amount of environmental benefit to using LNG if they have to, or if they want to remain on natural gas and maybe field gas is not available for them. But the economic savings for the traditional drilling and pressure pumping in the E&P market is pretty tough right now.

LNG is a great source for industrial fuelling, where they may suffer from outages and things of that nature and diesel is not an option. We've shifted our focus until diesel prices come back to the point where LNG becomes more economical.

Emissions Rules Decisively Favor Natural Gas

There have been a series of emissions standards that come into effect in recent years across industries that all serve to favor increased use of natural gas. Methane emissions controls from flaring and pipeline leaks, maritime emissions control areas and Tier 4 diesel emissions rules for on-road and off-road engines all have the effect of encouraging natural gas substitution.

Methane Emissions

Both the EPA and states have proposed or mandated tough new rules limiting the flaring of natural gas on drill sites as well as limiting leaks from pipelines and equipment. Since methane is natural gas, all methane molecules that are prevented from escaping to the atmosphere are available to be used as fuel, and often times the value of the captured gas makes the investment in new capture-equipment profitable. Methane emissions rules are generating good business opportunities.

Firms such as TRF Energy and Ferus Fuels are successfully deploying flare recapture equipment that enables drillers to make productive use of gas once thought unprofitable to manage. Gas that is cleaned up and used onsite is known as field gas and it is proving to be a very cost effective fuel resource. While field gas is not explicitly liquefied, it is often used in conjunction with

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LNG, and the services are often provided by the same vendors.

Flare gas recapture works by cooling the gas down and sending it through a separator where the natural gas liquids (NGL's) are stripped off from the methane. The NGL's are transported for sale and there is a good market for them. The methane is pressurized and used onsite to power drill rigs and pressure pumps at a much lower cost than diesel fuel which is typically used. The use of field gas is a win-win for industry and the environment, pollution is reduced and the molecules are converted into very cost effective fuel. Field gas is so cost effective that drillers and operators are expected to expand its use, but it requires converting equipment to run on gas instead of diesel.

FCBI: How much of your flare recapture business is driven by EPA methane emissions rules?

Sam Thigpen, TRF Energy: We haven't seen the big driver to be based around coming EPA methane rules but what we have seen as a big driver for that business, especially in North Dakota, is the state mandate to reduce flaring in North Dakota. We can show the operators improvement by reducing the amount of flare and getting some of those NGL's that we strip out into the market for them, instead of burning them. Now they're starting to open their eyes to applying it in other areas.

FCBI: How does the recapture equipment work and what technical advances have there been?

Sam Thigpen, TRF Energy: The process technology is tried and true. It is a refrigeration and pressure reduction process. There is some new membrane technology out there that is interesting and is expected to come to the market. But what I would say is the technological advancement in the flare capture business is taking this historical technology for stripping NGL's out of natural gas and making it portable. That is where we see really the technological advances, in the trailer mounts and making all of this equipment easier to deploy.

FCBI: Is the flare recapture process cost effective?

Sam Thigpen, TRF Energy: We've had some operators let us know that they are going to try to reduce drilling and completions program costs before they really try to cut into their drilling schedules. So they want to start with that as their first step and reduce their costs before they actually have to start cutting drilling schedules. The sentiment from some of the larger operators is that field gas could definitely be a great cost saving for them in their drilling and completion program.

We are happy to say that so far we've actually seen an uptick and interest in our business and our solutions because we offer cost savings to the operators and the E&P companies through the use of field gas. Nobody is a 100% insulated from a downturn in the oil price, but we have seen our business see new potential for growth in this downturn because of the solution that we have put together.

FCBI: How much does field gas cost for the end user?

Sam Thigpen, TRF Energy: You have to account for the commodity natural gas they use, plus you have the services and equipment on-site. So you are anywhere from \$0.85 to \$1.15 for the diesel gallon equivalent. It really gives

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them some economic incentive to put that in their program because even with diesel price being two dollars in the field these days, on average, there is still considerable savings to be had with field gas.

Travis Balaski, Ferus Fuels: There are savings on diesel fuel and there is an added revenue stream of NGLs, and in addition you have reduced liability in methane emissions. It's really hard to quantify the number here today as the rules change, but those are the three benefits we are seeing. The oil and gas industry is the quickest adopter of natural gas fuelling and are under pressure to prevent emissions for other reasons.

Maritime Emissions Control Areas

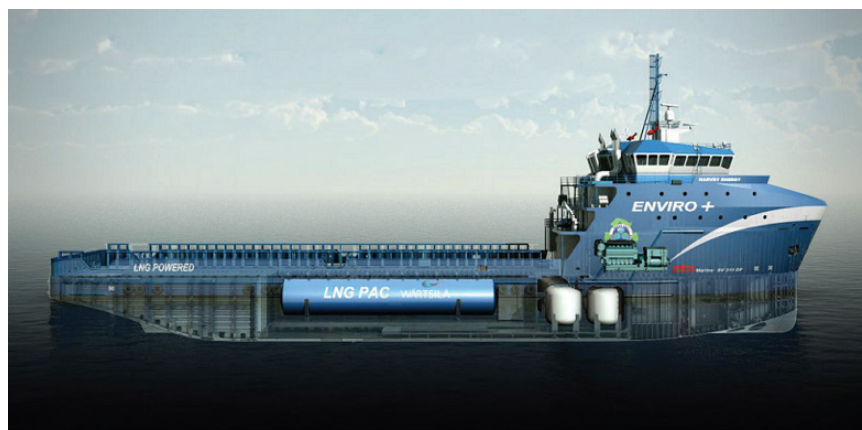
Tough new limits on sulfur emissions are being introduced in North America and Europe as of January 1, 2015. Vessels within the Emission Control Area (ECA), which is 200 miles from the coast, cannot have more than 0.1% sulfur content in their fuel. These new rules are forcing ship owners to install expensive scrubbers, burn expensive ultra-low sulfur diesel fuel (ULSD), or convert to LNG.

All three choices are expensive, but running scrubbers on heavy fuel oil is the most expensive and carries the highest maintenance burden. In the near term most ships are converting to dual fuel engines that burn both LNG and ultra-low sulfur diesel fuel.

Dual fuel engines allow ship owners the flexibility to comply with ULSD, but take advantage of LNG where it is available. LNG bunkering is just beginning to be built out, so it will take a few years before the use of LNG is common.

FCBI: How do you see the recent price shifts impacting the uptake of LNG for ships?

John Hatley, Wärtsilä: Diesel has fallen 18% since its June high and natural gas has fallen about 35% in the US. Since diesel has not fallen nearly as much as crude, there is still a pretty strong case for LNG, although not as strong as it was before.



LNG Fuelled ship.

Graphic by Harvey Gulf Marine

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FCBI: How well have the LNG solutions worked out in the field, from an operational perspective?

John Hatley, Wärtsilä: Natural gas complies with all the emissions requirements, even the tighter one's going forward across all emissions constituents. Diesel engines require baggage in terms of after-treatment devices to comply with all those emissions attributes as emissions tighten. That baggage requires weight, maintenance to ensure it performs correctly, and initial costs and concerns.

No matter what type of diesel engine it is, it requires some form of after-treatment, be it Exhaust Gas Recirculation (EGR) or Selective Catalytic Reduction (SCR), which only go after nitrogen oxides (NOx), or a scrubber which only attacks sulfur and SOx. Whereas gas does not require any of this excess baggage or extra systems to make it work as well as the obligations to dispose of the residuals that come from those operations.

FCBI: And does that translate into the bottom line for your customers?

John Hatley, Wärtsilä: Certainly it does. When you look at it as an entire system, natural gas is safe, clean, and very efficient in burning cleanly. It is also fairly low cost and it avoids all this excess baggage in terms of additional supporting elements to meet compliance.

FCBI: Have there been any downsides with LNG fuel from an operational and engine performance perspective?

John Hatley, Wärtsilä: On the operation and maintenance side, the maintenance intervals have been expanded dramatically and pushed farther out in the future with fewer component replacement exchanges. LNG fuel is a very, very clean burning fuel.

FCBI: So is Wärtsilä totally behind LNG?

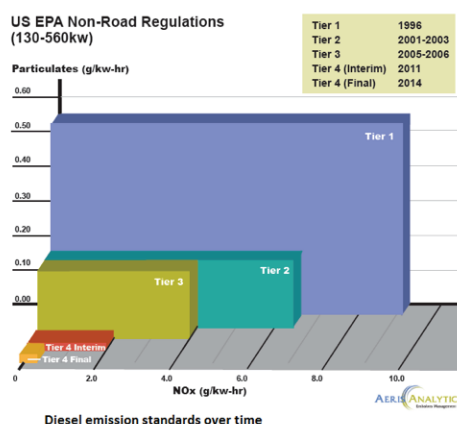
John Hatley, Wärtsilä: We see LNG fuel as a strategic element of our on-going, future market activity. Diesel Tier 4 emissions rules

Tier 4 emissions rules for diesel engines that are now in place require exhaust after-treatment devices that come with increased cost and maintenance requirements as well as the use of ultra-low sulfur diesel fuel that is premium priced. Tier 4 rules apply to uses of diesel engines, on road, off road, and marine.

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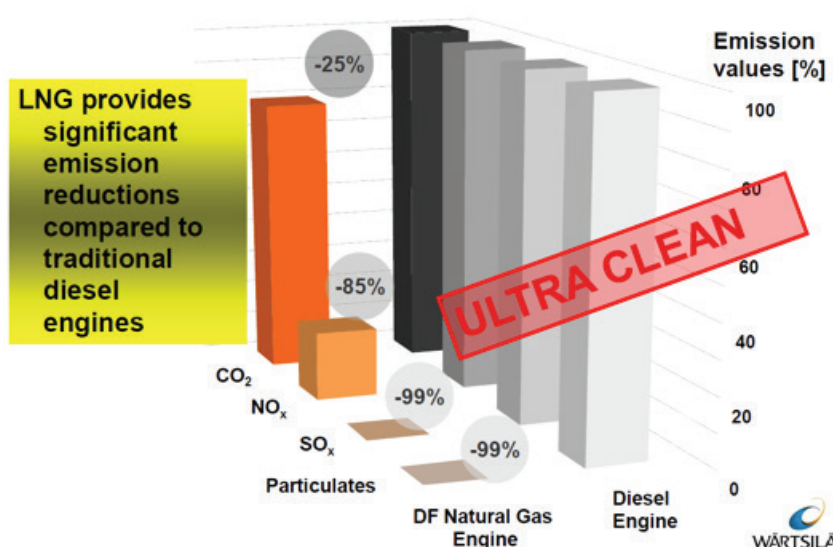


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Diesel Tier 4 after-treatment devices vary by manufacturer but include some combination of EGR or SCR to reduce formation of NO_x. SCR requires use of a liquid urea reagent called Diesel Exhaust Fluid (DEF) that must be refilled regularly. Some engines will also use diesel particulate filters that must be maintained.

LNG fuel beats all Tier 4 emission standards without the use of exhaust after-treatment devices. This simplifies engineering and reduces maintenance downtime.



FCBI: How are the Tier 4 diesel emissions rules impacting the use of LNG?

David Kailbourne, Rev LNG: There are two main issues with diesel, or the newer diesel truck Tier 4's since 2011. They are the added new diesel particulate filter as well as the regen urea system that are in the clean diesel trucks. We constantly speak with fleet owners, and we own twenty new diesel trucks ourselves. If you go and talk to fleet managers, they complain that the newest diesel trucks with Tier 4 controls are down for maintenance much longer than any other trucks in their fleet because of the additional equipment.

As such, they are looking to go to natural gas because the 100% spark ignited engine does not have the DPF or urea in them.

FCBI: So are you seeing the added maintenance as part of the decision making process now?

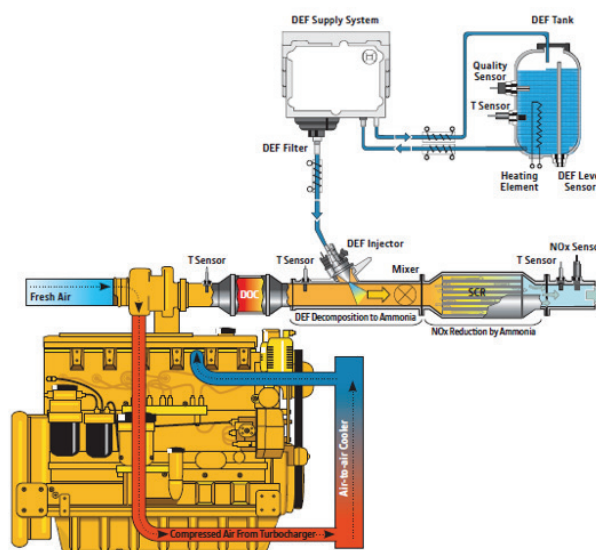
David Kailbourne, Rev LNG: I would say people have really started to recognize the maintenance issues over the last six months to a year because they've had enough time to look at the new Tier 4 emissions as well as their fleets. We constantly talk to fleet managers and it is something that comes up all the time. The diesel exhaust fluid and particulate filter required now on diesel trucks is costing them a ton of money because they are often out of service. That's why they are starting to look at LNG and CNG.

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Tier 4 diesel engine with SCR and DEF. graphic by John Deere.

FCBI: Are the fleet managers who are operating natural gas vehicles happy with the operational performance of the natural gas vehicles?

David Kailbourne, Rev LNG: If you talked to the president of our trucking division, or if you speak with other LNG fleet managers then I think they will tell you the same thing: the new Cummins 12 liter engine, which is 100% spark ignited, is a complete success. We have had almost zero downtime on those trucks since we purchased them earlier in 2014.

We just took delivery on eight brand-new 12 liters and we see absolutely zero issues with the natural gas engines. They are reliable and run as expected and compared to the diesel engines that we have to purchase, they are 100% better when it comes to out of service and downtime. And other fleet owners and managers that we speak to express the same thing.

There were some growing pains with the 16 liter engine a couple years ago, but the new 12 liter natural gas engines are a complete success. I think in a very short time in the future there could be an inflection point where fleet managers - if they had a choice and the price of the two types of fuel was exactly equal, would look to go to natural gas because they don't have those downtime issues.

Big opportunities exist in industry and virtual pipelines

LNG is being deployed on a temporary basis to industrial customers who want to mitigate seasonal price spikes in pipeline gas. Other small industrial customers, like farms with irrigation pumps or asphalt hot plants can burn through thousands of gallons of diesel fuel in a day and can be reliably converted to LNG with benefits of price stability, clean emissions, and quality engineering solutions.

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FCBI: Who are your industrial customers?

Sam Thigpen, TRF Energy: One is remote power generation where they want to burn natural gas on those sites for large power consumption from the portable generators. That's a big client for us. Mining is another application where we're seeing LNG is very feasible. The mining industry is still very much committed to looking at LNG fuelling solutions over diesel.

Additionally, power plants that use natural gas from a pipeline system in the area. When the pipeline system is overloaded and they see that there is a lack of supply available to their plant, then LNG is a good option for them to be vaporized and used as a kind of filler. This way they can keep their gas consumption where it needs to be.

We've deployed at a couple of different port terminals where they use natural gas in offloading or some process in the terminal. If a pipeline goes down for maintenance, from an outage standpoint we can throw in an LNG vaporizer and be a pipeline replacement and make a virtual pipeline, while their permanent pipeline is getting either installed or repaired.

There is a good case to be made for LNG in those types of businesses where the cost of the facility going down for a lack of gas supply far outweighs the cost of bringing in temporary fuelling solutions.

Ben Deal, LNG Energy: People get excited about exporting LNG, or powering a train, or powering a boat, but nobody thinks about an asphalt hot plant that burns 10,000 gallons a day, or an agriculture farm that has a bunch of irrigation pumps. Each one of those engines consumes an incredible amount of fuel. We are working in an area where the opportunities are just gigantic. Take our asphalt hot plant for example. EPA now understands that the existing fuel a lot of them use is waste oil, so they are burning dirty engine motor oil to run hot plants, or they're using diesel or propane, or natural gas if they are plugged into a natural gas pipeline.



An asphalt hot plant can burn 10-20,000 gallons of LNG per day

photo by Asphalt Education Partnership

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So the EPA has realized that one hot plant burns 10,000 gallons of LNG in a day or 6,000 gallons of diesel in a day and that is a significant amount of fuel. And you take a look at a taxicab, it burns 6,000 gallons a year or transit buses 10,000 gallons a year. We see they are burning more fuel in one day at a hot plant than these on-road applications during the full year. There are great opportunities in converting these types of facilities to LNG which can save operators money, improve air quality and operations at the same time.

David Kailbourne, Rev LNG: In LNG, the largest marketplace without a doubt is the HHP off-road marketplace. LNG for truck fleets is probably the lowest consumer that an LNG distributor looks to. LNG will be used anywhere that large quantities of propane or diesel are currently used today. By far the largest marketplace for LNG will be the marine sector. Every vessel that will be made in the US after 2017 will be a dual-fuel engine that is capable of burning LNG. The railroads are starting to adopt LNG as their fuel of choice in the tenders and will grow over the next decade.

There are extremely large amounts of opportunities for factories and other types of industries that are off-grid. They are currently using No. 4 or No. 6 oil or propane and so LNG has become a very economic and environmentally friendly choice for them.

A good case example is asphalt plants. Most in-situ asphalt plants already permanently in place use natural gas, but there are also a lot of asphalt plants that are mobile. When they are paving a road you move an asphalt plant three or four times a season. They use waste oil or they use propane as fuel. LNG can find a very large market here because an asphalt plant can use 10,000 of gallons of LNG a day.

Look at the University of Massachusetts at Amherst. That's a huge college campus and they are on traditional natural gas pipeline service. But in the winter months, the natural gas prices on the pipe are so expensive that they actually turn the natural gas pipe off and bring in LNG as a substitute to lower their fuel bill. You're looking at more and more colleges, more universities, hospitals and industry factories looking to do the same thing for peak winter season. But more and more of them are looking to do LNG just to get off that dirty No. 2, No. 4 or No. 6 oil which is some bad environmental quality stuff.

FCBI: Are supplies of LNG readily available at the moment?

Sam Thigpen, TRF Energy: I don't feel like we ever got to the point before the oil price dipped where we were really taxing the LNG supply here in the US. We've been able to get supplies pretty readily. Once the diesel price changes and LNG becomes economic again, the demand from just the E&P market alone could truly tax the current LNG supply. So we are still a firm believer in on-going development of LNG infrastructure because we believe that over time lack of infrastructure could be the bottleneck.

LNG equipment companies have stepped up over the past couple of years and really worked diligently to try to keep up with demand. I think that supply could be a bottleneck at some point in the future, but I don't think we're there yet. David Kailbourne, Rev LNG: We have agreements with every peak shaving merchant plant east of the Mississippi. And we have backup supply of LNG for customers, so there's no issue whatsoever in getting LNG to the marketplace that we deal with today. We've never had an issue at all.

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We are actually building the first LNG merchant plant in Towanda, Pennsylvania. That liquefaction facility will be operational in Q3 2015. It will produce 50,000 gallon per day LNG on a merchant basis.

It is much smaller than an LNG export plant that would make 1 million gallons per day. We are a skid mounted modular plant and so will produce liquid, we will also transport and dispense it to our customers. And typical on-road customers would be probably paying about \$2.50 DGE.

Ben Deal, LNG Energy: If there is one theme that I can provide you, it is that the off-road high horsepower market looking to utilize liquefied natural gas is liberated.

When I was at Clean Energy eight years ago we were always waiting for something, waiting for an engine, waiting for the Natural Gas Act, waiting for some policy to come in to play, we were always waiting on something. Today I am able to run as hard and as fast and talk to as many different people as I can, and I have all the tools in my tool belt that I need. So for me it is just about education, to educate these farmers, or growers, or an asphalt operator, or a mining operation that they can use natural gas and it is cheaper and it is cleaner and there's plenty of it available.

Conclusion

LNG retains decisive long term advantages over diesel and other competitive fuel options in the high horsepower marketplace, despite the recent collapse in price spreads. While most fuel consumers look to price first when determining fuel choice, other variables are also part of the equation such as fuel availability, engine performance and maintenance, conversion costs and compliance with environmental laws.

Diesel is a dirty fuel that has historically been a source of major pollution and public health problems. Efforts to improve the emissions impact of diesel fuel have reduced pollution but at the cost of increased technical complexity and engine maintenance. Tier 4 diesel engines require multiple components for exhaust after-treatment, as well as increased costs for ultra-low sulfur diesel and diesel exhaust fluids, whereas LNG does not. This means that LNG engines are simpler, require less maintenance and suffer less downtime. In addition, LNG has no sulfur in it and so it also beats the diesel emissions standards of today.

Natural gas engines are finally becoming mature and reliable, but in the near term the LNG market still suffers from some of the classic chicken and egg problem. LNG fuelling and distribution infrastructure is still in an early stage of development and while there is enough LNG to meet current demand, much more infrastructure will need to be built for LNG to reach its full promise. The maritime industry is a good example of the confluence between infrastructure development, emissions laws and fuel price. ECA laws have forced ships in US and European waters to turn to ultra-low sulfur diesel to meet compliance measures because there are very few LNG bunkering facilities available today. ULSD is an expensive fuel but it is widely available and with the recent drop in prices it is also more competitive. Ship owners may prefer LNG due its superior performance and reduced maintenance requirements, but until the bunkering facilities are available, ULSD will dominate. However, dual-fuel engines that can run on both LNG and ULSD will ease the transition.

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In the long run, the facts remain that methane is our most abundant fossil fuel and our most abundant renewable fuel. Methane is clean and helps lower carbon emissions compared to coal and petroleum. Oil markets are likely to continue to suffer from price volatility as international geopolitical events impact the markets while natural gas prices in North America are projected to remain low and stable for the foreseeable future.

The future for LNG remains as bright as ever. It will not be long before the public recognizes that LNG is an upgrade over diesel fuel, economically, technologically, and environmentally.

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