

**A Review and Evaluation of  
“Analysis of Alternative Fuel Options for  
Fleets” -- A Study Performed by Energy  
and Environmental Analysis, Inc.  
for the City of Phoenix, Arizona.**

**Prepared by the  
Clean Vehicle Education Foundation**



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## INTRODUCTION

The Clean Vehicle Education Foundation (CVEF) is a non-profit [501(c)(3)] technology research and education organization. CVEF's mission is to advance the research, development, demonstration and deployment of clean fuel-powered vehicles and to increase public awareness of the benefits of these vehicles.

In December 2005, the CVEF was contracted by Clean Energy® of Seal Beach, California to review and evaluate a study titled "Analysis of Alternative Fuel Options for Fleets," performed for the City of Phoenix, Arizona by Energy and Environmental Analysis, Inc., ("EEA"), a consulting firm in Arlington, Virginia. The study purports to examine the costs and benefits of available alternative fuel vehicle (AFV) options and makes recommendations to the City of Phoenix to help them respond to the changing alternative fuels market. CVEF was asked to perform a comprehensive review and evaluation of the data and assumptions used by EEA to determine the validity of the report's findings and recommendations with respect to natural gas vehicles (NGVs). This report is the result of that evaluation.

## OVERALL FINDINGS

The CVEF has concluded that EEA's "Analysis of Alternative Fuel Options for Fleets" includes serious errors and omissions that undermine the validity of many of its findings, calling into question many of its recommendations. CVEF finds that the errors and omissions do not appear to be random, but rather systematically skew the EEA analysis and recommendations *against* the natural gas vehicle option and *toward* the petroleum (gasoline/diesel) option. The most serious flaws in the analysis include the following:

- 1) EEA does not appear to have considered significant upcoming changes in national heavy-duty engine emission and fuel standards that are likely to substantially increase the cost of purchasing, operating and maintaining diesel vehicles beginning with MY 2007 vehicles.
- 2) The EEA analysis fails to recognize that a new generation of stoichiometric heavy-duty natural gas engines with greater efficiency and lower life-cycle costs are entering the market.
- 3) The EEA analysis fails to consider significant financial incentives for the purchase and use of natural gas vehicles and installation of natural gas fueling infrastructure provided by The Energy Policy Act of 2005 and the Highway Act (titled the "Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users"), signed into law in August of 2005. These incentives are directly applicable to the City of Phoenix, yet nowhere in the EEA analysis are they mentioned.
- 4) Much of the data apparently relied upon by EEA -- including technology, price emission and performance information -- are outdated and no longer reliable. Such "backward-looking" data are not appropriate for use in any future decision-making.
- 5) EEA's analysis is based on price projections that are unrealistic. EEA assumes much lower future petroleum prices and much higher natural gas prices than any of the major current forecasts.

Relying on incomplete information and faulty data, EEA concludes that, in the future, gasoline and diesel vehicles will be less costly and provide comparable or better emissions than natural



gas vehicles. When the errors and omissions made by EEA are corrected and properly accounted for, CVEF reaches the opposite conclusion: that natural gas vehicles will continue to be less costly and provide better emission performance than both gasoline and diesel vehicles. **Specifically, CVEF concludes that: (1) light-duty natural gas pickup trucks will have a 4.9 percent *advantage* rather than the 18.0 percent *penalty* forecast by EEA; and (2) heavy-duty natural gas buses will have a 20.5 percent *advantage* rather than the 18.2 percent *penalty* forecast by EEA.**

Considering the serious infirmities of the EEA analysis, CVEF concludes that, the proposed recommendations, if followed, would cost the City of Phoenix significantly more money for substantially less emissions reductions. Therefore, CVEF would advise the City of Phoenix *not* to make policy or purchasing decisions based on EEA's findings and recommendations.

## DETAILED REVIEW

The following is a page-by-page review of the EEA's report "Analysis of Alternative Fuel Options for Fleets." Where CVEF's analyses, findings or conclusions differ from those of EEA, references are provided. It should also be noted that assertions made by EEA in its report are generally undocumented, making it difficult, if not impossible, to ascertain and verify specific data sources upon which EEA might have relied. Many of the points addressed below are significant; while some are of minor importance.

### 1. INTRODUCTION

**Page 1: Introduction:** EEA states: "For the 2005 model year, the only natural gas original equipment manufacturer (OEM) vehicles available are two light-duty truck models, one small sedan, and several models of transit buses."

This is an incorrect statement that EEA repeats throughout the report. As shown in Appendix 1, a much wider selection of light- and light-medium-duty NGVs were available in 2005 than the models listed by EEA. In addition, medium/heavy-duty engines are available in scores of refuse trucks, street sweepers, heavy-duty work trucks, school buses, shuttle buses/vans and other medium- and heavy-duty vehicles.

**Page 2: Introduction:** EEA states: "To address these changing data, the cost benefit analysis examines the relative cost differences between different approaches, **which will remain generally accurate, even as the actual fuel or vehicle prices change.**" [Emphasis added]

This assertion is incorrect. For example, as discussed further below, EEA failed to include substantial new federal financial incentives in its calculations. These incentives were approved by Congress in July 2005, and signed into law by the President in early August. EEA, clearly had time to include them in its September report, but they failed to do so. When these incentives are included, and other errors are corrected, the cost benefit analysis included in the report is



shown to be highly inaccurate. Since many of their recommendations flow from that analysis, those recommendations also are invalid.

## 2. REVIEW OF ALTERNATIVE FUEL VEHICLE REQUIREMENTS AND TRENDS

### 2.1 OVERVIEW

**Page 3: 2.1 Overview:** EEA states: “Changes to the AFV fuels markets and the costs of AFVs have also made these vehicles less attractive economically from a fleet operators’ perspective.”

This is one of the many broad assertions made in this report, and is one of the report’s basic conclusions. And, it is generally wrong -- as demonstrated below.

**Page 3: 2.1.1 The Energy Policy Act:** EEA states: “The Energy Policy Act (EPAct) has been the most significant nation-wide driver for the development of the alternative fuels industry.”

This statement *might* have been true *if* the federal government had aggressively and fully implemented the Energy Policy Act of 1992 (EPAct). Unfortunately, as EEA explains later in its report, that did not happen. As a result, the effect of EPAct on the alternative fuels industry has not been significant.<sup>i</sup>

**Page 4: 2.1.1 The Energy Policy Act:** EEA states: “A few years ago, it was widely expected that DOE would impose such a [Private and Local Government Fleets] mandate.”

This is not correct. In fact, just the opposite was true, i.e., it was widely believed that the federal government would *not* move forward with the Private and Local Government mandate. Even though the original mandates were limited to federal, state and fuel provider (e.g., energy utility) fleets, they were widely disliked and seen as intrusive by those affected. To extend those mandates to thousands of other fleets was never seen as politically realistic.<sup>ii</sup>

**Page 4: 2.1.1 The Energy Policy Act:** EEA states: “One of the major programs developed under the EPAct is the U.S. Department of Energy’s Clean Cities Program (CCP) ... In the past, alternative fuel vehicles and its [sic] fueling infrastructure were strong program priorities ... However, the recent technological and environmental developments have dramatically reduced the emission benefits of alternative fuels, and the program emphasis has now shifted toward development of new ways to achieve additional petroleum displacement results ... The announcement of the new initiatives is seen as the first step in reducing program reliance on AFVs for petroleum displacement.”

EEA makes this statement and then attempts to support it by selectively choosing passages from an article in a Department of Energy newsletter.<sup>iii</sup> When the entire article is read, however, it makes the opposite point. The article states:

“Promoting traditional alternative fuels has long been Clean Cities' forte and remains its core focus. To accelerate petroleum displacement, the program will increase attention to alternative



fuel use and infrastructure development, as well as continue to focus on expanding opportunities for key niche markets. Clean Cities will also expand consumer outreach efforts to include off-road applications of alternative fuels.”

The article goes on to state: “Alternative fuels will remain the cornerstone of Clean Cities, but, in addition, the program will now work to:

- Increase the use of fuel blends (diesel/biodiesel, ethanol/gasoline, and compressed natural gas (CNG)/hydrogen),
- Accelerate sales of hybrid electric vehicles,
- Promote informed consumer choice on fuel economy, and
- Encourage the use of idle reduction technologies for heavy-duty trucks and other vehicles.”

It should be noted that, in quoting this section in its report, EEA deleted the reference to “compressed natural gas (CNG/hydrogen).”

The Director of the Clean Cities Program, Shelley Launey, has said that the additions to the program were intended to accelerate petroleum displacement, and should not be interpreted as reduced support for AFVs. She pointed out that the Clean Cities goal has always been the "reduction of petroleum consumption." "Our commitment is as strong as ever to alternative fuels -- especially non-petroleum, domestic fuels. When gasoline and diesel are used, we want to encourage efficient use. Encouraging idling reduction and higher fuel economy vehicles is not inconsistent with our AFV program." She also pointed out that hydrogen and hybrid vehicles were technologies that were not available in 1992 when the program was formed, and are logical extensions of the Clean Cities mandate.<sup>iv</sup>

**Page 5: 2.1.2 US Department of Transportation (DOT) Programs:** EEA states: “The US DOT encourages the use of alternative fuel transit buses as part of the Federal Transit Administration and the Federal Highway Administration’s (FHWA) Congestion Mitigation and Air Quality (CMAQ). Under these programs, transit agencies are eligible to receive significant funding for the purchase of alternative fuel transit buses. These programs are being reexamined currently and funding is being made available for electric hybrid buses fueled by diesel.”

There are two errors in this paragraph. First, while the FTA bus program funding is limited to transit buses, funding from the CMAQ program is not. All alternative fuel vehicles qualify. Second, in an effort to accelerate the introduction of hybrid-electric technology, these programs now make available funding to hybrid-electric vehicles. This funding is not limited to diesel-powered hybrids. Natural gas hybrids, such as those used in Denver, also qualify.

**Page 6: 2.1.2 US Department of Transportation (DOT) Programs:** EEA states: “The net result of this program is that the ‘Big 3’ auto-manufacturers (GM, Ford and Daimler Chrysler) who need the CAFE credits to comply with the standards offer flexible fuel vehicles (FFV). These vehicles can run on any mix of gasoline and ethanol or **methanol** [Emphasis added].”

Contrary to EEA’s statement, the OEM FFVs are not permitted to run on methanol.



**Page 6: 2.1.3 The US Environmental Protection Agency (EPA) Programs:**

This section contains a lengthy discussion of the Clean Fuel Fleet Program (CFFP), which is an all-but defunct program that has been overtaken by events. Noticeably absent is any mention of two significant EPA programs relevant to any analysis of the AFV market.

The first is the Clean School Bus USA program. Under this program, EPA provides grants to local school districts to retrofit, repower or replace older diesel school buses. The 2005 Highway Act, mentioned above, restructured the program. Under the new program structure, school buses that are certified to stricter emissions standards can receive grants equal to half the cost of an entire bus. Buses meeting minimum emission standards can receive only a quarter. Only natural gas engines meet these tighter emission standards.<sup>v</sup>

A second noteworthy EPA initiative is the Diesel Emission Reductions Program, which was included in the 2005 Energy Policy Act mentioned above. Under this program, grants and loans will be made available to State and local government agencies and non-profit organizations for reducing emissions from diesel engines. Repowering vehicles with alternative fuel engines would qualify. Congress will likely appropriate funding for this program for FY2007. Such funding would be expected to significantly alter the cost-benefits analysis, which is at the heart of the EEA report.

**Page 8: 2.1.3 The US Environmental Protection Agency (EPA) Programs:** EEA states: “Starting in 2005, the OBD requirements are more comprehensive for conversion kits. These requirements, coupled with increasingly stringent standards, are making it more difficult for kit manufacturers to offer the kits at reasonable costs, and some installers and system integrators are leaving the business or reducing the number of certified engine families.”

EEA is correct that new OBD requirements are making conversion system development more challenging and costly. They are incorrect, however, about the number of engine families for which conversion systems are available.

Prior to 2000, EPA was lax in its enforcement of alternative fuel vehicle conversion system regulations. As a result, while many different conversion systems were available, there was great variability in the quality of those systems (i.e., system emissions, reliability and performance). In 2000, EPA announced that it would begin enforcing its conversion-related regulations (referred to as “Memorandum 1A”), requiring conversion system manufacturers to phase in EPA OEM certification requirements. The cost and liability associated with such certifications is significant, causing many companies to leave the market. Today, the Small Volume Manufacturers (SVM) that produce conversion systems must adhere to EPA’s OEM requirements and guarantee the performance and reliability of their systems. As EEA points out, some of these SVMs are the companies that manufactured (and still manufacture) natural gas systems for the OEMs.

Appendix 1 includes the SVMs that sell EPA and/or CARB certified conversion systems, and the vehicles for which such conversions are available. There are actually more systems available for more engines today than OEM and SVM systems available two years ago.



**Page 9: 2.1.4 California Programs:** In discussing California’s Advanced Technology-Partial Zero Emission Vehicles (AT-PZEV) program, EEA states: “However, the primary thrust of the new standards is to force auto-manufacturers to develop and introduce low emission electric-hybrid vehicles.”

The statement is not correct. The AT-PZEV classification was established as part of a mechanism to transition California to a Zero Emission Vehicle economy, primarily based on fuel cell vehicles – not electric-hybrid vehicles. While a number of electric-hybrid vehicle sub-systems are necessary for fuel cell systems, gaseous fuel sub-systems are also necessary. That is why AT-PZEV credits are “for vehicles with advanced hybrid componentry or gaseous storage systems.”<sup>vi</sup> So, for example, the natural gas Honda Civic GX is classified as an AT-PZEV.

**Page 9: 2.1.4 California Programs:** EEA states: “Indeed, the new LEV II standards with SULEV and ATPZEV requirements will pose significant challenges for AFV manufacturers and conversion kit developers to comply with these standards.”

It is unclear why EEA choose to single out AFVs in this comment. As EEA points out, the SULEV and AT-PZEV requirements are very stringent.<sup>vii</sup> Attaining either of these classifications is difficult for manufacturers of any vehicle – independent of fuel type. That is why, in 2005, only five vehicle models qualified for AT-PZEV status<sup>viii</sup> and only 32 additional models qualified for SULEV status.<sup>ix</sup>

**Page 9-10: 2.1.4 California Programs:**

In this section, EEA discusses the California South Coast Air Quality Management District (SCAQMD) rules requiring fleet operators of transit buses, school buses, trash trucks, airport shuttles and taxis, street sweepers and heavy-duty utility trucks to buy clean-fueled models when they replace vehicles or add to their fleet. The rules are designed to remove old generation diesel-powered vehicles and replace them with the cleanest engines available, including CNG and other alternative fuel vehicles (but excluding any type of diesel vehicles). EEA also discusses the litigation that has surrounded the rules. However, EEA does not mention any developments after about March 2005. The CVEF provides a brief update here.

Since March 2005, a United States District Court in California issued a ruling that the SCAQMD’s fleet rules *are* applicable to state and local governments in California and are *not* preempted by the Clean Air Act<sup>x</sup>. The SCAQMD has issued an advisory notice to fleet owners and operators stating that, in general, its requirements are in full force and effect.<sup>xi</sup> These requirements have been described by the Western States Petroleum Association as a “de facto” mandate for natural gas vehicles.<sup>xii</sup> Consequently, it should be expected that demand for NGVs in the four counties in and around Los Angeles (i.e., Los Angeles, Orange, Riverside and San Bernardino) will continue to increase.

**Page 10: 2.1.4 California Programs:** EEA states that by 2010: “new diesel engines would have the same emissions as new Natural Gas engines.”



This is a critical statement that is repeated throughout EEA's report. EPA is scheduled to implement new, tighter emission standards for heavy-duty engines between model year 2007 and 2010.<sup>xiii</sup> However, EEA has no way of knowing whether diesel engine emissions will be comparable to natural gas engine emissions in 2010.

As explained below, there are three key reasons as why new diesel engines might *not* have the same emissions as 2010 natural gas engines: (1) the implementation of the 2010 standards may be delayed; (2) EPA's vehicle certification process does not provide accurate information to make comparisons; and (3) heavy-duty natural gas vehicles may well be less polluting than diesel vehicles post-2009.

First, the diesel engine industry may be successful in delaying the 2010 standard. There is recent precedent for this. In 1998, the California Air Resource Board (CARB) concluded that diesel emissions pose a threat to human health.<sup>xiv</sup> The resolution adopted by CARB called for "immediate and continuing efforts to replace diesel-fueled school and public transit buses with cleaner alternative-fuel buses," and set a goal of replacing the state's remaining diesel transit fleet by 2010. The diesel industry opposed the rules, stating at the time that, if given the opportunity to participate, it would deliver products that achieved the aggressive standards that CARB determined are needed to protect human health and the environment.<sup>xv</sup> Therefore, in February 2000, CARB approved the Fleet Rule for Transit Agencies, which allowed transit agencies to choose between two paths: an alternative fuel path and a diesel path.<sup>xvi</sup> Unfortunately, by 2004 when the new, tighter transit bus standards were to go into effect, no engine manufacturers were producing diesel engines that met CARB's standards. As a result, CARB was forced to relax the standards to levels that diesel engines could meet.<sup>xvii</sup> As EEA notes, "The [2010 EPA] standards of 0.2 g/bhp-hr NOx and 0.01 g/bhp-hr PM push the limits of technological feasibility and it is not yet clear if the standards can be attained by conventional diesel engines which are the majority of heavy-duty engines." (Page 22) If the 2010 deadline for the new emission standards approaches and no diesel engine manufacturer has agreed to produce a diesel engine that achieves those standards, Congress and the Administration will be under severe pressure to relax and delay the 2010 standards.

A second reason that diesel engines might not have the same emissions as natural gas engines in 2010 relates to the manner in which engines are certified. The primary concern for the City of Phoenix is the actual pollution that vehicles generate – not some less meaningful on-paper comparisons. Unfortunately, as EEA points out (Page 29), EPA certification is not necessarily a reliable measure of emissions performance. It has long been recognized that EPA's certification system significantly underestimates emissions from light-, medium- and heavy-duty vehicles because the certification procedures does not reflect real-life driving styles and conditions.<sup>xviii</sup>

A third reason that natural gas engines may continue to produce fewer emissions than diesel engines in 2010 and beyond concerns differences in their basic technology. Diesel engines are lean-burn "compression ignition" engines. While historically there have been performance advantages to compression ignition engines, it is increasingly difficult (and expensive) to reduce the next unit of emissions from this type of engine without reducing efficiency. In order to meet the very tight 2010 emission standards, heavy-duty natural gas engine manufacturers are moving to "stoichiometric" engines, which is the technology used in spark-ignited gasoline engines.<sup>xix</sup>



One of the primary advantages of stoichiometric engines is that, with the use of three-way catalysts, emissions can be reduced quite low without loss of efficiency. Cummins-Westport and Deere have already announced that they will be offering engines that meet the strict 2010 emission standards in model year 2007.<sup>xx</sup> When this technology is coupled with the inherently cleaner burning characteristics of natural gas and other advancements in natural gas engines, by 2010, it may be possible to surpass the 2010 standards. Diesel fuel cannot be used in stoichiometric engines, which closes off this fertile avenue for emissions improvement.

**Page 11: 2.1.5 Programs in Other States:** EEA states: “Many of the cities have abandoned the CNG/LNG transit bus programs. New York MTA has had operational and reliability problems with their CNG bus fleet and has decided to order only diesel or hybrid buses in the future.”

“Many” cities have *not* abandoned their natural gas transit programs. In the case of New York MTA, the decision was politically motivated – not driven by technical or economic considerations.<sup>xxi</sup> In fact, many of the natural gas transit fleets listed by EEA continue to expand, increasing the percentage of natural gas buses in the U.S. (The numbers EEA provides for natural gas buses in fleets such as Los Angeles and Washington, DC are outdated and low.) In addition, many new transit agencies are now becoming natural gas fleets. Appendix 2 lists the natural gas transit fleets in the U.S.

## 2.2 OVERVIEW OF AFV PRODUCT OFFERINGS AND FUTURE TRENDS

**Page 17: 2.2.1 Original Equipment AFVs:** EEA states: “While the [natural gas conversion system] suppliers cited above are relatively well known in the industry, a comprehensive compilation of all suppliers and installers is not possible within the scope of this report due to the large numbers of small businesses involved, with many entering or leaving the business each year.”

Appendix 1 includes a comprehensive compilation of natural gas conversion system suppliers and the vehicle models for which conversion systems are available. Contrary to EEA’s assertion, the number of conversion system suppliers has been relatively stable over the past several years. As discussed previously, the biggest shake-up occurred in 2000/2001 when EPA announced that it would be enforcing “Memorandum 1A.”

**Page 17: 2.2.2 Future Availability of AFVs:** EEA states: “Because of higher production and transportation expenses, alternative fuels generally cost significantly more (on an equivalent energy basis) than conventional fuels ...Until recently, natural gas has had a price advantage over gasoline. However, recent supply/demand imbalances have greatly increased natural gas prices even relative to gasoline prices, and forecasts do not show these prices going back down soon.”

This is another critical assertion that is at the heart of EEA’s findings and recommendations – and it is wrong. According to the U.S. Energy Information Administration (EIA), natural gas has had, has, and will continue to have a significant price advantage over both gasoline and diesel



fuel.<sup>xxii</sup> According to EIA, by 2010, diesel fuel is forecast to cost 40 percent more than CNG at the pump, and gasoline is forecast to cost 60 percent more.<sup>xxiii</sup>

In addition, EEA fails to mention the significant financial incentives that Congress enacted as part of the Highway Act.<sup>xxiv</sup> Beginning October 1, 2006, the legislation provides an excise tax credit (referred to as the Volumetric Energy Excise Tax Credit for Alternative Fuels or VEETC) to sellers of CNG or LNG.<sup>xxv</sup> The credit is 50-cent per gasoline-gallon-equivalent for CNG and 50-cents per *liquid* gallon for LNG when used as a motor vehicle fuel. The *user* of the fuel may be eligible for the credit if there is no sale of CNG or LNG prior to its use (e.g., customer owned-and-operated fueling).<sup>xxvi</sup> While this is not a rebate, in effect, it acts like one. In other words, the seller (or user of the fuel if the user owns and operates the CNG station) files a form with IRS once a quarter, and the U.S. Treasury sends a check. For municipal fleets, the amount of the check is 50 cents multiplied by the amount of fuel used.

EEA also fails to mention that, beginning in 2006, the cost of diesel fuel is expected to increase because of the phase-in of EPA's ultra low sulfur diesel (ULSD) regulation.<sup>xxvii</sup> Under this rule, major petroleum refiners must ensure that the sulfur content of on-road diesel fuel reaching users is not more than 15 parts per million (ppm). Currently, the average sulfur content of diesel fuel is 350 ppm. Because of probable sulfur contamination during transport (e.g., from pipelines and trucks), the refiners will actually be producing diesel fuel closer to zero ppm sulfur. It is unclear how much more it will cost to produce ULSD than regular diesel. In testimony, the petroleum refining industry forecast up to 50 cents per gallon, while EPA forecast only a few cents per gallon.<sup>xxviii</sup> However, more recently, EIA stated: "While considerable uncertainty exists in both the supply and demand estimates [for ULSD], this analysis indicates that even though the market could see supply meet demand at a cost increase for production between 5.4 and 7.6 cents per gallon, there are a number of scenarios in which inadequate supply of ULSD could result."<sup>xxix</sup> In other words, EIA believes the increase in cost for ULSD could be greater than 7.6 cents per gallon.

**Page 18: 2.2.2 Future Availability of AFVs:** EEA states: "BAF technologies has no current plans to offer a conversion kit for a 2005 Ford Crown Victoria ... As a result, the only CNG vehicles available in 2005/2006 are the GM full size pickup trucks and the Honda Civic as OEM products, and full size vans and SUV models from conversion kit manufacturers."

There are two errors in this passage. First, BAF *is* offering an EPA certified conversion system for 2005 Ford Crown Victorias, and is pursuing certification for the 2006 model.<sup>xxx</sup> The 2005 Crown Victoria is certified as a ULEV vehicle. The goal for the 2006 model is SULEV. Second, there are many more CNG models available than EEA indicates (See Appendix 1).

**Page 18: 2.2.2 Future Availability of AFVs:** EEA states: "Heavy-duty engines do not face much more stringent emission standards until later this decade."

This statement is puzzling. As explained previously, beginning with model year 2007 engines, (which are scheduled to be available in the fall of 2006 – less than 12 months from now), particulate matter (PM) must be cut by 90 percent (to 0.01) and NOx by 50 percent. While



EEA's statement is technically accurate (next year is, in fact, "later this decade"), the new standards are more imminent than the statement implies.

**Page 18: 2.2.2 Future Availability of AFVs:** EEA states: "Cummins has announced that it will continue to offer its diesel engine conversions to CNG to 2008/9 and was hopeful that it could develop CNG engine models in the near future to meet the California 0.5 g/bhp-hr urban bus NOx standard. It is widely expected that Deere and Mack will also continue to offer CNG conversions of heavy-duty diesels to 2007."

There are several errors in this passage. First, as mentioned above, both Cummins-Westport and Deere have already announced that they will be offering 2010 compliant engines by 2007. These engines will meet the 0.2 gm/bhp-hr NOx standard – not 0.5. Second, since they will meet the 2010 standard, neither manufacturer has indicated that these engines will be offered only through 2009. Third, neither manufacturer views their natural gas engines as conversions. Both consider them OEM products.<sup>xxxii</sup>

**Page 18: 2.2.2 Future Availability of AFVs:** EEA states: "In 2010, the NOx standard for heavy-duty engines will decline to 0.2 g/bhp-hr and this could pose a significant hurdle for CNG engines."

Given the announcements by Cummins-Westport and Deere, this statement is also puzzling. As indicated, both Cummins-Westport and Deere have announced that this issue has been resolved. Natural gas engines that meet the 2010 0.2 NOx standard will be available beginning with the 2007 models. It is the *diesel* engine manufacturers for which the 0.2 NOx standard "could pose a significant hurdle." Section 2.2.2 of the EEA report is titled "Future Availability of AFVs." There is no comparable section in the report concerning the "Future Availability of Diesel Engine Vehicles." If there were, that is where EEA would have repeated their point from page 22, namely: "The standards of 0.2 g/bhp-hr NOx and 0.01 g/bhp-hr PM push the limits of technological feasibility and it is not yet clear if the standards can be attained by conventional diesel engines which are the majority of heavy-duty engines."

**Page 18: 2.2.2 Future Availability of AFVs:** EEA states: "It is also not clear if CNG engines will have any NOx benefit over diesel engines in the 2010+ era."

As discussed above, natural gas engines may well have a NOx advantaged post-2009.

**Page 19: 2.2.2 Future Availability of AFVs:** In discussing heavy-duty hybrid-electric diesel buses, EEA states: "Initial data suggests that these systems could improve fuel economy by 20 to 40 percent depending on drive cycle ..."

In fact, initial data suggest far lower numbers. For example, a recent news report about Seattle's hybrid buses stated:

"Expensive new hybrid diesel-electric buses that were portrayed by King County Metro as 'green' heroes that would use up to 40 percent less fuel than existing buses have fallen far short of that promise. In fact, at times, the New Flyer hybrid articulated buses have gotten worse



mileage than the often-maligned 1989 dual-mode Breda buses they are replacing. Yet the hybrid buses cost \$200,000 more each than a conventional articulated diesel bus.<sup>xxxii</sup>

In a recent analysis of CT Transit's hybrid buses conducted by the University of Connecticut, researchers found that:

“... there is little to gain by switching from diesel-powered buses to diesel-electric hybrid. The hybrids did not reduce emissions as much as expected and were not significantly better in mileage, according to the study released Thursday ... Researchers say that the hybrid buses by Allison Transmission, a division of General Motors, supposedly have fuel economy 50 percent better than that of diesel buses. However, the study found fuel economy for the hybrids was only 10 to 15 percent better.”<sup>xxxiii</sup>

### 3. EMISSIONS BENEFITS OF ALTERNATIVE FUEL VEHICLES

#### 3.1 CERTIFICATION STANDARDS

**Page 23: 3.1 Certification Standards:** EEA states: “The phase in of the Tier II standards will result in large decreases (in percentage terms) to emissions from conventional gasoline and diesel vehicles by 2007 for light-duty vehicles and by 2010 for heavy-duty vehicles. These decreases are being made possible by large investments in emission control technology, but similar large investments in emission control technology for AFVs are not being made. While a few AFVs currently show emission benefits over conventional gasoline and diesel vehicles, it is unlikely that they can maintain their emission benefits beyond 2009 absent significant investment in new emission control technology.”

It is true that significantly more money is now being invested by the OEMs in making gasoline and diesel vehicles compliant with tighter emission standards. However, much of the emissions research and improvements for petroleum vehicles are transferable to natural gas systems,<sup>xxxiv</sup> and substantial R&D funding is being invested to improve NGV emissions.<sup>xxxv</sup> The fact that Cummins-Westport and Deere will be offering 2010 compliant heavy-duty natural gas engines in 2007 is just one illustration of this point. The inherent clean-burning qualities of natural gas engines allow them to stay ahead of diesel engine technology despite the significant R&D funding advantage of diesel engines. In addition, as discussed above, natural gas heavy-duty engines may well retain an emission advantage over diesel engines beyond 2009.

#### 3.2 EMISSIONS BENEFITS OF LIGHT-DUTY AFV

**Page 23: 3.2 EMISSIONS BENEFITS OF LIGHT-DUTY AFV**

It again should be emphasized that, when discussing emissions, on-paper comparisons and certification data may provide some useful information, but what is most important is the actual emissions produced by vehicles. For years, environmental organizations have complained that EPA's certification testing procedures significantly overstated the efficiency and emissions benefits of light-duty gasoline vehicles. EPA recently agreed, and has promised to overhaul the



testing procedures in 2006.<sup>xxxvi</sup> This problem has been exacerbated for hybrid technology. Recently, because of increased weight and horsepower, some gasoline hybrid electric vehicles have been under attack for delivering significantly less miles per gallon (and therefore, more emissions) than the performance to which they were certified. One news report stated: “One question lingers after driving the 2006 Lexus RX400h: How did it come to this, that Toyota is now selling a hybrid gas-electric vehicle with no tangible fuel economy benefits?”<sup>xxxvii</sup> A second problem in this area is emission degradation over time – especially with heavy-duty vehicles. While manufacturers must certify to a degradation level, there has been no systematic method in place to ensure these levels are not violated. Anecdotal evidence indicates that older heavy-duty vehicles often exceed emission levels.

**Page 23: 3.2 EMISSIONS BENEFITS OF LIGHT-DUTY AFV; 3.2.1 Natural Gas Vehicles** EEA states: “Natural gas vehicles can be certified to very low emission levels, but this requires considerable engineering development and expertise that is typically available only at auto-manufacturers.”

This is another puzzling assertion since EEA states on Page 17: “In fact, the GM natural gas vehicles utilize conversions supplied by Quantum, a system integrator that uses hardware from GFI Systems.” Non-auto manufacturer companies such as Quantum, GFI and Baytech all have “considerable engineering development and expertise” and are capable of producing natural gas systems that meet the most stringent emissions standards.

**Page 23: 3.2 EMISSIONS BENEFITS OF LIGHT-DUTY AFV; 3.2.1 Natural Gas Vehicles** EEA states: “The Crown Victoria NGV, a popular model that has been discontinued in 2005 ...”

Ford discontinued the natural gas Ford Crown Victoria in 2004.

**Page 24: 3.2 EMISSIONS BENEFITS OF LIGHT-DUTY AFV; 3.2.1 Natural Gas Vehicles** EEA states: “The Honda Civic natural gas model is certified to the most stringent California SULEV levels ...”

The natural gas Honda Civic GX is certified as an AT-ZEV, as noted by EEV on page 22.

**Page 24: 3.2 EMISSIONS BENEFITS OF LIGHT-DUTY AFV; 3.2.1 Natural Gas Vehicles** EEA states: “However, many end users have not had good experiences with conversion kits since they found in-use problems and difficulty in obtaining parts and service.”

As mentioned above, prior to 2000, EPA was lax in its enforcement of alternative fuel vehicle conversion system regulations. As a result, while the number of conversion systems available was high, there was great variability in the quality of those systems. The cost and liability of undertaking certification required by EPA after 2000 was significant. Therefore, lower-cost, lower-quality companies left the market. Today the Small Volume Manufacturers (SVM) that produce conversion systems must adhere to EPA’s OEM guidelines and guarantee the performance and reliability of their systems. While there have been no recent studies on



conversion customer satisfaction concerning performance and parts availability, anecdotal evidence is contrary to EEA's undocumented assertion.

**Page 25: 3.2 EMISSIONS BENEFITS OF LIGHT-DUTY AFV; 3.2.1 Natural Gas Vehicles** EEA states: "... Dallas reported problems with retrofit conversion of their police car fleet last year ..."

EEA makes this statement, but does not complete the story. Safety concerns in gasoline-powdered Ford Crown Victorias during high-impact accidents led the City of Dallas to order the conversion of 174 Crown Victoria police cars to natural gas. Some in the police department were vocal opponents of the conversions. Shortly after the vehicles were put into service, certain vehicles began to have problems that could not be explained. The "problems" suddenly ended, following media publicity and the attention of leadership of the Department. Today, all of the natural gas vehicles are in service.<sup>xxxviii</sup>

### **3.3 EMISSION BENEFITS OF HEAVY-DUTY AFV**

**Page 28: 3.3 EMISSION BENEFITS OF HEAVY-DUTY AFV; 3.3.1 Natural Gas HDV**

EEA states: "Cummins has stated that by 2007, it will be possible for natural gas engines to reduce NOx emissions to below 0.5 g/bhp-hr, implying that natural gas engines may continue to provide similar percentage benefits to 2009/2010. By 2010, the NOx standard of 0.2 g/bhp-hr, **a level that has not been demonstrated by any natural gas or diesel engine**, will be fully phased in. [Emphasis added] At this standard, it is unlikely that natural gas engines will have any emissions advantage."

As mentioned previously (and also on page 18 of EEA's report), both Cummins-Westport and Deere have announced that they will be offering 2010 compliant engines in 2007. Also as discussed above, natural gas engines may well continue to have an emission advantage in 2010 and beyond.

**Page 29: 3.3 EMISSION BENEFITS OF HEAVY-DUTY AFV; 3.3.1 Natural Gas HDV**

EEA states: "Because CNG engines are built at low volumes, there is speculation that these engines have more production variability."

EEA provides no reference for its speculation. CVEF has been unable to identify any study or analysis that supports this assertion.

**Page 29: 3.3 EMISSION BENEFITS OF HEAVY-DUTY AFV; 3.3.1 Natural Gas HDV**

In this section, EEA leans heavily on a study performed by the NYC MTA titled "*Comparison of Clean Diesel Buses to CNG Buses*" that purports to show that "clean diesel" transit buses can produce the same or less emissions than natural gas buses.

CVEF finds this study to be methodologically unsound for a number of reasons. For example, the study inappropriately compares older technology natural gas buses to newer technology diesel buses. A number of more rigorous and credible analyses have been conducted, the



conclusions of which are quite different from the New York study. One such study was performed in 2002 by the California Air Resources Board.<sup>xxxix</sup> The most recent comparative study of natural gas and diesel buses was completed in December 2005 on transit buses operated by the Washington Metropolitan Area Transit Authority (WMATA). The WMATA study concludes that its 2004 CNG buses produce 49 percent lower NO<sub>x</sub> emissions and 84 percent lower PM emissions than its 2004 diesel buses.<sup>xl</sup>

The difficulty with referring and relying on any of these studies, however, is that, from an emission perspective, they are ancient history. Unless the City of Phoenix plans to purchase pre-2004 heavy-duty engine technology, these studies are irrelevant since the technologies, emissions performance and cost of today's heavy-duty vehicles (and especially, vehicles sold beginning in model year 2007) will be very different than those tested.

**Page 30: 3.3 EMISSION BENEFITS OF HEAVY-DUTY AFV; 3.3.1 Natural Gas HDV**

EEA states: "Emissions of carbon dioxide from a natural gas bus are typically 15 to 20 percent higher than for a diesel bus on a full fuel cycle basis, because the engine is less energy efficient than a diesel engine."

EEA's statement is no longer true. The full cycle emissions of greenhouse gases (including methane) from diesel vehicles may have been less at one time, but this is no longer the case.<sup>xli</sup> In 2004, when the NO<sub>x</sub> limit on diesel engines was reduced from 4.0 gm/bhp-hr to 2.5 gm/bhp-hr, some efficiency was lost in complying diesel engines. Meanwhile, the efficiency of heavy-duty natural gas engines has continued to improve.<sup>xlii</sup> Importantly, the greenhouse gas advantage of heavy-duty natural gas vehicles is expected to increase further. All things equal, greenhouse gas production is directly proportional to energy used, and future diesel engines will require more energy to operate for two key reasons. First, as indicated, beginning in 2006, refiners must begin selling only ULSD. ULSD is a more refined product that will take more energy to produce. Second, and more importantly, the 2007 diesel engines will be less efficient than current engines, using more energy per mile traveled.<sup>xliii</sup>

**Page 30: 3.3 EMISSION BENEFITS OF HEAVY-DUTY AFV; 3.2.2 Bio-diesel**

In this section, EEA quotes emission numbers for bio-diesel when used in existing vehicles.

There are a number of problems with using these numbers. The 2007 diesel engines, which must operate on ULSD fuel, will be meeting the 0.01gm/bhp-hr PM standard, which is 90 percent below the current (2004) standard. It is questionable whether there will be any PM advantage from using biodiesel in post-2006 heavy-duty vehicles. It also is unknown whether the diesel engine manufacturers will warrantee post-2006 engines if they operate on biodiesel. Post-2006 diesel engines will be much more technologically sophisticated and, it is expected, fragile than current engines. As a result, they may not be able to tolerate the properties of biodiesel. No diesel engine manufacturer has yet announced what technologies will be used in their post-2009 engines. Therefore, the possible use of biodiesel in those engines is unknowable. Today, it is unclear whether or to what percentage engine manufacturers will allow biodiesel. At the low level of 2 percent, which was recently mandated by the state of Minnesota, truckers found fuel filters clogging, leading the state to back off on the requirement.<sup>xliv</sup> However, where biodiesel is used, it will continue to offer significant greenhouse gas and oil displacement benefits.



### 3.4 HYBRID VEHICLES

**Page 34: 3.4 HYBRID VEHICLES:** EEA states: “Heavy-duty hybrid buses have also been recently introduced in some cities in small numbers. One manufacturer, GM, suggests that fuel economy will improve by 50 to 70 percent in typical urban operation but only 20 to 30 percent benefit has been realized in actual use based on preliminary data.”

As discussed above, real-life experiences seriously call into question even these lower estimates.

## 4. COSTS AND BENEFITS OF ALTERNATIVE FUEL OPTIONS

### 4.1 ANALYSIS ISSUES

**Page 35: 4.1 Analysis Issues:** In its “costs” paragraph, EEA states: “The most obvious costs are the incremental costs of the AFV over a conventional gasoline light-duty vehicle or the incremental cost over a heavy-duty diesel vehicle, and **the cost of the fuel relative to the cost of gasoline or diesel.**” [Emphasis added]

As discussed above, the cost of natural gas is now -- and is expected to continue to be -- less than the cost of gasoline and diesel (EIA forecasts the cost will be significantly less). Therefore, this should have been listed under benefits – not costs.

**Page 35: 4.1 Analysis Issues:** EEA states: “There are also some hedonic (i.e. non-monetary) costs associated with vehicle reliability and availability for use, as well as hedonic costs associated with loss of performance and range limitations of alternative fuel vehicles of some types.”

EEA fails to mention any of the hedonic benefits of natural gas vehicle use, such as the feeling of wellbeing that occurs in some people who believe they are making a contribution to cleaning the environment or reducing America’s dependence on foreign oil. A second hedonic benefit is noise. Heavy-duty spark ignited engines are significantly quieter than comparable diesel cycle engines.<sup>xlv</sup> This not only affects the driver, but also benefits citizens that live near or stand by the vehicles. Yet a third benefit concerns smell. There have been anecdotal reports from drivers and others who refuel heavy-duty vehicles that, with natural gas vehicles, they do not end their shift with the smell of diesel fuel on their hands.

**Page 35: 4.1 Analysis Issues:** EEA states: “Reduction of imported oil is also claimed as one of the benefits of alternative fuel use, but in recent years, some of these alternative fuels such as natural gas, are also being imported.”

This statement is puzzling. Some natural gas has been imported into the U.S. for decades, but the percentage has been (and is forecast to continue to be) relatively small compared to petroleum (e.g., for 2004, only 15.5 percent of natural gas was imported compared to 65 percent of petroleum).<sup>xlvi</sup> The source of those imports is also important. The vast majority of imported natural gas (over 83 percent of the 15.5 percent) has come from Canada.<sup>xlvii</sup> While imports of natural gas are expected to rise, by 2020, they are still forecast to represent less than 20 percent



of all natural gas used in the U.S.<sup>xlviii</sup> It should also be noted that interest in bio-methane is growing around the world and in the U.S. DOE conservatively estimates that potential annual U.S. capacity of renewable bio-methane from landfills, animal waste and sewage is 1.25 quadrillion BTUs or almost 6 percent of current annual U.S. natural gas consumption.<sup>xlix</sup>

**Page 36: 4.1 Analysis Issues:** EEA states: “The fleets of the City of Phoenix require the use of specific vehicle types with specified performance levels to complete their mission. Because AFVs are available only in a few select models of cars, light trucks and heavy-duty vehicles, this factor could be a serious impediment to AFV use.”

It is assumed that EEA had access to information on the specific types of vehicles the City of Phoenix requires. Therefore, it is unclear why EEA did not provide an analysis of alternative fuel vehicles that meet the City’s specific requirements.

## 4.2 LIGHT-DUTY VEHICLES

**Page 36: 4.2 Light-Duty Vehicles:** EEA states: “Only three natural gas vehicles will be available in the 2005 + time frame: the Honda Civic, the Chevrolet half-ton pickup and the GMC half-ton pickup.”

As mentioned above, based on OEM announcements, only three *OEM-produced* light-duty vehicles will be available in the 2005+ timeframe. However, there are many SVM-produced options (see Appendix 1).

**Page 36: 4.2 Light-Duty Vehicles:** EEA states: “... it is possible that 2006 will be the last year that any natural gas vehicles are available.”

This is an unsubstantiated speculation. Is it *possible* that no OEMs will decide to make NGVs after 2006 and that all SVM will also decide to stop making conversion systems? Is it *possible* that all the OEMs will stop making gasoline vehicles? The answer to both questions is ...yes. It is *possible*. Is either of these statements probable? No.

**Page 36: 4.2 LIGHT-DUTY VEHICLES: 4.2.1 Cost Comparison:** EEA states: “The lifetime costs of a pickup truck using conventional gasoline, natural gas or E85 were analyzed. The price of a 2005 gasoline truck was taken as the list price of \$20,500 less a 10% discount for fleet purchasers for a net price of \$18,450. The flex-fuel option is a zero cost option while the announced natural gas option price is \$9,300.”

The \$9,300 incremental price cited by EEA for the light-duty truck fails to account for the new federal alternative fuel vehicle purchase tax credit of up to \$4,000. The vehicle seller can take this tax credit if the purchaser is a non-tax paying entity, such as the City of Phoenix. In addition, it does not reflect any special GM incentive.<sup>1</sup> Also, a significant portion of the incremental price for natural gas vehicles is represented by the on-board fuel storage tanks. It is expected that the price of these tanks will decline<sup>li</sup>



**Page 37: 4.2 LIGHT-DUTY VEHICLES: 4.2.1 Cost Comparison:** In addressing fuel costs, EEA states: “May 2005 gasoline costs at \$1.97 per gallon wholesale (including taxes) are quite high by historical standards. In contrast, natural gas prices of \$1.16 per gallon equivalent are not expected to decline much in the near future due to a domestic supply shortage with no capacity to significantly increase imports.”

As documented above, the U.S. EIA forecasts that gasoline and diesel prices will continue to be substantially greater than CNG prices. For example, EIA forecasts that diesel fuel prices will be 40 percent greater than CNG, and gasoline 60 percent greater than CNG. Also as previously discussed, EEA does not take into account the 50 cents per gallon excise tax credit for each gallon of natural gas used in vehicles beginning in October 2006. In addition, the published Southwest Gas rate for natural gas delivered to fueling stations (the G55 tariff) has varied during 2005 between \$0.89 and \$1.00 per gge. For its analysis, EEA used \$1.16.

**Page 38: TABLE 4-1 Lifetime Cost Comparison of Gasoline and Alternative Fuel Vehicles: Light-Duty Pickup Truck (cents per mile):**

Based on the discussion above, the following adjustments to EEA’s quantitative analysis are appropriate. When made, the analysis shows that, rather than an 18.0 percent *penalty*, light-duty natural gas pickup trucks have a 4.9 percent *advantage*.

*Purchase cost:* The \$4,000 vehicle purchase tax credit over 100,000 miles translates into a reduction of 4 cents per mile.

*Repair cost:* EEA does not provide any data to independently verify these numbers, so CVEF uses EEA’s numbers.

*Fuel cost:* Assuming 12.2 mpg for natural gas vehicles quoted by EEA, the 50 cents per gge excise tax credit translates into a reduction of 4.1 cents per mile. The 16-cent per gge difference in the price of delivered natural gas translates into a reduction of 1.3 cents per mile.

*Fuel Infrastructure cost:* EEA does not provide any documentation for this estimate. However, it should be noted that the City of Phoenix has already invested in and installed 18 natural gas fuel stations. The marginal cost of fueling more vehicles at those stations would likely be far less than the 3.11 cents per mile that EEA used in its calculations.

Analysis using the corrected figures shows that the cost of the natural gas light-duty truck would be 4.9 percent *less* than the gasoline version (39.07 [48.47 - 4 - 4.1 - 1.3] cents per mile for natural gas versus 41.07 for gasoline).

**Page 39: 4.2 LIGHT-DUTY VEHICLES: 4.2.1 Cost Comparison:** EEA states: “Arizona regulations allow fleets to apply for an exemption if the lifecycle costs of alternative fuel vehicles exceed conventional vehicle lifecycle costs by over 10 percent. This analysis shows that natural gas vehicles have costs in excess of this criterion.”

The adjusted analysis demonstrates that natural gas vehicles do *not* “have costs in excess of this criterion.”



**Page 40: Table 4-2 Qualitative Comparison of Alternative Fuel Vehicle Costs and Benefits Relative to 2005+ Gasoline Light-Duty Vehicles:**

Again, based on the discussion above, the following adjustments to EEA’s qualitative analysis are appropriate:

*Criteria Pollutants:* EEA states that there are no emission benefits for natural gas trucks outside of California. This is incorrect. For 2006, the General Motors website shows that their natural gas Silverado/Sierra pickup trucks are rated as SULEV (California) and Bin8 ULEV (EPA). The CARB website shows the gasoline version of the same vehicle rated significantly more polluting at LEV.

*Reduction in Fuel Imports:* EEA states there is no fuel import benefit from natural gas vehicles. As documented above, this is incorrect as there is a significant fuel import benefit for natural gas.

*Life cycle Cost:* EEA states that there is an 18 percent cost *penalty* for natural gas vehicles. This is incorrect. From the analysis above, there is a 4.9 percent *advantage*.

*Vehicle Availability:* EEA states that vehicle availability is poor, with only one model available. If SVM models are taken into account, there are actually many natural gas models available (see Appendix 1). In addition, the GM pickup truck is offered in several configurations – not just one.

*Future Fuel Availability:* EEA states that natural gas costs may be high during the next few years. The absolute cost of natural gas is less important than the relative cost of natural gas versus petroleum and other competing fuels. And as discussed, natural gas is forecast to maintain its considerable price advantage over gasoline and diesel fuel.

**4.3 HEAVY- DUTY ALTERNATIVE FUEL VEHICLES**

**Page 41: 4.3 Heavy Duty Alternative Fuel Vehicles 4.3.1 Cost Analysis:** EEA states: “In reality, the majority of heavy-duty natural gas vehicles in the U.S. today are transit buses ...”

While this is true, there are a growing number of heavy-duty trash trucks, street sweepers, school buses and delivery vehicles. EEA provides no comparative analysis of natural gas versus diesel in these applications.

**Page 41: 4.3 Heavy Duty Alternative Fuel Vehicles 4.3.1 Cost Analysis:** EEA states: “The LNG dump trucks have been found unsuitable for the duty cycle and any future LNG heavy-duty vehicle purchases will involve only the transit fleet.”

EEA provides no documentation to support this assertion, thus CVEF cannot address it. However, it is interesting to note that LNG-powered heavy-duty refuse trucks have been found to be satisfactory in a number of areas (e.g., Southern CA, PA, NJ). Also, dump and plow trucks converted to CNG are performing well in upstate New York, particularly on the New York State



Thruway and surrounding roads. The success of these trucks calls into question the contention that LNG dump trucks are unsuitable for Phoenix.

**Page 41: 4.3 Heavy Duty Alternative Fuel Vehicles 4.3.1 Cost Analysis:** EEA states: “Data from a recent comprehensive study of natural gas and diesel buses from New York City Metropolitan Transit Authority (MTA) are utilized in this report since detailed cost data from Phoenix was not available.”

It is unfortunate that EEA relied on this one study as the basis for their entire heavy-duty transit bus analysis. First, as discussed above, CVEF finds this study to be methodologically unsound, and its results are questionable. Second, there are a number of transit bus studies conducted in other jurisdictions that show natural gas buses with the same or lower costs. In fact, the most recent natural gas versus diesel transit bus comparative study concluded that natural gas buses had better fuel economy.<sup>lii</sup> However, most importantly, given the significant changes that have occurred -- and will continue to occur -- to heavy-duty engine standards, technology, cost and fuel prices, it would be imprudent and ill-advised to make future planning and purchasing decisions based on historic data (especially pre-2004 data).

**Page 41: 4.3 Heavy Duty Alternative Fuel Vehicles 4.3.1 Cost Analysis:** EEA states: “Nationally, a typical diesel transit bus is utilized for about 33,000 miles per year and has a fuel economy of 3.3 MPG so that annual diesel fuel consumption is 10,000 gallons.”

It is assumed that these data for Phoenix would have been readily available. It is unclear why EEA choose instead to use national data.

**Page 41: 4.3 Heavy Duty Alternative Fuel Vehicles 4.3.1 Cost Analysis:** EEA states “Fuel economy per unit of energy input of natural gas engines is significantly worse than that of a diesel engine, and the MTA reports indicate a range from 20 to 30 percent increase in fuel consumption for natural gas buses. We selected 25 percent for this analysis ...”

The 20-30 efficiency advantage for diesel engines quoted by MTA may have been true in the early 1990s, when first- or early second-generation natural gas engines and pre-2004 diesel engines were in use. It is not true today, however. (For example, the Washington, DC transit agency recently reported that CNG and diesel buses had basically the same fuel economy -- 2.4 mpg<sup>liii</sup>) The relative efficiencies of natural gas versus diesel engines have been drawing closer as emission standards have tightened (2004, 2007, 2010), and natural gas technologies have improved. Thus, any purported efficiency advantage for diesel engines will be even less true when model year 2007 engines are introduced.

Cummins-Westport International forecasts:

- Relatively stable cost-per-mile over the three time frames [pre-2007, 2007-2009 and post 2009] for natural gas, resulting from the combination of lower incremental engine/vehicle costs for natural gas engines to meet the emission standards and increased efficiency expected with the advanced natural gas technology



- Increasing diesel vehicle costs resulting from higher incremental engine/vehicle costs to meet the emission standards, combined with reduced efficiency and higher fuel costs (ultra low sulfur diesel – ULSD) with the advanced diesel technology.<sup>liv</sup>

Cummins-Westport further states that, because of these factors, the cost per mile advantage for diesel vehicles over natural gas vehicles will disappear during the 2007-2009 timeframe. After 2009, Cummins-Westport expects that natural gas engines will have a cost per mile advantage.<sup>lv</sup> A second study (conducted by TIAX LLC) reaches a similar conclusion.<sup>lvi</sup> TIAX concludes that 2010-technology heavy-duty NGVs will be “highly competitive with their diesel counterparts,” and, *if oil prices rise above \$31 per barrel*, heavy-duty natural gas vehicles will be less expensive over the lifetime of the vehicles.<sup>lvii</sup> As discussed above, EIA forecasts that petroleum will continue well above \$31 per barrel through 2030. Consequently, CVEF projects the miles per gallon estimate for natural gas to be the same as diesel.

**Page 42: 4.3 Heavy Duty Alternative Fuel Vehicles 4.3.1 Cost Analysis:** EEA states: “Maintenance costs are a major issue since the bulk of the experience with natural gas heavy-duty engines has been on first and second generation models. New York City MTA reported that scheduled and unscheduled maintenance over the 1994-2001 period resulted in natural gas buses having a maintenance cost increase over diesel buses of 20 cents per mile, a very large number. Other studies on newer vehicles report costs of about half that reported by New York City MTA, and we have selected a 10 cent per mile differential as being representative for newer third and fourth generation engine buses.”

Again, EEA has ignored the significant changes that are about to occur. When the 2007 diesel engines are introduced, costs of diesel bus maintenance are expected to increase sharply. The last time the EPA emission standards changed (in 2002/2004), there was a significant increase in diesel engine maintenance costs. Federal Express’ fleet manager phrased it this way: “He said his fleet had been experiencing failures with sensors, EGR valves, EGR coolers and injectors. ‘No huge horror stories, but lots of pain and **extraordinary costs.**’” {Emphasis added}<sup>lviii</sup>

These same problems are not expected for natural gas engines, however, as Cummins-Westport has stated. Therefore, rather than natural gas engines having a 10 percent maintenance cost *penalty*, it may be that they will have a maintenance cost *advantage*. However, for purposes of this analysis, CVEF has taken a conservative approach and assumed that maintenance expenses for 2007 diesel and natural gas buses will be comparable.

**Page 42: Table 4-3 Lifetime Cost Comparison of Diesel, Retrofit and Alternative Fuel Vehicles: Heavy-Duty Transit Bus (cents per mile)**

Based on the discussion above, the following adjustments to EEA’s quantitative analysis are appropriate. When made, the analysis shows that, rather than an 18.2 percent *penalty*, heavy-duty natural gas buses have a 20.5 percent *advantage*.

*Purchase Cost:* EEA states that a natural gas bus will cost \$45,000 more than the comparable diesel bus (\$300,000 versus \$345,000). EEA does not indicate the source of these numbers. Published data collected by the Department of Energy/Clean Vehicle Education Foundation Natural Gas Transit Users Group (TUG) show an average of \$328,506 for 10 recent diesel bus



purchases or bids, and \$357,794 for 14 recent CNG bus purchases or bids. The only LNG transit bus data that TUG collected shows Phoenix's cost was \$325,000 per bus in 1998 and \$332,000 in 2002.<sup>lix</sup> It is important to note that the cost of 2007 diesel transit buses will be significantly greater than historic costs. In a recent presentation, Dee Kapur, President of International Truck and Engine's truck group said that stricter diesel emissions standards starting with 2007 models could add \$5,000 to \$6,000 to the price of a new medium duty engine and up to \$10,000 to a new heavy-duty engine. "We recognize that this is a pretty significant increase in pricing ..." he said.<sup>lx</sup> Note that this increase is just for the engine. There will be other additional costs. For example, because of the increase in rejected heat as a result of the engine gas recirculation technology that most 2007 diesel engines will use, the cooling system must be larger – and more expensive. When all these costs are included, the cost of a 2007 diesel transit bus could increase by \$20,000 or more over 2006 models – which is the amount that heavy-duty vehicle operators have been anticipating.<sup>lxi</sup> Because of the differences in technology and fuel, the additional costs for natural gas engines should be minor. For example, as EEA points out (Page 43), most of the additional cost of natural gas buses is the result of non-engine parts (e.g., tanks and high-pressure piping and controls). These costs are unaffected by the 2007 engine technology. In addition, as noted above, the price of on-board storage tanks is expected to decline during 2006 (see note li). Therefore, CVEF conservatively assumes a net price increase for diesel transit buses of \$15,000 or 3 cents per mile.

EEA also fails to take into account the new federal income tax credit for the purchase of natural gas vehicles (which can be taken by the seller and passed on to the buyer if the buyer is a non-profit entity, such as the City of Phoenix). For a transit bus, the credit can be up to \$32,000 per bus or 6.4 cents per mile.<sup>lxii</sup>

It also is important to note that the U.S. Department of Transportation's Federal Transit Administration (FTA) provides the majority of funding for capital expenses for the nation's transit agencies. About 80 percent of the cost of new transit buses are covered by FTA grants. While this fact is not reflected in EEA's or CVEF's analysis, it can be argued that only 20 percent of the capital cost should be considered.

*Maintenance Costs:* Based on the discussion above, CVEF assumes the maintenance costs for diesel and natural gas 2007 buses will be the comparable, thereby reducing natural gas vehicle costs by 10 cents per mile from the estimate used by EEA.<sup>lxiii</sup>

*Fuel Cost:* As discussed previously, it is expected that the fuel efficiency advantage of diesel engines will essentially disappear with the introduction of the 2007 engines. However, for this analysis, CVEF conservatively assumes a 10 percent diesel advantage – versus the 25 percent assumed by EEA – with the reduction in miles per gallon applied to diesel (rather than increasing the miles per gallon of natural gas). This decreases the estimate of miles per gallon for diesel buses from 3.3 (used by EEA) to 2.87. Therefore, the calculated cost for diesel fuel would increase to 63.72 cents per mile from 55.41 cents per mile – an 8.31 cent per mile increase. Moreover, a substantial further decrease in diesel engine fuel efficiency is expected in 2010 when NOx emissions must be reduced by another 80 percent. However, no diesel engine manufacturer has announced which technology will be used to meet the 2010 standard.

Therefore, a comparison of 2010 compliant diesel engine costs with 2010 natural gas engine costs is not possible at this time.

Another adjustment must be made for the cost of ULSD. EEA has not accounted for the increase in the cost of diesel fuel as a result of the 2006 EPA ULSD requirement. As discussed above, the size of this increase is uncertain, but a very conservative estimate is 5 cents per gallon or 1.74 cents per mile.

Also, as with the light-duty vehicle analysis, EEA has failed to account for the federal excise tax credit of 50 cents per gasoline gallon of CNG (which is 55.6 cents per *diesel* gallon of CNG). (For LNG, the credit is larger – i.e., 83.5 cents per diesel gallon equivalent.) Using EEA’s miles per diesel-gallon figure for natural gas of 2.48, the value of the federal excise tax credit to the City of Phoenix will be 22.42 cents per mile.

*Fuel Infrastructure cost:* EEA does not provide any data to independently verify these numbers. However, it should be noted that the City of Phoenix has already invested in and installed 18 natural gas fuel stations. The marginal cost of fueling more vehicles at those stations would be expected to be far less than the 15.32 cents per mile that EEA used in its calculations.

Using the corrected numbers, the cost of the diesel transit bus would be 175.81 ( $164.50 + 3 + 8.31 + 1.74$ ), while the cost for the natural gas bus would be 147.31 ( $186.13 - 6.4 - 10 - 22.42$ ). With these adjustments, new diesel transit buses will have a 20.5 percent cost *penalty* over natural gas buses!

**Page 43: 4.3 Heavy Duty Alternative Fuel Vehicles 4.3.1 Cost Analysis:** EEA states: “In the heavy-duty vehicle case, natural gas currently provides a significant criteria-pollutant benefit, but no benefit in greenhouse gas emissions. However, this benefit will be reduced to zero by 2009/2010. Engine availability is expected to not be a significant issue till 2009/2010 ...”

There are two errors in this statement. First, as discussed above, heavy-duty natural gas engines now have a greenhouse gas advantage, and that advantage is expected to increase with the 2007 and 2010 engines. Second, as discussed above, the criteria emission benefits will definitely continue through 2009 and may well continue in 2010 and thereafter.

**Page 43: 4.3 Heavy Duty Alternative Fuel Vehicles 4.3.1 Cost Analysis:** In referring to future natural gas vehicles, EEA states: “... the only major drawbacks are the high lifecycle cost of this option and the reduction in payload and operating range.”

As discussed, it is expected that in 2007 -- and especially in 2010, it is heavy-duty diesel vehicles that will have the higher life cycle cost. Also, it should be noted that the APTA range requirements apply to transit buses using any fuel. Transit buses using either LNG or CNG meet the APTA requirements.

**Page 44: Table 4-4 Qualitative Comparison of Alternative Fuel Vehicle Cost and Benefits Relative to 2005 Diesel Heavy-Duty Vehicles:**



Based on the information provided above, the following adjustments to EEA's heavy-duty vehicle qualitative analysis are appropriate:

*Criteria Pollutants:* EEA states that there will be no criteria pollutant benefit for heavy-duty natural gas vehicles beyond 2009. CVEF disagrees -- the probability is that there will be such benefit.

*GHG Emissions:* EEA states that there will be no greenhouse gas benefit from natural gas vehicles, which is incorrect. There will be a 15-20 percent natural gas advantage.

*Reduction in Fuel Imports:* EEA states that there is no fuel import benefit from natural gas vehicles. This also is incorrect. There is (and will continue to be) a significant fuel import benefit from natural gas vehicles.

*Life Cycle Cost:* EEA states that a 13 percent cost penalty exists for natural gas vehicles. As demonstrated in CVEF's analysis above, natural gas vehicles will have a 20.5 percent advantage.

*Future Fuel Availability:* EEA states that natural gas costs may be high over the next few years. The absolute cost of natural gas is less important than the relative cost of natural gas versus competing fuels. As discussed previously, natural gas is forecast to maintain its substantial price advantage over gasoline and diesel fuel.

**Page 45: 4.3 Heavy Duty Alternative Fuel Vehicles 4.3.1 Cost Analysis:**

In this section, for the first time in its report, EEA discusses at length reducing emissions from existing diesel vehicles. As EEA points out, heavy-duty diesel vehicles are very long-lived, and, the older the vehicle, the more pollution it generates.<sup>lxiv</sup> In addition to programs such as idle reduction, using ULSD (which will be required beginning 2006) and reducing the use of older vehicles (and, of course, retiring and replacing older vehicles with new vehicles), the City of Phoenix has two options that can achieve significant emission reductions from older diesel vehicles: retrofits and repowers. With retrofits, the existing engine/vehicle is fitted with a device to reduce PM, NOx, air toxics, etc. With repowers, the engine is removed and replaced with a new, less polluting one. Repowers are more expensive, but they are more effective in reducing pollution. In addition, the older the vehicle, the less appropriate retrofit technology is. For vehicles older than 1998, retrofits are not recommended. Repowering with natural gas engines/systems can be a cost-effective option. EEA does not provide sufficient information to the City of Phoenix on which to base any retrofit/repower decisions. CVEF recommends that the City of Phoenix undertake a separate analysis of the costs and benefits associated with retrofits and repowers as they apply to the City's specific heavy-duty vehicles.

## **CVEF FINDINGS AND RECOMMENDATIONS<sup>1</sup>**

Given the errors and omissions noted above, CVEF concludes that many of EEA's findings and recommendations are invalid. Based on current information and the analysis provided above, CVEF makes the following recommendations to the City of Phoenix:

### **Light-Duty Vehicles**

#### **A. When replacing vehicles, replace them with natural gas vehicles where OEM or SVM models are available.**

While the emissions gap between natural gas and gasoline vehicles has narrowed, in most applications, natural gas vehicles will continue to have a criteria emissions advantage. Additionally, given the federal incentives, natural gas vehicles may also provide a lower life cycle cost. This is especially true in larger light- or medium-duty vehicles (greater than 8,500 pounds gvwr). Natural gas vehicles also offer a significant (up to 20 percent) greenhouse benefit over gasoline vehicles. Earlier this year, Arizona Governor Janet Napolitano established a Climate Change Advisory Group charged with developing recommendations for a program to reduce greenhouse gas emissions in Arizona. The report of the Advisory Group is due in 2006. Given the significant role that vehicles play in greenhouse gas production, the report will likely include a number of vehicle recommendations that will affect Phoenix's fleet.<sup>lxv</sup>

Despite the distinct advantages of natural gas vehicles, in some applications, buying gasoline-powered vehicles will be the best choice. For example, for vehicles that are driven minimal distances, the added first cost for a natural gas vehicle may not be worth the minimal emissions savings. However, the majority of light- and medium-duty vehicles purchased for use by the City of Phoenix should be natural gas. Some vehicles should be bi-fuel (i.e., able to operate on either natural gas or gasoline) so they can be driven to locations where natural gas fueling is not yet available. Vehicles operating primarily in the greater Phoenix area should be dedicated natural gas since dedicated natural gas vehicles provide the greatest emissions reduction.

#### **B. When gasoline vehicles must be purchased, they should be flex-fuel vehicles, and, where possible, the vehicles should operate on E85.**

While there is some debate over the criteria pollution benefits of operating vehicles on E85 (85 percent ethanol and 15 percent gasoline), E85 vehicles offer substantial greenhouse gas reductions and help reduce America's dependence on foreign oil. In addition, the federal government provides the blenders of E85 with 82 cents per gge tax credit, which helps ethanol to be competitive with gasoline. Also, as EEA points out, there is no price premium for OEM-produced flex-fuel vehicles. The City of Phoenix could negotiate a contract with a fuel provider to provide ethanol blends that are at least comparable with gasoline on a per btu basis.

#### **C. Existing (and any new) gasoline vehicles should operate on E10.**

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<sup>1</sup> In its FINDINGS AND RECOMMENDATIONS section, EEA repeats many of the erroneous assertions and conclusions that have already been addressed. Thus, CVEF does not address them again here.

Formerly called gasohol, E10 is a blend of 10 percent ethanol and 90 percent gasoline. All gasoline vehicles (as well as all flex-fuel vehicles) are capable of operating on E10. If E10 can be purchased cost-competitively with gasoline, it should be purchased and used.

**D. Continue to monitor hybrid developments.**

Hybridization technology is evolving rapidly and will play a critical role in reducing America's dependence on foreign oil. The City of Phoenix should monitor light-duty hybrid demonstration and deployment programs undertaken by other municipalities. Once costs and benefits are clearer, the issue should be revisited.

## **Heavy-Duty Vehicles**

**A. When replacing heavy-duty vehicles, replace them with natural gas vehicles where appropriate engine/chassis configurations are available and the duty-cycle is appropriate for the natural gas application.**

In all likelihood, it will be well into 2006 before the City of Phoenix decides on a future city transportation plan and begins to order new heavy-duty vehicles. This means that new vehicles delivered to Phoenix will be the 2007 models. As has been shown, the natural gas versions of these new vehicles will have a significant economic advantage over comparable diesel vehicles, and will offer continued criteria pollution and greenhouse benefits. The EEA report discusses only transit and aviation buses. The City of Phoenix should also investigate natural gas for trash truck, school bus, street sweeper and other heavy-duty municipal applications.

**B. Existing (and any new) diesel vehicles should operate on a biodiesel blend.**

As EEA discusses, biodiesel offers some criteria pollution benefits.<sup>lxvi</sup> It also offers substantial greenhouse gas and petroleum displacement benefits. While using high percentages of biodiesel may raise operational issues, when it can be used without damage to the vehicle or voiding of engine warranties, biodiesel should be used in existing and new diesel vehicles. Biodiesel blenders receive a tax credit of up to \$1.00 per gallon, which, like the ethanol blender credit, helps make biodiesel competitive with petroleum diesel. The City of Phoenix could negotiate a contract with a fuel provider to provide a biodiesel blend that is at least comparable with petroleum diesel on a cost per btu basis.

**C. Conduct a study of all of the City's existing heavy-duty diesel vehicles to identify which vehicles are candidates for retrofit or repower technologies, and then retrofit/repower the vehicles where technically and economically appropriate.**

Determining the feasibility, costs and benefits of retrofitting existing diesel vehicles with new emission reduction technologies is a complex process for a number of reasons. First, the compatibility and effectiveness of devices vary with engine manufacturers and the age of engines. Second, there is often an economic and emission performance gap between the claims of the manufacturers and the in-service performance of the devices. Third, there have been a number of reports of retrofit failures.<sup>lxvii</sup> Finally, there are a myriad of federal, state and even private funding programs for retrofits for different applications (e.g., transit, school bus, airport) that can significantly alter the City of Phoenix's cost-benefit analysis – vehicle by vehicle. Many of these same factors apply to repowers. Therefore, the City needs to do a vehicle-by-vehicle

evaluation of the applicable retrofit/repower technologies, costs and emission reduction benefits. And then plan and implement the appropriate technology on those vehicles for which it would be technically and economically appropriate.



Appendix 1  
EPA and/or CARB certified Natural Gas  
Light- and Light-Medium-Duty Vehicle Models

General Motors with SVM Systems from  
Baytech, DRV Energy/HFS and BAF Technologies

Engine	Make	Model	Baytech Corporation			DRV Energy/HFS			BAF Technologies		
			Bi-Fuel/ Dedicated	EPA/CARB	Model Year(s)	Bi-Fuel / Dedicated	EPA/CARB	Model Year(s)	Bi-Fuel / Dedicated	EPA/CARB	Model Year(s)
3.1L V6	Buick	Century				Bi-fuel	E	2003			
3.1L V6	Chevy	Malibu				Bi-fuel	E	2003			
3.1L V6	Pontiac	Grand Prix				Bi-fuel	E	2003			
3.4L V6	Chevy	Impala				Bi-Fuel	E	2003			
3.4L V6	Chevy	Monte Carlo				Bi-Fuel	E	2003			
3.4L V6	Olds	Alero				Bi-Fuel	E	2003			
3.4L V6	Pontiac	Grand Am				Bi-Fuel	E	2003			
3.4L V6	Pontiac	Grand Prix				Bi-Fuel	E	2003			
3.8L V8	Buick	LeSabre				Bi-Fuel	E	2003			
3.8L V8	Buick	Park Avenue				Bi-Fuel	E	2003			
3.8L V8	Buick	Regal				Bi-Fuel	E	2003			
3.8L V8	Chevy	Impala				Bi-Fuel	E	2003			
3.8L V8	Chevy	Monte Carlo				Bi-Fuel	E	2003			
3.8L V8	Pontiac	Grand Am				Bi-Fuel	E	2003			
3.8L V8	Pontiac	Grand Prix				Bi-Fuel	E	2003			
4.3L V6	Chevy	Astro Minivan	Bi + Ded	E + C	2000-03	Bi-Fuel	E	2003-05			
4.3L V6	Chevy	Astro Minivan	Dedicated	E + C	2004-05						
4.3L V6	Chevy	Blazer 2WD/4WD	Bi + Ded	E + C	2000-03	Bi-Fuel	E	2003-05			
4.3L V6	Chevy	Blazer 2WD/4WD	Dedicated	E + C	2004-05						
4.3L V6	Chevy	Express Cargo Van G1500/2500	Bi + Ded	E + C	2000-05	Bi-Fuel	E	2003-05			
4.3L V6	Chevy	Express Pass. Van G1500/2500	Bi + Ded	E + C	2000-05	Bi-Fuel	E	2003-05			
4.3L V6	Chevy	S-10 2WD/4WD	Bi + Ded	E + C	2000-03	Bi-Fuel	E	2003-05			
4.3L V6	Chevy	Silverado C/K1500 2WD/4WD	Bi + Ded	E + C	2000-05	Bi-Fuel	E	2003-05			
4.3L V6	Chevy	Sonoma 2WD/4WD	Bi + Ded	E + C	2000-03	Bi-Fuel	E	2003-05			
4.3L V6	GMC	Jimmy 2WD/4WD	Bi + Ded		2000-03						
4.3L V6	GMC	Jimmy 2WD/4WD	Dedicated	E + C	2004-05	Bi-Fuel	E	2003-05			
4.3L V6	GMC	Safari Minivan	Bi + Ded	E + C	200-03						
4.3L V6	GMC	Safari Minivan	Dedicated	E + C	2004-05	Bi-Fuel	E	2003-05			
4.3L V6	GMC	Savana Cargo Van G1500/2500	Bi + Ded	E + C	2000-05	Bi-Fuel	E	2003-05			
4.3L V6	GMC	Savana Pass. Van G1500/2500	Bi + Ded	E + C	2000-05	Bi-Fuel	E	2003-05			
4.3L V6	GMC	Sierra C/K1500 2WD/4WD	Bi + Ded	E + C	2000-05	Bi-Fuel	E	2003-05			
4.3L V6	Wrkhrs.	P Chassis	Bi + Ded	E + C	GM						
4.8L V8	Chevy	Silverado C/K1500 2WD/4WD				Bi-Fuel	E	2005			
4.8L V8	GMC	Sierra C/K1500 2WD/4WD				Bi-Fuel	E	2005			
5.3L V8	Cadillac	Escalade / Esc. EXT/ Esc. ESV	Dedicated	E + C	2004-05						
5.3L V8	Chevy	Avalanche	Dedicated	E + C	2004-05						
5.3L V8	Chevy	Silverado C/K1500 2WD/4WD	Bi + Ded	E + C	2004-05	Bi-Fuel	E	2003			
5.3L V8	Chevy	Suburban	Dedicated	E + C	2004-05						
5.3L V8	Chevy	Tahoe	Dedicated	E + C	2004-05						
5.3L V8	Chevy	Trailblazer (incl XL and ESV)	Dedicated	E + C	2004-05						
5.3L V8	GMC	Envoy (incl XL and ESV)	Dedicated	E + C	2004-05						
5.3L V8	GMC	Sierra C/K1500 2WD/4WD	Bi + Ded	E + C	2004-05	Bi-Fuel	E	2003			



## General Motors with SVM Systems from ECO-Fuel and Parnell Technologies

Engine	Make	Model	ECO-Fuel			Parnell Technologies		
			Bi-Fuel / Dedicated	EPA/CARB	Model Year(s)	Bi-Fuel / Dedicated	EPA/CARB	Model Year(s)
3.1L V6	Buick	Century	Bi-Fuel	E	2003			
3.1L V6	Chevy	Malibu	Bi-Fuel	E	2003			
3.1L V6	Pontiac	Grand Prix	Bi-Fuel	E	2003			
3.4L V6	Chevy	Impala	Bi-Fuel	E	2003			
3.4L V6	Chevy	Monte Carlo	Bi-Fuel	E	2003			
3.4L V6	Olds	Alero	Bi-Fuel	E	2003			
3.4L V6	Pontiac	Grand Am	Bi-Fuel	E	2003			
3.4L V6	Pontiac	Grand Prix	Bi-Fuel	E	2003			
3.8L V8	Buick	LeSabre	Bi-Fuel	E	2003			
3.8L V8	Buick	Park Avenue	Bi-Fuel	E	2003			
3.8L V8	Buick	Regal	Bi-Fuel	E	2003			
3.8L V8	Chevy	Impala	Bi-Fuel	E	2003			
3.8L V8	Chevy	Monte Carlo	Bi-Fuel	E	2003			
3.8L V8	Pontiac	Grand Am	Bi-Fuel	E	2003			
3.8L V8	Pontiac	Grand Prix	Bi-Fuel	E	2003			
4.3L V6	Chevy	Astro Minivan						
4.3L V6	Chevy	Astro Minivan						
4.3L V6	Chevy	Blazer 2WD/4WD						
4.3L V6	Chevy	Blazer 2WD/4WD						
4.3L V6	Chevy	Express Cargo Van G1500/2500						
4.3L V6	Chevy	Express Pass. Van G1500/2500						
4.3L V6	Chevy	S-10 2WD/4WD						
4.3L V6	Chevy	Silverado C/K1500 2WD/4WD						
4.3L V6	Chevy	Sonoma 2WD/4WD						
4.3L V6	GMC	Jimmy 2WD/4WD						
4.3L V6	GMC	Jimmy 2WD/4WD						
4.3L V6	GMC	Safari Minivan						
4.3L V6	GMC	Safari Minivan						
4.3L V6	GMC	Savana Cargo Van G1500/2500						
4.3L V6	GMC	Savana Pass. Van G1500/2500						
4.3L V6	GMC	Sierra C/K1500 2WD/4WD						
4.3L V6	Wrkhrs.	P Chassis						
4.8L V8	Chevy	Silverado C/K1500 2WD/4WD	Bi-Fuel	E	2005			
4.8L V8	GMC	Sierra C/K1500 2WD/4WD	Bi-Fuel	E	2005			

Ford with SVM Systems from  
Baytech, DRV Energy/HFS, BAF Technologies,  
ECO-Fuel and Parnell Technologies

	Baytech Corporation			DRV Energy/HFS			BAF Technologies		
Model	Bi-Fuel/ Dedicated	EPA/CARB	Model Year(s)	Bi-Fuel / Dedicated	EPA/CARB	Model Year(s)	Bi-Fuel / Dedicated	EPA/CARB	Model Year(s)
Crown Victoria				Bi + Ded	E	2003-04	Dedicated	E + C	2003+05
Grand Marquis				Bi + Ded	E	2003-04	Dedicated	E + C	2003+05
Town Car				Bi + Ded	E	2003-04	Dedicated	E + C	2003+05
E-350 Cab and Chassis									
E-350 Econoline 2WD									
E-450 Cab and Chassis							Dedicated	E + C	2002-06
Taurus Sedan/Wagon				Bi-Fuel	E	2004-05			
Sable Sedan/Wagon				Bi-Fuel	E	2004-05			

	ECO-Fuel			Parnell Technologies		
Model	Bi-Fuel / Dedicated	EPA/CARB	Model Year(s)	Bi-Fuel / Dedicated	EPA/CARB	Model Year(s)
Crown Victoria	Bi + Ded	E	2003-04			
Grand Marquis	Bi + Ded	E	2003-04			
Town Car	Bi + Ded	E	2003-04			
E-350 Cab and Chassis				Bi-fuel	E	2005
E-350 Econoline 2WD				Bi-fuel	E	2005
E-450 Cab and Chassis						
Taurus Sedan/Wagon	Bi-Fuel	E	2004-05			
Sable Sedan/Wagon	Bi-Fuel	E	2004-05			

Original Equipment Manufacturer

Model	Bi-Fuel / Dedicated	EPA/CARB	Model Year(s)
Chevy Silverado Pickup	Bi + Ded	E + C	2006
GMC Sierra	Bi + Ded	E + C	2006
American Honda	Ded	E + C	2006

## Appendix 2

### Natural Gas Transit Buses Operating in the United States

The information from the following table is drawn from the American Public Transit Association's (APTA) 2005 Transit Vehicle Database. The Database is based on an annual survey of APTA members. Therefore, the report excludes the dozens of agencies with natural gas powered transit buses that did not participate in the survey.

#### **Compressed Natural Gas**

AZ Phoenix	Regional Public Transp Auth	39
AZ Tucson	City of Tucson MTS	89
CA Bakersfield	Golden Empire Transit Dist	57
CA Chula Vista	Chula Vista Transit	25
CA Culver City	Culver City Munic Bus Lines	46
CA Davis	University Transport System	33
CA Fairfield	Fairfield/Suisun Transit Sys	2
CA Fresno	Fresno Area Express	25
CA Glendale	# City of Glendale Beeline	31
CA Los Angeles	LADOT (City of Los Angeles, DOT)	3
CA Los Angeles	Los Angeles County MTA	2040
CA Monterey	Monterey-Salinas Transit	17
CA Oceanside	North County Transit District	51
CA Oxnard	South Coast Area Transit	46
CA Riverside	Riverside Transit Agency	129
CA Sacramento	Sacramento Regional Tr Dist	258
CA Sacramento	University Transportation and Parking	5
CA San Bernardino	OMNITRANS	150
CA San Diego	San Diego Metro Tr Dev Bd	113
CA San Diego	San Diego Transit Corp	157
CA San Luis Obispo	# San Luis Transit	2
CA Santa Cruz	Santa Cruz Metro Transit Dist	9
CA Simi Valley	Simi Valley Transit	9
CA Stockton	San Joaquin Reg Transit Dist	3
CA Visalia	Visalia City Coach	5
CA West Covina	Foothill Transit	192
CA Woodland	Yolo County Transportation District	37
CO Colorado Springs	Springs Transit	3
CO Denver	# Regional Transportation Dist	3
DC Washington	Washington Metro Area Tr Auth	164
FL Clearwater	Pinellas Suncoast Tran Auth	4
FL Orlando	Central Florida Reg Trp Auth	16
FL Tampa	Hillsborough Area Reg Tr Auth	7
GA Atlanta	Metro Atlanta Rapid Tr Auth	324
GA Lawrenceville	Gwinnett County Transit	60
GA Marietta	Cobb Community Transit	15
ID Boise City	Valley Regional Transit	47
IL Rock Island	Rock Island County Metro MTD	21
IL Springfield	Springfield Mass Transit Dist	18
LA Baton Rouge	Capital Area Transit System	5
MA Boston	Massachusetts Bay Trp Auth	360
MI Detroit	# City of Detroit Dept of Transp	25
MI Muskegon Heights	Muskegon Area TS	3
MI Port Huron	Blue Water Area TC	30
MN Burnsville	Minnesota Valley TA	4

MO Saint Louis	Bi-State Development Agency	36
NH Durham	UNH Wildcat Transit	6
NJ Newark	New Jersey Transit Corp	82
NM Albuquerque	City of Albuquerque Tr Dept	81
NM Santa Fe	Santa Fe Trails	25
NV Las Vegas	Regional Trp Comm of So NV	7
NY Buffalo	Niagara Frontier Transp Auth	5
NY Ithaca	Tompkins Consolidated Area Transit	1
NY New York	MTA New York City Transit	480
NY New York	New York City Dept of Trp	356
NY Syracuse	CNY Centro	124
OH Cleveland	Greater Cleveland Reg Tr Auth	165
OH Grand River	LAKETRAN	12
OK Oklahoma City	Central Oklahoma T&P Auth	10
OR Salem	Salem-Keizer Transit	36
PA Erie	Erie Metropolitan Transit Authority	12
PA Johnsonburg	Area Transp Authy North Central PA	16
PA Reading	Berks Area Reading Trp Auth	7
PA State College	Centre Area Transp Auth	48
PA York	# York County Transp Auth	2
RI Providence	Rhode Island Public Tr Auth	25
TX Austin	Capital Metropolitan Trp Auth	30
TX Dallas	Dallas Area Rapid Transit	15
TX El Paso	El Paso Mass Transit Dept	70
TX Fort Worth	Fort Worth Transp Auth	123
TX Houston	Metro Tr Auth of Harris County	5
TX Laredo	Laredo Municipal Transit Sys	45
UT Salt Lake City	Utah Transit Authority	5
VA Arlington	Arlington County DPW	22
WA Seattle	Central Puget Sound RTA	47
WA Tacoma	Pierce Transit	169
WI Kenosha	Kenosha Transit	1
<b>TOTAL</b>		<b>6,750</b>
<b><u>Compressed Natural Gas &amp; Diesel</u></b>		
AZ Tucson	City of Tucson MTS	47
FL Clearwater	Pinellas Suncoast Tran Auth	10
<b>TOTAL</b>		<b>57</b>
<b><u>Compressed Natural Gas &amp; Electric Battery</u></b>		
CA San Bernardino	OMNITRANS	3
CO Denver	# Regional Transportation Dist	38
WA Seattle	Central Puget Sound RTA	20
<b>TOTAL</b>		<b>61</b>
<b><u>Compressed Natural Gas &amp; Gasoline</u></b>		
NY Buffalo	Niagara Frontier Transp Auth	5
<b>TOTAL</b>		<b>5</b>
<b><u>Liquefied Natural Gas</u></b>		
AZ Phoenix	City of Phoenix PTD	320
AZ Phoenix	Regional Public Transp Auth	48
AZ Scottsdale	City of Scottsdale Transit	25
AZ Tempe	City of Tempe Transp Div	104
CA Orange	Orange County Transp Auth	232
CA Santa Monica	Santa Monica's Big Blue Bus	89

IN Gary	Gary Public Transportation Corporation	8
TX Dallas	Dallas Area Rapid Transit	183
TX El Paso	El Paso Mass Transit Dept	35
<b>TOTAL</b>		<b>1,044</b>
<b><u>Liquefied Natural Gas Electric Battery</u></b>		
AZ Tempe	City of Tempe Transp Div	20
<b>TOTAL</b>		<b>20</b>

## Endnotes

<sup>i</sup> Telephone conversations with Richard Kolodziej, president of NGV America (December 12, 2005) and Brian Feehan, Managing Director, Propane Vehicles, the Propane Education and Research Council (December 13, 2005).

<sup>ii</sup> Telephone conversation with Gilbert Sperling, General Counsel, NGV America (January 4, 2006) and Curt Johnson, Lobbyist for the National Propane Gas Association (January 5, 2006).

<sup>iii</sup> *Clean Cities News* (Vol.8 Number 1, March 2004)

<sup>iv</sup> Telephone conversation with Shelley Launey, the Director of the U.S. DOE Clean Cities Program, December 19, 2005.

<sup>v</sup> Under the new structure, EPA is directed to “achieve an appropriate balance” between spending for replacement buses, retrofitting existing buses and alternative fuels. For replacements, grantees may receive the following for the purchase of alternative fuel and “clean diesel” school buses: (1) 50 percent of the cost of the new bus if it meets tight emission standards (namely: for MY2005 and 2006, 1.8 grams NO<sub>x</sub> plus NMHC and 0.01 PM; and for MY2007, 2008 and 2009, 0.2 NO<sub>x</sub> and 0.01 PM, i.e., the 2010 EPA heavy-duty emission standards); or (2) 25 percent of the cost of the new bus if it meets less strict emission standards (namely: for MY2005 and 2006, 2.5 grams NO<sub>x</sub> plus NMHC and 0.01 PM; and for MY2007, 2008 and 2009, “regulatory requirements” by EPA, which is assumed to mean the phase-in requirement to 2010 which is 1.2 grams NO<sub>x</sub> and 0.01 PM). Currently, the two manufacturers that produce natural gas engines for the school bus market (i.e., Deere and Cummins-Westport International) produce engines that meet the tighter standard, and, therefore, qualify for the 50 percent funding. In addition, both companies have announced that their engines will meet the tighter 2007 standards, too. No diesel engines meet the current tighter standards, and no diesel manufacturers are expected to meet the tighter 2007 standards. See P.L. 109-59, Sec. 6015.

<sup>vi</sup> See California Environmental Protection Agency /Air Resources Board Staff Report: Initial Statement Of Reasons, 2003 Proposed Amendments To The California Zero Emission Vehicle Program Regulations, January 10, 2003.

<sup>vii</sup> To qualify for California’s AT PZEV classification, a vehicle must:

- Be 90% cleaner than the average new 2003 model year car.
- Have zero evaporative emissions and a 15 year / 150,000 mile warranty.
- Have additional "ZEV-like" characteristics. A dedicated compressed natural gas vehicle, or a hybrid vehicle with engine emissions that meet the two standards above would be an AT PZEV.
- Hybrid-electric vehicles, however, must meet minimum componentry and other performance standards, such as regenerative braking, idle stop/start, traction drive boost, and minimum battery life.

<sup>viii</sup> “2005 Zero-Emission and PZEV Credit Vehicles” table at [www.arb.ca.gov](http://www.arb.ca.gov).

<sup>ix</sup> “2005 California Certified Vehicles” table at [www.arb.ca.gov](http://www.arb.ca.gov).

<sup>x</sup> Order of the United States District Court, Central District of California, in *Engine Manufacturers Association et al. v. South Coast Air Quality Management District*, May 6, 2005.

<sup>xi</sup> In the advisory titled “South Coast Air Quality Management District, Clean Fleet Vehicle Rules Advisory Notice To Fleets, Subject To SCAQMD Fleet Vehicle Rules 1186.1, 1191, 1192, 1193, 1194, 1195, and 1196, Implementation Of The Fleet Rules Following May 6, 2005 Order Of The U.S. District Court In Engine Manufacturers Association Et Al. V. South Coast Air Quality Management District, July 20, 2005”, the SCAQMD states:

- The Fleet Rules shall be in full force and effect as they apply to state and local public entities, including the State of California, counties, cities, and special districts
- The SCAQMD will not affirmatively enforce the requirements of the Fleet
- Rules as they apply to federal public entities.
- The Fleet Rules shall be in full force and effect as they apply to private entities under contract to state or local public entities, including the State of California, counties, cities, and special districts.

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- The SCAQMD will not affirmatively enforce the requirements of the Fleet Rules as they apply to private entities that are not under contract to state or local public entities.
  - The SCAQMD encourages all fleet operators to purchase clean-fuel vehicles to benefit the environment.

<sup>xii</sup> “SCAQMD Clean-Diesel Rule 'De Facto' Mandate For NGVs, Says Oil Industry,” New Fuels and Vehicles Online, September 27, 2001.

<sup>xiii</sup> Currently, EPA emission standards for heavy-duty engines are 2.5 grams per brake horsepower hour (gm/bhp-hr) for nitrogen oxides (NOx) and volatile organics compounds (VOCs) and 0.1 gm/bhp-hr for particulate matter (PM). Beginning with model year 2007 engines, those standards will be 0.2 gm/bhp-hr of NOx and 0.01 gm/bhp-hr of PM. However, EPA will permit a phase-in of the new NOx standard during model year 2007, 2008 and 2009. The manufacturers have indicated that they will implement that phase in by ensuring that all engines manufactured during the 2007-2009 period produce no more than 1.2 g/bhp-hr of NOx.

<sup>xiv</sup> “Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant Report,” unanimously adopted by CARB on April 22, 1998.

<sup>xv</sup> For example, according to a February, 2000 Engine Manufacturers news release, “Not only does EMA [the Engine Manufacturers Association] support CARB’s proposal, we have committed to pull ahead its deadline to meet more stringent particulate matter (PM) standards,” said Glenn Keller, EMA Executive Director. “We remain committed to improving diesel emissions reduction technologies and have vowed to meet CARB’s 0.01 PM standard by October 2002 - that’s a full 15 months ahead of the January 2004 deadline.”

<sup>xvi</sup> “Final Statement of Reasons for Rulemaking, Including Summary of Comments and Agency Responses; Public Hearing To Consider The Adoption Of A Public Transit Bus Fleet Rule And Emission Standards For New Urban Buses,” February 24, 2000.

<sup>xvii</sup> See “Staff Report: Initial Statement of Reasons; Proposed Modifications To The Fleet Rule For Transit Agencies And New Requirements For Transit Fleet Vehicles,” January 7, 2005. The final regulations are not yet available.

<sup>xviii</sup> “The Environmental Protection Agency says that, by the end of the year, it will propose significant changes to the way it estimates automobile fuel economy ratings. The agency has long been faulted for test methods, based on decades old driving habits, that in most cases overestimate the miles per gallon drivers can expect. A survey of 303 vehicles among those Consumers Union tested for model years 2000-2006 -- each driven 8,000 to 10,000 miles -- found that, in 90 percent of the cases, EPA mileage estimates were inflated, in some cases grossly so. Some Consumer Union tests showed vehicles falling 40 and 50 percent below EPA estimates in city fuel economy. The EPA is acting as consumer groups such as the American Automobile Association and Consumers Union are calling for such changes, and consumers, spurred by the latest surge in gasoline prices, are paying more attention to their fuel consumption.

EPA said three changes will be at the core of its proposal:

- Altering testing to reflect today's more aggressive and high-speed driving habits, as well as addressing congestion in cities and expanding suburbs.
- Accounting for vehicles driven in cold climates, where fuel economy suffers.
- Calculating the impact of accessories, such as air conditioners, that cut fuel economy.

Vehicles tested for EPA ratings are tested not by the EPA, but by auto manufacturers using EPA standards. The firms submit their results to the agency, which duplicates the tests in 10 percent of cases to check for accuracy. The wheels of the test vehicles, which are usually optimized models, never turn on real pavement. The testing is done on dynamometers, calibrated to simulate real-life conditions. The EPA test is based on 30-year-old standards. The city test requires that a vehicle be run for 11 simulated miles with 23 stops, about 5 minutes of idle time, at an average speed of 21 miles per hour on the highway, a 10-mile drive, and the average speed is 48 miles per hour on a smooth road.

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The tests do not account for extreme temperatures, the use of air conditioners, bad road conditions, or increased urban and suburban traffic jams -- all of which can reduce fuel efficiency. Further, today's drivers reduce their mileage by being far more aggressive in moving from intersections and passing each other on state roads, suburban roads, and at urban intersections." Quoted from NGVCommunications newsletter, November 25, 2005. Also see "EPA plans to overhaul tests to set more accurate mileage," USA Today, November 20, 2005.

<sup>xix</sup> See John Deere news release "John Deere Power Systems Showcases 9.0l Natural Gas Engines At Gathering Of Transit Industry Leaders," September 2005, and Cummins-Westport news release "Cummins Westport, DOE, And NREL Partner To Deliver Next Generation Natural Gas Engine Three Years Ahead Of U.S. Regulations," February 9, 2005. In these releases, these natural gas engine manufacturers announced that they would have 2010 compliant heavy-duty engines available for the market in 2007 using stoichiometric engines.

<sup>xx</sup> Ibid.

<sup>xxi</sup> In fact, prior to merging with New York MTA, Long Island MTA was in the process of expanding its natural gas transit bus fleet.

<sup>xxii</sup> According to the latest U.S. EIA forecast (Annual Energy Outlook 2006 with Projections to 2030, December 12, 2005), "the average U.S. wellhead price for natural gas in the *AEO2006* reference case declines gradually from the current level as increased drilling brings on new supplies and new import sources become available. The average price falls to \$4.46 per thousand cubic feet in 2016 (2004 dollars), then rises gradually to more than \$5.40 per thousand cubic feet in 2025 (equivalent to about \$10 per thousand cubic feet in nominal dollars) and more than \$5.90 per thousand cubic feet in 2030." As to petroleum, EIA forecasts that the price of oil is expected to be in the \$47 - \$59 range for the period from 2005-2030. "In the reference case ... the average world crude oil price continues to rise through 2006 and then declines to \$46.90 per barrel in 2014 (2004 dollars) as new supplies enter the market. It then rises slowly to \$54.08 per barrel in 2025 ... about \$21 per barrel higher than the price in *AEO2005* (\$32.95 per barrel) ... The prices in the *AEO2006* reference case reflect a shift in EIA's thinking about long-term trends in oil markets." Others are less sanguine about oil prices than EIA. According to a Reuters story reported in MSNBC On-line ("Goldman Sachs: Oil Prices to Stay High For Years" December 18, 2005), Goldman Sachs Global Investment Research recently stated: "We disagree ... that crude oil prices reached their peak levels earlier in 2005," said the firm's Global Investment Research. The story goes on to say that analysts said oil demand remained resilient and supply growth lackluster, prompting them to keep their average U.S. crude price forecast for next year unchanged at \$68 a barrel. They predicted oil prices could see 1970s-style price surges to as high as \$105 a barrel during this period. Other analysts are not as pessimistic.

<sup>xxiii</sup> Ibid. Table A3. Energy Prices by Sector and Source.

<sup>xxiv</sup> The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users or SAFETY-LU (P.L. 109-59), Sec 11113. This incentive is for alternative fuel used in vehicles. It is 50 cents per gge for CNG and 50 per liquid gallon for LNG (or 76.1 cents per gge). On a diesel gallon basis, this incentive is 55.6 cents for CNG and 84.6 cents for LNG. Since this is an excise tax credit – and not an income tax credit – it is available to any user, whether or not they are a tax-paying organization. In other words, it is available to the City of Phoenix.

<sup>xxv</sup> The incentive also applies to propane, hydrogen and some minor fuels.

<sup>xxvi</sup> For tax paying entities, partially offsetting the value of the excise tax credit is an increase in the motor fuels excise tax rate for both CNG and LNG. The CNG rate would increase from 4.3 cents per gasoline gallon equivalent to 18.3 cents. The LNG rate would increase from 11.9 cents to 24.3 cents on a LNG gallon basis. The increased tax rate will go into effect on October 1, 2006.

<sup>xxvii</sup> See "Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements," EPA, 40 CFR Parts 69, 80, and 86, published January 18, 2001.

<sup>xxviii</sup> See comments submitted to EPA on ULSD rule by: ExxonMobil (IV-D-228) p. 2-3; Independent Fuel Terminal Operators Association (IV-D-217) p. 3-5; Marathon Ashland Petroleum (IV-D-261) p. 2, (IV-F-74);

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NY Assoc. of Service Stations & Repair Shops (IV-F-45); Petroleum Marketers Association of America (IV-F-67); Phillips Petroleum Company (IV-D-250) p. 5; Ports Petroleum Co, Inc. (IV-F- 117) p. 190; U.S. Chamber of Commerce (IV-D-329) p. 5; and Western Independent Refiners Association (IV-D-273) p. 3, “Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements: Response to Comments,” EPA, EPA420-R-00-027, December 2000.

<sup>xxxix</sup> “The Transition to Ultra-Low-Sulfur Diesel Fuel: Effects on Prices and Supply”, The US Energy Information Administration, June 8, 2001

<sup>xxx</sup> See U.S. EPA Certificate of Conformity, April 27, 2005. Also see BAF news release “BAF CNG Crown Victoria Tests SULEV,” December 22, 2005

<sup>xxxix</sup> Deere and Cummins Westport, op. cit.

<sup>xxxii</sup> “Hybrid buses' fuel economy promises don't materialize: Older models have gotten better mpg,” Seattle Post Intelligencer, December 12, 2004.

<sup>xxxiii</sup> “Study Questions Advantages of Diesel-Hybrid Buses,” Newsday, September 15, 2005.

<sup>xxxiv</sup> December 21, 2005 conversation with David Lynch, Cummins-Westport Corporation.

<sup>xxxv</sup> For example, work is underway on the development and testing of a natural gas hybrid-electric transit bus in San Diego. The total cost for this development and demonstration project is \$1,000,000. (See minutes of the South Coast Air Quality Management District’s October 7, 2005 Board Meeting.)

<sup>xxxvi</sup> See Note xviii

<sup>xxxvii</sup> “Behind the Wheel/206 Lexus RX400h; The Hybrid Emperor’s New Clothes,” NY Times, July 31, 2005. Also see “Hybrid car owners wonder: Where’s the mileage?,” USA Today, February 6, 2005.

<sup>xxxviii</sup> Conversation with William Calvert of BAF Technologies, December 21, 2005.

<sup>xxxix</sup> This was a two-phased study. The first phase report was titled “Diesel and CNG Heavy-duty Transit Bus Emissions over Multiple Driving Schedules: Regulated Pollutants and Project Overview”. The second phase report was titled “Report of Partial Results: Emissions From Two Oxidation Catalyst-Equipped CNG Buses”. Both reports were issued in 2002. That study concluded that natural gas and diesel buses could both achieve very low (and comparable) PM reductions (if the diesel vehicles are equipped with catalyzed particulate traps) but that natural gas buses produce half the NO<sub>x</sub> of diesel buses. In addition, the natural gas buses produced less greenhouse gases, while the diesel buses produced significantly more nitrogen dioxide (NO<sub>2</sub>), the health effects of which are similar to ozone.

<sup>xl</sup> In this apples-to-apples study, a total of twelve 40-foot, low-floor WMATA buses were tested using West Virginia University’s Transportable Heavy-Duty Vehicle Emission Testing Laboratory. These buses were of two types: CNG and low-sulfur diesel (approximately 17 ppm sulfur). All CNG buses had lean burn natural gas engines and oxidation catalysts. All diesel buses had catalyzed particulate filters, and one group of diesel buses had exhaust gas recirculation (EGR). “Emission Testing of Washington Metropolitan Area Transit Authority (WMATA) Natural Gas and Diesel Transit Buses,” National Renewable Energy Laboratory, December 2005.

<sup>xli</sup> CARB, op. cit.; NREL, op. cit. Also, note the following: “With 2010 technology, natural gas vehicles are projected to have 16% lower CO<sub>2</sub> emissions compared with gasoline vehicles and 13% lower CO<sub>2</sub> emissions compared with diesel vehicles. The inherently lower greenhouse gas intensity of natural gas vehicles could be further exploited by optimized engine technology and new concepts for heavy-duty engines,” Market Development Of Alternative Fuels: Report Of The Alternative Fuels Contact Group, European Union, December 2003.

<sup>xlii</sup> “In addition to showing the emissions advantage of CNG buses, this project showed promising fuel economy results for the CNG buses compared with the diesel buses. The following fuel economy comparisons are made on a diesel gallon

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equivalent basis. The John Deere CNG buses exhibited a 9.0% fuel economy improvement compared with the MY 2004 DDC diesel buses and a 2.9% improvement compared with the MY 2000 DDC diesel buses.” NREL, *op. cit.*

<sup>xliii</sup> See for example “Fleets already concerned about '07 engine costs,” Diesel Progress North America, April 2004.

<sup>xliv</sup> TTNews.com, December 5, 2005.

<sup>xlv</sup> Presentation by Deere Power Systems to Annual Natural Gas Vehicle Conference, October 2001.

<sup>xlvi</sup> See “Annual Energy Outlook 2006 with Projections to 2030,” EIA, December 12, 2005. A very small quantity of gas is imported to the U.S. in the form of liquefied natural gas (LNG). Currently, there are only four active U.S. LNG importation terminals – in Boston, Massachusetts; Cove Point, Maryland; Savannah, Georgia; and Lake Charles, Louisiana. In 2004, imported LNG represented 0.59 trillion cubic feet (2.7 percent) of gas used in the U.S. However, technology and other improvements have made LNG importation increasingly cost competitive. In addition, natural gas resources are more evenly distributed around the world than petroleum, and a growing number of countries have discovered indigenous natural gas reserves that they are interested in selling in the international market. As a result, there are a number of current proposals to expand the existing four U.S. LNG importation terminals and build and operate new terminals in or near the U.S. As with all such large, often-competing energy projects, only a few (if any) of these will eventually be built. Importantly, while a number of OPEC countries are, or hope to be, LNG exporters, the number of non-OPEC LNG providers is growing. These include: Australia, Indonesia, Malaysia and Trinidad & Tobago.

<sup>xlvii</sup> *Ibid.*

<sup>xlviii</sup> *Ibid.*

<sup>xlix</sup> “Biogas For Transportation Use: A 1998 Perspective,” QSS Group, July 9, 1998 Commissioned by U.S. DOE)

<sup>1</sup> In a telephone conversation with GM’s Connie Scarpelli, she indicated that fleets would probably be eligible for a fleet discount on the GM natural gas pickup truck. (December 23, 2005).

<sup>li</sup> On-board fuel storage tanks used on most vehicles use special carbon fiber that also is in demand for combat vehicles. As a result of the war in Iraq, demand for that carbon product has increased sharply – as has the price. This has increased the price of natural gas storage cylinders significantly. The carbon fiber manufacturers are working to expand production, which is expected to begin coming online during 2006. This should reduce the price of the carbon – and, therefore, the cylinders. Telephone conversation with William Dick, president of Lincoln Composites, a major CNG tank manufacturer. December 10, 2005.

<sup>lii</sup> NREL, *op. cit.*

<sup>liii</sup> Proceedings of October 26-28, 2005 Transit Users Group meeting.

<sup>liv</sup> “Advantages And Opportunities With Cummins Westport Natural Gas Engines,” CWI presentation, 2005 (from CWI website)

<sup>lv</sup> *Ibid.*

<sup>lvi</sup> “Comparative Costs of 2010 Heavy-Duty Diesel and Natural Gas Technologies: Final Report,” TIAX LLC, July 15, 2005.

<sup>lvii</sup> *Ibid.*

<sup>lviii</sup> Quote from Dennis Beal, vice president of physical assets for Fed Ex Freight in “Fleets already concerned about '07 engine costs,” Diesel Progress North America, April 2004. Among related quotes from the article are:

- “Schneider's Duley [Steve Duley, vice president of purchasing for Schneider National], with 9000 tractors, said the 3% to 5% drop in mpg with '02 engines ‘has wiped out 10 years of fuel economy improvements ... Operating costs are 2 to 3 cents per mile more than pre-'02 engines for a total projected increased cost of \$15,000 per tractor.”

- “Fletcher's [Marty Fletcher, director of technology and training for U.S. Xpress] experiences at U.S. Xpress were similar. Between engine brands, fuel mpg is off as much as 9% ...”

<sup>lix</sup> Bus Price spreadsheet available from CVEF.

<sup>lx</sup> “Emissions Compliance Could Cost \$5,000-\$10,000 Per Engine,” Truckinginfo.com, November 9, 2005.

<sup>lxi</sup> See “Fleets already concerned about '07 engine costs,” Diesel Progress North America, April 2004.

<sup>lxii</sup> As discussed previously, the alternative fuel vehicle purchase credit is 50 percent of the incremental price, with a cap on the amount of incremental price covered. For heavy-duty vehicles, that cap is \$40,000. If the engine meets the most stringent emission standard, the credit is 80 percent. Since both the Cummins-Westport and Deere heavy-duty engines meet the most stringent standard, the vehicle buyer would be eligible a credit of up to \$32,000

<sup>lxiii</sup> This assumption is consistent with the findings of “Comparative Costs of 2010 Heavy-Duty Diesel and Natural Gas Technologies: Final Report,” TIAX LLC, July 15, 2005.

<sup>lxiv</sup> There are two reasons for this. First, the older vehicles were designed to meet less strict emission standards. The second is that engine emissions degrade over time. The following table shows how engine emission standards have changed over the last 20 years:

EPA Emission Standards for Heavy-Duty Diesel Engines  
(g/bhp-hr)

Year	NO <sub>x</sub>	PM
Heavy-Duty Diesel Truck Engines		
1988	10.7	0.6
1990	6	0.6
1991	5	0.25
1994	5	0.1
1998	4	0.1
2004	2.5	0.1
2007	1.2	0.01
2010	0.2	0.01
Urban Bus Engines		
1991	5	0.25
1993	5	0.1
1994	5	0.07
1996	5	0.05*
1998	4	0.05*
2004	2.5	0.1
2007	1.2	0.01
2010	0.2	0.01

\* - in-use PM standard 0.07

<sup>lxv</sup> There also is a municipal movement in the U.S. to reduce greenhouse gases. “Seattle Mayor Greg Nickels in February announced the U.S. Mayors Climate Protection Agreement, which aims to get cities to do what he feels the federal government is not as it backs away from the Kyoto Protocol. Nickels aimed to get 141 cities to join. The number is significant because the Kyoto accord has been signed by 141 countries. As of Friday, 168 cities had joined. None of Arizona's cities and towns has joined the effort, according to Nickels' Web site. Phoenix Mayor Phil Gordon was invited to

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sign the agreement, but he declined, said Marian Yim, counsel to the mayor. That's because some of the requirements were beyond the city's capabilities, such as making an inventory of local greenhouse-gas emissions, Yim said. Phoenix doesn't gather such data, and with budget cuts crimping ongoing operations, it's not feasible for the city to expand into this area, she said. Besides, Phoenix already is contributing through such efforts as its alternative-fuels program. It has moved a number of city-owned vehicles, as well as much of the bus fleet, to clean-burning fuel", "State to tackle climate change: 2 groups to work on plans for cutting Ariz. greenhouse gases," The Arizona Republic, Jul. 10, 2005.

<sup>lxvi</sup> As pointed out by EEA, use of biodiesel increases NOx slightly. The biodiesel industry has announced that they have developed a biodiesel blend that resolves this issue. As yet, no certification for this blend has yet been issued.

<sup>lxvii</sup> See, for example, "NYCT Experience With Clean Diesel Technologies," presentation to The World Bank, January 17, 2003.