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Report of the Alternative Fuel Vehicle Infrastructure Working Group

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V. Compressed Natural Gas Discussion and Recommendations

Oregonians rely on vehicles to deliver the essentials of our everyday life and to transport us to our jobs as well as for other vital activities. Without the transportation system, our economy would stop and our way of life would cease as we know it. Currently, we rely almost entirely on petroleum to fuel our transportation system. In 2008, the U.S. imported nearly 70 percent of our oil and Oregonians spent over $5 billion for gasoline and diesel. Most of this money left our state and a big portion left our country – often going to nations unfriendly to us. Unless we change course, these numbers will rise in the future, leaving the U.S. vulnerable to international pressures and bringing economic hardship to Oregon. The fact that the United States uses 25 percent of the world's oil, but has only 4 percent of the population and just 3 percent of the world's oil reserves, should be a call to action to diversify our transportation fuels.

Unfortunately, there is no one technology or alternative fuel that is going to replace petroleum. We have many options: natural gas, biofuels, propane, electric-based vehicles and hybrids of these technologies. We need to use all of these in applications where they make the most sense.

Compressed Natural Gas (CNG) technology is mature for both infrastructure and vehicles with promising improvements on the horizon. In most parts of the world, it is available as a transportation fuel today and use is growing. The economic advantage of CNG over gasoline has been steadily increasing as new technology to extract natural gas has created vast new recoverable reserves in the U.S.

The Working Group recognizes that CNG works best in fleet applications where vehicles return to base on a daily basis. For wider use, a network of publicly accessible CNG compressor stations would be required.

Background

New drilling technologies have unlocked new natural gas reserves from several sources such as shale, deep natural gas, coalbed methane and tight natural gas. These new technologies are now being employed around the globe to unlock sources once thought to be untouchable. The nation's reserves have surged by 35 percent recently, accounting for the largest increases in history. While we import nearly 70 percent of our oil, 98 percent of natural gas used in the U.S. comes from North America and by 2030, it is estimated that 98 percent will come from U.S. reserves alone. A recent study concluded that the U.S. has 118 years worth of natural gas resources at current production levels. Additionally, in 13 of the past 14 years, the amount of new natural gas discovered in the U.S. has exceeded the amount that has been extracted.

Renewable natural gas, or biomethane, is produced from organic sources, which starts out as biogas but is then cleaned up in a process called biogas to biomethane. Biomethane is naturally produced from organic materials as they decay. Sources of biomethane include landfills, waste water treatment systems, and any biomass material that is no longer living. Biomethane is also generated from animal operations where manure can be collected; the biomethane is generated from anaerobic digesters where the manure decomposes. Oregon currently has several operations converting biomethane to electricity. Because of biomethane's significant GHG emissions reductions, it is now being considered as a transportation fuel. Sweden has demonstrated the

potential of this fuel on a commercial scale in a real-world setting. Sweden estimates that biomethane could meet 10-15 percent of its transportation needs with current technology and could potentially meet 30 percent of its needs by 2030 with some technology advances. California and Sweden have signed agreements to advance the technology in California using landfill sites and waste water treatment facilities.

Natural gas extracted from th eearth comes in two options: Compressed Natural Gas and Liquefied Natural Gas. CNG is the most common option. CNG is usually compressed to 3600 PSI and can be used in applications from passenger vehicles to Class 8 tractor trailers.

Passenger vehicles can be dedicated (CNG only) or bi-fuel. Bi-fuel vehicles store both gasoline and CNG on board and can switch from CNG to gasoline automatically when CNG runs out. Ranges for CNG vehicles are typically the same as gasoline. However, most manufacturers have built CNG dedicated vehicles. There are over 50 manufacturers of CNG vehicles and over 150 models world wide, according to the Natural Gas Vehicle Institute. In addition there are 8.4 million CNG vehicles on the road with roughly 130,000 in the U.S.

Conversion and aftermarket companies have developed EPA approved conversion kits for vehicles but qualified vehicle models are limited at this time. New legislation proposed at the federal level would create new rules to allow EPA to simplify and streamline their certification process. Currently, the Federal EPA "certification" process for CNG conversion kits requires that each kit be certified for use on each vehicle and each model year of that vehicle. This is an expensive and time consuming process. EPA should certify engine and vehicle similar families rather than each engine or vehicle model to reduce time and costs to certify conversion kits. By simplifying this compliance process, we will not only incentivize conversion manufacturers to offer more systems for additional vehicle makes and models, but will eventually reduce the costs of these conversion systems.

LNG is liquefied natural gas and requires the fuel be stored at extremely low temperatures. LNG is specifically for the large Class 6-8 heavy vehicles. The advantage of LNG is that it densifies the fuel for easier storage and transport allowing vehicles more range. LNG is not part of the deployment strategy at this point.

Environmental Benefits

An Argonne National Laboratory report found that compared to gasoline powered light duty vehicles, CNG powered light duty vehicles reduced emissions of volatile organic compounds (VOCs) by 10 percent; carbon monoxide (CO) by 20-40 percent; NO_x by 0 percent, and particulate matter (PM) by 80 percent. For the last five years, the Honda GX, a CNG powered vehicle, has been declared to be the cleanest vehicle offered for sale in the U.S.

Natural gas use in heavy duty vehicles had even better results. A study completed by the National Renewable Energy Laboratory and the University of West Virginia studied numerous fleets and assessed their emissions. Fleets were assessed based on the vehicles drive cycles. As an example a transit bus with a city/suburban heavy vehicle route netted a 95 percent reduction in PM, 49 percent reduction in NO_x and a CO reduction of 75 percent compared to their petroleum diesel equivalents. According to NGVAmerica, natural gas vehicles produce between 93-95 percent less overall toxics compared with diesel and gasoline fuel vehicles. Converting one refuse truck from diesel to natural gas

is the equivalent of taking as many as 325 cars off the road in terms of pollution reduction. Areas such as Salt Lake City and the Los Angeles Basin have long used CNG to clean up air sheds.

The chart below illustrates the reductions in emissions compared to other fossil fuels.

Fossil Fuel Emission Levels - Pounds per Billion Btu of Energy Input

Pollutant	Natural Gas	Oil	Coal
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	0.000	0.007	0.016

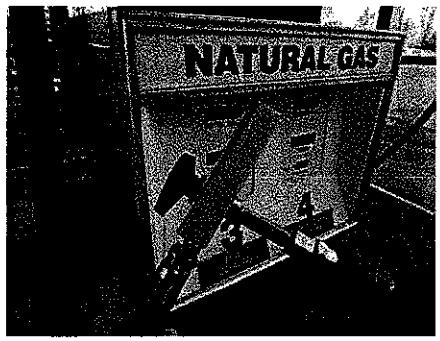
Source: EIA - Natural Gas Issues and Trends 1998

Natural Gas GHG Emission Reductions

Natural gas is comprised mostly of methane, a very simple molecule. The methane molecule consists of 1 carbon atom and 4 hydrogen atoms. When combusted in a spark-ignited engine, methane produces 20-29 percent less CO_2 emissions than gasoline or diesel.

As we did in the biofuels section, this report will reference the California Air Resources Board (CARB) reports for fuel pathways for California's low carbon fuel standard. This is not an endorsement of their numbers but only used as a reference. Numbers include a full life-cycle analysis (LCA) as explained in the biofuels section. However, indirect emissions are not considered as California deemed them insignificant for the fuels mentioned below except for CaRFG, which contains 9.4 percent ethanol. This ethanol percentage does include indirect land use emissions.

As mentioned above, California reformulated gasoline includes 9.4 percent ethanol. When a complete LCA was performed by CARB on both the petroleum and ethanol parts of the fuel a carbon intensity of 95.85 gCO_2e/MJ was arrived at. The LCA pathway for CNG was calculated at 68 gCO_2e/MJ. Adopters of light duty CNG vehicles would realize a 29 percent reduction in GHG.



The carbon intensity of Ultra Low Sulfur Diesel (ULSD) is 94.71 gCO_2e/MJ. This reduction from CaRFG is partly due to the higher energy density of diesel fuel. When compared to CNG a reduction of 28 percent of GHG emissions can be realized. These are significant reductions with technology available today.

Two biomethane pathways have been explored by CARB for their LCFS. Although technically these fuels could have been considered in the biofuels section we look at them here as the same technology is used for the vehicles and refueling infrastructure as CNG. Digester gas originated from dairies are rated at 13.45 gCO_2e/MJ and landfill gas came in at 11.26 gCO_2e/MJ. Of all the alternative fuels these are the cleanest when considering GHG emissions.

The following table is based on CARB assumptions

CaRFG	95.85 gCO_2e/MJ
ULSD	94.71 gCO_2e/MJ
CNG	68 gCO_2e/MJ
Dairy Digester Gas	13.45 gCO_2e/MJ
Landfill Gas	11.26 gCO_2e/MJ

Barriers

Natural gas vehicle technology has been available and used in most regions of the world for decades. Many recognize the economic, environmental and national security benefits of using natural gas technology. However, a lack of refueling infrastructure has caused natural gas vehicle demand to stagnate in many regions. In regions where natural gas vehicles (NGVs) have a strong market share, adoption is predominately due to a combination of inexpensive natural gas, a large number of public accessible refueling stations, favorable government policy and government incentives for vehicles, fuel and infrastructure.

CNG infrastructure is the barrier to market adoption of CNG vehicles. A metropolitan network of compressors and dispensers with card lock public access are required to give consumers options for refueling CNG vehicles. Investors are reluctant to pursue these opportunities without guaranteed markets developing. Consumers are reluctant to pursue home refueling appliances due to initial cost and lack of locations to refill their vehicles away from home.

Capital expense for a large fleet CNG system (including compression, storage and card lock dispensers) can cost $500,000 - $1 million, depending on the amount of fuel needed at any given time, with diesel displacement ranging from .5 to 1 million gallons annually. The highest cost-to-benefit ratio is seen in large fleets that return to base, such as buses, waste haulers, taxi cabs, distributors, delivery vehicles and some corporate fleets. These captive fleets are the key and basis to deployment of CNG infrastructure.

Oregon CNG Refueling Infrastructure

Oregon currently has existing CNG refueling infrastructure along the I-5 corridor, however, almost all of it is not accessible to the general public or private fleets. In the Medford region, Jackson County and Rogue Valley Transit District (RVTD) have CNG compressors. But refueling the CNG tanks is a slow process; it takes about 45 minutes to fill a bus. RVTD and Jackson County hope to build a regional fueling station in White City that would use modern fast fill technology. The two fueling stations are Jackson County's downtown pump and RVTD's pump on Crater Lake Avenue, the only public CNG in Oregon. Recently the city of Medford received a CMAQ grant to purchase a CNG powered street sweeper. The local natural gas provider, Avista, also has a CNG powered fleet with refueling capabilities but are unable to allow public refueling due to Public Utility Commission rules.

From the Medford region north, there is not any infrastructure until Springfield near Eugene. The Springfield facility is part of the state of Oregon's Department of Administrative Services (DAS) Motor Pool. The motor pool was shut down due to budget cuts recently, however the fueling systems are still operational and OSU is renting the facility for its motor pool needs. Salem has two compressor stations, one at the DAS Motor Pool and the other at the Salem Keizer Transit Districts facility. The state facility is closed to public refueling by statute. On special occasions, the transit facility has made arrangements with outside customers as an enroute stop but do not offer public refueling.

The Portland area has a state DAS facility operating as a card lock, however the motor pool site has been closed due to budget cuts. The Port of Portland has a compressor to refuel buses and other equipment but does not have the capability to offer public refueling at this time. NW Natural has some refueling capabilities but they are not suitable for public access and they have the same limitation as Avista in offering public refueling.

Deployment Strategy

Washington and California are developing CNG use. Oregon should deploy a strategy to put publicly accessible CNG refueling infrastructure along the I-5 corridor and work with neighboring states to complete a CNG corridor for the West Coast of the U.S. Our existing infrastructure and policies are inadequate to make this a reality. The existing infrastructure should be upgraded where needed and new infrastructure added. Policies should be enacted to allow public use and to encourage fleet and public use of CNG technologies.

Economic benefits of CNG over gasoline or diesel are highest in enterprises with return to base fleets. Fixed costs for these fleets are the capital costs for on site compression and incremental costs for fleet conversion. The higher the volume of gasoline or diesel displaced, the greater the return on investment for the enterprise. With incentives, large fleets can achieve acceptable paybacks for their investments in CNG. With public support of "outside the fence" public card lock dispensers, the upfront cost of infrastructure can be reduced.

A CNG advisory committee should be formed to make an assessment of our current infrastructure and what is needed to move forward. Up to this point, regions have acted on independently. Forming a statewide group could help advance CNG technology in the state of Oregon.

Technology

Natural gas is stored on board vehicles in specially designed and rated pressure vessels. CNG is safe and easy to dispense. It has physical properties which are lighter than air, meaning that rare leaks are easily dispersed and do not present an ignition potential like gasoline. CNG has a very high ignition temperature and very specific air to fuel ratios for combustion. CNG works with the common spark ignited internal combustion engine and can be easily adapted to hybrid technology for even higher operational savings. It is conceivable that the EV market will use some form of CNG for range enhancement and to increase flexibility of vehicles either with an internal combustion engine or fuel cell.

Conversion kits including control modules, valves, fittings and tanks have been available for decades. Original Equipment Manufacturer options for CNG have also been available for decades with deep market penetration in Europe, Asia and the Middle East. It is estimated that there are 8.4 million CNG vehicles worldwide.

There are fewer than 400 registered CNG vehicles in Oregon and currently the state of Oregon motor pool has the largest fleet of CNG vehicles. This fleet has provided economic and environmental benefits to the taxpayers of Oregon. Salem Area Transit, the Port of Portland and Rogue Valley Transit employ large stations to fuel and operate public transit buses with the same economic and environmental benefits.

The basic components for CNG infrastructure include: compressors, storage vessels, dispensers and card locks. Typically these stations are unattended. Refueling is typically less than 1 minute per gasoline gallon equivalent. These components are readily available today.

Policy

The state of Oregon has long supported the CNG market through the Business Energy Tax Credit program (Alternate Fuel Infrastructure tax credit). This tax credit is for the incremental cost of CNG vehicles and a 35 percent tax credit for refueling infrastructure.

There are federal tax credits on both vehicles and infrastructure and an alternate fuel tax credit on the fuel itself, however, the credits for the fuel have expired and the infrastructure and vehicle credits will sunset after December 31, 2010.

Legislation is being proposed in Congress (NAT GAS ACT) to increase both the amount of and sunset of federal tax benefits.

Recommendations

These reccommendations focus on compressed natural gas.

Implement and support a Low Carbon Fuel Standard (LCFS). This will encourage use of CNG technology and further advance biomethane technology.

Support and endorse extension of the federal Alternative Fuel Tax Credit and the Alternative Fuel Motor Vehicle Tax Credit as well as expand and extend the Alternative Fuel Infrastructure credit. The current fuel credit expired 12/31/2009 and the vehicle and infrastructure credits will expire 12/31/2010. Additionally, the state should support bills that would simplify and streamline the EPA process for certifying CNG conversion kits. There are currently two bills in congress to extent these credits and streamline the EPA certification process for conversion kits. Outreach and lobbying from groups such as the Western Governor's Association and NGVAmerica should be supported.

Support Oregon's existing Business Energy Tax Credit and Residential Energy Tax Credit programs to continue to provide important incentives for natural gas vehicles and infrastructure.

Model other states' programs for utility rate based treatment of CNG compression, storage and dispensing of CNG to general public.

Connect the I-5 corridor with CNG infrastructure accessible to the public. Both Washington and California have substantial numbers of CNG vehicles; we recommend Oregon ensure adequate CNG infrastructure along its section of I-5. Open state, public and utility CNG dispensers to the general public for purchase of CNG until adequate private investment is made.

Encourage municipalities to require its refuse collection contractors to use compressed natural gas (CNG) trucks.

Encourage TriMet and all transit throughout Oregon to use alternative fuels such as CNG.

Establish a statewide CNG advisory committee to assess our current infrastructure and make recommendations for moving forward.