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Evaluation, Specification, Deployment and Maintenance Considerations for Natural Gas Powered Heavy-Duty Commercial Vehicles

Developed by the Technology & Maintenance Council's (TMC)
LNG/CNG Task Force

ABSTRACT

Natural gas fuels can be a suitable alternative to diesel fuel for commercial vehicles in certain environments and applications. However, it is best to understand all facets of the operation, discuss them both internally and with local vendors (where applicable), and to establish realistic return-on-investment targets up front. Taking the time to build a proper business case and understand all the variables that come into play will pay dividends in terms of ensuring a successful natural gas vehicles deployment that meets corporate financial, reliability and acceptance expectations.

INTRODUCTION

This information report was developed to help commercial fleet management determine whether natural gas powered vehicles are a viable option for a given operation. This document covers the process of evaluating, specifying, deploying and maintaining vehicles with engines using compressed or liquefied natural gas as a primary fuel.

Since 2007, the adoption of natural gas as a commercial vehicle fuel has increased. Despite increased aquisition costs, the positive return on investment and emissions reductions associated with natural gas adoption, as compared to diesel, have demonstrated this engine technology can be a reasonable alternative to diesel — particularly in refuse truck and transit bus operations.

Vehicle manufacturers' expanded offering of engines and truck platforms have been important to the adoption of natural gas in fleet operations other than refuse and transit applications; however, the main reason for this increased adoption is the reduction in fuel-related expense.

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BACKGROUND / CHALLENGES

Since the late 1980s, emissions standards for heavy-duty diesel engines have become progressively more stringent. In order to meet 2010 emissions requirements, new aftertreatment technologies including diesel particulate filters (DPFs), selective catalytic reduction (SCR) utilizing diesel exhaust fluid (DEF) have become commonplace. The resultant increased vehicle complexity, coupled with new training and diagnostics procedures, have prompted some fleets to explore natural gas as an alternatives to diesel.

Some of the challenges associated with transitioning a commercial fleet operation from diesel to natural gas include:

- adopting to new engine technology,
- developing natural gas vehicle specifications to perform the same tasks as diesel fueled vehicle,
- dealing with limited natural gas fueling infrastructure,
- implementing new/different maintenance practices,
- training drivers/technicians
- modifying existing vehicle maintenance facilities to accomodate natural gas vehicle service procedures.

PROCESS

Fleets have reportedly experienced varying degrees of success in switching from diesel to natural gas powered vehicles. Successful implementations have been the result developing a business case based on thorough analysis, planning, decisionmaking and execution.

Cultivating clear corporate strategy and executive level buy-in is essential for a project of this magnitude. The strategy may include components such as enhancing corporate image, improving environmental sustainability and carbon footprint, realizing greater fuel savings, and responding to customer requests.

Evaluation

The evaluation process can be segmented into two general phases:

1. Start by defining an internal team that is responsible for gathering facts, developing scopes and objectives (e.g., budgets, expectations/results, cost benefit analysis and timelines for completion, etc.), and implementing action plans. The team should consist of a team leader and team members with various backgrounds and from various areas of the organization. The team should evolve to include resources outside your organization to enable an objective evaluation and successfulnatural gas vehicle deployment, if recommended and approved.
2. Get familiar with the available natural gas technology. Understanding other early adopters' successes, challenges and lessons learned will make for a smoother and more successful implementation.

The following steps should be considered when evaluating natural gas vehicles applicability:

a. Determine which lanes / operating areas have the greatest potential for natural gas powered vehicles and rank them (from highest potential to lowest potential).

b. Identify natural gas fuel availability for the lanes / locations selected.

c. Approach CNG and LNG fuel vendors / distributors (local utilities and "truck stop" fueling distributors) about:
   - fueling site visit opportunities
   - onsite vs. offsite refueling (if onsite, be sure to include local gas and electric utilities)
   - future site development
   - fuel pricing based on expected purchasing volumes

d. Determine CNG and/or LNG usage (e.g., give special consideration for offsite fueled LNG vehicles subject to extended operational out-of-service periods).

e. Work with vehicle manufacturers and dealers to develop preliminary specifications and obtain preliminary pricing;
f. Understand available full-service-leased vehicles options;
g. Determine any natural gas vehicle grants or incentives applicable in the jurisdiction(s) these units will operate, as well as any grant caveats and restrictions.
h. Determine if there are any local jurisdiction additional weight allowances for natural gas vehicles for the routes in question (e.g., state highways vs. Interstate network).
i. Understand various local jurisdictions' tax calculations/payment methods for CNG/LNG and this will impact on your company's business case.
j. When developing the cost/benefit analysis, consider:
    - higher aquistion costs
    - available funding and grants to offset higher initial aquistion costs
    - fuel price differentials (as compared with diesel)
    - life-cycle mileage (e.g., generally speaking, the higher the mileage, the greater the fuel cost savings)
    - higher maintenance costs (e.g., additional preventive maintenance and inspection requirements)
    - additional weight impact on payload and revenue
    - changes in resale value
    - increased out-of-route miles and driver time for off/site fueling
    - added shop tooling and training costs (if applicable)
    - changes in maintenance operation. For example, will the maintenance be done in-house or outsourced? If done in-house, shop upgrading costs should be considered. If outsourced, is the outside vendor able to handle natural gas engines and perform warranty repairs?

Specifications

While natural gas vehicles are not fundamentally different from more diesel-fueled vehicles, developing specifications for natural gas vehicle specification should be approached with special consideration.

One fundamental factor is the inherent lower energy content of natural gas as compared with diesel. To provide a travel range comparable to diesel, natural gas vehicles will need to have larger tanks and alternative mounting locations. For power takeoff (PTO) applications, fuel tank frame positioning must take in consideration ancillary equipment frame space requirements.

Specifications will differ for CNG and LNG vehicles. In the case of CNG vehicles, vertically stacked CNG tanks minimize any impact on frame space. For LNG vehicles, the LNG tanks will require additional frame space. Depending on other frame-mounted equipment requirements, a longer wheelbase may be necessary. Any wheelbase changes should be analyzed to ensure optimal weight distribution and end-of-frame swing clearance is sufficient based on existing trailing fleet.

If the natural gas vehicle life cycle is shorter than that of existing diesel units, lighter drivetrain components should be considered. While the natural gas vehicle will always be heavier than similarly equipped diesel vehicles, spec'ing lighter components will reduce the overall weight impact.

Once the units are in service for one or two months, it is a best practice to collect download engine data for analysis and collect driver feedback on engine performance (low and top speed), startability and gradeability. Based on driver feedback and engine downloads, work with the local dealer to review and optimize any engine parameters that may positively impact fuel consumption or vehicle drivability.

If maintenance is performed in-house, purchasing natural gas engines extended warranties will minimize any potential costs not included/expected in the original cost-benefit analysis. Most natural gas engines offer a limited engine compression brake option (especially true for spark-ignited engines). Consider other options when operating in mountainous environments or when engine compression brake usage is anticipated.

Vehicle Maintenance

In addition to other regulatory or internally established preventive maintenance operations, natural gas vehicles have to comply with specific maintenance requirements that relate to the natural gas delivery system and/or CNG/LNG tanks. With spark-ignited engines, spark plugs are a maintenance item, and their replacement is critical to engine performance and reliability.

Oil drain intervals, valve lash adjustments and other regular maintenance intervals can differ from diesel engines. Since many natural gas vehicles run very specific applications, always work with the engine manufacturer to determine the best service intervals for the vehicle.

Natural gas engine oils have different detergent and dispersant properties than diesel engine oils; therefore, it is critical to use the appropriate engine oil for the application. The correct engine oil application is based upon the ignition source utilized in the engine, and not dependent on the type of natural gas utilized (CNG or LNG). Spark-ignited engines require the use of dedicated natural gas engine oil for highway applications. These typically have reduced detergent requirements and the sulfated ash is limited to 0.6 percent. Engines that utilize diesel fuel compression as the ignition source will utilize API CJ-4 engine oils. As a rule, natural gas engines have reduced soot output (compression ignited engines) / no soot output (spark-ignited engines).

Depending on the State and local jurisdiction requirements, additional maintenance and inspections are required. Always understand these requirements and include them in the initial cost benefit analysis.

Driver Training

Be sure to review driver training requirements and develop driver training programs with the support of the engine and truck manufacturers. Some considerations include:

- CNG/LNG fundamentals and safety features (e.g., fuel pressure gauge, supply pressure gauge, emergency shutoff valves functionality, etc.)
- Operating CNG/LNG units (e.g., what's the same and different from a diesel in terms of horsepower and torque variation, compression brake for spark-ignited engines, daily vehicle trip inspection requirements, daily fuel filter(s) draining, different natural gas oil requirements (for top-up), fuel economy rpm range, etc.
- Fueling the truck (e.g., slow fill or fast fill, depending on setup), temperature and pressure effect on the actual amount of fuel added to the tank, personal protection equipment to be used when refueling, LNG tanks venting process, etc.)

NOTE: While issues pertaining to LNG fuel quality are subsiding, there is potential to have fuel issues with different stations that have different ranges of fuel temperatures, saturated and unsaturated, which will directly affect performance and range. In the case of CNG, fuel quality and compressor oil contamination issues can affect engine performance, impact reliability and result in unplanned downtime. Always work with the local fuel provider to understand and find ways to eliminate these issues. The optimal ambient temperature for both slow and fast fill (CNG only) is around 70°F, which allows tank pressure to be around 3,600 psi. Delivery and onboard pressures will drop with ambient temperatures (typically 30°F temperatures will result in fueling pres-

sures being between 2,700 to 3,000 psi). While actual fueling times remain the same, the total onboard fuel capacity is reduced therefore reducing the vehicle range. Always work with the local fuel provider to understand and find ways to eliminate these issues.

- In-cab displays (e.g., differences in fuel gauge, methane sensor check, low fuel pressure lamp functionality)
- Emergency procedures (e.g., in case the vehicle sustained CNG / LNG fuel tank or fuel supply damage, or a gas leak is discovered)

Emergency Response

In the event of an emergency, drivers and maintenance personnel should be prepared to respond appropriately. The following response checklist provides some basic guidelines:

- Inform first responders about the pressurized tanks.
- Do not approach the vehicle if there is a fire or there are any ignition sources.
- Do not smoke near the vehicle.
- Apply the park brakes, turn off battery at main battery disconnect, and leave the vehicle doors open.
- Close any manual shutoff and cylinder valves.
- Check for leaks using smell, sight and sound.
- Keep people and traffic away from the area.

⚠ DANGER: CNG is odorized and can be detected by smell. However, LNG is not odorized and cannot be detected by smell.

⚠ DANGER: Residual gas may still continue to leak even after ignition is off and switch manual shut-off valves are closed.

Returning a CNG vehicle to service after a fire or a collision greater than five mph requires a CNG system inspection to be performed by a certified inspector.

MAKING THE BUSINESS CASE

Proper research of the technological, specification and training aspects of natural gas vehicles will enable fleet management to determine whether there is a viable business case for using this alternative fuel in its operation.

In developing this business case, be sure to consider:

- any capital requirements
- a timeline with milestones/deliverables
- available resources (e.g., vendors, suppliers, etc.)
- return on investment
- the probability of meeting expectations

The following websites offer return-on-investment calculators and workbooks to help decide whether using natural gas makes sense for a given application.

http://webcache.googleusercontent.com/search?q=cache:BfQ5Six7GgAJ:nccleantech.ncsu.edu/wp-content/uploads/Alternative-Fuel-Vehicle-Cost-Calulator-Sample1.xlsx+&cd=4&hl=en&ct=clnk&gl=us

http://www.westport.com/products/automotive/wingpowersystem/natural-gas/payback-calculator

http://www.cngfleetspecialists.com/roi-calculator

http://calc.actresearch.net/

GRANTS AND FINANCIAL INCENTIVES

The following information may help in understanding the basics grants and financial incentives:

a. Who Might Have Funding

- Federal Sources
  - Environmental Protection Agency (EPA)
    National Clean Diesel Campaign

- US Department of Energy
  ** Office of Energy Efficiency and Renewable Energy (development of clean/efficient vehicles)*
  ** Clean Cities Loan Programs*
- US Department of Transportation
  CMAQ—Congestion Mitigation and Air Quality funds
  FTA TIGGER Grants—Transit Investment for Greenhouse Gas and Energy Reduction for transportation agencies
  FHWA TIGER Grants—Transportation Investment Generating Economic Recovery infrastructure grants

- Sources of Grant Information
  - *www.epa.gov/cleandiesel*
  - *http://www.afdc.energy.gov/laws/matrix*
  - EPA regional offices
  - Clean Cities coalitions
  - Regional diesel collaborative
  - State clean air coalitions
  - State air quality or environmental agencies
  - Councils of Government
  - State Department of Transportation
  - State energy agency
  - NGVC: *www.ngvc.org*

b. Who Will Prepare and Submit Application(s)?
   - Company team
   - Outside source(s) with expertise

c. Post Award
   - Contracts and Compliance

CONCLUSION

Natural gas as a fuel source can be a suitable alternative to diesel fuel for commercial vehicles in certain environments and applications. However, it is best to understand all facets of the operation, discuss them both internally and with local vendors (where applicable), and to establish realistic return-on-investment targets up front. Taking the time to build a proper business case and understand all the variables that come into play will pay dividends in terms of ensuring a successful natural gas vehicles deployment that meets corporate financial, reliability and acceptance expectations.