OPTION 2D
COMPRESSED NATURAL GAS FOR LIGHT-DUTY VEHICLES

Summary

In this option the staff evaluates the cost-benefit potential of compressed natural gas (CNG) light-duty vehicles in comparison to average gasoline vehicles.

The National Energy Policy Act of 1990 requires certain energy providers and government fleets to purchase alternative fuel vehicles (AFV). When buying new vehicles, these fleets must currently buy 75 percent of them from alternative fuel vehicle offerings. CNG vehicles would satisfy the federal AFV requirement.

Status

CNG vehicles are commercially available in limited quantities and vehicle models. While over 400 models of gasoline vehicles are offered for sale in model year 2005, only 5 models of CNG vehicles are available. Table 1 provides examples of light-duty CNG vehicles that are currently available or have recently been commercially available.[1] Over the last five years approximately 4,000 light-duty CNG vehicles were sold annually to fleet operators and private consumers in California.[2]

A number of market barriers continue to limit the penetration of CNG vehicles in California's population of light-duty vehicles. A CNG vehicle typically has reduced driving range compared to a gasoline vehicle. The relatively sparse availability of CNG refueling infrastructure accessible to the public, compared to petroleum fuels, further discourages private vehicle ownership.

To overcome the limited public fueling infrastructure, Honda recently began offering an optional home refueling system for their CNG vehicles for approximately $2,000.[3] Alternatively, the system may be leased by the homeowner from the automobile dealership at a monthly cost estimated to be in the range of $34 to $79, depending on the availability of state and local incentives. For homes with existing natural gas delivery, the refueling system has an installation cost estimated to be in the range of $500 to $1,500.[4]

Additionally, relatively low vehicle sales result in higher unit costs for CNG vehicles compared to gasoline vehicles. Fuel tanks capable of high pressure gas storage add significantly to incremental vehicle cost for CNG. These factors also reduce the number of CNG vehicle models offered by manufacturers.

Table 1. Recent Models of Light-Duty CNG Vehicles

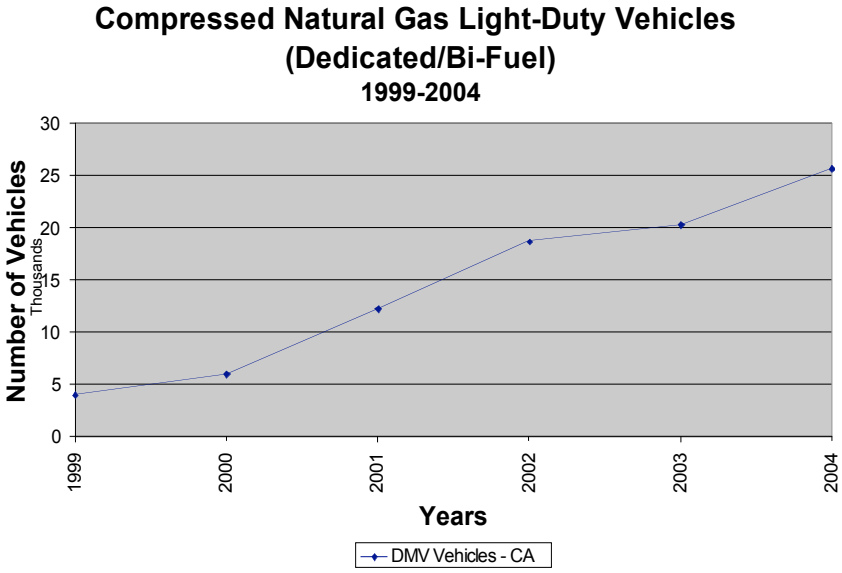
Maker	CNG Vehicle	Engine Displacement	Type of Natural Gas Engine
Current Light-Duty Vehicles Available			
GM	♦ C2500 Silverado 2WD ♦ K2500 HD Silverado 4WD ♦ C2500 HD Sierra 2WD ♦ K2500 HD Sierra 4WD	6.0 Liter V8	Dedicated CNG
Honda	♦ Civic GX	1.7 Liter L4	Dedicated CNG
Discontinued Light-Duty Vehicles			
Acura	♦ MDX SUV	3.5 Liter V6	Dedicated CNG
Daimler-Chrysler	♦ R-am Van / Wagon 2500 ♦ Ram Van / Wagon 3500	5.2 Liter V8	Dedicated CNG
Ford	♦ Crown Victoria Sedan	4.6 Liter V8	Dedicated CNG
Ford	♦ F-Series Light Duty Pickup	5.4 Liter V8	Bi-Fuel CNG / Gasoline
Ford	♦ Econoline E-450 Cut Away ♦ Econoline Van / Wagon ♦ F-Series Light Duty Pickup	5.4 Liter V8	Dedicated CNG
GM	♦ Express / Savana	5.7 Liter V8	Bi-Fuel CNG / Gasoline
GM	♦ Chevy Cavalier Sedan	2.2 Liter L4	Bi-Fuel CNG / Gasoline
Toyota	♦ Camry Sedan	2.2 Liter L4	Dedicated CNG

Assumptions

The staff assumed that a home refueling device is available and manufacturers increase production of CNG vehicle models, compared to our base case. Consistent with other options, CNG light-duty vehicles displace gasoline light-duty vehicles that average 22.7 miles per gallon.[5]

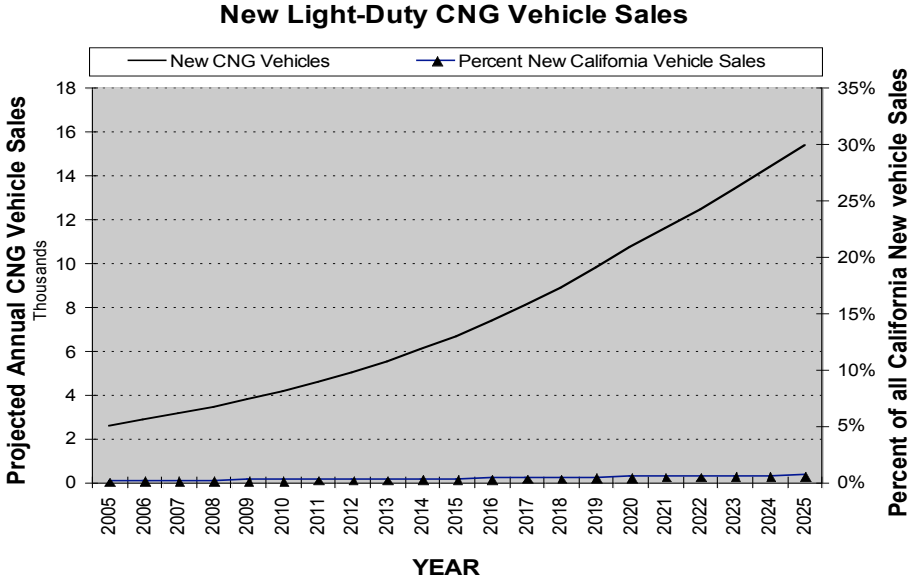
Light-duty CNG vehicles appear to be market-ready at this time. The staff believes CNG vehicles will penetrate the gasoline vehicle market if fuel and other operational savings offset their more costly vehicle purchase prices. To date, this has not been the case and sales have been limited. Over the past five years, annual light-duty CNG vehicles sales have increased approximately 50 percent each year. The Chart 1 illustrates the annual sales rate and the cumulative CNG vehicle population over the past five years.[6]

Chart 1



However, due to the discontinuation of their CNG vehicle lines by various vehicle manufacturers, the staff assumes a 10 percent annual increase in light-duty CNG vehicles sales through 2025 (Chart 2). This rate of increase is dependent on many variables such as the price and availability of natural gas fuel and future light-duty CNG offerings from vehicle manufacturers.

Chart 2



The staff assumed that incremental costs of light-duty CNG vehicles are reduced from today's $4,500 to $6,025 per vehicle to a lower range due to economies of scale.[7] Staff assumed average incremental costs of $2,500 to $5,000 per vehicle. In a full market driven scenario, where significant numbers of CNG vehicle sales occur, the incremental costs would be zero. The incremental cost includes on-board storage tanks that are estimated to cost $1,000 to $1,500.

Because of the limited range associated with CNG vehicles, the staff assumed the need for a home refueling unit (previously described). This unit requires 800 watts of electrical power and will deliver natural gas at a fill rate of 0.42 gasoline gallon equivalent per hour.[8] The Civic GX has a fuel capacity of 8 gallons gasoline equivalent (at a pressure of 3,600 pounds per square inch, gauge).[9]

Petroleum Reduction

Based upon the 10 percent CNG light-duty vehicle penetration rate assumed for the Fuel Substitution options, the amount of gasoline reduction produced by this option is shown in Table 2a and Table 2b. The California Air Resources Board (CARB) adopted a greenhouse gas (GHG) emissions standard for light-duty vehicles [AB 1493 (Pavley), Chapter 200, Statutes of 2002]. The GHG emissions standard requires reductions of GHG equivalent emissions beginning in 2009. The standard is currently in litigation. Scenarios were performed with and without the CARB GHG emissions standard in place. Results for all light-duty CNG vehicles available for model year 2005 (GMC Truck/Van, Honda Civic) are shown in Table 2a. Results for the CHG Honda Civic GX are shown separately in Table 2b.

Table 2a. Average Petroleum Reduction and Direct Non-Environmental Benefits for CNG Light-Duty Vehicles

Assumption of a 10% annual CNG light-duty vehicle penetration	Average Conventional Fuel Displaced (millions gallons)	Average Consumer Savings Discount rate (million $) 12%	5%	Average Change in Gov't Revenue Discount rate (million $) 12%	5%
2005 to 2010					
With GHG Standard					
• Low Fuel Price	63.19	($46.97)	($70.06)	($4.55)	($6.78)
• Very High Fuel Price	63.19	($46.97)	($70.06)	($4.55)	($6.78)
Without GHG Standard					
• Low Fuel Price	63.19	($46.97)	($70.06)	($4.55)	($6.78)
• Very High Fuel Price	63.19	($46.97	($70.06)	($4.55)	($6.78)
2005 to 2020					
With GHG Standard					
• Low Fuel Price	418.94	($154.08)	($329.02)	($15.26)	($32.77)
• Very High Fuel Price	418.94	($154.08)	($329.02)	($15.26)	($32.77)
Without GHG Standard					
• Low Fuel Price	418.94	($154.08)	($329.02)	($15.26)	($32.77)
• Very High Fuel Price	418.94	($154.08)	($329.02)	($15.26)	($32.77)
2005 to 2025					
With GHG Standard					
• Low Fuel Price	770.25	($200.39)	($508.66)	($19.97)	($51.06)
• Very High Fuel Price	770.25	($200.39)	($508.66)	($19.97)	($51.06)
Without GHG Standard					
• Low Fuel Price	770.25	($200.39)	($508.66)	($19.97)	($51.06)
• Very High Fuel Price	770.25	($200.39)	($508.66)	($19.97)	($51.06)

Table 2b. Average Petroleum Reduction and Direct Non-Environmental Benefits for Honda Civic GX CNG Vehicle

Assumption of a 10% annual CNG light-duty vehicle penetration	Average Conventional Fuel Displaced (millions gallons)	Average Consumer Savings Discount rate (million $)		Average Change in Gov't Revenue Discount rate (million $)	
		12%	5%	12%	5%
2005 to 2010					
With GHG Standard					
• Low Fuel Price	30.23	($43.01)	($64.01)	($2.59)	($3.85)
• Very High Fuel Price	30.23	($22.88)	($34.05)	($2.59)	($3.85)
Without GHG Standard					
• Low Fuel Price	30.23	($43.01)	($61.54)	($2.59)	($3.85)
• Very High Fuel Price	30.23	($22.88)	($32.75)	($2.59)	($3.85)
2005 to 2020					
With GHG Standard					
• Low Fuel Price	180.96	($128.06)	($267.87)	($8.00)	($16.91)
• Very High Fuel Price	180.96	($68.29)	($142.94)	($8.00)	($16.91)
Without GHG					
• Low Fuel Price	180.96	($128.06)	($267.87)	($8.00)	($16.91)
• Very High Fuel Price	180.96	($68.29)	($142.94)	($8.00)	($16.91)
2005 to 2025					
With GHG Standard					
• Low Fuel Price	324.60	($163.09)	($403.76)	($10.28)	($25.75)
• Very High Fuel Price	324.60	($87.02)	($215.60)	($10.28)	($25.75)
Without GHG Standard					
• Low Fuel Price	324.60	($163.09)	($403.76)	($10.28)	($25.75)
• Very High Fuel Price	324.60	($87.02)	($215.60)	($10.28)	($25.75)

Because the projected non-environmental benefit is negative, consumers choosing a CNG vehicle must find or accept additional benefits to make such a purchase worthwhile. When environmental net benefits and the external cost of petroleum dependency are included in the overall net benefit value, the final cost-benefit result is more competitive with the comparison gasoline vehicle. Nevertheless, the final result implies that an implementation strategy that offsets the negative consumer benefit would have to be developed if the estimated gasoline reduction is to be achieved. The strategy would have to provide additional positive consumer benefits, sufficient in magnitude to at least make the direct non-environmental benefit neutral. Table 3a and Table 3b numerate the direct benefits from 2005 model year CNG Light-Duty Vehicles (GMC truck/van and Honda Civic GX) combined and Honda Civic GX separately.

Table 3a. Petroleum Reduction and Benefits for CNG Light-Duty Vehicles

Petroleum Reduction and Benefits for Selected Alternative Fuel Scenarios							
Alternative Fuel Option or Scenario	Displacement in 2025, billion gallon gasoline equivalent	Reduction from Base Case Demand, percent	Highest Cumulative Benefit or Change, Present Value, 2005-2025, 5% discount rate, Billion $2005				
			A	B	C	D	A+B+C+D
			Direct Non-Environmental Benefit	Change in Government Revenue	Direct Environmental Net Benefit	External Cost of Petroleum Dependency	Direct Net Benefit
2005 Model Year CNG Light-Duty Vehicles							
2025 Low Petroleum Fuel Price w/GHG Standard	.08262	0.39	($623.25)	($51.06)	(0.007)	0.016	(674.36)
2025 Highest Petroleum Fuel Price w/GHG Standard	.08262	.056	($394.08)	$51.06)	(0.001)	0.016	(445.13)
2005 Honda GX CNG Vehicle:							
2025 Low Petroleum Fuel Price w/GHG Standard	.03378	0.16	($403.76)	($25.75)	0.003	0.015	(429.49)
2025 Highest Petroleum Fuel Price w/GHG Standard	.03378	0.23	($215.60)	($25.75)	0.003	0.015	(241.37)

Table 3b. Petroleum Reduction and Benefits for CNG Light-Duty Vehicles

Petroleum Reduction and Benefits for Selected Alternative Fuel Scenarios							
Alternative Fuel Option or Scenario	Displacement in 2025, billion gallon gasoline equivalent	Reduction from Base Case Demand, percent	Highest Cumulative Benefit or Change, Present Value, 2005-2025, 12% discount rate, Billion $2005				
			A	B	C	D	A+B+C+D
			Direct Non-Environmental Benefit	Change in Government Revenue	Direct Environmental Net Benefit	External Cost of Petroleum Dependency	Direct Net Benefit
2005 Model Year CNG Light-Duty Vehicles							
2025 Low Petroleum Fuel Price w/GHG Standard	.08262	0.39	($245.68)	($19.97)	(0.007)	0.016	(265.64)
2025 Highest Petroleum Fuel Price w/GHG Standard	.08262	.056	($155.09)	$19.95)	(0.007)	0.016	(175.03)
2005 Honda GX CNG Vehicle:							
2025 Low Petroleum Fuel Price w/GHG Standard	.03378	0.16	($163.09)	($10.28)	0.003	0.015	(173.35)
2025 Highest Petroleum Fuel Price w/GHG Standard	.03378	0.23	($87.02)	($10.28)	0.003	0.015	(97.28)

Key Drivers and Uncertainties

Below are the key uncertainties in this analysis:

- The number of vehicles that consumers would purchase given that CNG vehicles have a reduced range and a higher incremental cost compared to conventional gasoline powered vehicles.

- To what extent consumers would consider the benefits of a home-refueling device due to the additional cost added to the already higher incremental cost of the vehicle. The home refueling device is less of an issue for the GMC

trucks and vans since their use appears to be in a fleet application where central fueling would occur.

- The cost of large quantities of CNG stations necessary to support a significant increase of natural gas vehicles.

- Manufacturer interest in producing additional numbers of CNG vehicles.

Endnotes

[1] "Fuel Economy Guide 2000-2005," www.fueleconomy.gov, (April 10, 2005).

[2] DMV Vehicle Information, 8/26/04 Cenzer gaseous vehicle.

[3] "Honda And Fuel Maker Strengthen Alliance to Make Natural Gas Vehicle Home Refueling a Reality," 2004, http://automobiles.honda.com/info/news/article.asp?ArticleID=2004090950646, (April 10 2005).

[4]Dee-Ann Durbin, Associated Press, "Honda offers retail natural gas vehicle," Sacramento Bee, April 21, 2005; http://www.sacbee.com/24hour/autos/story/2332079p-10554243c.html

[5] Average fuel economy of the following (Fuel Economy Guide 2004-2005) gasoline vehicles that have a CNG counterpart:
`05 Honda Civic HX City: 35 MPG Hwy: 40 MPG Average=37.09
`05 Chevy Silverado/GMC Sierra 2500 City: 16 MPG Hwy: 20 MPG Average=17.58
`05 Chevy Express/GMC Savana Van City: 15 MPG Hwy: 19 MPG Average=16.57
`04 Crown Victoria City: 17 MPG Hwy: 25 MPG Average=19.86
Overall average=22.77
The EPA Fuel Economy Guide assumes driving at 55 percent city and 45 percent highway.

[6] DMV Vehicle Information, "8/26/04 Cenzer gaseous vehicle."

[7] Economies of scale occur within a firm when mass producing a good results in lower average cost *(internal economies of scale)* or within an industry *(external economies of scale)* as a result of improved logistics with skilled labor, parts, services and, transportation.

[8] Fuelmaker Corportation, *Phill-Fuel Your Car at Home,* April 26, 2005; http://www.myphill.com/faq.htm.

[9]American Honda Motor Company, 2005 Civic GX NGV, April 26, 2005; http://automobiles.honda.com/models/specifications_full_specs.asp?ModelName=Civic+GX&Category=3.